LA-UR-03-7627
ER2003-0709

Corrective Measures Study Report for Solid Waste Management Unit 16-021(c)-99

November 2003

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Los Alamos
NATIONAL LABORATORY

Los Alamos NM 87545

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Produced by
Risk Reduction and Environmental Stewardship Division–Remediation Services

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EXECUTIVE SUMMARY

This report describes the results of the Resource Conservation and Recovery Act (RCRA) corrective measures study (CMS) conducted at consolidated Solid Waste Management Unit (SWMU) 16-021(c)-99, located within Technical Area 16 (TA-16) at the Los Alamos National Laboratory (the Laboratory or LANL). This SWMU is associated with a former outfall located adjacent to Building 260, a building formerly used to process high explosives (HE). The former outfall and immediate area are also known as the TA-16-260 outfall, or the outfall source area (see Figure 1.2-1). The CMS was conducted according to the CMS plan for SWMU 16-021(c)-99, which was approved by the New Mexico Environment Department (NMED) in September 1999. The regulatory status of SWMU 16-021(c)-99 is shown in Table ES-1.

This CMS report proposes media cleanup standards (MCSs), evaluates remediation technologies, proposes corrective measure alternatives, and proposes a monitoring program to measure remedial progress for SWMU 16-021(c)-99 and nearby Cañon de Valle and Martin Spring Canyon. The CMS addresses surface and subsurface soils within the outfall source area and an underlying surge bed, as well as alluvial sediment, springs, surface water, and groundwater located within Cañon de Valle and Martin Spring Canyon. The identification and evaluation of alternatives for the site's deep vadose zone components (e.g., regional groundwater) was not conducted. A second CMS that will focus on regional groundwater will address these areas.

The CMS used the following process to develop MCSs: review of the Phase III RCRA Facility Investigation (RFI) (LANL 2003, 77965) list of chemicals of potential concern (COPCs) to identify CMS COPCs; review of the Phase III RFI risk assessment results; identification of applicable or relevant and appropriate requirements (ARARs); and identification or calculation of MCSs for each COPC.

The CMS COPCs identified include barium; manganese; hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX); hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine (MNX); and trinitrotoluene[2,4,6-] (TNT). CMS COPCs were identified for each area of the site.

The proposed ARARs for groundwater, surface water, and springs are the currently enforceable New Mexico Water Quality Control Commission (NMWQCC) human health standards for groundwater, 20 New Mexico Administrative Code (NMAC) 6.2.3103, Parts A and B. In applying these ARARs, this CMS treats all site waters as groundwater because of their interchangeability in the site hydrology. For alluvial sediment, the ARARs consist of NMAC 6.2.4103, Parts A and B. These ARARs contain both risk-based and standards-based (numerical standards) provisions from which the MCSs were derived. For the outfall source area, MCSs were derived from the Phase III RFI risk assessment results.

The risk-based provisions in the ARARs are dependent on the point of withdrawal of site waters and the human exposure scenario. Because of the future industrial use of the site and the presence of regional groundwater, this CMS identified two potential points of withdrawal for site waters: incidental water ingestion associated with industrial use and drinking water ingestion associated with residential use of the nearest municipal well. The latter point of withdrawal is applicable to shallow site groundwater because of the potential for shallow site groundwater to infiltrate to regional groundwater.

Risks associated with the industrial exposure scenario to shallow site water were calculated during the Phase III RFI and the results showed acceptable risk; according to the risk-based provisions of the ARARs, these results imply that remediation of site waters is not required. A risk assessment for residential use of the municipal well is planned for the regional groundwater CMS and will result in the development of risk-based MCSs for the CMS COPCs, including RDX and TNT, that existing numerical standards of the ARARs do not cover.

Proposed points of compliance (POCs) for the MCSs consist of five existing alluvial wells in Cañon de Valle, three existing alluvial wells in Martin Spring Canyon, two surface water sampling points along the perennial surface water reach of Cañon de Valle, one surface water sampling point in Martin Spring Canyon, and waters emanating from flowing springs. For alluvial sediment, the POCs are a set of statistically representative sediment sampling points at which leaching tests would be conducted. For the purposes of this CMS, compliance is defined as the attainment of the MCS for eight consecutive quarters of sampling results at a POC.

Several of the standard and innovative remediation technologies screened and identified as capable of attaining the MCSs were tested at the site. Technologies that rated favorably as a result of testing were assembled into corrective measures alternatives. These alternatives were evaluated using criteria consistent with the CMS Plan and RCRA.

For the outfall source area residual soils, the proposed alternative is soil removal and off-site disposal. For the outfall source area settling pond and surge bed, the proposed alternative is grouting of the surge bed to isolate residual HE and barium and maintenance of the cap that was installed in the settling pond area as part of the outfall source area interim measure.

For the Cañon de Valle and Martin Spring Canyon alluvial systems, the alternative is natural flushing of alluvial sediments and permeable reactive barrier (PRB) treatment of groundwater and surface water. The PRB is proposed to be composed of either zero valent iron or granulated activated carbon for HE treatment and calcium sulfate for the immobilization of barium. Final design of the PRB will be completed as part of the corrective measure implementation phase. Three PRBs for Cañon de Valle and one PRB for Martin Spring Canyon are proposed. The proposed alternative for springs is the installation of stormwater filters for the treatment of HE.

The proposed alternatives discussed above collectively constitute the proposed final remedy for 16-021(c)-99, with the exception of regional groundwater, which is deferred to the regional groundwater CMS.

Table ES-1
Summary of Proposed Action

SWMU Number	SWMU Description	HSWA	Radionuclide Component	Proposed Action	Rationale for Recommendation
16-021(c)-99	Outfall and drainage channel	Yes	No	Remediation	Contamination exceeds MCSs and poses the potential to adversely affect regional groundwater.

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1.0 INTRODUCTION

The purpose of this corrective measures study (CMS) report is to summarize all CMS activities and results to date; evaluate alternatives for remediation; and propose corrective measures, media cleanup standards (MCSs), and an associated monitoring program for Los Alamos National Laboratory (the Laboratory, or LANL) solid waste management unit (SWMU) 16-021(c)-99 and nearby Cañon de Valle and Martin Spring Canyon.

The Laboratory is a multidisciplinary research facility owned by the US Department of Energy (DOE) and managed by the University of California. The Laboratory is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 43 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons that contain perennial, ephemeral, and intermittent streams that run from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft. The eastern portion of the plateau stands 300 to 900 ft above the Rio Grande.

The Laboratory's Risk Reduction and Environmental Stewardship–Remediation Services (RRES-RS) project is involved in a national effort by the DOE to clean up facilities that were formerly involved in weapons production. The goal of the RRES-RS project is to ensure that the DOE's past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico.

RRES-RS, in coordination with the New Mexico Environment Department (NMED), has been actively investigating and assessing the contamination present in SWMU 16-021(c)-99 and adjacent Cañon de Valle and Martin Spring Canyon since 1990. Thus, the corrective measures and MCSs proposed in this CMS are the results of a series of extensive site-characterization and investigation efforts conducted by RRES-RS under the ongoing facility-wide investigation and the Resource Conservation and Recovery Act (RCRA) corrective action (CA) process.

1.1 Purpose and Regulatory Context

Under the RCRA CA Program (55 FR 30798; 61 FR 19432), the two main objectives of corrective action at a hazardous waste management facility are (1) to evaluate facility characteristics in relation to the nature and extent of the contaminant releases; and (2) to identify, develop, and implement appropriate corrective measure(s) to protect human health and/or the environment. At the Laboratory, the University of California and the DOE have instituted a CA program to protect human health and the environment from any potential releases of Laboratory-related hazardous waste or hazardous constituents.

For SWMU 16-021(c)-99, the CA investigation is taking place in accordance with both RCRA/HSWA requirements, as specified in Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 01585). Module VIII was issued to the Laboratory by the EPA on May 23, 1990, and modified on May 19, 1994 (EPA 1994, 44146).

For contaminants released from SWMU 16-021(c)-99 into adjacent Cañon de Valle and Martin Spring Canyon, CA is being implemented in phases. These phases—preliminary RCRA facility assessment (RFA), RCRA facility investigation (RFI), interim measures (IMs), corrective measures study (CMS), and corrective measures implementation (CMI)—are outlined in EPA RCRA CA guidance and are consistent with the EPA's traditional approach to executing RCRA CA (55 FR 30798, 61 FR 19432).

Now actively in the CMS phase of RCRA CA, SWMU 16-021(c)-99 is a high-priority site for the RRES-RS project's CA program. SWMU 16-021(c)-99's pervasive contamination and complex hydrogeology have drawn out site remediation and characterization efforts into an extensive process. Table 1.1-1 presents all scheduled, ongoing, or completed RCRA-driven corrective actions for SWMU 16-021(c)-99 to date.

1.2 Facility Location and Background

Technical Area-16 (TA-16) is located in the southwest corner of the Laboratory (Figure 1.2-1). It covers 2410 acres, or 3.8 mi^2. The land is a portion of that acquired by the Department of Army for the Manhattan Project in 1943. TA-16 is bordered by the Bandelier National Monument along State Highway 4 to the south and the Santa Fe National Forest along State Highway 501 to the west. To the north and east, it is bordered by TA-8, -9, -11, -14, -15, -37, and -49. TA-16 is fenced and posted along State Highway 4. Water Canyon, a 200-ft-deep ravine with steep walls, separates State Highway 4 from active sites at TA-16. Cañon de Valle forms the northern border of TA-16.

The administrative boundary or focus area for the CMS is shown in Figure 1.2-2. The boundary runs along State Highway 501, follows the basin drainage divide between Water Canyon and Cañon de Valle to the south, and incorporates Martin Spring Canyon, Fishladder Seep Canyon, and Cañon de Valle to the north. The administrative boundary includes all the surface and subsurface terrain within the boundary except (1) other SWMUs, and (2) Fishladder Seep and its sub-basin. These potential contaminant sources are being addressed within the scope of other RRES-RS activities.

The administrative boundary is designed to incorporate the major source of contaminants in the basin, the former TA-16-260 outfall, and associated fate and transport pathways within Cañon de Valle and Martin Spring basins. Monitoring and data analysis within the administrative boundary will support decisions for conducting remedial activities at other potential contaminant source locations as well.

1.3 CMS Report Overview

This CMS report proposes corrective measures and associated monitoring programs for remediating SWMU 16-021(c)-99 surface and shallow subsurface soils within the outfall source area, as well as alluvial sediments, surface water, alluvial groundwater, and springs located within Cañon de Valle and Martin Spring Canyon. Regional groundwater and the associated deep vadose zone are not addressed in this report, but will be addressed by a second CMS focusing on these areas. The scope of the CMS with respect to the shallow system components of the site is presented in Table 1.3-1.

The CMS uses the following process to develop MCSs: review of the Phase III RFI (LANL 2003, 77965) chemicals of potential concern (COPCs) to identify CMS COPCs, review of Phase III RFI risk assessment results, identification of applicable or relevant and appropriate requirements (ARARs), and identification or calculation of MCSs for each COPC. According to EPA guidance, use of ARARs is a CERCLA requirement that is also suited to the development of MCSs under RCRA (EPA 1998, 80120).

The proposed ARARs for groundwater, surface water and springs consist of New Mexico Water Quality Control Commission (NMWQCC) human health standards for groundwater, 20 New Mexico Administrative Code (NMAC) 6.2.3103, Parts A and B. Under this ARAR, all site waters are treated as groundwater because of their interchangeability in the site hydrology. For alluvial sediment, the ARARs consist of NMAC 6.2.4103 A and B. These ARARs contain both risk-based and standards-based

Table 1.1-1
Chronology of RRES-RS Activities at SWMU 16-021(c)-99

Date	Activity (Reference)	Synopsis of Activity
1990	RCRA facility assessment (RFA) (LANL 1990, 07512)	RFA initial site assessment is completed. Prior studies are summarized, and document extensive contamination in TA-16-260 sump water.
July 1993	Phase I RFI work plan—site characterization plan (LANL 1993, 20948)	“RFI Work Plan for Operable Unit 1082” is issued. Plan addresses Phase I sampling at SWMU 16-021(c).
May 1994	First addendum to Phase I RFI work plan (LANL 1994, 52910)	“RFI Work Plan for Operable Unit 1082, Addendum 1” is issued. Plan is approved by NMED in January 1995.
April 1995–November 1995	Phase I RFI site characterization	Phase I RFI is implemented, including Phase I investigation of SWMU 16-021(c)-99.
1995–1996	Interim action (IA)—best management practices (BMPs) (LANL 1996, 53838)	Sandbag dam and diversion pipe are installed upgradient from the former high explosives (HE) pond; sandbag dam is located east of the parking lot behind TA-16-260; geotextile fabric matting is placed in former HE pond area; eight hay bale check dams are placed within the SWMU drainage between the rock dam and the 15-ft-high cliff.
September 1996	Phase I RFI report (LANL 1996, 55077)	Phase I RFI report is issued. Data show widespread HE contamination at SWMU 16-021(c)-99, extending from the 260 outfall discharge point down to the sediment and waters of Cañon de Valle. Report is approved by NMED in March 1998.
September 1996	Phase II RFI work plan (part of LANL 1996, 55077)	Phase II RFI work plan is included in Phase I RFI report. Report is approved by NMED in March 1998.
November 1, 1996–December 23, 1996; May 1997–November 9, 1997	Phase II RFI site characterization	Phase II RFI is implemented at SWMU 16-021(c)-99.
September 1998	Phase II RFI report (LANL 1998, 59891)	Phase II RFI report is issued. Data confirm widespread HE contamination extending from the 260 outfall discharge point down to the sediment and waters of Cañon de Valle and show deeper subsurface contamination. Up to 1% total HE is detected in surge bed at a depth of 17 ft. Report documents risk to human health and the environment. Report is approved by NMED in September 1999.
September 30, 1998	CMS plan (LANL 1998, 62413.3)	CMS plan is issued. Alternatives are evaluated. Report includes Phase III RFI sampling plan and describes ongoing hydrogeologic investigations for the site. Report is approved by NMED in September 1999.
October 1998–present	Phase III RFI site characterization	Continued monitoring and sampling are used to characterize the temporal and spatial variability of site contamination; components of the site hydrogeologic system are undergoing continued evaluation.
October 1998–present	CMS—ongoing evaluation of alternatives	CMS is initiated. Series of soil and water corrective measures technologies are evaluated. Investigation of components of the site hydrogeologic system continues.

Table 1.1-1 (continued)
Chronology of RRES-RS Activities at SWMU 16-021(c)-99

Date	Activity (Reference)	Synopsis of Activity
September 30, 1999	Addendum to CMS plan (LANL 1999, 64873.3)	Addendum to CMS plan is issued. Addendum expands investigations to include deeper perched and regional groundwater potentially impacted by releases from SWMU 16-021(c)-99.
November 1999	Interim measure (IM) plan—abatement of potential risks at the source area (LANL 2000, 64355.4)	IM plan is issued. Plan specifies removal of the highly contaminated soil and tuff identified in the 260 outfall drainage channel. Plan is approved by NMED in April 2002.
November 12, 1999–November 18, 2000	Abatement of ongoing risks is initiated	TA-16-260 IM begins. Activities are interrupted by Cerro Grande fire. Initial stage of project is completed in November 2000.
January 7, 2000	Contained-in determination (NMED 2000, 64730)	NMED memo of contained-in determination is sent to the Laboratory (J. Brown) and DOE-ER (T. Taylor).
April 4, 2000	Designation of area of contamination (NMED 2000, 70649)	NMED designates SWMU 16-021(c)-99 an area of contamination. Purpose of designation is to allow material from entire drainage area to be excavated, processed, and segregated without invoking RCRA land disposal restrictions. Excavated material considered potentially hazardous waste is staged in covered piles within area-of-contamination boundary.
June 5, 2000	In situ blending authorization (NMED 2000, 67094)	NMED authorizes in situ blending in memo sent to the Laboratory and DOE. To ensure worker health and safety during the IM and after, settling pond soil is robotically blended in situ with clean or low HE concentration material to reduce maximum concentration of settling pond sediment to below-reactive limit.
August 4, 2001–October 13, 2001	Abatement of ongoing risks is completed	Remobilization and removal of isolated areas containing more than 100 mg/kg of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) is completed. Waste disposal stage of project is completed.
July 2002	260 outfall IM report (LANL 2002, 73706)	IM results are presented in IM report. Report is approved by NMED in January 2003.
March 2003	Revision 1 to CMS plan addendum—evaluation of alternatives (LANL 2003, 75986.2)	Addendum to CMS plan is updated. Investigation into deeper perched and regional groundwater and deeper vadose zone potentially impacted by releases from SWMU 16-021(c)-99 is expanded further. Plan is approved by NMED in March 2003.

Table 1.1-1 (continued)
Chronology of RRES-RS Activities at SWMU 16-021(c)-99

Date	Activity (Reference)	Synopsis of Activity
September 2003	Phase III RFI report (LANL 2003, 77965)	Report focuses on investigations into the surface water, alluvial groundwater, canyon sediment, and springs in Cañon de Valle and Martin Spring Canyon. Report includes analysis of data generated since Phase II RFI report (post-1998) and baseline risk assessments using a comprehensive database of both pre- and post-1998 data and emphasizes greater understanding of site hydrogeology and contaminant behavior. Report presents human health baseline risk assessments, one for source area, one for a selected reach of Cañon de Valle. In addition, a baseline ecological risk assessment is performed for that reach of Cañon de Valle.
November 2003	CMS report for alluvial system corrective measures evaluated/selected (this report)	CMS report for SWMU 16-021(c)-99 alluvial system. Report is a companion document to Phase III RFI report and relies heavily on the understanding of site hydrogeology and contaminant behavior outlined in that document. Report evaluates potential remedial technologies for each media and proposes appropriate technologies.
March 2006	CMS report issued for regional groundwater system—corrective measures evaluated/selected	CMS report for SWMU 16-021(c)-99 deep perched and regional groundwater system will be issued. Data will be used to support risk assessments that include the deep perched saturated zone and the regional aquifers as pathways.
Pending	Corrective measures implementation (CMI)	Final evaluation, selection, and design of selected treatment technology for impacted site media will be presented. CMI will include refinements to long-term monitoring program and criteria for establishing the attainment of media cleanup standards.
Pending	Long-term monitoring	Verification that remedies are/were effective.

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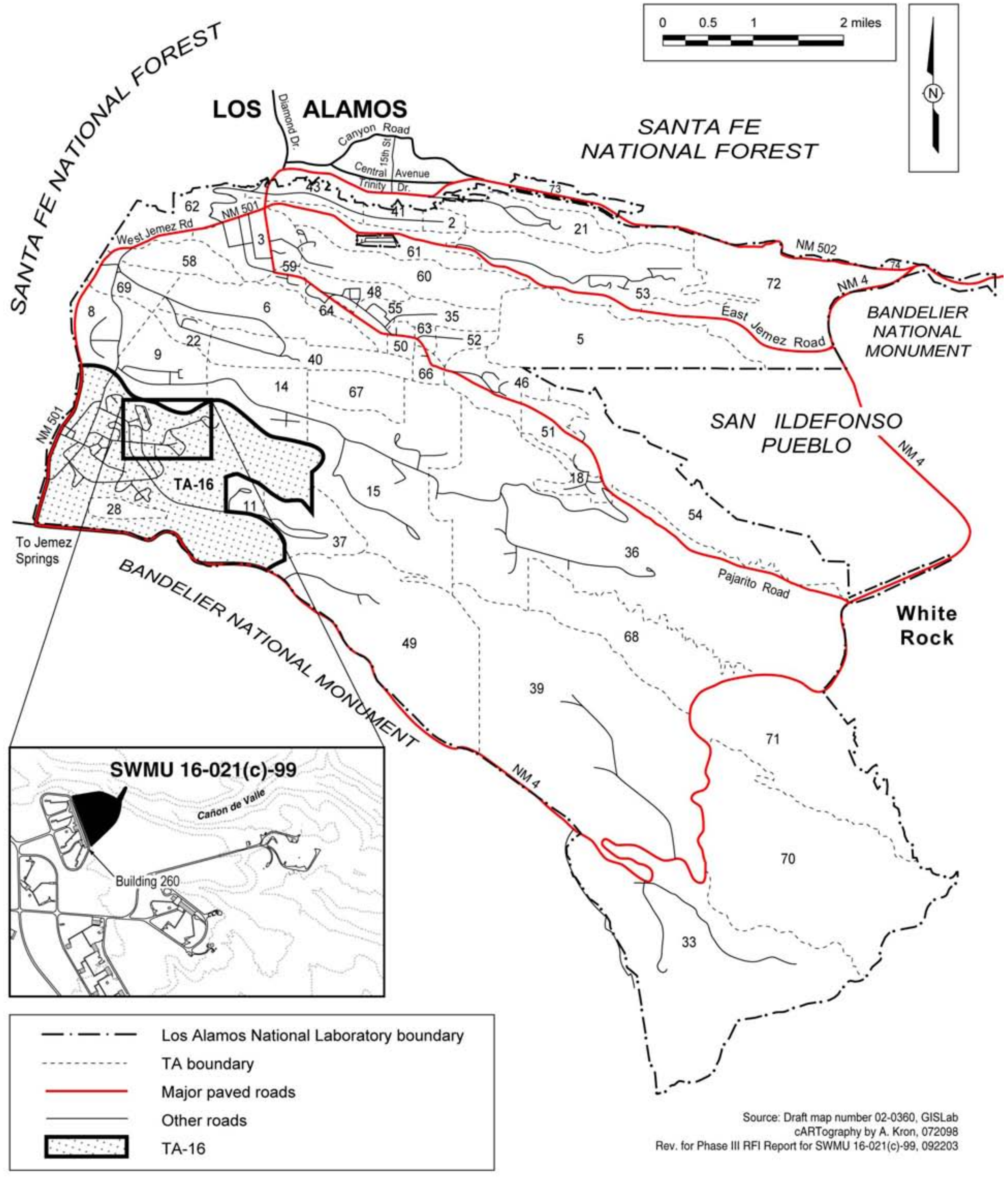

Source: Draft map number 02-0360, GISLab
cARTography by A. Kron, 072098
Rev. for Phase III RFI Report for SWMU 16-021(c)-99, 092203

Figure 1.2-1. Location of TA-16 with respect to Laboratory technical areas and surrounding landholdings; Building 260 is also shown

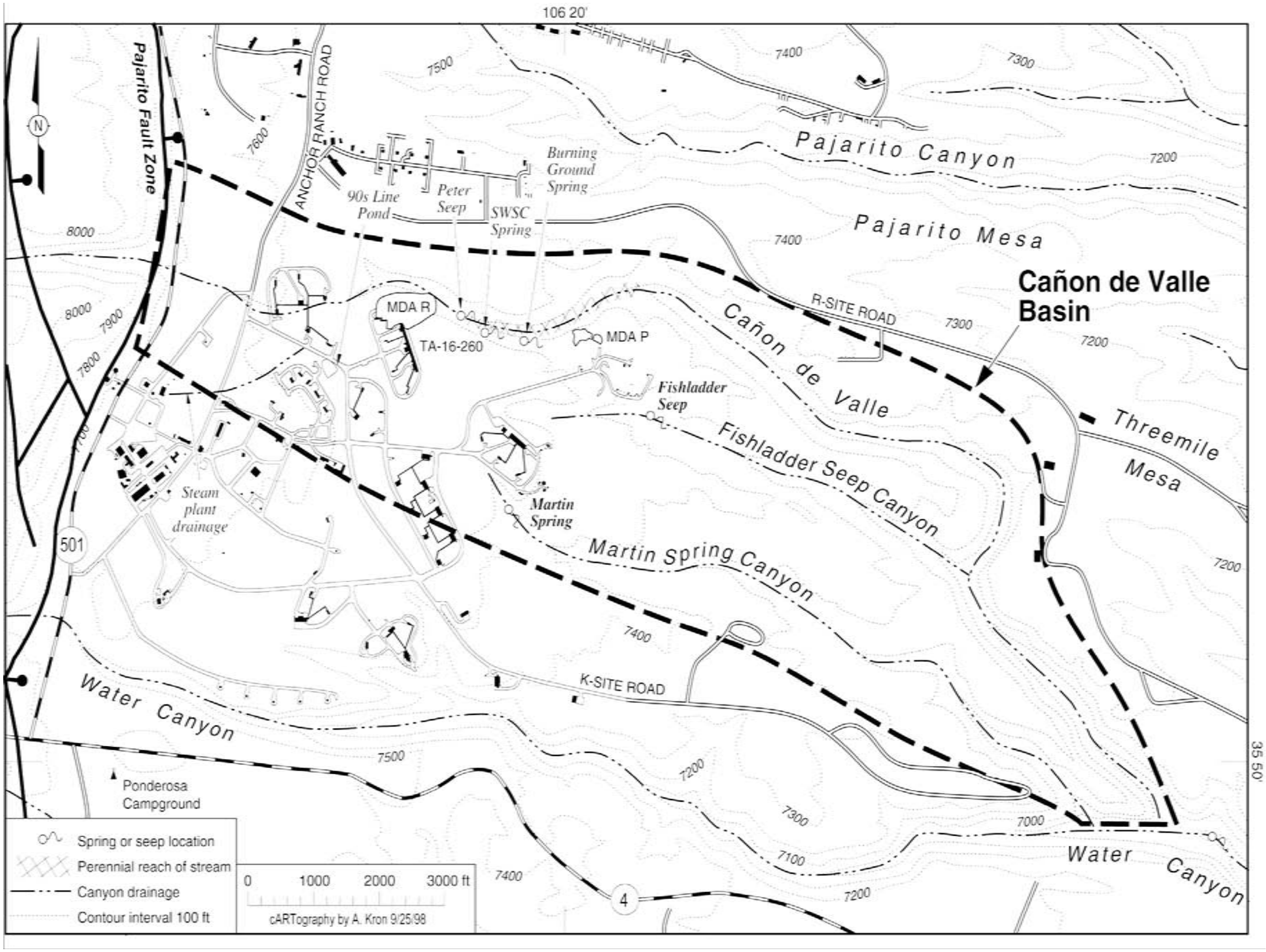

Figure 1.2-2. Administrative boundary for the SWMU 16-021(c)-99 CMS

Table 1.3-1
Scope of CMS Report and Components of SWMU 16-021(c)-99

Conceptual Model Component	CMS Scope
Outfall and pond surge beds	SWMU 16-021(c)-99 outfall area and settling pond 17-ft surge bed addressed in this report
Mesa vadose zone	Inaccessible to direct human and ecological exposure, though important in overall contaminant transport; addressed as part of springs component.
Alluvial sediments	Both Cañon de Valle and Martin Spring Canyon alluvial sediments addressed in this CMS
Springs	Springs in Cañon de Valle and Martin Spring Canyon addressed in this CMS
Surface water	Perennial surface water addressed in this CMS
Alluvial groundwater	Addressed in this CMS for Cañon de Valle (within approximately 7000 ft east of outfall) and Martin Spring Canyon
Deep vadose zone with perched groundwater table	Not addressed in this CMS; will be addressed by regional aquifer CMS
Regional aquifer	Not addressed in this CMS; will be addressed by regional aquifer CMS

(numerical standards) provisions from which the MCSs were derived. For the outfall source area, MCSs were derived from the Phase III RFI risk assessment results.

The risk-based provisions in the ARARs are dependent on the point of withdrawal of site waters and the human exposure scenario. Based on the future industrial use of the site and the presence of regional groundwater, two potential points of withdrawal for site waters were identified: incidental water ingestion associated with industrial use, and residential drinking water use at the nearest municipal well. The latter point of withdrawal is applicable to shallow site groundwater because of its potential to infiltrate to regional groundwater.

Risks associated with to shallow site water were calculated during the Phase III RFI and showed acceptable risk for a trail user; under the risk-based provisions of the ARARs, these results imply that remediation of site waters is not required. However, a risk assessment for the municipal well scenario has not been completed to date, but is planned for the regional groundwater CMS. This will result in a risk-based MCSs for those CMS COPCs not previously covered under existing numerical standards, including RDX and trinitrotoluene[2,4,6-] (TNT).

Although regional groundwater is addressed in a second CMS, the relationship between the shallow and deep systems and the contamination effects on the site’s deeper systems are considered in the evaluation of alternatives for the shallow system.

The preferred alternative identified in this CMS meets the following criteria:

- be protective of human health and the environment,
- attain the MCS for each media within a compliance time frame (CTF),
- provide source control to reduce or eliminate further releases of COPCs that are potentially threatening to human health and the environment, and
- comply with the standards for management of wastes generated as part of the CMI.

This CMS is organized into 8 sections. Section 1 provides an introduction and regulatory overview. Section 2 provides a site history. Section 3 presents a summary of current site conditions and the site conceptual model (SCM). Section 4 presents the MCSs proposed for the site. Section 5 presents the preliminary screening of remedial technologies to be used at the site. Section 6 presents the assembly and evaluation of corrective measures alternatives. Section 7 provides a summary of the preferred alternatives, their associated monitoring plans, and the uncertainties in the SCM that may require further definition as part of the CMI. Section 8 provides references. Appendix A is a list of acronyms and a glossary. Appendix B provides summary tables of Phase III RFI COPCs. Appendix C provides life cycle cost estimates for the corrective measures alternatives. Appendix D presents the public involvement plan (PIP).

2.0 SITE HISTORY

2.1 History of TA-16 Operations

TA-16 was established to develop explosive formulations, to cast and machine explosive charges, and to assemble and test explosive components for the US nuclear weapons program. Present-day use of this site is essentially unchanged, although facilities have been upgraded and expanded as explosives and manufacturing technologies have advanced.

The TA-16-260 facility, which has operated since 1951, is an HE-machining building that processes large quantities of HE. Machine turnings and HE washwater are routed as waste to 13 sumps associated with the building. Historically, the sumps were routed to the TA-16-260 outfall, where, historically, discharges as high as several million gal. per year occurred (LANL 1994, 76858).

In the late 1970s, the TA-16-260 outfall was permitted to operate by the EPA as EPA Outfall No. 05A056 under the Laboratory’s National Pollutant Discharge Elimination System (NPDES) permit (EPA 1994, 12454). The last NPDES permitting effort for this TA-16-260 outfall occurred in 1994. The NPDES TA-16-260 outfall was deactivated in November 1996; it was officially removed from the Laboratory’s NPDES permit by the EPA in January 1998. This waste stream is currently managed by pumping the sumps and treating the water at the TA-16 HE wastewater plant, which was completed in 1997.

Both the outfall and the drainage channel below the outfall are contaminated with HE and barium. The sumps and drainlines of this facility are designated as SWMU 16-003(k), and the outfall and drainage are designated as SWMU 16-021(c) in Module VIII of the Laboratory’s Hazardous Waste Facility Permit (EPA 1990, 01585). Following the Laboratory’s SWMU-consolidation effort, the two SWMUs are now collectively referred to as SWMU 16-021(c)-99. Prior to the Phase I RFI and Phase II RFI at SWMU 16-003(k) and 16-021(c), known contaminants included barium, RDX; TNT; and cyclotetramethylenetetranitramine (HMX). Suspected contaminants included other HE compounds, additional inorganic chemicals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and uranium.

2.2 SWMU Description

SWMU 16-021(c)-99 is a consolidation of two SWMUs: SWMU 16-003(k) and SWMU 16-021(c).

The part of SWMU 16-021(c)-99 that is designated SWMU 16-003(k) comprises 13 sumps and approximately 1200 ft of associated drainlines or troughs that ran from the HE machining building (TA-16-260) to the outfall. HE-contaminated water flowed from the sumps into the concrete drainlines and ultimately to the TA-16-260 outfall, located approximately 200 ft east of Building 260. Building 260 is located on the north side of TA-16 (Figure 2.2-1). The structure was originally built in 1951, with minor modifications made to the structure at a later date. SWMU 16-003(k) is not addressed in this CMS. Limited characterization was conducted as part of the Phase I RFI (LANL 1996, 55077).

The part of SWMU 16-021(c)-99 that is designated SWMU 16-021(c) comprises a well-defined upper drainage channel fed directly by the TA-16-260 outfall, a settling pond, and a lower drainage channel leading to Cañon de Valle. The settling pond, excavated during the 2000 IM, is approximately 50 ft long and 20 ft wide and was located within the upper drainage channel, approximately 45 ft below the outfall.

The drainage channel runs approximately 600 ft northeast from the outfall to the bottom of Cañon de Valle. A 15-ft near-vertical cliff is located approximately 400 ft from the outfall and marks the break between the upper and lower drainage channels.

A settling pond approximately 55 ft long is also part of SWMU 16-021(c)-99. HE-contaminated water from the outfall entered the settling pond about 40 ft from the TA-16-260 outfall. The settling pond and outfall drainage channel area were the primary source for the contamination identified in downgradient components of the SWMU 16-021(c)-99 hydrogeologic system. An IM was conducted during 2000 and 2001, and more than 1300 yd^3 of contaminated soil were excavated from the settling pond and channel. Approximately 90% of the HE that existed in the SWMU 16-021(c)-99 source area was removed during the IM (LANL 2002, 73706). The residual contamination in the TA-16-260 outfall source area is addressed in this report.

2.3 Adjacent Land Use

The land adjacent to the outfall site is dedicated to continued Laboratory operations. Other SWMUs located in the vicinity of the outfall are shown on Figure 2.3-1 and described below.

- Material Disposal Area (MDA) R (SWMU 16-019)—This MDA is located northwest (upcanyon) of the TA-16-260 outfall area. MDA R was constructed in the mid-1940s and used as a burning ground and disposal area for waste explosives and possibly other debris. Potential contaminants at this MDA include HE, HE byproducts, and metals (particularly barium). Use of the site was discontinued in the early 1950s. Soil removal and site investigations were conducted at MDA R following the Cerro Grande fire (LANL 2001, 69971.2), but barium and HE residual contamination are still present.
- The Burning Ground SWMUs [16-010(b), (c), (d), (e), (f), (h)-99, 16-028(a), and 16-016(c)-99]—These SWMUs are located on a level portion of the mesa in the northeast corner of TA-16. The burning ground was constructed in 1951 for HE waste treatment and disposal. Over the years, hundreds of thousands of pounds of HE and HE-contaminated waste material have been burned at this location. The remaining noncombustible material was subsequently placed in MDA P (SWMU 16-018), north of the burning ground (through 1984), or taken to TA-54 for disposal (1984 to present). A barium nitrate pile was located at the TA-16 Burning Ground for many years. Site investigations have been conducted at several of these SWMUs (LANL 2003, 76876). Information was also obtained from investigations conducted between 1997 and 2002 at Flash Pad 387 and the consolidated SWMU 16-016(c)-99. Flash Pad 387 underwent clean closure and the sites representing consolidated SWMU 16-016(c)-99 underwent voluntary corrective action (VCA) concurrently with the MDA P clean closure.

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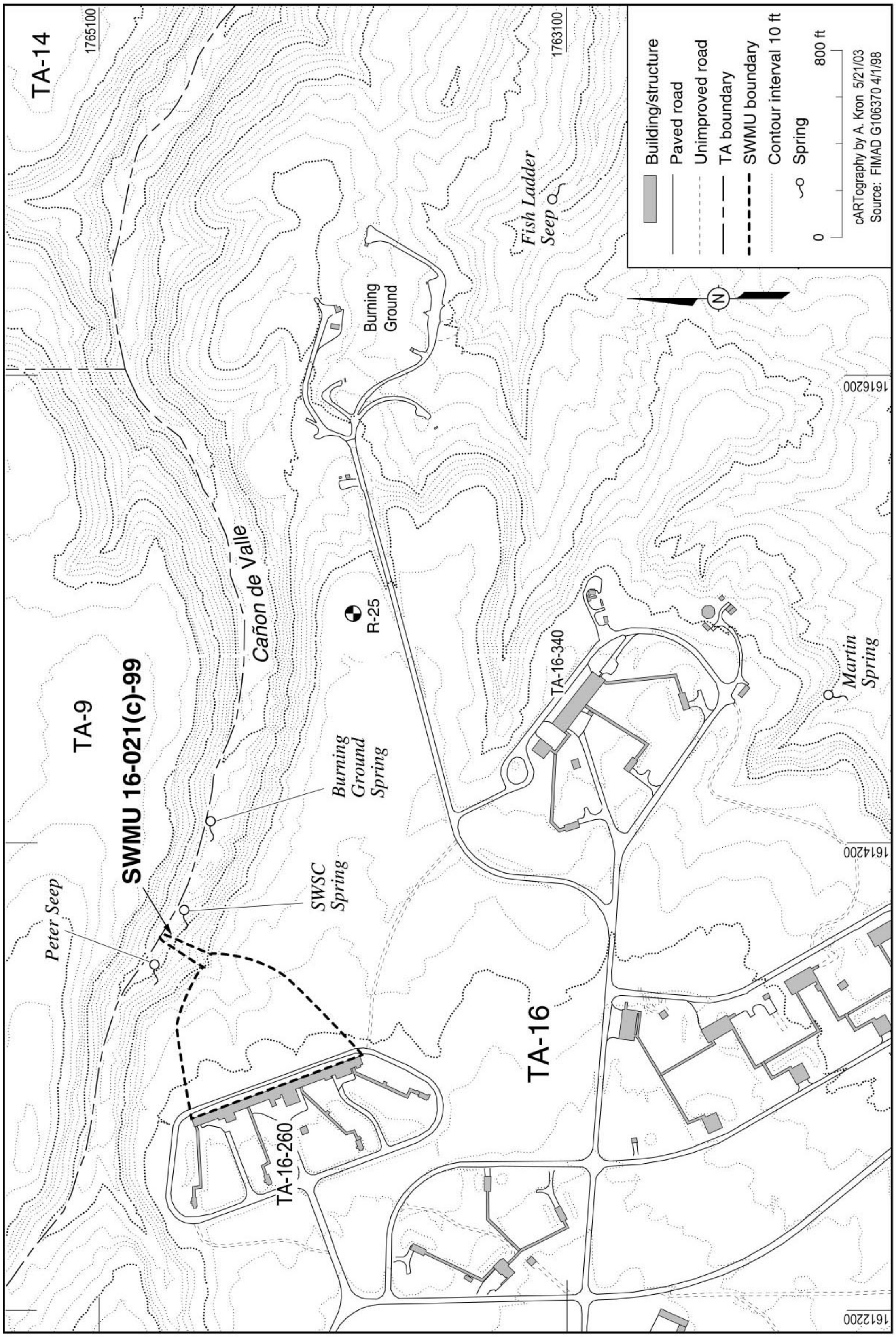

Figure 2.2-1. **Location of SWMU 16-021(c)-99 and associated physical features**

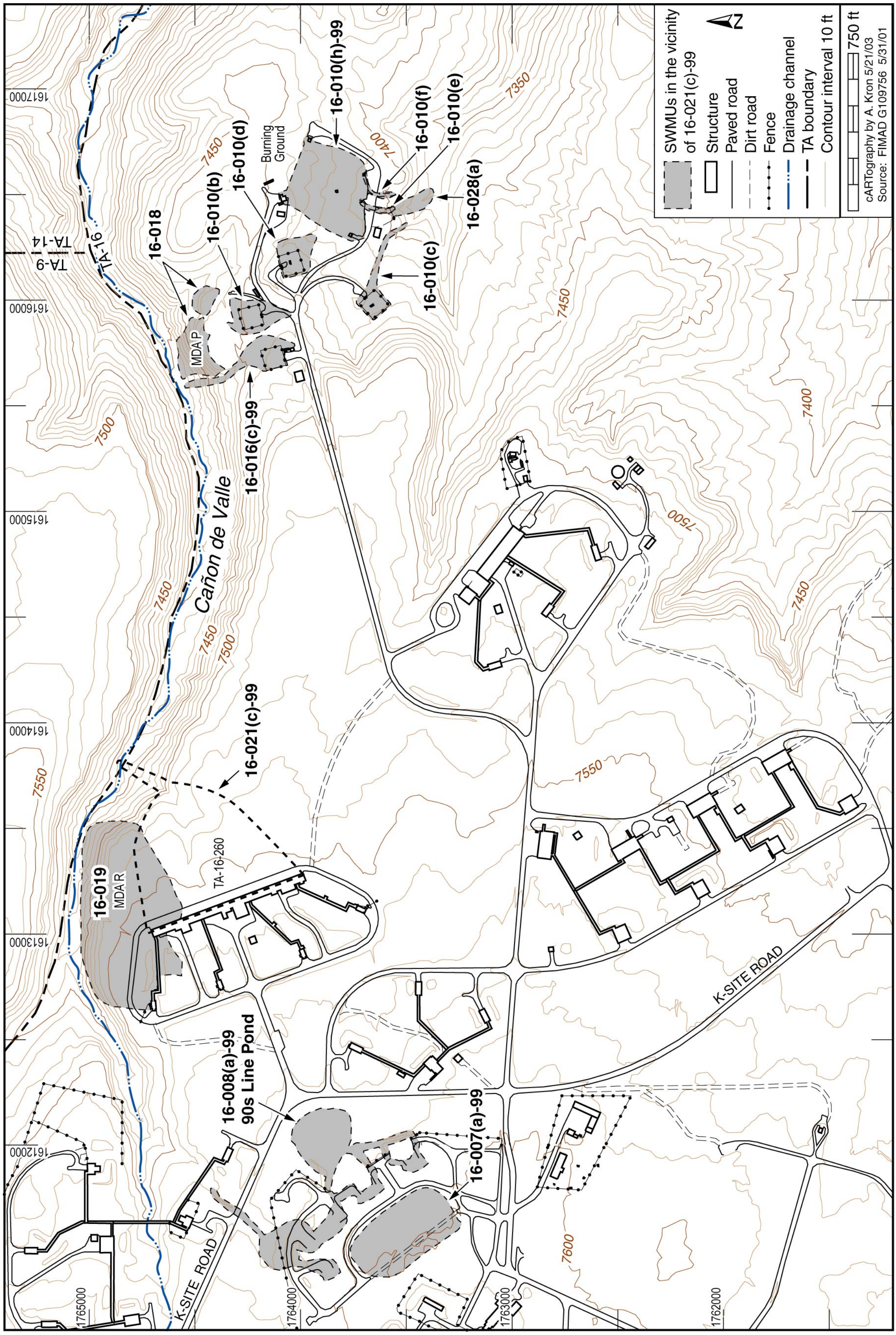

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Figure 2.3-1. SWMUs in the vicinity of SWMU 16-021(c)-99

MDA P (SWMU 16-018)—This MDA contained wastes from the synthesis, processing, and testing of HE; residues from the burning of HE-contaminated equipment; and construction debris. HE waste-disposal activities at this site started in the early 1950s and ceased in 1984. The site is located on the south slope of Cañon de Valle. Removal of hazardous waste and hazardous waste residues was recently completed at MDA P to support closure and entailed the removal of approximately 55,000 yd^3 of soil and debris (LANL 2003, 76876).

The 90s Line Pond portion of consolidated SWMU 16-008(a)-99. The 90s Line Pond is an inactive unlined settling pond located a few hundred ft southwest of Building 260. The pond received HE, barium, and organic chemicals from machining operations discharge from TA-16-89, -90, -91, -92, and -93. Visible HE has been removed from a site east of the pond.

Historically, these SWMUs contained contaminants similar to those found in SWMU 16-021(c)-99. Moreover, these SWMUs are located within the Cañon de Valle drainage.

2.4 Previous Environmental Investigations

Sampling and analysis data have been collected for the outfall [SWMU 16-021(c)-99] since the early 1970s and have indicated substantially elevated HE contamination in the sediment, the outfall, the outfall settling pond and drainage channel water. Concentrations of up to 27 wt% of HMX and RDX have been documented in the area of the settling pond. The data showed HE contamination extending from the discharge point to Cañon de Valle (Baytos 1971, 05913; Baytos 1976, 05920). These historical data have been summarized in the Phase I and II RFI reports for SWMUs 16-003(k) and 16-021(c) (LANL 1996, 55077; LANL 1998, 59891).

This section summarizes the data from the Phase I and II RFIs and the IM. The Phase III RFI data are summarized in section 3, “Current Site Conditions.” All available data for the site were used to build an SCM to support CMS activities.

2.4.1 Source Area Investigation and IM

The Phase I RFI primarily consisted of surface sampling and sample analysis within the drainage area. The Phase II RFI (LANL 1998, 59891) included surface sampling and analysis of surface and near-surface material within the drainage and sampling 13 boreholes (BHs) drilled to depths between 17 and 115 ft in and near the drainage. The Phase II RFI also included extensive field-screening for RDX and TNT using immunoassay methods, and sampling and analysis for HE and other chemicals.

Elevated concentrations of HE and barium were reported within drainage channel soils from the surface to the soil/tuff interface. Soil thicknesses were approximately 5.5 ft in the settling pond area and drainage at a distance of about 40 to 95 ft downstream from the outfall, and they were approximately 1 ft at a distance of 300 to 400 ft downstream from the outfall. Phase I and Phase II surface sampling and analyses showed that surface contamination did not extend laterally beyond the reasonably well-defined drainage.

Subsurface sampling and analyses indicated HE concentrations decreased rapidly below the soil/tuff interface. However, up to 1000 mg/kg of HE were detected in tuff within the uppermost tuff unit (Unit 4 of the Tshirege Member of the Bandelier Tuff, Qbt4) beneath the settling pond area. Approximately 1% HE was reported under the settling pond at a depth of 17 ft within a surge bed of Unit 4 of the Tshirege Member of the Bandelier Tuff (LANL 1998, 59891). Below this surge bed, HE was detected sporadically and at much lower concentrations (less than 5 mg/kg). However, thin surge bed deposits were reported in a borehole drilled into the center of the settling pond during the IM, at depths of 40 ft and 46 ft below ground surface (bgs), indicating multiple potential transmissive zones at depth (LANL 2002, 73706).

HE and barium are the principal contaminants found at the outfall, although several other metals, including cadmium, chromium, copper, lead, nickel, vanadium, and zinc, are consistently detected above background in the drainage. Other organic compounds (SVOCs, VOCs, and polychlorinated biphenyls) were also detected in one to four samples each. Details and results from the Phase I and Phase II RFIs are presented in two RFI reports (LANL 1996, 55077; LANL 1998, 59891). Phase III RFI (LANL 2003, 77965) results for the source area, including post-IM sampling results, are summarized in section 3.

From the winter of 2000 through the summer of 2001, an IM was conducted to remove contaminated material from the TA-16-260 outfall drainage area. The IM successfully removed the bulk of contamination from the outfall drainage channel. More than 1300 yd^3 of contaminated soil were excavated and disposed of at off-site facilities. Of this amount, more than 200 yd^3 of characteristic hazardous waste for reactivity (D003), which contained HE in concentrations of approximately 2 wt%, were treated by the selected disposal facility prior to disposition. An IM report for SWMU 16-021(c)-99 details the IM activities and results (LANL 2002, 73706).

2.4.2 Alluvial System Investigations

The Phase II RFI sampling in the Cañon de Valle alluvial system included the collection of surface and subsurface sediment, three pairs of overbank sediment samples, filtered and unfiltered surface water, and one quarterly round of filtered and unfiltered alluvial groundwater from five alluvial groundwater wells. These samples were collected during three different investigations in 1994, 1996, and 1997/1998.

Barium was the most abundant inorganic contaminant in sediment. For the surface samples, barium ranged from 6.3 mg/kg to 40,300 mg/kg. Other inorganic chemicals that were consistently measured above background include cadmium, chromium, copper, lead, nickel, vanadium, and zinc. Several HE were detected: the amino-dinitrotoluenes (A-DNTs), HMX, nitrobenzene, 3-nitrotoluene, RDX, 1,3,5-trinitrobenzene (TNB), and TNT. The two HE compounds highest in abundance and concentration were HMX and RDX. Their maxima were 170 mg/kg and 42 mg/kg, respectively.

Surface water samples and alluvial groundwater samples from five alluvial wells and Peter Seep were collected in Cañon de Valle. Filtered/unfiltered sample pairs were collected in 1994 and 1997/98; primarily unfiltered samples were collected in 1996. The concentration differences between the filtered and unfiltered samples are small. The inorganic chemicals identified as COPCs in all water were antimony, barium, chromium, lead, manganese, mercury, nickel, vanadium, and zinc. Barium is the most abundant, with concentrations ranging from 99 to 16,000 µg/L. As in the sediment, HE appears to be the other major COPC in Cañon de Valle surface water and alluvial groundwater. The HE COPCs identified were A-DNTs, HMX, nitrobenzene, 2-nitrotoluene, RDX, TNB, and TNT. RDX has the highest concentration, with a maximum concentration of 818 µg/L in surface water. Contaminant concentrations in surface water and groundwater generally decrease downgradient from Peter Seep to the confluence of Cañon de Valle with Water Canyon (LANL 1998, 59891).

Phase III RFI alluvial system investigation results are discussed in section 3, “Current Site Conditions.”

2.4.3 Subsurface System Investigation

The intermediate-depth borehole investigation included drilling five BHs (126 to 207 ft) at locations on the mesa top that were likely to intersect the perched water-bearing zones. The local trend of subunit-subunit contacts is to the north and east. Two of these BHs intersected ephemeral perched water. In each case, the water dissipated in less than 1 month. Analysis of this perched water indicated low concentrations (generally ppb) of HE.

The springs investigation included quarterly sampling of SWSC, Burning Ground, and Martin Springs. Results indicate that all three springs are contaminated with RDX and other HE. Several major cations and anions, including calcium, magnesium, sodium, and boron, were detected. Boron is particularly elevated (1800 µg/L) in Martin Spring. Aluminum, iron, barium, phosphate, and nitrate were also elevated. Although low levels (ppb) of VOCs have been detected in all three springs, detections were sporadic and occurred primarily during the quarterly sampling round of June 1997.

A time-series analysis of the springs data indicates extreme variability in the concentration of constituents (up to a factor of 20 in RDX concentration at Martin Spring). Similarities in element variability and flow-rate changes over time indicate that SWSC Spring and Burning Ground Spring are hydrogeologically related, but that Martin Spring probably represents a different hydrogeological system.

A potassium bromide tracer was deployed at SWMU 16-021(c)-99 during April 1997. A breakthrough of bromide ions was observed in SWSC Spring during August 1997. Bromide breakthrough may also have occurred at Burning Ground Spring during August 1997, but the effects were more subtle, due to partial masking by variability in all the anions (LANL 1998, 59891). These bromide results indicate that the springs are hydrologically connected to the SWMU 16-021(c)-99 source area.

3.0 CURRENT SITE CONDITIONS

This section describes current site conditions with respect to current and future site usage and the current concentration and distribution of COPCs. The latter discussion uses the SCM as a framework. The COPCs identified during the Phase III RFI (LANL 2003, 77965) reflect Phase III RFI organic and inorganic data, and Phase II RFI (LANL 1998, 59891) radionuclide data. Consequently, these COPCs are termed RFI COPCs. Given the results of the Phase III RFI risk assessment, for the CMS, a more restrictive set of CMS COPCs screening rules are applied, including ubiquity of detection, association with known sources as opposed to naturally occurring, and potential adverse effects on regional groundwater. These new screening criteria are described in section 3.2

3.1 Current and Reasonably Foreseeable Future Land Use

According to the Laboratory's comprehensive site plan of 2000 and its 2001 update (LANL 2000, 76100; LANL 2001, 70210.1), future land use at TA-16 is designated as HE research and development and HE testing. Most areas within TA-16 are active sites for the Engineering Science and Application Division of the Laboratory, and construction of new buildings and other facilities in the area is possible.

Accordingly, the Phase III RFI risk assessment assumed an industrial scenario for the outfall source area that incorporated potential exposures for an on-site environmental worker, a trail user, and a construction worker (LANL 1998, 59173). For Cañon de Valle and Martin Spring Canyon, the baseline risk assessment was limited to potential exposures associated with a trail user. Potential exposures and risks associated with extracted regional groundwater will be evaluated and quantified in the groundwater CMS.

3.2 Development of CMS COPCs

For the development of RFI COPCs, the Phase III RFI (LANL 2003, 77965) used a screening process that included state and federal standards and guidelines for water and screening action levels (SALs) for soil, sediment, and tuff. This process yielded a representative list of COPCs that were used for the Phase III RFI risk assessments for alluvial groundwater, surface water, springs, alluvial sediment, and water. For site water, the screening standards and guidelines are presented in Table 3.2-1.

Table 3.2-1
Phase III RFI Screening Standards and Guidelines for Canyon Waters

US EPA MCLs
EPA Region 6 Tap Water Screening Levels
NMWQCC Groundwater Standards for Irrigation Use (20 NMAC 6.2.3103)
NMWQCC Surface Water Standard for Livestock Watering (20 NMAC 6.4.900)
NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103)
NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103)
NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900)
2003 California DHS Action Level

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B, and C; 20 NMAC 6.4.900, “Standards applicable to attainable or designated uses unless otherwise specified in 20.6.4.101 through 20.6.4.899 NMAC,” Parts K, L, and M; EPA 2002, 76871; EPA 2003, 76867; and California DHS 2003, 76862.

The Phase III RFI risk assessment showed acceptable risk outside of outfall source area soils. The regional groundwater that lies more than 1000 ft beneath the site, however, is a component of the regional drinking water aquifer. Potential risks to regional groundwater were not assessed in the Phase III RFI, but will be assessed during the regional groundwater CMS, which is to be completed at a later date. Although certain RFI COPCs showed acceptable risks during the Phase III RFI risk assessment, they cannot be eliminated as CMS COPCs because the regional groundwater risk assessment has not yet been completed. These CMS COPCs include RDX, which has been detected in regional groundwater in monitoring well R-25 (LANL 2003, 75986.2) (Figure 3.2-1).

When developing the CMS COPCs, therefore, a measure of judgment must be used to eliminate those RFI COPCs that do not pose an unacceptable risk in the industrial scenario and do not pose a potential risk to regional groundwater. In recognition of these conditions, CMS screening criteria are used that are a subset of the Phase III RFI screening criteria. This subset recognizes both the current and future industrial use of the site as well as the presence of regional groundwater more than 1000 ft below the site.

The CMS COPC screening criteria for site waters are listed in Table 3.2-2. Both EPA maximum contaminant levels (MCLs) and NMWQCC standards are used, specifically NMWQCC, Subpart IV, 4103 A and B, for toxic pollutants at a threshold cancer risk of 10^{-5} and groundwater standards listed in NMWQCC, Subpart III, 3103 A and B. For compounds such as RDX which are not included in NMWQCC standards, and are not toxic pollutants subject to a 10^{-5} cancer risk threshold, EPA screening levels for tap water at a 10^{-6} cancer risk (EPA 2003, 76867) are used. For perchlorate, the California Department of Health Services (DHS) action level of 4 µg/L is used. Note that these CMS screening standards are different from the ARARs proposed in section 4 for regional groundwater, from which MCSs are, in part, derived.

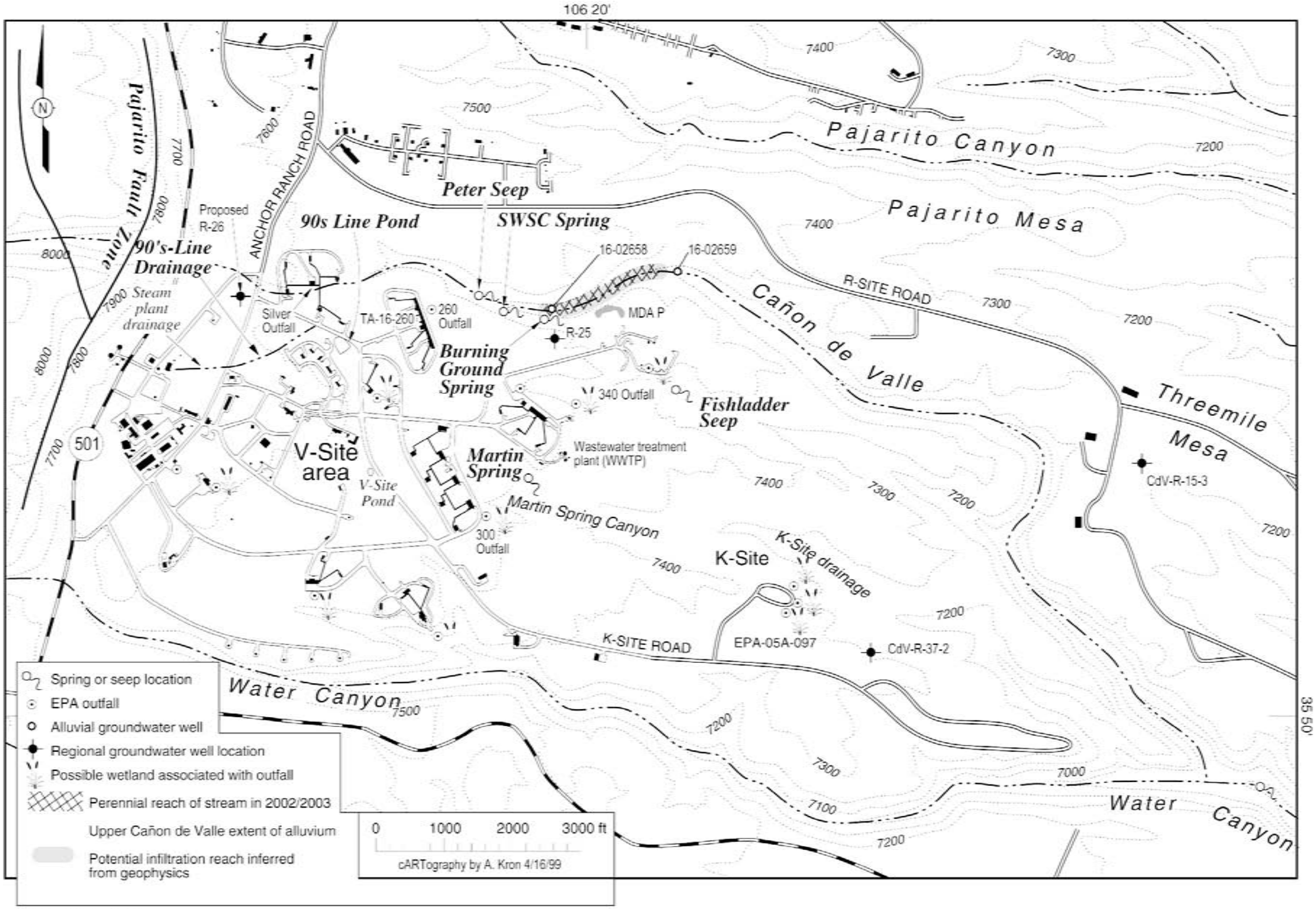

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Figure 3.2-1. **Map of surface physical features important for the SCM**

Table 3.2-2
CMS COPC Screening Criteria for Canyon Waters

US EPA MCLs
EPA Region 6 Tap Water Screening Levels
NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103)
NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103)
2003 California Department of Health Service (DHS) Action Level
Prevalence of detection
Relationship with an anthropogenic source
Potential for adverse effects on regional groundwater

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A and B; EPA 2002, 76871; EPA 2003, 76867; and California DHS 2003, 76862.

After comparison with the regulatory and advisory thresholds cited above, each COPC is then examined with respect to its prevalence and distribution, suspected sources, and potential to adversely affect regional groundwater.

The CMS COPCs identified for Cañon de Valle and Martin Spring Canyon groundwater, surface water, and springs are also carried over to alluvial sediment in these locations, if they were detected in sediment. Such a translation recognizes that alluvial sediment is an integral part of the hydrogeologic system.

The process for canyon waters CMS COPC identification can be summarized as follows:

1. Evaluate the RFI COPCs with respect to the regulatory and advisory thresholds. RFI COPCs that exceed a CMS COPC screening limit solely because the upper detection limit exceeds a CMS COPC screening limit are not included, if the maximum detected value did not exceed a screening limit.
2. Evaluate the COPCs with respect to Phase III RFI risk assessment results, and
3. Evaluate the COPCs with respect to prevalence of detection, association with known anthropogenic sources, and potential to adversely affect regional groundwater.

Outside the outfall source area, this process essentially seeks to identify which chemicals are a concern from the standpoint of potential risk to regional groundwater, given that risks associated with site waters and sediment for an industrial exposure scenario were acceptable. Generally, the process focuses on HE and barium. A related discussion is presented in section 4, where ARARs and MCSs are identified.

Inside the outfall source area, the Phase III RFI COPCs are accepted as CMS COPCs, based on the results of the risk assessment for that area. A discussion of MCSs for this area is also presented in section 4.

3.2.1 Cañon de Valle CMS COPCs

Cañon de Valle surface water CMS COPCs are barium, RDX, DNX, MNX and TNT. For alluvial groundwater the CMS COPCs are barium, manganese, RDX, MNX and TNT. For alluvial sediment, the CMS COPCs are barium, RDX and TNT. The selection of CMS COPCs from Phase III RFI COPCs is described in Appendix B. Supporting data are available in Appendix B and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

3.2.2 Martin Spring Canyon CMS COPCs

Martin Spring Canyon alluvial groundwater and alluvial sediment CMS COPCs are barium and RDX. In Martin Spring Canyon surface water, RDX is a CMS COPC. In addition, manganese is a CMS COPC for Martin Spring Canyon alluvial groundwater. The selection of CMS COPCs from Phase III RFI COPCs is described in Appendix B. Supporting data are available in Appendix B and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

3.2.3 Springs CMS COPCs

CMS COPCs for springs in Cañon de Valle and Martin Spring Canyon are RDX and TNT. The selection of CMS COPCs from Phase III RFI COPCs is described in Appendix B. Supporting data are available in Appendix B and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

3.3 SCM Overview

The SCM attempts to explain the existing distribution of contamination in terms of the contaminant chemical properties, contaminant source, contaminant source release history, the natural hydrogeology of the area, and any other significant factors for, and driving forces behind, contaminant migration. As site investigation activities have proceeded through Phase III, the SCM has been refined.

The SCM, which is depicted in Figure 3.3-1, applies to a roughly triangular area that is bounded on the north by Cañon de Valle, on the south by Water Canyon, on the west by the Pajarito fault zone, and on the east by the confluence of Water Canyon and Cañon de Valle (see Figure 3.2-1, an area of roughly 3 mi^2). This area encompasses other historical contaminant sources, in addition to the TA-16-260 outfall. Thus, the SCM is applicable to all historical contaminant sources at TA-16, particularly those affecting waters. Within the SCM, contaminant transport pathways are associated with tuff, sediment, and waters. Saturated flow systems occur in many different forms, including perennially and intermittently saturated fracture and surge bed systems in tuff, and alluvial groundwater in Cañon de Valle and Martin Spring Canyon, SWSC Spring, Martin Spring, Burning Ground Spring, Fishladder Seep, Peter Seep, and the 90s Line Pond.

Figure 3.3-1 shows the key components of the SCM centered at the outfall source area. These components are the outfall source area and settling pond surge beds (1); the mesa vadose zone extending from the mesa top to the canyon bottom and consisting of fractured and non-fractured tuff (2); canyon alluvial sediments (3); canyon springs (4); canyon surface water (5); canyon alluvial groundwater (6); the vadose zone extending from the canyon bottom to groundwater (termed the deep vadose zone), including the perched groundwater (7); and the regional aquifer (8); as defined by monitoring well R-25. While the regional aquifer was not included in the scope of the Phase III RFI, key results from the installation and sampling of R-25 are important to a general understanding of the SCM. Similarly, while Martin Spring Canyon is not shown on this figure, components such as springs, alluvial sediment, alluvial groundwater, and fracture pathways to deeper zones, apply there as well. Figure 3.2-1 presents a map of the site with respect to physical features that are important in the SCM.

Sampling and analysis results from the RFI (Phases I, II, III) confirm that all components of the SCM are contaminated with HE, although the specific contaminants, their concentrations and the distribution of contamination vary. In addition to HE, other COPCs were also found. This CMS focuses on providing

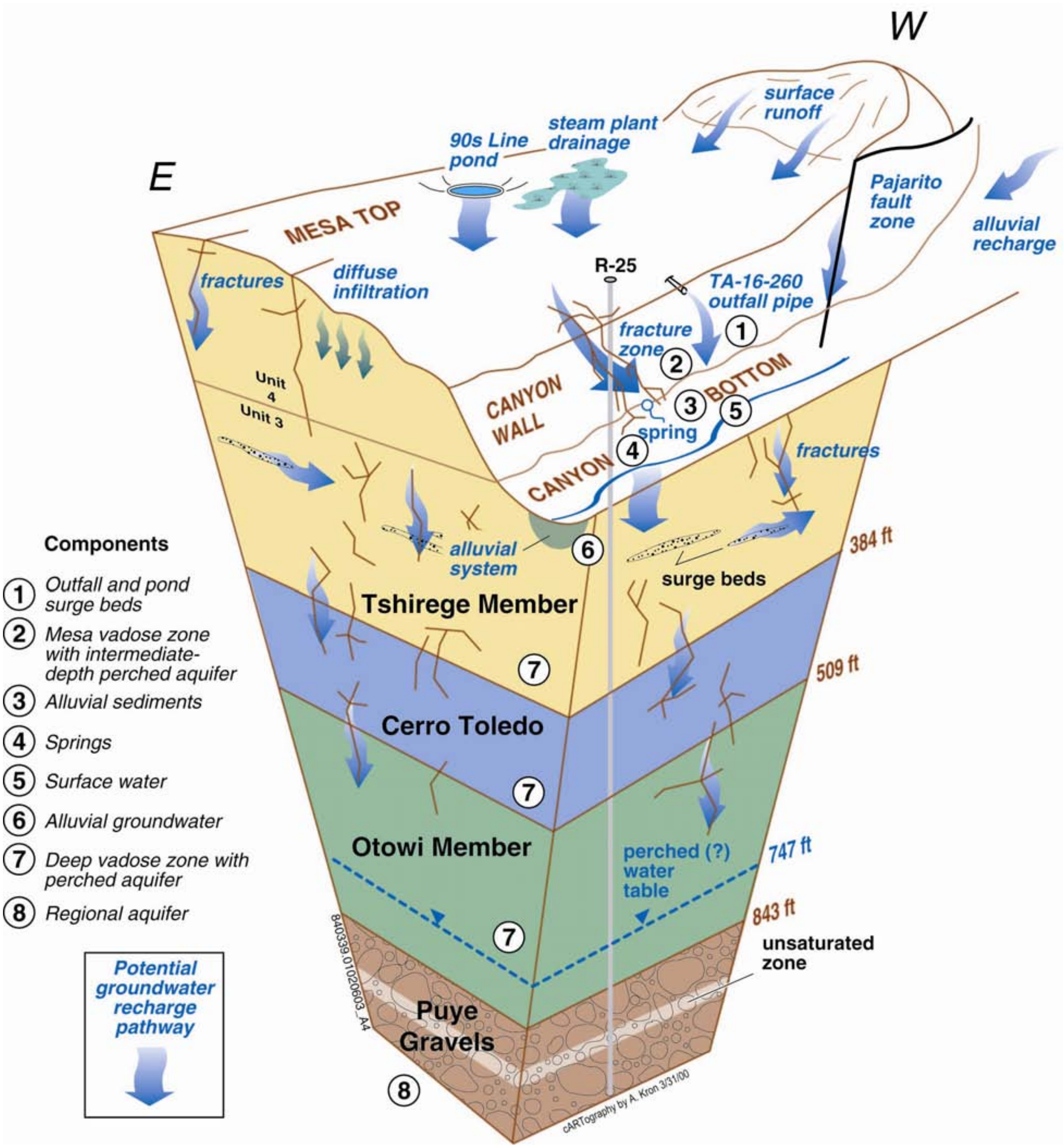

Figure 3.3-1. Hydrogeological and contaminant transport SCM for TA-16 and SWMU 16-021(c)-99

corrective measures for the following contaminated areas within the SCM (see Figure 3.3-1): the SWMU 16-021(c)-99 outfall source area and settling pond surge beds (component 1); the alluvial sediments, springs, surface water, and alluvial groundwater in Cañon de Valle (within approximately 7000 ft east of the outfall); and the sediments, springs, surface water, and alluvial groundwater in Martin Spring Canyon (components 3–6).

3.4 Component 1—Outfall Source Area and Surge Beds

The outfall source area and underlying surge beds are shown as component 1 on the SCM (Figure 3.3-1).

TA-16-260 outfall discharges during the past 50 yr served as a source for the HE and inorganic contamination found throughout the site (LANL 1998, 59891). Prior to the completion of the outfall source area IM, the principal contaminants in TA-16-260 outfall sediment were barium (up to 20,000 ppm) and HE (up to 20 wt%) (LANL 2002, 73706). Historically, discharge from the sumps at Building 260 to the outfall was reportedly as high as several million gal. per yr (LANL 1994, 76858). The outfall source area comprises a well-defined upper drainage channel that was fed directly by the building sumps, a settling pond, and a lower drainage channel that leads to Cañon de Valle. HE contamination in the outfall and drainage area has been recognized since at least 1960, when the first soil samples from the TA-16-260 outfall were analyzed.

The settling pond (and associated soil) which was removed during the 2000 IM (LANL 2002, 73706), measured approximately 50 ft long by 20 ft wide and was located within the upper drainage channel, approximately 45 ft below the TA-16-260 outfall. The drainage channel runs approximately 600 ft northeast from the outfall to the bottom of Cañon de Valle. A 15-ft, near-vertical cliff is located at a distance of approximately 400 ft from the outfall and marks the break between the upper and lower drainage channels. Prior to the IM, the upper part of the drainage channel (above the cliff) contained little vegetation and relatively little accumulated soil and sediment. The lower part of the drainage channel (below the cliff), which is steep and rocky, contained thick pockets of sediment.

Borings installed in the settling pond area revealed the presence of surge beds underlying the settling pond area at depths of approximately 17 and 45 ft. In the 17-ft bgs upper surge bed, RDX (4500 mg/kg), HMX (1700 mg/kg), and TNT (3500 mg/kg) were detected (LANL 1998, 59891). The 45-ft bgs lower surge bed contained RDX (4.4 mg/kg) and HMX (0.45 mg/kg) (LANL 2002, 73706). These surge beds (granular tuff with a sand-like texture) possess increased porosity and hydraulic conductivity and represent potential contaminant transport pathways leading away from the outfall source area. The lateral extent and continuity of the surge beds are unknown.

The outfall source area was substantially remediated when a large quantity of contaminated soil from the outfall and settling pond area was excavated and removed during the IM (LANL 2002, 73706). The main contaminants were barium, HE (HMX, RDX, and TNT), and HE-degradation products (dinitrotoluenes, A-DNT, and TNB). More than 1300 yd^3 of contaminated material containing an estimated 8500 kg of HE were removed from this area. The surge beds were not excavated during the IM. In general, excavation of the tuff did not prove feasible. Following IM excavation, the area of the settling pond was capped with a low permeability clay-soil mixture. Residual HE and barium contamination remains in pockets of soil distributed along the drainage channel. Although it contains elevated concentrations, the residual contaminated soil's total volume is estimated to be less than 100 yd^3. Figure 3.4-1 shows the outfall area and the location of post-IM sampling points.

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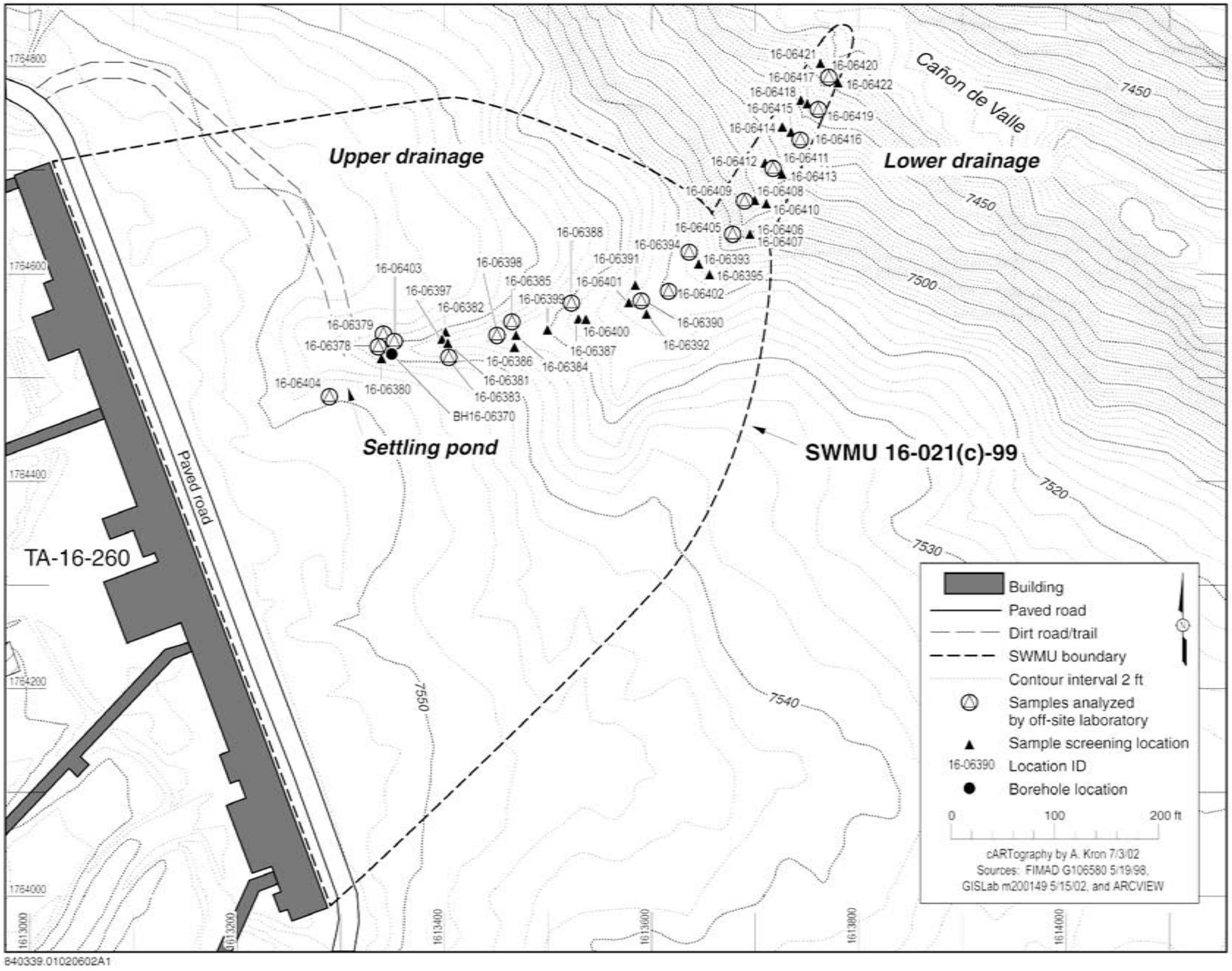


Figure 3.4-1. Outfall source area and the location of post-IM sampling points

Table 3.4-1 presents a summary of the sampling results for barium and HE in terms of distribution within post-IM and across soil and tuff. Post-removal concentration ranges, and the location ID for the maximum concentration, are summarized below:

Table 3.4-1
Summary of Barium and HE Post-IM Sampling (2000) Results

COPC	Media	Number of Analyses	Minimum (mg/kg)	Mean (mg/kg)	Maximum (mg/kg)
Barium	Soil	16	148	3275	8200
	Tuff	4	890	1698	3000
HMX	Soil	16	1.10	465	2000
	Tuff	4	6.80	283	670
RDX	Soil	16	0.50	115	745
	Tuff	4	16.0	327	1,200
TNT	Soil	16	0.13	32.8	270
	Tuff	4	1.00	86.8	330

- Barium remains in concentrations ranging from 148 to 8200 mg/kg (location ID 16-06420) and was detected above the background value (BV) in all but one post-removal analytical sample.
- HMX remains in concentrations ranging from 1.1 to 2000 mg/kg (location ID 16-06409).
- RDX remains in concentrations ranging from 0.5 to 1200 mg/kg (location ID 16-06379).
- TNT remains in concentrations ranging from 0.13 to 330 mg/kg (location ID 16-06379).

Several additional HE compounds, HE-related compounds, and other organic and inorganic compounds are present in the drainage channel, at low concentrations. A complete description of these results can be found in the Phase III RFI report (LANL 2003, 77965).

The Phase III RFI COPCs for the outfall source area are aluminum, arsenic, barium, manganese, thallium, uranium, HMX, RDX, and TNT. As discussed in section 3.2 above, these Phase III RFI COPCs are accepted as CMS COPCs.

3.5 Component 2—Mesa Vadose Zone

The mesa vadose zone is the unsaturated area between the land surface at the top of the TA-16 mesa and the bottom of Cañon de Valle (Figure 3.3-1). This vadose zone is shallower in depth than the deep vadose zone (component 7) and encompasses the flow paths for springs, such as Burning Ground Spring and Martin Spring. In the Phase II RFI report, the principal contaminant flow paths within the mesa vadose zone were hypothesized to be ribbon-like structures (LANL 1998, 59891). This description, while not geologically specific, reflects a mesa vadose zone flow regime that is dominated by surge beds and fractures, both of which possess higher permeability than the surrounding non-fractured tuff. Intermittent groundwater has been encountered in wells within this zone, which the Phase III RFI characterized as an intermediate-depth perched aquifer.

As part of the Phase II RFI, five boreholes were drilled on the TA-16 mesa top in the vicinity of the former outfall, the 90s Line Pond, and the head of Martin Spring Canyon. The boreholes were drilled to depths between 91 and 207 ft and were completed as wells in order to characterize the intermediate-depth perched aquifer and define the nature and extent of contamination. The initial results of the drilling were reported in the Phase II RFI report (LANL 1998, 59891). The Phase III RFI data provide an updated assessment of the mesa vadose zone hydrogeology based on chloride, bromide, and stable isotope tracers; results of hydraulic testing of core; and groundwater chemistry data from samples collected from Well 16-02665 (Martin Spring Canyon) after completion of the Phase II RFI (post-1998).

Tuff samples from the five intermediate-depth boreholes and from others installed within the mesa vadose zone indicate no contamination in the subsurface intervals except in an uncased borehole drilled in the TA-16-260 settling pond (LANL 1998, 59891; LANL 2002, 73706). These results indicate that mesa vadose zone tuff contamination is primarily concentrated beneath the outfall source area. On occasion, however, groundwater samples from the intermediate-depth wells located in Martin Spring Canyon and the 90s Line Pond have contained contaminated groundwater. The latter result indicates the presence of contaminant inventories at the 90s Line Pond. The Martin Spring Canyon result is evidence for heterogeneous flow paths within the mesa vadose zone tuff, likely involving fractures and surge beds.

In terms of transport, tracer and isotopic studies provided information about how rapidly water and contaminants have been transported downward into the mesa from the outfall source areas. Data from key mesa vadose zone wells show that HE contaminants have moved from the top of the mesa down to at least 130 ft bgs in 50 yr or less. The breakthrough of bromide tracer at SWSC Spring and Burning Ground Spring within a few months is additional evidence for rapid contaminant transport along preferential pathways such as fractures and surge beds in the mesa vadose zone. Finally, the presence of HE contamination detected in the approximately 700-ft-bgs perched aquifer at R-25 (LANL 2003, 75986.2), and in the underlying regional aquifer, indicates that these transport pathways extend from the mesa (or canyon bottom) downward to these horizons.

Mesa vadose zone surface fracture mapping and fracture characterization of boreholes were conducted at MDA P (LANL 2003, 76876), which is located approximately 2000 ft east of the outfall source area. Surface fracture mapping indicated that the fracture set has a statistically significant north-northwest preferred orientation. Fracture dip angles vary from sub-horizontal to steep. Fracture densities of 20–40 fractures per 100 ft were observed, with fracture apertures generally 1–2 mm wide, although widths of 50 mm were observed. In six boreholes installed at MDA P, natural fractures were observed in all cores, but more commonly in welded tuff units. Fracture coatings consisted of clays and black manganese oxides.

The variable concentrations and presence of contaminants detected in the vadose zone at TA-16 are typical of fracture (and surge bed) controlled transport and have important implications for the CMS decision process. First, it is not possible at the present time to accurately quantify the inventory of contaminants in the mesa vadose zone. Future characterization efforts at TA-16 may provide a better estimate of contaminant inventories, although it is unlikely that a detailed inventory will ever be achieved. Second, remediation of the subsurface inventory is not possible if its location remains unknown. For these reasons, in addition to a lack of exposure pathway to humans, the mesa vadose zone is not explicitly considered for remediation, although the manifestations of the mesa vadose zone in the form of springs are addressed as component 4. Furthermore, the surge beds that were discussed as part of the outfall source area (component 1) can be viewed as part of the mesa vadose zone.

Other uncertainties in the mesa vadose zone SCM involve the effects of the 2000 Cerro Grande fire and the current forest thinning, both of which may have altered the runoff/recharge hydrology of the mesa.

3.6 Component 3—Cañon de Valle and Martin Spring Canyon Alluvial Sediment

Alluvial sediment is present in both Cañon de Valle and Martin Spring Canyon. Cañon de Valle and Martin Spring Canyon sediments were studied during geomorphic studies and as part of a Phase III RFI sediment resampling effort (LANL 2003, 77965) of Phase II RFI sampling points. These studies identified COPCs in sediment and they provide insight into the magnitude of HE and barium loading on sediments and the nature of sediment transport processes. A total of about 21,000 kg of barium is estimated to have been present in Cañon de Valle sediment before the Cerro Grande fire. About 62% is estimated to have been stored in fine-grained sediment deposits outside the active channel, about 10% was in the active channel, and the remainder was in coarse-grained deposits in abandoned channel units. This indicates that flood events play a key role in mobilizing contaminated sediments in and along the channel. Post-fire sediment sampling results indicate a substantial downstream redistribution of barium and RDX due to post-fire flooding. Estimates of the total inventory of HMX and RDX in Cañon de Valle sediment before the Cerro Grande fire indicate approximately 50 kg of HMX was present, 50% of which occurred in fine-grained sediment and 50% of which occurred in coarse-grained sediment. Approximately 5 kg of RDX is estimated to have been present, of which about 60% was found in fine-grained sediment.

In 2002, the resampling of a subset of the 1996 active channel sampling locations as part of the Phase III RFI allowed a comparison of the barium and RDX concentrations in 1994–6 with the concentrations in the channel 6 years after the termination of effluent releases from the outfall (Figure 3.6-1 and Figure 3.6-2). This period also includes the effects of post-fire floods. In the reaches sampled, barium and RDX concentrations in 2002 are much lower than in 1996. This indicates that much of the barium and RDX present in the active channel in these reaches in 1996 was scoured and suspended in subsequent floods and transported downstream, depleting the active channel inventory. The amount that was redeposited on abandoned channels and floodplains is unknown. Both plots support the inference that much of the contaminant inventory that was stored in the active channel in 1996 was remobilized and transported downstream prior to 2002, either in post-fire floods or in other storm runoff events (LANL 2003, 77965).

Post–Cerro Grande fire sampling for barium and RDX in Martin Spring Canyon indicated much lower concentrations and much smaller inventories than in Cañon de Valle. The estimated barium and RDX inventories in Martin Spring Canyon are approximately 820 kg and 0.2 kg, respectively.

For barium, RDX, and HMX, the contaminant mass estimate is limited by the depth of the geomorphic sampling (maximum of 2 ft bgs). Although borehole sampling results from alluvial well installation conducted during the Phase II RFI indicated minimal contamination at the saturated alluvial/tuff contact (LANL 1998, 59891), sediment samples were not collected in overlying saturated and unsaturated alluvial sediments. Consequently, the vertical distribution of contamination is unknown between approximately 2 ft bgs and the alluvial/tuff contact which is located at approximately 5–6 ft bgs.

Site maps of recent (1999–2002) Cañon de Valle alluvial sediment concentrations of barium and RDX in the active channel are presented as Figures 3.6-3 and 3.6-4, respectively. For Martin Spring Canyon, site maps of recent (2000) alluvial sediment concentrations of barium and RDX in the active channel are presented as Figures 3.6-5 and 3.6-6. These maps show the distribution of the two contaminants.

3.7 Component 4—Springs in Cañon de Valle and Martin Spring Canyon

The springs and seeps in Cañon de Valle and Martin Spring Canyon are labeled component 4 on Figure 3.3-1. Known springs and seeps include Burning Ground Spring, SWSC Spring, and Martin Spring. Based on water geochemistry results from surface and groundwater sampling detailed in the

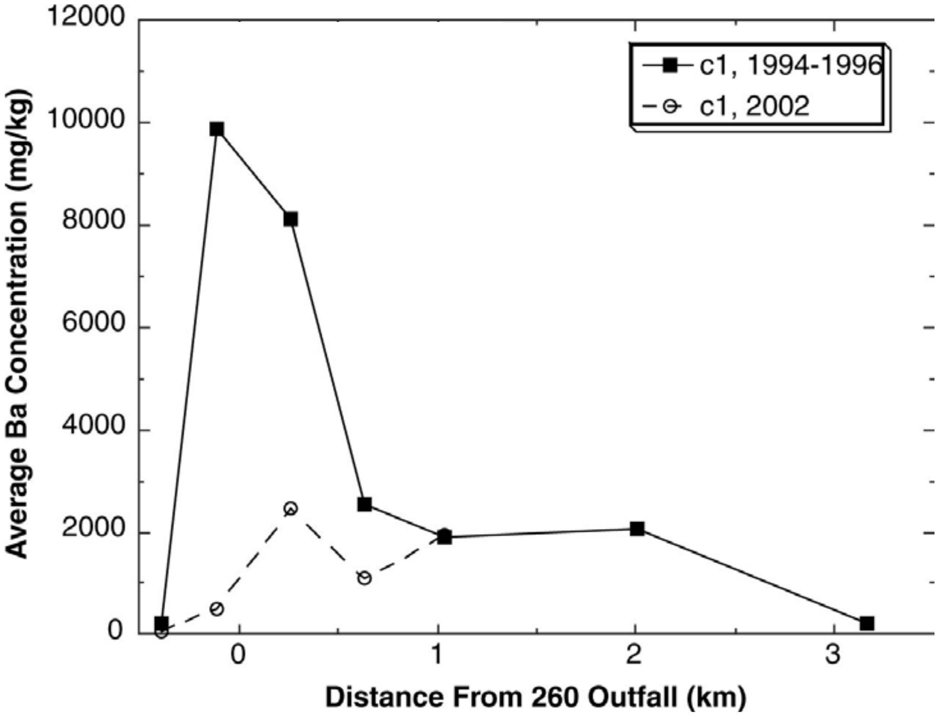


Figure 3.6-1. Plot of barium (Ba) concentrations (localized averages) in active channel samples (C1) in 1994–1996 and 2002

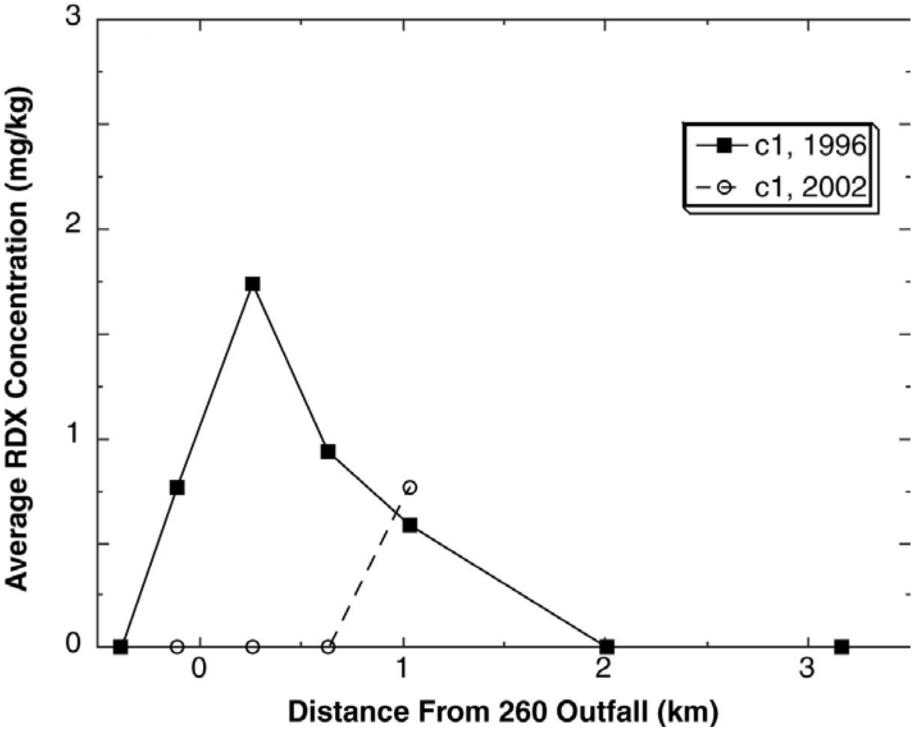


Figure 3.6-2. Plot of RDX concentrations (localized averages) in active channel samples (C1) in 1996 and 2002

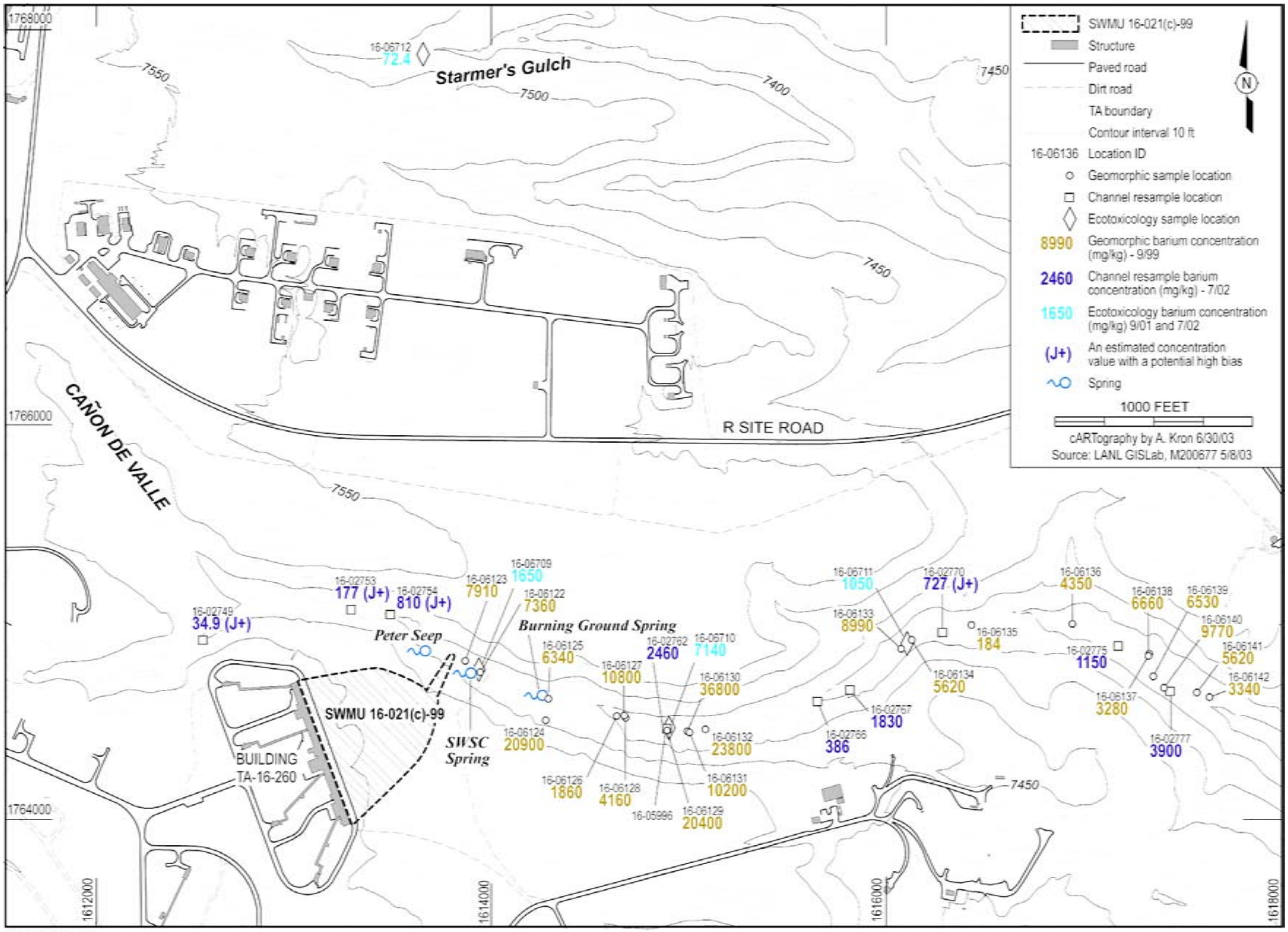


Figure 3.6-3. Recent (1999–2002) Cañon de Valle barium active channel alluvial sediment sampling results

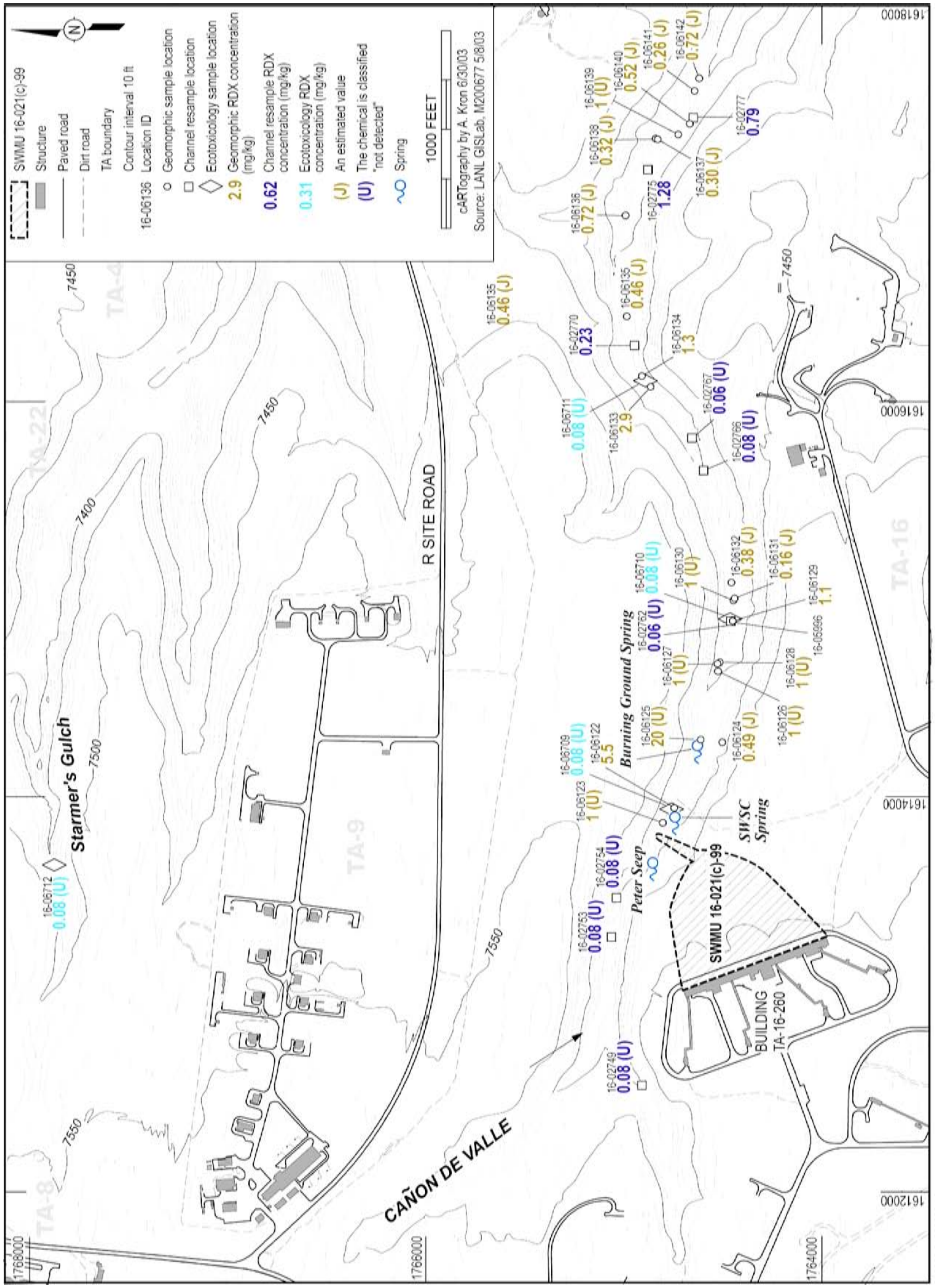
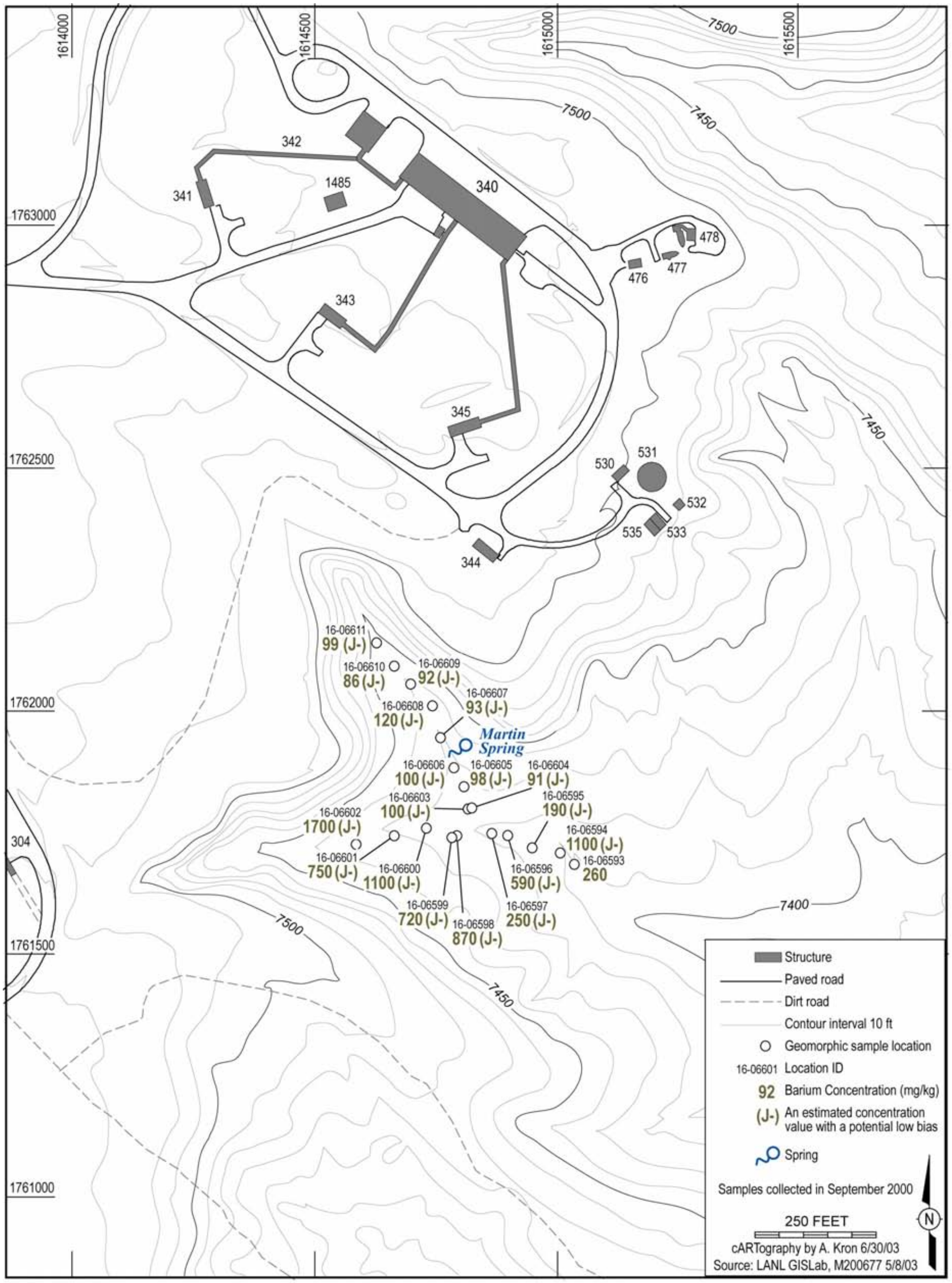


Figure 3.6-4. Recent (1999–2002) Cañon de Valle RDX sediment sampling results



Samples collected in September 2000

cARTography by A. Kron 6/30/03
Source: LANL GISLab, M200677 5/8/03

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Figure 3.6-5. Martin Spring Canyon barium sediment sampling results from 2000

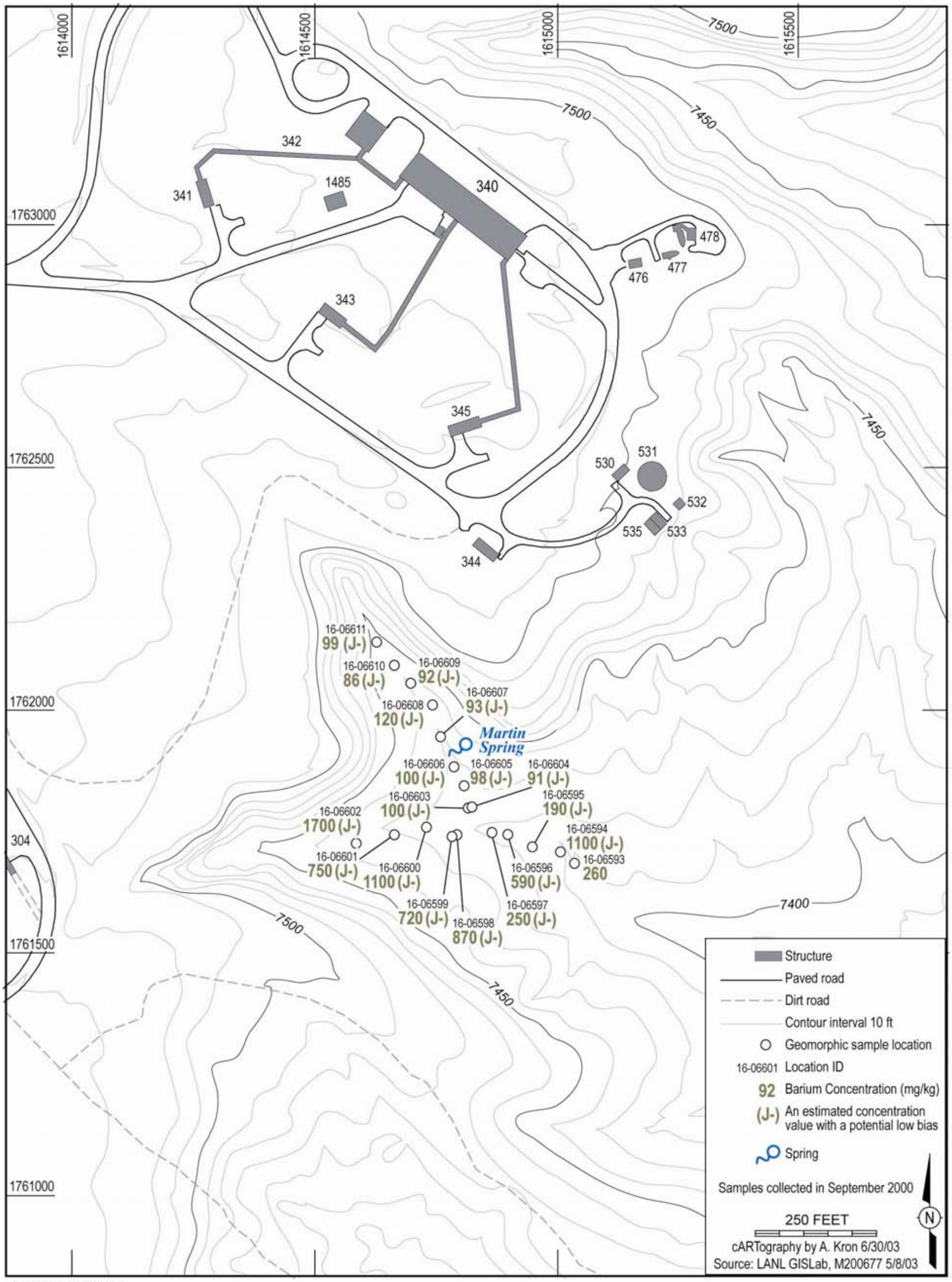

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Figure 3.6-6. Martin Spring Canyon RDX sediment sampling results from 2000

Phase III RFI (LANL 2003, 77965), it is considered possible that other, unknown springs or seeps may be discharging to the Cañon de Valle alluvial system. The current drought has substantially affected the flow rates from springs. Flow has decreased in Burning Ground Spring and flow from SWSC Spring and Martin Spring has stopped completely, as of this writing.

The Phase II and Phase III RFIs detected HE, barium, and other contaminants in SWSC Spring (in Cañon de Valle), Burning Ground Spring (in Cañon de Valle), and Martin Spring (in Martin Spring Canyon) (LANL 1998, 59891; LANL 2003, 77965). Key Phase II hypotheses concerning the SCM for the springs include

(1) The saturated systems that feed the springs may represent the discharge points of surge beds and fracture sets within the mesa;

(2) The springs are all located near the Unit 3/Unit 4 contact within the Tshirege Unit of the Bandelier Tuff, a zone characterized by several surge beds;

(3) The bromide tracer study demonstrates direct connectivity between the 260 outfall and SWSC Spring (and possibly Burning Ground Spring);

(4) The springs have multiple sources of groundwater recharge; and

(5) Contaminants in Martin Spring may come from a source other than the 260 outfall.

Martin Spring flow and chemistry are substantially different from the two Cañon de Valle springs.

Phase III RFI isotopic studies of the springs flow systems (LANL 2003, 77965) show that the springs have two main modes of recharge. These two modes can be described as (1) short residence-time pathways that are driven by individual rain or snowmelt events; and (2) slower, long residence-time pathways that provide “base flow” to the springs and whose flows are controlled more by longer-term climatic variations. The drought has lessened the frequency of the short residence-time recharge events, thus the contaminant concentrations observed during the drought are probably being transported via the slower, long residence-time base flow pathways. The stable isotope data indicate that base flow is largely recharged to the west, at elevations above TA-16 (and above any HE or barium contamination). Therefore, the base flow must be encountering a source of contamination in the mesa vadose zone as it travels to the springs.

Analyses of contaminant time-series data gathered since the IM was completed in 2000 and conducted as part of the Phase III RFI do not show any significant reduction in contaminant concentrations. This lack of reduction does not reflect the overall long-term effectiveness of the outfall source area IM; rather it is likely due to three factors: (1) the drought, (2) deeper vadose zone contamination and related inventory, and (3) the long residence-time component of springs flow. The drought has limited the transport of contaminants from shallow depths at the 260 outfall source area. Thus, there has not been enough water flow to flush out the existing contaminants. Contamination is still present in the vadose zone below the depths from which soil was removed during the IM, and this deeper contamination zone is what currently supplies the springs systems. The last factor might account for the lack of changes in springs contaminant concentrations in that analysis of trends in spring flow shows there is a long residence-time (base flow) component to springs discharge, on the order of several years.

The 2000 Cerro Grande fire and current forest thinning may alter the runoff/recharge relations on the mesa. If runoff increases as a result of loss of vegetative cover, recharge to the springs could decrease, thereby decreasing vadose zone transport of some contaminants. However, it is not known if the potential runoff/recharge shift would prove to be a substantial influence over the long term.

Representative Phase III RFI (LANL 2003, 77965) barium and RDX concentrations in site springs, surface water, and groundwater from 2000 to 2002 are shown in Figures 3.7-1 and 3.7-2, respectively.

3.8 Components 5 and 6—Canyon Surface Water and Alluvial Groundwater

Cañon de Valle and Martin Spring Canyon surface water and alluvial groundwater are important components of the SCM (Figure 3.3-1). Both represent potential human and ecological exposure sources and both are critical to the overall site hydrogeological regime which includes the regional groundwater. Surface water is present both perennially and intermittently along Cañon de Valle. The approximate extent of perennial surface water is shown in Figure 3.2-1.

Key hypotheses concerning the SCM include (1) surface runoff and spring flow contribute contaminants to the alluvial system, but the springs generally dilute the higher levels of contamination in the surface water and alluvial groundwater; (2) alluvial groundwater disappears downgradient from MDA P and therefore there may be a loss of water to underlying units; and (3) there appears to be mixing of alluvial groundwater and surface water downgradient from MDA P.

The Cañon de Valle saturated alluvium may be viewed as a fixed volume with inputs (springs, precipitation, and groundwater flow) and outputs (evapotranspiration and leakage into the underlying fractured tuff which lessens water volume). A conceptual water balance model is shown in Figure 3.8-1, in terms of gal. per ft of canyon per day. As detailed in the Phase III RFI report (LANL 2003, 77965), component flows were prepared using historical data on spring water flow; groundwater elevation in wells; historical averages for precipitation and evapotranspiration; and literature values for alluvial permeability, in the absence of actual data. Based on these component flows, the rate of infiltration was estimated.

Assuming a steady state, the rate of loss of groundwater to the underlying tuff is estimated to be approximately 2.6 gal. per day per ft of canyon.

In terms of water balance, the springs contribute substantial amounts of water to the canyon bottom; exchange also occurs between the surface water and alluvial groundwater and vice versa. These conditions affect contaminant distributions in the canyon bottom. Figure 3.8-2 presents examples of the effect of the springs, alluvial groundwater, and surface water interconnection on barium and RDX concentrations. Barium concentrations remain relatively consistent among the three types of water over low, medium, and high surface flow sampling events, probably due to buffering by barium-contaminated sediments. Alluvial groundwater barium concentrations are the highest, surface water concentrations are intermediate, and the springs concentrations are the lowest. These results show that the springs water dilutes the concentrations in the alluvial groundwater and surface water systems. The differences between the alluvial groundwater and surface water concentrations are largely controlled by the spatial distribution and buffering capacity of existing barium concentrations in the canyon sediment. For RDX, there is no consistency in contaminant concentrations. Springs water tends to have the lowest concentration and generally dilutes the alluvial groundwater and surface water.

Spatial trends of contaminants in surface water and alluvial groundwater, screening parameters, and flow provide other key insights into the alluvial system. Flow profiles indicate that there is a losing reach in the region between Burning Ground Spring and the area just upgradient from MDA P. In addition, temperature data, barium and RDX concentrations, and flow increases all indicate that alluvial

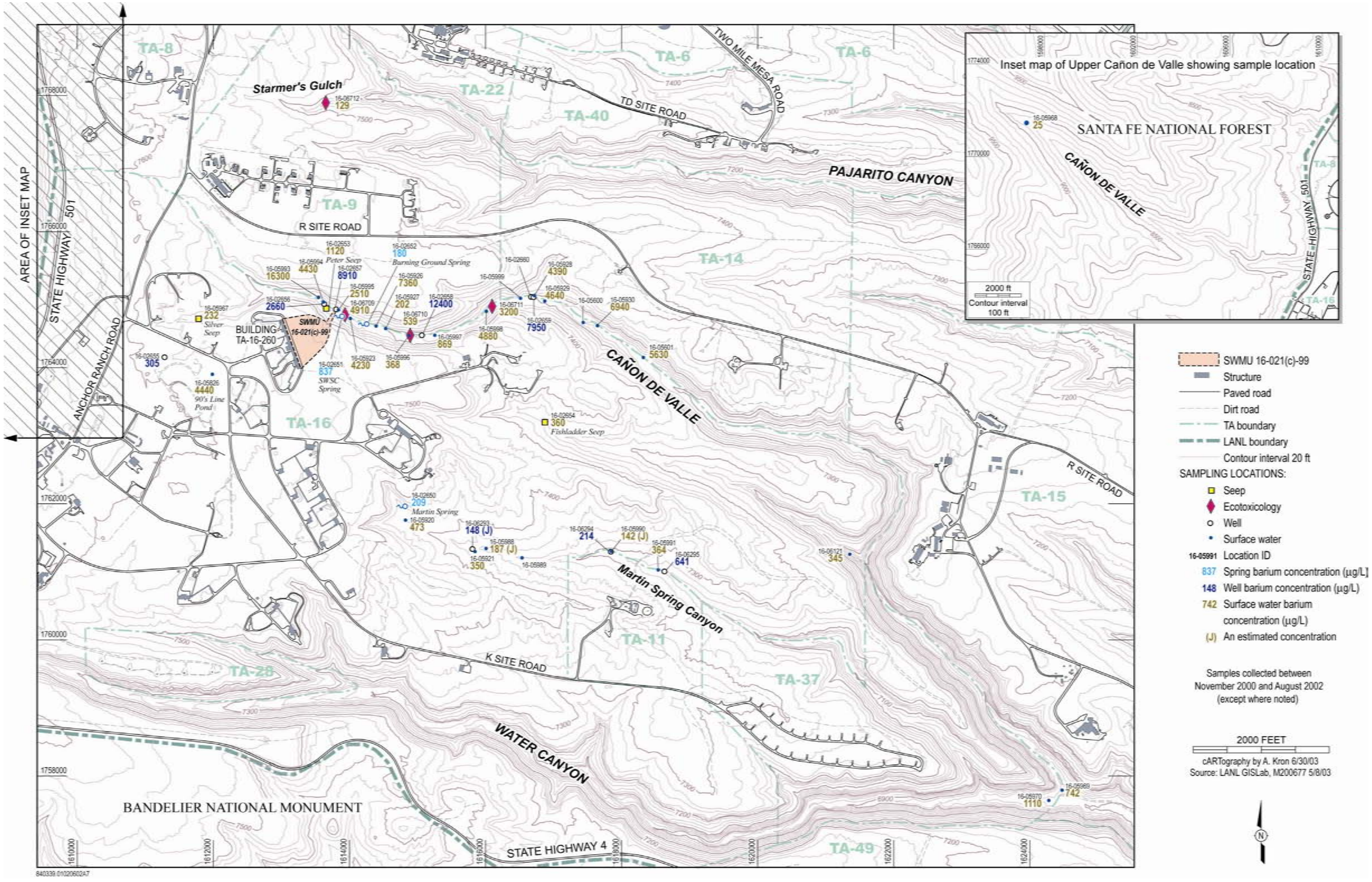

Figure 3.7-1. Representative barium concentrations in springs, surface water and alluvial groundwater from 2000-2002

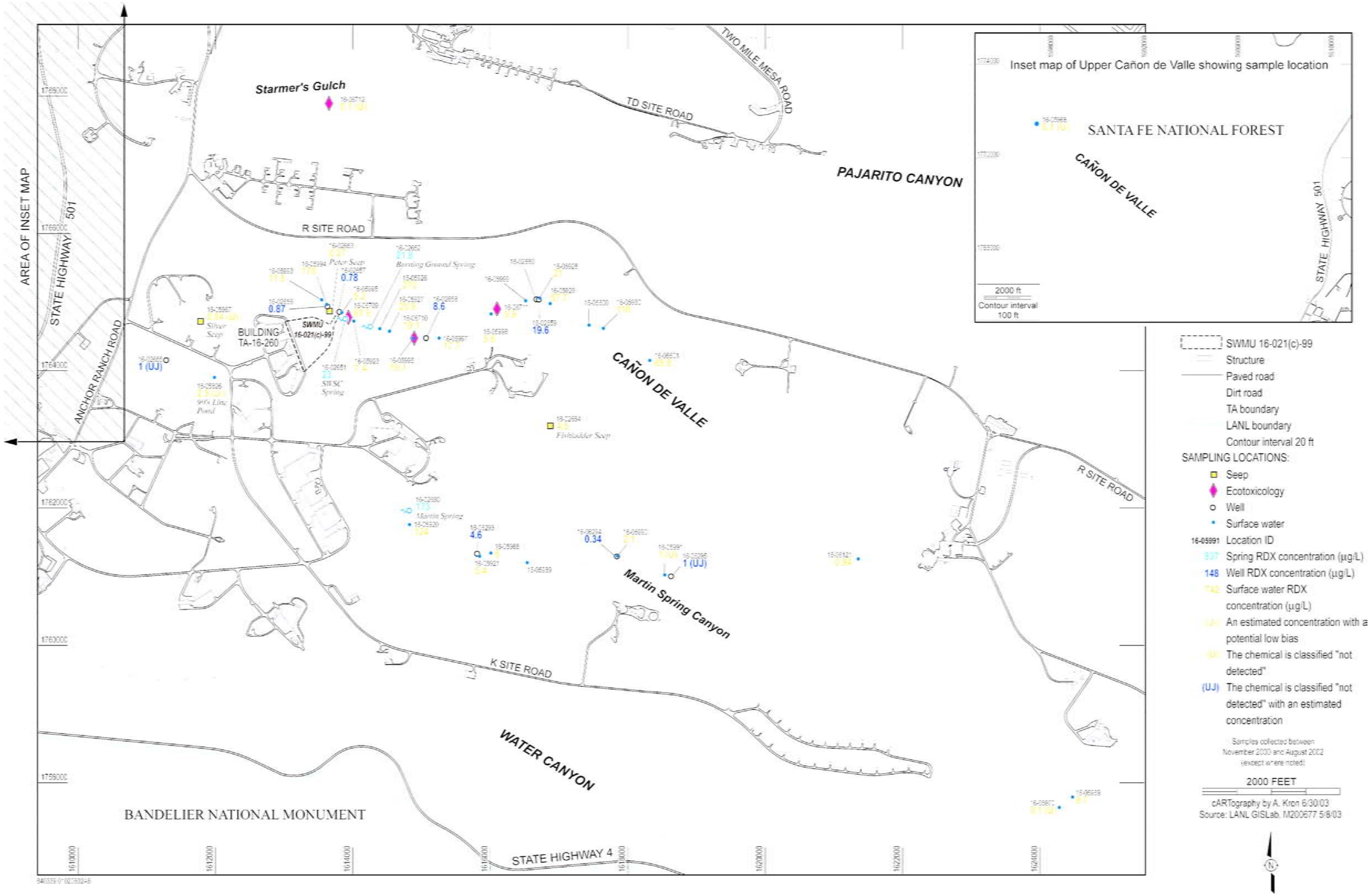

Figure 3.7-2. Representative RDX concentrations in springs, surface water and alluvial groundwater from 2000-2002

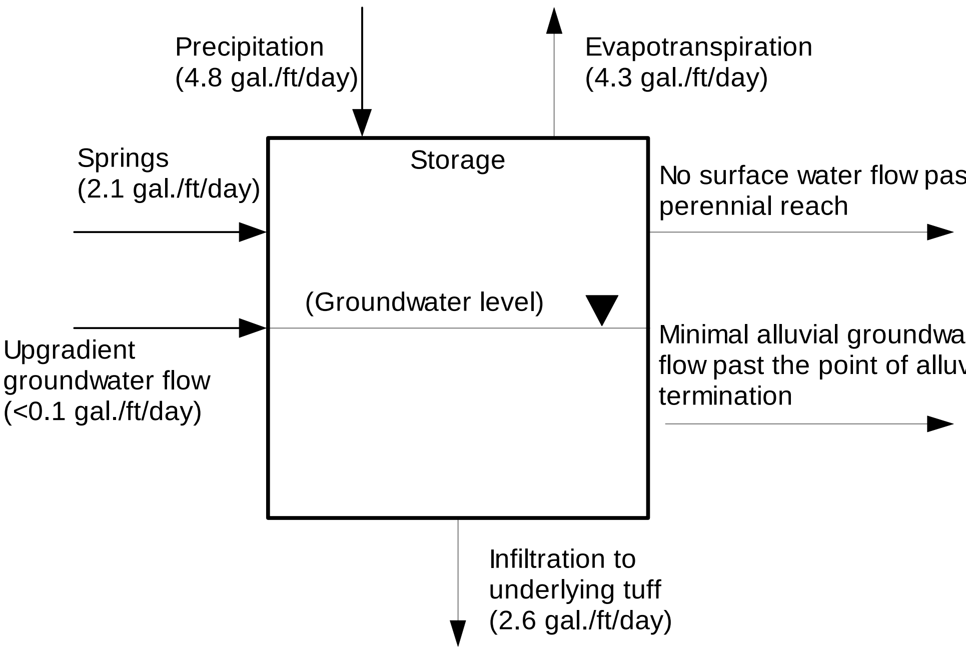

Figure 3.8-1. Conceptual water balance model for the Cañon de Valle alluvial system (in gal. per ft of canyon per day for an average water year)

groundwater may be discharging into the surface water system downgradient from Well 16-02659 (see Figure 3.2-1). The high RDX values in Well 16-02659 as compared with upgradient Well 16-02658 indicate that either RDX is being leached from secondary sources within the alluvial system or increased inputs into the alluvial groundwater system from higher concentration surface waters are occurring. In addition, the presence of both RDX and barium upgradient from the 260 outfall discharge point indicates that residual contamination at MDA R, the 90s Line Pond, as well as other upgradient sources may be contributing to the alluvial system.

The spatial trend for manganese concentrations in alluvial groundwater in Cañon de Valle indicates a strong positive correlation between manganese concentration and distance from the Cañon de Valle headwaters. In addition, manganese sediment concentrations are all within background. These facts indicate that naturally occurring manganese is dissolving as a result of reducing conditions present within alluvial groundwater, most likely as a result of the presence of organic matter. Whether this organic matter is naturally occurring or HE is not known.

Stable isotopic results indicate that surface waters respond much more rapidly to precipitation events and other discharges to the surface, whereas alluvial waters represent more well-mixed waters that have had time to interact with alluvial sediments.

Most of the data collected during the Phase III RFI indicate that the alluvial groundwater system in Cañon de Valle is heterogeneous in both contamination and hydrologic properties such as saturation. Contaminant concentrations in water do not represent a simple “plume” with decreasing concentrations from the source or center of the plume. Both RDX and barium increase and decrease in relative abundance in springs, surface waters, and alluvial groundwater. This is due to variable exchange

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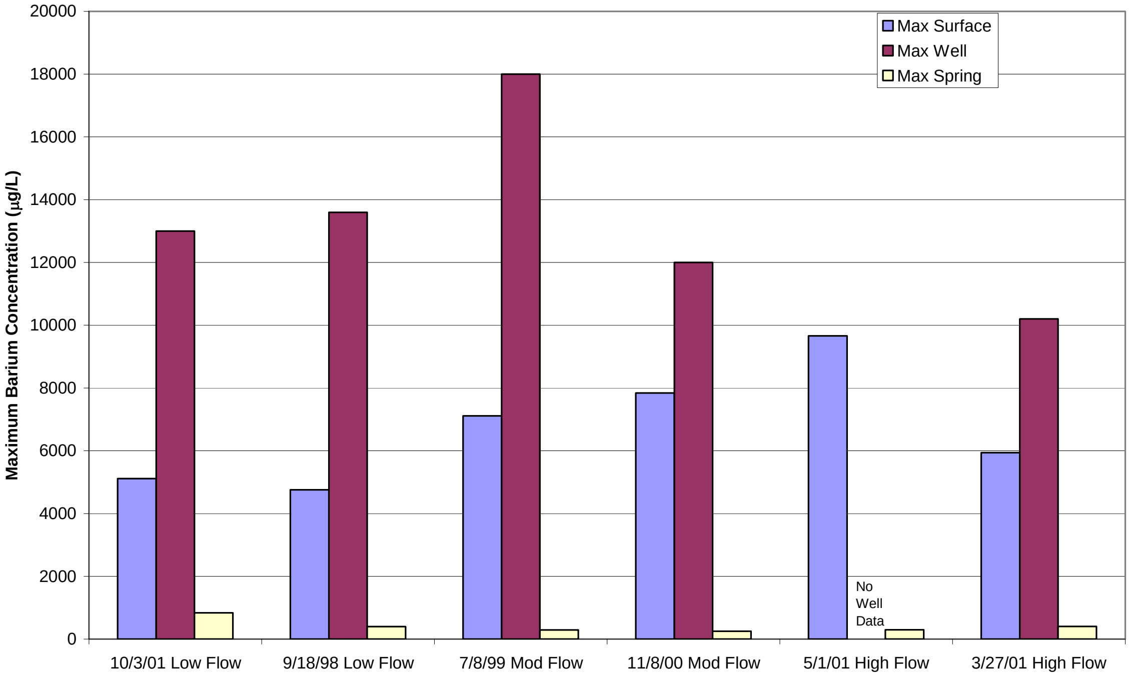


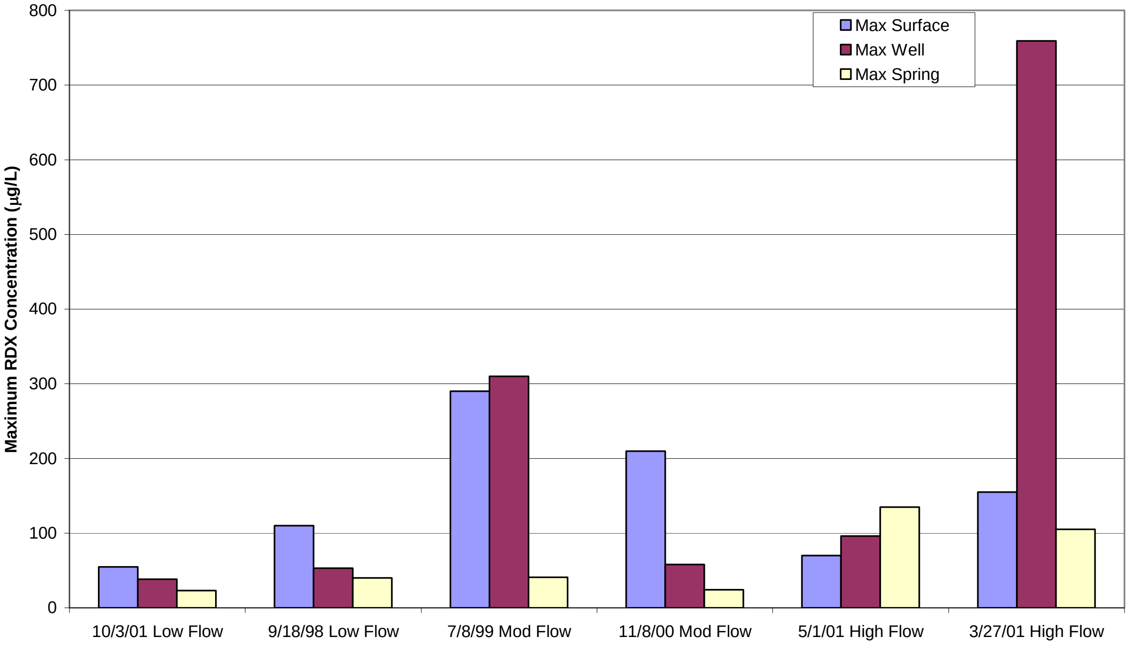


Figure 3.8-2. Comparison of barium (top) and RDX (bottom) concentrations among Cañon de Valle alluvial groundwater (Max. Well), springs (Max. Spring), and surface water (Max. Surface) for selected flow events from 1998 to 2002

between surface water and alluvial groundwater which is dependent on the flow regime; variable degrees of mobilization of vadose zone and alluvial sediments; location of contaminant inventories; and varying degrees of dilution from runoff, interflow, and vadose zone discharge. Similarly, the geophysics, the piezometer results, and the results of head monitoring in the alluvial wells indicate that the saturated system in the Cañon de Valle alluvium is heterogeneous with respect to saturation and permeability.

For Martin Spring Canyon, spring water provides alluvial groundwater and, prior to infiltration, surface water. Stormwater is an intermittent contributor to alluvial groundwater and surface water. As of this writing, Martin Spring has ceased to flow. Based on the SCM presented in the Phase III RFI report, Martin Spring served as the main source for Martin Spring Canyon contamination.

As part of Phase III RFI activities, a geophysical resistivity survey was conducted, the objectives of which included defining the lateral and vertical extent of saturated alluvium within Cañon de Valle along the survey lines and within the vicinity of established monitoring wells (LANL 2003, 77965). A secondary goal was to investigate potential vertical pathways for downward migration of meteoric water and groundwater to the Bandelier Tuff. A prominent low-resistivity feature was detected between alluvial groundwater monitoring wells 16-02658 and 16-02659 (see Figure 3.2-1 for locations of these wells). These zones are possible areas of saturation or elevated water content relative to the surrounding media, and they may indicate zones of enhanced groundwater recharge to the underlying tuff (although the correlation between resistivity and water content has not been field-verified at TA-16).

Representative Phase III RFI barium and RDX concentrations in surface water and alluvial groundwater are shown on Figures 3.7-1 and 3.7-2, respectively.

3.9 Components 7 and 8—Deep Vadose Zone and Regional Aquifer

The deep vadose zone and regional groundwater are labeled as components 7 and 8, respectively, on the SCM (Figure 3.3-1).

To better characterize the TA-16 deep vadose zone, two geophysical surveys were conducted as part of the Phase III RFI (LANL 2003, 77965) and the activities described in the CMS plan addendum (LANL 2003, 75986.2). The main objective of these surveys was to identify potential saturated zones deep in the mesa and the lateral extent of such zones. In 2001, an electromagnetic “flyover” survey was performed over the Laboratory. The survey data indicate a more conductive (presumably wetter, perhaps saturated) zone in the western half of the TA-16 mesa, ending in a steeply dipping zone of electrical conductivity in the vicinity of R-25. Wells CdV-R-37-2 and CdV-R-15-3 are located in the less conductive zone further to the east. These wells did not intercept the 700-ft-deep perched groundwater observed in R-25 (Kopp et al. 2002, 73707; Kopp et al. 2002, 73179.9). Zonge Engineering (Zonge) performed a controlled-source audio-frequency magneto-telluric (CSAMT) survey during 2002. The data indicate the presence of discrete, heterogeneous, sub-vertical, electrically conductive layers (presumably wetter, perhaps saturated) in Cañon de Valle and on the TA-16 mesa. The data also indicate a geophysical feature at R-25 which was interpreted to be the perched groundwater unit.

According to the geophysical surveys, the intermediate (approximately 700 ft) perched groundwater zone (and any associated contamination) below the TA-16 mesa is probably limited in extent. The Zonge data support the SCM hypothesis that vertical preferential pathways may be responsible for groundwater recharge and contaminant transport to perched groundwater zones (where present) and to the regional groundwater at R-25. Intermediate-depth wells, which are scheduled for 2003–2004, will provide further insight into vadose zone contamination and pathways.

In 1999, R-25 was drilled to a depth of 1942 ft from the mesa top above Cañon de Valle (see Figure 3.2-1) into regional groundwater. Based on the groundwater elevation in this well, confined conditions may be present. HE contamination (RDX, HMX, and TNT) was detected in R-25 during 1999 and continues to be detected (maximum detected RDX concentration is 75 µg/L) in quarterly samples (LANL 2003, 75986.2). Barium has been detected, but at low concentrations ranging from 2.4 to 73 µg/L (LANL 2001, 70295.5; LANL 2001, 71368.5; LANL 2002, 73712.5) that may be within background ranges. (A background study has not been completed for regional groundwater.)

The lack of contamination in the regional groundwater at monitoring wells CdV-R-37-2 and CdV-R-15-3 (Kopp et al. 2002, 73707; Kopp et al. 2002, 73179.9), which were designed as plume-definition wells and installed during 2001 and 2002, also places bounds on the extent of contamination within the framework of the SCM. The locations of these wells are shown on Figure 3.2-1. To assess the nature and extent of contamination, additional well installations are planned for the regional groundwater (LANL 2003, 75986.2).

3.10 Physical and Chemical Contaminant Characteristics and Environmental Fate

An important part of the site hydrogeological and contaminant transport SCM involves the chemical and physical properties of the contaminants and their behavior in the environment. Specific properties include the degree of saturation (barium minerals), the potential for ion exchange (barium) or adsorption (barium on metal oxides and HE on natural organic carbon), and the potential for natural attenuation and bioremediation.

The high specific gravity of RDX and HMX indicates that particulates of these compounds were probably deposited in the TA-16-260 outfall and settling pond, rather than carried into Cañon de Valle as particulates. Because of its lower specific gravity, this may not be true for TNT. The potential for particulate settling along the channel is also dependent on the flow velocity, flow rate, and residence time in the settling pond—all factors not studied during the operational period of the outfall. The probable lack of particulate transport into Cañon de Valle leaves transport of dissolved constituents within water discharged to the outfall as the primary transport mechanism for HE (and barium) into Cañon de Valle.

HE that is dissolved in groundwater partitions between a soluble and an adsorbed phase. Both tuff and sediment adsorb HE, though to a varying extent. On the basis of HE contaminant adsorption studies done on clays (Myers 2003, 76188), it can be inferred that tuff has a relatively low adsorption capacity (on the order of 1 mL/g) for RDX, HMX, and TNT. These constituents, however, are adsorbed onto organic carbon present in the Cañon de Valle alluvium, with the capacity for adsorption represented by the compound-specific organic carbon adsorption coefficient (K_{oc}). While the fraction organic carbon (FOC) in the alluvium is not known, FOC studies in Los Alamos Canyon (Hickmott 2003, 76190) indicate that the FOC ranges from 0.1% to 5%. Finer fractions, like fine sand and silt, which are representative of floodplain deposits, tend to be in the higher end of the FOC concentration range (e.g., 2 to 5%). Concentrations in the medium sand and larger fractions, which are representative of buried channel deposits, tend to be in the lower end of that range (e.g., 0.1 to 2%).

In contrast to HE, which does not dissociate in groundwater and is slightly soluble, barium nitrate dissociates into the barium cation and nitrate anion, and is freely soluble in water. In groundwater, barium will partition between dissolved, adsorbed, and solid phases, the latter including barite and witherite (LANL 1998, 59891). The respective partitioning fractions of the total barium inventory is not known. This uncertainty is important because certain barium phases, particularly barite and barium adsorbed by ion exchange, may not be available for groundwater transport, as discussed below.

Barium has an affinity for adsorption onto clays, oxides, and hydrous oxides, with literature values for equilibrium adsorption coefficients in soil ranging from 66 to 2800 mL/g (Myers 2003, 76188). While the concentrations of clays has not been studied in Cañon de Valle, clay content has been quantified for other canyons, and it is generally positively correlated with the fraction of fine particle size (Katzman 2003, 76850). For Cañon de Valle, the fine particle-size fraction appears to contain the highest contaminant inventories when compared to other geomorphic units, indicating that the clay content of the fine particle-size fraction may be higher. Barium adsorption onto these clay and oxide minerals takes the form of ion exchange and chemisorption, with adsorption onto clays primarily due to ion exchange. Furthermore, barium adsorption onto clay is thought to be irreversible under natural conditions. Once barium is adsorbed, it is immobilized or "locked down" on the clay surface (Myers 2003, 76188). Consequently, the ion exchange of barium on natural clay can serve as a means of immobilizing barium or retarding its movement in the environment.

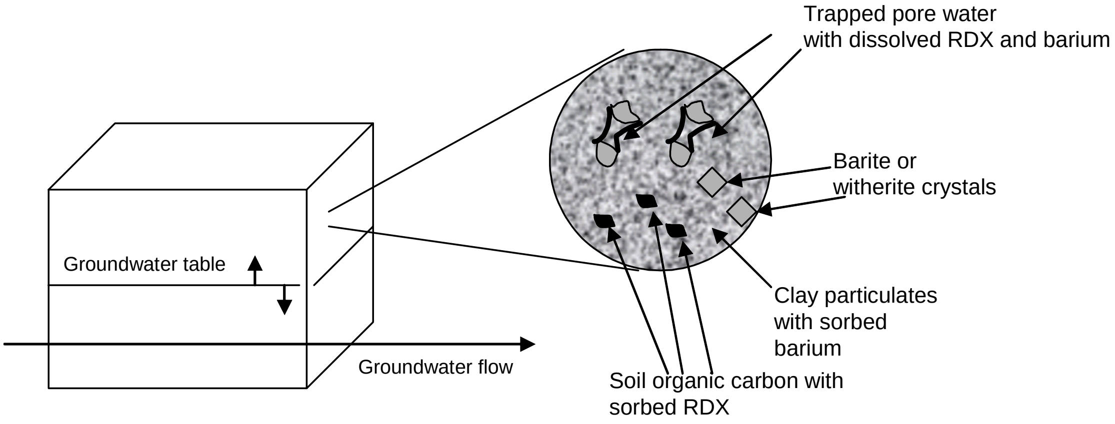
A literature search for barium adsorption studies on tuff was conducted, but yielded no published results. The dynamics of barium adsorption onto both tuff and alluvial sediment and the relative fraction of barium partitioning between its various forms is an important uncertainty in the SCM. Not all the barium inventory may be available for transport, but the fraction that is unavailable is not known.

Based on the preceding discussion, Figure 3.10-1 shows the conceptual vadose zone distribution of barium and RDX, the two primary CMS COPCs present in Cañon de Valle alluvial sediment. In Cañon de Valle, the alluvial water table fluctuates seasonally due to precipitation. Rising groundwater levels will desorb barium that is reversibly adsorbed and will dissolve barium minerals, primarily witherite. Rising groundwater also causes the release of RDX-containing pore water that was previously trapped in the vadose zone. RDX and barium are also present as adsorbed phases, with barium adsorbed onto clay particulates and other mineral phases and RDX adsorbed onto organic carbon present in the sediment. Alternatively, falling groundwater tables may cause the evaporation of water and the precipitation of barium minerals. In either scenario, the presence of these forms of barium and RDX in alluvial sediments represents a widespread, continuing source that is mobilized by stormwater or a rising alluvial groundwater table associated with episodic precipitation events in Cañon de Valle.

The relative adsorption potential of barium and RDX is reflected in their respective contaminant distributions. In R-25, barium has been detected, but at low concentrations that are at least a factor of 10 below the NMWQCC standard of 1000 µg/L, whereas RDX has been detected at a maximum concentration of 75 µg/L, this despite the prevalence of high barium concentrations in Cañon de Valle alluvial groundwater. This difference might be related to the higher relative adsorption potential for barium onto sediment and tuff. While the tuff adsorption potential for barium is unknown, sediment strongly adsorbs barium, particularly fine-grained sediment. Although the preferential path from the alluvial groundwater to the regional groundwater consists mostly of fractures in tuff, fractures that directly underlie the saturated alluvium may be filled with sediment, which serves to adsorb and retard barium.

The potential for biodegradation is another chemical property important to the long-term environmental fate of HE. TNT degrades aerobically and anaerobically, with reduction of the nitroso groups, eventually leading to cleavage and assimilation or mineralization of a portion of the TNT carbon. Groundwater analytical data from Cañon de Valle indicate active TNT degradation, with breakdown products typically present in higher concentrations than TNT itself.

The biodegradation of RDX and HMX in the environment also occurs aerobically and anaerobically (Card and Autenrieth 1998, 76873). Anaerobic degradation rates are typically greater than aerobic rates. For either pathway, nutrient concentrations are also important. In subsurface regions of the SCM, including the mesa vadose zone, canyon alluvium, and alluvial groundwater, the rate of natural biodegradation of



Block of Cañon de Valle alluvium

Figure 3.10-1. Conceptual distribution of RDX and barium in the Cañon de Valle vadose zone

RDX and HMX is likely to be low, given the lack of appropriate anaerobic conditions. The low concentrations of RDX breakdown products [MNX, DNX and hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX)] in groundwater and surface water support this hypothesis. RDX and HMX can also degrade chemically via an inorganic pH hydrolysis reaction (Layton et al. 1987, 14703); however, the potential for this degradation pathway at the site is unknown.

Barium does not biodegrade because it is an inorganic contaminant. As discussed above, the long-term environmental fate of barium is dependent upon its chemical state, whether precipitated, dissolved, or adsorbed.

3.11 SCM and Current Site Conditions Uncertainties

Despite the refinements made to the TA-16 SCM in the Phase III RFI (LANL 2003, 77965), uncertainties about the TA-16 system remain, as discussed below.

1. Characterization activities have not yet bounded the vertical extent of subsurface contamination beneath the potential source areas (other than the TA-16-260 source area) located on the mesa. Future drilling activities (e.g., at the 90s Line Pond) may address this uncertainty.

2. The uncertainties in the hydrogeology of the springs include the effects of terminating the TA-16-260 outfall and other discharges, the drought, the Cerro Grande fire, tree thinning, and the possibility of other springs or seeps discharging to the Cañon de Valle alluvial groundwater. As of this writing, Martin Spring is dry, and it is not known when flow will return. In addition, it is unclear if and when the benefits of the IM excavation at the outfall source area will be evident in Cañon de Valle springs (and in alluvial groundwater).

3. As noted in the 1998 Phase II RFI report, there is little evidence for a hydrogeological link between the TA-16-260 outfall and Martin Spring Canyon. Additional characterization performed since 1998 has reinforced the idea that the Martin Spring system is affected by contaminant sources other than the TA-16-260 outfall. There are other potential source areas, but these have not been positively identified as contamination contributors to Martin Spring Canyon. The planned mesa characterization through intermediate-depth borings should help address this uncertainty, as discussed in revision 1 to the CMS plan addendum (LANL 2003, 75986.2).

4. The hydrogeological interconnection between the canyon bottoms and the deeper groundwater systems, including the intermediate perched groundwater encountered in R-25 and the regional groundwater, is not well characterized. The lateral extent of the 700-ft perched groundwater encountered in R-25 is not well bounded (although monitoring wells CdV-R-15-3 and CdV-R-37-2 improved this). The Zonge geophysical survey conducted as part of the Phase III RFI (LANL 2003, 77965) indicates there may be an abrupt eastern boundary to the intermediate perched groundwater, but this has not been verified. These uncertainties will be addressed by other investigations proposed in revision 1 to the CMS plan addendum (LANL 2003, 75986.2).

5. Detailed characterization of the lateral distribution of contaminant concentrations within Cañon de Valle alluvium has not been completed. Of the estimated 7000 ft of suspected saturated alluvium downstream from the TA-16-260 outfall source area, monitoring wells are located along the first 4000 ft. In addition, alluvial groundwater and sediment characterization is incomplete in Cañon de Valle upstream from the confluence of Cañon de Valle with Water Canyon. The Canyons Team will sample the alluvial groundwater and sediment in these reaches as part of its investigation.

6. The permeability distribution in Cañon de Valle saturated alluvial sediment is not known. These data are important to refining the water balance and assessing the efficacy of groundwater remediation alternatives, and will be addressed by the CMI.

7. Potential areas of enhanced vertical groundwater infiltration within the Cañon de Valle alluvium can be inferred from geophysics resistivity results. The permeability of the sediment or fractures that comprise these areas is not known. Moreover, the correlation between geophysics resistivity data and water content has not been verified by field sampling. Additional subsurface investigations, as planned under revision 1 to the CMS plan addendum (LANL 2003, 75986.2), will help verify the geophysical interpretations.

4.0 MEDIA CLEANUP STANDARDS AND REMEDIAL ACTION OBJECTIVES

The fundamental objective of corrective action is to control or eliminate potential risks to human health and the environment by initiating remedies that reduce contaminated media concentrations to protective levels. During the CMS, accomplishing this objective is a twofold process involving the establishment of site-appropriate MCSs (addressed in this section) and the identification of one or more corrective measure alternatives (addressed in subsequent sections). In this section, a set of media- and contaminant- specific cleanup objectives are proposed for the outfall source area and Cañon de Valle and Martin Spring Canyon alluvial systems. Points of compliance (POCs) and a compliance time frame (CTF) are also proposed.

MCSs are generally derived from two sources: (1) existing state or federal standards determined to be ARARs and (2) a site-specific, human health and ecological risk assessment (EPA 1998, 80120). According to EPA guidance, use of ARARs is a CERCLA requirement that is also suited to the development of MCSs under RCRA. The process of MCS development for this CMS considers site-specific criteria such as:

- the presence of multiple contaminants in a medium at the site;
- cumulative risk exposure from other hazards not directly related to the analyzed release;
- the site's physical restrictions and accessibility;
- the land-use designation appropriate to the site (e.g. industrial); and
- the effectiveness, practicality, reliability, and cost of the selected corrective measures and the potential for achieving the MCS.

4.1 Identification of ARARs

Existing NMWQCC regulations 20 NMAC 6.2.3103 Parts A and B, for groundwater of less than 10,000 mg/L total dissolved solids (TDS) concentration establish contaminant concentration standards and specify a 10^{-5} cancer risk threshold for concentrations of toxic pollutants. Because the TDS concentration of alluvial groundwater is less than 10,000 mg/L, these regulations are proposed as site ARARs for alluvial groundwater. Because of the interchange between site surface water and alluvial groundwater, these ARARs are also proposed for surface water and spring water. In the discussion that follows alluvial groundwater, surface water and spring water are referred to as shallow site waters. With respect to the discussion in section 4.0, these ARARs, which are NMWQCC regulations, incorporate both standards and an acceptable risk threshold.

For alluvial sediment in the alluvial vadose zone, the proposed ARAR is the requirement that alluvial sediment contaminant concentrations should not cause shallow site water contaminant concentrations above the shallow site water ARAR cited above, as measured from the point of withdrawal (20 NMAC 6.2.4103).

Given the future industrial use of the site and the presence of regional groundwater beneath the site, there are two potential points of withdrawal. For incidental shallow site water ingestion associated with industrial use, the point of withdrawal is the shallow site water. For residential drinking water, the point of withdrawal is the location of the nearest municipal well that draws from regional groundwater. The latter point of withdrawal is applicable to shallow site water because of its potential to infiltrate to regional groundwater.

Potential risk shallow site water calculated during the Phase III RFI (LANL 2003, 77965) was acceptable. Potential risk associated with the transport of contaminated shallow site waters to regional groundwater and subsequent extraction for residential use has not been quantified. This potential risk will be determined during the regional groundwater CMS using a site-specific computer model to evaluate groundwater flow and solute transport to the closest municipal well.

The ARARs cited above are the basis for the MCSs for site shallow water and alluvial sediment. Based on the provisions of the ARARs, MCSs for all CMS COPCs are derived from either ARAR concentration standards or ARAR risk-based provisions for toxic pollutants based on potential risk to regional groundwater. For example, the MCS for barium is set by a concentration standard in 20 NMAC 6.2.3103

Part A. The calculation of risk-based MCSs for toxic pollutants for the residential drinking water pathway is deferred to the regional groundwater CMS.

Several CMS COPCs, such as RDX and TNT, are not currently listed in 20 NMAC 6.2.1101 as toxic pollutants, but are suspected carcinogens. For these compounds, a 10^{-5} acceptable cancer risk threshold, as established by the proposed ARARs, is proposed.

Although CMS COPCs such as RDX and TNT do not have MCSs resulting from this CMS (and therefore, in a strict sense, have no drivers for remediation under this CMS), it is appropriate for this CMS to develop corrective measure alternatives to address these CMS COPCs in addition to CMS COPCs with MCSs. Similar remediation technologies are suited to both, and remedial action in the shallow site water can be viewed as a measure of source control with respect to regional groundwater.

4.2 Outfall Source Area MCSs

4.2.1 Identification of Risk-Based MCSs for Soil and Tuff in the Outfall Source Area

Phase III RFI COPCs for the outfall source area are aluminum, arsenic, barium, manganese, thallium, uranium, HMX, RDX and TNT. As discussed in section 3.2 and in detail below, these Phase III RFI COPCs are retained as CMS COPCs.

The following exposure pathways were quantitatively evaluated in the human health risk assessment for the outfall source area soil that was conducted as part of the Phase III RFI (LANL 2003, 77965):

- inhalation of volatiles or dust particles;
- incidental ingestion, and
- dermal contact.

These pathways are the most likely for exposure pathways for human receptors at the outfall source area (LANL 1998, 59891; 2000, 64355.4). All human receptors are workers associated with industrial use of the site: the on-site environmental worker represents individuals involved in environmental monitoring, such as field sampling efforts; the trail user is a worker who uses the trails for recreation/exercise purposes such as walking or jogging; and construction workers are involved in more intrusive work activities, such as excavation.

Cumulative excess cancer risk to the environmental worker from potential exposures to COPCs in soil and tuff is slightly above the NMED's target level of 10^{-5} (NMED 2000, 68554), but within EPA's target risk range of 10^{-6} to 10^{-4} (EPA 1991, 76865). The cumulative excess cancer risk for the other receptors is below NMED's target level of 10^{-5} (NMED 2000, 68554). Noncancer hazard (HI) (>1.0) is associated with exposure to outfall source area COPCs for the construction worker but not the other receptors (HI<1.0).

The excess cancer risk for the environmental worker is due primarily to the presence of RDX and TNT. Site-specific screening action levels (SSALs) based on a 10^{-6} acceptable cancer risk threshold (the EPA ARAR) for RDX and TNT were calculated for outfall source area soil as part of the Phase II RFI (LANL 1998, 59891). These SSALs were developed in consultation with the NMED (LANL 1998, 59173) and in accordance with EPA guidance documents (EPA 1991, 58234; EPA 1998, 58751). The SSALs for RDX and TNT are 36.9 mg/kg and 135.0 mg/kg, respectively. The SSALs for RDX and TNT are proposed as MCSs for the outfall source area.

For the construction worker, the total HI from the Phase III RFI risk assessment was 1.9, of which 1.6 or 84% was attributed to TNT, RDX, and barium. Therefore, reduction of the HI below 1.0 will be the focus of remediation in the outfall source area. Post-remediation sampling will evaluate the concentrations of all the CMS COPCs in the calculation of the HI, but the residual concentrations of TNT, RDX and barium will determine whether the objective of attaining an HI<1.0 is met. In this calculation, the mean of post-remediation CMS COPC sampling results will be used, specifically the 95% upper confidence limit on the mean.

Because RDX and TNT are involved with both noncancer and cancer risks, the minimum of their respective MCSs are proposed as the site MCS.

The MCSs based on an HI <1.0 cannot be determined without post-remediation sampling results. An estimate of the MCS for barium, however, can be calculated if it is assumed that the post-remediation average concentrations of TNT and RDX are at their cancer risk MCSs for RDX and TNT, and that, furthermore, these cancer risk MCSs are the site MCSs. Following these assumptions, the barium MCS concentration would be approximately 10,000 mg/kg.

4.2.2 Outfall Source Area Surge Bed MCSs

The outfall source area risk assessments did not assess the contaminated surge beds beneath the source area because these areas are not directly accessible to humans. The concern with the surge beds lies in their potential to adversely affect groundwater, either by discharging to the alluvial groundwater systems or by discharging to regional groundwater via fracture and surge bed flow paths. Although placement of the settling pond cap as part of the outfall source area IM has alleviated the potential for ponding of water and subsequent infiltration of groundwater, subsurface fracture groundwater flow paths may still intercept the surge bed horizons.

Because of the absence of potential human exposure pathways and the lack of constant groundwater contact, MCSs for the surge beds are not defined and a best management practice (BMP) remedial objective that calls for the isolation or removal of the 17-ft surge bed is proposed. The focus of the BMP is the 17-ft surge bed, where RDX concentrations of approximately 900 mg/kg were encountered (LANL 1998, 59891), and not the 45-ft surge bed, where RDX concentrations of approximately 4 mg/kg were encountered. Other tuff discontinuities, such as powder beds, showed concentrations similar to those for the 45-ft surge bed, are similarly not addressed.

4.3 Proposed MCSs for Springs, Groundwater and Surface Water

The CMS COPCs for surface water, alluvial groundwater and springs in Cañon de Valle and Martin Spring Canyon are listed in section 3.2. The CMS COPCs include barium, manganese, RDX, DNX, MNX and TNT, though not all are present in every location.

For barium, the proposed MCS for alluvial groundwater and surface water consists of the barium NMWQCC standard for groundwater (1000 µg/L). For manganese, the proposed MCS consists of the manganese NMWQCC standard for groundwater (200 µg/L). If the manganese is naturally occurring, this MCS will not apply

RDX, DNX, MNX, and TNT do not have standards and are not listed as toxic pollutants subject to a 10^{-5} risk threshold. Nevertheless, as part of the industrial-trail user scenario, in the Phase III RFI (LANL 2003, 77965), cancer risks were calculated for these compounds as associated with incidental ingestion of site waters. The RFI determined that under this scenario the potential risk associated with site contaminants was less than 10^{-5}, which complies with the NMWQCC toxic pollutant ARAR.

Potential risks were not calculated for a second exposure scenario, residential ingestion of regional groundwater at the nearest municipal drinking water well. To date, no site-related contaminants have been detected at the closest municipal well, which is located approximately 4 mi from the site. Calculation of the potential risk and the corresponding MCSs for this scenario are deferred to the regional groundwater CMS. The regional groundwater CMS will calculate the potential risk and the risk-based MCSs for shallow groundwater by using a predictive groundwater transport model to calculate the transport of shallow site water contaminants to the closest municipal well.

At the present time, only an MCS for barium and manganese in groundwater and surface water is proposed. For other CMS COPCs in springs, surface water and groundwater, the MCSs will be developed as part of the regional groundwater CMS.

For all site waters, it is proposed that remediation is complete when the MCSs, developed either as part of this CMS or the regional groundwater CMS, are attained for eight consecutive quarters. This is consistent with current NMWQCC abatement standards in 20 NMAC 6.2.4103.

4.4 Proposed MCSs for Alluvial Sediment

The proposed ARAR for alluvial sediments stipulates that alluvial sediments not cause groundwater or surface water contaminant concentrations at the point of withdrawal that exceed the water ARARs. The alluvial sediment ARAR makes no distinction between groundwater and surface water because of the interchangeability of waters at the site.

For barium, the MCS for shallow site water is the NMWQCC standard. As discussed in section 3, the sediment-water partition coefficient for barium that describes the sediment barium concentration in equilibrium with a barium water concentration is not currently known. Therefore, testing of the sediment to determine compliance with the sediment ARAR is proposed using standard leaching test procedures, with test results averaged across the alluvial vadose zone in a statistically representative fashion.

For sediment CMS COPCs, such as RDX and TNT, without corresponding MCSs derived from NMWQCC standards, the sediment ARARs state that sediment concentration of contaminants not cause water contaminant concentrations to exceed a risk level of 10^{-5}. As discussed above, there are two points of shallow site water withdrawal: an industrial trail-user scenario in which shallow surface water is ingested and a regional groundwater drinking water scenario involving the nearest municipal well. Under the industrial trail-user scenario, site waters did not pose an unacceptable risk; and by inference, site alluvial sediments are not likely to cause water to exceed the risk threshold for this scenario.

Calculation of shallow site water MCSs that are protective of regional groundwater is deferred until completion of the regional groundwater CMS. Once established, these MCSs can be applied to leaching test results for sediments to determine compliance with the sediment ARAR. As with barium, the test results would be averaged in a statistically representative fashion across the alluvial vadose zone.

4.5 POCs

Compliance with the MCSs is determined at specified POCs. These are specific locations where regular sampling is conducted for the purpose of assessing progress in attaining the MCSs.

For the outfall source area, soils will be remediated to attain the risk-based MCSs. To determine compliance with the risk-based MCSs within the outfall source area, the POCs consist of post-remediation sampling points. The mean (95% upper confidence limit of the mean) would be calculated and compared to the MCSs to determine compliance.

For the outfall area settling pond 17-ft surge bed, a POC is not proposed, given that there are no MCSs. To gauge the success of the BMP for this area, however, a new groundwater well is proposed to be installed for the 17-ft surge bed horizon. This well will be used to test for the presence of contaminated groundwater within the surge bed.

The proposed groundwater POCs in Cañon de Valle consist of the five existing alluvial groundwater wells. The historical data that exists for these locations will enable a determination of remedial progress with respect to past trends. Progress in attaining the remedial objective of eight consecutive quarters of MCS compliance will also be determined at each POC.

For surface water, two POCs located along the perennial reach of surface water are proposed. The first surface water sampling point is proposed for the midpoint of the perennial reach; the second is proposed for the end of the perennial reach.

In Martin Spring Canyon, the three existing alluvial groundwater wells are proposed as the POCs. These wells may go dry, given that Martin Spring is currently dry. If Martin Spring stays dry, alluvial groundwater in Martin Spring Canyon may be seasonally, rather than permanently, present. Sampling of the POCs will be conducted during the seasonal periods when groundwater is present.

A single POC for Martin Spring surface water is proposed. Given that the spring has gone dry, surface water in Martin Spring may be limited to seasonal cycles or stormwater events. Sampling of the POC for compliance would be conducted during the periods when surface water is present.

For the springs in Cañon de Valle and Martin Spring Canyon, the proposed POC is spring water wherever it emerges from the ground. If spring flow is intermittent, sampling will be conducted during periods of flow.

For alluvial sediment, the proposed POCs are a statistically representative set of sediment sampling points at which samples would be collected and subjected to a leaching test to determine an equilibrium water contaminant concentration. The 95% upper confidence limit of the mean water concentration would then be calculated and compared to the water MCSs to determine compliance.

4.6 CTF

The CTF establishes the length of time required to attain the MCSs. A specific CTF is not proposed for the outfall source area, springs, or alluvial systems. Site conditions, including the magnitude and extent of contamination and potential risks, do not warrant the imposition of an urgent, set time frame in which the remedial objectives and MCSs must be attained. Rather, the time required to meet these targets will be used as an evaluation factor for remedial alternatives, recognizing that those alternatives that require less time to meet the remedial and MCSs are preferable.

5.0 SELECTION OF REMEDIATION TECHNOLOGIES AND SCREENING

5.1 Overview of the CMS Process

Prior sections of this CMS report have reviewed current site conditions, identified CMS COPCs for site media, and proposed MCSs and POCs. In the remaining sections of this report, remedial technologies are evaluated (section 5), corrective measure alternatives are formed using the screened technologies and evaluated (section 6), and the preferred corrective measure alternatives are proposed (section 7). The public enters the decision-making process following regulatory submittal of this document. The PIP is presented in Appendix D. Figure 5.1-1 presents a flow chart of the CMS process.

The focus of the remediation technology screening process is on barium and HE. Although manganese is listed as a CMS COPC for Cañon de Valle and Martin Spring groundwater, it is not known at present whether the presence of manganese is due to natural reducing conditions present in these canyons or is the result of reducing conditions caused by the presence of HE. In the latter case, the remediation of HE will alleviate these reducing conditions, and manganese groundwater concentrations will decrease.

5.2 Identification of Remediation Technologies

5.2.1 Sources for Technology Information

The process of selecting and evaluating corrective measure alternatives begins with reviewing all remediation technologies, both standard and innovative, that could be used to achieve the MCSs for the various site media. Sources of candidate technologies include literature reviews, working groups, and EPA databases.

Since January 1998, Laboratory personnel have participated in the DOE's Innovative Treatment and Remediation Demonstration (ITRD) Program's HE Advisory Group, a group whose goals are the identification and testing of potentially cost-saving remediation technologies for HE environmental contamination. The ITRD Program was designed to study HE and barium remediation technologies in both soils and water, focusing on the unique problems associated with DOE HE-processing facilities such as LANL and Pantex. Contamination at these sites differs from that found at many Department of Defense (DoD) sites because of the occurrence of barium and because the principal HEs used were HMX and RDX (the nitrosamines) rather than TNT and DNT (the nitroaromatics). In the ITRD Program, DOE facilities work cooperatively with the EPA, industry, national laboratories, and state and federal regulatory agencies to identify applicable, innovative, and cost-effective remedial technologies. For this CMS, the ITRD Program served as a resource for technologies and information about their effectiveness.

5.2.2 Overview of Technology Types

Remediation technologies may be broadly classified as either in situ (in place) or ex situ (removed from place). In situ technologies do not require removal of the media (i.e., in situ remediation of soils involves treatment in place rather than excavation). These definitions apply to site shallow groundwater, surface water, sediment, and soil.

Technologies can be further classified by their point of application and their operating principle. In general, in situ technologies have the advantage of minimally disrupting the local ecosystem, which, for Cañon de Valle, includes wetlands and a threatened and endangered species (the Mexican Spotted Owl).

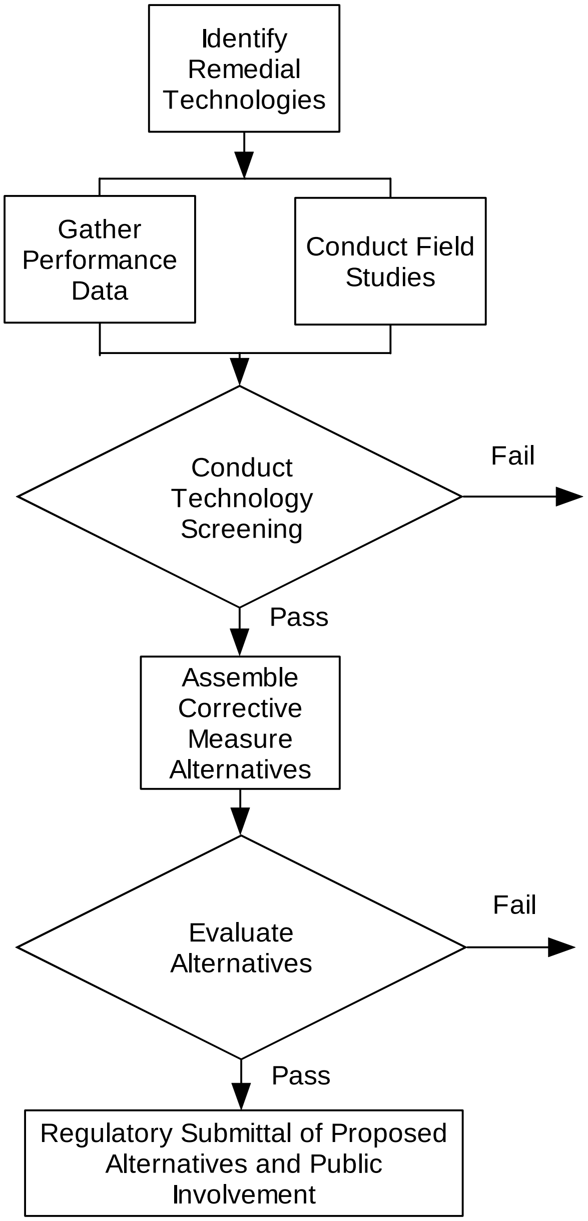


Figure 5.1-1. Flow chart of the CMS process for proposing alternatives

The disadvantages of in situ technologies include leaving contaminants or their byproducts in the environment and difficulties with demonstrating effectiveness and completion. Ex situ technologies, particularly when combined with off-site disposal, have the advantage of completely removing contaminants from the environment and the disadvantage of substantially disrupting the local ecosystem.

Containment technologies isolate the contamination and prevent migration and exposure. This isolation may prevent direct exposure or preclude contamination of other media, thereby preventing secondary exposure. One example of in situ technology is the capping of soils to prevent infiltration of surface water. One ex situ example is excavation of soils and their placement in a secure landfill.

Stabilization technologies limit the environmental movement of contaminants by altering the chemistry or physical state of the contaminant, usually by converting it into a non-soluble form. Like containment technologies, they may be either in situ or ex situ. Soil removal and stabilization at a secure landfill is an example of ex situ stabilization.

Other technologies destroy the contaminants and are typically ex situ. Examples include thermal destruction or incineration, chemical oxidation, and bioremediation, with bioremediation employed either in situ or ex situ. These are referred to, broadly, as thermal, physical-chemical, and biological treatment, respectively.

5.2.3 Standard Remediation Technologies

Several remediation technologies are considered standard proven technologies for the treatment of barium and HE in soil and water. Although they are standard, these technologies often have limitations regarding application and cost-effectiveness at a specific site. These limitations have been the impetus for the development of new innovative technology. Table 5.2-1 presents a list of standard remediation technologies that have been implemented on a production scale, in the field, for HE and barium at the Laboratory and at other sites across the country.

Table 5.2-1
Standard Technologies for Remediation of HE and Barium

Ex Situ Treatment of Soils
• Incineration • Thermal desorption • Stabilization and landfilling (for hazardous soils) • Landfilling without treatment (for nonhazardous soils) • Composting • Bioremediation and landfilling
In Situ Treatment of Soils
Low permeability caps Impermeable covers
Ex Situ Treatment of Water
• GAC[a] treatment for organic HE

[a] GAC = granulated activated carbon.

5.2.4 Innovative Remediation Technologies

Innovative technologies hold the promise of increased effectiveness and lower cost when compared to standard technologies. Any innovative technology needs to be compared with the standard baseline technologies to determine if there is any overall benefit to schedule, performance, cost, or regulatory acceptability.

The ITRD Program identified a list of innovative treatment technologies for in situ or ex situ applications at the Laboratory and at Pantex (LANL 1998, 62413.3). This list is shown in Table 5.2-2. Since the ITRD HE Advisory Group first met in 1998, several of these technologies have undergone significant development.

To augment the ITRD findings, a literature review was conducted for this CMS to gather additional information about technology performance status and data. For example, zero valent iron (ZVI) has shown promise as a technology for groundwater remediation of organic HE constituents when it is deployed as part of a permeable reactive barrier (PRB) (Wildman and Alvarez 2001, 80123). Similarly, calcium sulfate has shown promise for the immobilization of barium in groundwater by forming relatively insoluble barium sulfate (barite) (Wilkens et al. 2001, 79572).

5.3 Screening of Standard and Innovative Technologies

5.3.1 ITRD HE Working Group Screening of Technologies

Using the identified innovative technologies in Table 5.2-2, the ITRD HE Advisory Group screened each one for its applicability to sites at the Laboratory and Pantex (LANL 1998, 62413.3). To help with this evaluation effort, Pantex and the Laboratory provided detailed information about site monitoring, contaminant distribution, and geotechnical data to the ITRD HE Advisory Group. Additionally, the group toured SWMU 16-021(c)-99 and nearby Cañon de Valle and Martin Spring Canyon. The screening factors included the following requirements:

- Be protective of human health and the environment
- Attain likely MCSs
- Control the sources of releases to reduce or eliminate, to the extent practicable, further releases that may pose a potential unacceptable risk to human health and the environment
- Comply with standards for management of wastes

As a result of the screening, the innovative technologies shown in Table 5.3-1 were retained for further evaluation for use at SWMU 16-021(c)-99 and affected areas. Evaluation included pilot-scale testing. Some of the technologies eliminated by the ITRD, such as natural attenuation, were reconsidered for this CMS because of advances in the technology or advances in site characterization.

5.3.2 Recent Technology Pilot and Field Studies

To date, phytoremediation, composting, and chemical treatment using ZVI pilot-treatment studies have been completed by ITRD members and collaborators. Other important studies not listed in Table 5.3-1 include the Pantex in situ bioremediation field study (EPA 1996, 79573). These studies, as well as others, are described in greater detail below.

Table 5.2-2
Innovative Remediation Technologies Identified by the ITRD HE Advisory Group

Technology Name	Technology Class	In situ/Ex situ Medium
Bioaugmentation Biosep/DuPont process	Biological	In situ soils
Biodegradation(aerobic, anaerobic) with gas and liquid phase additions	Biological	In situ soils
Biodegradation with thermal enhancement	Biological	In situ soils
Biodegradation with natural attenuation	Biological	In situ soils
Biodegradation—phytoextraction	Biological	In situ soils
Soil flushing	Physical-chemical	In situ soils
Potassium permanganate treatment	Physical-chemical	In situ soils
Cobalt-60 irradiation	Physical-chemical	In situ soils
Fenton’s reactions	Physical-chemical	In situ soils
Chemoxidation	Physical-chemical	In situ soils
Soil heating with soil vapor extractions	Thermal	In situ soils
Soil vitrification	Thermal	In situ soils
Radio frequency heating	Thermal	In situ soils
Steam stripping	Thermal	In situ soils
Downhole burner (disco)	Thermal	In situ soils
Composting	Biological	Ex situ soils
Bioslurry—white rot fungi, bioslurry—indigenous microbes	Biological	Ex situ soils
Bioslurry-gas phase additions	Biological	Ex situ soils
ZVI abiotic reduction	Physical-chemical	Ex situ soils
Solvent extraction	Physical-chemical	Ex situ soils
Fenton’s reagent	Physical-chemical	Ex situ soils
Base hydrolysis with humic acid	Physical-chemical	Ex situ soils
Solvated electrons	Physical-chemical	Ex situ soils
Gamma irradiation	Physical-chemical	Ex situ soils
Molten salt	Physical-chemical	Ex situ soils
Electron beam	Physical-chemical	Ex situ soils
UV[a]/peroxide	Physical-chemical	Ex situ surface and groundwater
Peroxone	Physical-chemical	Ex situ surface and groundwater
Titanium oxide/UV	Physical-chemical	Ex situ surface and groundwater
Phytoremediation	Biological	In situ surface and groundwater
Electron beam	Physical-chemical	Ex situ surface and groundwater
ZVI	Physical-chemical	Ex situ surface and groundwater
Supercritical water oxidation	Physical-chemical	Ex situ surface and groundwater
Biotreatment	Biological	Ex situ surface and groundwater
Reactive barriers	Physical-chemical	Ex situ/in situ surface and groundwater

[a] UV = ultraviolet.

Table 5.3-1
Innovative Technologies Recommended for Further Study by ITRD HE Advisory Group

Technology	Media	Nature of Pilot Study
Chemical treatment/ZVI	Soil	Laboratory-scale
Bioslurry with ZVI	Soil	Laboratory -scale
Phytoremediation	Water	Pilot-scale
Passive barrier	Water	Laboratory- and pilot-scale
Bioremediation—vapor phase augmented	Soil	Pilot-scale
Composting	Soil	Pilot-scale

5.3.2.1 Martin Spring Canyon Stormwater Filter: Field Study

A pair of stormwater filters was installed at Martin Spring (IT Corporation 2001, 80122) as part of a feasibility study for treatment of HE- and barium-contaminated springs water. The filters were designed and constructed by StormWater Management, Inc., of Portland, Oregon (Figure 5.3-1). Stormwater filters are commonly used to treat runoff from parking lots. To treat both the barium and HE, it was necessary to install two separate units, each with a different filter medium. The first unit contains GAC to remove HE, and the second unit contains ion exchange resin to remove barium. The units were plumbed in series such that springs water first encountered the GAC filter, then the ion exchange resin filter.

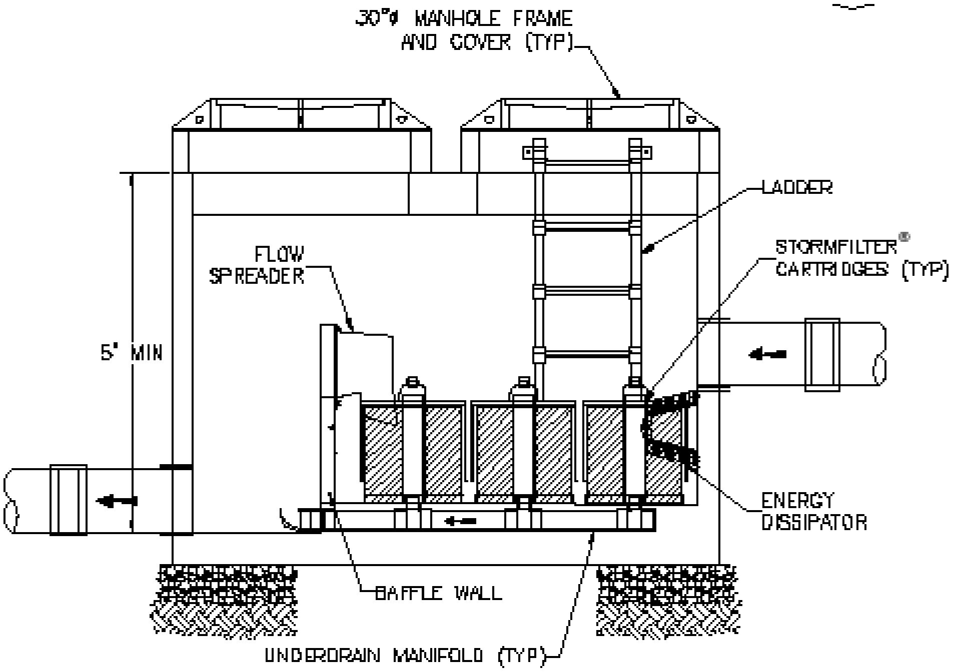


Figure 5.3-1. Typical stormwater filter, side view
(diagram courtesy of StormWater Management, Inc.)

For RDX, the units have performed well to date, but barium breakthrough has been detected earlier than anticipated, the cause of which is not known.

5.3.2.2 Phytoremediation: Field Study

HE has been shown to degrade in constructed wetlands (Sikora et al. 1997, 80124). Natural wetlands may also have some HE degradation ability. At Burning Ground Spring, a 200 m^2 natural wetland area is present between the spring outlet and the confluence with the main Cañon de Valle channel. This wetland was the focus of an investigation into the potential for phytoremediation of RDX and TNT (IT Corporation 2002, 79576). Concentrations of the parent compounds and primary metabolites were monitored at several locations within the wetland. The study also examined the capability of the dominant plant species to take up RDX. These plant species include sago pondweed (*Potamogeofpectinatus L.*), water stargrass (*Heteranthera dubia*), elodea (*Elodea canadensis*), parrotfeather (*Myriophyllum aquaticum*), reed canary grass (*Phalaris arundinacea L.*), wool grass (*Scirpus cyperinus*), and sweetflag (*Acorus calamus L.*). The specific objectives were to

> monitor levels of RDX and TNT breakdown products across the Burning Ground Spring wetland and determine if any reduction in parent compound concentration by wetland plants can be detected,
>
> monitor concentrations of primary metabolic breakdown products to help determine if degradation of RDX and TNT is occurring in the wetlands,
>
> observe seasonal trends in HE concentrations and wetland degradation performance, and
>
> conduct bench-scale laboratory studies of selected wetland plant species that are present at the Burning Ground Spring site and determine if they are capable of taking up HE.

The overall objective of the study was to assess the effectiveness of wetlands as an in situ treatment technology for the HE-contaminated surface waters present in Cañon de Valle.

The results from the Burning Ground Spring wetland investigation indicate that, under the current surface water flow pattern and retention time from the spring outlet to the confluence with Cañon de Valle, there is no evidence for a reduction in RDX and TNT concentrations from phytoremediation. Certain locations within the wetland, however, showed evidence of RDX biodegradation caused by microbial degradation. This indicates that the wetland area could be modified to enhance the microbial degradation processes (e.g., increasing water residence time under anaerobic conditions).

5.3.2.3 TNT and RDX Removal Using ZVI

In 1997, University of Nebraska researchers conducted laboratory tests of ZVI's ability to remove TNT and RDX from water and soils. The effectiveness of ZVI in removing TNT and RDX from contaminated soil slurries in the laboratory indicates that ZVI might be successfully used to remediate these compounds from contaminated soil and water on a field scale (Hundal et al. 1997, 79575).

5.3.2.4 Composting and ZVI: Field Study

In 2000, a pilot-scale composting study was conducted at TA-16 (IT Corporation 2002, 79577). The study used surface soils from the outfall source area (prior to the IM excavation of these soils) to test both a conventional composting process and the Grace Bioremediation Technologies Daramend™ ZVI treatment process (EPA 1996, 79573). This study investigated technologies that could, to varying degrees, effectively treat the highly contaminated HE and barium soils in the outfall source area. In the study, ammonium sulfate was used to immobilize barium through the formation of a relatively insoluble barium sulfate precipitate (barite). Ammonium sulfate was also a soluble-nitrogen source for the compost.

Conventional composting achieved substantial reductions in total HE concentrations, with HE levels likely meeting or exceeding potential appropriate treatment goals for the outfall source area drainage channel derived wastes. Barium was effectively stabilized by the ammonium sulfate. The most significant limitations of conventional composting are the time required for treatment, the space requirements, and the large increase in waste volume; amendments comprise approximately 70% of the waste. Daramend™ did not perform as well as conventional composting, and potential HE treatment goals were not reached; however, in other studies (EPA 1996, 79573) Daramend™ successfully reduced HE concentrations to levels comparable to those achieved through conventional composting and the process remains potentially advantageous due to its minimal increase in waste volume.

Pilot testing of both methods have shown that elevated temperatures and the maintenance of anoxic reducing conditions are critical for success. The composting experiments were negatively affected by large diurnal fluctuations in ambient air temperature due to the low thermal mass of the treatment piles. The Daramend™ experiments were subject to moisture-content control problems due to uneven drying rates within the small treatment piles and the non-uniform distribution of added water which was, in turn, due to the limitations of hand mixing methods. Both temperature and moisture requirements would be easier to meet in the field, where the larger masses of soil would reduce rapid soil drying and diurnal temperature fluctuations.

For the IM treatment of soils, excavation and off-site disposal were selected over on-site treatment such as composting. This decision was made on the basis of cost and on the time and space required for on-site composting of excavated soils.

5.3.2.5 Pantex In Situ Bioremediation of HE-Contaminated Soils: Field Study

The first pilot-scale field demonstration of a technology for in situ remediation of vadose zone soils contaminated with HE was conducted at Pantex in 1999–2000 (Rainwater et al. 2002, 79752). The HE of concern at the demonstration site were RDX, TNT, and TNB. To stimulate the anaerobic conditions required for biodegradation, the system used nitrogen injection through a well array to flood the vadose zone. After 300 days of operation, the concentrations of HE were reduced by approximately one-third. While promising, applying this technology in Cañon de Valle would be difficult, given the long narrow configuration of the canyon and the difficulty of attaining an adequate nitrogen flooding of the soil.

5.3.2.6 Massachusetts Military Reservation, Camp Edwards: Innovative Technology Evaluation

An innovative technology evaluation program was initiated by the US Army and National Guard Bureau in March 2000 to identify and investigate promising innovative technologies for remediating soil and groundwater contaminated with explosives at Camp Edwards (Weeks and Veenstra 2001, 79580). This program specifically targeted technologies and vendors that had demonstrated success with remediating HE-contaminated soils. Promising technologies for soil and groundwater remediation were selected for laboratory treatability studies based upon each vendor’s response to a request for a proposal specific to Camp Edwards. The technologies chosen for the soil program were composting, solid-phase bioremediation, low temperature thermal destruction (LTTD), bioslurry, chemical oxidation, and chemical reduction. Using soils from the Known Distance Rocket Range at Camp Edwards, treatability studies were performed for composting, solid-phase bioremediation, LTTD, and bioslurry. Although the soil contained RDX, TNT, HMX, dieldrin, lead, and other contaminants, the goal of the studies was to address explosives. The study obtained the following results:

- Composting successfully treated washed (by soil washing) soils and partially succeeded in degrading HE compounds in unwashed soils. The results indicated that HMX concentrations were reduced to cleanup goals; however, RDX concentrations were not reduced to levels below cleanup goals.
- Solid-phase bioremediation using the Daramend™ process, which uses ZVI, effectively degraded HE compounds to levels below soil cleanup goals in one of the two studies performed on the washed soils and in one of the two studies performed on the unwashed soils.
- Low-temperature thermal destruction appears to effectively reduce the concentrations of HE compounds to levels below soil cleanup goals in unwashed and washed soils at temperatures of 250oC and 300oC.
- Bioslurry results using intermittently stirred reactors met soil cleanup goals over a period of 35 days in both unwashed and washed soils. Soil cleanup goals were met only in the continuously stirred reactors using previously washed soils.
- Chemical oxidation (using Fenton's Reagent) partially succeeded in degrading explosive compounds in washed soils. Concentrations of explosive compounds were reduced, but not to levels below cleanup goals.
- Using ZVI with the addition of aluminum sulfate, chemical reduction was effective in washed soils. Concentrations of explosive compounds were reduced to levels below cleanup goals. Tests were not conducted on unwashed soils.

5.3.3 Screening of All Technologies

The candidate technologies from all sources, including the ITRD HE Advisory Group and literature searches, are presented in Table 5.3-2, along with the screening evaluations. The evaluation of screening factors is summarized in this table through a plus (+) and minus (–) system. In the evaluation, feasibility, given site-specific conditions, is weighted more heavily than other factors. This is because feasibility assesses whether the technology is applicable from a practical standpoint. Advancement of a technology to the next stage of the CMS process (development and evaluation of corrective measure alternatives), is indicated by either a yes or no. A more complete description of the evaluation of each technology is presented below.

5.3.3.1 Ex Situ Treatment of Soils

The ex situ treatment of soil implies that soil is excavated and either treated on-site or treated, and disposed of, off-site. In the case of off-site treatment, clean soil is imported. Assuming a 2-km excavation length in Cañon de Valle, and a cross-sectional area of 10 m^2, the volume of excavated soil is approximately 20,000 m^3. This volume is probably conservative given the fact that the width of the active channel in several areas of Cañon de Valle is less than 1 m across. Soil contamination, however, may not be limited to the active channel (LANL 2003, 77965). Moreover, post-excavation soil swell may increase

Table 5.3-2
Final Screening of Remedial Technologies

Technology Name	Protection of Human Health and the Environment	Ability to Meet Media Cleanup Standards	Ability to Control Releases	Compliance with Standards for Management of Wastes	Feasibility Given Site-Specific Conditions	Retained for Further Evaluation?
Ex Situ Treatment of Soils						
Incineration	+[a]	+	+	+	-[b]	No
Low-temperature thermal destruction	+	+	+	+	-	No
Soil washing	+	+	+	+	-	No
Off-Site landfilling (nonhazardous soils)	+	+	+	+	+	Yes
Off-Site stabilization	+	+	+	+	+	Yes[c]
Soil bioslurry	+	+	+	+	+	Yes[c]
Composting (including accelerated)	+	+	+	+	+	Yes[c]
In Situ Treatment of Soils						
Composting	-	-	-	+	-	No
Bioremediation (vapor-phase augmented)	-	-	-	+	-	No
Low permeability cap (source area)	+	+	+	+	+	Yes
Grouting of source area surge beds	+	+	+	+	+	Yes
Stabilization of barium by sulfate addition	+	+	+	+	-	No
Flushing of alluvial sediments	+	+	+	+	+	Yes
Ex Situ Treatment of Groundwater						
GAC treatment for RDX	+	+	+	+	+	Yes
Ion exchange treatment for barium	+	+	+	+	+	Yes
In Situ Treatment of Groundwater						
PRBs—GAC	+	+	+	+	+	Yes
PRBs—ZVI	+	+	+	+	+	Yes
Stormwater filters	+	+	+	+	+	Yes
Slurry walls	-	-	-	-	-	No
Phytoremediation	-	-	-	+	-	No
Monitored natural attenuation	-	-	-	N/A[d]	-	No

[a] + = favorable. [b] - = unfavorable [c] Likely to be feasible for off-site hazardous treatment only.

[d] N/A = not applicable.

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the in situ volume by 10%. Alternatively, a limited excavation of areas with elevated concentration may be feasible if more restricted excavation length and corresponding soil volume are removed.

In general, excavating areas such as the one that contains Cañon de Valle alluvial sediments is problematic due to National Environmental Policy Act (NEPA) and wetlands concerns, including the disturbance of wetlands and Mexican Spotted Owl habitat. Nevertheless, excavation could be effective if coupled with the appropriate remediation technologies, and the anticipated soil volume is not prohibitive. Excavation and candidate treatment technologies have been developed into corrective measure alternatives and are evaluated in section 6.

(a) Incineration

Incineration was first demonstrated on explosives-contaminated soil in 1982 at the Savannah Army Depot (Sisk 1998, 58940). Projects have been completed at four sites, with costs that range from $250 to $600 per ton. Pilot-scale feed rates were 200–400 lb/hr, and full-scale rates are estimated to be 20–40 ton/hr. The advantages of incineration are (1) it is a process that can handle a wide range of waste characteristics and contaminant concentrations, (2) it has a large treatment rate, (3) it has little downtime, (4) it is not affected by the weather, and (5) it can treat both liquids and solids. Incineration has been used to treat explosive compounds and reduce levels to 1 mg/kg. Neither incineration nor any thermal treatment removes inorganic barium. Consequently, other technologies, such as soil washing with water, must be used in tandem with thermal treatment.

The disadvantages of incineration include a negative public perception, the need for air pollution control equipment and air permitting to control byproducts, high mobilization and demobilization costs ($2–3.5 million), and the energy-intensive nature of the process. On average, 2 yr are required to obtain regulatory approval for incineration.

In general, on-site treatments of remediation wastes will require a corrective action management unit (CAMU) permit. The CAMU permitting alone may require several years. The difficulties involved in obtaining a CAMU permit meant that off-site disposal was favored for the IM remediation project (LANL 2000, 64355.4).

On the basis of the preceding discussion, incineration is not retained as a preferred technology, despite its proven ability to meet standards. Primarily because of the high permitting costs and negative public perception, and the relatively small volume of soil that is anticipated, its feasibility is unfavorable and it is not retained for further evaluation.

(b) Low-Temperature Thermal Destruction

Low-temperature thermal destruction is similar to incineration, except that lower temperatures are used. In this process, soil containing trace explosives residues is heated in a rotary kiln to volatilize or desorb contaminants. Volatilized contaminants are destroyed in a thermal oxidizer or adsorbed onto carbon. Thermal desorber units are typically smaller than incineration units and require less mobilization expense and consequently less threshold soil volumes to justify their use. Consequently, per-ton costs are less than incineration (approximately $150 per ton). Like incineration projects, thermal desorber projects require an extended permitting process, including a trial testing period. Although the process is similar in operating principle to incineration, the public and regulatory perception is somewhat better, and it has been widely used for soil remediation, primarily for petroleum hydrocarbon and chlorinated hydrocarbon remediation. Like incineration, thermal desorption will not remove barium, which would require a technology such as soil washing for removal.

As an on-site treatment requiring a RCRA CAMU permit, thermal desorption would require a lengthy permitting process. Moreover, given the successful IM remedial action, which used off-site soil disposal cost-effectively, on-site treatments are at an economic disadvantage. Therefore, any on-site treatment would have to show significant cost advantages over off-site disposal.

Schedule and cost requirements dictated by the CAMU permitting required for on-site treatment however, place on-site treatment in general at a disadvantage, especially for the relatively small volume (20,000 m^3) of soil in this case. For these reasons, the feasibility of thermal desorption is unfavorable and it is not retained for further evaluation.

(c) Soil Washing

Soil washing has been shown to be effective for such HE as RDX and TNT (Weeks and Veenstra 2001, 79580). Soil washing also removes barium, if it is present in a soluble form such as witherite (barium carbonate). Soil washing has been successfully used in technology demonstration projects and in full-scale site-remediation projects (EPA 1993, 79565). To treat barium-containing wash water, sulfate precipitation or ion exchange would be used. The average cost for soil washing is $170 per ton, including excavation (Federal Remediation Technologies Roundtable 2002, 79570).

The principle of soil washing is largely based on separating soil particles by size and density, which takes advantage of preferential HE adsorption onto the FOC within soil. In essence, the process is one of waste volume reduction, with the FOC subjected to other treatment, or off-site disposal. The clean fraction is returned to the excavation.

As an on-site treatment, soil washing would require a CAMU permit, so it suffers from the same disadvantages as incineration and low-temperature thermal destruction. Moreover, soil washing must be implemented with other technologies that address HE. For these reasons, the feasibility of soil washing is unfavorable and it is not retained for further evaluation.

(d) Off-site Landfilling without Treatment (Nonhazardous Soils)

Off-site landfilling was used successfully on nonhazardous soil during the IM remediation of the outfall source area (LANL 2002, 73706). Hazardous wastes were shipped to Waste Management's Chemical Waste Management (CWM) Subtitle C facility in Lake Charles, Louisiana, where the waste was treated using their EPA-approved bioremediation process. Nonhazardous wastes were loaded directly from the pile into 30 yd^3 end-dumps and shipped to Waste Management's industrial waste landfill in Rio Rancho, New Mexico, at a cost of approximately $50 per ton. Off-site landfilling requires compliance with land disposal restriction (LDR) under RCRA. Because of its successful implementation at TA-16 as part of the 260 IM and MDA P (LANL 2003, 76876) projects, and the assumption that most soils, sediments, and tuff should qualify as nonhazardous, this technology is retained for further evaluation.

(e) Off-site Stabilization

Stabilization of HE-contaminated soil has been demonstrated at the Umatilla Army Depot site (EPA 1995, 58942; Channel 1996, 58943). Stabilization was the selected remedy for the Umatilla Army Depot Burning Ground because its soil contained metals as well as explosives. Incineration was also evaluated, but addressing the metals would have required stabilization after incineration, for a total cost of $15 million. The cost of stabilization alone was estimated at $4 million. An on-site landfill accepted the stabilized soil, which had to meet toxicity characteristic leaching procedure (TCLP) criteria for metals as well as separate leaching criteria for HE. Laboratory- and pilot-scale tests were performed using combinations of Portland cement, fly ash, and GAC as amendments. Carbon in the cement mix improves performance, 5% GAC provides optimal performance. The full-scale recipe used only 10% Portland cement, no fly ash and 1–1.5% GAC. This reduced recipe caused about 10% of the waste to fail TCLP, requiring breakup and retreatment. Approximately 30,000 tons of soil was processed, at a cost of approximately $5 million.

The Umatilla Army Depot stabilization operation had a capacity of 80 ton/hr and a cost of $170 per ton (turnkey). It is estimated that costs at other sites would range from approximately $150 to $200 per ton (turnkey costs). There is about a 50% increase in volume over the starting amount. To better stabilize barium as insoluble barium sulfate, stabilization amendments could also include sulfates. At the Laboratory's MDA P, stabilization was used on barium-hazardous soils at a cost, including transportation and treatment at a Texas landfill, of approximately $250 per ton (Criswell 2003, 80121).

The cost of stabilizing nonhazardous soils precludes its application to the outfall source area soils and nonhazardous canyon alluvial sediments. If hazardous soils or sediments were encountered, however, stabilization is a feasible ex situ technology. Judging by the existing barium sediment concentrations in Cañon de Valle, barium-hazardous sediments may be encountered during the excavation of Cañon de Valle. Based on the preceding discussion, stabilization is retained for further evaluation.

(f) Soil Bioslurry

Slurry phase biotreatment was demonstrated successfully at the Joliet Army Ammunition Plant in 1995 and 1996 and at the Iowa Army Ammunition Plant in 1997 and 1998 (US Army Environmental Center 2003, 79578). Bioslurry consistently achieved removal rates above 99%, with a high rate of mineralization. These studies, which were performed in support of feasibility studies at Joliet and Iowa Army Ammunition Plants, developed comprehensive concept designs and cost estimates for full-scale application of aerobic and anaerobic bioslurry processes. The studies found that bioslurry systems have higher construction and facility costs, but lower operation and maintenance costs, when compared to composting. An estimated unit cost of $230–270 per ton is close to that of composting.

Bioslurry was evaluated as an HE soil-remediation technology as part of treatability studies conducted at the Massachusetts Military Reservation, Camp Edwards (Weeks and Veenstra 2003, 79580). The tests used previously treated (by soil washing) and untreated soils. The results successfully met soil cleanup goals over a period of 35 days in both the unwashed and washed soils.

Bioslurry is feasible for the off-site treatment of soils, and is retained for further evaluation. Like stabilization, it is a candidate technology for the off-site treatment of hazardous soils and sediments only.

(g) Composting

The broad category of composting includes conventional composting (land-farming) and accelerated composting processes such as Daramend™ (EPA 1996, 79573), a composting process with ZVI soil amendments, and Chemical Waste Management's two-stage, solid-phase (TOSS) composting process (Waste Management, Inc. 2003, 79582), which was used for the off-site treatment of hazardous soils from the IM excavation of the outfall source area (LANL 2002, 73706). The underlying operating principle of each is bioremediation, and excavation is generally required prior to composting so that the soil can be worked.

Both the Daramend™ and the more conventional composting technologies were evaluated in the feasibility study conducted at TA-16 (see section 5.3.2). TOSS is a two-stage solid-phase bioremediation technology that involves both anaerobic and aerobic treatment stages. For the first stage, HE-contaminated soil is combined with a carbon source, an innoculum, vitamins, and water to achieve anaerobic conditions. The resulting mixture is formed into a static pile or placed in a bermed construction area or box to facilitate the chemical reduction of nitroaromatic and nitramine explosives. For the second stage, the anaerobically treated soil is combined with yard waste compost and built into an aerated biopile. The biopile may be aerated by forced air which is conveyed through perforated piping buried within the pile or by turning the pile with a compost turner.

Previous testing of TOSS has demonstrated TNT-removal efficiencies that are greater than 99% (Waste Management, Inc. 2003, 79582). Moreover, TOSS was used successfully as an off-site treatment for the hazardous soils excavated during the IM remediation at the outfall source area, as referenced above.

For the IM at the outfall source area, composting was ruled out as a method for treating on-site hazardous and nonhazardous soils on the basis of cost, time needed for treatment, and space considerations. Based on the preceding information, composting by TOSS is retained for further evaluation as an off-site treatment of hazardous soil, sediments, or tuff, but not as an on-site treatment.

5.3.3.2 In Situ Treatment of Soils

(a) Composting

While shown to be effective ex situ (see section 5.3.2), composting either the outfall source area soils or canyon alluvial sediments in situ would not be feasible, given the requirement for soil amendment and working of the soil. Moreover, the small volume of outfall source area soils (less than 100 yd^3), precludes cost-effective in situ treatment. For these reasons, composting is not retained for further evaluation as an in situ treatment.

(b) Bioremediation with Vapor-Phase Augmentation

Used at Pantex as part of a feasibility study (Rainwater et al. 2002, 79752), this technology used nitrogen injection through a five-spot injection well pattern to flood the vadose zone, thereby stimulating the anaerobic conditions required for biodegradation (see section 5.3.2). After 300 days of operation, the concentrations of HE were reduced by approximately one-third. Although it is promising, application of this technology at Cañon de Valle would be difficult, given the long narrow configuration of the canyon and the difficulty of attaining adequate nitrogen flooding of the soil. For these reasons, this bioremediation technology is not retained for further study.

(c) Low Permeability Cap

Installing a low permeability cap in Cañon de Valle to prevent the further leaching of HE from canyon alluvial sediments by precipitation would not be effective or practical. According to the SCM, residual barium and HE is present in the vadose zone and could be mobilized by rising alluvial groundwater. A cap would not address groundwater. Moreover, installation is not practical given the long narrow configuration of the canyon and the lack of a well-defined area of sediment contamination.

A low permeability cap was installed for the outfall source area settling pond as part of the IM. The purpose of the cap was to preclude the infiltration of stormwater into lower horizons, including the surge beds. Because the cap is in place and is presumably effective, it will be retained as a technology for the outfall source area, including the surge beds.

(d) Grouting of Source Area Surge Beds

In situ grouting with clay-based grouts has been used to isolate mine waste drainage (EPA and DOE 1997, 79569) and prevent underflow in dams (USGS 2001, 79579). Isolating the surge bed within the outfall source area by grouting would prevent groundwater flow into the contaminated areas of the surge beds. Contamination would remain in place, but would be isolated from further contaminant transport. Grouting is feasible because the surge beds possess a relatively higher permeability than the surrounding tuff. An implementation would require (1) better definition of the extent of the surge beds, and (2) the installation of boreholes for grouting. Grouting is retained for further evaluation.

(e) Barium Stabilization by Sulfate Addition

The in situ stabilization of barium in sediments entails mixing in calcium sulfate to enable the formation of insoluble barium sulfate (McGraw 2003, 80700). While this would be feasible ex situ, the in situ application would be difficult to implement given the requirements of sediment amendment and of mixing for several (in Cañon de Valle), potentially at depths of up to 5 ft. Such a disruption to the canyon is not likely to be feasible, given wetlands and NEPA concerns. While ex situ treatments requiring excavation pose similar disruptions, the general effectiveness of ex situ over in situ favors ex situ technologies. For these reasons, this technology is not retained for further evaluation.

(f) Flushing of Alluvial Sediments

Soil flushing is a process, which is naturally ongoing in canyon alluvial sediments, by which precipitation and stormwater serve to flush contaminants. According to the SCM, the canyon sediments, both saturated and unsaturated, contain HE and barium residues that are mobilized by water. These HE and barium residues may take several forms, including sorbed, dissolved, and, in the case of barium, precipitated. Remediation by soil flushing removes and captures the flushed contaminants. Natural flushing is slow, particularly under drought conditions. Induced flushing adds water to accelerate the process.

Either natural stormwater or induced flushing must be coupled with another technology that captures or treats the resulting contaminated water. Otherwise, the resulting groundwater may infiltrate into underlying tuff and potentially migrate to the regional aquifer. At TA-16, where protecting the underlying regional aquifer is a focus, the control of flushed water is a concern, particularly because the water creates a higher static head, which may increase vertical infiltration. Two technologies for containing the resulting contaminated water are (1) groundwater recovery and treatment, and (2) a system which treats groundwater as it flows through the PRB.

In the initial technology screening conducted by the HE Advisory Group as part of the CMS plan (LANL 1998, 62413.3), the potential for failing to contain soil-flushing water was cited as a negative factor. Subsequent Phase III RFI geophysics conducted in Cañon de Valle, however, identified canyon regions that are likely to be areas of enhanced infiltration (LANL 2003, 77965). These potential infiltration areas could allow proper placement of groundwater recovery or PRB systems so that flushing water would be treated prior to infiltration. These groundwater recovery or treatment systems may consist of recovery wells, interceptor trenches, or PRBs. On the basis of the preceding discussion, soil flushing is retained for further evaluation.

5.3.3.3 Ex Situ Treatment of Groundwater

Ex situ treatment of groundwater involves recovering groundwater with wells or recovery trenches, treating the water in a central above-ground treatment plant, and then discharging the treated water back into the alluvium. The methods for groundwater recovery, including wells and interceptor trenches, are further evaluated in section 6.

(a) GAC Treatment for RDX

Treating RDX with GAC has been done successfully on field-scale HE-remediation projects (Card and Autenrieth 1998, 76873; Federal Remediation Technologies Roundtable 2002, 79570; Pantex Plant 2003, 79784). GAC's high capacity to adsorb RDX and the simplicity of the technology make it attractive for use in RDX groundwater treatment plants. GAC treatment may also be useful for an in situ application such as a PRB or stormwater filter. On this basis of prior treatment success, the technology is retained for further evaluation.

(b) Ion Exchange Treatment for Barium

Ion exchange treatment of dissolved barium has been used with success on several field-scale projects (American Water Works Association 1990, 80125). In a treatment plant setting, ion exchange treatment typically consists of packed beds of sorbent, either ion exchange resin or clay beds such as zeolites. As part of the Martin Spring stormwater filter study, ion exchange was used for barium, but premature breakthrough, which may have resulted from mechanical difficulties with the stormwater filter was a problem (IT Corporation 2001, 80122).

The preferential adsorption of barium onto ion exchange resin can cause difficulties and expense with the regeneration of the resin. This may favor natural zeolites or conditioned clays that are less expensive and can be landfilled. On the basis of this discussion, ion exchange for barium is retained for further evaluation.

5.3.3.4 In Situ Treatment of Groundwater

(a) PRBs

Within the last 10 yr, PRBs have been developed for the treatment of dissolved groundwater contaminants, particularly recalcitrant contaminants such as chlorinated volatile organics which do not readily biodegrade. When compared to ex situ groundwater recovery and treatment, PRBs offer several advantages, primarily the potential for low operating costs due to low maintenance of an in situ system. A conceptual drawing of a PRB is shown in Figure 5.3-2.

PRBs commonly contain ZVI, the oxidation of which helps to create reducing conditions needed for the degradation of contaminants. To treat barium, a PRB using calcium sulfate to form immobile barium sulfate has also been reported (Wilkens et al. 2001, 79572) (EPA 2003, 79568). While GAC PRBs have not been found in the literature, in principle, GAC PRBs should also be effective given the effectiveness of ex situ GAC groundwater treatment for RDX.

In the laboratory, ZVI has shown promise as an in situ treatment of explosives residues, such as RDX, in groundwater. A ZVI PRB in Cañon de Valle would likely consist of a ZVI-containing PRB in which ZVI was deployed as an active medium. In the form of a bed of iron filings and inert media, such as pea gravel, a ZVI PRB degrades RDX while groundwater flows through the PRB. The technology can be deployed alone, or in combination with other technologies such as soil flushing. Although the exact mechanism is unknown, the reducing environment of the zero valent metal is thought to promote the reductive degradation of RDX. Recently, an anaerobic bioremediation component was shown to be an important part of the process (EPA 2000, 79567). Based on the ability of PRBs to successfully treat other

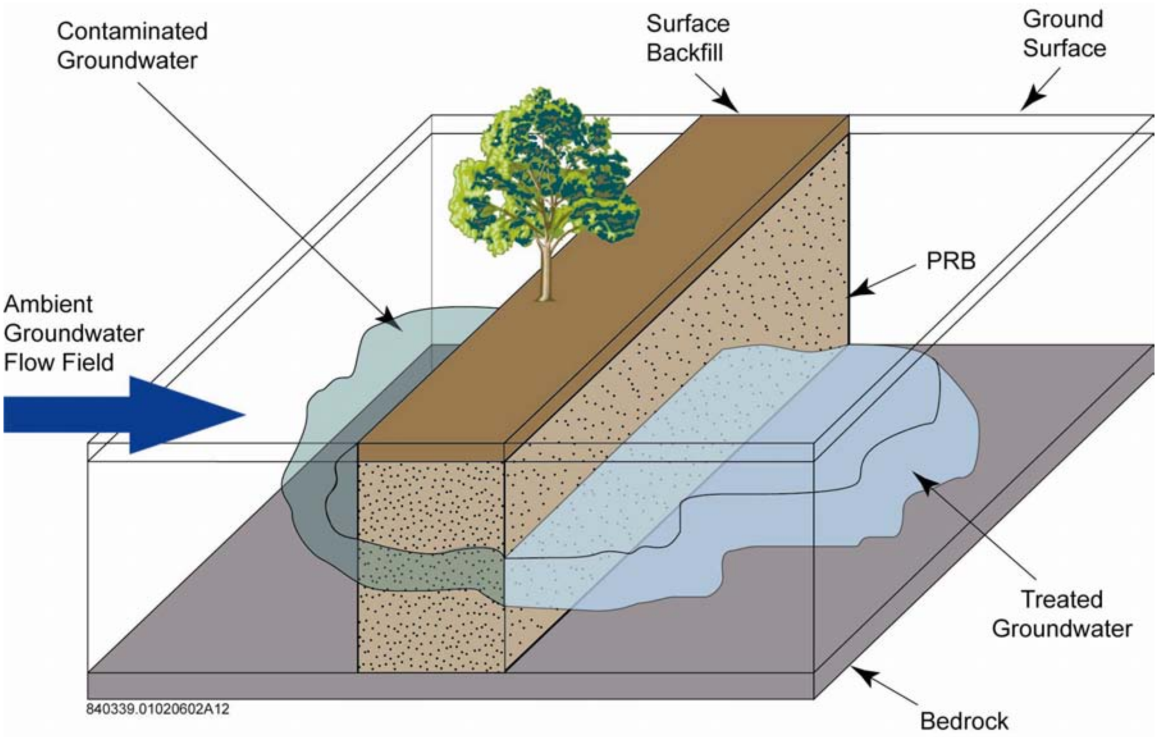


Figure 5.3-2. Conceptual drawing of a PRB

contaminants, and their potential to successfully treat RDX and barium, the technology is retained for further evaluation.

(b) Stormwater Filters

As part of a field feasibility study, stormwater filters were installed in Martin Spring Canyon (IT Corporation 2001, 80122). These filters used GAC to treat RDX and ion exchange resin to treat barium (see section 5.3.2). The filters proved to be effective for RDX, though barium showed breakthrough, which may have been due to mechanical difficulties. The filters are an attractive option because of their relatively low cost (approximately $60,000) and suitability for use at the springs. Stormwater filters could potentially be combined with other technologies such as PRBs. Despite the difficulties experienced with barium in the field study, the technology is retained for further evaluation.

(c) Slurry Walls

Slurry wall technology is used to either divert groundwater from contaminated soils or prevent contamination of clean soils. In addition, slurry walls can also be used to direct groundwater through a PRB. In Cañon de Valle, use of a slurry wall is difficult to envision, given that the canyon vadose zone sediments are already contaminated with barium and RDX. A slurry wall may have some utility during canyon excavation to divert groundwater around the excavation, but given the shallow depth of the alluvium, a recovery trench is more suitable. In addition, given the narrow configuration (approximately 10-20 ft wide) of Cañon de Valle alluvium, use of a slurry wall to deflect groundwater through a PRB would not be required. For these reasons, slurry wall technology is not retained for further evaluation.

(d) Phytoremediation

Phytoremediation did not effectively remediate such HE as TNT and RDX (IT Corporation 2002, 79576) as part of a wetland system at Burning Ground Spring (see section 5.3.2). Some evidence of RDX degradation was detected, but it was attributed to an anaerobic microbial pathway. Implementation would require alternate aerobic/anaerobic zones, which would entail alternately flooded and dry zones. Zones of flooding have the potential to increase vertical infiltration of contaminated groundwater. The slow rate of degradation, coupled with practical problems, precludes this technology from further evaluation.

(e) Monitored Natural Attenuation (MNA)

Natural attenuation is defined as dilution, dispersion, volatilization, adsorption, biodegradation, and abiotic reactions that reduce contaminant concentrations in site groundwater or soil over time. MNA is a site remediation alternative in which the progress of natural attenuation is monitored by periodic testing. Its use has been prompted by the observation that sites such as petroleum hydrocarbon contamination sites often clean themselves up over a period of a few years, principally by natural biodegradation. By contrast with petroleum hydrocarbons, however, natural attenuation of HE compounds is not well documented. It is generally thought to be slow because of the recalcitrance of HE organic compounds such as RDX and HMX to biodegradation, except under unusually anaerobic conditions. One exception is TNT, which is generally more receptive to natural biodegradation.

As an inorganic contaminant, barium is not biodegradable. Barium, however, an opportunity for MNA because of its propensity to adsorb onto clay and other minerals through an ion exchange or adsorption process. Furthermore, once sorbed, the barium may stay “locked down,” making it unavailable for further migration. This may explain why RDX has been observed at relatively high concentrations in groundwater from regional aquifer well R-25 with respect to RDX concentrations in Cañon de Valle alluvial groundwater, whereas barium has been detected at relatively low concentrations (less than 100 µg/L), despite its presence at higher relative concentrations in alluvial groundwater and sediment over a long reach of Cañon de Valle. At present, however, the process is not well understood, nor has it been characterized for site-specific conditions.

For the above reasons, MNA is not retained for further evaluation for the purposes this CMS, however, it may be a viable option for the regional groundwater corrective measure (contaminant migration pathways to potential receptors are longer for regional groundwater).

6.0 DEVELOPMENT AND EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

6.1 Assembly of Remediation Technologies into Corrective Measure Alternatives

The identification and screening of remediation technologies identified potentially applicable technologies, both standard and innovative, that are capable of attainment of MCSs and remedial objectives for the site. In this section, those technologies are assembled into corrective measure alternatives and associated conceptual designs and subjected to evaluation. This evaluation yields the preferred alternative that is proposed for a specific area of the site. Depending on the site conditions, corrective measure alternatives may consist of one or more technologies. Moreover, the alternatives are not mutually exclusive; a combination of one or more alternatives may be preferred.

The focus of the remedial alternatives is barium and HE. Although manganese is listed as a CMS COPC for Cañon de Valle and Martin Spring groundwater, it is not known at present whether the presence of manganese is due to natural reducing conditions present in these canyons or is the result of reducing conditions caused by the presence of HE. In the latter case, the remediation of HE will alleviate these reducing conditions, and manganese groundwater concentrations will decrease.

Based on remedial objectives developed in section 4, the following areas of the site are the focus of this CMS:

- Outfall source area residual soils and tuff,
- Outfall source area settling pond and 17-ft surge bed,
- Cañon de Valle springs, surface water, alluvial sediment, and alluvial groundwater,
- Martin Spring Canyon spring, surface water, alluvial sediment, and alluvial groundwater.

Table 6.1-1 presents the candidate corrective measure alternatives for these areas. For the outfall source area, excluding the settling pond, the sole alternative is soil removal and off-site disposal. Tuff is not addressed by this alternative, only soil. The mean tuff barium and TNT concentrations do not exceed the MCSs (as estimated in section 4.0) outside of the settling pond. For RDX, the mean tuff concentration is slightly above (45 mg/kg) the MCS for RDX (36.9 mg/kg); however, tuff does not pose the same degree of potential hazard as soil with regard to dust generation during potential construction.

Alternatives for the outfall source area settling pond 17-ft surge bed (referred to as the surge bed hereafter) are:

- excavation and off-site disposal of the surge bed and cap installation (replacement of the existing cap) on the settling pond;
- in-situ grouting of the surge bed and maintenance of the existing settling pond cap; and,
- maintenance of the existing settling pond cap but no action for the surge bed.

For Cañon de Valle and Martin Spring Canyon springs and alluvial systems, three alternatives consisting of several technologies are described. These are:

- alluvial sediment excavation for HE and barium and off-site disposal, with stormwater filters for springs;
- natural flushing of sediments for HE and barium removal coupled with PRB (ZVI or GAC and calcium sulfate) alluvial groundwater treatment (for HE and barium) and stormwater filter treatment for springs; and,
- natural and induced flushing of sediment (for HE and barium) and recovery of spring and groundwater and treatment in a central treatment system, followed by injection discharge of treated water (induced flushing) to alluvial sediment.

6.2 Process for Evaluation of Corrective Measure Alternatives

Corrective measure alternatives are compared and contrasted using criteria established in the CMS Plan (LANL 1998, 62413.3), including:

- performance and reliability,

Table 6.1-1
Proposed Corrective Measure Alternatives

Site Area	Alternative Number	Description
Outfall source area (excluding settling pond)	I.1	Soil removal and off-site treatment and disposal
Outfall source area settling pond and 17-ft surge bed	II.1	Excavation and offsite disposal of the 17-ft surge bed and replacement/maintenance of the existing cap
	II.2	In situ grouting of the 17-ft surge bed and maintenance of the existing cap
	II.3	Maintenance of existing cap and no action for the surge beds
Canyon springs and alluvial system	III.1	Sediment excavation and offsite disposal, with storm water filters for springs
	III.2	Natural flushing of sediments coupled with PRB[a] (ZVI[b] or GAC[c] and calcium sulfate) alluvial groundwater treatment and storm water filter treatment for springs
	III.3	Natural/induced flushing of sediments and recovery of spring and groundwater (by interceptor trenches) and treatment in a central treatment system

[a] PRB = permeable reactive barrier.
[b] ZVI = zero valent.
[c] GAC = granulated activated carbon.

- reduction of toxicity, mobility, or volumes of contaminants or wastes,
- effectiveness in achieving MCSs,
- time required for implementation,
- ease of installation,
- long-term reliability,
- institutional constraints,
- mitigation of human health and environmental exposures,
- other considerations, such as safety and waste minimization; and
- cost.

These criteria are compliant with Task VIII of Module VIII of the Hazardous Waste Facility Permit for Los Alamos National Laboratory (NM0890010515) (EPA 1994, 44146) and RCRA CA guidance (55 FR 30798; 61 FR 19432), though ordered differently. Sections 6.2.1 through 6.2.11 further explain these criteria.

6.2.1 Performance and Reliability

These criteria are used to assess both the effectiveness of considered remedial approaches in controlling the source of release and the impacts associated with the potential remedy. The effectiveness of remedial approaches at similar sites and under analogous conditions is considered.

6.2.2 Reduction of Toxicity, Mobility, or Volumes of Contaminants or Wastes

This criterion is used to evaluate whether the proposed alternatives are effective at reducing the contamination at the site and determines if the remedy successfully eliminates or reduces the toxicity, reduces the ability of the contaminant(s) to move, or substantially decreases the volume.

6.2.3 Effectiveness of Remedy in Achieving Target Concentrations

This criterion is used to assess each alternative with regard to its ability to achieve the target MCSs.

6.2.4 Time Required for Implementation

This criterion is used to assess the time required to implement each potential alternative and the time anticipated to see the results. The setup and implementation of an alternative includes the design, mobilization, demobilization, construction, permitting, establishment of a monitoring system, and waste acceptance for off-site disposal. For hazardous waste treatment, permits are required prior to construction.

6.2.5 Ease of Installation

The ease of installation criterion is used to consider the degree of difficulty that implementing the alternatives will entail. Examples of site conditions that may affect implementation include depth to water table, heterogeneity of surface and subsurface materials, terrain, and site location. Other conditions include the need for special permits or agreements, equipment availability, and the location of suitable off-site treatment or disposal facilities.

6.2.6 Long-Term Reliability

Evaluation of long-term reliability is used to assess the alternatives with respect to length of time that an alternative can be maintained in an effective condition.

6.2.7 Institutional Constraints

This criterion is used to consider the alternative’s regulatory requirements, including federal, state, local, and public health regulations, or permitting requirements that may substantially affect the implementation of the alternatives.

The laws and regulations that may apply to the SWMU 16-021(c)-99 CMS under the proposed EPA Subpart S and Module VIII of the Laboratory’s Hazard Waste Facility Permit (EPA 1994, 44146); the medium (e.g., surface water or soil) to which each relevant regulation applies; and the wetlands permitting process and threatened and endangered species protection under NEPA are discussed hereafter. Wetlands issues pose a major institutional requirement that may preclude certain corrective measure alternatives.

Generator and Transporter Requirements Any action resulting in the generation of hazardous and solid wastes under the CMS will comply with the regulations under 20 NMAC 4.1.100 which adopts 40 CFR Part 260 et seq. for hazardous waste management. These requirements will also apply to the hazardous and solid wastes generated during the treatment of soils and water.

Land Disposal Restrictions The restrictions on the land disposal of hazardous wastes address mitigation of the hazards that are posed by waste constituents. All SWMU 16-021(c)-99 activities that generate hazardous waste as part of the RCRA corrective action will comply with the LDR requirements of 20 NMAC 4.1.400 which adopts 40 CFR Part 268. If a media is treated in situ and a waste is not generated, the LDRs do not apply, as stated in the Federal Register Volume 63, pages 28556-28634, published May 26, 1998. However, any ex-situ CMS treatment (soil or water) that generates a waste is required to comply with LDR requirements.

Public Participation and Community Relations RCRA § 7004 encourages public participation in the development, revision, implementation, and enforcement of any regulation, guideline, information, or program activities. The Public Participation and Community Relations regulation is currently implemented in the RRES-RS project through community interactions with stakeholders such as Citizen’s Advisory Board, the Northern New Mexico pueblos, the County of Los Alamos, and officials of the community. Public participation activities specific to SWMU 16-021(c)-99 are included in Appendix D as part of the PIP.

The National Environmental Policy Act Section 102(2)(c) of the National Environmental Policy Act (NEPA) requires that all federal agencies prepare an environmental assessment (EA) for all major federal actions that have the potential of affecting the quality of the human environment. The DOE has established procedures for compliance with NEPA. These procedures are defined in 10 CFR 1021 and 40 CFR 1500–1508. Before implementing a CMS alternative, all NEPA procedures will be completed. The environmental safety and health (ESH) questionnaire will be completed and reviewed by the Laboratory’s NEPA team. A significant NEPA issue for this CMS is the presence of the threatened Mexican Spotted Owl. Other NEPA issues relevant to the site are covered under the wetlands section which follows hereafter. Because of the importance of NEPA issues at this site, the permitting process is described in detail.

Wetlands Permitting Process Figure 6.2-1 illustrates of the wetlands permitting process. This process which is applicable to projects in most states is more specialized for projects in Northern New Mexico, where projects are subject to the Albuquerque District Regulatory Office of the United States Army Corps of Engineers (USACE). The USACE is charged with enforcing Section 404 of the Clean Water Act (CWA) subject to the review and authority of the EPA Office of Wetland Protection.

Wetlands Identification

The permitting process begins with a determination of the applicability to the subject project of the requirements of Section 404 of the CWA. Applicability is established based on two primary components: (1) the proposed project must contain jurisdictional waters, and (2) these waters are expected to be affected by dredge and fill activities during project construction or operation. With respect to the Section 404 permit, jurisdictional waters include navigable waters of the US, interstate waters (lakes, rivers, and streams), interstate wetlands, all impoundments of these waters, and tributaries to these waters. For federally funded projects, determination of the presence of jurisdictional waters typically

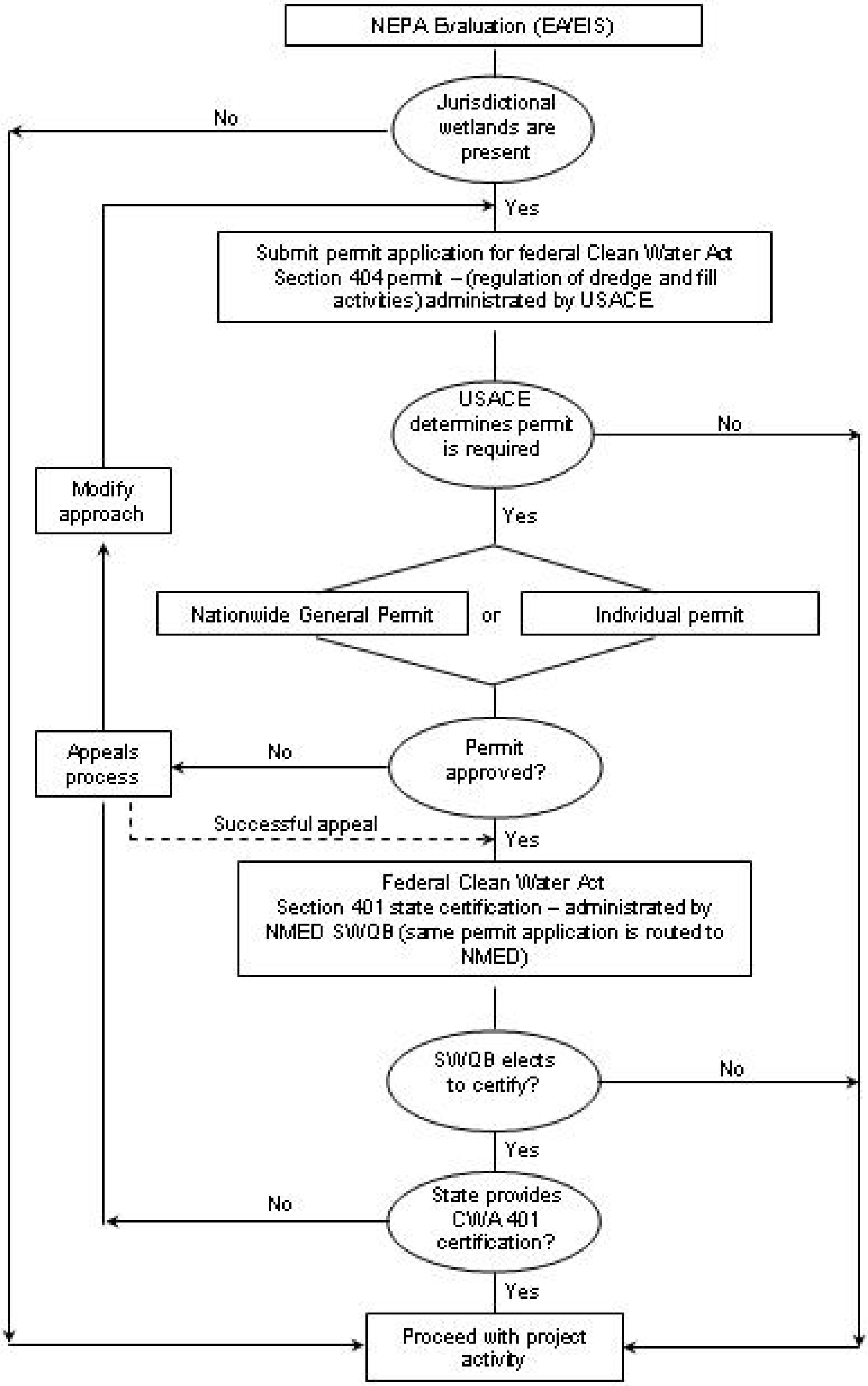


Figure 6.2-1. Flowchart of wetlands permitting process

occurs during the NEPA review phase of the project; either through an EA or an environmental impact statement (EIS). Wetlands are determined to be present according to the findings of a review of vegetation, soil, and hydrologic indicators.

404 Applicability Determination and Submittal of Section 404 Permit to USACE

After establishing that jurisdictional waters are present, the applicability of Section 404 is evaluated with regard to types of activities expected to occur during construction and long-term operation of the project. In general, the USACE has determined that activities that involve placement of fill material, ditching, levee construction, road construction, or land-clearing in an area that could affect jurisdictional waters require permitting under Section 404 of the CWA. If there is any question about the applicability of the Section 404 permit, or the type of permit for which to apply, arrangements can be made through the USACE Albuquerque district secretary for consultation. Officially, the determination of applicability is made by the USACE district office after formal review of the Section 404 Permit application for the project.

In New Mexico, application is submitted for the Section 404 permit by use of a joint application for a permit through the Department of Army and the Surface Water Quality Bureau (SWQB). In general, the joint permit application requires the following:

- information about the applicant;
- name of project and affected water bodies;
- nature, purpose, and duration of the project activity;
- reason(s) for discharge of dredged or fill material into wetlands or water body;
- maps illustrating limits of wetlands or water bodies to be dredged or upland areas to receive dredge discharges; and
- description of water quality impacts and mitigation measures.

USACE Determines if Permit Required

Based on the criteria presented, the Albuquerque District of the USACE determines if a Section 404 permit is required for the project. For projects that require Section 404 permitting, there are two general permitting options. A particular project may be permitted as an individual or under a pre-existing nationwide permit (NWP). The USACE has developed 39 NWPs that address types of typical construction projects and activities whose wetland impacts are considered minimal. The specific NWP for the cleanup of hazardous and toxic wastes in NWP 39, which provides exemption for activities contained entirely on sites under the regulations of the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA). In general, issues related to the NWPs are discussed through consultation with the USACE before the application is made, and the applying party understands whether or not an NWP can be obtained and what the permit requirements entail.

USACE Permit Approval

After the applicability of Section 404 applicability is established and the application is made for the permit, the USACE makes a determination as to whether the project can be permitted under either an individual permit or NWP. The review process takes 45 days for NWPs and from 60 to 120 days for individual permits. If an individual permit is sought, a public review and response period is required, and the USACE conducts or updates the NEPA EA or EIS for the project. The process of conducting additional NEPA evaluation opens the project to scrutiny of all areas covered by NEPA, including, but not limited to, threatened and endangered species, natural and cultural resources, historical properties, and public involvement.

In general, permits are not issued if

- there is a practicable alternative which would have less impact;
- the discharge would violate any applicable federal legal standards;
- it would result in significant degradation of waters of the US and
- unless appropriate and practicable steps have been taken to minimize potential adverse effects.
- Permit denials of individual or NWP permit components can be appealed subject to the provisions of 33 CFR Part 331. The appeals process can take up to a maximum of 180 days.
- *CWA Section 401 State Certification*

Under Section 401 of the CWA, the State of New Mexico has the option to certify any Section 402 or 404 CWA permits or licenses. If the certification option is exercised, the state can deny, approve, or approve conditionally the subject permit. In New Mexico, the SWQB of the NMED is charged with this responsibility. Typically, SWQB approval requires that the project be in accordance with applicable state laws and regulations, such as the New Mexico Surface Water Quality Standards.

In general, the NMED elects to certify Section 404 NWPs if affected streams are perennial or intermittent. Certification is typically waived for small ephemeral streams. All Section 404 individual permits undergo state certification. The state has up to 60 days to conduct or waive Section 401 certification. If for any reason a Section 404 permit cannot be certified under Section 401, the applicant has to make appropriate modifications (e.g., mitigation measures, engineering controls, best management practices), and resubmit the permit application through the process.

The Clean Water Act The CWA requirements apply to the CMS at SWMU 16-021(c)-99 if additional discharges, impacts to stormwater, or release of treatment agents will result from implementing the CMS. Under the proposed corrective measure alternatives, only groundwater treatment uses chemicals that may be subject to provisions of the CWA.

The Clean Air Act The Clean Air Act is not applicable for the CMS because there are no anticipated air releases. Typically, dust is mitigated for health and safety reasons during excavation activities.

The Toxic Substances Control Act The Toxic Substances Control Act(TSCA) is not applicable to the CMS at SWMU 16-021(c)-99 because no significant TSCA constituents are present.

NMED Groundwater Discharge Permit

A groundwater discharge permit is required for any discharge of treated groundwater to the subsurface. An application and permitting process involves development of a sampling and analysis plan to ensure that the discharge meets discharge standards.

6.2.8 Mitigation of Human Health and Environmental Exposures

Each alternative was evaluated with respect to its capability to mitigate short- and long-term potential risks to human receptors both during and after implementation. There were no associated environmental risks to ecological receptors (LANL 2003, 77965).

6.2.9 Cost

The relative costs of each alternative were compared. The cost estimate for each alternative included costs for each phase of implementation, including design construction and operations and maintenance (O&M). In accordance with RCRA guidance (55 FR 30798; 61 FR 19432), a 30-yr lifetime is assumed. Costs are reported in terms of capital and installation costs and 30-yr O&M costs, which are presented in terms of net present value (NPV), assuming a discount rate of 5%, net of inflation. Wherever possible, costs are based on prior projects at the Laboratory. The costs estimates are accurate to approximately plus or minus 15%.

Costs were divided into design, permitting, installation, and operations and maintenance activities. Costs for all proposed alternatives are presented in Appendix C.

6.2.10 Other Considerations

Additional criteria important in the evaluation of the alternatives include:

- public acceptance of feasible technologies;
- the safety of nearby environments as well as workers during implementation; and
- energy efficiency, pollution prevention and waste minimization, and resource conservation.

6.3 Outfall Source Area

One alternative is proposed for this area: soil removal and off-site treatment and disposal. The volume of residual soil to be removed is expected to be less than 100 yd^3.

6.3.1 Soil Removal and Off-Site Disposal (Alternative I.1)

Under this alternative, outfall source area soils with levels of contamination that exceed the MCSs are removed by excavation and disposed of off site in a permitted landfill. The focus of the remediation will be on barium, TNT and RDX, because these comprise the majority of the potential non-cancer and cancer risk in the outfall source area. This alternative excludes contaminated tuff underneath the existing cap system within the settling pond. The previously completed IM removed the majority of highly contaminated soil. Currently, a maximum of 100 yd^3 of soil with contamination levels above the MCSs remain in isolated pockets in the area.

Because of the presence of hazardous concentrations of HE, the IM used expensive remote excavation methods. Based on analytical results, the remaining soils do not pose an explosive hazard and can be removed by skid loaders and hand digging. On-site field analytical techniques, such as immunoassay methods, are proposed to be employed to ensure that all soil with contamination levels that exceed the soil MCSs are removed and that soils meet the LDRs. If acceptable for disposal, soils will be loaded into roll-off bins for transport to a licensed disposal facility. If hazardous soils are encountered, they will be disposed of off site and treated by a licensed hazardous waste treatment facility. Treatment by the facility will consist of bioremediation for HE, which was shown to be a successful form of treatment for both MDA P and outfall source area soils excavated during the IM. Soils that are hazardous for barium would be treated by stabilization.

6.3.2 Evaluation of Alternatives

6.3.2.1 Performance and Reliability

Because soil removal and off-site disposal offer the potential of removing all residual soil with contaminant levels above the MCSs, it thereby precludes exposure to contaminants at levels above the MCSs. The performance and reliability for this alternative are high.

6.3.2.2 Reduction of Toxicity, Mobility, or Volumes of Contaminants or Wastes

Soil removal and off-site disposal of soils with contaminant levels above the MCSs reduce the toxicity of the remaining soil. A requirement for off site disposal in a hazardous waste landfill is that the LDRs are met, which by definition limits contaminant mobility. This alternative does not increase or reduce the volume of excavated soil. Based on available soil analytical data, hazardous wastes are not expected.

6.3.2.3 Effectiveness of Remedy in Achieving Target Concentrations

Soil removal and off-site disposal are effective at achieving the MCSs for contaminant concentrations within the outfall source area. Under this alternative contaminated soil is physically removed from the site and is no longer accessible.

6.3.2.4 Time Required for Implementation

For soil removal, the time required to meet the MCSs at the site is simply the time required to complete the field excavation. Excavation activities, including mobilization, excavation, waste manifesting, post-removal confirmation sampling, and demobilization for soils with contaminant levels above the MCSs for barium, RDX and TNT will likely require from two to four weeks to complete.

6.3.2.5 Ease of Installation

Excavation of the outfall and related areas was conducted as part of the IM (LANL 2002, 73706). The greatest challenge for soil removal is the identification, through the detection of contaminant levels above the MCSs, of soils to be excavated. Ideally, field analytical methods for the identification of RDX, TNT and barium will be used to minimize the analysis time required to identify the vertical and horizontal limits of excavation.

6.3.2.6 Long-Term Reliability

Soil removal and off-site disposal of the remaining outfall soil are reliable because soils are removed from the site. Provided the soil meets the required LDRs, there would be no residual liability as a result of off-site disposal.

6.3.2.7 Institutional Constraints

Soil excavation was conducted as part of the IM. Local institutional constraints attendant upon the removal of a maximum of 100 yd^3 of soils are expected to be minimal, with the exception that institutional activities at TA-16 may impose limits on the operational hours. To qualify for off-site disposal, excavated soils must meet the LDRs, but given the success of the IM and the relatively lower concentrations of COPCs detected for residual soil, meeting these requirements should not be a problem.

6.3.2.8 Mitigation of Human Health and Environmental Exposures

Excavation and off-site disposal of soil with contaminant levels above the MCSs offer the best way to attain MCSs in the outfall source area. Both potential human health and environmental risks will be obviated by this action.

6.3.2.9 Costs

The total costs for this alternative (see Appendix C) are estimated to be $162,000.

6.3.2.10 Other Considerations

The public has already accepted the use of soil removal both at the outfall source area as part of the IM and at MDA P. Therefore, public acceptance of soil removal at the outfall source area is expected. NEPA concerns should not be a factor given that the outfall source area is not located on the canyon floor where wetlands are located. Due to the small expected volume of soil (100 yd^3 or less), waste minimization is not a factor. Likewise, safety is not expected to be a major concern.

6.4 Outfall Source Area Settling Pond and Surge Bed

6.4.1 Excavation and Disposal of the Surge Bed (Alternative II.1)

In this alternative, blasting is used to break up the tuff overlying the surge bed, after which the tuff and surge bed are excavated. Before excavation, three additional borings are installed to better define the extent of the surge bed. After excavation, the settling pond cap is replaced, and long-term monitoring and maintenance, including sampling of a new groundwater monitoring well, are implemented.

During the IM, excavation of the tuff was attempted using a 60,000-lb. track-mounted excavator, and the rate of excavation progress was slow. Drilling and blasting of the intact tuff overlying the surge bed to break up the intact rock would allow excavation to proceed at a faster pace. Pneumatic drills would be used to install the borings for the blasting charges. After blasting and excavation to the surge bed horizon, the surge bed would be excavated and hauled off site for disposal. These wastes will likely be hazardous, and treatment at the accepting facility by bioremediation would be required. Off-site bioremediation of hazardous wastes was successfully used on hazardous HE waste from the outfall source area IM. Tuff would be returned to the excavation. In this way off site hauling of waste would be minimized.

The cap system, consisting of two barriers, was installed in the settling pond area as part of the IM. Under all alternatives for this area, this cap system will be either left in place or replaced. The purpose of the system is to provide hydrologic barriers to water infiltration so that migration of residual HE and barium under the caps is minimized.

The first barrier was installed at the final depth of the settling pond excavation (in tuff at the bottom of the excavation test pit), which ranged from 3 to 4 ft. below ground surface (bgs). The surface of the test pit was covered with several inches of hydrated 3/8 bentonite. The pit was then filled with processed castoff aggregate and compacted with the wheeled loader. The rock layer was subsequently covered with an 8-in. layer of crushed tuff amended with 2.5% (by weight) dry bentonite and 1.5% hydrated bentonite. This layer was also compacted with a wheeled loader.

The second barrier was installed at the depth of the soil/tuff interface. The barrier consisted of multiple compacted 4-in. lifts of crushed tuff amended with 2.5% (by weight) dry bentonite (approximately twenty 50-lb bags of 3/8 bentonite per lift). Each lift was manually mixed with rakes to ensure blending of the bentonite and crushed tuff. Following blending, the lifts were compacted with the wheeled loader. Four lifts were installed in this manner. The fourth layer was amended with 1.5% bentonite and was hydrated following placement. A finish cap of compacted crushed tuff was placed over the hydrated layer, bringing the average total thickness of the barrier to 20 in. In total, this barrier consisted of 40 yd^3 of crushed tuff amended with ninety-eight 50-lb bags of 3/8 bentonite. The saturated permeability of the barriers is estimated to be less than 1×10^{-7} cm/s.

6.4.2 In-Situ Grouting of the Surge Bed with Existing Settling Pond Cap Maintenance (Alternative II.2)

In this alternative, the extent of the surge bed is first defined using three additional borings and sampling. The surge bed is then isolated with a clay-based grout applied by pressure grouting through boreholes that intercept the surge bed. A monitoring well on the downgradient edge of the surge bed is proposed so that the effectiveness of the grouting can be determined. Under this alternative, the existing settling pond cap is maintained following repair, if necessary, of borehole areas.

6.4.3 No Action for the Surge Bed and Maintenance of Existing Cap (Alternative II.3)

Under this alternative, the existing cap would be inspected and maintained to ensure that surface water cannot infiltrate lower horizons, including the 17-ft surge bed. The weakness of this alternative is its inability to control the potential for subsurface fracture to allow lateral groundwater flow to the surge bed. This preferential pathway is discussed in section 6.4.4.

6.4.4 Evaluation of Alternatives

6.4.4.1 Performance and Reliability

If the surge bed is defined and excavated to its full extent, then excavation of the surge bed would be a removal action that would reduce the potential for contaminant migration. However, the complete extent of the surge-bed is not known, and excavation to its full extent may not be practical.

Grouting the surge bed offers a means of isolating the surge bed from groundwater and thereby reducing the potential migration of contaminants. Grouting is expected to be reliable because the grout is essentially impermeable to water. Grouting is more practical with regard to the extent of the surge bed. Unlike excavation, which may prove impractical if the surge bed is too extensive, grouting can be feasibly expanded outside the practical and economic limits of excavation.

Alone, maintenance of the existing cap system, with no action for the surge bed, would preclude surface water infiltration but not groundwater contact with the surge bed via a lateral, upgradient fracture pathway. If groundwater contact does not occur through this pathway, then the existing cap itself and its occlusion of surface water will suffice for the long term. However, additional site characterization is required to determine if the lateral subsurface pathway is important.

In the face of these considerations and uncertainties, grouting offers a superiority of performance and reliability over excavation. Both excavation and grouting are preferable to maintenance of the existing cap alone.

6.4.4.2 Reduction of Toxicity, Mobility, or Volumes of Contaminants or Wastes

Excavation of the surge bed would serve to remove barium and HE in the surge bed, thereby reducing their potential mobility. Although excavation does not eliminate the potential for fracture groundwater flow, the contamination in the surge bed would be removed. Grouting both isolates the surge bed and reduces contaminant mobility. Grouting potentially offers superior isolation than excavation because excavation of the entire surge bed may not be practical, whereas the feasibility grouting is less sensitive to the extent. The capping alternative might preclude stormwater contact, but it would not preclude groundwater contact that might occur with the surge bed through lateral fractures.

Under the excavation alternative, contaminated surge bed materials would be hauled off site for disposal in an approved landfill. This alternative does not destroy or reduce the toxicity of the contaminants; rather, it would transfer the contaminants to a permitted landfill. Contaminant mobility would be reduced because disposal in the landfill would eliminate direct contaminant contact with groundwater. Moreover, the waste would be required to meet LDRs that preclude contaminant migration.

Given these considerations, the grouting alternative is rated more favorably than excavation. Both excavation and grouting alternatives are rated more favorably than cap maintenance alone.

6.4.4.3 Effectiveness of Remedy in Achieving Target Concentrations

An MCS was not established for the surge bed. Rather, a BMP objective that seeks to preclude potential for contaminant migration from the surge bed was established. As discussed above, the alternatives differ in their ability to prevent potential groundwater contamination, which is integral to the attainment of the BMP objective.

Groundwater flow via upgradient, lateral fractures has the potential for intercepting the surge bed and transporting contaminants. The goal of the excavation of the surge bed is to remove as much highly contaminated material as is possible from the surge bed. Grouting isolates the contaminated material and prevents contact with groundwater. Accordingly, excavation and grouting alternatives are rated higher than the capping alternative.

6.4.4.4 Time Required for Implementation

Definition of the extent of the surge bed using three borings is a part of both the excavation and grouting alternatives. Up to six months or more may be required to complete such an investigation. Following the investigation, the actual implementation will require another six months for planning and execution.

The capping alternative is already in place at the site. The capping alternative is therefore rated higher than the other alternatives with respect to this criterion.

6.4.4.5 Ease of Installation

Implementation of the excavation alternative, including blasting, would not be difficult. First, the backfill and cap system placed during the IM would be removed. Drilling and blasting of the overlying tuff would then proceed, followed by excavation of the surge bed. Site restoration would consist of backfilling of the tuff rubble, followed by the installation of a replacement low permeability cap system. Given the proximity to existing operations within Building 260, blasting may pose institutional difficulties, as discussed in section 6.4.4.7.

Following installation of the three borings for further surge bed definition, grouting of the surge bed would be conducted in new or existing boreholes. If the existing cap is penetrated, it would be repaired.

Obviously, ease of installation is greatest for the existing cap system, followed by grouting, then excavation.

6.4.4.6 Long-Term Reliability

As discussed, both excavation and grouting are more reliable than a cap alone, because HE and barium in the surge bed are either no longer physically present or are isolated. Grouting has the advantage of allowing the surge bed to be over-grouted (grouted beyond its apparent extent), whereas over-excavation of the surge bed, if extensive, may prove difficult. For these reasons, grouting is rated higher for long-term reliability than excavation. Both alternatives are superior to maintenance of the cap alone.

6.4.4.7 Institutional Constraints

Excavation of the surge bed, including the use of blasting, may encounter institutional constraints in the form of Building 260 restrictions. These constraints may range from limitations on operational hours to a prohibition on blasting, in which case the excavation alternative is not feasible. The former constraint would be applicable to grouting operations as well. It is less critical for cap maintenance. NEPA concerns should not be a factor for any of these alternatives. Based on these considerations, the capping alternative would face fewer institutional constraints with regard to implementation.

6.4.4.8 Mitigation of Human Health and Environmental Exposures

The presence of the cap in all alternatives precludes contact with contaminated tuff within the settling pond area, thereby mitigating potential risks to a construction worker, although the MCSs are not met.

With regard to the surge bed, a concern is the potential to cause groundwater contamination. Both grouting and excavation isolate or remove (respectively) HE and barium contamination in the surge bed. As stated earlier, cap maintenance by itself does not address lateral groundwater flow in fractures that may intercept the surge bed, causing the potential for contaminant migration. Accordingly, both grouting and excavation are rated as superior to cap maintenance alone.

6.4.4.9 Costs

Capital and 30-yr O&M costs for these alternatives are shown in Table 6.4-1.

6.4.4.10 Other Considerations

Either excavation or grouting alternatives for the surge bed would likely be preferred by the public over a no action alternative. In general, the public favors removal of contamination rather than contaminant isolation. Alternative II.1 involves blasting and excavation in rock (tuff). Safety concerns are greater with this alternative than with the grouting alternative (II.2). The cap maintenance alternative has the fewest safety concerns, and also generates the least quantity of waste.

6.4.5 Uncertainties and Additional Data Requirements

The extent of the surge bed and the extent of the contamination require further definition. These will be addressed by the boring installations completed as part of the alternative implementation. The importance of mesa vadose-zone fracture groundwater flow into the surge bed area is also not known. Uncertainty in this flow influences the consideration of alternatives. If such flow is not present, then the existing cap

Table 6.4-1
Outfall Source Area Settling Pond 17-ft Surge Bed Alternative Costs

Site Area	Alternative Number	Description	Capital Costs	30 Year O&M Costs (NPV)	Total Cost (NPV)
Outfall source area settling pond 17-foot surge bed	II.1	Excavation and offsite disposal of the 17-ft surge bed and replacement/maintenance of the existing cap	$ 293,000	$ 105,000	$ 398,000
	II.2	In situ grouting of the surge beds and maintenance of the existing cap	$ 211,000	$ 105,000	$ 316,000
	II.3	Maintenance of existing cap and no action for the surge beds	N/A	$ 105,000	$ 105,000

N/A = not applicable

protects against infiltration from the surface, which is the only other source of groundwater, and further measures may not be required.

6.5 Canyon Springs and Alluvial System

The canyon springs and alluvial system encompass springs, surface water, alluvial sediment and alluvial groundwater in both Cañon de Valle and Martin Spring Canyon. For HE and barium, three corrective measure alternatives consisting of several technologies are proposed for these areas. These alternatives differ markedly in the aggressiveness of the approach, the time frame for effectiveness, and the impacts to the canyons.

Excavation of sediments (Alternative III.1) is an aggressive approach whose goal is to remove HE and barium contaminated sediments within either limited sections of the canyons or throughout the entire contaminated length. The advantage of excavation is that such a removal action could obviate the need for groundwater or surface water remediation. As discussed in earlier sections, however, unidentified contaminated seeps or springs may contribute contaminated water to the alluvium. Moreover, other historical sources within the drainage basin may result in the recontamination of the Cañon de Valle sediments. Given the presence of these historical sources, long-term control of groundwater and surface water in the canyon might be required even if excavation were implemented.

The disadvantage of excavation is that it would disrupt the riparian system, including wetlands, although presumably site restoration could restore wetlands damage. To permit excavation, it is likely that an EIS, as opposed to a simpler and less onerous EA, would be required. The other alternatives preserve the current state of the canyon and rely on containment and treatment of springs and groundwater, with sediment remediation by natural or induced sediment flushing, rather than removal. Inherently, these containment/treatment alternatives remove contaminated mass much more slowly than excavation.

In the sections that follow, the alternatives for the springs and the canyon alluvial system are described in greater detail and are compared using the evaluation criteria.

6.5.1 Excavation and Off-site Disposal (Alternative III.1)

In this alternative, canyon sediment, surface and alluvial soils would be excavated to the extent practical. Excavated soil and sediment would be disposed of off site. The canyons would then be restored as closely as possible to their natural condition. Either a limited or extensive excavation could be conducted. For HE and barium, however, the most recent site data (reviewed in section 3) do not support a limited excavation. Although HE and barium sediment contamination appear concentrated in the upper reach of Cañon de Valle before the floods associated with the Cerro Grande fire occurred, post-flood sampling results do not indicate such concentrations (see Figures 3.6-1 and 3.6-2). The sediment contaminant trends indicated by these sampling results, however, apply only to the upper 2 ft bgs, where all RFI sediment sampling was conducted. Deeper sampling may reveal other trends.

In the absence of sediment contaminant concentrations that would indicate a more limited excavation, Cañon de Valle alluvium would be excavated to a distance of approximately 6600 ft east from the former outfall. Assuming a cross-sectional area of 100 ft^2 gives a sediment volume of 25,000 yd^3. This volume calculation is likely to be a conservative one and is assumed to include the Martin Spring Canyon sediments and any post-excavation soil volume increase (soil swell).

Excavation would cause substantial disruption of the Cañon de Valle riparian system. A permit from the US Army Corps of Engineers would be likely to be required under the wetlands permitting process described in section 6.2. This permit may entail an EIS, rather than an EA. In addition to a factor of 10 increase in expense, an EIS would also require up an additional 2 yrs for completion. NEPA issues, such as disruption of the Mexican Spotted Owl habitat, also require consideration. These permitting issues, although potentially difficult, could be mitigated by the intended objective (remediation) and a commitment to restore wetlands destroyed by the excavation.

Upstream of the excavation, alluvial groundwater flow would be diverted around the excavation using an interceptor trench and one or more bypass pipes. Surface water and springs would be similarly diverted around the excavation. Following installation of bypass pipes, time would be required to drain as much water as possible from the soils.

Two haul roads into the Cañon de Valle would have to be constructed. Alternatively, a conveyor system could be used. Excavation would be conducted during the dry season to minimize the volume of wet soils. A staging area would be required for the stockpiling and sampling of soils. Soils with any degree of saturation would require drainage and air-drying to minimize hauling expenses for off-site disposal.

The limits of the excavation would be defined by the available sediment sampling data and by additional sediment sampling data collected along the upper reach of Cañon de Valle and Martin Spring Canyon. Currently, the data is available for sediments to approximately 2 ft bgs in depth. This limited data set indicates that barium-hazardous sediments are present, and would be shipped off-site for stabilization. For purposes of the cost estimate for this alternative, half of the soil volume is assumed to contain hazardous levels of barium. For the MDA P project, barium-hazardous soil was hauled to Texas for stabilization at a cost of approximately $250 per ton. For both the 260 IM and MDA P, nonhazardous soil was transported for disposal at an industrial landfill in Albuquerque at a cost of approximately $50 per ton.

Restoration of the site would require post-excavation sampling, importation of clean fill similar in hydraulic conductivity to the native sediments, and restoration of wetlands and vegetation. Restoration of surface water flow might present difficulties because of the unique configuration of soil and sediment types that give rise to surface water. Should these difficulties arise, installation of buried tanks at existing springs and seeps to form wildlife watering ponds could be an alternative.

Under this alternative (as well as Alternative III.2), one stormwater filter would be installed on each spring for treatment. The filter would use GAC to treat HE. A typical stormwater filter consists of a steel or pre-cast concrete tank with an inlet and outlet for the surface water and treatment modules for contaminant removal. Water flows in and out of the tank by gravity, and is treated by the treatment modules inside of the tank (see Figure 5.2.3)   Two stormwater filters have already been installed in Martin Spring Canyon (see section 5.2).

Monitoring requirements for this alternative would consist of the installation and sampling of seven new alluvial wells after excavation. Five wells would be installed in Cañon de Valle (to replace the five lost to excavation) and three wells would be installed in Martin Spring Canyon (to replace the three wells lost to excavation).

6.5.2 Flushing of Sediments, PRB Groundwater Treatment, and Stormwater Filters for Springs (Alternative III.2)

Rather than excavate contaminated sediment, both Alternatives III.2 and III.3 rely on the flushing of contaminated sediment by groundwater and stormwater to remove contaminants. In the case of the PRB option, the flushing is natural and occurs as a result of precipitation events only. In the case of the groundwater recovery and central treatment option, the flushing is both natural and induced, the latter consisting of reinjection of treated spring water and groundwater.

Both of these alternatives recognize that within the Cañon de Valle drainage lie several historical sources in addition to SWMU 16-021(c)-99. Given these other sources, excavation of the Cañon de Valle sediment alone might not suffice to control potential infiltration of contaminated groundwater, and additional means of long-term groundwater control and treatment within Cañon de Valle would be necessary. Conversely, control and treatment of contaminated groundwater without excavation would be sufficient to reduce or eliminate groundwater infiltration in Cañon de Valle, and would not destroy canyon wetlands or be subject to NEPA regulations associated with excavation.

As characterized in the SCM, stormwater is a major factor in contaminant transport through the canyon alluvium. Stormwater causes the mobilization of sediment contaminants by leaching of surficial sediments and by increasing the groundwater elevation in the alluvium, both leading to subsequent downgradient transport. Stormwater also causes transport of contaminated sediments. If stormwater in the form of either surface or groundwater, can be controlled and remediated prior to infiltration to deeper underlying units, then precipitation events and ensuing stormwater can achieve alluvial sediment remediation by flushing out the water soluble contaminants. The disadvantage of natural flushing is that precipitation is less frequent under the current drought conditions.

In this alternative, the treatment technology for the remediation of groundwater is a PRB composed of either ZVI or GAC for HE such as RDX and calcium sulfate for barium stabilization. The choice between ZVI or GAC will be made as part of the CMI process and the additional testing that will be conducted as part of the CMI. To control the flushed water and prevent infiltration into the deep vadose zone, several PRBs are proposed. The PRBs would be designed to treat baseline groundwater flow and storm surges, from both hydraulic and contaminant loading standpoints.

PRBs have been developed within the last 10 years for the treatment of dissolved groundwater contaminants, particularly contaminants such as chlorinated VOCs and compounds such as HE that do not readily biodegrade. Commonly, PRBs contain zero valence metal, the oxidation of which helps to create the reducing conditions necessary for the degradation of these compounds. The exact mechanism of ZVI contaminant destruction is unknown; however, recent evidence indicates that a bioremediation component may play a stronger role. Although the proof of the concept is limited to laboratory studies, the technology is promising enough to warrant consideration, along with GAC, as a component of the PRB corrective measure alternative.

A conceptual drawing of a PRB is shown in Figure 5.3-2. PRB installation involves cutting a deep trench perpendicular to groundwater flow and then filling the trench with the active components, such as iron filings (in the case of a ZVI), and inert sand. The permeability of a PRB is designed to be higher than the native aquifer material so that groundwater will flow freely through the barrier. The installation depth of a PRB is critical to ensuring that underflow bypassing of the PRB is avoided. The thickness of the PRB also is critical because thickness relates to the residence-time required for contaminant degradation.

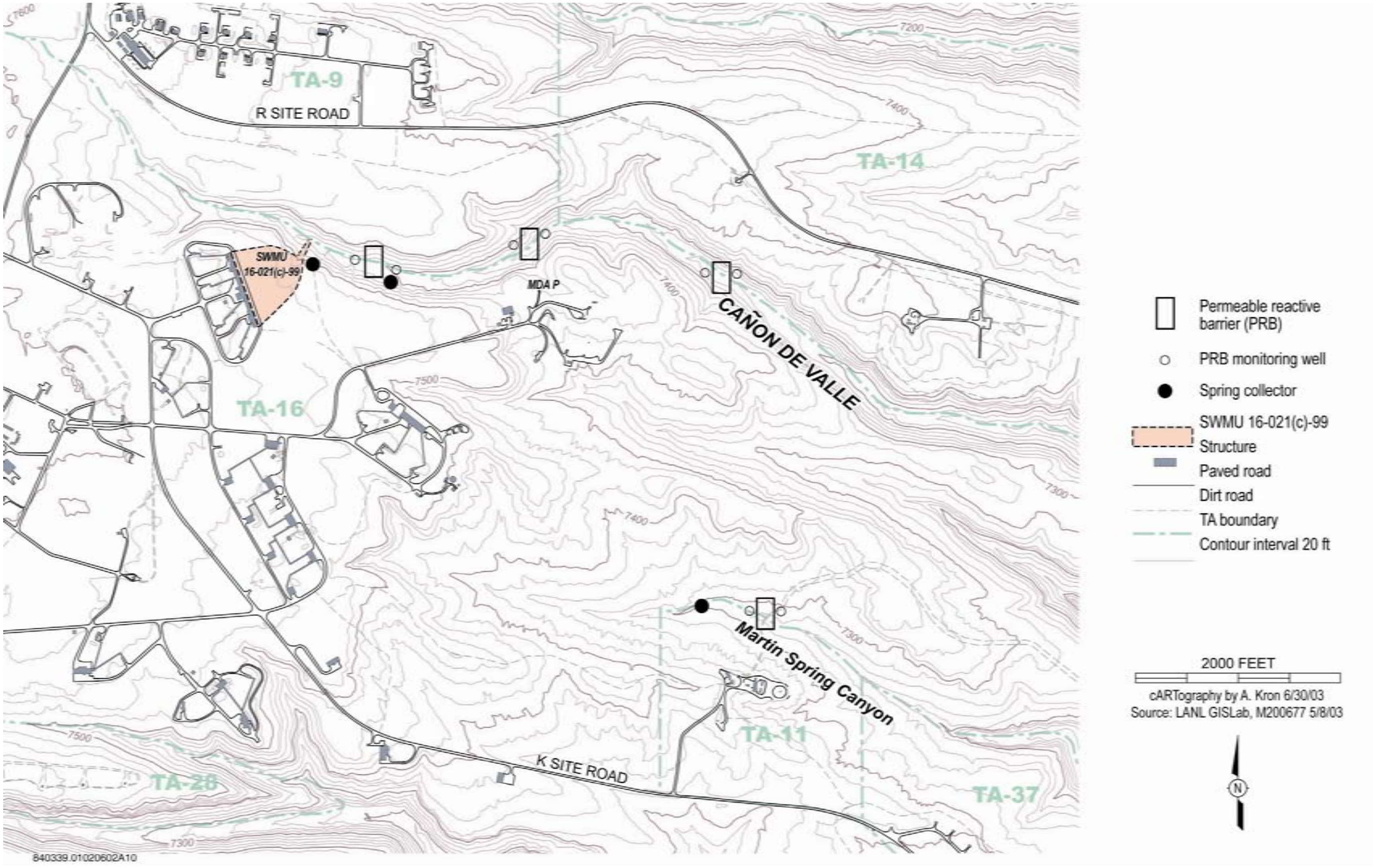
A ZVI PRB composed of iron filings that are exposed to groundwater will eventually rust away, requiring the replacement of the ZVI. The lifetime of the ZVI is dependent on the flow velocity through the PRB, the PRB thickness, and the geochemistry of the groundwater. In general, it is difficult to predict the lifetime of the ZVI bed. Similarly, GAC will eventually require replacement because HE, as well as naturally occurring humic organic compounds, will deplete the bed. Further testing of both GAC and ZVI will be conducted as part of the CMI. For the purposes of this CMS, ZVI or GAC bed replacement at the end of 15 years is assumed.

To treat barium contaminated groundwater, a bed of calcium sulfate can be added to the PRB, so that the barium precipitates as barium sulfate and is immobilized. Fouling of the calcium sulfate bed and a reduction in permeability and effectiveness is an operational concern, and bed replacement may be required.

PRBs are generally expensive to install, but inexpensive to operate. There are no pumps or electricity required. Groundwater flows through the PRB at rates determined by aquifer hydraulic gradients and permeability. Overall remediation rates can be slow if the groundwater flow rate and pore volume changeout rates are low. Typically, PRBs are more often employed as barriers to prevent further groundwater contaminant migration than as methods for remediating an existing groundwater plume. In Cañon de Valle, the alluvium pinches out approximately 7000 ft from the outfall. In this sense, the Cañon de Valle alluvial plume of contaminants is already self-limiting, and a PRB barrier at the end would be effective only for storm surges that advance the saturated edge. Once these storm surges are past, the saturated edge of the Cañon de Valle alluvium will retreat again.

Because the Cañon de Valle alluvium pinches out, the Cañon de Valle alluvium is essentially a fixed alluvial volume with a limited extent. Within this extent, the amount of water in storage depends on the rate of inflow and outflow (see section 3). If the leakage is constant throughout the reach, then PRBs would probably not be cost effective. If the infiltration is preferential in certain reaches of Cañon de Valle, then the strategic placement of a PRB in these areas may reduce the number of PRBs (or interceptor trenches under Alternative III.3). In fact, evidence presented in the Phase III RFI (LANL 2003, 77965) supports the presence of reaches of preferential infiltration along Cañon de Valle.

A conceptual layout of this alternative is shown in Figure 6.5-1. The system for Cañon de Valle consists of three PRBs placed in front of suspected area of enhanced groundwater infiltration and near the point of alluvium termination (the extent of alluvium is shown in Figure 3.2-1). Except for the eastern-most PRB, surface water is not treated by the PRB. A major component of surface water, spring water, is treated by stormwater filters placed on the springs. For the eastern-most PRB, an infiltration gallery would be constructed on the upgradient side of the PRB to enable the infiltration of stormwater and surface water surges into groundwater, where the waters are treated by the PRB. Without such an infiltration gallery, storm surges of contaminated surface water might bypass the PRB treatment configuration.



cARTography by A. Kron 6/30/03
Source: LANL GISLab, M200677 5/8/03

Figure 6.5-1. Conceptual layout of Alternative III.2 PRBs along Cañon de Valle and Martin Spring Canyon

For Martin Spring Canyon, one PRB is placed downgradient from Martin Spring. The spring collectors (stormwater filters) are shown in Figure 6.5-1. Each spring collector system will consist of a stormwater filters for organic HE, such as RDX. Given the presence of the stormwater filters on Martin Spring, the purpose of the PRB in this location is to treat stormwater surges of groundwater and surface water not emanating from the spring.

Monitoring of the effectiveness of the PRB involves the installation of two monitoring wells per PRB, one upgradient and one downgradient. A total of eight new monitoring wells accompany this alternative.

6.5.3 Flushing of Sediments with Water Treatment in a Central Treatment Plant (Alternative III.3)

The third alternative (Alternative III.3) consists of a series of groundwater interceptor trenches installed in Cañon de Valle and Martin Spring Canyon for the recovery of groundwater. As in the second alternative (Alternative III.2), stormwater surges of surface water would be controlled by the final interceptor trench through use of an adjacent upgradient infiltration gallery. Otherwise, surface water is not treated. For springs, which comprise the primary source of surface water, spring collector catch basins would be installed at the spring outlet. All water would be piped and treated in a central treatment plant and returned through upstream injection wells to alluvial groundwater. Although recovery wells, rather than interceptor trenches are an option, low transmissivity, which is associated with a thin saturated groundwater alluvium and potentially low or variable hydraulic conductivity, implies that interceptor trenches would be more effective.

This alternative also relies on natural precipitation events for flushing of surficial sediments, but in contrast to the second alternative (Alternative III.2), natural flushing is supplemented by induced flushing consisting of the upstream reinjection of treated water into alluvial groundwater. In this manner, flushing of the groundwater horizon is enhanced. Stormwater surges, with their higher volumes for both groundwater and surface water, present an opportunity to expedite flushing because the increased volume can be recycled between interceptor trenches and injection wells. The danger of recycling a higher volume of water is that the likelihood of infiltration may be increased; however, the contaminant concentrations of the groundwater water will have been reduced by treatment. As in the first alternative, drought conditions adversely affect the rate of sediment remediation.

A conceptual layout of the system is shown in Figure 6.5-2. A series of five groundwater interceptor trenches and five injection wells are located along the Cañon de Valle. At the last (eastern-most) interceptor trench, an infiltration gallery captures storm surges of surface water, causing infiltration to groundwater and capture in the interceptor trench. Spring waters are intercepted using a spring collector catch basin at spring outlets. All intercepted water is pumped to a central treatment plant located adjacent to MDA P, where it is treated by GAC and ion exchange (either resin or zeolite), followed by discharge to a series of injection wells. Injection wells will consist of 12- or 24- in. wells that will be installed using a backhoe or bucket rig. Injection flow rates to the injection wells can be balanced to allow for a natural flux of groundwater and surface water through the entire system, or injected water can be focused on a specific interceptor trench/injection well pair in an attempt to concentrate the flushing action along a particular reach.

As part of this alternative, two alluvial groundwater monitoring wells would be installed for each interceptor trench, one upgradient and one downgradient. These well would be used to determine the effectiveness of the interceptor trench with regard to hydraulic control of groundwater. The monitoring plan for this alternative consists of the sampling of these twelve new wells (ten in Cañon de Valle and two

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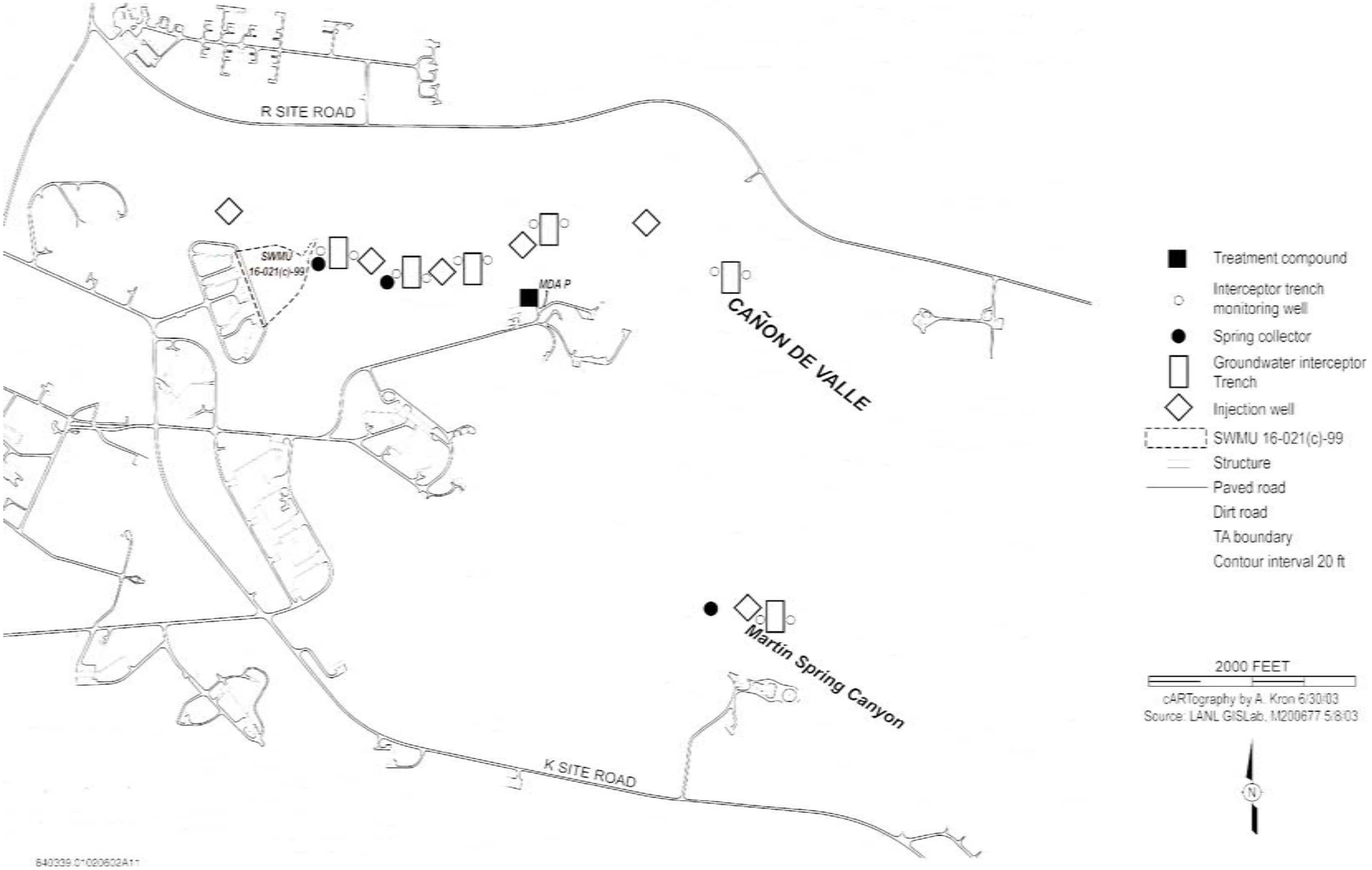

Figure 6.5-2. Conceptual layout of Alternative III.3, groundwater interceptor trenches and injection wells

in Martin Spring Canyon). Monthly sampling will also be required for the treated groundwater discharged to the injection wells.

In a typical GAC treatment system, spent GAC is replaced with fresh GAC by a GAC vendor, who then removes the spent GAC from the site and regenerates it by thermal treatment, which destroys RDX. For barium, the spent ion exchange resin or natural zeolite bed is disposed of by landfilling, rather than regenerated on-site. Because of the strong affinity of barium for ion exchange, regeneration will not be cost effective.

Permit requirements include groundwater discharge permit and NEPA and wetlands assessments. Intrusive activities include interceptor trench installation, injection well installation, utility trench installation to the interceptor trenches and injection wells (for power and piping), and installation of spring collector catchbasins.

The treatment system would consist of two 5000-lb pound carbon adsorbers (for organic HE), followed by two 5000-lb ion exchange or zeolite adsorbers for barium. The treatment compound would consist of a building (approximately 30 ft by 30 ft) to house the treatment system. Before installation of the treatment system, a lift station with a surge tank would be constructed at the bottom of the outfall. This surge tank would be equipped with a level control to maintain a constant level in the surge tank and a pump for pumping of water to the treatment system. After treatment, the water would be discharged to a series of five injection wells along the length of Cañon de Valle and one well in Martin Spring Canyon. Power would be distributed to the interceptor trenches by direct burial-underground power cables. Piping for treated and untreated groundwater would consist of 2-in. HDPE piping laid in a shallow trench below the frost line (approximately 2 ft below grade)

A concern with this approach is that the baseline groundwater flow into Cañon de Valle is uncertain, having been estimated only through the conceptual water balance performed as part of the Phase III RFI (LANL 2003, 77965). In addition, Martin Spring, the primary source of alluvial groundwater in Martin Spring Canyon, is now dry. For Cañon de Valle, the estimated flow rate is approximately 30,000 gal./yr. However, storm surges were not accurately captured by the water balance, which relied on average measurements of saturated thickness. In addition, the springs water component of flow was much higher, which would provide additional water for the system. Under the assumptions of the water balance, all baseline water flows contribute approximately 10 gal. per minute (gpm) of water. Because of recycle, the baseline flow rate of the treatment system would be higher, as high as 20 gpm. Storm surges may increase this flow rate to a range of 100 to 200 gpm for short periods. As part of the design of such an alternative, in situ permeability measurements and a test interceptor trench are recommended to ascertain permeabilities, the flow rate of treated water, and the capacities of interceptor trenches and injection wells. As discussed earlier, current drought conditions may reduce these assumed flow rates.

6.5.4 Evaluation of Alternatives

6.5.4.1 Performance and Reliability

Performance and reliability are assessed relative to the achievement of MCSs for alluvial groundwater and sediment. Excavation of canyon alluvial sediments (Alternative III.1) would remove a substantial mass of HE and barium contamination. Removal of the sediment (the upper 2 ft of which contain an estimated 21,000 kg of barium, 50 kg of HMX and 5 kg of RDX) would remove a contaminant mass similar to the estimated mass of 8,500 kg of HE removed from the outfall source area during the IM. Moreover, the estimates of the mass of HE and barium that would be removed using this alternative are potentially low, given that the sample depth was limited to 2 ft bgs.

An important difference between the outfall source area and alluvial sediment, however, is that while there may be more barium in alluvial sediments, there is also less HE in alluvial sediments. For the IM, excavation was effective (and cost-effective), because of the quantity of HE removed, the fact that the outfall soils acted as an HE source, and, in general, the greater threat posed by HE to regional groundwater quality. In contrast, the excavation of Cañon de Valle for the purpose of removing substantially less HE (a quantity that potentially poses a much smaller risk to the regional aquifer) may not be cost effective.

Removal of an estimated 21,000 kg of barium in Cañon de Valle sediments would seem critical to achieving the MCS for water. However, although barium mass appears high, a substantial fraction of the barium mass is likely adsorbed to sediment clays and minerals, thereby retarding both its dissolution and transport in groundwater. If this adsorption is irreversible, the barium is unavailable for contaminant transport. As pointed out in section 3, the dynamics of barium adsorption and its irreversibility are not currently known, but are deserving of study. The low barium groundwater concentrations in R-25, despite its overall significant mass and extent, indicates that this retardation may be occurring. In summary, the amount of barium that is available in sediment and that is capable of causing alluvial/groundwater contamination in excess of the barium MCS may be less than the amount indicated by the estimate of barium mass.

Other important factors in the evaluation of the criteria for performance and reliability are the presence of historical sources along the canyon drainages as well as the unknown seeps and springs which may be contributing contamination to the alluvium. As hydrologic low points, both Cañon de Valle and Martin Spring Canyon are susceptible to additional contaminant fluxes from unknown seeps, springs and stormwater run-off, all of which may be intermittent. Given this circumstance, removal of the sediments by excavation without groundwater treatment may not be as reliable an alternative as groundwater treatment without excavation (Alternatives III.2 or III.3); long-term groundwater treatment, using either a PRB or interceptor trenches, captures and treats canyon alluvial groundwater, regardless of its point of origin.

The estimated soil volume of 25,000 yd^3, representing an excavation distance of approximately 6600 ft, is not prohibitive. The soil volume removed by the IM from the outfall source area was approximately 1300 yd^3 (LANL 2002, 73706), and the soil volume removed from MDA P was approximately 50,000 yd^3 (LANL 2003, 76876).

Flushing of surface and alluvial soils, the primary sediment remediation mechanism for both Alternatives III.2 and III.3 would be much slower than excavation in attaining the MCSs. The exact amount of time required to attain the MCSs cannot be predicted. Moreover, long-term forecasts indicate a high probability of drought, which reduces the frequency of natural flushing, although drought would also reduce the potential for infiltration and potential contamination of regional groundwater, as discussed previously.

Because of soil and sediment heterogeneities, flushing might not be as effective in attaining the MCSs as excavation. In addition, a portion of the barium sediment inventory may not be removable by flushing because of the high ion exchange affinity of barium for the clay matrix of these soils. Regulatory and public acceptance that this barium is inaccessible for further transport may be required under Alternatives III.2 and III.3.

Comparing Alternatives III.2 and III.3, the performance and reliability of attaining the MCSs for waters relies on the ability of the groundwater and surface water treatment systems, either PRBs or the central treatment plant, to treat contaminated waters, both surface water and groundwater. Storm surges would lead to surges in groundwater, which either a PRB or a treatment system would be required to capture and remediate to below the MCSs. With a PRB, operational reliability depends in part upon breakthrough and ease of bed replacement. In a treatment plant, breakthrough of either a GAC or ion exchange system is handled by simply replenishing the treatment system with fresh GAC or ion exchange media. Moreover, the treatment system offers operational redundancy by using two GAC and ion exchange treatment vessels in series, so that if breakthrough occurs in the lead vessel, the lead vessel can be changed, thus ensuring that the discharge water meets the MCSs and the requirements of the groundwater discharge permit. In contrast, breakthrough of the PRB media, either of the ZVI, GAC, or calcium sulfate bed would require replacement of the respective bed within the PRB, a process which requires excavation.

Another advantage of central treatment over PRBs is its expandability. Although additional PRBs can be added to the canyons in response to further characterization, their relatively higher expense and difficulty of installation compared with interceptor trenches offer less performance flexibility.

Reliability arguments can also be applied to spring treatment by stormwater filter, which Alternatives III.1 and III.2 use, but Alternative III.3 does not. With a central water treatment plant (Alternative III.3), the performance of the treatment system can be easily monitored. Monitoring and replacement of stormwater filters, however, involve inspection and possibly entry into the stormwater filter via a manhole, which is a confined-space entry procedure.

In general, among the last two alternatives, a central, above-groundwater treatment system is more reliable than a PRB. Further, PRBs are an innovative technology without a long track record, whereas a central treatment plant for water treatment uses mature technologies. The attractiveness of PRBs lies in their potential for cost-savings over the project lifetime because of their potentially low O&M costs.

In terms of performance and reliability, interceptor trenches and a central treatment system (Alternative III.3) and PRBs (Alternative III.2) rank highest, primarily because they provide for the long-term treatment of groundwater within Cañon de Valle and Martin Spring Canyon. If historical sources and the potential for contaminated groundwater inflow from unseen springs and seeps within Cañon de Valle were not present, and the depth of contamination in sediment could be shown to be limited, excavation as a one-time action would be ranked highest.

6.5.4.2 Reduction of Toxicity, Mobility, or Volumes of Contaminants or Wastes

In general, preference is given to alternatives that destroy, rather than transfer, contaminants (including all byproducts) because destruction of contaminants destroys toxicity and liability. Use of ZVI in a PRB, for example reductively destroys RDX. Use of GAC in a PRB, by contrast, transfers RDX to the carbon, where it is immobilized and its volume is reduced. With regard to barium, use of calcium sulfate in a PRB immobilizes, but does not necessarily eradicate, barium, making it inaccessible for further environmental transport.

Excavation of the sediments moves the contaminants from one location to another, with the second location presumably posing less of an environmental and human health threat. Under the restriction of LDR disposal for sediments under the excavation alternative, land disposal of excavated sediments is assumed to be safe.

Within a central treatment system (Alternative III.3) using GAC and ion exchange, contaminants are transferred and their volume is reduced in the carbon adsorption process, but they are not destroyed. However, with off-site thermal regeneration of spent carbon, a common allowable process for GAC vendors, RDX is subsequently destroyed. Flushing of the contaminants by stormwater and groundwater surges would not in itself reduce the toxicity of the contaminants, but because the resulting groundwater water and surface water would be contained and treated, a reduction of mobility and contaminant volume would occur. In summary, the extent of reduction of toxicity and mobility depends on the completeness of groundwater and surface water treatment. Actual toxicity reductions are possible in the treatment system. For example, a ZVI PRB reductively degrades and destroys RDX and other HE such as TNT, whereas a GAC PRB adsorbs HE, but eventually the GAC will require replacement, with spent GAC either land-filled or thermally regenerated in a process that destroys HE. Similarly, a groundwater and surface water treatment system transfers RDX to GAC, after which the GAC is disposed of or regenerated by the GAC vendor.

For this criterion, treatment by PRB (Alternative III.2) is rated higher than either excavation (Alternative III.1) or interceptor trenches and central treatment (Alternative III.3) primarily because it potentially destroys RDX and other HE (in a ZVI PRB) and immobilizes barium through the formation of barium sulfate.

6.5.4.3 Effectiveness of Remedy in Achieving Target Concentrations

Related to performance and reliability, this criterion directly addresses the alternative’s capability to meet MCSs. As discussed previously, excavation of sediments with springs treatment by stormwater filters (Alternative III.1) might yield an immediate attainment of the MCSs in groundwater in Cañon de Valle. The presence of historical sources within the Cañon de Valle drainage, however, may cause recontamination of sediments. Because these other historical sources are located on the edge of the mesa, outside of the saturated alluvium, transport into Cañon de Valle would occur by stormwater. Given the prediction of a long-term drought in the area, this recontamination of Cañon de Valle sediments would be slow, but the potential remains. Furthermore, the presence of unknown springs and seeps may cause additional recontamination of sediments. For these reasons, both Alternatives III.2 and III.3 offer better long-term potential for attaining the MCSs than does excavation (Alternative III.1).

For the first two alternatives, stormwater filters are used for spring remediation. For the third alternative, spring water is recovered and treated. All three alternatives are capable of attaining the MCSs for spring water, although a central treatment plant is more effective, primarily because the treatment systems are above-ground and more frequently monitored as part of general plant operations.

6.5.4.4 Time Required for Implementation

This criterion involves not only the time required for implementation, but the time required for the alternative to reach full effectiveness.

The advantage of excavation (Alternative III.1) is that it is immediately effective as a source removal action; once implemented, however, the long-term reliability of excavation is questionable given the presence of other historical sources within the Cañon de Valle drainage. Moreover, the excavation alternative would require more time to implement because of extensive permitting requirements, possibly including an EIS.

Permitting lead-time for the other two alternatives (Alternatives III.2 and III.3) would be roughly equivalent, with the exception that a groundwater discharge permit would be required for the central treatment plant alternative. This alternative would also be more intrusive than the PRB alternative, because of its use of a greater number of interceptor trenches and injection wells. As for the time required for effectiveness, the central treatment alternative and its greater number of interceptor trenches, as well as its ability to recycle water (thereby increasing the flux of water through contaminated sediment horizons), offers superior effectiveness in a shorter time than the PRB alternative. However, the time required for installation of the central treatment alternative is potentially greater than for the PRB alternative because of more construction, both subsurface and aboveground.

6.5.4.5 Ease of Installation

This criterion is limited to the difficulty of the actual installation, or in the case of excavation, completion of the excavation, including site restoration. Permitting and other institutional concerns are covered under the institutional criterion.

All of the alternatives have been completed at other sites. While site-specific logistical difficulties may be present, excavation of the canyon sediments is straightforward. Bypassing of the groundwater and springs involves installation of bypass pipes. Preferably, the excavation would be conducted during the dry part of the year to avoid undue soil saturation. Moreover, excavation on this scale has been completed at MDA P, although the area for the excavation was not linear and was not obstructed by trees and other obstacles.

The PRB (Alternative III.2) and central treatment (Alternative III.3) with interceptor trenches would involve subsurface excavation (for PRB and interceptor trench installation) and well installation. In addition, the central treatment alternative would involve installation of subgrade utility lines, including power and piping to both the interceptor trenches and injection wells. A treatment system building and associated equipment would also have to be installed. In general, the central treatment alternative would be more difficult to install than the PRB alternative.

6.5.4.6 Long-Term Reliability

For groundwater contamination sites in general, source excavation of the contaminated soil or sediment offers better long-term reliability than alternatives that involve the control of the resulting groundwater. This principle was applied to the outfall source area IM excavation, where source removal was more expedient and reliable than any attempts to control the resulting contaminated groundwater or stormwater.

Within the Cañon de Valle drainage, however, the presence of multiple historical sources and the possibility of unknown spring or seep discharges of contaminated water to the canyon alluvial system make this generalization less valid. Although known springs are treated by stormwater filters, excavation alone, without long-term groundwater control and treatment, may be less reliable than long-term groundwater control and treatment without excavation.

Of the groundwater control and treatment alternatives, the recovery of canyon waters and treatment in a central plant (Alternative III.3) offers slightly better long-term reliability than a PRB system (Alternative III.2). First, PRBs have not been installed long enough to assess their long-term reliability. Potential problems include fouling of the PRB, with a resulting decrease in treatment effectiveness. Second, an aboveground, central treatment system allows near real-time monitoring of reliability. Moreover, a central treatment system can be easily modified to enhance the performance. With a PRB, this operational flexibility is not present.

6.5.4.7 Institutional Constraints

A number of institutional constraints are associated with the excavation alternative (Alternative III.1), particularly in Cañon de Valle, where NEPA and wetlands issues, the latter potentially including an EIS, predominate. As part of the NEPA-permitting public involvement process, stakeholders must weigh the relative merits of excavation versus the potential adverse impacts excavation would have on the riparian system of Cañon de Valle.

Institutional constraints associated with the other alternatives are fewer than for excavation. Potential NEPA and wetlands issues include installation of trenches for PRBs, groundwater recovery, installation of stormwater filters, and piping and electrical runs for a water treatment system. Rather than an EIS, an EA process is likely for either of these alternatives.

6.5.4.8 Mitigation of Human Health and Environmental Exposures

Based on the results of the Phase III RFI ecological risk assessment, site conditions do not pose a risk to the environment (LANL 2003, 77965).

For canyon springs and alluvial systems, the MCSs (both the proposed MCS for barium and future MCSs to be developed as part of the regional groundwater CMS) have as their goal the protection of regional groundwater as a drinking water resource. As discussed above, Alternatives III.2 and III.3 are superior with respect to Alternative III.1, excavation. Although excavation removes a substantial mass of barium, the estimated RDX inventory in the upper 2 ft of sediment is only 5 kg. Moreover, additional contaminant transport from historical sources or unknown seeps along the Cañon de Valle drainage may re-contaminate clean, back-filled sediment.

If groundwater control is not comprehensive under either Alternatives III.2 or III.3, however, contaminated groundwater may still infiltrate into the deep vadose zone and potentially affect the regional aquifer. In these alternatives, placement of the PRBs or interceptor trenches was optimized with respect to reaches of enhanced infiltration, as inferred from Phase III RFI geophysical results. However, these areas of suspected enhanced infiltration have not been confirmed by borings or wells in the field. Moreover, there may be other areas that have not been identified. If areas of enhanced infiltration are not present, and there is a fairly constant rate of infiltration along the entire reach of the alluvium, PRBs or interceptor trenches may be less protective than excavation.

The comparison of the alternatives for this criterion rests in an evaluation and weighing of the relative uncertainties. With excavation, there is the uncertainty regarding continuing alluvial groundwater contamination from other historical sources following excavation, which, under this alternative, would not be controlled. For either the PRBs or interceptor trench alternative, uncertainties are present with regard to the location and nature of infiltration. If infiltration is widespread and diffuse, neither PRBs nor interceptor trenches offer complete control.

6.5.4.9 Costs

Capital and installation and 30 year O&M costs for the alternatives are shown in Table 6.5-1.

6.5.4.10 Other Considerations

In general, the public prefers contaminant removal to in-situ treatments. Excavation is generally viewed as aggressive action that eliminates contamination from the area. Given the lack of public access to Cañon de Valle, the public appreciation of the aesthetic and ecological value of the canyon, which might otherwise preclude excavation is low, although an extended permitting process involving an EIS would doubtless increase public awareness. Given geological uncertainty and heterogeneity, in-situ treatments often require years to attain standards, and this length of time tends to decrease public acceptance. With regard to pollution prevention and waste minimization, excavation of sediments generates more waste, in the form of excavated sediment, than does natural or induced flushing, which separates contaminants from soil. For Alternatives III.2 and III.3, generated wastes are essentially equivalent, although a ZVI PRB degrades HE in-situ, as opposed to central treatment, which generates spent GAC, which then may be regenerated to destroy HE. With regard to safety, success implementing these alternatives at other sites

Table 6.5-1
Canyon Springs and Alluvial System Alternative Costs

Site Area	Alternative Number	Description	Capital Costs	30 Year O&M Costs (NPV)	Total Cost (NPV)
Canyon springs and alluvial system	III.1	Sediment excavation and offsite disposal, with storm water filters for springs	$ 8,899,000	$ 626,000	$ 9,525,000
	III.2	Natural flushing of sediments coupled with PRB (ZVI and calcium sulfate) alluvial groundwater treatment and storm water filter treatment for springs	$ 2,069,000	$ 1,597,000	$ 3,666,000
	III.3	Natural/induced flushing of sediments and recovery of spring and groundwater (by interceptor trenches) and treatment in a central treatment system	$ 1,115,000	$ 2,640,000	$ 3,755,000

indicates that all alternatives can be performed safely. The disadvantage of central treatment (Alternative III.3) with respect to safety, is that a dedicated staff is required for O&M over 30 yr, which raises the potential for safety problems.

6.6 Uncertainties and Additional Data Requirements

The vertical distribution of contaminants within the sediments and vadose zone has only been characterized to a depth of approximately 2 ft below grade. If contaminants are limited to this depth, a limited rather than a full excavation of canyon sediments could be considered.

The nature of barium adsorption on sediments is not currently known, particularly with regard to the potential irreversibility of the adsorption. If adsorption is irreversible, than total barium loadings in the sediment are not a true indication of the potential for groundwater transport of barium.

Further definition of the nature and areas of possible groundwater infiltration from the alluvial system to the deep vadose zone would improve the placement of PRBs or interceptor trenches.

7.0 DESCRIPTION AND JUSTIFICATION OF THE PREFERRED ALTERNATIVES

7.1 Outfall Source Area Soils

Soil removal with off-site disposal is proposed as the preferred alternative for the outfall source area soils outside the settling pond. Soil removal will achieve the risk-based MCSs for this area. Under this alternative, soils will be removed from this area through a combination of manual and machine excavation.

7.2 Outfall Source Area Settling Pond and Surge Bed

Alternative II.2, grouting of the surge beds and maintenance of the existing cap, is proposed as the preferred alternative for this area. Although grouting does not remove HE and barium, the clay-based grout isolates contamination from contact with groundwater. In combination with maintenance of the cap system in the settling pond, grouting attains isolation of the HE and barium. Grouting offers more flexibility than excavation. This flexibility will be useful if surge bed contamination is found to exceed the immediate area of the settling pond during the investigative phase of this alternative. Finally, grouting is generally safer than excavation in terms of implementation and is the most cost-effective alternative. To demonstrate that this BMP is effective, a monitoring well would be installed on the downgradient edge of the grout mass. This well would be checked for groundwater quarterly and sampled if groundwater was found. Quarterly monitoring would continue for a period of 3 yr. Thereafter, monitoring would be conducted twice per yr.

7.3 Canyon Alluvial Systems

Because of a lack of risk associated with the exposure pathways determined by the Phase III RFI risk assessment (LANL 2003, 77965), no risk-based MCSs for the alluvial systems in Cañon de Valle and Martin Spring canyon are identified at the present time. Calculation of risk-based MCSs for regional groundwater is deferred to the regional groundwater CMS. An MCS was identified for barium and manganese (section 4). As discussed in section 3.0, it is not known whether manganese present in alluvial groundwater is natural or related to the presence of HE.

For the canyon alluvial systems, including springs, surface water, groundwater, and sediment, Alternative III.2, PRBs with spring water collection by stormwater filter, is proposed as the preferred alternative. This alternative is best able to attain the MCSs and cost-effectively protect regional groundwater. PRBs would be placed strategically in areas of suspected infiltration along the Cañon de Valle to treat groundwater before it infiltrates the deep vadose zone.

Excavation of Cañon de Valle and Martin Spring Canyon is not justified by the contaminant sediment loadings and the presence of historical sources within the Cañon de Valle drainage. Substantial inventories of contaminants have been recorded for these historical sources. Although contaminants have not been identified within the saturated alluvium, their identification within the Cañon de Valle drainage indicates that stormwater could potentially carry them into Cañon de Valle, where, without groundwater treatment, infiltration to the deep vadose zone and regional groundwater could occur. Such flows could also recontaminate the clean backfilled sediment that would be placed as a part of an excavation alternative.

Excavation is not economically justified. Because the contaminant mass of RDX is estimated to be approximately 5 kg within Cañon de Valle sediment, excavation would not be cost-effective. Although the barium sediment inventory appears high, barium has not been detected in R-25, despite detections of elevated concentrations along the entire saturated alluvium of Cañon de Valle. Whether or not the substantial quantity of barium in the upper 2 ft of sediment is available for dissolution in groundwater is unclear at present. As discussed earlier, a portion of the COPCs inventoried may be bound in either insoluble sulfate or irreversible adsorption.

Excavation might also entail considerable NEPA permitting difficulties that might preclude implementation even if excavation were proposed. By contrast, construction and operation of the proposed preferred alternative, which minimally impacts sensitive wetlands and the Mexican Spotted Owl, should encounter less permitting complexity.

The groundwater recovery and treatment alternative, although at least as effective as the PRB alternative, incurs high O&M costs and requires a dedicated staff to maintain and operate. In addition, drought conditions may reduce the volume of water available for recovery and treatment.

The proposed alternative relies on natural flushing of alluvial sediments and treatment of the resulting groundwater. Under the drought conditions that are anticipated, this process will be slow, and the possibility exists that the alluvial groundwater will dry up. If the alluvial groundwater dries up, the potential for infiltration of contaminated groundwater from the canyon alluvium will be reduced. When the groundwater returns, the PRBs will function to treat groundwater.

The conceptual design of the proposed alternative consists of three PRBs installed in Cañon de Valle and one installed in Martin Spring Canyon. The design for the, eastern-most PRB in Cañon de Valle includes an infiltration gallery and small retention area on the upgradient side to allow stormwater surges to infiltrate groundwater and be treated by the PRB. In this manner, contaminated stormwater surges will not overrun the treatment system. The PRBs use ZVI or GAC for the treatment of HE, and calcium sulfate for the immobilization of barium. An identical infiltration gallery will be installed on the upgradient side of the Martin Spring Canyon PRB. Because of the stormwater filters on Martin Spring, the PRB in Martin Spring Canyon will serve primarily to treat stormwater surges of surface water and groundwater. Martin Spring is now dry. For the springs, the design installs stormwater filters for the treatment of HE and barium. This conceptual design will be finalized during the CMI phase.

Under the proposed alternative, the perennial reach of surface water in Cañon de Valle is not disturbed. Springs water, which is the principle component of surface water flow, is treated by stormwater filters. In addition, the perennial reach of surface water is encompassed by the system of PRBs, so that groundwater resulting from infiltrated surface water, at the end of the surface water reach, is treated. Surface water quality will improve under the proposed alternative.

Contaminant transport both to and within regional groundwater will be studied as part of the regional groundwater CMS. This study will incorporate the findings for the regional groundwater wells to be installed. The findings for these new wells may require changes to the proposed alternative.

7.4 Monitoring Plan

The monitoring plan for the proposed alternative would consist of new monitoring well installation and of sampling of new and existing wells and surface water. As part of the installation, a pair of monitoring wells will be installed upgradient and downgradient from each PRB. These wells will be used to assess PRB effectiveness. Proposed points of compliance are five existing alluvial groundwater monitoring wells in Cañon de Valle and two existing monitoring wells in Martin Spring Canyon. These wells would be sampled quarterly for the first 3 yr and twice per yr thereafter. As part of the monitoring plan, two surface water samples from Cañon de Valle and Well would also be sampled at the same frequency.

7.5 Schedule

Task VIII of Module VIII of the Hazardous Waste Facility Permit for Los Alamos National Laboratory (NM0890010515) (EPA 1994, 44146) specifies requirements for the completion of CMS activities, including a schedule. Table 7.5-1 presents a schedule of CMS and CMI activities.

Table 7.5-1
Schedule of CMS/CMI Activities[a]

Activity	Schedule
CMS Report	November 2003
Draft Statement of Basis (SOB) Issued by NMED	90 days after submittal of CMS Report
Public Comment Period (SOB)	60 days
Final SOB Issued by NMED	60 days after end of public comment period
Submit CMI Plan to NMED	120 days after NMED issues final SOB
NMED Approves CMI Plan	90 days after submittal of CMI plan to NMED
Submit CMI Engineering Design to NMED	90 days after NMED approves CMI Plan
NMED Approves CMI Engineering Designs	90 days after submittal of CMI Engineering Design
CMI Implementation–begin soil removal	60 days after NMED approves CMI Engineering design
CMI Implementation–begin water treatment systems	60 days after NMED approves CMI Engineering Design
CMI Implementation–soil removal complete	180 days after beginning CMI implementation
CMI Implementation–water treatment systems complete	1 year after beginning CMI implementation
Initial monitoring for CMI Performance	1 year after completion of CMI implementation
Submit CMI Report	90 days after completion of initial monitoring for CMI implementation
Monitoring for CMI Performance	Continuing until CMI cleanup criteria are met

[a] NMED Consent Order schedule will take precedence over the schedule outlined here.

8.0 REFERENCES

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Copies of the reference library are maintained at the NMED Hazardous Waste Bureau; the DOE Los Alamos Site Office; the US Environmental Protection Agency, Region 6; and RRES-RS. This library is a living collection of documents that was developed to ensure that the administrative authority has all material needed to review the decisions and actions proposed in this document. However, documents previously submitted to the administrative authority are not included.

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Appendix A

Acronyms and Glossary

A-1.0 LIST OF ACRONYMS AND ABBREVIATIONS

AOC	area of concern
A-DNT	amino-dinitrotoluene
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BH	borehole
BMP	best management practice
BV	background value
CA	corrective action
CAMU	corrective action management unit
CdV	Cañon de Valle
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMI	corrective measures implementation
CMS	corrective measures study
COPC	chemical of potential concern
CSAMT	controlled-source audio-frequency magneto-telluric
CWA	Clean Water Act
CWM	Chemical Waste Management
DNT	dinitrotoluene
DHS	Department of Health Services
DNX	hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
DoD	US Department of Defense
DOE	US Department of Energy
EA	environmental assessment
EIS	environmental impact statement
EPA	US Environmental Protection Agency
ER	environmental restoration
ES&H	environmental safety and health
ESH	Environment, Safety, & Health (a former Laboratory Division)
FOC	fraction organic compound
GAC	granular activated charcoal
HE	high explosive(s)
HI	hazard index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane (cyclotetramethylenetetranitramine)
HSWA	Hazardous and Solid Waste Amendments of 1984
ITRD	Innovative Treatment Remediation Demonstration
IM	interim measure
LANL	Los Alamos National Laboratory
LDR	land disposal restriction
LTTD	low temperature thermal destruction
MCL	maximum contaminant level
MCS	media cleanup standards
MDA	material disposal area
MNA	monitored natural attenuation

MSC	Martin Spring Canyon
MNX	hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
NEPA	National Environmental Policy Act
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NPDES	national pollutant discharge elimination system
NPV	net present value
NWP	nationwide permit
OU	operable unit
PCB	polychlorinated biphenyl
POC	point of compliance
PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RRES-RS	Risk Reduction & Environmental Stewardship–Remediation Services
SAL	screening action level
SCM	site conceptual model
SSAL	specific screening action level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWQB	state water quality bureau
SWSC	sanitary wastewater system consolidation
TA	technical area
TCLP	toxicity characteristic leaching procedure
TNB	1,3,5-trinitrobenzene
TNT	trinitrotoluene[2,4,6-]
TNX	hexahydro-1,3,5-trinitroso-1,3,5-triazine
TOSS	two-stage solid-phase
TSCA	Toxic Substances Control Act
US	United States
USACE	United States Army Corps of Engineers
VCA	voluntary corrective action
VOC	volatile organic compound
ZVI	zero-valent iron

A-2.0 GLOSSARY

absorption — The penetration of substances into the bulk of a solid or liquid.

adsorption — The surface retention of solid, liquid, or gas molecules, atoms, or ions by a solid or a liquid.

alluvial — Relating to geologic deposits or features formed by running water.

alluvium — Clay, silt, sand, and gravel transported by water and deposited on streambeds, flood plains, and alluvial fans.

analysis — Includes physical analysis, chemical analysis, and knowledge-of-process determinations. (Laboratory Hazardous Waste Facility Permit)

aquifer — Body of permeable geologic material whose saturated portion is capable of readily yielding groundwater to wells.

area of concern (AOC) — Areas at the Laboratory that might warrant further investigation for releases based on past facility waste-management activities.

background level — Naturally occurring concentrations (levels) of an inorganic chemical and naturally occurring radionuclides in soil, sediment, and tuff.

barrier — Any material or structure that prevents or substantially delays movement of solid-, liquid-, or gaseous-phase chemicals in environmental media.

baseline risk assessment (also known as risk assessment) **—** A site-specific analysis of the potential adverse effects of hazardous constituents that are released from a site in the absence of any control or mitigation actions. A baseline risk assessment consists of four steps: data collection and analysis, exposure assessment, toxicity assessment, and risk characterization.

bentonite — A clay composed of the mineral montmorillonite and variable amounts of magnesium and iron, formed over time by the alteration of volcanic ash. As bentonite can *adsorb* large quantities of water and expand to several times its normal volume, it is a common additive to drilling mud.

chemical — Any naturally occurring or man-made substance characterized by a definite molecular composition, including molecules that contain radionuclides.

chemical analysis — Process used to measure one or more attributes of a sample in a clearly defined, controlled, systematic manner. Often requires treating a sample chemically or physically before measurement.

chemical of potential concern (COPC) — A chemical, detected at a site, that has the potential to adversely affect human receptors due to its concentration, distribution, and mechanism of toxicity. A COPC remains a concern until exposure pathways and receptors are evaluated in a site-specific human health risk assessment.

cleanup levels — Media-specific contaminant concentration levels that must be met by a selected corrective action. Cleanup levels are established by using criteria such as protection of human health and the environment; compliance with regulatory requirements; reduction of toxicity, mobility, or volume through treatment; long- and short-term effectiveness; implementability; cost; and public acceptance.

Code of Federal Regulation (CFR) — A codification of all regulations developed by federal government agencies and finalized by publication in the Federal Register.

conceptual hydrogeologic model — Mathematical approximation of the occurrence, movement, and quality of groundwater in a given area and the relationship of that groundwater to the surface water, soil water, and geologic framework in that area.

confluence — Place where two or more streams meet; the point where a tributary meets the main stream.

contaminant — Any chemical (including radionuclides) present in environmental media or on structural debris.

corrective action — Action to rectify conditions adverse to human health or the environment.

corrective measures implementation (CMI) plan — A detailed plan and specifications to implement the approved remedy at the facility. It is the third step of the corrective-action process. It includes design, construction, maintenance, and monitoring of the chosen remedy.

corrective measures study (CMS) — A formal process to identify and evaluate remedy alternatives for releases at the facility (55 Federal Register 30798).

dilution attenuation factor — Ratio of contaminant concentration in soil leachate to the concentration in groundwater at the receptor point and is used to account for dilution of soil leachate in an aquifer.

discharge — Accidental or intentional spilling, leaking, pumping, pouring, emitting, emptying, or dumping of hazardous waste into or on any land or water. (RCRA, 40 CFR 260.10)

disposal — The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters. (40 CFR Part 260.10)

DOE — See US Department of Energy

ecological screening level (ESL) — An organism's exposure-response threshold for a given chemical constituent. The concentration of a substance in a particular medium corresponds to a hazard quotient (HQ) of 1.0 for a given organism below which no risk is indicated.

effluent — Liquid discharged as a waste, such as contaminated water from a factory or the outflow from a sewage works; water discharged from a storm sewer or from land after irrigation.

environmental assessment (EA) — A report that identifies potentially significant environmental impacts from any federally approved or federally funded project that may change the physical environment. If an EA shows significant impact, an environmental impact statement (EIS) is required.

environmental impact statement (EIS) — Detailed report, required by federal law, on the significant environmental impacts that proposed major federal projects would have on the environment.

EPA — See US Environmental Protection Agency

ephemeral — Said of a stream or spring that flows only during and immediately after periods of rainfall or snowmelt.

evapotranspiration — The combined discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces, and by transpiration from plants.

exposure pathway — Mode by which a receptor may be exposed to contaminants in environmental media (e.g., drinking water, ingesting food, or inhaling dust).

fault — A fracture, or zone of fractures, in rock along which there has been vertical or horizontal movement; adjacent rock layers or bodies are displaced.

Federal Register — The official daily publication for Rules, Proposed Rules, and Notices of federal agencies and organizations, as well as Executive Orders and other Presidential Documents.

flood plain — The portion of a river valley that is built of overbank sediment deposited when the river floods.

geohydrology — The science that applies hydrologic methods to the understanding of geologic phenomena.

groundwater — Water in a subsurface saturated zone; water beneath the regional *water table*.

Hazardous and Solid Waste Amendments (HSWA) — The Hazardous and Solid Waste Amendments of 1984 (Public Law No. 98-616, 98 Stat. 3221), which amended the Resource Conservation and Recovery Act of 1976, 42 U.S.C. § 6901 et seq.

hazardous constituent — Those constituents listed in Appendix VIII to 40 CFR Part 261.

hazardous waste — Any solid waste is generally a hazardous waste if it

- is not excluded from regulation as a hazardous waste,
- is listed in the regulations as a hazardous waste,
- exhibits any of the defined characteristics of hazardous waste (ignitability, corrosivity, reactivity, or toxicity), or
- is a mixture o*f* solid waste and hazardous waste.

See 40 CFR 261.3 for a complete definition of hazardous waste.

HSWA module — Module VIII of the Laboratory's Hazardous Waste Facility Permit. This permit allows the Laboratory to operate as a treatment, storage, and disposal facility.

hydraulic conductivity — The rate at which water moves through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

hydraulic gradient — The rate of change of hydraulic head per unit of distance in the direction of groundwater flow.

hydraulic head — Elevation of the water table or potentiometric surface as measured in a well.

Hydrogeologic Workplan — The document that describes activities planned by the Laboratory to characterize the hydrologic setting beneath the Laboratory and to enhance the Laboratory's groundwater monitoring program.

hydrogeology — The science that applies geologic methods to the understanding of hydrologic phenomena.

hypothesis — A proposition stated as a basis for further investigation.

industrial-use scenario — Industrial use is the scenario in which current Laboratory operations continue. Any necessary remediation involves cleanup to standards designed to ensure a safe and healthy work environment for Laboratory workers.

infiltration — Entry of water into the ground.

injection well — A well into which fluids are injected (40 CFR 260.10). It should be noted that the ER Project is not using this term in its RCRA context (i.e., the injection of hazardous-waste liquid into the well under specific, approved conditions) but for adding water and/or tracers to the saturated zone during well tests of hydrologic behavior.

interim measure — Short-term actions taken to respond to immediate threats to human health or to prevent damage or contaminant migration to the environment.

interflow — A runoff process that involves lateral subsurface flow in the soil zone.

intermittent stream — A stream that flows only in certain reaches due to losing and gaining characteristics of the channel bed.

land disposal restrictions (LDR) — Requirements in 40 CFR 268 that specify treatment standards that are protective of human health and the environment when hazardous waste is land disposed.

leachate — Any liquid, including any suspended components in the liquid that has percolated through or drained from hazardous waste (40 CFR 260.10).

leaching — The separation or dissolving out of soluble constituents of a solid material by the natural action of percolating water or by chemicals.

medium (environmental) **—** Any media capable of absorbing or transporting constituents. Examples of media include tuffs, soils and sediments derived from these tuffs, surface water, soil water, groundwater, air, structural surfaces, and debris.

medium (geological) **—** The solid part of the hydrogeological system; may be unsaturated or saturated.

migration — The movement of inorganic and organic species through unsaturated or saturated materials.

migration pathway — A route (e.g., a stream or subsurface flow path) that controls the potential movement of contaminants to environmental receptors (plants, animals, humans).

mixed waste — Waste that contains both hazardous waste (as defined by RCRA) and radioactive waste (as defined by the Atomic Energy Act [AEA] and its amendments).

model — A mathematical approximation of a physical, biological, or social system.

monitoring well — A well or borehole drilled for the purpose of yielding groundwater samples for analysis.

National Pollutant Discharge Elimination System (NPDES) — The national program for both issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits and imposing requirements under Sections 307, 318, 402, and 405 of the Clean Water Act.

operable unit (OU) — At the Laboratory, one of 24 areas originally established for administering the ER Project. Set up as groups of potential release sites, the OUs were aggregated based on geographic proximity for the purpose of planning and conducting RCRA facility assessments and RCRA facility investigations. As the project matured, it became apparent that 24 were too many to allow efficient communication and to ensure consistency in approach. Therefore, in 1994, the 24 OUs were reduced to six administrative “field units.”

outfall — The vent or end of a drain, pipe, sewer, ditch, or other conduit that carries wastewater, sewage, storm runoff or other effluent into a stream.

perched groundwater — Groundwater that lies above the regional water table and is separated from it by one or more unsaturated zones.

percolation — Gravity flow of soil water through the pore spaces in soil or rock below the ground surface.

perennial stream — A stream or reach that flows continuously throughout the year.

piezometer — A tightly cased well drilled for the purpose of measuring hydraulic head or water level at a discrete depth; ideally only open at the bottom but usually constructed with a very short screen interval.

piezometric surface — The surface that represents the static head in an aquifer: applies to both confined and unconfined aquifers (also called potentiometric surface).

polychlorinated biphenyls (PCBs) — Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contains such substances. PCBs are colorless, odorless compounds that are chemically, electrically, and thermally stable and have proven to be toxic to both humans and animals.

porosity — The ratio of the volume of interstices in a soil or rock sample to its total volume expressed as a percentage or as a fraction.

preliminary remediation goal (PRG) — Acceptable exposure levels, protective of human health and the environment, that are used as a risk-based tool for evaluating remedial alternatives.

RCRA facility investigation (RFI) — The investigation that determines if a release has occurred and the nature and extent of the contamination at a hazardous waste facility. The RFI is generally equivalent to the remedial investigation portion of the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) process.

receptor — A person, plant, animal, or geographical location that is exposed to a chemical or physical agent released to the environment by human activities.

recharge — The process by which water is added to the zone of saturation, either directly from the overlying unsaturated zone or indirectly by way of another material in the saturated zone.

regional aquifer — Geologic material(s) or unit(s) of regional extent whose saturated portion yields significant quantities of water to wells, contains the regional zone of saturation, and is characterized by the regional water table or potentiometric surface.

regulatory standard — Media-specific contaminant concentration levels of potential concern that are mandated by federal or state legislation or regulation (e.g., the Safe Drinking Water Act, New Mexico Water Quality Control Commission regulations).

release — Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous waste or hazardous constituents into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles that contain any hazardous wastes or hazardous constituents).

remediation — The process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health and the environment; the act of restoring a contaminated area to a usable condition based on specified standards.

residential-use scenario — The standards for residential use are the most stringent of the three current- and future-use scenarios being considered by the ER Project and is the level of cleanup the EPA is currently specifying for SWMUs located off the Laboratory site and for those released for non-Laboratory use.

Resource Conservation and Recovery Act (RCRA) — The Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976. (40 CFR 270.2)

retardation — The act or process that reduces the rate of movement of a chemical substance in water relative to the average velocity of the water. The movement of chemical substances in water can be retarded by adsorption and precipitation reactions, and by diffusion into the pore water of the rock matrix.

risk assessment — See *baseline risk assessment.*

risk characterization — The summarization and integration of the results of toxicity and exposure assessments into quantitative and qualitative expressions of risk. The major assumptions, scientific judgments, and sources of uncertainty related to the assessment are also presented.

screening action level (SAL) — Medium-specific concentration level for a chemical derived using conservative criteria below for which it is generally assumed that there is no potential for unacceptable risk to human health. The derivation of a SAL is based on conservative exposure and land-use assumptions. However, if an applicable regulatory standard exists that is less than the value derived by risk-based computations, it will be used for the SAL.

screening assessment — A process designed to determine whether contamination detected in a particular medium at a site may present a potentially unacceptable human-health and /or ecological risk. The assessment utilizes screening levels that are either human-health or ecologically based concentrations derived by using chemical-specific toxicity information and standardized exposure assumptions below which no additional actions are generally warranted.

sediment — (1) A mass of fragmented inorganic solid that comes from the weathering of rock and is carried or dropped by air, water, gravity, or ice; or a mass that is accumulated by any other natural agent and that forms in layers on the earth's surface such as sand, gravel, silt, mud, fill, or loess. (2) A solid material that is not in solution and either is distributed through the liquid or has settled out of the liquid.

site characterization — Defining the pathways and methods of migration of the hazardous waste or constituents, including the media affected, the extent, direction and speed of the contaminants, complicating factors influencing movement, concentration profiles, etc. (US Environmental Protection Agency, May 1994. "RCRA Corrective Action Plan, Final," Publication EPA-520/R-94/004, Office of Solid Waste and Emergency Response, Washington, DC)

site conceptual model — A qualitative or quantitative description of sources of contamination, environmental transport pathways for contamination, and biota that may be impacted by contamination (called receptors) and whose relationships describe qualitatively or quantitatively the release of contamination from the sources, the movement of contamination along the pathways to the exposure points, and the uptake of contaminant by the receptors.

soil gas — Those gaseous elements and compounds that occur in the void spaces in unsaturated rock or soil. Such gases can move through or leave the rock or soil, depending on changes in pressure.

soil water — Water in the unsaturated zone, regardless of whether it occurs in soil or rock.

solid waste — Any garbage; refuse; sludge from a waste treatment plant, water-supply treatment plant, or air-pollution-control facility; and other discarded material including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities.

solid waste management unit (SWMU) — 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 a facility at which solid wastes have been routinely and systematically released. This definition includes regulated units (i.e., landfills, surface impoundments, waste piles, and land treatment units) but does not include passive leakage or one-time spills from production areas and units in which wastes have not been managed (e.g., product-storage areas).

spring — The site where groundwater discharges to the ground surface.

stakeholder — As used in this document, stakeholder refers to any party or agency, whether inside or outside the Laboratory, interested in or affected by Environmental Restoration Project issues and activities.

technical area (TA) — The Laboratory established technical areas as administrative units for all its operations. There are currently 49 active TAs spread over approximately 40 square miles.

tracer — A substance, usually a radioactive isotope, added to a sample to determine the efficiency (chemical or physical losses) of the chemical extraction, reaction, or analysis. The tracer is assumed to behave in the same manner as that of the target radionuclides. Recovery guidelines for tracer results are 30% to 110% under the current contract laboratory statement of work and will be 40% to 105% under the new statement of work. Correction of the analytical results for the tracer recovery is performed for each sample. The concentration of the tracer added needs to be sufficient to result in a maximum of 10% uncertainty at the 95% confidence level in the measured recovery.

transmission loss — Reduction in surface water flow by seepage into the channel bed.

transmissivity — A measure of the rate at which water is transmitted through a cross section of aquifer having the dimensions unit width and total saturated thickness as height, under a unit hydraulic gradient; also hydraulic conductivity times aquifer thickness.

transport or transportation — The movement of a hazardous waste by air, rail, highway, or water. (40 CFR 260.10)

treatment — Any method, technique, or process, including elementary neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste; recover energy or material resources from the waste; or so as to render such waste nonhazardous or less hazardous; safer to transport, store, or dispose of; or amenable for recovery or storage; or reduced in volume.

treatment, storage, and disposal (TSD) facility — An interim status or permitted facility in which hazardous waste is treated, stored, or disposed.

tuff — A compacted deposit of volcanic ash and dust that contains rock and mineral fragments accumulated during an eruption.

underflow — Groundwater flow beneath the bed of a non-flowing stream; such water is often perched in the channel alluvium atop the bedrock surface.

unsaturated zone — The zone between the land surface and the regional water table and between perched zones of saturation. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure.

US Department of Energy (DOE) — Federal agency that sponsors energy research and regulates nuclear materials for weapons production.

US Environmental Protection Agency (EPA) — Federal agency responsible for enforcing environmental laws. While state regulatory agencies may be authorized to administer some of this responsibility, the EPA retains oversight authority to ensure protection of human health and the environment.

vadose zone — The unsaturated zone. Portion of the subsurface above the regional water table in which pores are not fully saturated.

water balance — The relationship between water input (precipitation) and output (runoff, evapotranspiration, and recharge) in a hydrological system; the partitioning of precipitation among these components of the hydrological cycle.

water content — (Also gravimetric moisture content) The amount of water in an unsaturated medium, expressed as the ratio of the weight of water in a sample to the weight of the oven-dried sample; often expressed as a percent.

water table — The top of the regional saturated zone; the piezometric surface associated with an unconfined aquifer.

A-3.0 METRIC TO US CUSTOMARY UNIT CONVERSION TABLE

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

Appendix B

Supporting Information for CMS COPC Identification

Appendix B
List of Tables

B1 Cañon de Valle CMS COPCs

Cañon de Valle surface water CMS COPCs are barium, RDX, DNX, MNX and TNT. For alluvial groundwater the CMS COPCs are barium, manganese, RDX, MNX and TNT. For alluvial sediment, the CMS COPCs are barium, RDX and TNT. The selection of CMS COPCs from Phase III RFI COPCs is described in this section, and is developed using the CMS COPC screening criteria presented in section 3.2. Supporting data are available in the accompanying tables and supporting text and supporting text and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

B1.1 Cañon de Valle Surface Water

Cañon de Valle surface water inorganic RFI COPCs that exceed their CMS COPC screening limits include antimony, barium, nitrate-nitrite as N, perchlorate, silver, thallium, and uranium. Organic RFI COPCs that exceeded their CMS COPC screening limits are RDX, DNX, MNX, TNT, tetrachloroethene, and trichloroethene. Supporting data are available in Tables B-1 and B-2 and from Appendix G of the Phase III RFI report (LANL 2003, 77965).

On the basis of frequency of detection and distribution, antimony is not a CMS COPC. The percentage of total samples containing detectable antimony was 13 percent; of 20 samples with detectable antimony, only one antimony sample exceeded the screening limit in surface water. Moreover, based on regional groundwater sampling results from R-25 (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), antimony did not exceed a screening limit.

Barium is a CMS COPC. It was detected in 100 percent of samples; of 151 detections, 81 exceeded the CMS screening limit.

Nitrate-nitrite as N was detected in 61 percent of samples, but exceeded the screening limit in only 1 of 39 samples showing detectable nitrate-nitrite as N. The remaining sample results were at least a factor of 10 below the screening limit. Nitrate-nitrite as N did not exceed a screening limit in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons nitrate-nitrite as N is excluded as a CMS COPC.

Silver was detected in 15 percent of surface water samples, but only two surface water samples of 23 samples showing detectable silver exceeded the screening limit standard. In addition, silver present in sediment and surface water did not cause unacceptable risks in the Phase III RFI risk assessment. Finally, elevated silver concentrations have not been detected in R-25 (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, silver is not included as a Cañon de Valle surface water CMS COPC.

Perchlorate was detected in 8% of Cañon de Valle surface water samples. All samples showing detectable perchlorate are from 2000; recent sample results (through March 2002) have not detected perchlorate. Perchlorate has not been detected in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, perchlorate is not included as a CMS COPC for Cañon de Valle surface water.

Thallium was detected in 18 percent of total samples, but exceeded a CMS screening limit in only 3 unfiltered samples. No filtered samples exceeded the screening limit. One sample result from R-25 regional groundwater sampling exceeded the screening limit; all other results fell below the screening limit. Based on these considerations, thallium is not a CMS COPC.

Uranium was included as an RFI COPC because its maximum detection limit exceeded the screening limit. For samples with detectable uranium, the maximum concentration fell below the screening limit.

Table B-1
Phase III RFI Cañon de Valle Surface Water Inorganic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Antimony	Max. Detected Value	6.4 (J)[b]	na[c]	6	na	Yes	13
	Max. Undetected Value	33 (U)[d]	na	6	na	Yes	
Barium	Max. Detected Value	16300	1000[e]	2000	na	Yes	100
Cesium	Max. Detected Value	800	nav[f]	nav	nav	nav	na
Mercury	Max. Detected Value	0.97	0.77[g]	2	na	Yes	3
	Max. Undetected Value	1 (U)	0.77[g]	2	na	Yes	
Nitrate-Nitrite as N	Max. Detected Value	49200	10000[e]	nav	na	Yes	61
	Max. Undetected Value	1110 (U)	10000[e]	nav	na	No	
Perchlorate	Max. Detected Value	17.1	4[h]	nav	na	Yes	8
	Max. Undetected Value	20 (U)	4[h]	nav	na	Yes	
Selenium	Max. Detected Value	5.33	5[g]	50	na	Yes	22
	Max. Undetected Value	5 (U)	5[g]	50	na	No	
Silver	Max. Detected Value	1380	50[e]	100	na	Yes	15
	Max. Undetected Value	10 (U)	50[e]	100	na	No	
Thallium	Max. Detected Value	5.9 (J)	na	2	na	Yes	18
	Max. Undetected Value	5.6 (U)	na	2	na	Yes	
Uranium	Max. Detected Value	1.91	5000[e]	30	na	No	59
	Max. Undetected Value	126 (U)	5000[e]	30	na	Yes	

Table B-1 (continued)
Phase III RFI Cañon de Valle Surface Water Inorganic COPCs

Sources: 20 NMAC 6.2.3103, "Standards for groundwater of 10,000 mg/l TDS concentration or less," Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; EPA 1989, 08021; and California DHS 2003, 76862.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[c] na = not applicable.

[d] (U) = The chemical is classified "undetected."

[e] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

[f] nav = not available.

[g] NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900).

[h] 2003 California DHS Action Level.

Table B-2
Phase III RFI Cañon de Valle Surface Water Organic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Bis(2-ethylhexyl)phthalate	Max. Detected Value	1.6 (J)[b]	na[c]	6	na	No	na
	Max. Undetected Value	12 (U)[d]	na	6	na	Yes	
DNX	Max. Detected Value	1.3 (J-)[e]	nav[f]	nav	0.61	Yes	na
	Max. Undetected Value	0.5 (U)	nav	nav	0.61	No	
Methylene Chloride	Max. Detected Value	1.1 (J)	100[g]	5	na	No	3
	Max. Undetected Value	38 (U)	100[g]	5	na	Yes	
MNX	Max. Detected Value	0.97 (J-)	nav	nav	0.61	Yes	na
	Max. Undetected Value	0.5 (U)	nav	nav	0.61	No	
Nitroglycerin	Max. Detected Value	1.1 (J)	nav	nav	4.8	No	4
	Max. Undetected Value	5 (U)	nav	nav	4.8	Yes	
RDX	Max. Detected Value	290	nav	nav	0.61	Yes	74
	Max. Undetected Value	0.87 (U)	nav	nav	0.61	Yes	
Tetrachloroethene	Max. Detected Value	42	20[g]	5	na	Yes	12
	Max. Undetected Value	5 (U)	20[g]	5	na	No	
Trichloroethene	Max. Detected Value	10	100[g]	5	na	Yes	9
	Max. Undetected Value	5 (U)	100[g]	5	na	No	
TNT	Max. Detected Value	6.2	nav	nav	2.2	Yes	15
	Max. Undetected Value	5 (U)	nav	nav	2.2	Yes	

Table B-2 (continued)
Phase III RFI Cañon de Valle Surface Water Organic COPCs

Sources : 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[c] na = not applicable; total sample count less than 20.

[d] (U) = The chemical is classified as "not detected."

[e] (J-) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual with a potential low bias.

[f] nav = not available.

[g] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

Moreover, uranium is not a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, uranium is not included as a CMS COPC.

RDX was detected in 74 percent of surface water samples. Of 67 samples showing detectable RDX, 65 exceeded the screening limit. TNT was detected in 15 percent of samples. Of 14 samples showing detectable TNT, 5 exceeded the screening limit. RDX breakdown products DNX and MNX have been detected in surface water. Finally, MNX, RDX, and TNT have been detected in deep groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons these compounds are included as CMS COPCs.

Tetrachloroethene and trichloroethene were detected in 12 percent and 9 percent of surface water samples, respectively. Of 4 samples showing detectable tetrachloroethene, 3 results exceeded the screening limit. Of 3 samples showing detectable trichloroethene, 1 result exceeded the screening limit. All samples exceeding the screening limits were from Fishladder Canyon. With the exception of a sample taken from Peter Seep, these compounds were not detected in other surface water samples. Occasionally, these compounds have been detected in deep groundwater in R-25, though not at levels above screening limits (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). These compounds are not retained as CMS COPCs for this CMS. Fishladder Canyon will be investigated in 2004 and 2005 as part of a separate investigation (LANL 1993, 20948).

B1.2 Cañon de Valle Alluvial Groundwater

The Cañon de Valle alluvial groundwater inorganic RFI COPCs that exceed their CMS COPC screening limits are antimony, barium, cadmium, manganese, perchlorate, and thallium. The organic RFI COPCs are chloromethane, dinitrobenzene, MNX, RDX, and TNT. Supporting data are available in Tables B-3 and B-4 and from Appendix G of the Phase III RFI report (LANL 2003, 77965).

Antimony was detected in 32 percent of samples, but of 29 samples showing detectable antimony, no filtered samples and only one unfiltered sample had results that exceeded the screening limit. Moreover, as discussed in section 3.2.1.1, antimony is not a CMS COPC in regional groundwater at R-25. For these reasons, antimony is not a CMS COPC for Cañon de Valle alluvial groundwater.

Barium is a CMS COPC. Barium was detected in 100 percent of samples, with 140 of 154 sample results exceeding the screening limit. Barium has been detected in R-25, though concentrations are at least a factor of 10 lower than the screening limit (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5).

Cadmium was detected in 54 percent of samples, but only 9 samples of 88 samples showed results that exceeded the screening limit; all but one were unfiltered samples. Moreover, cadmium is not a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, it is excluded as CMS COPC.

Manganese was detected in 98 percent of Cañon de Valle groundwater samples, of which 115 of 158 sample results exceeded the screening limit. Manganese was not listed as an RFI COPC for Cañon de Valle surface water. Manganese in sediment from Cañon de Valle was not listed as RFI COPCs because manganese was not present above background concentrations. Alluvial groundwater data sorted by distance from the outfall indicate that manganese concentrations uniformly increase with distance. Its presence within alluvial groundwater, which is in intimate contact with sediment containing manganese within background, strongly indicates that manganese is most likely naturally occurring. However, the

Table B-3
Phase III RFI Cañon de Valle Alluvial Groundwater Inorganic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Antimony	Max. Detected Value	10.9 (J)[b]	na[c]	6	na	Yes	32
	Max. Undetected Value	20 (U)[d]	na	6	na	Yes	
Barium	Max. Detected Value	18000	1000[e]	2000	na	Yes	100
Cadmium	Max. Detected Value	11.3	10[e]	5	na	Yes	54
	Max. Undetected Value	5.9 (U)	10[e]	5	na	Yes	
Cesium	Max. Detected Value	1300	nav[f]	nav	nav	nav	na
Cyanide (Total)	Max. Detected Value	10	5.2[g]	200	na	Yes	na
	Max. Undetected Value	10 (U)	5.2[g]	200	na	Yes	
Manganese	Max. Detected Value	4340	200[h]	50	na	Yes	98
	Max. Undetected Value	10 (U)	200[h]	50	na	No	
Mercury	Max. Detected Value	4.4	0.77[h]	2	na	Yes	15
	Max. Undetected Value	0.44 (U)	0.77[h]	2	na	No	
Perchlorate	Max. Detected Value	19.1	4[i]	nav	na	Yes	10
	Max. Undetected Value	4.79 (U)	4[i]	nav	na	Yes	
Rubidium	Max. Detected Value	900	nav	nav	nav	nav	na
	Max. Undetected Value	50 (U)	nav	nav	nav	nav	
Thallium	Max. Detected Value	7.6 (J)	na	2	na	Yes	29
	Max. Undetected Value	9.1 (U)	na	2	na	Yes	

Table B-3 (continued)
Phase III RFI Cañon de Valle Alluvial Groundwater Inorganic COPCs

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Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; EPA 1989, 08021; and California DHS 2003, 76862.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain that usual.

[c] na = not applicable.

[d] (U) = The chemical is classified "undetected."

[e] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

[f] nav = not available.

[g] NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900).

[n] NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103).

[i] 2003 California DHS Action Level.

Table B-4
Phase III RFI Cañon de Valle Alluvial Groundwater Organic COPCs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Chloromethane	Max. Detected Value	44 (J)[b]	na[c]	nav[d]	1.5	Yes	5
	Max. Undetected Value	10 (U)[e]	na	nav	1.5	Yes	
Dinitrobenzene[1,3-]	Max. Detected Value	12	nav	nav	3.7	Yes	1
	Max. Undetected Value	13 (U)	nav	nav	3.7	Yes	
MNX	Max. Detected Value	0.65	nav	nav	0.61	Yes	na
	Max. Undetected Value	0.5 (U)	nav	nav	0.61	No	
Nitrobenzene	Max. Detected Value	0.36 (J-)[f]	na	nav	3.4	No	1
	Max. Undetected Value	50 (U)	na	nav	3.4	Yes	
RDX	Max. Detected Value	759	nav	nav	0.61	Yes	73
	Max. Undetected Value	1 (UJ)[g]	nav	nav	0.61	Yes	
TNT	Max. Detected Value	46.6	nav	nav	2.2	Yes	3
	Max. Undetected Value	13 (U)	nav	nav	2.2	Yes	

Sources: 20 NMAC 6.2.3103, "Standards for groundwater of 10,000 mg/l TDS concentration or less," Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[c] na = not applicable.

[d] nav = not available.

[e] (U) = The chemical is classified "not detected."

[f] (J-) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual with a potential low bias.

[g] (UJ) = The chemical is classified "not detected" with an expectation that the reported result is more uncertain than usual.

increasing trend with distance from the outfall indicates that manganese has been leached from naturally occurring manganese in sediment by reducing conditions caused by the presence of organic material. It is not known whether this organic material is naturally occurring (organic humus) or HE.

Manganese is occasionally detected above the screening limit in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), but comparisons against background have not been completed. For these reasons, manganese is included as a CMS COPC for Cañon de Valle alluvial groundwater.

Perchlorate was detected above its screening limit in Cañon de Valle alluvial groundwater during 2000, but it has not been detected above the screening limit in later results (through March 2002). Perchlorate has not been detected in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). Due to the low concentration and infrequent detection in alluvial groundwater, it does not likely pose a contaminant risk to regional groundwater. For these reasons, perchlorate is not included as a CMS COPC for Cañon de Valle alluvial groundwater.

Thallium was detected in 29 percent of samples, but of 158 samples showing detectable thallium only 2 sample results exceeded the screening limit. One sample result from R-25 regional groundwater sampling results exceeded the screening limit (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5); all other results fell below the screening limit. Based on these considerations, thallium is not a CMS COPC.

Chloromethane was detected in only 5 percent of groundwater samples in Cañon de Valle. A single sample exceeded the CMS COPC screening level. All other sample results fell below the screening limit. Chloromethane has not been detected in deep groundwater in R-25. For these reasons, it is not included as a CMS COPC.

RDX was detected in 73 percent of samples, with 66 of 69 of samples exceeding the screening limit. TNT was detected in 3 percent of samples. Of 14 samples with detectable TNT, 5 exceeded the screening limit. MNX, though detected in only 4 samples, has been detected in deep groundwater in R-25 (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), along with RDX and TNT. For these reasons, RDX, MNX and TNT are CMS COPCs.

B1.3 Cañon de Valle Alluvial Sediment

In accordance with the CMS COPCs screening criteria set forth in section 3.2, sediment RFI COPCs are CMS COPCs if the sediment RFI COPCs are either groundwater or surface water CMS COPCs. On this basis, the alluvial sediment CMS COPC are barium, RDX and TNT. Supporting data are available in Tables B-5 and B-6 and from Appendix G of the Phase III RFI report (LANL 2003, 77965).

B2 Martin Spring Canyon CMS COPCs

Martin Spring alluvial groundwater and alluvial sediment CMS COPCs are barium and RDX. RDX is a CMS COPC for Martin Spring Canyon surface water. In addition, manganese is a CMS COPC for Martin Spring Canyon alluvial groundwater. The selection of CMS COPCs from Phase III RFI COPCs is described in this section. Supporting data are available in the accompanying tables and supporting text and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

Table B-5
Phase III RFI Inorganic COPCs in the Cañon de Valle Sediment

Chemical	Number of Analyses	Number of Detects	Concentration Range (mg/kg)	Background Value (BV)* (mg/kg)	Number of Detects Above BV	Number of Non-Detects Above BV	Percent Detected for 20 Samples or Greater(**)[a]
Antimony	46	12	[0.032][b] to 2.6	0.83	7	16	26
Barium	46	46	34.9 to 37300	127	43	0	100
Boron	46	18	0.799 to 10.6	nav[c]	nav	nav	39
Cadmium	46	19	[0.04] to 1.98	0.4	4	4	41
Chromium	46	46	3.5 to 33.1	10.5	7	0	100
Cobalt	46	46	1.5 to 17.5	4.73	26	0	100
Copper	46	46	2.84 to 232	11.2	32	0	100
Lead	46	46	5.08 to 163	19.7	32	0	100
Mercury	46	42	[0.0038] to [0.2]	0.1	0	1	91
Nickel	46	46	2.34 to 40.3	9.38	22	0	100
Selenium	46	12	0.289 to 2.02	0.3	11	34	26
Silver	46	44	0.125 to 167	1	40	0	96
Thallium	46	16	0.0392 to [1.4]	0.73	0	30	35
Vanadium	46	46	8.9 to 33.7	19.7	7	0	100
Zinc	46	46	20 to 259	60.2	8	0	100

* *Source* : (Ryti et al, 1998, 59730)

***Source:* (EPA 1989, 08021).

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] [ ] = The value in brackets is below detection limits, although some chemicals may be detected at values within this range.

[c] nav = not available.

Table B-6
Phase III RFI Organic COPCs in Cañon de Valle Sediment

Chemical	Number of Analyses	Number of Detects	Concentration Range (mg/kg)	Percent Detected for 20 Samples or Greater(*)[a]
A-2,6-DNT[4-]	46	22	[0.08][b] to [5]	48
A-4,6-DNT[2-]	46	22	0.0393 to [5]	48
Benzo(a)pyrene	16	1	[0.0339] to [0.93]	na[c]
Benzoic Acid	16	3	0.23 to [2.3]	na
Di-n-butylphthalate	16	1	[0.058] to [0.93]	na
Fluoranthene	16	2	0.0177 to [0.91]	na
Hexachlorobenzene	16	1	0.0756 to [0.93]	na
HMX	46	33	[0.08] to 290	72
Indeno(1,2,3-cd)pyrene	16	1	[0.0339] to [0.93]	na
Methylphenol[4-]	16	2	0.141 to [0.93]	na
Naphthalene	16	1	[0.0339] to [0.93]	na
Pyrene	16	3	0.0187 to [0.91]	na
Pyridine	16	1	0.16 to [0.93]	na
RDX	46	27	0.0615 to [20]	59
TNT	46	20	[0.08] to [5]	43

**Source:* (EPA 1989, 08021).

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] [ ] = The value in brackets is below detection limits, although some chemicals may be detected at values within this range.

[c] na = not applicable.

B2.1 Martin Spring Canyon Surface Water

Martin Spring Canyon surface water RFI COPCs that exceed their CMS COPC screening limits are aluminum, arsenic, barium, lead, manganese, and RDX. Supporting data are available in Tables B-7 and B-8 and from Appendix G of the Phase III RFI report (LANL 2003, 77965).Supporting data are available from Appendix B and Appendix G of the Phase III RFI report (LANL 2003, 77965).

Aluminum was detected in 81 percent of samples, of which all 21 samples exceeded the screening limit. Aluminum was eliminated as an RFI COPC in Cañon de Valle surface water because it is likely to be naturally occurring (LANL 2003, 77965). A similar analysis for Martin Spring surface water could not be completed because of a lack of data (number of analyses). Aluminum is listed as an RFI COPC for Martin Spring sediment; however, only one sample at a concentration of 17,000 mg/kg exceeded the background concentration of aluminum (15,400 mg/kg). Given that surface water is derived primarily from Martin Spring spring water, and that aluminum is not a RFI COPC in spring water indicate surface water is picking up aluminum from sediment, where it only slightly exceeds background.

Aluminum has occasionally been detected above a CMS COPC standard in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), but a comparison against background values has not been completed. Aluminum is a constituent of clays and tuff, which likely serves as a natural source. For these reasons aluminum is eliminated as a CMS COPC for Martin Spring Canyon surface water and groundwater.

Arsenic was detected in 27 percent of samples, of which 1 unfiltered of 7 samples showed results above the screening limit. In addition, arsenic in Martin Spring Canyon surface water did not exceed a screening limit for filtered samples. A lack of data quantity (number of analyses) precluded a geochemical analysis against background for arsenic in Martin Spring Canyon surface water. A geochemical analysis against background eliminated arsenic from Cañon de Valle surface water, groundwater and all springs, including Martin Spring, which is a primary source of Martin Spring Canyon surface water. Arsenic is listed as a Martin Spring Canyon sediment RFI COPC, where 7 samples exceeded the background concentration of 4 mg/kg and the maximum detected arsenic concentration was 10 mg/kg. There are no known anthropogenic sources for arsenic. Finally, arsenic on occasion exceeds the CMS COPC groundwater standard in regional groundwater, but not consistently (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, arsenic is eliminated as a CMS COPC in Martin Spring Canyon surface water.

Barium was detected in 100 percent of surface water samples, but only 1 sample exceeded the screening limit. Other results, which are below the barium screening limit, are consistent with Martin Spring barium concentrations, from which Martin Spring Canyon surface water is primarily derived. For these reasons, barium is not included as a CMS COPC for surface water in Martin Spring Canyon.

Lead was detected in 54 percent of samples. Of samples with detectable lead, three of 14 samples exceeded the screening limit. Only one filtered sample for lead exceeded a screening limit for surface water. A lack of data quantity (number of analyses) precluded a geochemical analysis against background for lead in Martin Spring Canyon surface water. A geochemical analysis against background eliminated lead from Cañon de Valle surface water. Lead did not exceed a screening limit in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, lead is excluded as a CMS COPC.

Table B-7
Phase III RFI Martin Spring Canyon Surface Water Inorganic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Aluminum	Max. Detected Value	21600 (J+)[b]	5000[c,d]	50	na[e]	Yes	81
	Max. Undetected Value	216 (U)[f]	5000[c,d]	50	na	Yes	
Antimony	Max. Detected Value	5.3 (J)[g]	na	6	na	No	12
	Max. Undetected Value	33 (U)	na	6	na	Yes	
Arsenic	Max. Detected Value	75.1	100[h]	10	na	Yes	27
	Max. Undetected Value	4.5 (U)	100[h]	10	na	No	
Barium	Max. Detected Value	8560	1000[h]	2000	na	Yes	100
Boron	Max. Detected Value	2530	750[c]	nav[m]	na	Yes	100
Cobalt	Max. Detected Value	136	50[c]	nav	na	Yes	46
	Max. Undetected Value	2.4 (U)	50[c]	nav	na	No	
Lead	Max. Detected Value	46.1	50[h]	15	na	Yes	54
	Max. Undetected Value	2.3 (U)	50[h]	15	na	No	
Manganese	Max. Detected Value	66800	200[j]	50	na	Yes	92
	Max. Undetected Value	3.7 (U)	200[j]	50	na	No	
Mercury	Max. Detected Value	1.1	0.77[k]	2	na	Yes	12
	Max. Undetected Value	0.1 (U)	0.77[k]	2	na	No	
Selenium	Max. Detected Value	38.3	5[k]	50	na	Yes	31
	Max. Undetected Value	4.5 (U)	5[k]	50	na	No	

Table B-7 (continued)
Phase III RFI Martin Spring Canyon Surface Water Inorganic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Thallium	Max. Detected Value	0.0819 (J)	na	2	na	No	8
	Max. Undetected Value	45 (U)	na	2	na	Yes	
Vanadium	Max. Detected Value	111	100[d]	nav	na	Yes	85
	Max. Undetected Value	3.91 (U)	100[d]	nav	na	No	

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of

[b] (J+) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual with a potential high bias.

[c] NMWQCC Groundwater Standard for Irrigation Use (20 NMAC 6.2.3103).

[d] NMWQCC Surface Water Standard for Livestock Watering (20 NMAC 6.4.900).

[e] na = not applicable.

[f] (U) = The chemical is classified "undetected."

[g] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[h] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

[i] nav = not available.

[j] NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103).

[k] NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900).

Table B-8
Phase III RFI Martin Spring Canyon Surface Water Organic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL(μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
RDX	Max. Detected Value	200	nav[b]	nav	0.61	Yes	na[d]
	Max. Undetected Value	1 (U)[c]	nav	nav	0.61	Yes	

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] nav = not available.

[c] (U) = The chemical is classified "not detected."

[d] na = not applicable, sample count less than 20

Manganese was detected in all samples and exceeded its screening limit in 13 of 24 samples from Martin Spring Canyon surface water. The presence of manganese in surface water above the screening limit is likely related to the dissolution of manganese as a result of the reducing conditions caused by organic material, either naturally occurring or HE. The situation is similar to that found for Cañon de Valle alluvial groundwater, but the percentage of samples showing detectable manganese that exceed the screening limit was much higher for Cañon de Valle alluvial groundwater. Occasionally, manganese is detected above the CMS COPC screening limit in regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), but comparisons against BVs have not been completed. For these reasons, manganese is not included as a CMS COPC for Martin Spring Canyon surface water.

RDX was detected in 12 of 15 samples. Of the 12 samples showing detectable RDX, all samples exceeded the screening limit. For this reason, RDX is a CMS COPC.

B2.2 Martin Spring Alluvial Groundwater

The Martin Spring Canyon groundwater RFI COPCs that exceed their CMS COPC screening limits are aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, perchlorate, thallium, zinc, and RDX. Supporting data are available in Tables B-9 and B-10 and in Appendix G of the Phase III RFI (LANL 2003, 77965).

Aluminum and lead have previously been eliminated as CMS COPCs in Martin Spring surface water in the previous section; these elements are also likely to be naturally occurring in Martin Spring alluvial groundwater, given that groundwater and surface water are primarily derived from Martin Spring water. As discussed in the previous section, these elements are not CMS COPCs with respect to R-25 regional groundwater. For these reasons, they are eliminated as alluvial groundwater CMS COPCs in Martin Spring Canyon.

Arsenic was detected in 32 percent of samples. Of 22 samples showing detectable arsenic, 5 sample results exceeded the screening limit. Arsenic on occasion exceeds the CMS COPC groundwater standard in regional groundwater, but not consistently (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, arsenic is eliminated as a CMS COPC in Martin Spring Canyon alluvial groundwater.

Barium was detected in 100 percent of samples, of which 5 of 30 samples exceeded the screening limit. Barium is included as a CMS COPC on this basis.

Beryllium was detected in 63 percent of samples, of which 3 of 19 samples results exceeded the screening limit. Beryllium has been detected only once above the screening limit in R-25 regional groundwater ((LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons beryllium is not a CMS COPC.

Cadmium was detected in 37 percent of samples, of which 4 of 11 sample results exceeded the screening limit. All filtered sample results were below the CMS COPC screening limit. Cadmium is not a CMS COPCs with respect to R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons cadmium is not included as a CMS COPC.

Chromium was detected in 83 percent of samples, of which 2 of 25 exceeded the screening limit.

Table B-9
Phase III RFI Martin Spring Canyon Alluvial Groundwater Inorganic COPCs

Chemical	Sample Concentration (μg/L)		NMWQCC Standard (μg/L)	EPA MCL (μg/L)	EPA Region 6 Tap Water PRG (μg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Aluminum	Max. Detected Value	530000 (J)[b]	5000[c,d]	50	na[e]	Yes	100
Arsenic	Max. Detected Value	132	100[f]	10	na	Yes	32
	Max. Undetected Value	4 (U)[g]	100[f]	10	na	No	
Barium	Max. Detected Value	38000 (J)	1000[f]	2000	na	Yes	100
Beryllium	Max. Detected Value	78	na	4	na	Yes	63
	Max. Undetected Value	0.22 (U)	na	4	na	No	
Boron	Max. Detected Value	2250	750[c]	nav[h]	na	Yes	93
	Max. Undetected Value	500 (U)	750[c]	nav	na	No	
Cadmium	Max. Detected Value	70 (J+)[i]	10[f]	5	na	Yes	37
	Max. Undetected Value	0.92 (U)	10[f]	5	na	No	
Chromium	Max. Detected Value	1200	50[f]	100	na	Yes	83
	Max. Undetected Value	4 (U)	50[f]	100	na	No	
Cobalt	Max. Detected Value	125	50[c]	nav	na	Yes	60
	Max. Undetected Value	380 (U)	50[c]	nav	na	Yes	
Copper	Max. Detected Value	860	500[d]	1000	na	Yes	80
	Max. Undetected Value	56.9 (U)	500[d]	1000	na	No	
Lead	Max. Detected Value	995	50[f]	15	na	Yes	83
	Max. Undetected Value	3.53 (U)	50[f]	15	na	No	
Manganese	Max. Detected Value	37000 (J)	200[j]	50	na	Yes	100
Mercury	Max. Detected Value	4.1	0.77[k]	2	na	Yes	40
	Max. Undetected Value	0.34 (U)	0.77[k]	2	na	No	
Nickel	Max. Detected Value	450	200[c]	nav	na	Yes	77
	Max. Undetected Value	40 (U)	200[c]	nav	na	No	

Table B-9 (continued)
Phase III RFI Martin Spring Canyon Alluvial Groundwater Inorganic COPCs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Perchlorate	Max. Detected Value	17	4[l]	nav	na	Yes	na
	Max. Undetected Value	4.16 (U)	4[l]	nav	na	Yes	
Selenium	Max. Detected Value	29.6 (J+)	5[k]	50	na	Yes	17
	Max. Undetected Value	8 (UJ)[m]	5[k]	50	na	Yes	
Silver	Max. Detected Value	28	50[f]	100	na	No	23
	Max. Undetected Value	160 (U)	50[f]	100	na	Yes	
Thallium	Max. Detected Value	6.16	na	2	na	Yes	23
	Max. Undetected Value	3.8 (U)	na	2	na	Yes	
Vanadium	Max. Detected Value	1100	100[d]	nav	na	Yes	93
	Max. Undetected Value	8.4 (U)	100[d]	nav	na	No	
Zinc	Max. Detected Value	6600	10000[j]	5000	na	Yes	80
	Max. Undetected Value	43.9 (U)	10000[j]	5000	na	No	

Sources: New Mexico Administrative Code [NMAC] (20 NMAC 6.2.3103). "Standards for groundwater of 10,000 mg/l TDS concentration or less," Parts A, B, and C; (20 NMAC 6.4.900). "Standards applicable to attainable or designated uses unless otherwise specified in 20.6.4.101 through 20.6.4.899 NMAC,"; EPA 2002, 76871; EPA 2003, 76867; EPA 1989, 08021; and California DHS 2003, 76862.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[c] NMWQCC Groundwater Standard for Irrigation Use (20 NMAC 6.2.3103).

[d] NMWQCC Surface Water Standard for Livestock Watering (20 NMAC 6.4.900).

[e] na = not applicable.

[f] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

[g] (U) = The chemical is classified "undetected."

[h] nav = not available.

[i] (J+) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual with a potential high bias.

[j] NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103).

[k] NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900).

[l] 2003 California DHS Action Level.

[m] (UJ) = The chemical is classified "undetected" with an expectation that the reported result is more uncertain than usual.

Table B-10
Phase III RFI Martin Spring Canyon Alluvial Groundwater Organic COPCs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
RDX	Max. Detected Value	23	nav[b]	nav	0.61	Yes	na[c]
	Max. Undetected Value	1 (U)[d]	nav	nav	0.61	Yes	

Sources: 20 NMAC 6.2.3103, "Standards for groundwater of 10,000 mg/l TDS concentration or less," Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] nav = not available.

[c] na = not applicable because number of samples is less than 20

[d] (U) = The chemical is classified "not detected."

Moreover, all filtered chromium groundwater sample results were below the CMS COPC screening limit. Finally, chromium did not exceed the screening limit in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, it is excluded as a CMS COPC.

Manganese was detected in 100 percent of samples. Of 30 samples with detectable manganese, 24 sample results exceeded the screening limit. Its presence within alluvial groundwater, which is in intimate contact with sediment containing manganese within background, strongly indicates that manganese is most likely naturally occurring; however, the high fraction of sample results that exceed the screening limit suggest that manganese has dissolved from sediments as a results of reducing conditions caused by organic material, either naturally occurring or HE. Occasionally, manganese is detected above the CMS COPC screening limit in regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), but comparisons against background has not been completed. For these reasons, manganese is included as a CMS COPC for Martin Spring Canyon alluvial groundwater.

Mercury was detected in 40 percent of samples, of which 2 samples of 12 exceeded the screening limit. All filtered sample results were below the screening limit. Mercury is not a CMS COPC with respect to R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons mercury is excluded as a CMS COPC.

In 2000, perchlorate was detected once above the screening limit. All other sample results were below the detection limit. Perchlorate has not been detected in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, it is excluded as a CMS COPC.

Thallium was detected in 23% of alluvial groundwater samples, of which 3 of 7 sample results exceeded the screening limit; no filtered sample results exceeded the screening limit. One sample result from R-25 regional groundwater sampling results exceeded the screening limit (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5); all other results fell below the screening limit. For these reasons, thallium is not included as a CMS COPC for Martin Spring Canyon alluvial groundwater.

Zinc was detected in 80 percent of samples, of which 1 of 24 sample results exceeded its screening limit in one sample. All filtered sample results fell below the screening limit. Moreover, zinc is not a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, zinc is excluded as a CMS COPC for Martin Spring Canyon alluvial groundwater.

RDX was detected in 4 of 14 samples, of which two exceeded the screening limit. RDX is a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5), and is included as a CMS COPC.

B2.3 Martin Spring Canyon Alluvial Sediment

Martin Spring Canyon sediment RFI COPCs that are included as Martin Spring groundwater and surface water CMS COPCs are barium and RDX. These are also Martin Spring Canyon alluvial sediment CMS COPCs Supporting data are available in Tables B-11 and B-12 and in Appendix G of the Phase III RFI (LANL 2003, 77965).

B.3 Springs

CMS COPCs for springs in Cañon de Valle and Martin Spring Canyon are RDX and TNT. The selection of CMS COPCs from Phase III RFI COPCs is described in this section. Supporting data are available in the accompanying tables and in the Phase III RFI report, Appendix G (LANL 2003, 77965).

Table B-11
Phase III RFI Inorganic COPCs in Martin Spring Sediment

Chemical	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Background Value (BV)* (mg/kg)	Number of Detects Above BV	Number of Non-Detects Above BV	Percent Detected for 20 Samples or Greater(**)[b]
Aluminum	20	20	8500 to 17000	15400	1	0	100
Arsenic	20	20	2.6 to 10	3.98	7	0	100
Barium	20	20	86 to 1700	127	10	0	100
Boron	20	18	[0.0726][c] to 43	nav[d]	nav	nav	90
Cadmium	20	20	0.048 to 1	0.4	5	0	100
Chromium	20	20	5.2 to 30	10.5	7	0	100
Cobalt	20	20	2.9 to 5.8	4.73	2	0	100
Copper	20	20	4.9 to 100	11.2	7	0	100
Lead	20	20	11 to 120	19.7	9	0	100
Mercury	20	20	0.042 to 2.3	0.1	18	0	100
Selenium	20	20	0.258 to 1.58	0.3	19	0	100
Silver	20	20	1.3 to 2.2	1	20	0	100
Vanadium	20	20	9.1 to 36	19.7	3	0	100

* *Source:* Ryti, R., Longmire P., Broxton D., Reneau S., McDonald E. 1998. “Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory”. Los Alamos National Laboratory report LA-UR-98-4847. Los Alamos, New Mexico.

(**)*Source:* EPA (US Environmental Protection Agency). 1989. "Risk Assessment Guidance for Superfund Human Health Evaluation Manual, Part A" Section 5.9.3, Evaluate Frequency of Detection. July 1989. (EPA 1989, 08021).

[a] mg/kg = milligrams per kilogram.

[b] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[c] [ ] = The value in brackets is below detection limits, although some chemicals may be detected at values within this range.

[d] nav = not available

Table B-12
Phase III RFI Organic COPCs in Martin Spring Sediment

Chemical	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Percent Detected for 20 Samples or Greater(*)[b]
Amino-2,6-dinitrotoluene[4-]	20	6	0.12 to 0.36	30
Amino-4,6-dinitrotoluene[2-]	20	10	0.039 to 0.37	50
Benzo(a)anthracene	5	3	[0.0373][c] to 0.31	na[d]
Benzo(a)pyrene	5	3	[0.0336] to 0.39	na
Benzo(b)fluoranthene	5	3	[0.0362] to 0.43	na
Benzo(g,h,i)perylene	5	2	[0.0476] to 0.15	na
Benzo(k)fluoranthene	5	2	[0.0439] to 0.37	na
Benzoic Acid	5	1	[0.0253] to [0.0438]	na
Bis(2-ethylhexyl)phthalate	3	2	0.025 to [0.37]	na
	5	1	0.041 to [0.0886]	na
Chrysene	5	2	[0.0526] to 0.37	na
Fluoranthene	5	2	[0.0367] to 0.69	na
Indeno(1,2,3-cd)pyrene	5	2	[0.0466] to 0.16	na
Phenanthrene	5	2	[0.0564] to 0.4	na
Pyrene	5	3	[0.0395] to 0.89	na
RDX[e]	20	4	0.13 to 0.92	20
Trinitrotoluene[2,4,6-]	20	8	0.14 to 1	40

(*)*Source:* EPA (US Environmental Protection Agency). 1989. "Risk Assessment Guidance for Superfund Human Health Evaluation Manual, Part A" Section 5.9.3, Evaluate Frequency of Detection. July 1989. (EPA 1989, 08021).

[a] mg/kg = milligrams per kilogram.

[b] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[c] [ ] = The value in brackets is below detection limits, although some chemicals may be detected at values within this range.

[d] na = not applicable.

[e] RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

The RFI COPCs that exceed their CMS COPC screening limit are barium, mercury, nitrate-nitrite as N, perchlorate, thallium, uranium, RDX, and TNT. Supporting data are available in Tables B-13 and B-14 and in Appendix G of the Phase III RFI (LANL 2003, 77965).

The springs Phase III data set covers all springs in Cañon de Valle and Martin Spring Canyon, including SWSC Spring, Burning Ground Spring, and Martin Spring. Currently, only Burning Ground Spring is flowing.

Barium exceeded the CMS COPC screening limit (1000 µg/L) only once in 193 sample results. Concentrations of barium in springs have been relatively consistent, in the 100 to 300 µg/L range. Barium has been detected in R-25, though concentrations are at least a factor of 10 lower than the screening limit (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons it is not included in the list of CMS COPCs for springs.

Mercury was detected in 6 percent of samples, of which 1 of 12 exceeded the screening limit. Mercury is not a CMS COPC with respect to R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons mercury is excluded as a CMS COPC for springs.

All analytical results for nitrate-nitrite as N fell below the screening limit at Burning Ground Spring. At Martin Spring, 2 of 31 sample results exceeded the screening limit. At SWSC Spring, 2 of 23 samples exceeded the screening limit. In addition, nitrate-nitrite as N is not a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, it is therefore eliminated as a CMS COPC.

According to the Phase III RFI data for the springs, perchlorate was detected above its screening limit in 14 of 70 samples from SWSC Spring, Burning Ground Spring, and Martin Spring during 2000–2001. Sample results from 2002 did not exceed the screening limit. Moreover, perchlorate has not been detected in R-25 regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, perchlorate is not included as a CMS COPC for springs.

Thallium was detected in 28 percent of samples, of which 5 of 56 sample results exceeded the screening limit. One sample result from R-25 regional groundwater sampling results exceeded the screening limit (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5); all other results fell below the screening limit. For these reason, thallium is eliminated as a CMS COPC for springs.

Uranium was detected in 69 percent of samples. One sample (of 43) was equal to the screening limit, with all others below the screening limit. Uranium is not a CMS COPC with respect to regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, uranium is excluded as a CMS COPC.

Both RDX and TNT are present in springs water, although TNT exceeded its screening limit only once in springs water. RDX exceeded its screening limit in all sample results. Both compounds are present in regional groundwater (LANL 2001, 70295.5; LANL 2001, 71368.5; and LANL 2002, 73712.5). For these reasons, RDX and TNT are included as CMS COPCs.

Table B-13
Phase III RFI Inorganic COPCs in Springs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Antimony	Max. Detected Value	4.7 (J)[b]	na[c]	6	na	No	16
	Max. Undetected Value	20 (U)[d]	na	6	na	Yes	
Barium	Max. Detected Value	1310	1000[e]	2000	na	Yes	100
Boron	Max. Detected Value	2840	750[f]	nav[g]	na	Yes	76
	Max. Undetected Value	500 (U)	750[f]	nav	na	No	
Cesium	Max. Detected Value	500	nav	nav	nav	nav	na
	Max. Undetected Value	500 (U)	nav	nav	nav	nav	
Cyanide (Total)	Max. Detected Value	3.2 (J)	5.2[h]	200	na	No	na
	Max. Undetected Value	13 (U)	5.2[h]	200	na	Yes	
Mercury	Max. Detected Value	1	0.77[i]	2	na	Yes	6
	Max. Undetected Value	0.2 (U)	0.77[i]	2	na	No	
Nitrate-Nitrite as N	Max. Detected Value	3800000	10000[e]	nav	na	Yes	97
	Max. Undetected Value	1000 (U)	10000[e]	nav	na	No	
Perchlorate	Max. Detected Value	17.5	4[j]	nav	na	Yes	11
	Max. Undetected Value	958 (U)	4[j]	nav	na	Yes	
Rubidium	Max. Detected Value	7000	nav	nav	nav	nav	na
	Max. Undetected Value	500 (U)	nav	nav	nav	nav	
Thallium	Max. Detected Value	7.1 (J)	na	2	na	Yes	28
	Max. Undetected Value	7.6 (U)	na	2	na	Yes	

Table B-13 (continued)
Phase III RFI Inorganic COPCs in Springs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Uranium	Max. Detected Value	60	5000[e]	30	na	Yes	69
	Max. Undetected Value	126 (U)	5000[e]	30	na	Yes	

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; EPA 1989, 08021; and California DHS 2003, 76862.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of undetects not reported by this table.

[b] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[c] na = not applicable.

[d] (U) = The chemical is classified "undetected."

[e] NMWQCC Groundwater Human Health Standard (20 NMAC 6.2.3103).

[f] NMWQCC Groundwater Standard for Irrigation Use (20 NMAC 6.2.3103).

[g] nav = not available.

[h] NMWQCC Surface Water Standard for Wildlife Habitat (20 NMAC 6.4.900).

[i] NMWQCC Groundwater Other Standards for Domestic Water Supply (20 NMAC 6.2.3103).

[j] 2003 California DHS Action Level.

Table B-14
Phase III RFI Organic COPCs in Springs

Chemical	Sample Concentration (µg/L)		NMWQCC Standard (µg/L)	EPA MCL (µg/L)	EPA Region 6 Tap Water PRG (µg/L)	Exceeds Screening Limit	Percent Detected for 20 Samples or Greater[a]
Dinitrobenzene[1,3-]	Max. Detected Value	1.1	nav[b]	nav	3.7	No	5
	Max. Undetected Value	20 (U)[c]	nav	nav	3.7	Yes	
Nitrobenzene	Max. Detected Value	2.4 (J)[d]	na[e]	nav	3.4	No	3
	Max. Undetected Value	200 (U)	na	nav	3.4	Yes	
RDX	Max. Detected Value	330 (J+)[f]	nav	nav	0.61	Yes	98
	Max. Undetected Value	91.3 (UJ)[g]	nav	nav	0.61	Yes	
TNT	Max. Detected Value	3	nav	nav	2.2	Yes	5
	Max. Undetected Value	20 (U)	nav	nav	2.2	Yes	

Sources: 20 NMAC 6.2.3103, “Standards for groundwater of 10,000 mg/l TDS concentration or less,” Parts A, B and C; EPA 2002, 76871; EPA 2003, 76867; and EPA 1989, 08021.

[a] The percent detection value is calculated based on all analyses taken for a chemical. Resulting values might therefore appear less than expected due to the inclusion of

[b] nav = not available.

[c] (U) = The chemical is classified "not detected."

[d] (J) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual.

[e] na = not applicable.

[f] (J+) = The chemical is classified "detected," but the reported concentration value is expected to be more uncertain than usual with a potential high bias.

[g] (UJ) = The chemical is classified "not detected" with an expectation that the reported result is more uncertain than usual.

Appendix C

Corrective Measure Alternative Cost Estimates

Appendix D

Public Involvement Plan

Los Alamos
NATIONAL LABORATORY

Corrective Measures Study
SWMU 16-021(c)-99, TA-16
Public Involvement Plan

2 December 2003

RRES

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Public Involvement Plan

Purpose of Public Involvement

As described in Section Q, Task II, Section D of Module VIII of the Laboratory's Hazardous Waste Facility permit, the Laboratory is required to incorporate community relations planning into the Corrective Measures Study process. Risk Reduction and Environmental Stewardship–Remediation Services (RRES-RS) has developed an outreach program to provide the public timely and complete access to information and the decision-making process.

This public involvement plan identifies specific activities that the Laboratory will undertake to disseminate information and facilitate public involvement during the CMS project at Solid Waste Management Unit (SWMU) 16-021(c)-99. This plan is considered a working document; therefore some of the processes or schedule may change throughout the duration of the project. The objectives of the plan are to:

- provide the public/stakeholders with timely and objective information to assist them in understanding the potential risks associated with the site, the proposed remediation alternatives, and solutions;
- provide interpretations of data
- ensure that the public/stakeholders concerns are understood and considered in the decision-making process;
- provide the surrounding communities with public access to RRES-RS program technical staff; and,
- increase RRES-RS contact with the public/stakeholders in ways that encourage interaction and involvement in the corrective action process.
- The RRES-RS Program is accountable to:
- anyone who resides in the communities surrounding the Laboratory or has an interest in the activities of the Resource Conservation and Recovery Act (RCRA) corrective action process at the Laboratory,
- organizations representing or protecting specific groups or interests in our region, and
- public agencies including local, state, federal, and tribal governments.

Project Description

TA-16 was established during World War II for the development of explosive formulations, production and machining of explosive charges, and the assembly and testing of explosive components for the U.S. nuclear weapons program. Present-day use of this site is essentially unchanged, although facilities have been upgraded and expanded as explosive and manufacturing technologies have advanced.

The TA-16-260 facility is a high explosive- (HE) machining building that processes large quantities of HE. Machine turnings and HE wastewater were routed as waste to 13 sumps associated with the building. Historically, discharge from the sumps was routed to an outfall that was permitted to operate by the EPA as EPA 05A056 under the Laboratory's National Pollution Discharge Elimination System (NPDES) permit. The last NPDES permitting effort for this outfall occurred in 1994. The NPDES outfall was deactivated in November 1996, and it was officially removed from the Laboratory's NPDES permit by the EPA in January 1998.

The outfall, drainage channel below the outfall, and underlying alluvium and vadose zone are contaminated with the primary chemicals of potential concern, primarily HE wastes and barium. The combined areas of the outfall, pond area, and drainage are designated as SWMU 16-021(c)-99. Potential exposure pathways to human and ecological receptors include ingestion of groundwater and surface water, soil and sediment inhalation of suspended particulate matter, adsorption through dermal contact with affected soils or water, and ingestion related to food chain effects.

TA-16 is located in the southwest corner of the Laboratory. It covers 2410 acres, or 3.8 square mi. The land is a portion of that acquired by the Department of Army for the Manhattan Project in 1943. TA-16 is bordered by Bandelier National Monument along State Road 4 to the south and by the Santa Fe National Forest along State Road 501 to the west. To the north and east, it is bordered by TA-8, -9, -14, -15, and -49. TA-16 is fenced and posted along State Road 4. Water Canyon, a 200-ft-deep ravine with steep walls, separates State Road 4 from active sites at TA-16. Cañon de Valle forms the northern border of TA-16. Security fences surround the production facilities.

The Laboratory has implemented a phased corrective action program for SWMU 16-021(c)-99 in accordance with the requirements of Module VIII of the HSWA permit. The corrective action process, including those phases currently being implemented, include the following:

- RCRA facility assessment (RFA),
- Phase I RFI,
- RFI Phase II,
- Interim measure (IM) of source removal,
- RFI Phase III,
- CMS (current), and,
- Corrective Measure Implementation (CMI) (future).

Target Audience

For the purposes of this plan, the public includes all individuals, organizations, or public agencies potentially affected by the CMS phase of the project. Surrounding communities potentially affected by the CMS include Los Alamos County, San Ildefonso Pueblo, Santa Clara Pueblo, Cochiti Pueblo, Santa Fe, and Espanola and smaller communities.

Project Objectives

The purpose of the CMS is to evaluate the alternatives for remediation, and propose corrective measures, media cleanup standards, and a long–term monitoring program for SWMU 16-021(c)-99 and nearby Cañon de Valle and Martin Spring Canyon.

Proposed activities, purpose and date

Activity	Purpose	Projected Date
Mailer to Laboratory's mailing list, composed of individuals, organizations, and government and tribal officials in northern New Mexico	Introduce RRES-RS program, the SWMU-021(c)-99 High Performing Team, the RCRA corrective action process and the current RFI/CMS phases of the project. Notify public of planned open house.	December 2003, and every 6 months throughout the CMS/CMI.
Information Sheet to be posted on-line and made available in public reading room	Highlight the history and current activities at SWMU-16-021(c)-99 site. Provide update of CMS status.	January 2003, and every 6 months throughout the CMS/CMI.
Newspaper notice informing the public about SWMU-021(c)-99 activities	Placed in the Albuquerque Journal North, Santa Fe New Mexican, Rio Grand Sun, and the Los Alamos Monitor to advise the public on general project activities. Notify public of planned open house.	January 2003, and every 6 months throughout the CMS/CMI.
Open house hosted at Los Alamos Area Office or elsewhere	Provide informal overview through posters, handouts, and provide for interaction/Q&A with RRES-RS program staff.	January 2003, and every 6 months throughout the CMS/CMI.
Web Site at http://erproject.lanl.gov/	Access to all RFI and CMS documentation on the RRES-RS virtual library web site, and available at the Laboratory's Public Reading Room. Documents posted will include the CMS Plan and the CMS Report.	January 2003, and every 6 months throughout the CMS/CMI.
Tour of Cañon de Valle	Tour to view site setting, site habitat, and other site conditions.	May, 2003
Public comments to be maintained and made available on-line	Comments will be solicited throughout the project via all mechanisms listed above. The RRES-RS project staff will identify major public concerns.	January 2003, and every 6 months throughout the CMS/CMI.

Key Messages

The CMS process proposes preferred alternatives for site remediation. The choice of a preferred alternative involved criteria such as effectiveness, reliability, safety, ability to meet the remediation objectives, institutional constraints, and cost. At this site, additional important factors for consideration include the presence of wetlands and Mexican Spotted Owl habitat in Canon de Valle. The proposed preferred alternatives are the result of a balanced approach that considers these criteria and factors.

Key Contacts

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