FINAL NATURAL RESOURCE DAMAGE ASSESSMENT PLAN FOR LOS ALAMOS NATIONAL LABORATORY

Prepared by

The Los Alamos National Laboratory Natural Resource Trustee Council

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TABLE OF CONTENTS

LIST OF EXHIBITS

LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
BLM	Bureau of Land Management
BVs	Background Values
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Consent Order	Compliance Order on Consent
CWA	Clean Water Act
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DPU	Los Alamos Department of Public Utilities
FWS	U.S. Fish and Wildlife Service
HEA	Habitat Equivalency Analysis
LANL	Los Alamos National Laboratory
LANLTC	Los Alamos National Laboratory Natural Resource Trustee Council
MDA	Materials Disposal Area
MOA	Memorandum of Agreement
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
PCBs	Polychlorinated biphenyls
Plan	Natural Resource Damage Assessment Plan
PAS	Preassessment Screen
PPP	Public Participation Plan
PRS	Potential Release Site
QMP	Quality Management Plan
RCDP	Restoration and Compensation Determination Plan
REA	Resource Equivalence Analysis

RSRLs	Regional Statistical Reference Levels
SDWA	Safe Drinking Water Act
SWMU	Solid Waste Management Unit
TA	Technical Area
TEV	Total Economic Value
VCNP	Valles Caldera National Preserve

EXECUTIVE SUMMARY

The Los Alamos National Laboratory (LANL) is a U.S. Department of Energy (DOE) facility in north-central New Mexico. Scientific research began at LANL in 1943 with U.S. government efforts to develop and test nuclear weapons. In recent decades, operations at LANL have broadened to include research pertaining to national security, energy resources, and environmental quality. This document serves as the LANL Natural Resource Damage Assessment (NRDA) Plan (Plan). The development of a Plan is intended to ensure that the NRDA is conducted in a planned and systematic manner and at a reasonable cost (43 C.F.R. § 11.30(b)).

Public lands, waters, air, and living resources are held in trust for the benefit of all people and future generations. Since the 1970s, the U.S. Congress has enacted a number of statutes to protect and manage the natural resources that belong to all Americans. Several of these statutes designate natural resource trustees to serve as stewards of natural resources on behalf of the public.[1] In particular, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §§ 9601 to 9675) includes provisions to conduct a NRDA (42 U.S.C. § 9607(f)) -- a process for replacement, restoration, rehabilitation, or acquisition of equivalent resources injured by the release of hazardous substances. This process is codified in the Department of the Interior regulations (43 C.F.R. §11). The trustees for natural resources in and around LANL, as well as the NRDA process, are discussed in greater detail below.

Trustees undertake natural resource damage assessments on behalf of the public. The purpose of these assessments is to define the scope and scale of natural resource restoration required to make the public whole for natural resource injuries and associated service losses.

Since 1943, activities on the LANL site have resulted in the release of radiological and other hazardous contaminants into the environment. Cleanup of the site and decommissioning began as early as the 1970s, and will likely continue for several more

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[1] More specifically, CERCLA as amended (42 U.S.C. 9601 *et. seq.*), the Oil Pollution Act of 1990 (OPA) (33 U.S.C. 2701 *et. seq.)* and the Federal Water Pollution Control Act (the "Clean Water Act" (CWA)), as amended (33 U.S.C. 1251 *et. seq.*), authorize the Federal government, states, and Indian tribes to recover, on behalf of the public, damages for injuries to, destruction of, or loss of natural resources belonging to, managed by, appertaining to, or otherwise controlled by them (42 U.S.C § 9607(f)(1); 9601(16)). Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), when there is injury to, destruction of, loss of, or threat to the supporting ecosystems of natural resources, the Trustees are also authorized to act (40 C.F.R. Subpart G § 300.600).

years. While cleanup efforts continue, trustees of natural resources in and around LANL are conducting a NRDA.

This Plan describes the LANL Trustees' current understanding of the assessment work necessary to complete the NRDA. Inclusion of an assessment activity in this Plan does not guarantee it will be undertaken, and implementation of initial studies may result in the addition of studies to the current list or may deprioritize others.

THE LANL TRUSTEES

Designated Federal, state, and Tribal governments are authorized to act as trustees of natural resources on behalf of the public. In this role, trustees may assess and recover damages for natural resource injuries resulting from the release of hazardous substances or oil to the environment. The Los Alamos National Laboratory Natural Resource Trustee Council (LANLTC) includes representatives from the following organizations:

- DOE.
- The U.S. Department of Agriculture, acting through the Forest Service.
- Pueblo of Jemez.
- Pueblo de San Ildefonso.
- Santa Clara Pueblo.
- The State of New Mexico, acting through the Natural Resources Trustee of the Office of Natural Resources Trustee.

The party responsible for discharges and releases of oil or hazardous substances at this site (i.e., the "responsible party") is DOE. DOE is also responsible for site remediation. In addition, as noted above, DOE is a Trustee. The LANLTC has agreed to follow a cooperative assessment process, as recommended by the Department of the Interior (DOI) NRDA regulations, meaning that DOE and the other Trustees are jointly and collaboratively conducting the assessment.

THE NRDA PROCESS

The ultimate goal of the assessment is to replace, restore, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances. To achieve this goal, trustees will complete a number of interim steps, which are outlined within the DOI NRDA regulations promulgated pursuant to the principal NRDA statutes, including CERCLA, and which can generally be divided into three sequential phases.[2] These phases are presented graphically in Exhibit ES-1, and are described below.

In the **Preassessment Phase**, a review of readily available information is conducted that allows the trustees to make an early decision as to whether a NRDA can and should be performed. During this phase, the trustees determine whether an injury has occurred and

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[2] 43 C.F.R. Part 11.

if a pathway of exposure exists.[3] The preassessment phase is a pre-requisite to conducting a formal assessment. The LANLTC has completed this process and released a Preassessment Screen (PAS) in January 2010 (LANLTC 2010). The PAS confirmed that a formal assessment of injuries to resources is warranted.

Development of the present Plan, indicated by a red outline in Exhibit ES-1, is the first step within the **Assessment Phase** of a NRDA. There are two primary components of the Assessment Phase: planning and implementation. First, the trustees must write a plan to ensure that the assessment is performed in a systematic manner, and that the methodologies selected can be conducted at a reasonable cost. Second, the Plan is implemented.

After completing injury determination, injury quantification, and damages determination, the trustees enter the **Post-Assessment Phase.** As part of this phase, the LANLTC will prepare: (1) a Report of Assessment detailing the results of the Assessment Phase; and (2) a Restoration Plan that describes how natural resources and the services they provide will be restored.

Although the various phases and steps of a NRDA are set forth as a sequential process within the DOI NRDA regulations, in practice, assessment of different natural resources may occur at different rates: for some categories of injury the LANLTC may choose to proceed through the steps in a sequential order; in others the availability of existing information or the ability to establish reasonably conservative assumptions may allow the LANLTC to take an alternative, but still sound, approach to establishing the scale and scope of required restoration. For example, the LANLTC may from time to time identify early restoration opportunities — i.e., chances to commence with a restoration project before the assessment is complete. Because these opportunities may be short-lived in duration, the LANLTC may agree to pursue them and to eventually include them as a part of the offset of resource injuries. Prior to agreement and implementation of early restoration projects, the LANLTC intends to enter into an early restoration memorandum of agreement.

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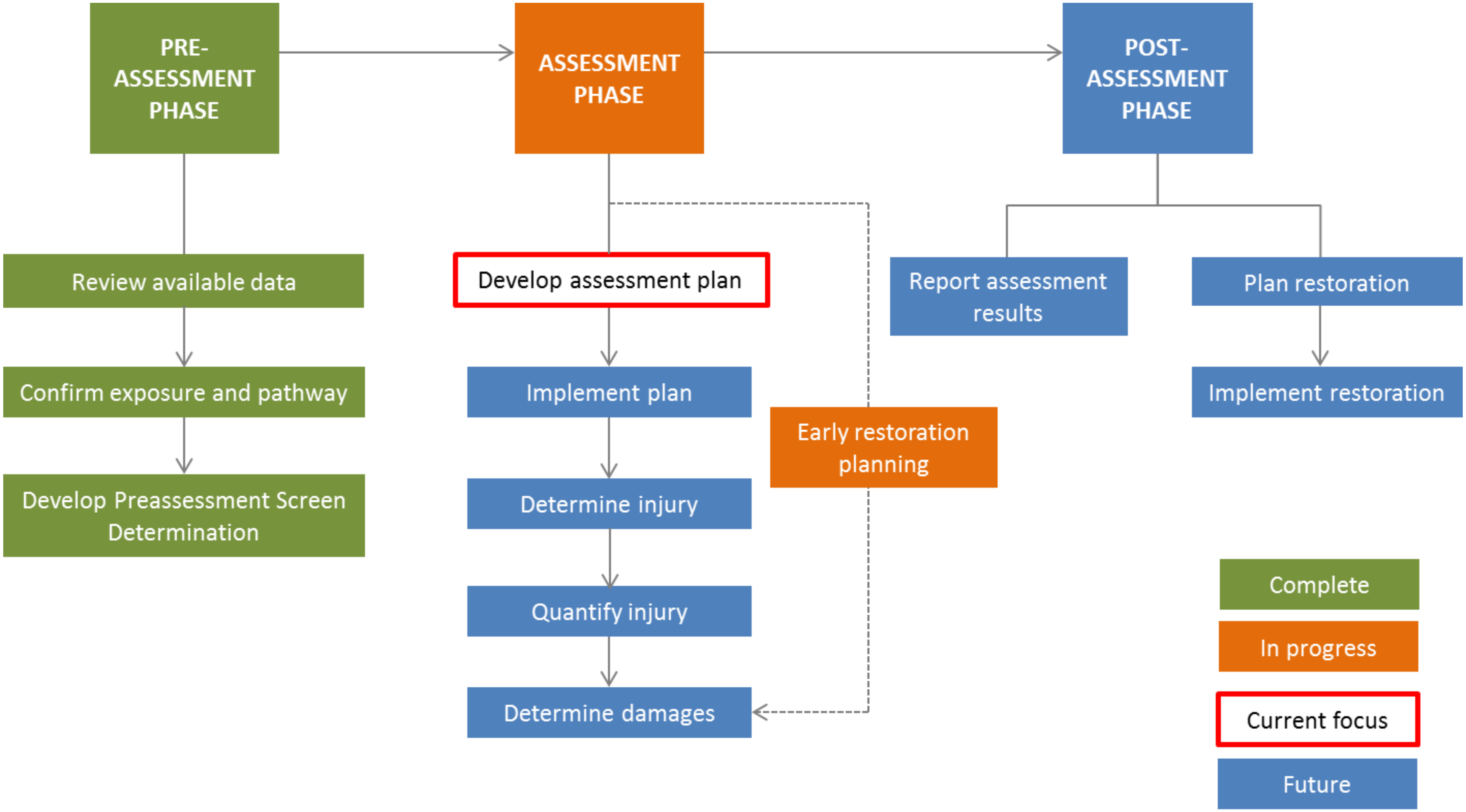
[3] “Injury” is generally defined in the regulations as a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substance” (43 C.F.R. § 11.14(v)).

EXHIBIT ES-1 PHASES OF THE NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS



NATURAL RESOURCES AND RESOURCE SERVICES

LANL, made up of various mesas, canyons, and adjacent aquatic habitat in the Rio Grande, is situated in a semi-arid region that supports a variety of ecosystems and associated natural resources (LANL 2006a). Natural resources are defined in the DOI NRDA regulations as "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources…" (43 C.F.R. §11.14(z)). Natural resources potentially affected by the release of hazardous substances from LANL operations include, but may not be limited to: surface water, groundwater, sediment, soil, plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. Unique habitats found in and around LANL that may have been exposed to contaminants range from a juniper-savanna community along the Rio Grande, the aquatic habitat in the Rio Grande, a mixture of piñon-juniper woodland, ponderosa pine communities, mixed conifer forests, and spruce-fir forests on the mesa tops, to wetland and riparian habitat where ephemeral or intermittent streams flow through the canyons.

Over 1,370 species of flora and fauna have been identified at LANL, including 256 species of plants, 246 species of fungi, 193 species of insects and arthropods, 140 species of birds, 64 species of mammals, and 24 species of reptiles (LANL 1997). Federally listed species potentially inhabiting LANL include the black-footed ferret, Southwestern willow flycatcher, and Mexican spotted owl. There are also a number of sensitive species in the area including the Rio Grande chub, Jemez Mountains salamander, and the spotted bat (LANL 2011c).

Ecosystems and resources in and around LANL provide a wide-range of services, including both ecological and human services. Ecological services are those services provided by natural resources that benefit wildlife and ecosystems. Human services include the services natural resources provide to humans. The DOI NRDA regulations define services as the "physical and biological functions performed by the resource including the human uses of those functions" (43 C.F.R. § 11.14(nn)). Natural resource services are "a metric for measuring resource conditions and resource restoration" (73 Fed. Reg. 57,259) and, as such, they are compensable if they are reduced as a result of a release of hazardous substances. In addition, natural resource services can provide the metric by which natural resource injuries and the benefits of natural resource restoration may be quantified.

Human services generally fall into two categories at LANL, recreational uses and Pueblo community services. Pueblo members may utilize natural resources to an extent and in ways that are different from the general population, and natural resources also may play a different role in Pueblo communities than they do in other sub-populations in and around LANL.

Examples of ecological and human services provided by LANL natural resources include:

- Surface water and sediment resources: habitat for invertebrates and other aquatic organisms; recreational services including fishing, swimming, and boating; Pueblo services such as provision of clay and subsistence fishing;

- Soil resources: nutritive substrate for the growth of plants, shelter for burrowing animals, and cleansing of groundwater as it passes through soils;
- Groundwater resources: clean groundwater discharging to surface waters, human use services such as drinking water, nonuse option values; and
- Biota: nutrient cycling services, pollination, as food sources for other animals and humans, nonuse existence values.

More information on LANL natural resources and resource services is provided in Chapter 2.

ASSESSMENT PHASE ACTIVITIES

The LANLTC is currently in the assessment phase of the NRDA. The assessment involves a number of steps, described in more detail in Chapters 3-5, including assessment planning, pathway determination, injury determination, injury quantification, damage determination, and restoration.

INJURY DETERMINATION

Determining injury to natural resources under the DOI's NRDA regulations consists of documentation that there is: (1) a pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and (2) injury of a natural resource of interest (i.e., surface water, sediment, soil, groundwater, biota), as defined in 43 C.F.R. § 11.62. The LANLTC anticipates applying a variety of approaches to determine if an injury to a natural resource has occurred, ranging from comparisons of hazardous contaminant concentrations to promulgated thresholds to identifying measurable adverse changes in resources.

INJURY QUANTIFICATION

Once injury to natural resources has been documented, the LANLTC will quantify the injury for the resources (43 C.F.R. § 11.70(a)(1)). The purpose of the injury quantification step is to define the scope of lost ecological services (compared to baseline services) and natural resource injuries, and to allow for selection and scaling of restoration projects. Quantified injuries form the basis for scaling restoration projects designed to compensate the public for lost or injured natural resources, consistent with the intention of the DOI regulations to restore natural resources.

The LANLTC will likely quantify ecological injury in terms of the magnitude of adverse change to the resource and associated lost services on a habitat basis, but may also quantify injury to specific resources of concern using a resource equivalency approach.[4] For groundwater resources, the LANLTC will likely quantify losses using a resource equivalency approach to estimate the amount of restoration needed to compensate for the nature and extent of groundwater injury. The volume of injured groundwater will be

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[4] A habitat equivalency analysis involves generating a quantitative estimate of services loss in a specific geographic area; whereas a resource equivalency analysis focuses on quantifying lost ecosystem services to a specific species or species group.

calculated as a stock or a flux and the associated lost services will be estimated in comparison to baseline conditions. With the exception of evaluating in greater detail the extent to which institutional controls are used in and around LANL to limit public access, the LANLTC does not anticipate assessing potential recreational use losses at this time. For Pueblo losses, the LANLTC expects to quantify impacts to Pueblo communities using a variety of approaches, to be determined by the Pueblos.

DAMAGES DETERMINATION AND RESTORATION

Once injuries to natural resources in the assessment area are quantified, the LANLTC will determine the appropriate scale of damages required to fully compensate the public. Damages represent "the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources" (43 C.F.R. § 11.14(l)). In this case, the LANLTC anticipates calculating natural resource damages by determining the appropriate scale of restoration projects needed to fully compensate for quantified injuries, and calculating damages as the cost, in dollars, to perform the restoration projects. If possible, the LANLTC may pursue primary restoration (i.e., restoration of resources injured by releases from LANL) in connection with the remedy. However, primary restoration may not always be possible, and further, will likely not be sufficient to compensate the public for the time period, prior to restoration, that the public has experienced a loss of natural resources and associated services (i.e., "interim losses"). Hence, the LANLTC will focus on pursuing compensatory restoration (i.e., restoration of injured resources of similar type and quality to resources injured as a result of LANL releases) to offset the injuries and losses that have occurred.

PROPOSED ACTIVITIES FOR THE ASSESSMENT

As noted above, this Plan represents the LANLTC's current understanding of the activities that may be necessary to identify and quantify injury to natural resources and their services in and around LANL, and to determine the appropriate scale and scope of restoration. Inclusion of an activity within this Plan does not guarantee that it will be undertaken, and efforts and analyses not included within the Plan may be deemed necessary at a later date. As such, this Plan is not intended to limit the extent and nature of studies that may be undertaken in the course of the assessment, but to provide a framework within which the LANLTC will begin to prioritize efforts and implement the NRDA. The identified activities fall generally within four categories:

1. **Use of existing data to identify potential injury to site resources.**

   A large volume of environmental data has been collected both on LANL and from adjacent areas in the past few decades. These data represent a valuable source of information on the past and recent condition of natural resources, and they will be used, to the extent possible, to help evaluate occurrence and magnitude of potential injury. Analyses that may be undertaken include the comparison of existing data measuring concentrations of contaminants in various environmental media (e.g., surface water, groundwater, sediment, and soil) to selected injury thresholds, and review of scientific studies conducted on-site for non-assessment purposes, but which may present results related to the condition of natural resources and/or the potential for resource injury to have occurred as a result of hazard substance releases.[5]

2. **Collection of new data and analysis of existing information on groundwater and human use services.**

   Collection of additional data and the compilation of existing information on the services provided by groundwater under baseline conditions and uncertainties with respect to quantifying the injury to groundwater (i.e., volume of injured groundwater) as well as information on lost human uses, particularly Pueblo community uses, are warranted. For example, the LANLTC anticipates undertaking an effort to talk with regional groundwater experts on the potential services groundwater provides at and around LANL; an effort to assess the potential human use losses resulting from institutional controls related to the release of hazardous substances at LANL; and a number of activities to assess potential impacts to Pueblo communities.

3. **Field collection of additional ecological data to determine injury to site resources and changes in resource services.**

   Preliminary analyses of existing site data by the LANLTC has indicated that additional data collection to fully characterize contamination and injury to site resources may be warranted. For example, biota sampling data are currently limited and additional information on exposure and adverse effects in birds, mammals, reptiles, and amphibians is warranted. Collection of new data to fill existing gaps or to answer questions raised through the analysis of existing data, will likely represent a significant proportion of activities conducted as part of the assessment.

4. **Quantification and damages studies to identify and scale restoration.**

   Once the injury analyses have been completed, the LANLTC will undertake efforts to use the information on natural resource injuries and associated service losses to identify restoration projects needed to compensate for lost ecological, groundwater, and human services (either specific projects or the types of projects), the scale of such projects, and establish the expected costs (on a specific project basis or based on estimated unit-costs for the types of restoration projects identified).

TIMING / RELATIVE PRIORITIZATION

To help guide future assessment efforts, the LANLTC has grouped planned assessment activities into four informal categories. The assignment of an activity to a particular

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[5] An "injury threshold" is a concentration of a contaminant found in a given media type or resource which has been demonstrated (e.g., in the peer-reviewed scientific literature) to cause a "…measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource" (43 C.F.R. § 11.14(v)).

category (and, therefore, the expected relative prioritization of the effort) is based on a variety of factors including but not necessarily limited to:

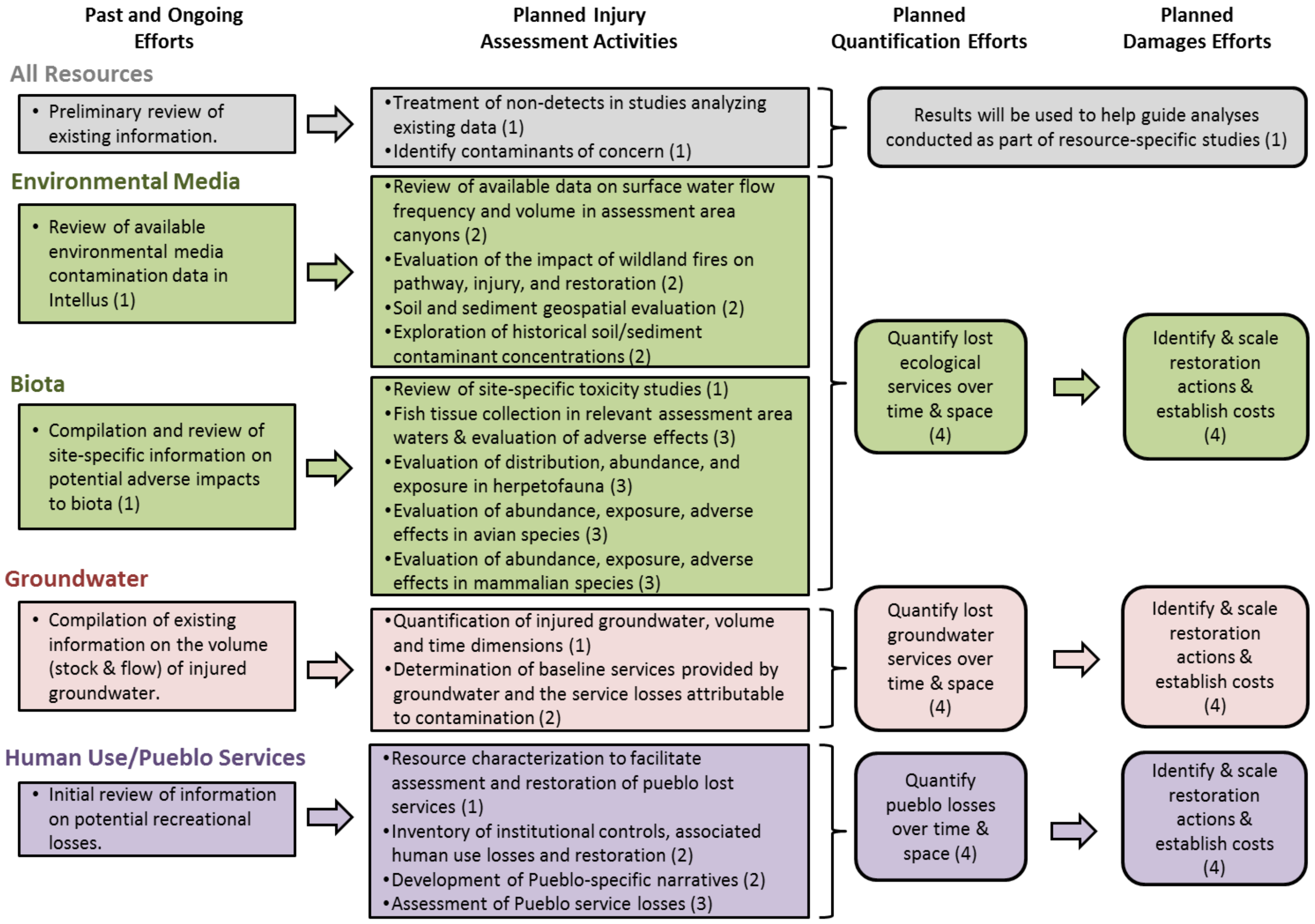
- use of existing information;
- likely cost effectiveness;
- technical sequencing requirements (i.e., some studies may have a higher priority if the activity needs to be completed earlier in the assessment process because it generates data or results upon which subsequent assessment efforts are based or vice versa for efforts that are to be completed later in the process);
- efforts that, in the LANLTC's view, may be more likely to clarify the existence or extent of injury; and/or,
- efforts most likely to contribute to the understanding of the appropriate scale and scope of required restoration.

Based on these types of considerations, the LANLTC has grouped the assessment activities in this Plan into the following four categories:

1. Initial priorities,
2. Nearer-term priorities,
3. Middle-term priorities, and
4. Longer-term priorities.

Initial priorities are those activities the LANLTC believes will help frame the assessment of ecological, groundwater, human use, and Pueblo losses and include evaluations of existing information and analyses that are presently ongoing. The nearer-term priorities are assessment activities that are expected to generate information of significant use for planning future efforts (e.g., in determining whether future field work is warranted and in refining potential field study designs or data analyses) and include efforts involving the analysis or evaluation of information that can be obtained through literature searches and/or interviews (i.e., does not require field sampling). Middle-term priorities include efforts expected to generate information of significant use in understanding the scale and scope of injury and required restoration, and field-study collection efforts (that are deemed warranted after the analysis of existing information). Longer-term priorities include remaining activities that depend on the prior completion of other efforts. Exhibit ES-2 lists the assessment activities identified in this Plan, and indicates the current relative priority group assigned to each effort (i.e., 1, 2, 3, or 4; with 1 being the highest relative priority) in parentheses.

EXHIBIT ES-2 PLANNED ASSESSMENT ACTIVITIES AND PRIORITIZATION CATEGORIES



Past and Ongoing Efforts | **Planned Injury Assessment Activities** | **Planned Quantification Efforts** | **Planned Damages Efforts**

All Resources

- Preliminary review of existing information.

- Treatment of non-detects in studies analyzing existing data (1)
- Identify contaminants of concern (1)

Results will be used to help guide analyses conducted as part of resource-specific studies (1)

Environmental Media

- Review of available environmental media contamination data in Intellus (1)

- Review of available data on surface water flow frequency and volume in assessment area canyons (2)
- Evaluation of the impact of wildland fires on pathway, injury, and restoration (2)
- Soil and sediment geospatial evaluation (2)
- Exploration of historical soil/sediment contaminant concentrations (2)

Biota

- Compilation and review of site-specific information on potential adverse impacts to biota (1)

- Review of site-specific toxicity studies (1)
- Fish tissue collection in relevant assessment area waters & evaluation of adverse effects (3)
- Evaluation of distribution, abundance, and exposure in herpetofauna (3)
- Evaluation of abundance, exposure, adverse effects in avian species (3)
- Evaluation of abundance, exposure, adverse effects in mammalian species (3)

Quantify lost ecological services over time & space (4)

Identify & scale restoration actions & establish costs (4)

Groundwater

- Compilation of existing information on the volume (stock & flow) of injured groundwater.

- Quantification of injured groundwater, volume and time dimensions (1)
- Determination of baseline services provided by groundwater and the service losses attributable to contamination (2)

Quantify lost groundwater services over time & space (4)

Identify & scale restoration actions & establish costs (4)

Human Use/Pueblo Services

- Initial review of information on potential recreational losses.

- Resource characterization to facilitate assessment and restoration of pueblo lost services (1)
- Inventory of institutional controls, associated human use losses and restoration (2)
- Development of Pueblo-specific narratives (2)
- Assessment of Pueblo service losses (3)

Quantify pueblo losses over time & space (4)

Identify & scale restoration actions & establish costs (4)

Notes: Efforts reflected in this exhibit do not match directly to those described in Chapter 6 since some activities are split up in this exhibit to illustrate the connections between various activities. Efforts without a prioritization ranking are activities that have already been completed. Restoration actions may include primary restoration (actions to restore injured resources) or compensatory restoration (actions to restore resources of similar type and quality elsewhere).

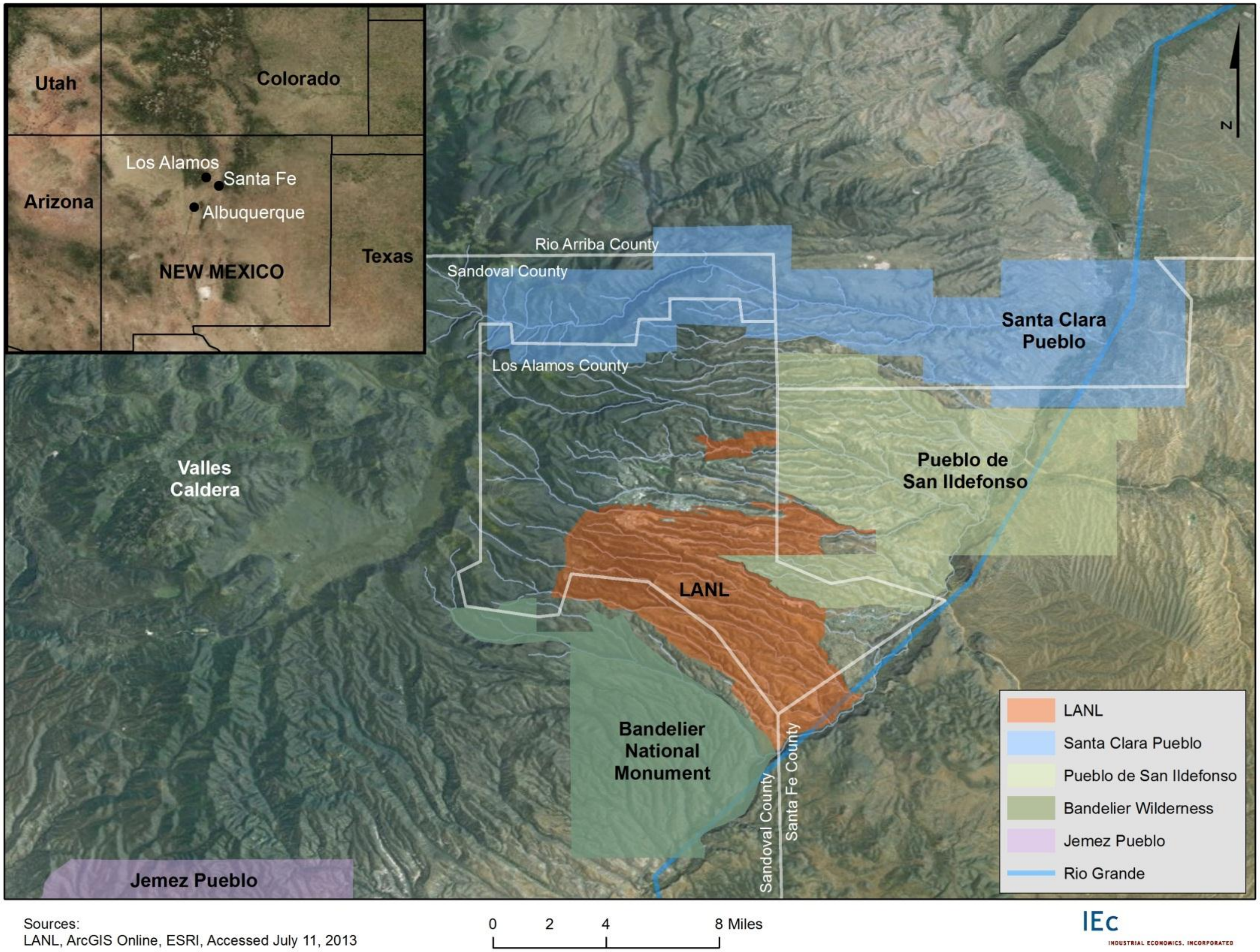
CHAPTER 1 | INTRODUCTION AND BACKGROUND INFORMATION

LANL is a DOE facility situated on approximately 27,500 acres (approximately 40 square miles) in north-central New Mexico, approximately 60 miles north of Albuquerque and 25 miles northwest of Santa Fe (Exhibit 1-1). Scientific research began at LANL in March of 1943 with the inception of Project Y of the Manhattan Project, the U.S. government's effort to develop and test nuclear weapons. In recent decades, operations at LANL have broadened beyond nuclear weapons development to include missions pertaining to "national security, energy resources, environmental quality, and science" (DOE 1999 p. S-1).

Operations conducted at LANL have resulted in the release of hazardous substances to the environment. Under Federal law, Federal, state, and Tribal governments are authorized to act as trustees of natural resources on behalf of the public (e.g., CERCLA, 42 U.S.C. § 9607 (f); see also 43 C.F.R. §11). In this role, it is the responsibility of the trustees to plan and implement actions to restore, replace, or acquire the equivalent of natural resources and resource services injured as a result of the release of hazardous substances to the environment. Trustees may conduct a NRDA to assess and recover damages from the parties responsible for the release, and use those damages to implement restoration actions. Damages may include the cost of primary restoration activities to restore the injured resources and the services provided by those resources to their baseline condition (i.e., the condition that would have existed but for the release), as well as the cost of compensatory restoration actions to compensate for interim losses pending restoration (73 Fed. Reg. 57,260). All damages recovered as a result of this damage assessment will be used to undertake actions to restore, replace, or acquire the equivalent of the resources that were injured and the services those resources would have provided.

To meet its responsibilities, the LANLTC is conducting a NRDA. The NRDA process started with the development and release of the Preassessment Screen for LANL in January, 2010 (LANLTC 2010). This document, the Natural Resource Damage Assessment Plan, is intended to outline the approach the LANLTC will take to quantify injury and assess damages and restoration. This chapter presents background information and discusses the NRDA process, the assessment area, and the LANLTC. Subsequent chapters present information on natural resources in and around LANL, the services those resources provide, and the assessment approaches the

EXHIBIT 1-1 MAP OF LANL



Sources:
LANL, ArcGIS Online, ESRI, Accessed July 11, 2013

LANLTC anticipates employing in the NRDA to determine and quantify natural resource injuries, and to calculate damages. The final chapter includes assessment activities that the LANLTC anticipates undertaking.

There are numerous existing sources of information on the history of LANL (both pre-and post-Federal operations), past and ongoing hazardous substance releases, the fate and transport of those substances in the environment, the effects of these released substances in the environment, and current and ongoing remedial actions. In this Plan, we provide some of this information as context for the proposed efforts. Readers are referred to those sources cited in the References section herein for a more in-depth understanding of this information.

PURPOSE

The purpose of this Plan is to outline the approach the LANLTC will take to assess damages for injuries to natural resources stemming from releases of hazardous substances, ensuring that the NRDA is conducted in a planned and systematic manner and at a reasonable cost. It is the intent of the LANLTC that this Plan will serve as a living document, and is therefore subject to change and amendment as the NRDA progresses.

LOS ALAMOS NATIONAL LABORATORY TRUSTEESHIP AUTHORITY

The LANLTC includes representatives from the following organizations:

- DOE.
- The U.S. Department of Agriculture, acting through the Forest Service.
- Pueblo of Jemez.
- Pueblo de San Ildefonso.
- Santa Clara Pueblo.
- The State of New Mexico, acting through the Natural Resources Trustee of the Office of Natural Resources Trustee.

These Trustees have signed a Memorandum of Agreement (MOA) regarding the conduct of this NRDA. The U.S. Department of the Interior, Bureau of Indian Affairs (BIA), was a trustee signatory to the 2008 LANLTC MOA. In May 2013, the BIA withdrew from the LANLTC citing lack of dedicated authorized financial support and resources. The MOA authorizes the LANLTC to perform a variety of activities, including planning for and performing assessment activities. The MOA also “provides a framework for coordination among the Parties in accordance with the authority established under CERCLA, [the

Clean Water Act and the Oil Pollution Act]" (DOE et al. 2008, p. 2).[6] DOE and the State of New Mexico Trustee designees act as the co-lead Trustees on behalf of the LANLTC.

POTENTIALLY RESPONSIBLE PARTIES

The primary party responsible for discharges and releases of oil or hazardous substances at LANL is DOE. As noted above, DOE is also a Trustee. Other parties may be considered potentially responsible parties as additional information is obtained during the assessment.

LOS ALAMOS NATIONAL LABORATORY: SITE DESCRIPTION AND HISTORY

As noted above, LANL is an approximately 27,500 acre facility located northwest of Santa Fe, New Mexico. The assessment area is situated on the Pajarito Plateau, and is characterized by a series of narrow mesas and canyons on the western bank of the Rio Grande River between the Jemez Mountains to the West and the Sangre de Cristo Mountains to the East. The Pajarito Plateau region is bounded on the south by Cochiti Canyon, on the east by the Rio Grande, on the north by Santa Clara Canyon, and on the west by the Jemez Mountains. Bordering LANL are the town of Los Alamos to the North, the Santa Fe National Forest to the West, Bandelier National Monument to the South, and the Pueblo de San Ildefonso, and the town of White Rock to the East. Referred to as the Los Alamos Laboratory during World War II, LANL was renamed Los Alamos Scientific Laboratory in 1947, and received its current name, Los Alamos National Laboratory, in 1981 (DOE and NNSA 2008 et al.; LANL 2007).

Historical and archaeological evidence indicates that the ancestors of current inhabitants of Rio Grande Pueblos occupied extensive areas of the Pajarito Plateau, including areas of the Plateau that eventually became LANL. The Pueblo people have always used the area's natural resources for traditional and ceremonial purposes since time immemorial. Large lithic sites have been found on the mesa tops near LANL dating as far back as 4000 BC (Sando 1998b). The area potentially affected by LANL releases is part of the ancestral territories of the Pueblo de San Ildefonso, Santa Clara Pueblo, and Pueblo of Jemez, among other Pueblos, and holds significant cultural, environmental, and religious significance. The entire Pueblo life-way is natural resource-based and natural resources are inextricably intertwined with all aspects of Pueblo existence, including sustenance, shelter, economy, and religion. Although the Pueblos' current land base is but a fraction of their ancestral territories, unlike other Tribes that were moved onto reservations, the Pueblos continue to live on lands they never left and their interaction with resources on their lands and surrounding traditional territories is far more extensive than that of the general population. Therefore Pueblo members view their lands and resources as non-fungible commodities that cannot necessarily be replaced.

Over 700 years ago, the ancestors of the current Pueblo people began to construct villages on the mesas, meadows, and water corridors that drain the eastern slopes of the Jemez Mountains. From these villages, these people hunted, gathered important resources,

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[6] CWA: Clean Water Act (33 U.S.C. 1251 §§ et seq.); OPA: Oil Pollution Act (33 U.S.C. 2701).

planted various crops, and performed ceremonies, including burial of the dead. The ruins of these ancestral sites retain tremendous spiritual status for members of the modern day Pueblo communities. Furthermore, each ancestral site retains an honorable legacy and significance that is well-documented in the oral history of the people (Pueblo de San Ildefonso, 2010a).

During the westward expansion by pioneers of European origin, a portion of the Pajarito Plateau was recognized by the United States through confirmation of the so-called Ramon Vigil Land Grant, which was based on a grant to Pedro Sanchez during the period of Spanish sovereignty. The United States later purchased the Ramon Vigil Land Grant and retained 80 percent of it for inclusion in the Manhattan Project, which later became LANL. The area was used for ranching, farming, and timber production. In 1887, the Denver & Rio Grande Western Railroad began operations on the Pajarito Plateau, bringing with it an influx of homesteaders and ranchers. A portion of the original land grant was sold in 1917 by the homesteader Harold H. Brook to Ashley Pond, who established the Los Alamos Ranch School. The ranch was condemned and taken over by the Federal government in 1943 for the Manhattan Project (Pueblo de San Ildefonso, 2010b). Other lands were secured from the U.S. Forest Service and from the predominantly Hispanic homesteaders at that time (LANL 2006).

Scientific research began at the site in March of 1943 with the inception of Project Y of the Manhattan Project, which was the U.S. government's effort to develop and test nuclear weapons. Pueblo people inhabited the Pajarito Plateau and were living in accordance with their traditional beliefs and practices in and around LANL during this time. The Federal government limited access to lands and natural resources of the Pueblos during the Manhattan Project. Over the years, scientific investigations expanded into a variety of related fields, and geographically onto adjacent mesa tops. More recently, increased but still limited access has been allowed on site.

LANL is divided administratively into a number of smaller areas called Technical Areas (TAs), which were and are centers for different operations.[7] A map of LANL showing the TAs is presented in Exhibit 1-2. Operations conducted over the years at LANL have resulted in the release of hazardous substances into the environment (see Appendix A). For example, in the 1940s, radioactive liquid wastes were discharged directly into Acid Canyon, a tributary to Pueblo Canyon, as a result of operations associated with the Manhattan Project. Untreated discharges continued until 1951, when a wastewater treatment plant was constructed to manage liquid wastes for TA-51. Discharges continued, though radiological contamination was somewhat reduced due to the treatment process (LANL 1996). In addition to liquid waste disposal, radioactive and hazardous wastes were commonly buried on-site, sometimes in secret locations, because the wastes being disposed of were classified (e.g., Material Disposal Site F in TA-6 (DOE and

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[7] Currently, LANL is divided into 48 TAs. These areas include building sites, experimental areas, support facilities, roads, and utility rights-of-way, in addition to over 2,000 structures. The LANL site also consists of buffer areas for security and safety, and areas held in reserve for potential future use.

NNSA 2008 Appendix I; U.S. Energy Research and Development Administration 1977, LA-6848-MS).

Remedial activities and decommissioning began at LANL as early as the 1970s (Exhibit 1-3). Beginning in 1989, DOE began remedial activities under the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §§ 6901 to 6992k). As part of these remedial efforts, "Potential Release Sites" (PRSs) were identified and investigated. These PRSs include Solid Waste Management Units (SWMUs), Areas of Concern (AOCs), and Materials Disposal Areas (MDAs) (Exhibit 1-4). In 2005, DOE, the University of California, and the State of New Mexico entered into a Compliance Order on Consent (Consent Order) to undertake remedial actions at LANL, with the intent of investigating and implementing any needed corrective measures by the end of 2015.[8] The Consent Order expressly outlined the approach for conducting three broad categories of hazardous waste remedial investigations: facility-wide investigations, canyon investigations, and Aggregated Technical Area investigations.[9] It required LANL to group PRSs into larger aggregate areas, but also included provisions for the discovery of new sub-sites within LANL.[10] Finally, it detailed both general and specific technical approaches to site-wide remediation.

Remedy versus NRDA: "Remediation" and "restoration" represent two related, but distinct processes under CERCLA. Remediation is intended to address human health and ecological risks associated with contamination. NRDA, the goal of which is restoration of injured natural resources and associated services, is the process through which the public is compensated for injuries to natural resources caused by the contamination or the remediation, itself. Restoration includes "… actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided… such actions are in addition to response actions… [or] exceed the level of response actions determined appropriate…" (C.F.R. § 11.14(ll)). NRDA also takes into consideration the time period over which the natural resources are injured until such time as the remedy or restoration returns those resources, and the services they provide, to their baseline condition.

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[8] Prior to the Consent Order remedial actions were required under Module III of LANL's RCRA Hazardous Waste Facility Permit (NMED 2004).

[9] The Consent Order does not address radionuclide cleanup, it only addresses cleanup of non-radionuclide hazardous wastes.

[10] There are 29 aggregate areas in total. A list of aggregate areas is included in Table I-22 of Appendix I of DOE and NNSA 2008.

Remedial activities are currently being addressed in a number of PRSs, including the following (DOE and NNSA 2008 Appendix I):

- **MDAs:** MDAs are distributed throughout various TAs. These areas occur within canyons or on mesa tops. A list of some of the major MDAs is available in Tables I-1 and I-3 of DOE and NNSA 2008. Identified MDAs are currently being investigated as part of targeted Aggregated Technical Area investigations. Investigation and remediation of individual MDAs are generally addressed separately.
- **SWMUs and AOCs**: SWMUs and AOCs are distributed throughout various TAs, many of which have already been investigated.
- **Firing Sites:** A number of firing sites exist in the southern part of LANL around TAs-11, 16, 36, and 39. Clean-up of firing sites is being undertaken only upon closure (or designation of inactivity) of these sites. As a result, clean-up of a portion of LANL's firing sites has been "deferred." Lists of non-deferred and deferred firing sites are included in Tables I-5 and I-6, respectively, of DOE and NNSA 2008. In addition to the MDAs, SWMUs, AOCs, and firing sites, canyon investigations have been completed for each of the LANL canyons. These investigations have primarily focused on sediment and groundwater contamination, with additional investigation of surface water and biota in some canyon systems. Additional sites have been identified, but either have not yet been investigated or require additional investigation. A list of sites requiring continued investigation is included in Table I-23 of DOE and NNSA 2008.

To-date, according to the LANL website, 1,369 of the more than 2,000 PRSs have been remediated.

Current operations at LANL which may result in the release of hazardous substances must be conducted in accordance with permits granted by the State of New Mexico. To the extent that operations have resulted in releases of hazardous substances in violation of applicable permits, and contribute to natural resource injury, such injuries are compensable under the NRDA process.

EXHIBIT 1-2 MAP OF LANL SHOWING TECHNICAL AREAS

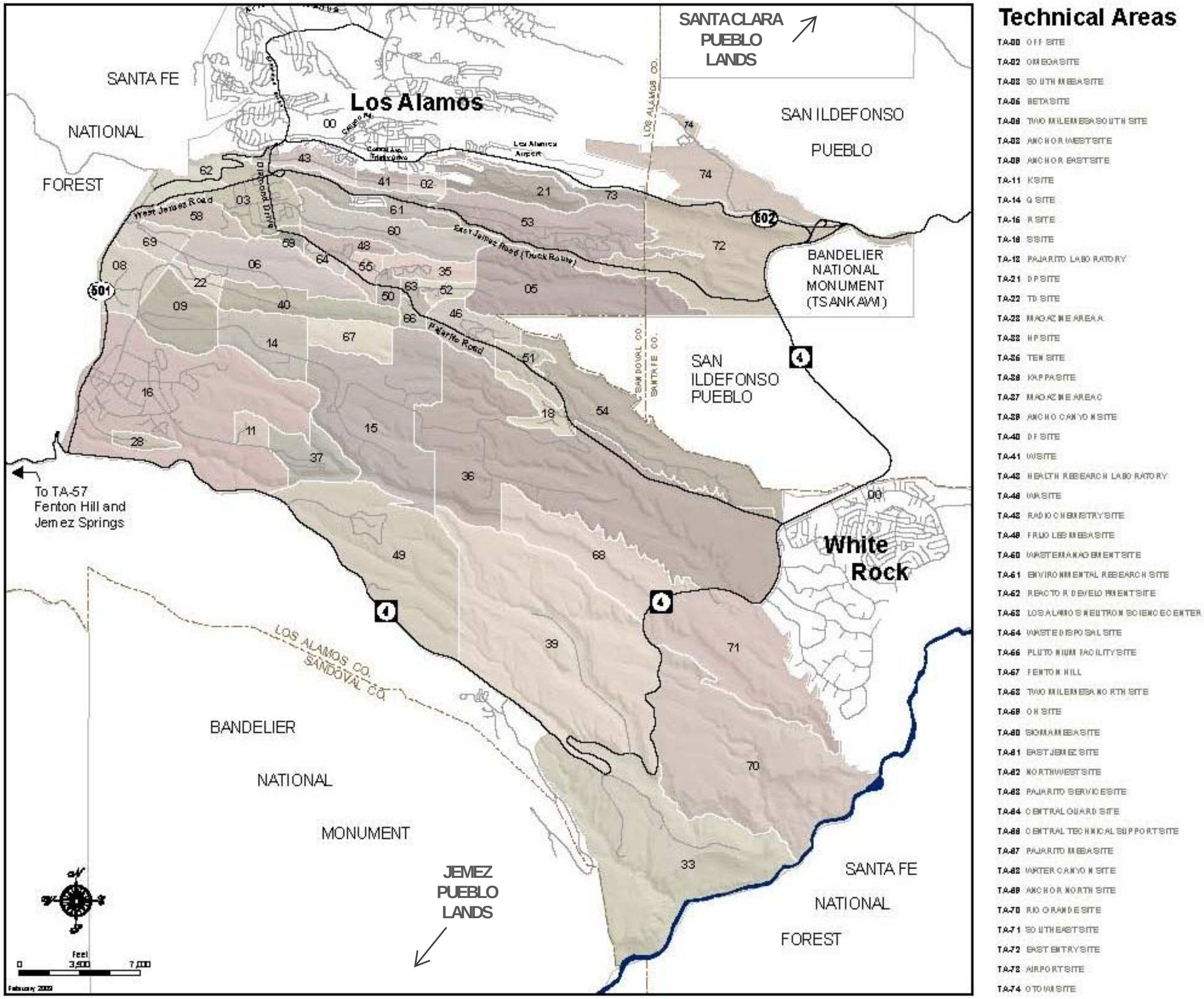


EXHIBIT 1-3 TIMELINE OF REMEDIAL ACTIVITIES AT LANL

1975

Removal of:

- Plutonium-contaminated experimental facility in TA-33
- Plutonium filter facility in TA-21

1981-1982

Decommissioning/removal of:

- Actinium-contaminated filter building in TA-21
- LAMPRE I in TA-35
- Titanium-contaminated lab in TA-35
- Contaminated air scrubbers in TA-35
- Plutonium-contaminated incinerator in TA-42
- Plutonium facility at DP West in TA-21

1986

Removal of:

- Radioactive liquid waste lines along Diamond Dr. at Pajarito Rd. from TA-3 to TA-50

1991

Decommissioning of:

- Water boiler reactor in TA-2
- Reactor facility in TA-52
- LAPRE II in TA-35

1997

Decommissioning of:

- Phase separator pit in TA-35

1999-2001

Decommissioning/removal of:

- Building 86 tritium facility in TA-33
- Flash pad and burn tray at TA-16
- Contaminated sediments in S. Fork of Acid Canyon (TA-00)

2002

Decommissioning/removal of:

- Inactive septic tanks in TA's -21, -51, and -54
- MDA P in TA-16
- Surface impoundment in TA-53

2003-2004

Decommissioning/removal of:

- "Cold dump" in TA-21
- Contaminated sediments and soils below outfall in TA-21
- French drain at Omega West in TA-61
- Soils in TA-16

2005-2008

Cleanup of:

- Former drum storage area in TA-33 (2005)
- 28 SWMUs/AOCs (2006)
- 8 SWMUs/AOCs (2007)
- 13 SWMUs/AOCs (2008)

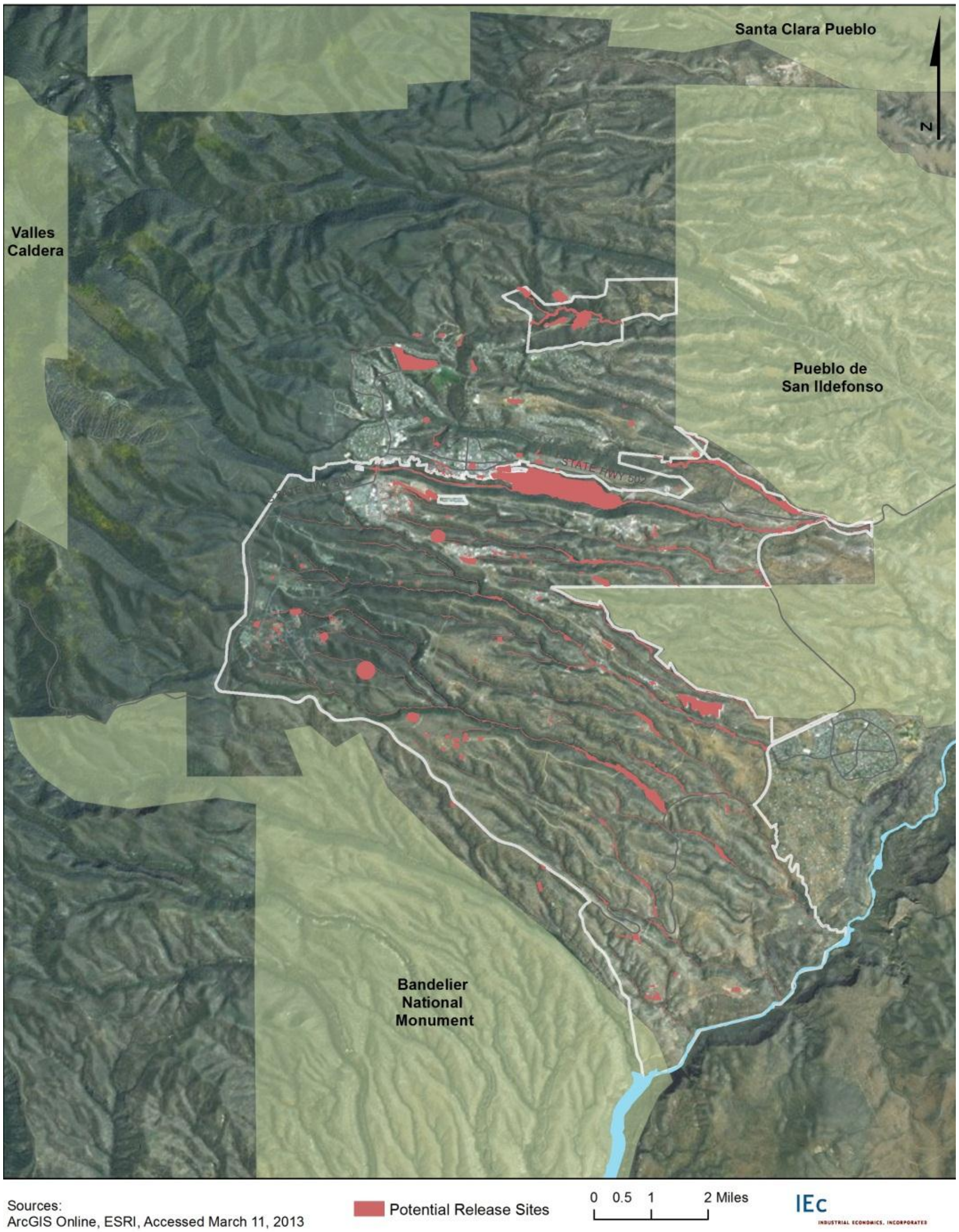
2008-Present

Cleanup of:

- Soil and debris at MDA B in TA-21
- Delta Prime East and West in TA-21
- Tritium Systems Test and Assembly area in TA-21
- 34 SWMUs/AOCs (2010)
- 83 SWMUs/AOCs (2011)

Sources: DOE 1999; DOE 2008; LANL 2007, 2008a, 2009a, 2010, 2011a, 2012.

EXHIBIT 1-4 POTENTIAL RELEASE SITES



Sources:
ArcGIS Online, ESRI, Accessed March 11, 2013

Note: Potential release sites illustrated in the above map include solid waste management units, materials disposal areas, and areas of concern.

PUEBLO COMMUNITY PRESENCE

As noted earlier in this Chapter, LANL and its environs are part of the ancestral territories of the Pueblo de San Ildefonso, Santa Clara Pueblo, Jemez Pueblo, and other Federally-recognized Pueblos. As such, the study area holds significant cultural, environmental, and religious significance for members of the modern-day Pueblo communities.

Historical and archaeological evidence indicates that the ancestors of current inhabitants of Rio Grande Pueblos occupied extensive areas of the Pajarito Plateau. The Pajarito Plateau region is bounded on the south by Cochiti Canyon, on the east by the Rio Grande, on the north by Santa Clara Canyon, and on the west by the Jemez Mountains. As early as 9500 BC, small groups of Paleoindian hunter-gatherer populations are thought to have followed bison herds up and down the Rio Grande, making trips to the Pajarito Plateau to procure obsidian and other subsistence resources. Isolated projectile points have been found at LANL from the period between 9500 BC and 5500 BC. Between 5500 BC and AD 600, archaic hunter-gatherer groups hunted with spears and atlatl (spear-throwers) on the Plateau. Today, remains of campsites from this period are found at LANL. (LANL 2006).

From AD 600 to 1150, the northern Rio Grande area became dominated by horticulturalist groups, who began to make painted pottery, and continued to hunt with bow and arrow. While most of the surviving cultural sites from this period are at lower elevation near the Rio Grande, the Pajarito Plateau was used on a seasonal basis by these groups as well as by travelling hunter-gatherer groups (LANL 2006).

From AD 1150 to 1325, the number of above-ground habitation sites greatly increased on the Plateau. Remains of these sites are commonly found throughout LANL. Cavate structures (rooms dug into cliffsides) likely made their first appearances during this period (LANL 2006).

From AD1325 to 1600, Ancestral Pueblo settlements on the Pajarito Plateau became increasingly aggregated into large population clusters, including Tsankawi, Tsirege, Navawi, and Otowi Pueblo sites (LANL 2006). The area occupied by LANL, including these sites, was recognized by the United States Indian Claims Commission as part of the ancestral lands for the present Pueblo de San Ildefonso. From these villages, people hunted, gathered important resources, planted various crops, and performed ceremonies, including burial of the dead. The ruins of these and other ancestral sites retain tremendous spiritual significance for members of the modern-day Pueblo communities. Each ancestral site retains an honorable legacy and significance that is documented in the oral history of the region’s Pueblo people (Pueblo de San Ildefonso, 2010a).

Reflecting this long history of habitation, LANL researchers have documented a large number of archaeological resources within LANL boundaries. Despite some sites not yet being surveyed or disclosed, as of 2006, over 1,933 archaeological sites have been recorded within LANL, including 1,796 prehistoric sites, most of which are Ancestral Pueblo sites dating to the 13th through 15th centuries. LANL archaeologists classify the sites into five major categories: ceremonial sites, natural features, ethnobotanical gathering sites, artisan material gathering sites, and traditional subsistence features. Such sites include cavates, plaza pueblos, kivas, graves, rock art, garden plots, pit structures, and other structures and objects (LANL 2006). Of 440 sites assessed, 378 have been determined to be eligible for nomination to the National Register of Historic Places (LANL 2006).

As is clear from the area’s history, Jemez, San Ildefonso, and Santa Clara Pueblos' management, use, and occupation of their ancestral homelands in the Jemez Mountains and Pajarito Plateau began well before European presence, and continues to this day, despite three changes of sovereigns -- Spain, Mexico, and then in 1848, the United States -- governing New Mexico. Each Pueblo’s village has been at its present location for centuries. The Pueblos are among the oldest occupied settlements in the United States, and Pueblo people have lived since time immemorial at their ancestral homes on or near the Pajarito Plateau. Although some Pueblo members gained limited access to LANL via employment at the site, after the U.S. government’s activities began in 1943, little or no access was granted to Pueblo people for many years. In recent years, some Federally-owned parcels have been returned to Pueblo and Los Alamos County ownership. However, despite the transfer of lands back to the Pueblos, the current boundaries of each Pueblo do not encompass all of each Pueblo's ancestral territory. Each Pueblo’s current landholdings include an area recognized as an original Spanish land grant that was confirmed by a U.S. patent. In addition, the United States since then has recognized additional lands for exclusive use of each Pueblo, holding lands in trust and protecting them from loss or taking. Throughout its history, each Pueblo has consistently and relentlessly sought to protect and maintain its inherent rights to its ancestral territory, both within and beyond its current landholdings. More recently, increased, but still limited, access has been allowed on the LANL site itself. Where allowed, Pueblo members continue to utilize LANL lands and resources for a variety of activities, including cultural and religious rituals; and lands surrounding LANL are widely used by Pueblos for traditional activities.

The Pueblos of Jemez, San Ildefonso, and Santa Clara, as well as other Pueblos in the region, continue to actively use and rely upon the plant, animal, and water resources of the study area for a variety of purposes, including food, medicinal, traditional practices, production of crafts, and ceremonial purposes. For example, Pueblo people continue to use clays for pottery, use natural pigments as body paint, and use traditional plants and animals for consumption, medicines, and ceremonial purposes. Each Pueblo's identity, history, and sense of being is directly linked to its traditions, which are in turn firmly rooted in the natural world. The Pueblo people share a world-view that ties them to the earth and water, believing that they are one, bound together to bring the riches of the earth for the people of the Pueblo. This concept has given the Pueblo people the foresight to understand the uses and capabilities of what could be produced and sustained both in the present and for the generations to come. Pueblo customs and practices govern every aspect of life at each Pueblo, including the management and use of natural resources. Each Pueblo considers threats to the natural resources in and around LANL as threats to their very existence. It is therefore critical to understand that, in the Pueblo belief system, the relative health of the natural environment of the Pueblos circling LANL is intrinsically related to the physical, emotional, and communal health and welfare of these Pueblo communities.

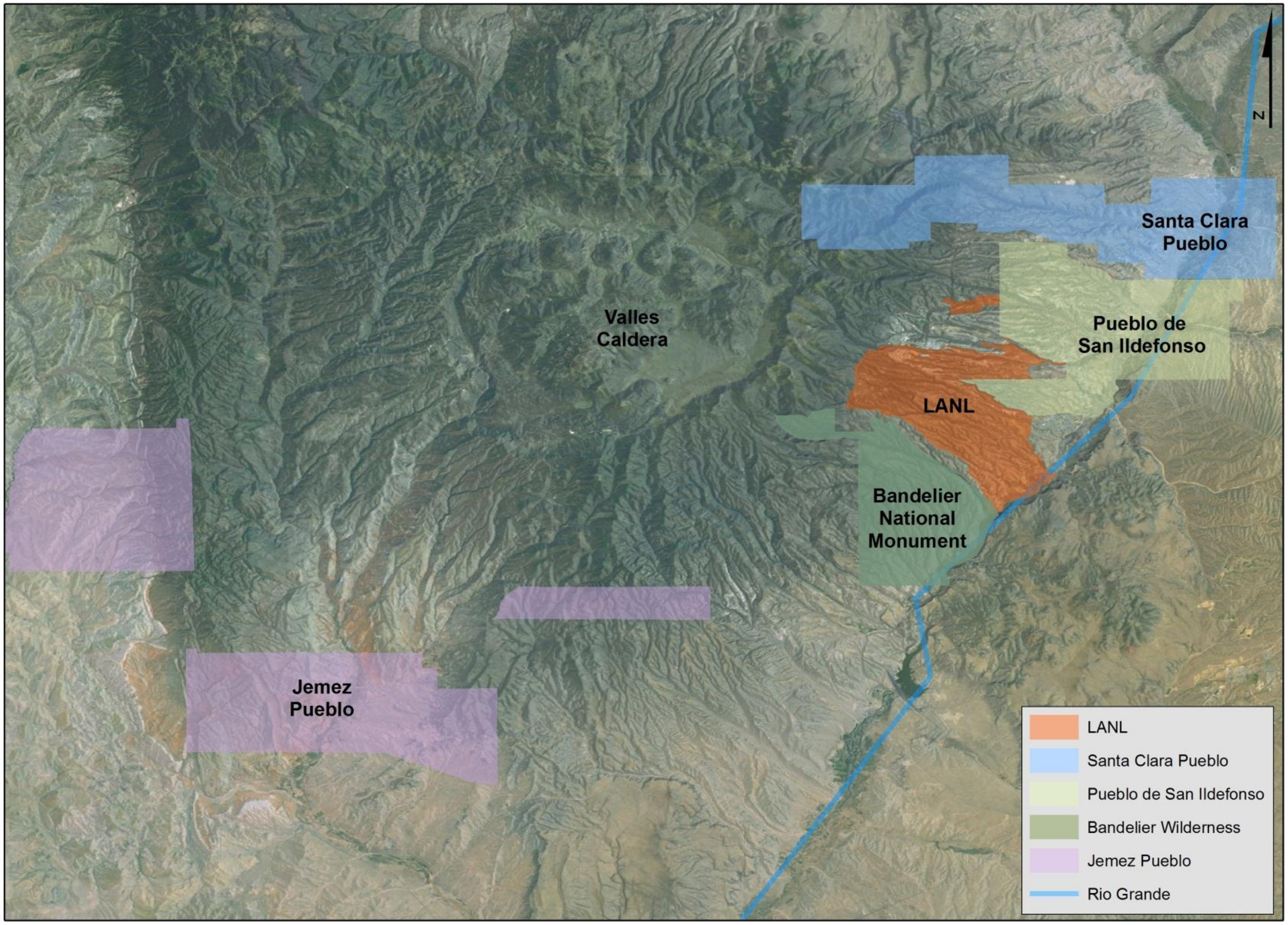
Exhibit 1-5 illustrates the location of the Pueblo Natural Resource Trustee council members in relation to current-day boundaries of LANL. Each Pueblo is unique and the descriptions below on the history and importance of areas and natural resources from each of the three Pueblos on the LANLTC are provided as an example and are not intended to represent other Pueblos.

Pueblo de San Ildefonso

The Pueblo de San Ildefonso is a Federally-recognized Native American Tribal Government. The Pueblo's grant and reservation lands are Federally protected ("Tribal Trust Lands"). These lands include meadows, mesas and canyon systems of the eastern Jemez Mountains and Rio Grande Valley of north-central New Mexico. In addition to the Tribal Trust Lands, the people of San Ildefonso have, for many generations, acted as stewards for lands with cultural, environmental, and religious significance, extending outside of the Tribal Trust Lands, and referred to as the San Ildefonso Ancestral Domain. The Ancestral Domain, recognized by the United States government, extends onto lands owned and occupied by the DOE (LANL), National Park Service (Bandelier National Monument), National Forest Service (Santa Fe National Forest), as well as various state, county and private lands. The western portion of the Pueblo de San Ildefonso shares a common boundary with LANL, and the Pueblo holds the distinction of being the only Federally-recognized Native American tribal government to share a common boundary with a national nuclear weapons and research facility.

As noted above, operations at LANL have resulted in the release of contaminants to the environment including to Pueblo lands and areas used by Pueblo members. In particular, these releases have resulted in contamination of the groundwater and soils and waters of the canyon systems on which LANL was built, many of which flow directly onto Pueblo lands. It is the Pueblo's belief that activities at LANL have impacted not only the natural environment, but also the traditional/religious uses of those natural resources within the Ancestral Domain that are still recognized as "sacred" by the people of the Pueblo.

EXHIBIT 1-5 MAP OF PUEBLO LANDS



Sources:
LANL, ArcGIS Online, ESRI, Accessed July 11, 2013

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Santa Clara Pueblo

Santa Clara Pueblo, a Federally-recognized Native American Tribal Government, is located approximately 25 miles northwest of the City of Santa Fe, and shares a border with the Pueblo de San Ildefonso. The Pueblo's grant and reservation lands are federally protected and span portions of the Jemez Mountains and Rio Grande Valley of north-central New Mexico. Santa Clara Pueblo people also maintain traditional, ceremonial, and religious uses of lands and natural resources throughout the Pajarito Plateau, including but not limited to portions of what is now the Valles Caldera National Preserve. Early maps show that LANL's predecessor, known as "Site Y", "Project Y" or "the Los Alamos Site" shared a boundary with Santa Clara Pueblo from at least 1943 to 1945 and that the area now located between LANL and Santa Clara was once referred to as "Area E" within Site Y during the Manhattan Project (Vincent C. Jones, Manhattan: The Army and the Atomic Bomb (1985, Center of Military History, United States Army) at 85, 328-29, and Map 5).[11] The Pueblo's current closest border to LANL is approximately five miles from the current-day boundary of LANL.

Santa Clara Pueblo is concerned in particular with potential impacts of air deposition and contaminant transport via particulates from historic and on-going LANL activities. The Pueblo is downwind of LANL and wind rose and monitoring data by both the Pueblo and LANL show that the prevailing winds come from the southwest (from LANL towards Santa Clara Pueblo). Santa Clara Pueblo also is concerned about whether the fault system underlying LANL, which connects to the Santa Clara Pueblo landbase, provides a means of transport for groundwater contamination since the termination of various south-north trending concealed active faults, such as the Sawyer Canyon Fault, is not fully understood.

Jemez Pueblo

The Pueblo of Jemez is a Federally-recognized Native American Tribal Government located in north-central New Mexico. Approximately 3,400 tribal members reside in the village of Walatowa located on New Mexico State Highway 4 approximately 50 miles northwest of Albuquerque on the southwest flank of the Jemez Mountains. The Village of Walatowa is approximately 30 miles southwest of Los Alamos, and the Jemez Tribal Boundary is only 11 miles from LANL. The Pueblo of Jemez lands consist of three parcels considered the Tribal Reservation. These areas are known as: the *Jemez Pueblo* Grant, the *Canada de Cochiti* Grant, and the *Espiritu Santo* Grant.

The Pueblo of Jemez is a sovereign nation with a governing system that is rooted in prehistory. The Jemez people are a predominantly agricultural tribe with limited financial resources, as there is little economic development in this area. The Pueblo of Jemez is

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[11] It is not known whether and to what degree hazardous substances released from LANL-related operations have come to be located in "Area E" or Pueblo land and, if so, the degree to which remedial actions at LANL may address them, and it is therefore included within the scope of assessment activities described in this Plan.

the only Towa-speaking tribe and approximately 90 percent of the Jemez people speak the indigenous Towa language.

Unlike the other three Accord Pueblos, the Pueblo of Jemez is located on the western side of the Pajarito Ridge. The main potential contaminant pathway from LANL is air emissions that drift over the Ridge into the Valles Caldera, primarily during winter months. The headwaters of the Jemez River form in the expansive Valles Grande within the Caldera. A concern of Pueblo members is that the river serves as a pathway for contaminants from LANL deposited in the Caldera to the Pueblo proper. The river water is used for irrigating crops which are staples of the Jemez diet, and shallow wells drilled in the river alluvium are the sole source of drinking water at the Pueblo and another potential contamination pathway.

The proximity of LANL to hundreds of Jemez archeological and cultural resources, particularly in the Valles Caldera, is of great concern to the Jemez people. Shrines, plant and animal collection sites, holy trails, and artifacts of the Jemez' presence in the mountains named for them are central to the daily lives of the Jemez people. Pilgrimages to Redondo Peak and other peaks within the Caldera on sacred trails used by the Jemez for centuries are a frequent activity for most Jemez tribal members.

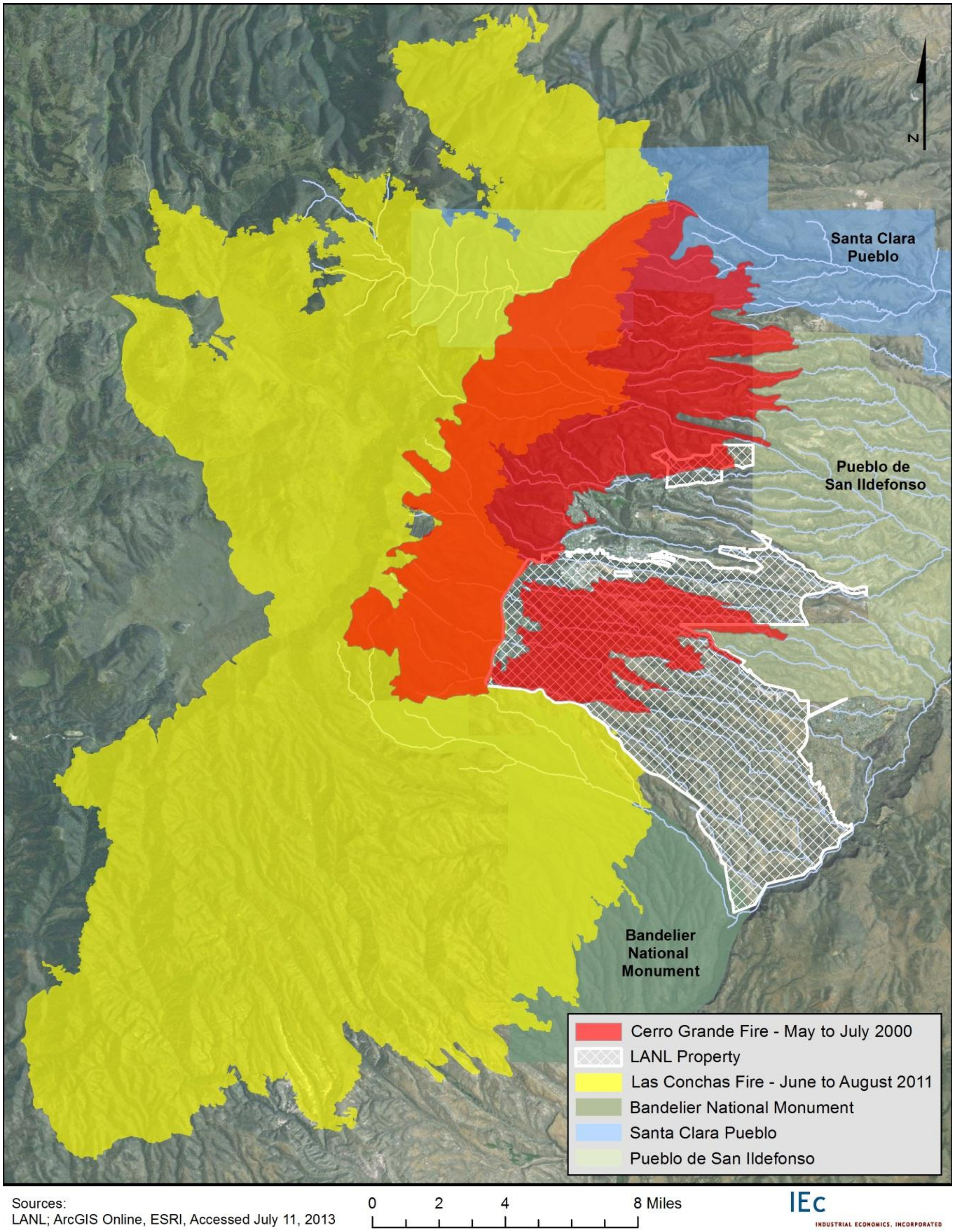
FIRE HISTORY

Wildfires are an important influence on the New Mexico landscape, including ecosystems in the LANL area. Since the 20th century, large wildfires have swept through the Jemez Mountains in roughly twenty year cycles. In 1954, the Water Canyon Fire burned large portions of the Water Canyon watershed and consumed nearly 3,000 acres. In 1977, the La Mesa Fire burned 15,444 acres of pine forests in the Jemez Mountains, including portions of Ancho and Water Canyon watersheds. In 1996, the Dome Fire burned more than 16,000 acres of forestland in the Jemez Mountains (University of Arizona 2012); and in 1998, the Oso Fire burned approximately 5,185 acres in the Santa Fe National Forest.

More recently, extended drought has caused the region surrounding LANL to be susceptible to fires. The Thompson Ridge Fire impacted the Valles Caldera in the summer of 2013. In 2000, approximately 43,000 acres of forest in and around LANL burned during the Cerro Grande fire (Exhibit 1-6). Approximately 7,684 acres, or 28 percent of the vegetation at LANL, was burned to varying degrees by the fire (LANL 2007). Furthermore, significant portions of the watersheds that cross LANL were affected, including Guaje, Rendija, Pueblo, Los Alamos, Pajarito, and Water Canyon watersheds. In 2011, the Las Conchas fire burned approximately 156,600 acres in the Jemez Mountains, including portions of the Los Alamos, Pajarito and Water Canyon watersheds and over 16,000 acres of forested lands in the Santa Clara Creek watershed of Santa Clara Pueblo. Except for a one-acre spot fire in TA-49, no LANL property was burned (LANL 2011b) (Exhibit 1-6).

While many of these fires are naturally-occurring and can help reset ecological communities, all fires have the potential to affect natural resources and the human use of those resources, as well as the fate and transport of hazardous contaminants released to the environment. For example, in an analysis of a suite of contaminants in storm water immediately after the Cerro Grande fire, global fallout-associated radionuclides (cesium-137 and strontium-90) and metals (copper, lead, manganese, selenium, strontium, uranium, and zinc) were elevated above pre-fire levels in Los Alamos Canyon. These contaminants appeared to be associated with mobilized sediment (Johansen et al. 2001). Such mobilization has the potential to move released hazardous substances away from their origin of release, down canyons, and into lower drainages and ultimately the Rio Grande. In addition, it has the potential to make more bioavailable contaminants that might otherwise be bound to soils. As such, historical fires and the potential for future wildfires to affect baseline conditions and the movement of contaminants will be taken into consideration by the LANLTC in the damage assessment process, as necessary within each of the assessment activities discussed in Chapter 6.

EXHIBIT 1-6 MAP OF CERRO GRANDE AND LAS CONCHAS FIRES



Sources:
LANL; ArcGIS Online, ESRI, Accessed July 11, 2013

OVERVIEW OF THE NRDA PROCESS

It is the intent of the LANLTC to conduct the NRDA according to the DOI NRDA Regulations at 43 C.F.R. Part 11. These regulations describe the process by which trustees may conduct a NRDA. This process includes the following three phases:

- Preassessment,
- Assessment, and
- Post-Assessment.

To date, as noted above, the LANLTC has completed the Preassessment Phase, and released the Preassessment Screen in January 2010. The LANLTC is now undergoing the Assessment Plan Phase. The Assessment Phase, which includes drafting this Plan and conducting the NRDA, includes the following six steps:

- Assessment planning,
- Pathway determination,
- Injury determination,
- Injury quantification,
- Damage determination, and
- Restoration.

Each of the steps to be followed in assessing injury and damages is discussed in greater detail in the chapters that follow.

If possible, the LANLTC may pursue primary restoration in connection with the remedy. However, primary restoration may not always be possible, and further, will likely not be sufficient to compensate the public for the time period, prior to restoration, that the public has experienced a loss of natural resources and associated services (i.e., "interim losses"). Hence, the LANLTC will focus on the compensable value of natural resources and pursue compensatory restoration (i.e., restoration of injured resources of similar type and quality to resources injured as a result of LANL releases). The compensable value of a natural resource refers to the loss experienced by the public in the interim time period between resource injury and recovery to baseline. For this reason, such injuries are often referred to as "interim losses."

USE OF AVAILABLE DATA

Analysis of existing data by the LANLTC is already underway, including preliminary pathway determination, injury determination, and injury quantification efforts. To the extent possible, the LANLTC anticipates using existing information to inform the NRDA process. Such information includes data and information collected as part of site investigation and remediation.

Going forward, the LANLTC anticipates evaluating existing information and data prior to undertaking additional data collection as part of the NRDA process, to better understand where additional information would assist in establishing injuries and required restoration. Such efforts are likely to inform the need for and extent of any additional primary research or study to support the assessment. To the extent that additional primary studies are required as part of the NRDA, the LANLTC will attempt to address data gaps in phases, taking into consideration the likely impact of the data gap on the scope or scale of required restoration.

In some circumstances, historical data may be of a lower quality than data collected more recently, due to advances in sampling and analytical technologies. Further, LANL databases, such as the Intellus database, may not always contain contextual information about the nature of the studies in which data were collected, which may be important for understanding the quality and usability of the data. The Quality Management Plan, (QMP) presented in Appendix B, addresses the issue of data quality for the assessment.

INTENT TO PERFORM A TYPE B ASSESSMENT

Declaration of the type of assessment to be performed is an express component of a Damage Assessment Plan (43 C.F.R. § 11.31(b)). Specifically, the DOI NRDA regulations outline two assessment approaches: Type A and Type B assessments. Type A assessments are “standard procedures for simplified assessments requiring minimal field observation to determine damages as specified in section 301(c)(2)(A) of CERCLA.” (43 C.F.R. § 11.14(ss)). Type B assessments are “alternative methodologies for conducting assessments in individual cases to determine the type and extent of short- and long-term injury and damages, as specified in section 301(c)(2)(B) of CERCLA.” (43 C.F.R. § 11.14(tt)). The Type A procedures generally do not apply to complex sites such as LANL. It is the intent of the LANLTC to perform a Type B Assessment.

GEOGRAPHIC SCOPE

The geographic scope of the assessment area includes all locations where contaminants have come to be located. This includes, but is not necessarily limited to:

- LANL property and vicinity (i.e., Los Alamos County lands);
- Natural resources within areas “…belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States… any State or local government, any foreign government, any Indian tribe…” (43 C.F.R. § 11.14(z));
- The Rio Grande River extending from those areas adjacent to the LANL property downstream to, and including, Cochiti Lake;
- The Valles Caldera National Preserve (VCNP); and
- The geographic dimensions of contaminated groundwater plumes from releases from LANL operations.

The LANLTC will also consider potential injuries to biological organisms that may have moved out of the above geographic range. Further, the LANLTC will include human service losses (e.g., impacts to Pueblo communities), the geographic scope of which may extend beyond the actual footprint of hazardous substances contamination.

TEMPORAL SCOPE

Trustees can seek recovery of damages for both primary restoration and compensatory restoration. Compensatory restoration actions are intended to compensate for the “interim loss” in natural resource services from the time of the release through return of the injured resource to its baseline condition. As such, compensatory loss estimation requires selection of a time period over which losses will be estimated.

The temporal scope of this assessment will be based on determination of both injury to natural resources and corresponding reductions in natural resource services. Documented natural resource exposure to hazardous contaminant releases within the study area has occurred since at least the 1940s, with the inception of the weapons-related research conducted at LANL during WWII. Therefore, injury to ecological resources and corresponding service losses due to contamination have likely occurred since at least that time and are expected to continue into the future.

Some natural resource injuries and subsequent damages may be assessed in a manner that allows for separate estimation of damages pre- and post-December 11, 1980 (the date Congress enacted CERCLA). In those cases the trustees will focus on estimating damages after December 11, 1980. In other cases, injuries and damages may be less clearly separable and the LANLTC may assess damages for the entire time period of injury. For example, impacts to Pueblo communities may be assessed from the time Pueblo members began noticing changes in their environment, and may continue indefinitely. In either case, information available from pre-1980 may be used by the LANLTC in understanding baseline conditions as well as injuries and damages post-1980.

In terms of prospective assessment of damages, injuries will be quantified, and damages calculated, through the expected date of resource recovery to baseline. Note that some injuries may be considered permanent if baseline conditions are not expected to be reestablished. The rate of resource recovery will be determined based on information related to remedial and restoration activities, natural attenuation, and resource recoverability.

PUBLIC PARTICIPATION

The LANLTC intends for public participation to be an important component of the Plan development process. Public participation in the NRDA process is outlined in the LANLTC Public Participation Plan (PPP). As outlined in the PPP, the LANLTC proposes to make the Plan available for review and comment by Federal agencies, state agencies, Indian tribes, and any other interested member of the public for a period of at least 30 calendar days, with reasonable extensions granted as appropriate, in accordance with 43 C.F.R. § 11.32(c)(1). As noted above, this Plan may be modified at any stage of the assessment as information becomes available and as specific study plans are developed (43 C.F.R. § 11.32(e)). Significant modifications will be made available for review and comment by any interested public party or individual. Non-significant modifications may be made available for review and comment, but implementation of such modifications need not be delayed as a result of the review.

The LANL Natural Resource Damage Assessment website, available at http://www.lanlnrda.org, provides updated information to the public regarding the status of the assessment and restoration process and opportunities for public involvement.

ASSESSMENT TIMELINE

The LANLTC does not have a fixed timeline for the completion of the NRDA process. As called for in the DOI regulations for NRDA under CERCLA, the LANLTC intends, where possible, to coordinate the assessment with the remedial process. The timeline of the assessment will also be adjusted to accommodate public participation and environmental conditions (e.g., any required field studies may be subject to seasonal constraints, assessment of resources may be limited by weather and/or other factors).

OUTLINE OF THE REMAINDER OF THE DOCUMENT

The remainder of this document contains the following chapters and appendices:

- Chapter 2, Natural Resources and Resource Services,
- Chapter 3, Injury Determination,
- Chapter 4, Injury Quantification,
- Chapter 5, Damages Determination,
- Chapter 6, Ongoing and Planned Assessment Activities,
- Appendix A, Site Operations and Hazardous Substance Release Information,
- Appendix B, Quality Management Plan,
- Appendix C, Injury Definitions,
- Appendix D, Potential Contaminants of Concern, and
- Appendix E, Background Values Used at LANL.

CHAPTER 2 | NATURAL RESOURCES AND RESOURCE SERVICES

LANL is located on the Pajarito Plateau, situated between the Jemez and Sangre de Cristo mountain ranges. The Pajarito Plateau is divided into a network of mesas and canyons that run roughly east to west (DOE and NNSA 2008). These canyons were formed as water drained from the Jemez Mountains in the west into the Rio Grande to the east of the site.

The climate in Los Alamos County is described as a temperate, semiarid mountain climate, receiving an average of approximately 19 inches of precipitation per year (LANL 2012). The majority of the rain falls in mid- to late summer, and most canyons support only ephemeral streams (LANL 2012). In addition, drought conditions have existed periodically across much of the area since 1998. The Los Alamos area is currently experiencing a severe drought that began in 2011. As a result of the region's climate, the majority of water in and around LANL exists as groundwater. Specifically, a large aquifer exists beneath the eastern portion of the Pajarito Plateau, which is recharged by precipitation falling in the Jemez Mountains.

LANL and surrounding areas support a diverse ecosystem including terrestrial, open water/aquatic, and riparian/wetland habitats. Dominant habitat types include forested habitats on mesa tops, grasslands in the Valles Caldera, open water in the Rio Grande, and riparian areas along the Rio Grande, and where intermittent streams exist. Additional information on habitat types is presented in the natural resources section below.

NATURAL RESOURCES

Unique habitat types in and around LANL form components of a complex ecosystem. The ecosystem as a whole is comprised of a variety of natural resources. Natural resources are defined in the DOI regulations as:

> *Land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: surface water resources, ground water resources, air resources, geologic resources, and biological resources* (43 C.F.R. § 11.14 (z)).

Below, these natural resources are described in the context of LANL, as they are categorized within the DOI NRDA regulatory framework, including a brief description of the natural resources services that they provide. Existing sources provide more detailed discussion of both assessment area resources as well as resource services (e.g., LANL 2010; LANL 2007; LANL 1997; LANLTC 2010).

SURFACE WATER

Surface water resources are defined in the DOI regulations as:

> *The waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas* (43 C.F.R. § 11.14(pp)).

Further, surface waters in the State of New Mexico are defined as:

> *Rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, reservoirs or natural ponds. Surface waters of the state also means all tributaries of such waters, including adjacent wetlands, any manmade bodies of water that were originally created in surface waters of the state or resulted in the impoundment of surface waters of the state, and any 'waters of the United States' as defined under the Clean Water Act that are not included in the preceding description* (20.6.4.7.S(5) NMAC).

As noted above, LANL is situated in a semi-arid region, and therefore perennial surface water is relatively scarce (Exhibit 2-1).[12] Although springs located high in the Jemez Mountains provide sufficient flows to maintain perennial streams in the upper reaches of Canon de Valle, Guaje, Los Alamos, Pajarito, and Water Canyons, because of evaporation, transpiration, and infiltration into the underlying alluvium, these flows do not travel very far across LANL. Instead, the majority of watersheds crossing LANL either experience ephemeral flows in direct response to precipitation events or more prolonged but intermittent flows as a result of snowmelt and precipitation runoff. While ephemeral streams only occur directly after precipitation events, intermittent streams may last for several weeks or more. Naturally occurring perennial reaches exist in the lower portions of Ancho and Chaquehui Canyons, and the Homestead Spring feeds a perennial flow several hundred meters long in Pajarito Canyon. In addition, sanitary effluent discharges from wastewater treatment plants create perennial flows in both Sandia and Pueblo Canyon (LANL 2005). These canyon systems at LANL act as a conduit for runoff to the Rio Grande (LANL 2010).

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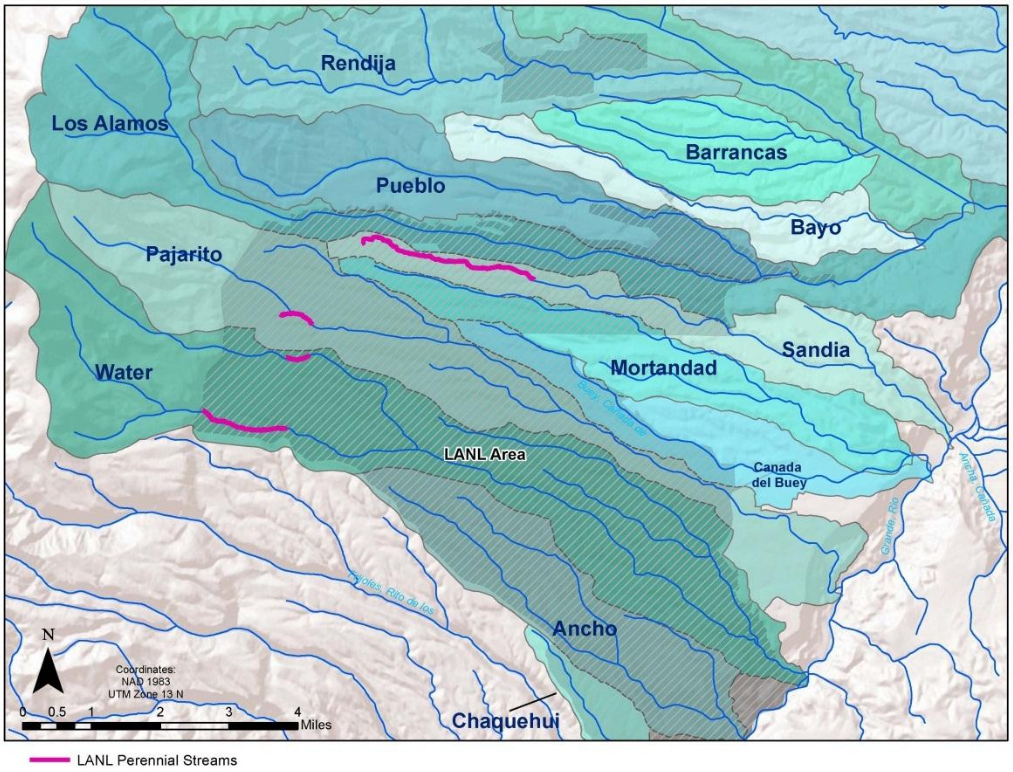
[12] The importance of surface water quality in the region is highlighted by the adoption of anti-degradation standards by the State of New Mexico (20.6.4.8 NMAC).

EXHIBIT 2-1 PERENNIAL STREAMS AT LANL



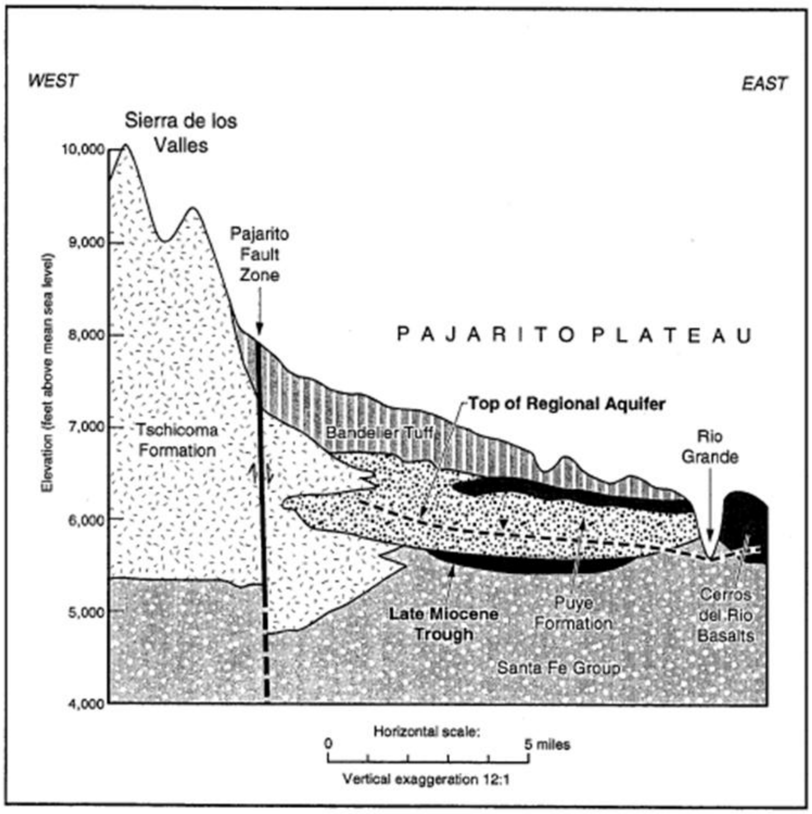
GEOLOGIC RESOURCES

Geologic resources are defined in the DOI regulations as:

> *Those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground and surface water resources* (43 C.F.R. § 11.14(s)).

The Pajarito Plateau lies between the Jemez Mountains and the Rio Grande in an area of local subsidence called the Espanola Basin (LANL 2005). The majority of the mesas in and around LANL are composed of Bandelier Tuff, the uppermost stratum of the Pajarito Plateau, deposited 1.6 to 1.2 million years ago following eruptions of the Valles and Toledo Calderas. Bandelier Tuff includes ash fall, ash fall pumice, and rhyolite tuff (LANL 2010). On the western edge of the Plateau, Bandelier Tuff gives way to the volcanic rocks of the Tschicoma Formation, which form the bulk of the Jemez Mountains. The Puye Formation lies directly below Bandelier Tuff and consists of conglomerated debris eroded from volcanic activity in the Tschicoma Formation. Near the eastern edge of the Plateau, erosion by the Rio Grande has exposed portions of the deeply buried Santa Fe Group and Cerros del Rio Basalts. The Santa Fe Group extends across the Rio Grande Valley and is over 3,300 feet thick (LANL 2005; Exhibit 2-2).

EXHIBIT 2-2 GEOLOGICAL CROSS SECTION OF THE PAJARITO PLATEAU



Source: Reproduced from (LANL 2005).

GROUNDWATER

Groundwater resources as defined in the DOI regulations are:

> *water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves. It includes ground water resources that meet the definition of drinking water supplies* (43 C.F.R. § 11.14(t)).

Groundwater resources occur in three principal modes beneath LANL:

1. **Perched alluvial groundwater** in the narrow and shallow alluvial sediments in the bottoms of the canyons that cross LANL. This water is highly variable and in many places ephemeral.
2. **Deep or intermediate perched groundwater** in the formations residing between the land surface and the regional water table, which is typically several hundred feet deep over most of the area. These intermediate perched water bodies are not well characterized and the extent of contamination within them is not currently fully delineated.

3. **The regional aquifer** consists of an extensive zone of saturated formations underlying LANL and surrounding areas. Its depth (the top of the water table) ranges from about 1,000 feet to zero at the Rio Grande, into which it drains. Its thickness has not been fully quantified, and may vary depending on the elevation of underlying geology. It is composed of sedimentary sands, silts, and gravels, as well as volcanic basalts and tuffs.

AIR

Air resources are defined in the DOI regulations as:

> *Those naturally occurring constituents of the atmosphere, including those gases essential for human, plant, and animal life* (43 C.F.R. § 11.14(b)).

In the context of NRDA, although injury to air is sometimes assessed, the atmosphere is generally considered to be a pathway for the movement and re-suspension of hazardous substances, and by which other natural resources may be exposed. Operations at LANL are known to have produced, and continue to produce, emissions of hazardous substances. Although LANL operates under a Title V Clean Air Act permit and the National Emission Standards for Hazardous Air Pollutants for Radionuclides regulatory limits, any releases in violation of a permit are compensable under NRDA. As a result the LANLTC anticipates evaluating the potential for hazardous substances to have been released to and traveled via the air pathway. To the extent that injury to air is determined, the LANLTC will consider formally assessing injury to this resource, but will likely focus injury quantification efforts on other resources.

BIOLOGICAL RESOURCES

Biological resources are defined in the DOI regulations as:

> *Those natural resources referred to in § 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition* (43 C.F.R. § 11.14(f)).

As noted above, LANL and the surrounding area is biologically diverse and supports a variety of ecosystems. The Pajarito Plateau includes five unique vegetation zones (LANL 2006a). The juniper-savanna community dominates the eastern portion of the plateau along the Rio Grande. Moving upward in elevation to the west, piñon-juniper woodland dominates mid-elevation (6,200 feet - 6,900 feet) mesa-tops. Higher elevation areas (6,900 feet – 7,500 feet) are dominated by ponderosa pine communities. Finally, mixed conifer forests (e.g., Douglas fir, ponderosa pine, and white fir) and spruce-fir forests dominate high elevation areas (7,500 feet – 9,500 feet) in the western portion of the plateau extending into the Jemez Mountains.

Aspen forests, grasslands, shrublands, open water, and unvegetated lands (e.g., basalt cliffs and talus) are present in the assessment area and are controlled by topography, soils, and moisture content rather than primarily by elevation (LANL 2003). For example, the Valles Caldera consists of a mixture of grasslands in low areas and the peaks are vegetated by ponderosa pine forests, mixed conifer forests, aspen forests, and spruce-fir forests.

Riparian and wetland habitat zones include but are not limited to cottonwood and willow dominated habitats (such as those along the Rio Grande), mixed grasses and wooded herbaceous vegetation, box elder, grass/sedge meadows, and sandbars and mudflats (LANL 2003; LANL 2011). Changes in baseline conditions, such as bark beetle outbreaks, fire, and drought have altered some habitat types over time in the assessment area.

Past surveys conducted by LANL biologists have identified 1,370 species of flora and fauna at LANL (LANL 1997). These studies have found a wide variety of terrestrial flora and fauna, including 256 species of plants, 246 species of fungi, 193 species of insects and terrestrial arthropods, 140 species of birds, 64 species of mammals, and 24 species of reptiles. In addition, the Pajarito Plateau also serves as a wintering ground and stop over point for many species of migratory birds. Currently, 21 of the terrestrial species are listed as threatened or sensitive by the State of New Mexico or the Federal government (Exhibit 2-3).

While the scarcity of surface water on the Pajarito Plateau limits the amount of riparian habitat available, springs and effluent runoff provide enough flow to support 339 species of aquatic invertebrates and eight species of amphibians. Furthermore, while no fish have been found on LANL property, the Rio Grande is home to various species of fish and, as of 2000, a coldwater brook trout fishery exists in the upper reaches of Los Alamos Canyon (Lusk et al. 2002).[13]

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[13] The upper reaches of Los Alamos Canyon have not been surveyed for fish since the Cerro Grande Fire. Since that time, the Los Alamos Reservoir has undergone extensive dredging, dam rehabilitation and other work, so the current status of fish in the fishery is unknown.

EXHIBIT 2-3 LANL THREATENED AND SENSITIVE SPECIES

TYPE	COMMON NAME	PROTECTED STATUS[1]	POTENTIAL TO OCCUR[2]
Fish	Rio Grande Chub	NMS	Moderate
Amphibian	Jemez Mountains Salamander	NMS, FCS	High
Birds	American Peregrine Falcon	NMT, FSOC	High
	Arctic Peregrine Falcon	NMT, FSOC	Moderate
	Bald Eagle	NMT, NHNM	High
	Broad-billed Hummingbird	NMT	Low
	Gray Vireo	NMT	Moderate
	Loggerhead Shrike	NMS	High
	Northern Goshawk	NMT, FSOC	High
	Yellow-billed Cuckoo	NMS, FCS	Moderate
Mammals	Big Free-tailed Bat	NMS	High
	Goat Peak Pika	NMS, FSOC	Low
	Gunnison’s Prairie Dog	NMS FCS	Low
	Long-legged Bat	NMS	High
	New Mexico Meadow Jumping Mouse	NME, FCS	Moderate
	Red Fox	NMS	Moderate
	Ringtail	NMS	High
	Spotted Bat	NMT	High
	Townsend's Pale Big-eared Bat	NMS, FSOC	High
	Western Small-footed Myotis Bat	NMS	High
Plants	Greater Yellow Lady's Slipper	NME, FCS	Moderate
	Wood Lily	NME, FCS	High
Insect	New Mexico Silverspot Butterfly	FSOC	Moderate

1: FCS - Federal Candidate Species, FSOC - Federal Species of Concern, NHNM - Natural Heritage New Mexico, NME - New Mexico Endangered, NMS - New Mexico Sensitive Taxa, NMT - New Mexico Threatened.
2: Low = No known habitat exists on LANL, Moderate = Habitat exists though the species has not been recorded recently, High = Habitat exists and the species is recorded to occur at LANL.
Source: LANL 2011c

NATURAL RESOURCES SERVICES

Ecosystems are complex, variable systems. As a result, ecosystems such as those present at LANL provide a wide range of services, including ecological and human services. The DOI regulations include the following definition for services:

> *The physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource* (43 C.F. R. 11.14(nn)).

Further, in describing the DOI regulations, the DOI indicated:

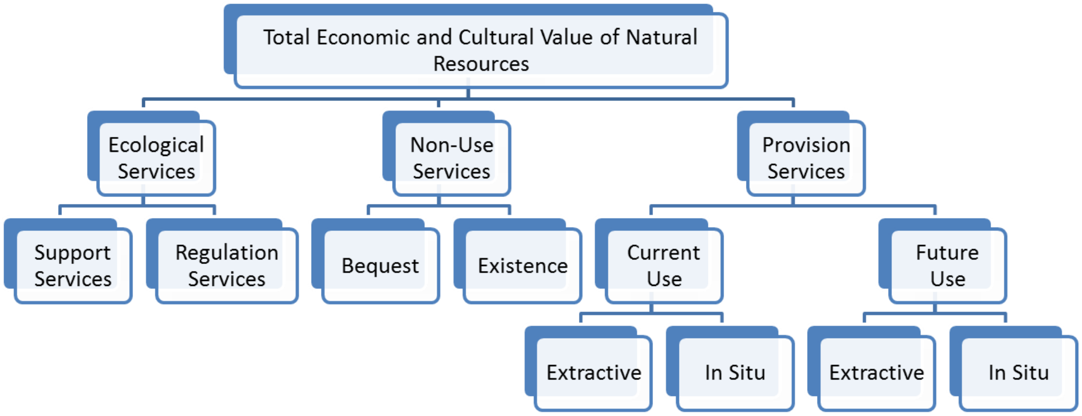
> *"services" are a metric for measuring resource conditions and resource restoration. They are not abstract functions that are disassociated from natural resources, and they are restored or replaced by actions related to the quality, quantity, or availability of natural resources* (73 Fed. Reg. 57,259).

In defining services in this way, the DOI regulations and associated writings specifically identify as compensable the services one component of an ecosystem provides to another, such as through a food chain, as well as the human uses of the resource, if they are reduced as a result of a release of hazardous substances. The DOI regulations further describe services as the metric by which the benefits of natural resources may be quantified.

ECOLOGICAL AND HUMAN SERVICES DERIVED FROM LANL NATURAL RESOURCES

One simple categorization of natural resource services (encompassing both human and ecological services) is provided in Exhibit 2-4. Examples of services provided by each of the five broad categories of natural resources detailed in the DOI regulations (surface water, air, geological, biological, and groundwater resources) are discussed in greater detail below and presented in Exhibit 2-6.

EXHIBIT 2-4 NATURAL RESOURCE SERVICES



In general, each of the natural resources described in the previous section provides a variety of ecological services. Researchers have spent considerable effort identifying and describing ecological services. The 2004 National Research Council Report entitled Valuing Ecosystem Services: Toward Better Environmental Decision-Making provides a good summary of relevant literature on ecosystem services. For example, in discussing aquatic ecosystems, the report notes:

> *Other, less intuitive, goods and services have been recognized only as knowledge of the global ecosystem has evolved. Some of these include maintenance of biodiversity, and contributing to biogeochemical cycles and global climate* (NRC 2004, p. 79).

As noted above, the assessment area is complex and includes a number of habitat types. The mesas and canyons that define the topography of LANL provide variable habitat for a wide range of plant and animal species that provide a number of ecological services. Practical examples of ecological services include the provision of cover and habitat for biological resources, the cycling of nutrients, pollination; and, as noted above, supporting ecosystem food chains. For example, forest and associated plant communities provide protective cover to animals, aid in nutrient cycling, moderate hydraulic flows through the canyons, and improve water clarity by removing sedimentation of particulate matter in the watershed.

The types of services that humans derive from natural resources are also varied and numerous. They can range from a sense of enjoyment from the knowledge the resource exists or from interacting with the natural world, to the economic value derived from extractive uses of resources to a sense of economic or social security stemming from the knowledge that natural resources are available for extraction, if necessary. The two broad categories of services that humans derive from natural resources that are discussed in this Plan are recreational uses (e.g., hunting, bird-watching, hiking, biking) and Pueblo services (i.e., services related to uses of natural resources that are specific to Pueblo communities). Natural resource services specific to Pueblo communities are discussed in greater detail in a separate section below and in Exhibit 2-7.

SURFACE WATER SERVICES

The limited presence of perennial surface water makes such flows a scarce resource on the Pajarito Plateau. Surface water (including sediment resources) provides an important habitat for a range of biological organisms and provides a suite of ecological and human services. While important from an ecological perspective, the limited availability of perennial streams does restrict recreational use of surface water at LANL to secondary contact recreation (NMED 2007). However surface waters of the Rio Grande are commonly used for recreational purposes. Further, there are a host of other services surface water can provide humans, including Pueblo services.

For purposes of the NRDA, because the LANLTC is focusing on resources and the services that surface waters provide, including the provision of habitat, the LANLTC will focus on all surface water regardless of its duration or legal status.

AIR SERVICES

All advanced biological organisms respire, with air resources providing for exchange of gases, supporting metabolism. Air resources also support regional weather patterns, serving as a conduit for the delivery of precipitation to land. At the same time, one of the most predominant services provided by air is assimilation of natural and anthropogenic emissions. For example, LANL has a number of point source air emission locations, which rely on the dilution of contaminants through wind dispersion.

For purposes of the NRDA, although the LANLTC recognizes the importance of air as a resource in general, as well as the specific importance of clean air to the maintenance of the health and welfare of humans and animals, the LANLTC will focus on air resources primarily as a pathway for released hazardous substances to make their way to other natural resources.

GEOLOGICAL SERVICES

Geological resources, including soil resources, provide a number of services for the proper maintenance of ecosystems, as well as for humans directly. For example, soil and other geological resources are responsible for cleaning groundwater as it passes through the ground, and provide a nutritive substrate for the growth of plants and shelter for burrowing animals. Geological minerals can be a source of nutrients for biological organisms and, when extracted by humans, a source of materials for the plethora of goods manufactured and used in our economy.

To the LANLTC's knowledge, there are currently no extractive uses of geological resources on LANL property; however surrounding Pueblos are well known for their use of clay resources to make culturally-important pottery (see also the section on services provided to Pueblos below). In addition, groundwater, the purity of which is maintained by the geology through which it passes, is used in and around LANL (see below).

BIOLOGICAL SERVICES

Biota that inhabit the area provide a wide range of ecological services including nutrient cycling, pollination, and as food sources. Insects, amphibians, reptiles, birds, and small mammals serve as food sources for larger animals including raptors and large mammals. Many insects help maintain healthy ecosystems through pollination and nutrient cycling. Amphibians, reptiles, birds, and bats help to control insect populations. Plant species across the area provide ground cover and foraging and nesting habitat for a variety of animal species. Additionally, many of the services listed above are interdependent (43 C.F.R. 11.71 (b)(4)). For example, soil and vegetation interact to:

- Intercept and store energy from solar radiation, provide a growth medium for plants, and provide substrate for nutrient cycling and decomposition;
- Support rich assemblages of plant and animal species; diverse habitat for vegetation, fish, birds, and mammals; and highly productive ecological communities;
- Provide cover and food for aquatic and terrestrial biota, contribute to physical habitat complexity through the production of trees, shrubs and root masses, and regulate the supply of nutrients within the ecosystem; and
- Provide critical connectivity between upland and aquatic habitats and a corridor for dispersal of plant and animal species.

Biological resources also provide a range of human services including recreational services such as fishing, hunting, and wildlife viewing; as well as Pueblo services including support of subsistence plant harvesting, and hunting and other services specific to the Pueblos, which are discussed in greater detail below.

GROUNDWATER SERVICES

The literature has documented a wide range of services that are provided by groundwater. These include both services directly accrued to people (e.g., drinking water), as well as ecological services (both *in situ* as well as a result of clean groundwater discharging to surface waters). For example, the National Research Council book, published by the National Academy of Sciences press, Valuing Groundwater: Economic Concepts and Approaches states:

> *The total economic value (TEV) of ground water is a summation of its values across all of its uses. Sources of values have been classified into use values (sometimes called direct use values) and nonuse values (also known as passive use values, existence values). The use values arise from the direct use of a good or asset by consuming it or its services. For ground water, these would include consumption of drinking water and other municipal or commercial uses. Nonuse values arise irrespective of such direct use. Thus in the economist's jargon the total economic value of a given resource asset includes the summation of its use and nonuse values across all service flows. The notion of total economic value is fundamental to ground water valuation and should enter into management decisions regarding use of water resources. Valuation is a useful tool if the values can help inform decision-makers. The relevant issue is how the TEV of ground water will change when a policy or management decision is implemented* (NRC 1997, p. 48).

In addition to the National Research Council text, the range of services, including both use and nonuse services, provided by groundwater is well documented in other sources (e.g., EPA 1995; Bergstrom et al. 1996). Published studies have demonstrated the economic value the public holds for these various services (e.g., Bergstrom et al. 2001). For example, the public likely holds an option value for groundwater that represents an individual's willingness-to-pay to reduce or eliminate uncertain future risks associated with groundwater resources. Option value, or more accurately "option price", is well established in the economics literature generally (see Freeman 2003), and specifically with respect to groundwater protection (see Bergstrom et al. 2001). Option prices may reflect ecological, use, and non-use values; that is, the option price an individual is willing to pay reflects all of the values that individual may hold for a groundwater resource.

At LANL, groundwater in the deep regional aquifer is currently being used as a source of potable water for the towns of Los Alamos and White Rock as well as LANL and the Bandelier National Monument. The Los Alamos Department of Public Utilities (DPU) operates twelve wells across three well fields (Exhibit 2-5) to supply drinking water to over 8,000 customers.[14] In addition to this use value, members of the public may also

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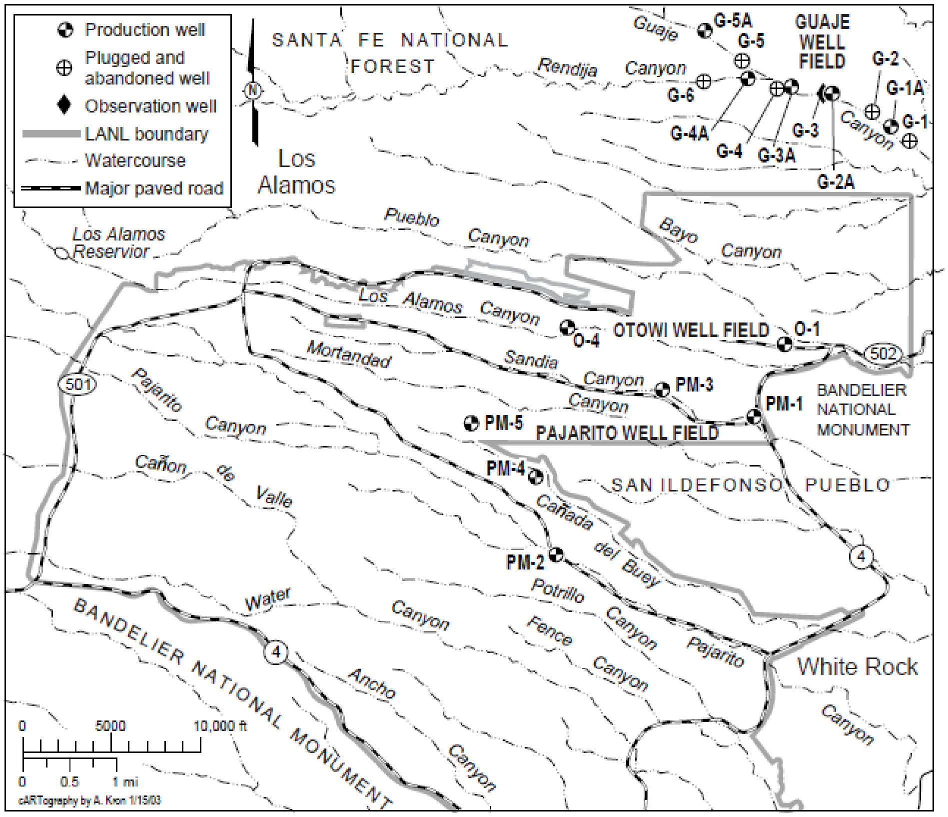
[14] Groundwater is a highly utilized and important resource. The Los Alamos DPU currently has 6,741.3 acre-feet per year of available water rights, 5,541.3 of which it exercises via pumping of a number of groundwater wells. In 2005, DPU customers

hold nonuse values for groundwater at and around LANL, including an option value, as described above. Groundwater at LANL also holds use and nonuse values for the Pueblo communities, as discussed further in Services Provided to Pueblo Communities section below.

EXHIBIT 2-5 PRODUCTION WELLS OPERATED BY THE LOS ALAMOS DEPARTMENT OF PUBLIC UTILITIES



Source: Reproduced from (LANL 2003).

As described above, natural resources at and around LANL provide a variety of ecological and human services. Examples of these services are also presented in Exhibit 2-6.

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used 4,300 acre-feet per year of water, and this amount is expected to increase in the future to 7,600 acre-feet per year under low-water use projections and 9,400 acre-feet per year under high-water use projections (Los Alamos Department of Public Utilities 2006).

EXHIBIT 2-6 ECOLOGICAL AND HUMAN SERVICES PROVIDED BY NATURAL RESOURCES

NATURAL RESOURCE CATEGORIES	ECOLOGICAL SERVICES	HUMAN SERVICES[1]
Surface water (e.g., sediment and hyporheic zone)	Habitat for biological organisms	Secondary contact recreation in perennial streams
	Drinking water for biological organisms	Fishing, boating in Rio Grande
Air	Clean air for biological organisms respiration	Clean air for humans respiration
	Exchange of gases for biological organisms	Assimilation of natural and anthropogenic emissions
	Regulation of regional weather as conduit for precipitation	
Geological (e.g., surface soil, vadose zone)	Groundwater cleansing properties	Source of material for manufactured goods
	Nutritive substrate for plants	
	Shelter for burrowing animals	
Biological (e.g., mammals, birds, fish, amphibians, reptiles, invertebrates, plants, fungus, microbes)	Earthworms cycle nutrients	Food source for humans
	Pollination by insects	Hunting
	Food sources for many biological organisms	Fishing
	Insect population control	Wildlife viewing
	Plants provide cover and shelter	Existence values
Groundwater (e.g., springs and seeps)	Clean groundwater discharging to surface waters	Use values including as a drinking water source
	Drinking water source for organisms through seeps and springs	Nonuse values including existence and option values

[1] Human services also include services natural resources provide specifically to Pueblo communities, which are described in more detail in the section below.

SERVICES PROVIDED TO PUEBLO COMMUNITIES

Pueblo members may utilize natural resources to an extent and in ways that are different from the general population (Harper et al. 2002; Nadasdy 2003; Turner 2005). In addition, the role that natural resources play in the culture of these communities may differ from that of the general population. “Culture” in this context encompasses the lived experiences and all of the material and spiritual relationships that indigenous peoples have with all of the elements of the natural world. Drawing on published anthropological research, culture in the context of this Plan incorporates practice, which consists of the everyday activities of the people on the land.

In general, natural resources provide provisioning, regulating, cultural, and supporting services to Pueblo members. As a result, Pueblo service losses can encompass adverse changes in three broad areas of the Pueblos' natural resource-based uses, including but not limited to: (1) economies (e.g., food, money, and livelihoods); (2) traditional knowledge (e.g., languages, values, teachings); and (3) spiritual values (e.g., ceremonies, sacred histories, places).

As a result of differences in the nature and extent of services Pueblo communities derive from the environment — and differences in the way in which changes in these services affect these communities — it may be necessary to describe and quantify service losses for Pueblo communities separately from service losses to the general public. Given these differences, specific restoration actions may also be required to fully compensate for losses in Pueblo community services.

Exhibit 2-7 provides a matrix of natural resources, ecosystem services associated with these resources, and examples of associated Pueblo uses. The exhibit is organized according to "Natural Resource Categories," which include resources that are likely to have been injured at Los Alamos: surface water, groundwater, geologic resources, biological resources, and air. For each type of natural resource, there are several "Ecosystem Service Categories," as defined by the Millennium Ecosystem Assessment and National Academy of Sciences (Millennium Ecosystem Assessment 2005). These categories are: cultural and amenity, provisioning, regulating, and supporting and habitat. For each category, there are multiple "Associated Pueblo Services" that are beneficial and of value to Pueblo members. Finally, for each service, examples are listed of "Specific Pueblo Uses" at Los Alamos. These examples are based on input received from Santa Clara Pueblo, San Ildefonso Pueblo, and Jemez Pueblo respecting each Pueblo's uses. This is not intended, however, to be an exhaustive list of Pueblos' respective uses nor does it intend to suggest that each Pueblo's uses can be assumed to be the same as, or a proxy for, inferring other Pueblo uses. Further, this list is not all-inclusive; identification of specific sites as examples should not be interpreted as a de-emphasis of the importance of other areas that are not listed. Recognizing that this matrix is a simplification of a complex association of values with natural resources, it attempts to illustrate the critical links that exist between natural systems and Pueblo uses of resources in those systems in relation to the area in and around LANL.

EXHIBIT 2-7 PUEBLO NATURAL RESOURCE SERVICES MATRIX

NATURAL RESOURCE CATEGORIES[1]	ECOSYSTEM SERVICE CATEGORIES[2]	ASSOCIATED PUEBLO SERVICES[3]	EXAMPLES OF SPECIFIC USES[3]
Surface water (for example, sediment and hyporheic zone)	Cultural & Amenity	Water supply (subsistence, ceremonial, spiritual)	Life-giving source
			Drinking water (feasts)
		River features (subsistence, ceremonial)	Fishing camp sites
	Provisioning	Water supply	Drinking water (daily), irrigation
			Bathing, cleaning water
	Regulating	Water purification	Clean water (less disease)
		Climate regulation	Stable climate (maintaining habitat for species collected)
	Supporting & Habitat	Aquatic/riparian habitat for sacred plants/animals	Plant/animal collection for subsistence food, medicine, materials, ceremony
		Key species habitat	Other fish, reptiles, mammals, birds
Air	Cultural & Amenity	Information, education, observation, language	View-shed
	Provisioning	Clean air supply	Respiration
	Regulating	Climate regulation	Stable air patterns
Geological (for example, surface soil, vadose zone, and rocks)	Cultural & Amenity	Spiritual sites, sacred grounds, landmarks and landscape features, traditional use areas	Archaeological sites
		Traditional ecological knowledge, information, education, observation, language, inspiration, community cohesion, heritage	Solitude, quite, dark for meditation and ceremony; spiritual connection to Mother Earth
			Historical places, names, songs, stories, calendar
			Language, linguistic landmarks, mnemonics
			Cultural recognition/association
			Heritage, multi-generational ties
			Environmental restoration/

NATURAL RESOURCE CATEGORIES[1]	ECOSYSTEM SERVICE CATEGORIES[2]	ASSOCIATED PUEBLO SERVICES[3]	EXAMPLES OF SPECIFIC USES[3]
			stewardship, education/jobs
			Traditional Cultural Properties (TCPs)
			Scenic vistas, recreational experience, trails
			Social-economic opportunities
	Provisioning	Raw materials (subsistence, medicinal, sacred)	Clay for material
			Soil to white wash buildings
			Clay for dancing
			Ground (dirt floor) for ceremonies, dancing
			Areas for reciprocity
			White volcanic ash
		Ornamental use (spiritual, artistic)	Clay for pottery
			Soil to make paints
	Regulating	Erosion control	Stable soils, dust reduction
		Nutrient cycling	Fertile soils (habitat for foods collected)
	Supporting & Habitat	Terrestrial habitat for sacred plants/animals	Plant/animal collection for subsistence food, medicine, materials
		Key species habitat	Elk/deer and other wildlife
Biological (for example, aquatic, riparian, and terrestrial wildlife, including mammals, birds, fish, amphibians, reptiles, invertebrates, plants, fungus, microbes)	Cultural & Amenity	Traditional ecological knowledge, information, education, observation, language, inspiration, community cohesion, heritage	Traditional foods and medicines knowledge
			Wildlife, hunting information and skills
			Fish, fishing information and skills
			Plant identification, gathering information
			Nutrition, health education

NATURAL RESOURCE CATEGORIES[1]	ECOSYSTEM SERVICE CATEGORIES[2]	ASSOCIATED PUEBLO SERVICES[3]	EXAMPLES OF SPECIFIC USES[3]
			Cultural recognition/association
			Environmental restoration & stewardship, education and careers
			Materials for barter, trade, reciprocity
			Aesthetics, existence, viewing, ecotourism
	Provisioning	Gathered foods and medicines (subsistence, healing, sacred)	
		Hunted and fished animals (clothing/blankets, subsistence, healing, sacred)	Deer, elk, rabbit, other wildlife and fish
		Raw materials (sacred, subsistence use, shelter)	Wood for burning
		Ornamental use (spiritual, artistic)	Wood for buildings
			Plant/animal parts for hats, pigments/dyes
			Animals parts (hide) for clothing, shoes
			Animal parts (bones, teeth, shells) for jewelry
	Regulating	Biological control	Infestation control
			Predator/prey population control
		Waste treatment	Nutrient cycling
		Biodiversity, food web	Culturally important species
	Supporting & Habitat		Independent species
Groundwater (includes springs and seeps)	Cultural & Amenity	Spiritual sites, sacred grounds, landmarks and landscape features, traditional use areas	Life-giving source
			Drinking water (feasts)
			Place of worship
	Provisioning	Water supply	Drinking water (daily)
			Bathing, cleaning water

NATURAL RESOURCE CATEGORIES[1]	ECOSYSTEM SERVICE CATEGORIES[2]	ASSOCIATED PUEBLO SERVICES[3]	EXAMPLES OF SPECIFIC USES[3]
	Regulating	Water security (e.g. providing base flow and sustainable sources of spring water)	Clean water availability

Notes:

1. Natural resources potentially injured at and around LANL, as listed in DOI NRDA regulations, include surface water/sediment, groundwater, geologic resources, biological resources, and air.
2. Ecosystem services are the benefits to ecosystem functions, including provisioning, regulating, supporting, and cultural services; listing of these ecosystem services is not necessary to demonstrate the direct link between injured resources and Pueblo lost services, but illustrates the interconnectedness of ecosystem health and human services.
3. Note that some of these services may not necessarily change as a result of natural resource injury, but are referenced to provide a broad overview of the services provided by these resources.

CHAPTER 3 | APPROACH FOR INJURY DETERMINATION

Determination of injury to natural resources under the DOI's regulations consists of documentation that there is: (1) a pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and (2) that injury of a natural resource of interest (i.e., air, surface water, sediment, soil, groundwater, biota) has occurred, as defined in 43 C.F.R. § 11.62.

Pathway is defined as:

> *The route or medium through which…a hazardous substance is or was transported from the source of the discharge or release to the injured resource* (43 C.F.R. § 11.14(dd)).

Injury is defined as:

> *A measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a…release of a hazardous substance* (43 C.F.R. § 11.14 (v)).

For certain resource categories, the DOI regulations provide more specific definitions for what constitutes injury to that particular resource (Appendix C). For several resource categories, for example, exceedance of a Federally- or state-promulgated criterion (e.g., an ambient water quality criterion, in the case of surface water, or a maximum contaminant level, in the case of groundwater) is indicated to be a *per se* injury. For other resources (e.g., sediment), however, no criteria have been promulgated at either the Federal level, by the State of New Mexico, or by the participating Pueblos governments.

INJURY DETERMINATION APPROACH

As described in this Plan, the LANLTC anticipates applying a variety of approaches to determine if an injury to a natural resource has occurred, ranging from comparisons of hazardous contaminant concentrations to promulgated thresholds to identifying measurable adverse changes in resources. As part of the assessment, the LANLTC will decide upon appropriate adverse effects endpoints or criteria to use when quantifying service losses based on a variety of factors (e.g., nature of the contaminants, potentially exposed receptors, review of available toxicity information). For example, to determine injury to sediment resources (and the biota that live in or on the sediment), the LANLTC may apply thresholds published in the peer reviewed literature that correspond to the likelihood of observing adverse effects, develop site-specific criteria based on paired site-specific sediment chemistry and toxicity data, or conduct field studies to demonstrate injury. The LANLTC will also evaluate injuries to natural resources caused by remedial actions (see also the section entitled "Coordination with Remedial Actions" below). For example, the LANTC will consider the occurrence or likely occurrence of earth moving, tree removal, and/or habitat disruption caused as result of contaminant cleanup operations. Such actions will be considered in the context of the baseline condition of the affected resources (see also the section entitled "Baseline" in Chapter 4).

The LANLTC will explicitly take into consideration state- and Federally-promulgated criteria (including Federally-approved tribal criteria)[15], as well as potential injury thresholds established by the Pueblos, indicative of either ecological injury or Pueblo service losses. Regardless of whether the LANLTC focuses on per se thresholds or a measureable adverse change, the LANTC anticipates determining discrete thresholds above which injury has likely occurred and below which injury is unlikely. That is, for injury to be documented in a given resource, a particular effect must be determined to be adverse, able to be measured, and able to be linked to a hazardous substance release or determined to be the result of exposure to a hazardous substance. Criteria for each of these determinations will be established on a study-by-study basis.

In establishing a measureable adverse change or injury threshold, alternatives exist with regard to the metric (i.e., measurement unit or endpoint) chosen. In some cases, more than one type of adverse effect may be evaluated (e.g., enzymatic changes, impacts on growth), and that effect may be measured at a variety of biological levels (e.g., individual organism, population, habitat). As a part of the assessment process, the LANLTC will select appropriate metrics, based on available information for each resource of interest. For example, for biological resources, the LANLTC may focus on the endpoints of growth, reproduction, and survival of organisms exposed to contamination (e.g., an injury threshold representative of a statistically significant reduction in benthic invertebrate abundance).

In certain circumstances, additional requirements in the DOI regulations must be fulfilled in order to use certain promulgated criteria as injury thresholds. For example, if the LANLTC chooses to use applicable water quality criteria in surface or groundwater as injury thresholds, the relevant waters must first be identified as being committed to the applicable use (e.g., as a potable water supply, as habitat for aquatic life) (43 C.F.R. § 11.62).

The selection of metrics for injury determination will be made in a manner to allow for consistency throughout the NRDA process. That is, the LANLTC will focus on metrics that will be relevant for purposes of injury quantification and, ultimately, restoration identification and scaling. For example, when determining if an injury to a bird species has occurred, the LANLTC could focus on the reduction of fledglings produced as a result of exposure to a hazardous substance, as such an injury can be both linked to a quantifiable service loss (i.e., reduction in the number of birds) and restoration (i.e., a restoration project may be scaled based on its propensity to provide nesting habitat that

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[15] For example, Santa Clara Pueblo has Clean Water Act 303(d) authority and federally approved criteria pursuant to that authority.

would yield increased numbers of birds). Taking this type of approach will help facilitate both efficiency in the assessment as well as provide for quantification of restoration success (i.e., that the public has been made whole by a given restoration project).

CONTAMINANTS OF CONCERN

HAZARDOUS SUBSTANCES

The natural resource damage assessment will focus on direct and indirect injuries stemming from exposure to released hazardous substances as defined in section 101(14) of CERCLA.[16] Categories of hazardous substances upon which the assessment will focus include elements (in particular, radionuclides and metals), inorganic compounds (salts), organic compounds (in particular, explosives and persistent organic pollutants like polycyclic aromatic hydrocarbons and polychlorinated biphenyls (PCBs)), and petroleum hydrocarbons. The specific contaminants of concern on which the injury analysis will focus will be chosen by the LANLTC as part of the assessment process (the effort is described in Chapter 6, “Identification of contaminants of concern and development of ecotoxicological profiles”). This effort will also involve identifying any contaminants of concern for which ecotoxicological information is unavailable, so that the LANLTC can develop an approach to address the uncertainty regarding potential injury from these hazardous substances. Appendix D presents information on a sub-set of these contaminants, and provides general information on the distribution of these contaminants throughout the assessment area.

PATHWAY

As noted above, an important step in determining injury to natural resources is to establish a pathway from a known release of a hazardous substance to exposure of a trust natural resource. A determination that a pathway(s) for resource exposure to a variety of contaminant release from LANL operations exists was made by the LANLTC in the LANL Preassessment Screen (LANLTC 2010).

As part of the assessment planning process the LANLTC reviewed existing site-specific data and information sources. Contaminants for which a pathway for resource exposure has been confirmed include, but are not limited to a suite of radionuclides, PCBs, metals, and solvents. These contaminants have been released through a variety of mechanisms, ranging from uncontrolled operational releases to accidents resulting in spills. Site operations and hazardous substance release information for the site is summarized in Appendix A. Through a variety of physical and chemical processes, the contaminants moved through various environmental media and in some cases may have transformed into breakdown products or formed complexes. Once contaminants are in environmental media, biological resources are exposed through direct contact, consumption, or inhalation. A conceptual site model demonstrating potential routes of exposure of natural resources to hazardous substance released from LANL operations is provided below (Exhibit 3-1).

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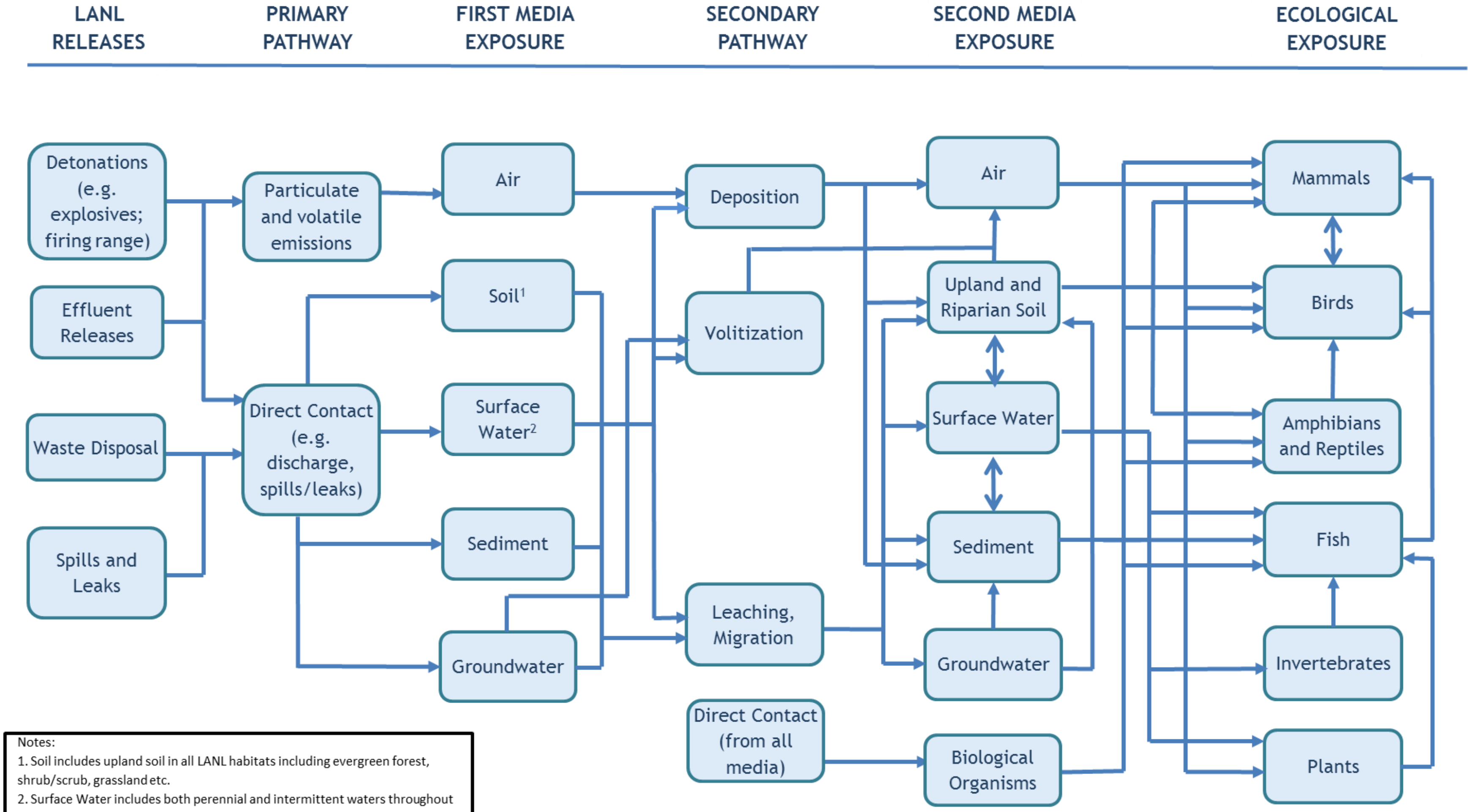
[16] Indirect injuries include, for example, injuries to natural resource stemming from implementation of environmental remediation.

EXHIBIT 3-1 CONCEPTUAL SITE MODEL DEMONSTRATING POTENTIAL ROUTES OF EXPOSURE OF NATURAL RESOURCES TO HAZARDOUS SUBSTANCES FROM LANL OPERATIONS



Notes:
1. Soil includes upland soil in all LANL habitats including evergreen forest, shrub/scrub, grassland etc.
2. Surface Water includes both perennial and intermittent waters throughout LANL Property.
3. Intake routes from media to ecological receptors include absorption, inhalation, and ingestion.

In some circumstances, there may be both anthropogenic and natural sources of contaminants in the environment. As contaminants move away from their location of release and are re-released into the environment through various fate and transport mechanisms, uncertainty about the contaminants' sources increases. In addition, although the geographic scope of the assessment includes all areas where releases of hazardous contaminants have come to be located (see Geographic Scope section in Chapter 1), there are some geographic areas where data on contaminant concentrations are not available because environmental sampling has not been undertaken.

The LANLTC may conduct pathway and/or fate and transport assessment studies in order to guide potential future sampling efforts. Although such studies are not explicitly called out in this Plan, the LANLTC recognizes that such studies are an efficient way to determine the likelihood of resource exposure and injury. To the extent that the individual studies conducted under this Plan address data gaps for certain resources or geographic areas, the LANLTC will confirm pathway(s) prior to conducting exposure, injury determination or quantification, or damages determination efforts.

CONFIRMATION OF EXPOSURE

Consistent with 43 C.F.R §§ 11.31(c)(1) and 11.37, this Plan must document that natural resources have been exposed to hazardous contaminants. Consistent with 43 C.F.R § 11.25(d), the LANL Preassessment Screen presented estimates of concentrations of hazardous substances in various environmental media in Appendix A of that document (LANLTC 2010). That presentation of measured contaminant concentrations in environmental media, and its reference herein, fulfills the requirement of confirmation of exposure. To the extent that individual efforts conducted under this Plan address data gaps for certain resources or geographic areas, the LANLTC will confirm exposure prior to conducting injury determination or quantification or damages determination efforts.

COORDINATION WITH REMEDIAL PROCESS

DOI's NRDA regulations indicate that:

> *The Assessment Plan shall contain information sufficient to demonstrate that the damage assessment has been coordinated to the extent possible with any remedial investigation feasibility study or other investigation performed pursuant to the NCP* (43 C.F.R § 11.31(a)(3)).

A summary of the historical evolution of remedial oversight and actions is detailed in the Preassessment Screen (LANLTC 2010). Remediation of environmental contamination at LANL is ongoing and will continue into the future. The 2005 Consent Order related to non-radionuclide hazardous wastes requires that all corrective actions be completed by 2015 (NMED 2004). The extent to which this goal will be achieved, and the timing of remediation of radionuclide contamination not covered by the Consent Order, have yet to be determined. However, LANL and the New Mexico Environment Department (NMED) have acknowledged that it is not likely that all corrective actions will be completed by

2015, and have extended certain deadlines under the Consent Decree beyond 2015.[17] Uncertainty related to the efficacy of remediation may also persist into the future.

As set forth in the LANLTC Memorandum of Agreement, it is the intent of the LANLTC to coordinate, where possible, the NRDA process with the remedial process (LANLTC 2008). This coordination is important for two reasons. First, it can inform the quantification of post-remedy injuries to natural resources. Second, as discussed below, in some cases, cleanup that is beyond the required remediation or additional augmentation of the post-remedial environment may be undertaken as compensation for natural resource damages.

Remedial actions often do not fully return natural resources and/or lost services to baseline conditions (i.e., the conditions that existed prior to the release of the hazardous substances). Further, remedial actions that involve, for example, earth moving and other physical alterations of the environment, may also result in unavoidable additional injury. The LANLTC intends to identify and quantify both the extent to which natural resources are returned to their baseline condition after remediation (i.e., post-remedy residual injury) as well as remedy-induced injuries. This will be based on a review of remedial documents, when available, including documents that describe the post-remedy condition of the remediated site. In circumstances where remediation has been completed, or the result of the remedy can be reasonably estimated, the LANLTC will take into consideration the result of the remedy as part of the injury quantification step of the assessment. In circumstances where the ultimate remedy for a particular habitat or resource is unknown, the LANLTC may make reasonably conservative assumptions about the nature and extent of post-remedy conditions and additional injuries caused by a range of likely remedial approaches.

As noted above, where remedial actions have not yet been completed, it may be possible to include additional remediation above and beyond that required by the remedial process to address human and ecological health risks in order to proactively address residual natural resource injury or service losses. In some cases, this additional remediation may result in an improvement in natural resources and the services they provide from their baseline condition. The LANLTC will look for such opportunities to influence the remedial process, where appropriate. Any restoration credit for remediation work proposed as compensation for natural resource injuries will have to receive the approval of the LANLTC and may be reviewed by the public as part of restoration planning.

RATE OF RESOURCE RECOVERY

Recovery period is defined as:

> *…either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the Trustee Council and documented in the Assessment Plan* (43 C.F.R. §11.14(gg)).

The rate of resource recovery will be determined based on information on the nature of remedial and restoration activities, expected natural attenuation, and estimates of resource

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[17] See http://www.nmenv.state.nm.us/HWB/documents/LANL_Extensions_as_of_5-20-2013.pdf.

recoverability derived from the literature. If available, site-specific time-series data may be used to estimate trends in natural resource recovery. Similarly, for remediated areas, pre- and post-remedial monitoring data may be used to assess the likelihood of resource recovery. In some cases, assumptions and/or modeling may be used. Finally, as alluded to above, to the extent that resources can be returned more quickly to their baseline condition through alternative or more aggressive remediation or primary restoration, such actions may be considered by the LANLTC.

CHAPTER 4 | INJURY QUANTIFICATION

Once injury to natural resources has been documented, the DOI NRDA regulations state that:

> *the authorized official shall quantify for each resource determined to be injured and for which damages will be sought, the effect of the discharge or release in terms of the reduction from the baseline condition in the quantity and quality of services* (43 C.F.R. § 11.70(a)(1)).

Further, the regulations state:

> *In the Quantification phase, the extent of the injury shall be measured, the baseline condition of the injured resource shall be estimated, the baseline services shall be identified, the recoverability of the injured resource shall be determined, and the reduction in services that resulted from the discharge or release shall be estimated* (43 C.F.R. § 11.70(c)).

When natural resources are injured by the release of hazardous substances, the services they provide may be reduced or eliminated. For example, if hazardous substances in canyon sediments reduce the abundance of sediment-dwelling biota, which serve as prey to fish and birds, this reduction in available food may reduce the ability of the canyon-bottom habitat to support baseline fish and bird population numbers. However, the range of adverse effects that may be caused by the release of hazardous substances into the environment is quite variable, and dependent on a number of biological, chemical, or physical factors. For example, increased concentrations of organic carbon in soils and sediments can mitigate the toxic effects of certain hazardous substances. Similarly, certain species are more or less susceptible to a given hazardous substance.

The purpose of the injury quantification step is to define the scope of lost ecological services and natural resource injuries, and to allow for selection and scaling of primary or compensatory restoration projects.[18] Quantified injuries form the basis for scaling restoration projects designed to compensate the public for lost or injured natural resources, consistent with the purpose of the DOI regulations to restore natural resources.

As called for in DOI's regulations, this chapter presents the methodologies and approaches the LANLTC anticipates applying in order to determine baseline conditions

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[18] Primary restoration refers to restoration of an actual injured resource, whereas compensatory restoration refers to restoration of resources of similar type and quality elsewhere.

(as an important step in injury quantification) and to quantify injury to natural resources and the services they provide.[19]

Based on the current knowledge and understanding of the site, the LANLTC anticipates taking the following approaches for injury quantification. The LANLTC may also consider different approaches if new information becomes available as the assessment proceeds.

- **Ecological.** The LANLTC anticipates using habitat and/or resource equivalency methods (described in more detail below) in the assessment of ecological injuries. As such, the LANLTC will likely quantify ecological injury in terms of lost services on a habitat basis focusing on representative species in each habitat type, and/or quantify injury to specific resources of concern (e.g., threatened or endangered species, species of special cultural importance).
- **Groundwater.** Injury to groundwater will be quantified using a resource equivalency method, as the total volume of injured groundwater (calculated as a stock or flux) and the associated lost services (as compared to baseline conditions).
- **Recreational (human uses).** With the exception of evaluating in greater detail the extent to which institutional controls are used in and around LANL to limit access to certain areas as well as how recreational losses may relate to Pueblo lost services, the LANLTC does not anticipate assessing potential recreational use losses at this time.
- **Pueblo services**. The LANLTC expects to quantify the change in use of natural resources and/or subsequent impacts to Pueblo communities using one of several injury quantification approaches, including, but not limited to stated preference surveys, direct cultural use assessment, habitat equivalency analyses (that support the safe continuation of traditional uses by a Pueblo), and modified resource equivalency approaches.

These approaches that the LANLTC anticipates using within the above loss categories are discussed in greater detail below.

BASELINE

Baseline is *"the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred"* (43 C.F.R. § 11.14(e)). As required by the DOI regulations, the LANLTC anticipates determining *"the physical, chemical, and biological baseline conditions and*

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[19] Under certain circumstances, "The effects of a discharge or release on a resource may be quantified by directly measuring changes in services provided by the resource, instead of quantifying changes in the resource itself." This approach is stated as being valid when three conditions hold: "(1) The change in the services from baseline can be demonstrated to have resulted from the injury to the natural resource; (2) The extent of change in the services resulting from the injury can be measured without also calculating the extent of change in the resource; and (3) The services to be measured are anticipated to provide a better indication of damages caused by the injury than would direct quantification of the injury itself" (43 C.F.R. 11.71(f)).

the associated baseline services for injured resources at the assessment area" and quantifying injury based on a reduction in services (43 C.F.R. § 11.72(a)). Therefore, determination of baseline will take into account the affected natural resources and the level of services that they would have provided in the absence of the hazardous substance release. That is, baseline reflects all of the conditions that would have existed but for the release of hazardous substances. Baseline conditions will also be taken into account when quantifying and scaling the benefits of restoration projects.

For example, surface water resources in the vicinity of the Los Alamos and White Rock town sites may be affected by stormwater under baseline conditions. Similarly, while no contaminants have been found in groundwater used for public water supplies at concentrations that exceed the U.S. Environmental Protection Agency's (EPA) Maximum Contaminant Levels, naturally occurring contaminants would be considered part of baseline.

Under the DOI regulations, baseline conditions may be established based on the review of historical, pre-release data and information, or on reference locations that exhibit similar physical, chemical and biological conditions as the assessment area, excluding contamination (43 C.F.R. § 11.72). The fact that releases of hazardous substances and oil have occurred within the assessment area prior to the establishment of regular or standardized approaches for the collection of physical, chemical and biological data will likely necessitate the use of suitable reference locations in lieu of historical data for purposes of baseline determination.

If pre-release information is used, it is important to recognize that baseline is not defined to be those conditions that would exist "absent any activity" or that would have existed "if the activity that resulted in the contaminant release did not occur." Instead, baseline is the world "but-for the release," with all other factors held constant. As such, the principal challenge in applying pre-release data at sites with a long-term history of releases is establishing that other factors did not lead to confounding changes (e.g., long term changes in species composition or abundance unrelated to site-specific releases). In some cases such determinations cannot be made, and thus information from control or background sites will need to be used.

The approach the LANLTC will use to define baseline may vary by natural resource or by the service being assessed. For example, certain contaminants would not have existed at measurable levels near LANL absent releases from LANL operations. Similarly, for some contaminants, measured levels may be so low as to constitute a *de minimis* contribution to injury. In such instances baseline may effectively be considered to be "no contamination".

For purposes of establishing baseline in the context of ecological and groundwater injury quantification, the LANLTC will attempt to define resource-specific contaminant concentrations that would be expected absent LANL releases, and will take into consideration any potential service losses caused by such baseline concentrations when quantifying injury. Practically, the LANLTC will evaluate available information on background and LANL-related contaminant concentrations and assess the potential magnitude and extent of injuries as a whole, and then establish the appropriate baseline for each resource being evaluated in the context of the particular analysis or studies being conducted. There are at least two sources of published background values for selected contaminants that may be used to establish baseline in the context of the assessment: site-specific Background Values (BVs) established pursuant to the Consent Order, and Regional Statistical Reference Levels (RSRLs). These values are reproduced in Appendix E. In some circumstances, the LANLTC may undertake additional site-specific studies to determine baseline concentrations of particular contaminants in particular resources, or define baseline in a manner consistent with the analytical approach being applied in a particular study, as necessary. This includes, but is not limited to, evaluating changes in contaminant concentrations attributable to the occurrence of wildfires within or near the assessment area.

For purposes of establishing baseline in the context of quantifying Pueblo service losses, it will be important to isolate the impact of the release of contaminants from other factors (e.g., loss of access to a resource unrelated to the release of contaminants, general technological and social modernization) influencing changes within Pueblo communities during the timeframe in question. Specifically, the assessment will need to determine if the people in these communities would be using the natural environment more or differently today if contaminants had not been released into the environment.

ECOLOGICAL INJURY QUANTIFICATION

As noted above, the LANLTC anticipates applying resource equivalency approaches as part of the LANL NRDA. Consistent with this approach and the DOI regulations, the LANLTC will quantify injury to natural resources based on reductions in the level of services provided by resources over time attributable to hazardous substances releases. Furthermore, as noted above, injury quantification will consider the effect of remedial activities in the assessment area on the return of injured natural resources to their baseline condition.

Two variants of resource equivalency the LANLTC anticipates using at LANL are discussed below: habitat equivalency analysis (HEA) and resource equivalency analysis (REA). Whereas HEA typically relies on measures of the percentage service losses per unit of land (generating injury measures expressed in area-time measures such as acre-years), REA measures service losses per unit of resource (generating injury measures such as bird-years or fish biomass-years).

Both of these methods are commonly applied in the context of NRDA, because both methods not only provide quantitative measures of lost services, but also can be used within the context of service-to-service approaches to scaling restoration projects to compensate for natural resource service losses. That is, these methods provide an effective way to produce both quantitative measures of lost services as well as a scale of required restoration projects. While restoration scaling is part of the damages determination phase of NRDA (see Chapter 5, below), one of the reasons why resource equivalency is a preferred approach is because it facilitates the restoration scaling and damages determination step.[20] The following sections describe circumstances in which each approach tends to be more appropriate.

RESOURCE EQUIVALENCY ANALYSIS

REA is most commonly selected to quantify lost ecosystem services when the injury is specific to a particular species or species group, particularly when the nature of the injury includes acute lethality to a known, or estimable, number of organisms. The unit of injury is the number of organisms lost (or their biomass), and may also potentially include their lost future somatic (i.e., physical) growth and/or reproductive potential. Essentially, REA blends population modeling with discounting to put past and future changes in the selected measurement unit into a common present value.

An advantage of REA is its targeted focus on species specifically identified as having been adversely affected by a release of a hazardous substance. Challenges associated with using this method can include identifying detailed life history information for species of concern. In addition, REAs that span more than one generation (i.e., REAs that attempt to quantify lost future reproduction of organisms) are subject to additional challenges, and their results, subject to additional uncertainty. If population models are used, it is necessary to specify parameters and relationships that may not be known with a great deal of certainty (Zafonte et al. 2005). If, instead, direct calculations of lost individuals are used, it becomes necessary to make a decision as to how many generations into the future it is reasonable to extend estimated foregone reproduction, and as Zafonte et al. note, "[i]t is difficult… to construct a rationale that links … recovery to a specific number of entirely lost future generations." The LANLTC anticipated mitigating this issue by estimating compensatory project benefits in the same fashion as losses.

HABITAT EQUIVALENCY ANALYSIS

Like REA, the first phase of a HEA involves generation of a quantitative estimate of service loss (the second phase providing a quantitative estimate of gains from potential restoration projects). HEA is most commonly undertaken when injury or service losses can more reasonably be said to accrue to a geographic area.

The primary challenges of conducting a HEA are (1) how to estimate service losses within the study area, and (2) how to combine different service loss estimates across multiple species (or species groups) to generate an overall service loss estimate for a given area. Allen et al. (2005) state:

> *Choosing which service or services to use in a HEA can be based on: (1) the ability of (a) service(s) to represent the habitat as a whole; (2) the particular importance of (a) service(s) because of legal protections, high public values, or particular agency interest; or (3) the service(s) lost and gained can be readily measured or estimated for the habitats being analyzed. Choosing the*

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[20] As noted in 73 Fed. Reg. 57,259, "Methodologies that compare losses arising from resource injury to gains expected from restoration actions are frequently simpler and more transparent than methodologies used to measure the economic value of losses."

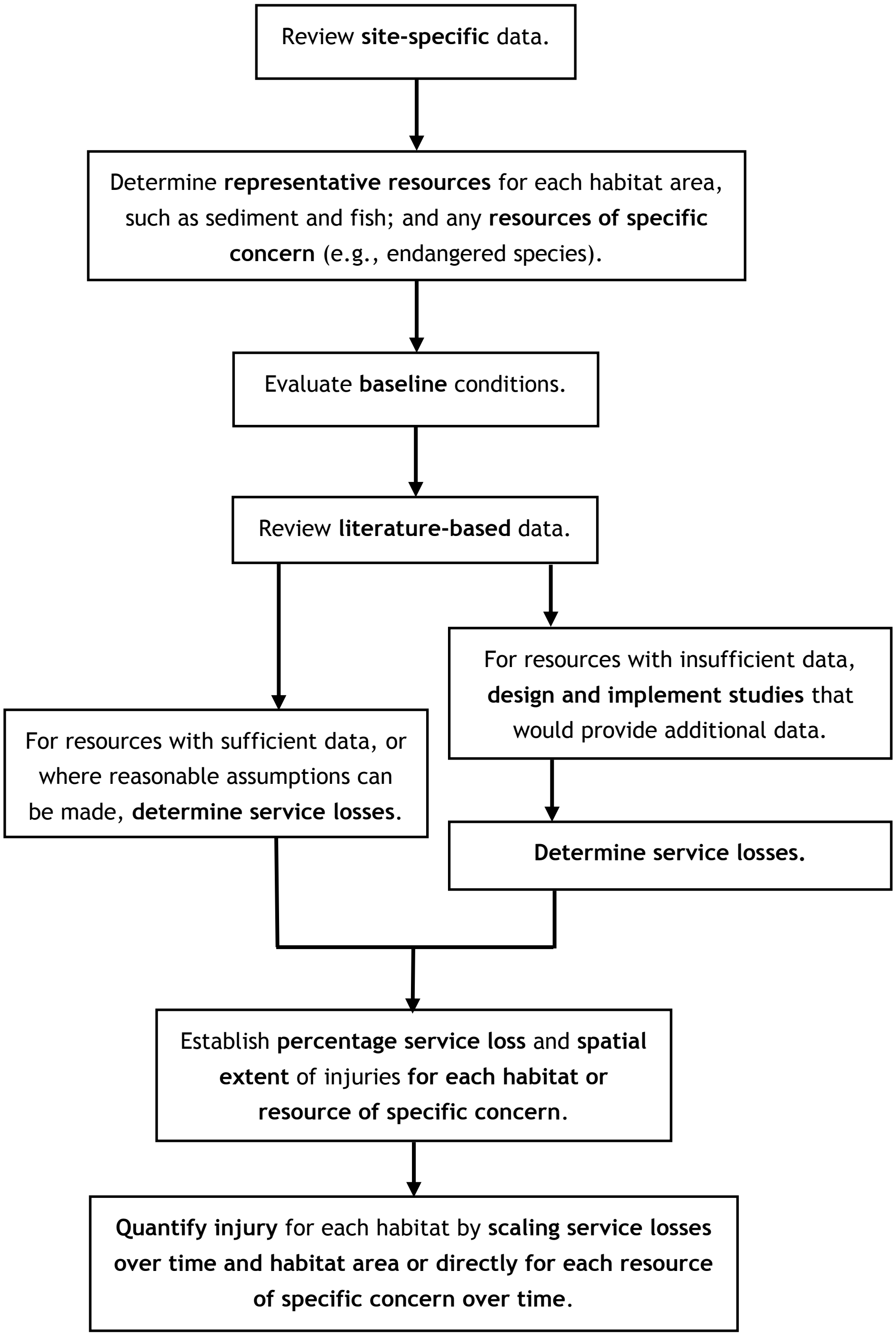
> *"right" service(s) for a habitat is not always straightforward, and different choices can lead to very different results in terms of the amount of needed restoration that is indicated by the HEA calculation.*

In order to generate resource service loss estimates in the context of HEA, there are two general approaches:

- **Contaminant-centric approaches.** These approaches involve comparisons of measured or modeled contaminant values with either literature-based thresholds, or literature-based or site-specific exposure-response functions, to estimate service losses. These approaches are widely used and are adaptable to broad ranges of case circumstances. Some limitations include the uncertainty regarding the application of literature-based thresholds to site resources, the availability of toxicological information, and the uncertainty involved with developing an exposure-response function based on individual threshold values.
- **Field-centric approaches.** These approaches rely on field-based measures of ecological functions (e.g., benthic community density and character, percent native live cover, native plant species richness). Field-based approaches can be particularly useful when causality of potential field impacts is unlikely to be at issue, and are useful for estimating benefits of restoration projects that are unrelated to contaminant presence. However, field-based measures can be costly to collect and it may be difficult to tease out adverse effects due to exposure to hazardous substances from effects due to other anthropogenic or natural influences (e.g., adverse effects from river dams or natural predators).

The LANLTC anticipates using both of these approaches, or a combination thereof, to generate service losses. Because services provided by natural resources in a given geographic area may be interdependent, the LANLTC will assess service losses on a sub-set of potentially adversely-affected resources that constitute major components of the habitats within the assessment area, based on available information or information generated as part of the assessment. The LANLTC will identify, evaluate, and select approaches for developing an estimate of habitat service losses, which may include focusing on one metric or one representative resource for a given habitat, or an approach for combining multiple measures of service losses into an overall estimate of habitat service losses on a percentage basis. Exhibit 4-1 depicts the approach for injury quantification the LANLTC will take in the context of conducting a HEA.

EXHIBIT 4-1 INJURY QUANTIFICATION METHODOLOGY IN THE CONTEXT OF HEA



HABITATS FOR WHICH INJURY MAY BE QUANTIFIED

For purposes of injury quantification, the LANLTC anticipates quantifying ecological service losses to representative resources within general local habitat types; however, as necessary, the LANLTC may quantify injury to individual sub-habitats, including isolated wetlands, springs, or upland areas. Broad habitat types likely to be evaluated include canyon bottom habitat, upland terrestrial habitat, and aquatic habitat, described below. As part of the assessment, the LANLTC will likely divide the broader habitat types into sub-sections for which service losses are quantified based on factors such as topography, hydrology, and the likely extent of contamination.

- **Canyon Bottom Habitat:** canyon bottom habitat that is permanently wet may be assessed separately from canyon bottom that is only temporarily wet during a portion of the year. Potential representative resources the LANLTC may use to quantify injury include, but are not limited to fish and sediment macroinvertebrates for time periods when canyon bottoms are wet; earthworms and other soil-dwelling biota when canyon bottoms are dry; amphibians, reptiles, and birds and mammals.
- **Upland Terrestrial Habitat:** includes the terrestrial habitats that comprise the canyon walls and mesa tops that are generally dry year-round. Forested habitat may be evaluated separately from shrub-scrub/grassland type habitats. Targeted representative resources may include, for example, terrestrial invertebrates and insectivorous and omnivorous birds and mammals.
- **Aquatic Habitat:** includes the in-stream and riparian habitats of the Rio Grande and the open water habitat of the Cochiti Lake and its immediate surrounding shoreline habitat. Representative resources that may be used to quantify injury include: sediment macroinvertebrates, fish, amphibians, reptiles, birds, and mammals.

GROUNDWATER INJURY QUANTIFICATION

It is anticipated that a REA approach will be used for assessing and scaling restoration for groundwater losses. As noted above, resource equivalency methods are based on balancing the injury to natural resources that has occurred over time with an equivalent amount of restoration, taking into account the nature and duration of the injury and the nature and timing of the restoration. Thus, for a groundwater REA, it is necessary to characterize the baseline quality of the groundwater, quantify the amount of injured groundwater, and delineate the timeframe of the injury.[21]

The quantity of injured groundwater can be quantified as a static volume, which is the amount of injured groundwater at a given point in time (also referred to as a stock of groundwater). It can alternatively be quantified as a flux, which is the volume of water passing through the aquifer over a unit of time (e.g., on an annual basis). Both types of injury quantification approaches require information about the spatial extent of the

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[21] Here we describe only the information needed for the quantification of groundwater injury. Chapter 5 provides a description of how REA will be used to scale restoration in order to develop estimates of damages.

groundwater contamination and the physical properties of the aquifer. For example, in order to calculate static volume (or stock), the surface area and the thickness of the groundwater contaminant plume is needed. In addition, the porosity of the aquifer (the fraction of the total aquifer space that contains groundwater) is also needed. Delineating the timeframe of injury includes determining when it began, how it may have changed over time, and when (or if) it will end. Whether injury is quantified as a static volume and/or flux is typically decided based on specific conditions encountered at a site and the types of groundwater restoration being considered. The specific method(s) for quantifying injury to groundwater will be determined as a part of the assessment.

If there are additional losses associated with groundwater, such as impacts to Pueblo communities, appropriate methods for quantification will be developed as the assessment progresses. For instance, contamination arising from LANL activities has been detected within Pueblo de San Ildefonso boundaries. Quantification of such losses to-date and estimated damages in the future will be developed as part of the assessment.

Addressing Contamination of the Vadose Zone and Geological Resources

The DOI regulations list geologic resources as a separate category of natural resources, and suggest quantification of injury to such resources in terms of “[t]he volume of geologic resources that may act as a source of toxic leachate” (43 C.F.R. § 11.71 (k)(3)). Thus, the LANLTC anticipated addressing contamination in the vadose zone as a pathway and reservoir of contaminants.

QUANTIFICATION OF HUMAN SERVICE LOSSES

Although there is a broad range of services that humans derive from natural resources (e.g., commercial harvest; see description of services in Chapter 2), the two principle categories of human losses associated with releases of hazardous substances for which trustees typically seek compensation are recreational use losses and tribal-related losses. Each of these categories is discussed in greater detail below.

Preliminary investigation of potential recreational use losses by the LANLTC has indicated that recreational use service losses are unlikely to have occurred as a result of hazardous substance releases at LANL. As a result, the LANLTC does not anticipate conducting targeted assessment of recreational use impacts. The information on which this determination was based is summarized below. However, to the extent that new data or information become available related to potential recreational use losses, the LANLTC may initiate additional data review or primary assessments related to any such losses. The LANLTC also acknowledges that an aspect of recreational losses may relate to Pueblo lost services if there is a future inability to enjoy unrestricted uses of natural resources.

RECREATION

Recreational activities on LANL are limited to publicly accessible areas. Hiking is the primary recreational activity, with publicly accessible trails in portions of Los Alamos, Mortandad, Pajarito, Water, and Ancho canyons (LANL 2010b). In addition, while water levels do not permit primary contact recreational activities, such as swimming and rafting, some limited secondary contact (i.e., wading and bathing) has been observed in

Sandia Canyon (Lusk et al. 2002). While public access is restricted to limited areas of LANL, the surrounding public lands support numerous recreational activities, including fishing, hunting, hiking, mountain biking, swimming, rafting, and skiing. Public lands in close vicinity to LANL include the Santa Fe National Forest, Rio Grande, Bandelier National Monument, and VCNP. This section provides an overview of the most commonly pursued recreational activities, including discussion of where the activities occur and any associated restrictions.

- **Fishing**: Many types of fish are caught on the public lands surrounding LANL, including bass, catfish, and trout. Fishing is allowed on most rivers, streams, and ponds in the Santa Fe National Forest. Fishing is also allowed on the Rio Grande and on a limited basis in the tributaries that drain the VCNP (NM Game & Fish 2013a). Fishing is not allowed in Bandelier National Monument or on LANL property (DOE 2003). Fishing advisories are in place for mercury and PCBs in the Cochiti Lake and for PCBs only in the Rio Grande from the Cochiti Lake upstream to the confluence with the Chama River (NMED 2011). Similar advisories exist in lakes across New Mexico as well as portions of the Rio Grande upstream of LANL operations, and therefore the extent to which LANL contamination has caused these restrictions is unclear. Fishing restrictions, stemming from DDT (dichlorodiphenyltrichloroethane) release by the National Park Service in the 1950s, exist in portions of the Bandelier National Monument (Judy, personal communication, January 2012). No other fishing advisories exist on the tributaries of the Rio Grande that flow through or adjacent to LANL property (Hansen et al., personal communication, January 2012).
- **Hunting**: Hunting, including for deer, elk, antelope, sheep, bear, and turkey occurs on public lands surrounding LANL. Hunting is allowed on the Santa Fe National Forest, and is restricted to elk and turkey hunting on the VCNP (NM Game & Fish 2013b). No hunting is allowed on Bandelier National Monument or on LANL property (DOE 2003). No wildlife advisories or hunting restrictions have been issued in the areas around LANL as a result of contamination or species health (Mower, personal communication, September 2011).
- **Swimming**: No swimming restrictions are in place on the Rio Grande or its tributaries in the area surrounding LANL (Schiffmiller and Ford-Schmidt, personal communication, September 2011). The Los Alamos Reservoir, which once supported primary contact activities, has been closed since the Cerro Grande fire in 2000 and no longer supports primary contact activities such as swimming, though such activities could have occurred prior to the fire (NMED 2007).
- **Rafting**: Non-motorized boating, such as kayaking and rafting, is allowed throughout the Northern Rio Grande, including sections near LANL (BLM 2011). In addition, motorized boating is allowed on the Cochiti Lake (USACOE 2012). No water sports restrictions are in place on the Rio Grande adjacent to LANL (Ford-Schmidt, personal communication, September 2011), and water

flows in the tributaries of the Rio Grande in and around LANL are not sufficient to support primary contact activities, such as rafting (NMED 2007).

- **Hiking, Mountain Biking**: There are a number of public trails surrounding LANL property, including within Bandelier National Monument, nearby U.S. Forest Service lands, and on private property to the east and north of LANL (McKown 2010). On LANL property, there are a few open trails in the northwest part of the LANL site and the southeast part, several controlled access trails (e.g., Mortandad Canyon trail, ADC trail), and a number of closed trails (e.g., Ancho canyon trail) (McKown 2010). While the public enjoys access to the majority of Bayo Canyon, public access to the former TA-10 in Bayo Canyon is restricted as a result of institutional controls meant to contain radionuclide contamination (LANL 2009). Additionally, hiking and mountain biking restrictions do exist on public lands surrounding LANL; however, these restrictions are not related to LANL activities (Judy et al., personal communication, January 2012).
- **Skiing:** In the winter, Nordic skiing is possible throughout the high elevation public lands surrounding LANL. Alpine skiing is limited to privately owned Pajarito Mountain Ski Area. Some skiing restrictions occur in public lands surrounding LANL that are unrelated to LANL contamination (Judy et al., personal communication, January 2012).
- **Other Recreation**: No other recreational advisories or restrictions are in place in the areas around LANL and no primary use restrictions exist on the Rio Grande around LANL (Jankowitz et al., personal communication, January 2012).

In addition, limited recreational activities are available to the public on Pueblo lands surrounding LANL. The Pueblo de San Ildefonso allows recreational fishing by permit at its fishing pond along the Rio Grande. The Santa Clara Pueblo allows camping, fishing, and picnicking by permit in the Santa Clara Canyon.

Potential Contaminant Effects

Impacts of contamination on recreational opportunities can manifest in a variety of ways, ranging from fish consumption advisories to closures of sites and facilities. Under the DOI NRDA regulations, to the extent that contamination causes changes to available services in terms of recreational quality, public access, and recreation demand, these changes are compensable (43 C.F.R. § 11.71(e)). Given the existence of hazardous substance-related institutional controls in and around LANL which limit access to the site, the LANLTC is proposing a study to inventory the nature and extent of such controls (see Chapter 6) and the potential resulting impacts on human use and behavior.

However, the LANLTC has identified a limited potential for losses in recreational opportunities (or decreases in the values the public holds for such activities) occurring as a result of LANL-related hazardous substances releases. For example, it is possible that some recreators in the area avoid fishing or otherwise modify their behavior due to concern about contamination, but the LANLTC is unaware of any documented impacts on recreator behavior. Conversations with resource managers did not reveal any suggestion of likely recreational impacts. Further, current information suggests that the public actively recreates in a variety of ways in and around LANL. As such, the LANLTC is not proposing study of recreational impacts and no studies of recreator behavior are proposed in this Plan at this time.

PUEBLO LOST SERVICES

“Pueblo lost services” refer to a loss in natural resource services of importance to one or more of the Pueblo Trustee governments or members of Pueblo communities in the vicinity of LANL, for which separate natural resource restoration actions may be needed. As stated in Chapter 2, as a result of differences in the nature and extent of services Pueblo members derive from the environment—and differences in the way in which *changes* in these services affect Pueblo communities—it may be necessary to describe and quantify service losses to Pueblo communities separately from service losses to the general public. That is, specific restoration actions may be required to fully compensate for losses in Pueblo community services. However, because restoration of resources and services to Pueblos may also restore flow of service to the general public, double counting will have to be evaluated.

The techniques available to assess changes in Pueblo members’ uses of the environment in the context of NRDA are less well-developed (and have been applied less frequently) than the techniques used for other categories of natural resource services. As a result, damage assessments involving Pueblo lost use of natural resources have generally relied on similar methods as applied to other service categories (modified and supplemented to reflect unique circumstances of Pueblo member use), or on methods applied to assess other impacts on indigenous cultures (e.g., land claims, cultural impact assessment). Other tribes have started the process of assessing losses in the context of a natural resource damage assessment (e.g., as part of the Hanford Reservation NRDA in Washington), and the LANLTC may coordinate with these tribes to learn from their experience and determine if similar approaches might be applied to the LANL assessment.

Examples of methods which have been applied to measure service losses to tribal communities in the context of NRDA include:

- **Assessment of changes in tribal services.** This includes assessment and analysis of changes in levels of traditional knowledge, cultural practices, and relationships resulting from shifts in the use of natural resources caused by the presence of hazardous contaminants. Such an analysis is generally based on applied anthropological and ethnographic approaches.
- **Direct assessment of loss of resource use.** This can involve application of revealed preference techniques, user surveys, and existing data. For example, assessment of the number of individuals who previously utilized a site, the nature and frequency of that use, substitution or alternative behaviors, and the expected recovery period for the activity.

- **Habitat and resource equivalency.** This involves the use of resource-based measures to quantify the level of service loss under the assumption that ecological service losses are a proxy measure of tribal service losses.
- **Stated preference.** This involves the use of surveys to elicit tribal attitudes and preferences towards an injured resource.

These approaches may be used in combination to assess changes in services resulting from the release of hazardous contaminants to the environment. Each of these approaches, all of which are available to the LANLTC, is discussed in greater detail below.

Assessment of Changes in Pueblo Services

One approach for conducting Pueblo service loss assessment is to inventory and evaluate existing documentary records related to Pueblo uses of and services provided by natural resources. This would include consideration of all of the relevant information held by the participating Pueblo communities that can be located and accessed from archives. These sources would include scientific reports and academic studies on historic use and traditional cultural context; environmental philosophy and ethnographic descriptions of land and river-based practices; newspaper and media reports on environmental and health issues affecting the communities; studies on the health and social status of the communities; and transcripts of oral narratives.

The goal of this type of assessment is to evaluate and organize the existing information so that it can be analyzed in ways that are supported by, and consistent with, the criteria and ethics of standard social science research practice, the conventions of the best strategies of community-based participatory research, and the most advanced ethnographic approaches. The ultimate objective is to gain as complete an understanding as possible (using documentary sources) of the community and its interactions with the natural environment and how these behaviors have changed over time and in response to the presence of hazardous contaminants.[22] In this context, primary sources would be given priority as they provide more validity than secondary sources as meaningful indicators of change and service flow interruption. Ultimately, all of the materials in the available record could be assessed for their relative contribution to the objectives of the work: understanding the nature and scope of interruptions to ecosystem service flows within the affected communities due to the presence of hazardous contaminants. The goal is to produce an assessment record that meets the needs of the NRDA process and is sound

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[22] Cultural changes can impact a community in terms of time; social cohesion; the intergenerational transfer of knowledge and identity and of the speaking/use of indigenous languages; their economic self-sufficiency; and even the maintenance of the population on the territory. For example, in a recent assessment at another site, a tribal trustee developed seven cultural indicators affected by changes in ecosystem services over time. These indicators relate to water, fishing, and the use of the river; horticulture, farming, and basket-making; medicine plants and healing; hunting and trapping; well-being of children, youth and family; food security and sustainable livelihoods; and transmission of community knowledge to future generations. For each of the indicators, measures of ecosystem impairment were causally linked (where relevant) to cultural injury or interruption of resource services.

and valid from a social scientific perspective, but is also consistent with the communities' values and traditions to assure that the results are accepted.

Although this approach draws heavily on the existing evidentiary base, it also involves identification and consideration of data gaps. Where appropriate and required, primary research efforts such as oral history research, can be applied to focus on gathering information directly from people who had used and who continue to use the natural resources and to ask them directly how their knowledge of environmental contamination affected their cultural practice.

The principal strengths of the applied indigenous community research methodology includes utilization of existing information to the fullest extent possible; applying approaches to organization and review of available information that are well-accepted; recognizing the complex relationship between indigenous communities and natural resources; explicitly considering baseline factors; and enhancing the probability of community acceptance of the results. The principal weaknesses involve the time and cost to implement the work, the need for information that may be considered confidential or proprietary, and the challenge of quantifying results such that they can be used to support restoration scaling using evidence that is typically qualitative in nature.

Direct Assessment of Loss of Resource Use

Some impacts on Pueblo uses of natural resources may be relatively limited in geographic scope and/or temporal scope. Others may be of a magnitude that may not warrant a substantial research effort, or may be very well-defined (e.g., the loss of access to a culturally significant area for a limited period of time). In these cases, direct assessment of lost use can provide a basis for assessing service losses.

The strengths of this approach are its simplicity: the direct measure of changes in use to establish service losses, the ability to control for baseline factors in the assessment, and the fact that the information required to conduct such an assessment is generally available with limited additional effort. The principal disadvantage is the failure of the approach to see changes recognizing the complex relationship between indigenous communities and natural resources.

Habitat and Resource Equivalency

Resource equivalency methods may be used to define the level of service losses that have resulted from the release of hazardous contaminants, serving as proxy measures for Pueblo service losses. In such cases a biological measure of resource injury (such as the presence of phytotoxicity or of contamination levels that make it unsafe to use a given resource) is assumed to provide a better indication of lost services than direct measures of changes in a Pueblo member's behavior.

The benefit of a habitat or resource-based approach to scaling impacts is that it is relatively easy to conduct, can be explicitly designed to address baseline issues, and avoids potential confidentiality issues. The principal weaknesses are that (1) the service loss measures developed are not a direct measures of the change in services, and the method may fail to address the complex relationship between Pueblo communities and natural resources; and (2) the concept of equivalency must carefully consider the unique values embodied in Pueblo lands and resources due to Federal trust and tribal self-governance attributes. The Pueblos govern themselves on lands they have always occupied and have never left. Pueblo members therefore view their lands and resources as non-fungible commodities that cannot be easily "replaced" with lands and resources lacking these valuable attributes. While land exchanges can and do occur and can be important in the context of returning ancestral lands to the Pueblos, such exchanges require Congressional approval. All of these factors must be considered in any discussion of restoration scenarios that contemplate replacing equivalent lands that provide equivalent service flows.

Stated Preference

Stated preference approaches involve the application of public opinion surveys to elicit information from individuals regarding their use of a resource, and/or attitudes and preferences towards an injured resource or restoration strategy. For example, the LANLTC may use a survey to understand the frequency with which Pueblo members fish or hunt, the species they target, and consumption rates. Such surveys might be applied as a direct approach to service loss quantification, or might be combined with the approaches discussed above.

In a few cases stated preference methods have been applied to directly assign economic values to foregone cultural use (Duffield 1999). That is, these studies provide economic measures of the value of lost services, without necessarily defining the nature and extent of the loss of use or cultural harm.

The strength of the stated preference methods is the ability to pose to a respondent any hypothetical alternative scenario (i.e., the method is not limited to observing behaviors under limited actual conditions). While more flexible than revealed preference approaches, stated preference surveys can be costly and time consuming to administer, and may not be consistent with Pueblo policies or values. As a result, researchers often look to apply revealed preference methods to assess changes in human use of natural resources, since such methods are generally less controversial and pose fewer challenges. Revealed preference studies, however, typically address a narrower set of values than stated preference.

Combination Approaches

As noted above, the approaches outlined may be conducted independently, or combined in order to assess Pueblo lost services.

As part of the assessment, the LANLTC will conduct an analysis that relies on existing information to define the scope and scale of Pueblo lost services. That analysis may be used to determine whether additional research is needed to support injury quantification and damages determination related to Pueblo lost services.

CONSIDERATION OF REMEDY IN INJURY QUANTIFICATION

As noted in Chapter 2, the LANLTC will take into consideration remedial actions as part of the NRDA. If remedial actions do not return natural resources and resource services to baseline, loss estimates will reflect the difference between the natural resource services provided after completion of the remedy and the resource services expected under baseline (residual injuries). Similarly, if remedial actions lead to an enhancement of natural resources and resource services above and beyond baseline, quantified losses will be adjusted accordingly. However, actions that are not above and beyond required remedy are not considered restoration and will not be given “credit” under the NRDA. The LANLTC will evaluate data and information to reduce uncertainty around the likely end-state of the environment and/or apply reasonably conservative assumptions regarding the extent to which remedial activities will or will not return natural resources to their baseline condition.

CHAPTER 5 | DAMAGES DETERMINATION

Once injuries to natural resources in the assessment area are quantified, the LANLTC will determine the appropriate scale of damages required to fully compensate the public. While damages are “the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources” (43 C.F.R. § 11.14(l)), there is a clear intention in the DOI regulations to focus on the actual restoration of natural resources rather than on valuing the change in the public’s willingness to pay to avoid the injury. Specifically,

> *The measure of damages is the* ***cost of (i) restoration or rehabilitation of the injured natural resources*** *to a condition where they can provide the level of services available at baseline, or (ii)* ***the replacement and/or acquisition of equivalent*** *natural resources capable of providing such services* (43 C.F.R. § 11.80(b) (emphasis added)).

Further, in describing the regulations, DOI stated that it:

> *does not believe that Congress intended to allow trustee agencies to simply restore the abstract services provided by a resource, which could conceivably be done through an artificial mechanism. For example, nothing in the language or legislative history of CERCLA suggests that replacement of a spring with a water pipeline would constitute “restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.” CERCLA requires that natural resource damages be based on the cost of restoring, rehabilitating, replacing and/or acquiring the equivalent of an actual natural resource* (58 Fed. Reg. 39,339, July 22, 1993).

In the 2008 revisions to the DOI NRDA regulations, DOI modified the regulations to express a preference for direct selection and scaling of restoration options, over estimation of the monetary value of lost services. In the preamble to the revised regulations DOI stated, in reference to interim lost services (i.e., compensable values):

> *We believe that in many cases, restoration-based approaches can lead to timelier, more efficient, and more cost effective [restoration of natural resources and the services those resources provide] —which is the key objective of these revisions. The NRDAR process is streamlined by focusing directly on restoration alternatives that address losses, rather than on first estimating the monetary value of losses and then determining how to address them with appropriate projects. Moreover, the transparency involved in comparing resource gains to*

> *resource losses reduces controversy and transaction costs, and encourages collaborative efforts to identify projects that yield high human and ecological benefits relative to their monetary cost* (73 Fed. Reg. 57,259).

APPROACH TO DAMAGES DETERMINATION

In light of this guidance, there are two general steps the LANLTC anticipates taking to determine natural resource damages once injuries have been quantified. These are:

1. Determine the appropriate scale of restoration projects needed to fully compensate for these quantified injuries.
2. Calculate damages as the cost, in dollars, to perform the restoration projects.

However, it is important to note that monetizing the damages (i.e., calculating the cost of identified restoration actions) is optional. The LANLTC may decide to identify the suite of specific restoration projects required to compensate for quantified losses and agree to pursue these projects after evaluating them using various criteria including the type and level of benefits provided without determining the precise cost of each of the projects. Or the LANLTC may decide to identify the type and quantity of restoration actions expected to compensate for the losses, and use the estimated costs of these actions to monetize the damages.

An important component of Step 1 is the consideration of general criteria for evaluation of restoration projects indicated in the DOI NRDA regulations (43 C.F.R. § 11.82(d)), as well as any site-specific criteria or objectives for particular restoration projects. Factors for consideration explicitly listed in the DOI NRDA regulations include, but are not limited to:

- the technical feasibility of the restoration action,
- the cost-benefit and cost-effectiveness of the restoration,
- results of actual or planned response actions,
- potential for additional injury or adverse effects on human health and safety to be caused by the restoration action,
- the natural recovery period and the ability of the natural resources to recover without restoration, and
- consistency and compliance with Federal, state, and Pueblo policies (43 C.F.R. § 11.82(d)).

In addition to these restoration criteria, the LANLTC may consider additional criteria when identifying, scaling, and selecting restoration projects, such as, for example:

- the relevance of the project to the natural resource damage assessment (i.e., nexus to injury),
- proximity of the project to the LANL site and/or Pueblo lands,
- potential for immediate and long-term benefits,

- likelihood of providing benefits to multiple natural resources or providing both ecological and cultural benefits, and
- likelihood of the project proceeding without NRDA funding.

The LANLTC may also identify additional criteria as the assessment proceeds. For example, if a particularly sensitive or important biological receptor is determined to be injured as a part of the assessment, the LANLTC may prioritize projects that provide benefits for this species.

In addition to considering the criteria above, when selecting and implementing restoration actions, the LANLTC will take measures to avoid double counting. Double counting may occur when evaluating damages associated with resources that provide multiple, overlapping benefits and services.

ECOLOGICAL DAMAGES DETERMINATION

As indicated in Chapter 4 above, the LANLTC anticipates using HEA or REA to determine ecological losses. The LANLTC therefore also anticipates using these approaches when scaling restoration.

Specifically, use of equivalency based scaling approaches will mean that the LANLTC will identify and quantify the services provided by proposed restoration projects as part of the scaling process. This will mean that, as restoration projects are identified and evaluated, attention will need to be paid to the particular suite of services the restoration projects are anticipated to provide. Whenever possible, the LANLTC will endeavor to target restoration that will replace, rehabilitate, restore, or acquire the equivalent of those resources and the services they provide that were found to be injured (i.e., in-kind replacement). In some cases, the LANLTC may choose to engage in environmental restoration that is deemed worthwhile (but is not in-kind in nature) if it restores *similar* resources or resource services as were injured or restores resources or resource services that are deemed to be highly important ecologically when restoration of the *same* type and quality is unavailable or not possible. In these circumstances, the LANLTC will evaluate the relative differences between the type and quality of the injured resources and the resources to be restored, and may adjust the scope or scale of required restoration accordingly. For example, the LANLTC may develop compensation ratios to account for potential differences in ecological services provided by different habitat types (e.g., wetland versus open water habitat). Such ratios may be applied to assure that any trade-offs in the habitats or resources targeted for restoration result in restoration projects that are sufficient to make the public whole.

GROUNDWATER DAMAGES DETERMINATION

As with the damages determination approach for ecological losses described above, the LANLTC anticipates identifying, scaling, and determining the cost (as necessary) of restoration projects required to compensate the public for groundwater losses. There are a wide range of restoration projects that could be performed to restore lost groundwater services, such as primary restoration of injured groundwater (e.g., pump and treat) or prevention of groundwater contamination. Projects will be chosen based on restoration criteria, and will be scaled using a resource equivalency method–that is the LANLTC anticipates implementing restoration actions to replace the quantity (i.e., stock or flux volume) of groundwater shown to be injured in the injury quantification phase of the assessment.

PUEBLO DAMAGES DETERMINATION

As noted in Chapter 4, there are a range of injury quantification approaches available to assess the scope and scale of Pueblo lost services. The damages determination approach will need to be consistent with whichever injury quantification approach is used. Similar to ecological damages determination, damages determination for Pueblo lost services will be based on the cost of identified restoration projects required to compensate for quantified losses. Restoration projects will need to be identified and scaled accordingly to compensate affected Pueblos with services of the same nature and scope as those services which are determined to have been lost.

RESTORATION AND COMPENSATION DETERMINATION PLAN

The determination of appropriate damages and restoration will be summarized in a Restoration and Compensation Determination Plan (RCDP), to be produced by the LANLTC. The RCDP will evaluate restoration alternatives and describe the selection process followed in choosing the preferred alternatives. The LANLTC will seek input from the public regarding potential restoration projects, as outlined in the PPP, and the RCDP will be made available to the public for review and comment.

CHAPTER 6 | ONGOING AND PLANNED ASSESSMENT ACTIVITIES

The preceding chapters have introduced some of the key components of the LANL NRDA, and discussed the framework and general approaches with which the LANLTC will conduct the assessment. The assessment, itself, will comprise a series of linear and iterative analyses aimed at assessing the magnitude of natural resource injury resulting from hazardous substance releases from LANL and the specific set and scale of restoration projects that will be implemented to make the public whole for this injury. Some assessment efforts are already underway and preliminary efforts have been completed or are ongoing. In particular, the LANLTC has conducted a preliminary review of available data as part of the assessment planning process, and anticipates beginning the assessment with an evaluation of available data in a formal way, followed by the implementation of specific field studies, as necessary, to fill data gaps. The ongoing and planned efforts the LANLTC anticipates undertaking as part of the assessment are described in greater detail below.

This Plan represents the LANLTC's current understanding of the assessment activities that may be necessary to robustly identify and quantify injuries to natural resources and the services they provide on and around LANL and identify and scale restoration. Inclusion of an activity within this Plan does not guarantee that it will be undertaken, and efforts not included within this Plan may be deemed necessary at a later date. This Plan does not limit in any way the extent and nature of analyses that maybe undertaken in the course of the assessment. Rather, it provides a framework within which the LANLTC will begin to implement the assessment. As these efforts progress and additional information is generated, the LANLTC may modify this Plan, and may provide amendments to this Plan for public review and comment.

As with any formal scientific investigation, specific study plans will be drafted prior to implementing the activities, which will outline the approach the LANLTC will use, as well as to assure that any data generated are of a type and quality sufficient for meeting the stated goals of the investigation. A QMP for the assessment is included in Appendix B, which will be used as a guide in the implementation of individual efforts; however, as detailed in the QMP, individual Work Plans and Quality Assurance Project Plans will be drafted for each study to be undertaken as part of the assessment.

ASSESSMENT ACTIVITIES AND PRIORITIZATION

As mentioned above, as part of the assessment planning process, in addition to conducting preliminary information review and evaluation, the LANLTC identified and prioritized a list of discrete assessment activities that are expected to assist in identifying and quantifying the scale of natural resource injury stemming from releases of hazardous substances from LANL, and to identify and scale restoration activities to compensate the public for this injury.

The LANLTC also prioritized planned efforts based on:

- use of existing information;
- likely cost effectiveness;
- technical sequencing requirements (i.e., some assessment activities may have a higher priority if the analysis needs to be completed earlier in the assessment process because it generates data or results upon which subsequent assessment efforts are based or vice versa for efforts that are to be completed later in the process);
- efforts that, in the LANLTC's view, may be more likely to clarify the existence or extent of injury; and/or,
- efforts most likely to contribute to the understanding of the appropriate scale and scope of required restoration.

Based on this prioritization, assessment activities are grouped into one of four categories: (1) initial priorities, (2) nearer-term priorities, (3) middle-term priorities, and (4) longer-term priorities. These priority categories may change as new information and results are generated as part of the assessment. As the assessment progresses, the LANLTC may also develop sub-categories within each of the four categories to help identify specific assessment activities to move forward with.

Initial priorities are those activities the LANLTC believes will help frame the assessment of ecological, groundwater, human use, and Pueblo losses and include evaluations of existing information and analyses that are presently ongoing. With a better understanding of the initial framework for injuries and losses, the LANLTC can make more informed decisions regarding the need for subsequent efforts. Nearer-term priorities are assessment activities that are expected to generate information of significant use for planning future efforts (e.g., in determining whether future field work is warranted and in refining potential field study designs or data analyses) and efforts involving the analysis or evaluation of information that can be obtained through literature searches and/or interviews (i.e., does not require field sampling). Middle-term priorities include efforts expected to generate information of significant use in understanding the scale and scope of injury and required restoration, and field-study collection efforts (that are deemed warranted after the analysis of existing information). Longer-term priorities include remaining activities that depend on the prior completion of other efforts. Ongoing efforts and planned activities are listed in Exhibit 6-1, and discussed in greater detail below.

EXHIBIT 6-1 ONGOING AND PLANNED NRDA ACTIVITIES[23]

CATEGORY / RESOURCE	ACTIVITY	OBJECTIVE	STATUS
INITIAL PRIORITIES (1)			
ENVIRONMENTAL MEDIA	Review of available environmental media contamination data in Intellus	Summarize available surface water, soil, and sediment data and compare to information on adverse ecological effects from peer reviewed literature.	Ongoing
	Compilation and review of site-specific information on potential adverse impacts to biota	Summarize available information on impacts to biota and compare to information on adverse ecological effects from peer reviewed literature.	Ongoing
BIOTA	Review of site-specific toxicity studies and development of additional sampling plans as necessary	Compile and review available soil and sediment and/or plant toxicity studies to determine what conclusions may be drawn with respect to injury determination and quantification for environmental medium and associated biota.	Planned
CONTAMINANTS OF CONCERN	Identification of contaminants of concern and development of ecotoxicological profiles	Determine the major contaminants of concern for injury assessment and develop profiles summarizing ecotoxicity information.	Planned
DATA MANAGEMENT	Treatment of non-detects in studies analyzing existing data	Evaluate the range of options for handling non-detect sample results in order to determine a preferred path forward for treatment of non-detects in existing data.	Planned
GROUNDWATER	Quantification of injured groundwater, volume and time dimensions	Quantify injured groundwater volume and time dimensions using existing information and information obtained from activities listed in this Plan.	Planned
PUEBLO SERVICES	Resource characterization to facilitate assessment and restoration of Pueblo lost services	Organize and present characterization and monitoring contaminant information for use by Pueblo members as well as the general public, determine where contamination has not been adequately characterized for NRDA purposes, and identify where additional characterization or monitoring of contaminant concentrations might be needed.	Planned
NEARER-TERM PRIORITIES (2)			
ENVIRONMENTAL MEDIA	Review of available data on surface water flow frequency and volume in assessment area canyons	Compile and review information on surface water flow in order to better characterize when and for how long canyons are understood to be wet habitat.	Planned
	Evaluation of the impact of wildland fires on pathway, injury, and restoration	Determine and evaluate the role of wildlife fires as a pathway, as a baseline ecological factor, and as a possible basis for restoration actions.	Planned

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[23] Exhibit 6-1 lists assessment efforts relevant to performing the NRDA per DOI's NRDA regulations (43 C.F.R. § 11). The LANLTC may not complete all of the listed activities or may add others; for instance, the results from a particular analysis may deem a subsequent activity unnecessary or may indicate that additional work is warranted.

CATEGORY / RESOURCE	ACTIVITY	OBJECTIVE	STATUS
	Soil and sediment geospatial evaluation	Identify which surficial soils and sediments are likely to have been exposed to contamination, and identify geographic areas where additional sampling may be necessary to characterize contamination for injury assessment purposes.	Planned
	Exploration of historical soil and sediment contaminant concentrations	Explore historical soil and sediment contaminant concentrations and evaluate whether additional sampling is warranted to determine soil and sediment baseline conditions.	Planned
GROUNDWATER	Determination of baseline services provided by groundwater and service losses attributable to hazardous substance contamination	Describe the services provided by groundwater in and around LANL under baseline conditions and how these services have been impacted by the release of hazardous contaminants.	Planned
HUMAN SERVICES	Inventory of institutional controls, description of associated limits on human use of the site, and identification of restoration projects	Determine the extent to which institutional controls at the LANL site, past, current, and expected future, are related to the release of hazardous contaminants, define the geographic scope and nature of these controls, and describe the types of human uses that may be impacted.	Planned
PUEBLO SERVICES	Development of Pueblo-specific narratives of cultural use and perceptions of natural resources	Document the relationship between the affected Pueblo communities and injured natural resources, identify natural resources and nature and extent of services they provide, and document the risks and perception of risks associated with exposure to injured natural resources.	Planned
MIDDLE-TERM PRIORITIES (3)			
BIOTA	Fish tissue collection in relevant assessment area waters and evaluation of adverse effects	Conduct electroshocking to determine if/where fish are present, collect information on fish distribution, abundance, and deformities, collect fish tissue samples, analyze contaminant concentrations, assess potential correlations between field measures and exposure, and compare exposure to information on adverse ecological effects from peer reviewed literature.	Planned
	Evaluation of distribution, abundance, and exposure in herpetofauna	Collect information on amphibian and reptile species distribution and abundance, collect soil and/or sediment samples and possibly tissue samples, and determine whether correlations exist between distribution and abundance metrics and either habitat characteristics or measures of exposure to contaminants.	Planned
	Evaluation of abundance, exposure and adverse effects in avian species	Collect information on reproductive success, abundance, and diversity; evaluate the exposure of selected avian species to LANL-related contaminants, as indicated through measurements of contaminants in eggs; evaluate potential correlations between field metrics and exposure.	Planned
	Evaluation of abundance, exposure and adverse effects in mammalian species	Collect information on abundance and diversity; evaluate the exposure of selected mammalian species to contaminants of concern through	Planned

CATEGORY / RESOURCE	ACTIVITY	OBJECTIVE	STATUS
		measurements of contaminants in tissues; evaluate potential correlations between field metrics and exposure.	
PUEBLO SERVICE LOSSES AND DAMAGES	Assessment of Pueblo Service Losses	Identify data gaps and select and implement appropriate approach(es) to fill those gaps to determine Pueblo service losses associated with LANL hazardous substance releases.	Planned
LONGER-TERM PRIORITIES (4)			
ECOLOGICAL SERVICE LOSSES AND DAMAGES	Quantification of ecological injuries and service losses	Compile and analyze resource-use specific information from previous analyses to quantify lost services.	Planned
	Determination and monetization of ecological damages	Identify and scale restoration projects needed to compensate for ecological injuries and associated lost services.	Planned
GROUNDWATER SERVICE LOSSES AND DAMAGES	Determination and monetization of groundwater damages	Identify and scale restoration projects needed to compensate for groundwater injuries and associated lost services.	Planned
PUEBLO SERVICE LOSSES AND DAMAGES	Determination and monetization of Pueblo damages	Identify and scale restoration actions needed to compensate affected Pueblos for service losses experienced as a result of LANL hazardous releases.	Planned

LANL has a lengthy operational and remedial history, and a number of ecological, toxicological, and other studies have produced information of potential use in the NRDA. Much of the data collected to-date are available in the Intellus database, and include soil, sediment, and surface water data. The assessment activities in this Plan build on available information from past efforts and are intended to address key data gaps and/or remaining uncertainties.

INITIAL PRIORITIES

REVIEW OF AVAILABLE ENVIRONMENTAL MEDIA CONTAMINATION DATA IN INTELLUS

Objectives: To (1) determine past, current, and potential future injuries to resources based on comparisons of measured concentrations of site contaminants of concern to regulatory standards or adverse effects information in the peer reviewed literature; (2) identify contaminants of concern most strongly associated with potential injuries (e.g., by virtue of having a greater magnitude of exceedances of effects thresholds); and (3) identify locations with higher or lower levels of exposure to hazardous substances, to help inform site selection in potential future injury studies.

Need/Rationale: Although comparing measured concentrations of hazardous substances in natural resources to literature-based thresholds is not always sufficient to determine injury in accordance with the DOI NRDA regulations,[24] this approach is cost-effective

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[24] Appendix C provides complete definitions of injury to natural resources.

and widely used to identify potential injuries. For example, within the context of a cooperative assessment, such comparisons can provide a basis for reaching agreement on injury determination and/or quantification assumptions. These comparisons can also help document the existence of a pathway between sources of releases and receptors, and/or may suggest that additional field or lab studies on certain biological receptors, geographic locations, or contaminant combinations may be appropriate.

Approach: Preliminary work on this analysis is ongoing, and has focused on the LANL site, surrounding Pueblo lands, the Rio Grande from the confluence with Rio Chama to the Cochiti Lake and appropriate reference locations. The first component of a more formal implementation of this task will involve assembling and evaluating available data from Intellus in accordance with the QMP for an agreed-upon set of contaminants of concern. The second component of this analysis will require identification of consensus adverse effects thresholds (i.e., site-specific and/or generic values from the literature, against which the LANLTC will compare contaminant concentrations). This effort will also include an evaluation of media and contaminant-specific baseline conditions, which will include, to the extent possible, a characterization of the concentration ranges of hazardous substances expected to be present on and around LANL but for LANL hazardous substance releases. As part of this evaluation, contaminants will be identified as having one or more of the following origins: natural sources, LANL site operations, and/or other anthropogenic sources.

COMPILATION AND REVIEW OF SITE-SPECIFIC INFORMATION ON POTENTIAL ADVERSE IMPACTS TO BIOTA

Objectives: To (1) determine past, current, and potential future injuries to terrestrial, riparian, and aquatic biota based on comparisons of measured tissue concentrations of contaminants of concern to literature-based effects thresholds; (2) identify contaminants of concern that may be most strongly associated with potential biological injuries (e.g., by virtue of having a greater magnitude and/or exceedance of effects thresholds; and (3) identify species and/or locations with higher or lower levels of exposure to hazardous substances, to help inform site selection in potential future field studies of biota.

Need/Rationale: Biological resources provide a suite of essential ecological services. Comparison of contaminant tissue concentrations to appropriate adverse impact thresholds is a cost-effective, widely used approach to identifying potential biological injuries. While comparisons of measured concentrations in tissues to thresholds may not, in itself, be sufficient to determine and quantify injury in accordance with the DOI regulations[25], such analyses will inform the LANLTC's understanding of the nature and extent of potential injury. Within the context of a cooperative assessment, these kinds of comparisons can provide a basis for reaching agreement on injury determination and/or quantification assumptions. These studies can also help document the existence of a pathway between sources of releases and receptors, and/or may suggest that additional

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[25] Appendix C provides complete definitions of injury to natural resources.

field or lab studies on certain biological receptors/locations/contaminant combinations may be appropriate.

Approach: This analysis will focus on the LANL site, Pueblo lands, the Rio Grande, and appropriate reference areas. The first component of this task will involve assembling and evaluating available data. Much of the data collected to-date on biological resources is present in site-reports, and will need to be extracted and added to a natural resource assessment database in accordance with the QMP. Although data on contaminant concentrations in biota exist in the Intellus database, the database is not comprehensive and often does not include critical data such as the particular species. The second component of this analysis requires identification of adverse effects thresholds (i.e., site-specific and/or generic values from the literature, against which the LANLTC will compare contaminant concentrations). This effort will also include an evaluation of baseline conditions, which will include to the extent possible a characterization of the concentration ranges of hazardous substances expected to be present in biota on LANL and surrounding areas but for LANL hazardous substance releases. As part of this evaluation, contaminants will be identified as having one or more of the following origins: natural sources, LANL site operations, and/or other anthropogenic sources.

REVIEW OF SITE-SPECIFIC TOXICITY STUDIES AND DEVELOPMENT OF ADDITIONAL SAMPLING PLANS AS NECESSARY

Objective: To compile and review available soil, sediment, and/or plant toxicity studies to determine what conclusions may be drawn with respect to injury determination and quantification for environmental media and associated biota.

Need/Rationale: Some contaminants adhere to soils and sediments, and associated invertebrates and plants are an important part of many terrestrial and aquatic food webs. Reliance on existing information can be a cost-effective way to determine injury, and thus the LANLTC proposes to evaluate existing testing approaches and results to determine whether available data are of sufficient quantity and quality to meet assessment needs.

Approach: Documentation of reduced survival, growth, reproduction or other adverse effects arising from exposure of biota or plants to hazardous substances in LANL soils or sediments relative to reference area soils or sediments is an injury under DOI NRDA regulations. Toxicity testing has been undertaken at LANL. For example, chironomid toxicity testing has been conducted as part of investigations in Sandia Canyon (LANL 2007a). This analysis will involve a detailed review of available information, documenting, compiling, and summarizing the studies undertaken at LANL that evaluated the toxicity of soils or sediments. This effort will also include a careful review of these results from a NRDA perspective, including an evaluation of test acceptability, assessment of test relevance, and determination of adequacy of spatial coverage. If available information is deemed insufficient for NRDA purposes, the LANLTC may develop and implement additional studies to test the toxicity of soils and sediments in and around LANL. Studies may include standard test organisms such as chironomid or earthworms.

IDENTIFICATION OF CONTAMINANTS OF CONCERN AND DEVELOPMENT OF ECOTOXICOLOGICAL PROFILES

Objectives: To (1) determine the major contaminants of concern for injury assessment purposes; (2) identify and evaluate those contaminants of concern for which toxicity literature, criteria and/or standards are not available and develop an approach to address the uncertainty with regard to injury from these hazardous substances; and (3) develop profiles summarizing ecotoxicity information pertaining to a subset of contaminants.

Need/Rationale: Identifying those contaminants of concern that are the primary injury drivers (i.e., those contaminants that likely contribute the most to injury at their observed concentration in LANL media) will help the LANLTC estimate natural resource injuries pertaining to both ecological and human use losses. A list of the main contaminants of concern will allow the LANLTC to narrow subsequent injury studies to focus on those contaminants most likely to contribute to injury quantification, saving time and resources. Additionally, identifying any potential contaminants of concern for which information on adverse effects is not available will allow the LANLTC to develop an approach to address this uncertainty.

Approach: This effort will begin with a compilation of site-specific environmental contaminant data and toxicity information, including a review of information on radiological contamination as well as inorganic and organic contaminants. After an initial review of information, the LANLTC will focus on a subset of contaminants for which to develop ecotoxicology profiles. These profiles will take the form of a short description focusing on the sources, pathways, and potential effects of the subject contaminant. The profiles will allow the LANLTC to develop a list of contaminants of concern to focus on in the assessment. This effort will include evaluations of those contaminants already identified as being potential injury drivers, including radionuclides, cesium-137 and plutonium isotopes in particular, polycyclic aromatic hydrocarbons (PAHs), copper, lead, hexavalent chromium, zinc, and explosives.

TREATMENT OF NON-DETECT SAMPLES IN STUDIES ANALYZING EXISTING DATA

Initial data evaluation conducted by the LANLTC found that a substantial number of contaminant concentration records in the Intellus database are identified as “non-detects.” The reported concentration value for these records does not appear to be uniform and appears to include values that represent one of a number of potential measures, including the Adjusted Reporting Limit, Estimated Quantitation Limit, Instrument Detection Limit, Method Detection Limit, Practical Quantitation Limit, or Required Detection Limit. Occasionally the value is simply reported as “0” or a number that does not appear to be any of the types of values listed above.

While it is not necessarily clear from the record documentation what value specifically is reported for each record, the actual concentration of the contaminant in question is likely something less than the value reported. In the context of the NRDA, non-detect samples are more likely to impact injury estimates in cases where the value being reported exceeds an injury threshold. Initial data evaluation has identified a number of contaminant and environmental medium combinations for which the reported values exceed literature-based adverse effects levels. For example, numerous measures of antimony in sediment, and selenium in soil indicated to be non-detects include reported values that are greater than concentrations that may correspond to resource injury; as such, the true concentrations of these contaminants, and whether or not contaminants are present at concentrations sufficient to cause injury, is unknown. A similar problem arises when a sample indicated to be a non-detect is reported as a zero value; in this case, applying the zero value may result in an assumption of lack of injury where injury may be present.

Despite these analytical challenges, records identified as “non-detects” represent valuable historical information that cannot be replicated. Thus, the LANLTC prefers not to simply remove these data from the analysis but rather anticipates the need to identify the most analytically sound and least biased manner in which to treat the information contained in these records. Substitution approaches, such as using some proportion of the detection limit have been widely used, but have varying effects on the results, depending on the frequency of non-detects in the dataset (Helsel 2005; Floit et al. 1996).

Objective: To evaluate the range of options for handling non-detect sample results in order to determine a preferred approach for treatment of non-detects in existing data, and develop recommendations for additional data collection efforts if warranted.

Need/Rationale: Because of the substantial number of contaminants measured as non-detects, the LANLTC aims to develop a method to use these data in a manner that reduces uncertainty in data analyses.

Approach: For efforts that rely upon the analysis of historical data, the LANLTC will evaluate a variety of options for handling non-detect sample results within each analysis. As a detailed analysis of non-detect samples for every media type and contaminant in each individual study area will not be feasible, the LANLTC may prioritize detailed evaluations of non-detects in cases where:

- The extent of non-detects included within the group of samples to be analyzed is substantial (e.g., > 30 percent of available samples); and/or
- The reported value of non-detect samples frequently exceeds the lowest identified injury threshold for a given contaminant and environmental medium; and/or
- The detection/reporting/quantitation limit value (where known) exceeds the lowest identified injury threshold for a given contaminant and environmental medium; and/or
- Other evidence (e.g., toxicity testing results) indicates that injury to a specific resource due to a given contaminant is likely.

Evaluation of existing samples identified as non-detects may also indicate that additional data collection is warranted to adequately characterize contaminant exposure. In these instances, the LANLTC will select laboratory methods for which the detection limits are sufficiently low such that the lowest detectable concentration of a contaminant does not exceed levels that have been identified as likely to be injurious.

QUANTIFICATION OF INJURED GROUNDWATER, VOLUME AND TIME DIMENSIONS

Hazardous substance discharges from LANL have resulted in contaminated groundwater, in some cases above drinking water standards. The use of drinking water standards is only one of the possible criteria to determine injury to groundwater. For example, injury to groundwater may also be determined based on a measurable adverse change in the chemical quality of the resource or the potential for groundwater to injure other resources, such as surface water. The LANLTC will use available information to quantify the amount of groundwater injured over time. The metric(s) chosen for injury quantification will depend on several factors, including the nature of the injury and service loss, the hydrogeologic setting, as well as the nature of groundwater restoration projects that may be identified to offset injuries to groundwater.

Objective: To quantify the volume of injured groundwater in and around LANL attributable to LANL releases of hazardous substances, and determine the time (i.e., number of years) over which groundwater has been and will continue to be injured, using existing information and information obtained from the other groundwater assessment activities listed in this Chapter.

Need/Rationale: The LANLTC will need to understand the quantity of injured groundwater in order to scale and determine the amount of restoration required to compensate the public for any losses.

Approach: This effort will involve (1) compiling available information on the likely timeframe groundwater has been injured at and around LANL, (2) comparing groundwater contaminant concentrations to chosen injury thresholds to determine potential injury, (3) compiling and analyzing information on the areal and vertical extent of contamination, and (4) combining these pieces of information on time and extent of injury to estimate the quantity of injured groundwater.

This analysis may be reevaluated after the “Determination of baseline services provided by groundwater and service losses attributable to hazardous substance contamination” effort is completed. An understanding of the nature of groundwater services impacted by releases from LANL operations will help inform the metric used to quantify the volume of injured groundwater. For example, if groundwater resources were used as a drinking and irrigation water source under baseline, a flux or flow might be used to quantify the volume of injured groundwater; whereas, if groundwater resources provided nonuse values under baseline (i.e., existence or option to use values) and the groundwater flow was not utilized, stock volume might be a more appropriate metric to quantify injured groundwater. As noted above, the quantification method will also likely depend upon the nature of the injury, the hydrogeologic setting, and the nature of the restoration projects that have been selected to offset the injuries.

Another example is a high flow sandy aquifer for which an important service is the provision of high quality discharge to a surface water body, but contamination has adversely affected this service. If a restoration project is identified that involves the protection of water quality for an aquifer that similarly discharges to a surface stream, then flux may be an appropriate quantification metric to calculate the injured volume and scale the restoration. Alternatively, calculating a static volume to quantify injury might be a more appropriate approach for a high porosity, low flow aquifer (e.g. an un-fractured volcanic tuff or a clay) for which an important service is existence value.

RESOURCE CHARACTERIZATION TO FACILITATE ASSESSMENT AND RESTORATION OF PUEBLO LOST SERVICES

Objectives: Pueblo member use of natural resources may differ in type and intensity from members of the general public. Due to contamination of natural resources and subsequent natural resource injury, Pueblo members may not engage in certain activities and may not use certain injured resources. Others may continue to engage in traditional activities but do so with concern(s) about the risks these activities pose to them (i.e., a loss in the value of these activities to these community members). Observed changes in use may be prudent due to a lack of full characterization of natural resources and the dynamic nature of contaminants in the environment. The purpose of this effort will be to (1) organize and present contaminant characterization and monitoring information, (2) determine where contamination has not been adequately monitored or characterized for purposes of NRDAR, and (3) if necessary, identify where additional characterization or monitoring of environmental contaminant concentrations is needed to understand natural resource injury(ies), Pueblo service losses, or alternatively, restore lost services where use of injured resources does not present a risk to community members.

Need/Rationale: The presence of contaminants in the study area environment and related resource injuries may have contributed to Pueblo members altering their use of these resources. There are a number of ongoing LANL remedial efforts to characterize and monitor contaminant concentrations within and around the site. There is a need, however, to define whether this information is adequate for Pueblo assessment purposes, including determination of injury, lost uses/services, and restoration. For example, a concern expressed by trustee Pueblo representatives is whether the nature and extent of contamination of natural resources has been adequately characterized. This information is needed by Pueblo governments to develop resource management and land use policies to facilitate resource recovery and to minimize risks that contaminated resources may pose to Pueblo end-users. For example, information obtained from this effort may be useful to the Pueblos in developing institutional or other limitations on resource use due to releases of hazardous contaminants from LANL operations. This effort will require close coordination with Pueblo community members and resource managers to fully understand concerns and information needs.

Approach: A substantial amount of environmental characterization has been conducted in and around LANL. However, additional characterization of contamination in the environment may be necessary for Pueblo assessment purposes, including injury determination and quantification, lost services/uses quantification, and restoration planning, implementation, and effectiveness monitoring. Organization of existing information and gathering additional information on the nature and extent of contamination and condition of injured resources will be performed. For example, additional characterization may be undertaken to verify whether Pueblo uses of natural resources that may have been limited due to concerns about exposure to hazardous substances can be safely resumed. Any additional field sampling of environmental media would be conducted pursuant to the QMP.

The factors that will need to be determined in this study are:

- Do existing sampling and characterization efforts provide enough information and the right type of information to inform Pueblo member use?
- Assuming there is enough information and the right type of information to inform Pueblo use, can this information be better organized and presented to Pueblo members to facilitate decisions about resource use? What is the most effective means to communicate this information to the public?
- What additional information is needed? Over what time period?
- What is the most cost-effective means to obtain additional monitoring and characterization information?

NEARER-TERM PRIORITIES

REVIEW OF AVAILABLE DATA ON SURFACE WATER FLOW FREQUENCY AND VOLUME IN ASSESSMENT AREA CANYONS

Objective: To compile and review existing data on surface water flows in canyons within the assessment area, including information on the frequency and volume of flows.

Need/Rationale: An understanding of the frequency and volume of water flows within assessment area canyons will allow the LANLTC to better understand the ecological functioning of these dynamic systems. Riparian habitats support different wildlife species when water is present than when it is absent. Additionally, water is an important and scarce resource in New Mexico. A better understanding of the use of wet canyon bottom habitats by biological resources will allow the LANLTC to gauge the relative importance of this rare habitat type as well as the specific biological resources that may use it.

Approach: The first component of this task involves assembling and compiling existing information on surface water flows within assessment area canyons. The second component involves evaluating the available data, and determining whether data are sufficient to estimate the frequency and volume of flows within each of the canyons.

EVALUATION OF THE IMPACT OF WILDLAND FIRES ON PATHWAY, INJURY, AND RESTORATION

Objectives: To determine and evaluate the role of wildlife fires in the movement of contaminants, as a pathway, as a baseline ecological factor, and as a possible basis for restoration actions.

Need/Rationale: Fire has played a major role in redistributing contaminants released from LANL operations, and in modifying the environment around LANL. In addition to understanding the past role of fire, it may be necessary to project the future role of fire in redistributing contaminants of concern, in assessing likely future injury, in changing the baseline condition of injured resources, and in planning for sustainable restoration projects. Actions to reduce the impacts of future fire (e.g., fuels management) or assistance in the recovery of burned ecosystems, may present cost-effective restoration actions.

Approach: This analysis will focus on the LANL site and surrounding Pueblo lands. The first step involves compiling existing information and research on past fires and the impact these fires have had on the LANL environment and contaminant transport. The second step involves evaluating existing information in the context of the natural resource damage assessment.

SOIL AND SEDIMENT GEOSPATIAL EVALUATION

Objectives: To (1) identify geographic areas where surficial soils and sediments are more or less likely to have been exposed to potentially injurious contaminant concentrations; and (2) identify geographic areas where additional sampling may be necessary to adequately characterize contamination for natural resource damage assessment purposes.

Need/Rationale: The LANLTC is concerned that the distribution of releases of hazardous substances in and around LANL associated with LANL operations may not be fully characterized; in particular, the potential for past aerial emissions to have resulted in the contamination of surficial soils and sediments in distal areas (including Pueblo lands), which may in turn expose biota and other resources.

Approach: For this effort, the LANLTC will (1) compile existing information on the geospatial extent of contamination, (2) determine the appropriate baseline conditions for soils and sediments in the assessment area, and (3) evaluate available surficial soil and sediment contaminant concentration data and the likelihood of contaminant transport pathways to areas where contamination has not been fully characterized. The approach to be used may include:

- Exploratory analyses of available soil and sediment data for visual evaluation of spatial patterns, as well as confirmation of known and potential source locations;
- Evaluation of potential spatial correlations between soil and sediment data and prevailing wind directions;
- Estimation techniques designed to identify potential “hot spots” (i.e., areas with expected contaminant concentrations in excess of specific thresholds) in areas with sparse data, using information on sources and pathways for contaminant releases in combination with data on prevailing wind directions.

Any “hot spot” areas, if identified, might be reasonable sites to target in field studies of biota. For example, preliminary data review as part of the assessment planning process identified Los Alamos and Sandia canyons as potential hot spots which may warrant targeted attention during the NRDA. Similarly, locations where sampling data are sparse but aeolian transport data indicate a likely transport pathway could be identified as priority areas for additional sampling. The focus of this type of analysis will be on identifying areas of likely contamination to support additional field work, if deemed necessary, rather than reconstructing the history of the site's aerial emissions as an end in and of itself. The LANLTC will decide if additional field work is warranted, or if existing information and professional judgment on the potential extent of contamination are sufficient for NRDA purposes.

EXPLORATION OF HISTORICAL SOIL AND SEDIMENT CONTAMINANT CONCENTRATIONS

In general, soils and sediments contain organic material and solid particulates resulting from natural erosion of parent materials, man-made global fall-out, and man-made LANL fallout. Sediments sequestered in ponds, beaver dams, or other features coupled with tree cores, information on the forest management history, and information on the history of reported releases from a site are often used to reconstruct the geochronology of hazardous releases (Church et al. 2007). This geochronological reconstruction includes periods representing: (1) pre-release baseline; (2) enhanced release era; and (3) post release conditions. If sediment core from a basin are determined to contain LANL release byproducts, then it follows that soils from this basin also were likely to have been affected by LANL releases and further investigation may be warranted. Conversely, if no LANL release byproducts are observed in a continuous record for the basin, then the basin was not likely affected by LANL releases.

Finally, since sediments sampled in traps represent a mixture of soils from the basin, analyzing the sediments can be a very effective soil screening approach in comparison to soil sampling. The LANLTC recognizes that this effort will be informed by an understanding of wind dispersion processes, the locations and general types of known aerial contaminant releases, and the locations and general types of available historic sediment traps observed via historical aerial photographic analysis.

Objectives: To (1) explore historical soil and sediment contaminant concentrations; and (2) evaluate whether additional sampling is warranted to determine soil and sediment baseline conditions.

Need/Rationale: As noted in the analysis above ("Soil and Sediment Geospatial Evaluation"), the LANLTC is concerned that available information is insufficient to determine baseline conditions for soil and sediment resources on and around LANL. An understanding of the comprehensiveness of available information will allow the LANLTC to determine whether existing information is sufficient or if additional sampling may be warranted to provide information necessary to assess baseline conditions, and the geographic and temporal extent of potential soil and sediment contamination.

Approach: This effort will be completed in a phased approach. (1) The first phase consists of compiling existing information and information from previous assessment efforts (including “Soil and Sediment Geospatial Evaluation”) on background soil and sediment conditions and contaminant levels on and around LANL, forest management history, and the history of past reported releases. (2) The second phase consists of evaluating the information compiled during phase one and determining if the available information is sufficient, for NRDA purposes, to determine baseline conditions for soil and sediment resources on and around LANL. (3) If available information is deemed insufficient by the LANLTC, the LANLTC may decide to proceed with phase three. The third phase consists of a small scale field effort to collect a limited number of sediment core samples in selected locations on and around LANL. As noted above, sediment core samples can provide information on background contaminant concentrations and potential injury to sediment resources as well as to soil resources. The sampling locations will be carefully determined based on areas that are most likely to provide information on background soil and sediment contaminant concentrations as well as areas likely to provide contaminant concentration data related to LANL releases. (4) In the fourth phase, the LANLTC will evaluate results from the core samples in conjunction with existing data and determine whether there is enough information to make a determination on background and LANL-related soil and sediment contaminant concentrations or whether additional field sampling is warranted.

DETERMINATION OF BASELINE SERVICES PROVIDED BY GROUNDWATER AND SERVICE LOSSES ATTRIBUTABLE TO HAZARDOUS SUBSTANCE CONTAMINATION

Objective: To describe the services provided by groundwater in and around LANL, to define baseline conditions, and to determine how these services, which may include use, nonuse and in situ services, have been impacted by releases of hazardous contaminants.

Need/Rationale: An understanding of the services provided by groundwater that has been contaminated by LANL releases under baseline conditions is necessary to determine to what extent services have been adversely affected. Identifying groundwater services and determining how these services have been affected, in conjunction with quantifying the volume of injured groundwater, will inform the identification and scaling of appropriate restoration projects to restore, rehabilitate, replace, or acquire the equivalent of the injured resource and any lost services. As noted above, this information will also help support decisions regarding the value and need for additional groundwater injury studies, and therefore should be undertaken early in the assessment process.

Approach: This effort will involve the identification and development of a description of the services that are provided by groundwater in and around LANL, including their baseline conditions, and how those services have been impacted by contamination. The analysis should address the full range of services, including use, non-use, and in situ services. Determining the range of groundwater services provided under baseline conditions, particularly the human services may require an understanding of the institutional, political, legal, and economic conditions associated with groundwater resources as well as an understanding of hydrological factors. The services provided by groundwater resources at and around LANL will be identified using existing information on current and past use of groundwater resources and through interviews with local groundwater resource experts.

INVENTORY OF INSTITUTIONAL CONTROLS, DESCRIPTION OF ASSOCIATED LIMITS ON HUMAN USE OF THE SITE, AND IDENTIFCATION OF RESTORATION PROJECTS

As discussed in Chapter 4, based on review of existing information, the LANLTC is proposing an assessment to determine and describe the past, current, and future geographic and temporal scope of contaminant-related institutional controls which could impact human use (including, but not necessarily limited to, both Pueblo and recreational uses) of natural resources in and around LANL. At this time, however, the LANLTC is not proposing additional study of potential effects of site releases on recreational behavior.

Objectives: To (1) determine the extent to which past, current, and expected future institutional controls at LANL are related to the release of hazardous contaminants, (2) define the geographic scope and nature of these controls, (3) determine the extent and duration of necessary institutional controls, and (4) describe the types of human uses that may be impacted.

Need/Rationale: Lost human use opportunities at LANL, if present, are likely to be associated with institutional controls made necessary by the presence of hazardous contaminants released from site operations. These restrictions may result in quantifiable services losses. However, some controls may relate to areas that are subject to access restrictions under baseline conditions. Based on this effort, the LANLTC will be able to determine if additional assessment of potential changes in the scale and scope of human services provided by natural resources is called for, taking into consideration baseline.

Approach: An inventory of institutional controls will be developed. These controls will be screened to determine if they are related to the presence of a hazardous substance released from LANL operations. A set of maps will be developed that present these controls, for past, present and expected future conditions. Once this inventory is completed, the nature of any expected changes in human services will be described and restoration actions can be identified to restore those losses. Additionally, observed media contaminant concentrations from the "Resource Characterization to Allow for Restoration of Pueblo Lost Services" effort described below, will be used in combination with the inventory of institutional controls to determine the need for, scope, and duration of existing controls (or the need for additional controls) on the use of natural resources by the general public as well as Pueblo community members. The location of any identified areas in relation to areas with limited access for other reasons (e.g., national security) will also be evaluated to account for baseline.

DEVELOPMENT OF PUEBLO-SPECIFIC NARRATIVES OF CULTURAL USE AND PERCEPTIONS OF NATURAL RESOURCES

Objectives: To (1) document the relationship between the affected Pueblo communities and injured natural resources, (2) to the extent possible and in a manner respectful of

Pueblo confidentiality needs, identify natural resources which are important to the health, welfare, economy, tradition, and cultural integrity of each Pueblos' respective members and the nature and extent of services that they provide (under baseline and current conditions); taking into consideration cultural differences between Pueblo communities, and (3) document the risks and perception of risks associated with Pueblo members' exposure to injured resources, taking into account exposure from Pueblo members' unique and intensive uses of these resources. (e.g., NPT 2010; CTUIR 2012; Yakama 2010).

Need/Rationale: Natural resources in the LANL assessment area provide many services to Pueblo members in ways that are distinct from the general public, including social, cultural, spiritual, medicinal, recreational, and subsistence services, uses, and values. The resources that are used by Pueblo members, particularly those that support the cultural integrity and continuity of each Pueblo, must be identified in a manner consistent with internal Pueblo confidentiality needs, including those that would have existed and been used by members in the absence of LANL releases. An understanding of how natural resources are used by Pueblo members will provide information on how Pueblo members may have changed their behavior due to the risks and/or perception of risks from exposure to injured natural resources. Additionally, an understanding of the unique relationship Pueblo community members have with natural resources in the study area will be useful when establishing the appropriate type and scale of primary and compensatory restoration at the LANL site. These Pueblo-specific narratives will describe historic and current uses of natural resources on the Pajarito Plateau and the central role those resources have in defining Pueblos' culture and economy.

Approach: Study teams assigned from each Pueblo will collectively or independently develop and implement this effort. Experts from various disciplines will be identified to develop study plans and lead each study. Methods may include (1) compiling existing literature and historical data related to natural resources and associated Pueblo services now and prior to LANL contaminant releases (such as historical reports, scientific papers, and oral histories), (2) interviews with Pueblo members, elders and/or historians, and (3) the development of reports describing findings. Given the nature of the information to be relied upon, it may be necessary to establish protocols for the handling of confidential information or to find alternative means to express frequency and duration of resource use by Pueblos in a manner that does not require more explicit discussion of information that may not be allowed to be divulged by a Pueblo. These narratives will describe the intrinsic value of natural resources to each of the Pueblos' respective members and how these uses relate to respective Pueblo community culture, economies, behaviors and overall well-being.

MIDDLE-TERM PRIORITIES

FISH TISSUE COLLECTION IN RELEVANT ASSESSMENT AREA WATERS AND EVALUATION OF ADVERSE EFFECTS

Objectives: To (1) conduct electroshocking work on LANL property to identify if fish are present; (2) collect information on fish species distribution, abundance, and presence of physical deformities; (3) collect tissue samples from areas where fish are present, potentially including the Rio Grande, Guaje Creek, and Jemez River and tributaries, in order to evaluate potential contamination in fish; and (4) determine whether correlations exist between the distribution and abundance of select species and either habitat characteristics or measures of exposure to contaminants.

Need/Rationale: Fish provide a number of ecological, cultural, and recreational services. Not only do they serve as a food resource for aquatic and terrestrial predators and humans, fish also support recreational and cultural activities. This study will help the LANLTC determine whether fish have been injured due to exposure to LANL-related contaminants and the extent of such injury. Measurements of contaminants in the site media will also contribute to the LANLTC's determination of exposure pathways to these receptors.

Approach: This study involves determining the presence of fish on and around LANL, collection of information on physical deformities and fish species distribution and abundance, and if fish are present, fish collection, tissue collection, and chemical analyses. This effort also involves correlating distribution and abundance estimates with habitat characteristics or contaminant exposure and comparison of chemical analyses results to effects thresholds and reference location results. Conducting fish census work will indicate whether or not fish are present on LANL. Fish tissue analyses and information on deformities and abundance will provide direct indications of fish exposure to hazardous substances and potential adverse effects. For this study, the LANLTC will conduct electroshocking in LANL canyons during periods of water flow. In areas where fish are known to be present, they will select a suite of target fish species based upon criteria including the species' life histories, the technical feasibility of tissue collection, and the anticipated abundance of fish on site and at reference locations. Information on the abundance of fish species and presence of any deformities will be collected in addition to fish tissue samples. To the extent possible, sufficient numbers of fish of each target species will be collected to allow for statistically rigorous analysis of concentrations of multiple contaminants of potential concern. Tissue samples will be tested for selected contaminants of concern, focusing on those contaminants that are expected to adversely affect fish.

EVALUATION OF DISTRIBUTION, ABUNDANCE, AND EXPOSURE IN HERPETOFAUNA

Objectives: To (1) collect information on amphibian and reptile species distribution and abundance; (2) collect collocated samples of soil or sediment for contaminant analysis and possibly tissue samples; and (3) determine whether correlations exist between the distribution and abundance of select species and either habitat characteristics or measures of exposure to contaminants.

Need/Rationale: Amphibians and reptiles are important components of the terrestrial and riparian environment on the LANL site. Frogs and toads can be valuable indicator species, as they integrate environmental changes that occur in both terrestrial and aquatic habitats (Foxx et al. 1999). Amphibians and reptiles are also important components of the food web as a food source for many birds of prey. Additionally, the Jemez Mountains salamander (*Plethodon neomexicanus*), a terrestrial salamander found on the LANL site, is listed as a sensitive species in Los Alamos County.

This study will help the LANLTC determine whether native amphibian and reptile species in and around LANL have been injured due to exposure to hazardous substance releases and the extent of such injury. Measurements of contaminants of concern in the other environmental media will also contribute to the LANLTC's determination of exposure pathways to these receptors.

Approach: The LANLTC will design a study that will examine amphibian and reptile community characteristics (potentially including abundance, diversity, and age structure) in areas in and around LANL thought to be potentially influenced by contaminant releases, as well as in reference areas. The study will also involve the collection of soil and/or sediment samples and possibly tissue samples. Sediment and soil samples will be collected for purposes of environmental and contaminant characterization and habitat characteristics will also be documented. Semi-quantitative or quantitative sampling methods may be employed for tissue sampling. Both live and dead animals may be targeted for collection and collected specimens will be analyzed for contamination. Contaminant analyses will focus on identified contaminants of concern, including organic contaminants such as dioxins/furans and DDT, for which existing data are lacking. Live animals not retained for contaminant measurements, or for use as voucher specimens, will be returned to their collected location. Where contaminant concentrations are to be measured, investigators should select laboratory methods the detection limits of which are sufficiently low such that the lowest detectable concentration of a contaminant does not exceed levels that have been identified as injurious.

EVALUATION OF ABUNDANCE, EXPOSURE, AND ADVERSE EFFECTS IN AVIAN SPECIES

Objectives: To (1) collect information on reproductive success, abundance, and diversity of bird species across one or more gradients of contamination at LANL; (2) evaluate the exposure of selected avian species to contaminants of concern through measurements of contaminants in eggs; and (3) evaluate potential correlations between the reproductive and population metrics and measures of contaminant exposure or habitat characteristics.

Need/Rationale: Birds can be exposed to contaminants in the environment through direct digestion of contaminated media (e.g., water or food items), yet relatively few direct measurements of contaminants in wild avian tissues are currently available. This study will support an assessment of injury to the avian community and will inform our understanding of the pathway between hazardous contaminant sources and avian receptors. Additionally, this study may suggest future lines of inquiry with respect to injury assessments of particular species. Focusing on eggs is particularly appropriate, as early life stages tend to be the most susceptible to the effects of many contaminants.

Surveys conducted between 2010 and 2012 documented 95 species of birds on LANL; 40 species were detected during winter bird surveys and 76 species detected during summer breeding bird surveys (Hathcock and Keller 2012). Six of the species detected are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). A healthy bird community is fundamental to a healthy ecosystem. Negative relationships between bird species richness, abundance, and population density and background radiation exposure have been document in birds, particularly terrestrial birds eating soil invertebrates (Møller and Mousseau 2007, Møller and Mousseau 2010). Birds, in particular "appear to be the most efficient indicator of low level radiation" (Moller and Mousseau 2010).

Approach: This field study involves a survey of bird community status and egg collection. For the population survey, the LANLTC will measure the abundance and diversity of birds in an appropriate number of operational and other contaminated areas, remediated areas, and in suitable reference areas. Specific methods may include line transects or point counts, or documenting birds through visual and auditory means. Physical soil samples may also be gathered to measure contaminant concentrations.

For egg collection, the LANLTC will select a suite of bird species based upon criteria including the species' life histories, the technical feasibility of egg collection, and the anticipated abundance of nests onsite and at reference locations. To the extent possible sufficient numbers of eggs of each species will be collected to allow for statistically rigorous analysis of concentrations of multiple contaminants of concern. Specific efforts will be made to minimize the effects of egg collection on species' populations. Similar to the community survey, eggs will be collected from a diversity of nests located across areas in various conditions to allow for comparison between locations (e.g., remediated areas, un-remediated areas, and reference areas). Eggs will be tested for selected contaminants of concern, likely focusing on both lipophilic organic contaminants (as these may be maternally deposited into the yolk), as well as metals that are expected to partition preferentially to shells. Detection limit and sample volume restrictions may result in the need to composite eggs within nests prior to analysis, and will likely limit the total number of contaminants that can be analyzed within a given sample.

We note that depending on the species and contaminants targeted for analysis, it may also be appropriate to collect blood and/or feather samples.

EVALUATION OF ABUNDANCE, EXPOSURE, AND ADVERSE EFFECTS IN MAMMALIAN SPECIES

Objectives: To (1) collect information on abundance and diversity of mammalian species across one or more gradients of contamination at LANL; (2) evaluate the exposure of selected mammalian species to contaminants of concern through measurements of contaminants in tissues; and (3) evaluate potential correlations between the population metrics and measures of contaminant exposure.

Need/Rationale: Mammals can be exposed to contaminants in the environment through direct digestion of contaminated media (e.g., water or food items). This study will inform our understanding of the pathway between hazardous contaminant sources and mammalian receptors and may suggest future lines of inquiry with respect to injury assessments of particular species. Surveys conducted on LANL have documented a number of mammalian species including Rocky Mountain elk, mule deer, cottontail rabbits, grey fox, bobcat, and coyote (LANL 2004).

Approach: Previously collected mammalian tissue samples and information on mammalian communities at and around LANL will be evaluated as part of prior efforts (including the "compilation and review of site-specific information on potential adverse impacts to biota" activity) and will be used in conjunction with information gleaned from this study to determine and quantify potential adverse effects to mammalian species. This field study involves a survey of mammalian community status and tissue collection. For this study, the LANLTC will select a suite of mammal species based upon criteria including the species' life histories, the technical feasibility of tissue collection, and the anticipated abundance onsite and at reference locations. For the population survey, the LANLTC will measure the abundance and diversity of selected mammalian species in an appropriate number of operational and other contaminated areas, remediated areas, and in suitable reference areas. Specific methods may include traps or canine scent surveys. Physical soil samples may also be gathered to measure contaminant concentrations. For tissue collection, to the extent possible sufficient numbers of samples of each species will be collected to allow for statistically rigorous analysis of concentrations of multiple contaminants of concern. Specific efforts will be made to minimize the effects of tissue collection on species' populations.

Tissue samples will be tested for selected contaminants of concern, likely focusing on lipophilic organic contaminants as well as metals and radionuclides. Analysis results will be compared to consensus adverse effects thresholds to estimate potential injury in LANL mammalian species.

ASSESSMENT OF PUEBLO SERVICE LOSSES

Objectives: To identify data gaps and select and implement appropriate approach(es) to fill those gaps to determine Pueblo service losses (i.e., nature and extent of changes in Pueblo member use of natural resources) associated with LANL hazardous substance releases. This information ultimately will be used to support decision-making regarding the scale and scope of potential primary and compensatory restoration for lost human services experienced by Pueblos.

Need/Rationale: Decisions regarding the scale and scope of primary and compensatory restoration may require additional information on changes in perception or use of natural resources by Pueblo members that have occurred or that can reasonably be expected to occur as a result of the presence of LANL-related contaminants in the environment. The quantification of Pueblo losses as part of this effort will provide the necessary information to make decisions regarding the scale and scope of primary and/or compensatory restoration actions required to compensate Pueblo community members.

Approach: This effort will build upon the information obtained from the “Resource characterization to facilitate assessment and restoration of Pueblo lost services” and “Development of Pueblo-specific narratives of cultural use and perceptions of natural resources” efforts described above, to determine and quantify Pueblo losses stemming from injuries to natural resources in the study area. Pueblo Trustees will collectively or independently develop and implement individual effort(s) to (1) compile and review available information related to Pueblo services (including existing information and information obtained from the efforts described above), (2) identify what data are most useful and necessary for injury assessment to identify the link between LANL contaminants, injured resources, and service losses, (3) assess the nature and extent of lost services experienced by Pueblo members, and (4) propose additional activities that would fill any identified data gaps. This effort will need to address confidentiality of Pueblo information (or identify alternate means to establish injury and service losses without violating internal Pueblo confidentiality requirements) and will distinguish changes in natural resource services to Pueblo members that are unrelated to contaminant releases from those that are the result of natural resource injuries stemming from LANL hazardous substances releases. The following specific tasks will be identified in individual study plan(s), which may be customized according to the preferences and needs of each Pueblo:

- Compile existing information and information obtained from previous efforts.
- Clearly identify the information needed to support analysis of the extent of Pueblo lost services (including losses incurred through the avoidance of certain activities or uses of natural resources out of concern for the risks posed by certain activities and/or service losses associated with risks and/or perception of risks).
- Evaluate the compiled information and determine what sensitive information shall not be released, what information is necessary for assessing Pueblo service losses (and may require data sharing agreements), and what information is still missing that will help link LANL contaminants to injured resources and changes in member behaviors and services. This effort will result in identification of the information needed (and data available) and appropriate methodology to assess the nature and extent of Pueblo lost services and restoration selection and scaling.
- Evaluate and select sound approach(es) to fill gaps and assess lost services due to the release of contaminants, as distinct from other factors that have led to changes in Pueblo members’ perception and use of resources over time.
- Define approaches that will protect confidential information or will allow for acceptable proxies to describe injury or service loss without violating internal Pueblo confidentiality requirements.

Following these plans, one or more efforts will be implemented to assess lost Pueblo services attributable to the release of hazardous substances and to identify restoration options and scaling. These activities may include one or more of the approaches described in the Pueblo Lost Services section in Chapter 4.

LONGER-TERM PRIORITIES

QUANTIFICATION OF ECOLOGICAL INJURIES AND SERVICE LOSSES

Objectives: To quantify the ecological injures and associated service losses in terrestrial, riparian, and aquatic habitats in the past, present, and potentially in the future as a result of site-related contamination and associated remedial actions.

Need/Rationale: In order to determine the scale and type of restoration actions required to compensate the public, the LANLTC will need to understand the scale and scope of injuries and service losses.

Approach: This effort involves two steps. The first step involves compiling information obtained from the ecological analyses described above. This information will likely include the degree to which sample concentrations (i.e., in soil, sediment, and biota) exceed identified injury thresholds, information on the adverse effects of varying levels of contamination, as well as ecological information (e.g., abundance and/or distribution of species, species community health). The second step of this effort is to analyze the compiled data in order to develop the necessary inputs for a habitat or resource equivalency analysis including the geographic and temporal scope of losses and the magnitude of losses.

DETERMINATION AND MONETIZATION OF ECOLOGICAL DAMAGES

As discussed in Chapter 5, there are a number of ways to estimate natural resource damages. Damages are “the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources” (43 C.F.R. § 11.14(l)). The LANLTC is focusing on the implementation of restoration projects that will compensate for the quantified ecological losses. The LANLTC may decide to focus on identifying specific restoration actions or on establishing average unit restoration costs for a set of restoration actions.

Objective: To identify restoration projects needed to fully compensate the public for quantified ecological losses and determine the cost of these restoration actions.

Need/Rationale: In order to compensate the public for injured natural resources and lost services resulting from hazardous releases from LANL, restoration projects must be identified and scaled appropriately.

Approach: This effort involves three steps. The first step consists of the identification of a suite of restoration projects that would restore those natural resources and services injured as a result of hazardous substance releases from LANL. The second step involves determining the appropriate scale and scope of selected restoration projects needed to fully compensate for the quantified injuries. The third step consists of calculating damages as the cost, in dollars, to perform the restoration projects.

DETERMINATION AND MONETIZATION OF GROUNDWATER DAMAGES

As discussed in Chapter 5, the LANLTC anticipates identifying and scaling restoration projects to compensate the public for groundwater losses using resource equivalency methods and a replacement cost approach, as necessary.

Objective: To identify restoration projects needed to fully compensate the public for quantified groundwater injury and service losses and, if necessary, determine the cost of these restoration actions.

Need/Rationale: In order to compensate the public for injured groundwater resources and service losses resulting from hazardous releases at LANL, restoration projects must be identified and scaled appropriately.

Approach: The first step in this analysis consists of identifying the appropriate type(s) of restoration project(s) needed to compensate the public for the groundwater resources and services determined to have been lost as a result of LANL related contamination. The second step involves determining the appropriate scope and scale of identified restoration projects needed to fully compensate for the quantified injuries. Lastly, the LANLC will calculate damages as the cost, in dollars, to perform the selected restoration projects.

DETERMINATION AND MONETIZATION OF PUEBLO DAMAGES

Consistent with the ecological damages efforts described above, the LANLTC anticipates conducting restoration projects to restore any Pueblo service losses. Primary restoration will restore currently lost uses of natural resources, and compensatory restoration will provide for compensation for Pueblo specific service losses pending full restoration of injured resources.

Objectives: To identify and scale appropriate primary and/or compensatory restoration actions needed to compensate affected Pueblos for service losses experienced as a result of LANL hazardous releases.

Need/Rationale: Restoration projects must be identified and scaled appropriately to compensate Pueblo members for lost services resulting from LANL releases of hazardous substances, and to restore those services.

Approach: This effort uses information obtained from the Pueblo assessment activities described in this Chapter, and involves three main steps. The first step consists of identifying relevant restoration projects that restore services of the same nature and scope as those services which have been determined to have been lost as a result of LANL contamination. The second step involves determining the appropriate scale and scope of the projects needed to fully compensate for the quantified losses. The third step consists of calculating damages as the cost, in dollars, to perform the selected restoration projects.

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APPENDIX A: SITE OPERATIONS AND HAZARDOUS SUBSTANCE RELEASE INFORMATION

WATERSHED	TECHNICAL AREA	CURRENT AND HISTORIC ACTIVITY	CONTAMINANTS DETECTED ABOVE BACKGROUND OR SCREENING LEVELS	RESOURCES WITH DOCUMENTED CONTAMINATION	SOURCE
Ancho Canyon	39	Firing site, explosive storage facilities MDA Y	Uranium isotopes, TATB, PCBs, copper, cyanide, mercury	Sediment	LANL 2011e
	49	Firing site, MDA AB	Plutonium and Uranium isotopes	Sediment	LANL 2011e
Barrancas Canyon	10	Firing site	PCBs, chromium, lead, zinc	Sediment	LANL 2009c
Bayo Canyon	0	Firing site	Barium, lead, perchlorate, selenium	Sediment and soil	LANL 2009c
	10	Firing site, nuclear processing facilities	Strontium-90, PCBs, chromium, lead, zinc	Sediment and soil	LANL 2009c
Canada Del Buey	46	Nuclear reactor research, solid waste storage	Plutonium-239/240, PCBs, antimony, cobalt, lead	Sediment and intermediate aquifer	LANL 2009e
	51	Waste disposal research	Aluminum, antimony	Sediment	LANL 2009e
	52	Nuclear reactor research	Plutonium-239/240, lead	Sediment	LANL 2009e
	54	MDA G, MDA J, MDA L	Americium-241, plutonium isotopes, tritium, PCBs, VOCs, aluminum, antimony, cyanide	Sediment and alluvial groundwater	LANL 2009e
	63	Firing site, photographic equipment	Plutonium-239/240, lead	Sediment	LANL 2009e
Chaquehui Canyon	33	Firing site, tritium operations, MDA E, MDA K	Tritium, PCBs, cyanide, vanadium	Sediment	LANL 2011e
Guaje Canyon	0	Transformer storage site	PCB, DDT, lead	Soil	LANL 2009c

WATERSHED	TECHNICAL AREA	CURRENT AND HISTORIC ACTIVITY	CONTAMINANTS DETECTED ABOVE BACKGROUND OR SCREENING LEVELS	RESOURCES WITH DOCUMENTED CONTAMINATION	SOURCE
Los Alamos Canyon	2	Nuclear reactor research	Cesium-137, strontium-90, tritium	Sediment, soil, and alluvial groundwater	LANL 2004a
	21	Plutonium processing plant, polonium and tritium research laboratories	Actinium-227, americium-241, cesium-137, plutonium-238/239/240, polonium-210, strontium-90, tritium, uranium 234/235/238, TCA, TCE, TPH-DRO, arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, perchlorate, zinc	Sediment, soil, and alluvial groundwater	LANL 2004a
	41	Weapons development, sewage treatment plant	Radionuclides	Sediment and soil	LANL 2004a
	43	Health Research Laboratory	Radioisotope labeling compounds, solvents	None currently	LANL 2004a
	53	LANSCE	Radionuclides, organic and inorganic chemicals	Sediment	LANL 2004a
	61	Administrative facilities	PCBs	Soil	LANL 2004a
	73	Municipal landfill, waste incinerator	Organic and inorganic chemicals	Soil	LANL 2004a
Mortandad Canyon	3	Radioactive liquid waste lines, liquid effluent releases	Cesium-137, plutonium-238/239, strontium isotopes, uranium isotopes, cyanide, potassium chromate	Sediment and groundwater	LANL 2006b
	35	Research facilities, waste water releases	Barium-140, cesium-137, lanthanum-140, plutonium, ruthinium-106, strontium isotopes, technetium-99, tritium, uranium isotopes, ferric chlorate, iron sulfate, nitric acid, strontium nitrate, chromium	Sediment and groundwater	LANL 2006b
	48	Radiochemistry and nuclear medicine research facility	Americium-241, cesium-137, cobalt-60, plutonium isotopes, ruthinium-106, strontium-90, sodum-22, uranium isotopes, perchloric, hydrochloric, hydrofluroic, and nitric acids, barium, copper, lead, manganese, mercury, strontium, zinc	Sediment, soil, and groundwater	LANL 2006b

WATERSHED	TECHNICAL AREA	CURRENT AND HISTORIC ACTIVITY	CONTAMINANTS DETECTED ABOVE BACKGROUND OR SCREENING LEVELS	RESOURCES WITH DOCUMENTED CONTAMINATION	SOURCE
	50	Waste water treatment Plant	Americium-241, cesium-137, cobalt-60, plutonium isotopes, potassium-40, Ra-226, thorium-232, tritium, strontium isotopes, yitrium-90, PCBs, PAHs, chloride, chromium, fluoride, perchlorate, sodium	Sediment, soil, and groundwater	LANL 2006b
Pajarito Canyon	3	Firing site, administrative facilities, vacuum repair shop	Tritium, PCBs, 1,4-dioxane	Sediment	LANL 2008b
	8	Firing sites, MDA Q	PCBS, di-n-butylphthalate, naphthalene, arsenic, barium, chromium, lead, mercury silver, vanadium, silver	Sediment	LANL 2008b
	9	Explosives development, solid waste storage, MDA M	Tritium, RDX, TATB, cadmium, chromium, copper, mercury, nitrate, thallium, perchlorate	Sediment	LANL 2008b
	15	Firing sites	Barium-140, lanthanum-140, strontium-90, uranium isotopes, PAHs, RDX, SVOCs, TNT, arsenic, barium, beryllium, chromium, copper, lead, mercury, nickel, thallium.	Sediment	LANL 2008b
	18	Firing sites, USTs, solid waste storage	Tritium, 1-2DCA mercury, nitrate, perchlorate	Sediment and alluvial groundwater	LANL 2008b
	54	MDA G, MDA H, MDA J	Tritium	Sediment and groundwater	LANL 2008b
	59	Administrative and research facilities	Radionuclides, photographic chemicals, SVOCs, VOCs	None currently	LANL 2008b
	69	Solid waste storage, incinerator ash pond	Dioxins, furans, PCBs, barium, lead, silver	Sediment and soil	LANL 2008b

WATERSHED	TECHNICAL AREA	CURRENT AND HISTORIC ACTIVITY	CONTAMINANTS DETECTED ABOVE BACKGROUND OR SCREENING LEVELS	RESOURCES WITH DOCUMENTED CONTAMINATION	SOURCE
	6, 22, 40	Firing sites, explosives storage facilities, MDA F	Cesium-137, strontium-90, uranium, acetone, benzene, carbon tetrachloride, HMX, PCBs, perchlorethylene, PETN, RDX, sodium carbonate, sodium hydroxide, sodium thiosulfate, TNT, trichloroethylene, aluminum, barium, calcium, chromium IV, cobalt, copper, cyanide, fluoride, iron magnesium, nitrite, nitrate, phosphate, silver, sulfate, zinc	Sediment	LANL 2008b
Pueblo Canyon	0	Waste water treatment plant	Plutonium 239/240, DDT, PCBs, other inorganic and organic chemicals, mercury, other metals	Sediment and soil	LANL 2004a
	73	Municipal landfill, waste incinerator, ash pile	Plutonium 239/240, DDT, PCBs, other inorganic and organic chemicals, mercury, other metals	Soil	LANL 2004a
	Former 1 and 45	Manhattan Project activities	Americium-241, cesium-137, plutonium-239/240, strontium-90, uranium-234, PAHs, PCBs, Pesticides, antimony, arsenic, cadmium, chromium, copper, mercury, silver, lead nickel	Sediment, soil, and alluvial groundwater	LANL 2004a
	Former 31	East Receiving Yard, sanitary waste outfalls	PCBs	Soil	LANL 2004a
Rendija Canyon	0	Firing site, asphalt batch plant	Asphalt, antimony, arsenic, cadmium, cobalt, iron, lead, manganese, mercury, nickel, perchlorate, selenium, vanadium	Sediment and soil	LANL 2009c
Sandia Canyon	3	Liquid effluent releases, asphalt batch plant, PCB storage site	PAHs, PCBs, pesticides, TPH-DRO, arsenic, barium, cadmium, chromium, copper, cyanide, lead, mercury, molybdenum, nickel, silver, and zinc	Sediment, soil, and groundwater	LANL 2009d
	53	LANSCE	Radionuclides, PAHs, PCBs, TPH-DROs, lead, phosphate, sodium molybdate, zinc	Sediment, soil, and groundwater	LANL 2009d
	60	Administrative facilities	Organic and inorganic chemicals	Sediment and groundwater	LANL 2009d
	61	LA County municipal landfill, PCB storage site	PCBs, petroleum hydrocarbons, lead	Soil and groundwater	LANL 2009d

WATERSHED	TECHNICAL AREA	CURRENT AND HISTORIC ACTIVITY	CONTAMINANTS DETECTED ABOVE BACKGROUND OR SCREENING LEVELS	RESOURCES WITH DOCUMENTED CONTAMINATION	SOURCE
	72	Firing sites	cesium-137, europium-152, strontium-90, uranium isotopes, PAHs, PCBs, and TPH-DROs, beryllium, cadmium, chromium, copper, lead, mercury, silver, thallium	Sediment, soil, and groundwater	LANL 2009d
Water Canyon	11	Firing sites, burn area	Uranium isotopes, bis(2-ethylhexyl)phthalate	Sediment	LANL 2011d
	14	Firing sites, burn area	Uranium isotopes, RDX	Sediment	LANL 2011d
	15	Firing sites, DHART and PHERMEX facilities, MDA Z	Uranium isotopes, beryllium, copper, lead	Sediment and soil	LANL 2011d LANL 2011f
	16	Firing sites, explosives storage and processing facilities	Uranium-234/238, bix(2-ethylhexyl)phthalate, HMX, PAHs, PCBs, PCE, RDX, TATB, TNT, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, vanadium, zinc	Sediment	LANL 2011d
	36	Firing sites	Uranium isotopes, di-n-butylphthalate, PCBs, TATB, lead, cobalt, copper	Sediment	LANL 2011d LANL 2011f
	49	Firing site, MDA AB	Americium-241, plutonium isotopes, uranium isotopes, vanadium	Sediment	LANL 2011d

APPENDIX B: QUALITY MANAGEMENT PLAN

Los Alamos National Laboratory
Natural Resource Damage Assessment
Quality Management Plan

Draft | October, 2013

LANL NATURAL RESOURCE DAMAGE ASSESSMENT QUALITY MANAGEMENT PLAN CONCURRENCES

Name: ____

Title: State of New Mexico – ONRT Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Title: Pueblo de San Ildefonso Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Title: Jemez Pueblo Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Title: Santa Clara Pueblo Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Name: ____

Title: U.S. Department of Agriculture Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Title: U.S. Department of Energy Representative, LANLTC

Signature:____________________________________ Date:____________

Name: ____

Title: LANL NRDA Quality Assurance Coordinator

Signature:____________________________________ Date:____________

TABLE OF CONTENTS

LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
CAR	Corrective action record
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	Chain of custody
DAT	Data analysis tool
DOE	U.S. Department of Energy
DQO	Data quality objectives
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
LANL	Los Alamos National Laboratory
LANLTC	Los Alamos National Laboratory Natural Resource Trustee Council
NMED-OB	New Mexico Environment Department Oversight Bureau
NRDA	Natural resource damage assessment
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
QMP	Quality Management Plan
SOP	Standard Operating Procedures

INTRODUCTION

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. §§ 9601 *et seq.*) provides the authority for natural resource trustees to assess damages to natural resources resulting from releases of certain hazardous substances. For the Los Alamos National Laboratory (LANL) natural resource damage assessment (NRDA), natural resource trustees include representatives of the U.S. Department of Energy (DOE), the Pueblo de San Ildefonso, Jemez Pueblo, Santa Clara Pueblo, the State of New Mexico through the Office of Natural Resource Trustee, and the U.S. Department of Agriculture Forest Service. Representatives of these organizations have formed a Trustee Council (LANLTC) to pursue the NRDA of LANL and the surrounding area.

The purpose of this Quality Management Plan (QMP) is to document the LANLTC's Quality Systems and to provide a blueprint for how the LANLTC will plan, implement, and assess its Quality Systems for NRDA work performed by or on behalf of the LANLTC. Consistent with EPA 2001, this Plan presents the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces for those planning, implementing, and assessing all activities conducted under this NRDA.

1.0 MANAGEMENT AND ORGANIZATION

1.1 IMPORTANCE OF DATA QUALITY

Many of the management decisions being made to accomplish the LANL NRDA require the use of environmental data. The collection, compilation, evaluation and reporting of environmental data are necessary to carry out the functions of the NRDA including identification of data gaps; assessment of the severity, location and extent of injury; and making appropriate decisions as to the needed type and scale of restoration actions. Careful study design and appropriate interpretation of results, including consideration of uncertainty and data quality, are essential to achieve these goals.

1.2 GOALS AND OBJECTIVES OF THE QUALITY SYSTEM

This QMP has been developed in order to ensure that all environmental data and related information relied upon in this NRDA are scientifically valid for their intended use. Information associated with the derivation of data (methods, precision, bias, completeness, comparability, sensitivity, and representativeness) is necessary to inform decision-making about the appropriate use of the data. Further, the development of work plans, study-specific Quality Assurance Project Plans (QAPPs), as well as data management processes and data review processes are necessary to ensure that data generated and used for purposes of the NRDA are sound to achieve these objectives, quality assurance (QA) practices should be incorporated into all phases of study design and data collection (including assembly of historical data as well as new data generation), from the planning stages through implementation, assessment and ultimately dissemination of data products and services.

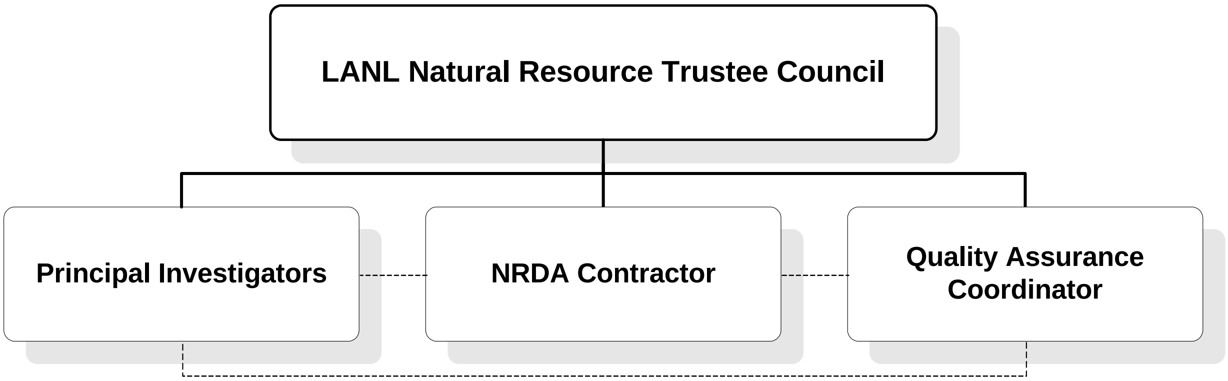
1.3 POLICY

This QMP establishes a policy to implement a Quality System as part of NRDA activities, that will ensure that all environmental data, whether historical or acquired during NRDA investigations, will be scientifically valid (e.g., reproducible); of acceptable completeness, representativeness, and comparability; and be of a known and documented quality. It is also the policy of the LANLTC to disseminate information in an accurate, clear, complete, and unbiased manner. The LANLTC recognizes that the implementation of a quality assurance program requires trustee commitment and support as well as the involvement of the entire staff involved in the NRDA, and that every participant in the NRDA plays an integral part in quality assurance.

1.4 ORGANIZATIONAL CHART

The Quality Assurance Management organization for the LANL NRDA is shown in Exhibit 1.

EXHIBIT 1 QA MANAGEMENT ORGANIZATION FOR LANL NRDA



Solid lines – formal lines of authority
Dashed lines – advisory/coordination/contracting

1.5 RESPONSIBILITIES

The LANLTC has overall program management responsibilities for the NRDA including data quality management. The NRDA Contractor has responsibility for management and communication of specific quality assurance activities with advisory input from the LANLTC and also works closely with Principal Investigators in the technical design of work plans to help ensure that these documents meet the LANLTC's needs. Principal Investigators are responsible for project-specific design and implementation of the quality assurance/quality control (QA/QC) activities. The Quality Assurance Coordinator oversees QA program implementation, contributing to the work plan development, data review, and documentation processes. Specific responsibilities of the LANL Quality Assurance Coordinator include:

- Annually reviewing the LANL NRDA QMP, revising it if changes are necessary, and obtaining appropriate document approvals.
- Overseeing the verification and validation of the historical and newly acquired data for the LANL NRDA.
- Identifying and delegating responsibility for responding to specific QA/QC needs, and ensuring timely answers to requests for guidance or assistance including interpretation of the QMP and providing guidance on compliance.
- Ensuring all work plans and standard operating procedures (SOPs) are technically reviewed and approved prior to collection and/or analysis of environmental data, as necessary.
- Ensuring that problems and deficiencies identified in technical audits and data assessments are resolved.

2.0 QUALITY SYSTEM DESCRIPTION

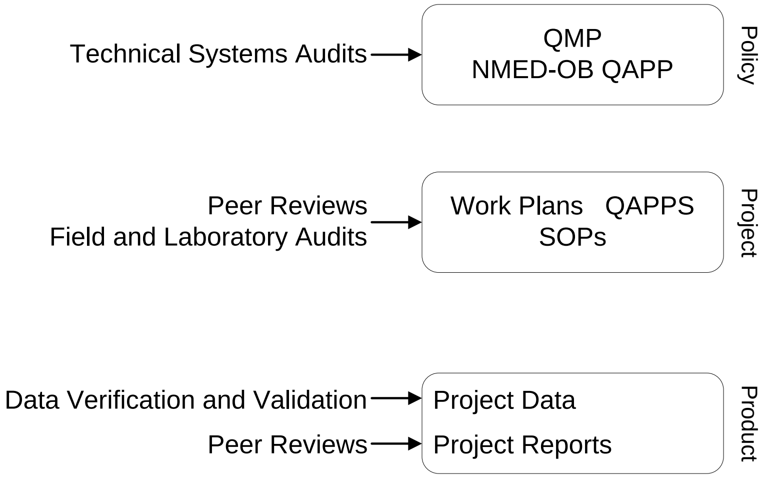
The goal of the Quality System is to ensure that the acquisition and use of environmental data, whether historical or generated under the oversight of the LANLTC, includes sufficient up-front planning and review to ensure data quality is adequate to meet project goals. In order for the data to be useful for the NRDA, the data must be of known and documented quality: it must have sufficient supporting documentation such that data users can evaluate whether the data meet the needs of their intended use. This is achieved by ensuring that adequate QA tools are used throughout the entire data collection and assessment process (from initial planning through data usage). The tools used in the Quality System include:

- This QMP
- The New Mexico Environment Department DOE Oversight Bureau Quality Assurance Project Plan for Environmental Monitoring Programs 2009 (NMED-OB QAPP)
- Work plans including associated QAPPs that may be developed to support NRDA activities
- SOPs

- Peer reviews
- Technical systems audits
- Field and laboratory audits
- Data verification and validation

Exhibit 2 depicts the relationship of these tools to one another. The LANLTC, NRDA Contractor, QA Coordinator, Principal Investigators and appropriate staff participate in and are responsible for the creation and implementation of each of these tools.

EXHIBIT 2 COMPONENTS OF THE QUALITY SYSTEM



Quality system components shall be consistent with, and supportive of, project objectives (i.e., will have a graded approach, as described in EPA 2001). In other words, the level of application of quality system controls to an environmental data program can vary according to the intended use of the results and the degree of confidence needed in the quality of the results. For example, if historical data are being used to support planning for additional sampling and analysis, the degree of required review and documentation may be less than that for the use of historical data that may be used for the formal documentation of injury.

Specifically, it is the responsibility of the QA Coordinator working with the LANLTC, NRDA Contractor, and Principal Investigators to ensure that the following objectives are achieved:

- All environmental data used and generated are of known and acceptable quality for their intended use. The data quality information developed with all environmental data is documented and available within the data management system. The LANLTC will make every effort to take into consideration the intended use and objective(s) of previously generated data when making a determination on its applicability to the NRDA; the LANLTC will also consult with DOE to clarify the context under which data were collected when using existing data.

- If new data are to be collected, the intended uses of the data are defined before the data collection effort begins, so that appropriate QA measures can be applied to ensure a level of data quality commensurate with the project data objectives. The determination of this level of data quality takes into account the prospective data needs of secondary uses as well as the primary intended use. The assigned level of data quality, specific QA activities, and data acceptance criteria must be explicitly described in each individual QAPP.
- General audit and data review procedures are stated during the planning process for the acquisition and use of any data used in the NRDA process. The audits and data assessments should be documented and provided with the final data reports.

2.1 DESCRIPTION

It is the policy of the LANLTC that:

- This QMP is implemented as described herein and reviewed annually to ensure that it continues to accurately describe the organization and quality management policies of the LANLTC.
- The data quality information developed for all environmental data generated under the NRDA will be documented and meet the minimum requirements of the NMED-OB QAPP and any applicable LANL requirements.
- Data quality information will be made available along with the data themselves such that limitations of data quality are understood.
- Data will be in a format such that it can be uploaded to the Intellus database, if necessary.

2.2 PRINCIPAL COMPONENTS OF THE QUALITY SYSTEM

2.2.1 Quality Management Plan

This QMP documents and defines the overall policies, organization objectives, and functional responsibilities for achieving the LANLTC’s goals and has been prepared in accordance with EPA QA/R-2: EPA Requirements for Quality Management Plans (March 2001).

This QMP documents how the LANLTC structures its Quality System. A Quality System describes the policies and procedures for ensuring that work processes, products, or services satisfy stated expectations or specifications (EPA 2001). This QA program functions at the management level through LANLTC goals and management policies, and at the analytical level through the full set of tools that comprise the Quality System. The QA program is designed to minimize system-based error, encourage constructive, documented problem solving, and provide a framework for continuous improvement within the organization.

2.2.2 New Mexico Environment Department Oversight Bureau QAPP and LANL QA documents

The NMED-OB QAPP provides details that complement the requirements and guidance in this QMP. The NMED-OB has collected and analyzed many samples and the resulting data were generated under the requirements of this QAPP. Incorporation of this QAPP enables understanding of the quality of the historical data provided by the NMED-OB for incorporation into the Intellus database (see Section 2.2.3) and generation of comparable data in any new sample collection events under the NRDA.

In addition, there are a number of potentially applicable documents produced by LANL, available from the Plans and Procedures page of Los Alamos National Laboratory website (http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php). For example, there is a document on standard operating procedures for field quality control samples (LANL 2007b), for field decontamination of equipment (LANL 2010c), and for sample containers and preservation (LANL 2007c).

2.2.3 Intellus Database

The Intellus database was implemented in 2012 to provide the public access to all data generated by DOE for environmental remediation and monitoring purposes. The Intellus database includes environmental monitoring data collected by LANL and the NMED-OB as well as a variety of data visualization tools to access and evaluate the data.

Quality control data for samples like spikes and blanks in at least some cases are included in the Intellus database, but cannot be readily combined with their associated environmental data. However, the LANLTC understands that quality control data are required to be maintained by the organizations that provide the measurement data to Intellus. As noted previously, the LANLTC will make every effort to take into consideration the intended use and objective(s) of previously generated data (including data from Intellus) when making a determination on its applicability to the NRDA and will consult with DOE or NMED-OB, as necessary, to clarify the context in which data were collected.

The Department of Energy requires that all analytical data associated with NRDA activities be transmitted to the Intellus database. Thus, data generated in support of the NRDA must be properly formatted and validated to facilitate upload into the Intellus database.

2.2.4 Use of Data Produced Outside NRDA Process

Historical (as well as contemporary) data for LANL are available in the Intellus database, and/or may be available through individual programs operated at the site. In addition, the State of New Mexico and participating Pueblos may have data that are relevant to the assessment. When datasets generated outside the NRDA process are deemed useful for formulating or performing a study, it is important to understand the quality of the data.

In the case of the Intellus database, fields labeling and categorizing data will need to be fully evaluated, and a determination made as to whether the data meet the data quality goals for the NRDA. However Intellus data, as well as other sources of data, are likely to fall into the following four categories:

- **Universal Use.** Datasets that are fully validated, and meet all current QA/QC guidelines are suitable for all general environmental regulatory purposes, including NRDA. However, specific sample results within validated datasets may be qualified as "estimated" or "rejected" (labeled unusable) for various reasons. Such results may not be considered adequate for "Universal Use", but would be classified under one of the remaining three categories listed below. Sample results may be rejected (qualified "R") during validation for a number of reasons (reasons for which are coded in the Intellus database). Results rejected due to clearly inadequate methods or sample handling issues should not be used for any purposes. However, the LANLTC believes results rejected for certain method inadequacies may be of adequate quality for informing qualitative evaluations. For example, if samples are held beyond two times the published holding time for an analysis, results may be rejected under the LANL validation guidelines. However, these results may still be adequate for evaluating if a certain compound was detected at any time in an area. Thus, positive results, even if considered biased low, may be very informative. Also, if certain QC results are not reported by a laboratory the results may be rejected, however there may be other measures of accuracy or precision to inform the data user that data are of acceptable quality for qualitative use.
- **Qualitative Use Only**. Datasets that are of partially known or suspect quality because study design and/or QA/QC information for sampling and analysis are incomplete, or data that have been validated as described above and qualified as estimated due to QA/QC limitations identified during the review, may be suitable for qualitative use. The LANLTC believes that such data likely can be considered suitable for qualitative use and may be considered suitable for further evaluation based on project specific DQOs and intended end uses. For example, qualitative use could include use of data for evaluating data trends over time, or for planning studies and sampling design.
- **Limited or Provisional Use**. Datasets that are of unknown quality may be suitable for limited or provisional use. For example, datasets that have information on sampling and analytical methods, but lack an adequate level of supporting study design and/or QA/QC information; or are summarized and only provide ranges of concentrations fall into this category. What distinguishes these data from data in the "Qualitative Use Only" category above primarily is that data quality is not documented. However, these datasets, although not formally documented, may in some cases be more useable than data in the "Qualitative Use Only" category. Regardless, study design should include considerations as to the datasets limitations. For example, data may be reported in peer review journals, but limited QA information is provided. The LANLTC believes that these data likely can be used on a limited or provisional basis. Depending on the source and

ancillary information the LANLTC may use such data for planning purposes, e.g., assessing general trends, or to establish analytes of interest for further study.

- **Not Acceptable for Use**. Datasets that have no information available or ascertainable as to the study design, sampling and/or analytical methods; or data that are documented that inappropriate sampling and/or analytical methods were used (e.g., sample preservation was not used, holding times were grossly exceeded for labile compounds, or the acceptance criteria for measurement bias were not satisfied for the entire dataset) should not be used for NRDA purposes.

The general types of information reviewed and the overall criteria used to categorize the quality level of a dataset are summarized in Exhibit 3. Exhibit 3 is not meant to be prescriptive, but is intended to serve as an overall guide to the data usability evaluation process. Once a dataset has been identified as useful for formulating or performing a study, the Principal Investigator, under the direction of the LANLTC, will work with the QA Coordinator to detail QA/QC considerations specific to the type of data being reviewed, and will develop criteria to categorize the quality and usability of the dataset. Data should be assigned an overall usability category that is equivalent to the lowest category applied to any single criterion (e.g., data that are ranked “Universal Use” for four of the criteria and “Qualitative Use” for two should be considered suitable for ”Qualitative Use” overall. Work Plans or reports relying on data generated outside the NRDA process shall describe the data review procedure undertaken as part of the work plan or report development, as well as the results of those efforts (i.e., whether or not specific results or datasets were included/excluded from use). The QA Coordinator shall advise as to the appropriate nature and type of data review procedures for use in connection with specific efforts.

EXHIBIT 3 CRITERIA MATRIX FOR QUALITY LEVELS DESCRIBING USABILITY OF DATA FOR NRDA PURPOSES

QUALITY LEVEL	UNIVERSAL USE	QUALITATIVE USE ONLY	LIMITED OR PROVISIONAL USE	NOT ACCEPTABLE FOR USE
Criterion 1: Documentation Status	Fully Documented QA	Partially Documented QA	Unknown Quality, Conditionally Acceptable for Qualitative Uses	No information available
Criterion 2: Data Sources	Accompanying report provides complete description of study design and sample location(s) with justification and rationale.	Report is generally complete and well written but lacks sufficient detail in a few areas. Sampling locations specified, but not located with GPS or equivalent.	Accompanying report is incomplete but does provide sufficient information for one or more parameters of interest. Sampling locations may not be well specified.	No information available on background and conduct of study. Significant questions regarding sampling locations.

QUALITY LEVEL	UNIVERSAL USE	QUALITATIVE USE ONLY	LIMITED OR PROVISIONAL USE	NOT ACCEPTABLE FOR USE
Criterion 3: Documentation	Work Plan, QAPP, chain-of-custody records, SOPs, and similar field and laboratory documentation exists and is available for review.	Documentation exists for most areas but is insufficient or lacking in a few areas considered non-critical.	Documentation generally not available but sufficient information is known or available via other sources to establish validity of field and analytical procedures.	Documentation non-existent, not available for review, or status unknown.
Criterion 4: Analytical Methods	Analytical procedures follow documented standard methods such as EPA or ASTM.	Analytical procedures non-standard but sufficiently documented to establish validity of and ensure confidence in data.	Analytical procedures nonstandard and not well documented, but data are believed to be valid due to other information provided.	Insufficient information provided or available via other sources to establish validity of data.
Criterion 5: Data Quality Indicators	Study had established data quality indicators and data substantially meet all acceptability criteria for completeness, comparability, representativeness, precision, and accuracy.	Data quality indicators not established, but data appear to meet minimum standards for DQIs.	Data quality indicators not established; data appear to not satisfy minimum standards for one or more non-critical DQIs.	Data fail to meet minimum standards for one or more critical DQIs, or not possible to evaluate DQIs
Criterion 6: Data Review	Study incorporated all or most of the full range of QA/QC procedures, e.g., blanks, spikes, duplicates, data review, and data validation.	Study generally employed and documented established QA/QC procedures but did not conduct data validation.	Nonstandard or incomplete QA/QC procedures were followed.	No QA/QC procedures employed or documented.
Criterion 7: Data Reporting	Data reported in standard units and are reasonable and internally consistent. Methods followed meet current standards for scientific investigation and were followed consistently.	Data appear to be of acceptable quality but methods may not meet current standards but are judged to have produced data equivalent to current methodologies.	Portions of the data appear to be of questionable quality due to age, changes in methods, and/or failure to follow current standards for scientific investigation.	The overall data quality is questionable due to outmoded methodologies, poor performance, and/or apparent lack of consistency with current standards.

ASTM = American Society for Testing and Materials
DQI = Data quality indicators (i.e., information about the completeness, comparability, representativeness, precision, and accuracy of the data)
GPS = Global positioning system

2.2.5 Work Plans and QAPPs

All LANL NRDA projects that involve the generation of new environmental data (activities that involve the measurement, monitoring or collection of physical, chemical, or biological data) are required to document all aspects of the project's sampling design, sample collection, analysis, quality control, and data management activities in a work plan. In particular, work plans should incorporate the EPA Data Quality Objectives process, and generally include but not necessarily be limited to the following elements:

- Cover page with title and date
- Signatory page (including the Principal Investigator(s) and QA Coordinator)
- Background/introduction
- Study measurement endpoints
- Sampling design strategy (e.g., numbers and types of samples, sampling locations, sampling timing, and identification of analyses that will be conducted on the samples)
- Detailed methods, including new, study-specific SOPs or references to SOPs
- A description of the statistical methods to be used in interpreting results, and power calculations, as necessary
- Provisions for health and safety, as applicable
- Descriptions of all permissions needed to conduct the study (e.g., collection permits, paperwork documenting approval for work on-site at LANL)
- References

Accompanying the work plan must be a study-specific QAPP that describes the methods for documenting and assessing environmental data, QA, QC, and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. The QAPP should follow the EPA guidelines for QAPP preparation (EPA 2002). A review checklist for developing a QAPP was adapted from this EPA guidance and is provided in **Attachment A**. This checklist is a general guide for the preparation of QAPPs. Not all studies will require the same level of information. The QMP should be referenced in the QAPP, and any inconsistencies with the QMP noted. Note there should be some overlap of information between the work plan and the QAPP, so these documents can be used by project personnel independently.

2.2.6 Standard Operating Procedures

Work plans submitted for the NRDA must include SOPs to describe detailed sample collection and laboratory procedures. The SOPs may be incorporated by reference, but should be submitted, reviewed and approved at the same time as the corresponding work plan and QAPP (see Section 7.3).

SOPs that are developed *de novo* (or that are adapted from existing SOPs) for specific work plans should include detailed equipment/materials lists and, as appropriate, should include associated datasheets into which researchers record sample numbers, measurements, and other pertinent information.

Sampling SOPs must describe requirements for sampling and/or sample processing undertaken for QA purposes (e.g., the frequency of collection of duplicate samples or measurements, field blanks, etc.). These SOPs must also specify and describe sample containers, volumes, and preservation requirements as well as sample labeling procedures, shipping/handling procedures, and equipment calibration, cleaning/decontamination methods and frequencies. If samples are to be composited in the field or in the laboratory, these methods should also be described. Overall, SOPs should be consistent with EPA Guidance for Preparing SOPs (QA/G-6).

The LANL NRDA Contractor will maintain internal SOPs for the management of environmental data submitted to the Intellus database. These SOPs should be written by personnel performing the routine data management tasks and reflect actual data processing practices. SOPs should be prepared in document control format and should be submitted to the NRDA Contractor and QA Coordinator for approval and maintenance in a permanent file.

2.2.7 Audits

Field and laboratory audits may be performed by the QA Coordinator or designee pursuant to any audit requirements set forth in the work plans for new data collection efforts. The field audits will be performed during sample collection, and laboratory audits will be performed before or during analysis. The audit checklists will be based on the performance criteria specified in field and laboratory SOPs, general work plan protocols, project specific QAPP requirements, and requirements outlined in audit procedures of the EPA National Enforcement Investigation Center "NEIC Procedures Manual for the Contract Evidence Audit and Litigation Support for EPA Enforcement Case Development" (EPA 330/9-89-00). Field Team Supervisors or Laboratory Project Managers will be informed of the findings and recommendations of the audit before the auditors leave the field operations area or laboratory. A written report discussing the audits will be submitted to the NRDA Contractor, the appropriate Principal Investigator, and the audited facility or team.

If an audit involves formal findings that are requested to be corrected, the Principal Investigator will be responsible for providing a summary of corrective actions and the timeline for its implementation to the NRDA Contractor. After approval by the NRDA Contractor, the QA Coordinator will review the response from the audited party and sign off on the corrective action after verifying its implementation.

3.0 PERSONNEL AND TRAINING

Personnel must demonstrate competence in the areas where they have responsibility. All personnel are responsible for complying with QA/QC requirements that pertain to their area of responsibility. Each staff member must have a combination of experience and education to adequately demonstrate a specific knowledge appropriate to their particular area of responsibility.

LANLTC members and participants are required to draw upon their educational background, experience, professional symposia, and on-the-job training. The NRDA Contractor, QA Coordinator and Principal Investigators must have documentation in the

QA file that they have read, understood and agreed to follow the most recent version of the QMP, SOPs and work plans as appropriate to their responsibilities.

Proper training and ability need to be demonstrated for personnel collecting data for studies. When a work plan and QAPP are submitted, key personnel involved and their qualifications need to be reviewed and assessed by the QA Coordinator or designee. If, in the QA Coordinator's view, personnel designing or implementing studies do not possess adequate qualifications, the QA Coordinator shall immediately inform the LANLTC, which will make a determination as to the appropriateness of the individual continuing to work in the given role.

4.0 PROCUREMENT OF ITEMS, SERVICES, AND ACTIVITIES

Contractors and suppliers are responsible for the quality of work performed, including items or services provided by subcontractors and secondary suppliers. The Quality System requires that all applicable field and laboratory facilities, equipment, and services be capable of producing acceptable quality data in an efficient manner with minimum risk to personnel.

Cooperating laboratories will ensure:

- Acceptable environmental conditions (lighting, ventilation, temperature, noise levels)
- Acceptable utility services (electricity and voltage control; purity, pressure, and supply of water and air)
- Acceptable general laboratory equipment (analytical instrumentation support, air conditioners, furnaces, generators, refrigerators, incubators, laboratory hoods, sinks, counters)
- Routine inspection and preventive maintenance for all facilities and equipment

Field and laboratory equipment used to conduct environmental data operations will be calibrated prior to work, following work, and at intervals according to specifications in the manufacturers' instructions. These procedures must be addressed in each work plan and QAPP and documented in SOPs. The NRDA Contractor and/or the QA Coordinator will ensure that acceptable equipment is used in the field and the laboratory, and that it is maintained in good working order.

5.0 DOCUMENTS AND RECORDS

5.1 DOCUMENT REVIEW REQUIREMENTS

Quality system documents, including revisions, must be prepared and reviewed for conformance with the quality system requirements and approved for release by the QA Coordinator.

Technical guidance documents such as work plans, QAPPs, and SOPs for assessment activities, in some cases, may need to be peer-reviewed, signed by the Principal Investigator(s) and the QA Coordinator, then approved by the LANLTC. Decisions about whether or not assessment documents need to be peer reviewed will be made by the

LANLTC with input from the Quality Assurance Coordinator. The purpose of a peer review is to ensure that technical documents reflect appropriate scientific factual information and judgments. Qualified individuals independent from those responsible for the original work product shall serve as peer reviewers. For any given review effort, qualified peer reviewers may include members of LANLTC organizations (i.e., internal peer reviewers), but consideration would be given to including at least one person not regularly associated with LANLTC activities at LANL (i.e., external peer reviewers).

The QA Coordinator shall ensure appropriate QA/QC measures are included in all technical guidance documents. The Principal Investigator and the QA Coordinator are jointly responsible for the proper use of these documents, which is ensured through the training and audit processes. The NRDA Contractor provides higher-level oversight to ensure documents are consistent with overall LANLTC priorities.

Once approved, quality system and technical guidance documents are provided to the NRDA Contractor for storage in the LANL NRDA Record File (currently a Microsoft SharePoint website) for storage of assessment-related files.

Project reports (e.g., reports on injury studies) developed for this NRDA that contain data or reporting the results of environmental data operations may also be subject to independent peer review to confirm that the data or results reflect appropriate scientific factual information and judgments. Once finalized, these documents will be maintained by the LANLTC.

5.2 RECORDS

Every dataset that is downloaded from Intellus or an equivalent data repository should be accompanied by a related file documenting the source of the data and the contact for additional information. If such files are not readily available, every effort should be made to acquire them. Documentation on the source of the data and associated QA/QC is essential for drawing meaningful interpretations related to the usability of the data contained in the database.

5.3 DOCUMENT AND RECORD RETENTION

Generally, project QA/QC documents, including the approved work plans, QAPPs, SOPs and revisions, chain-of-custody (COC) forms, corrective action records (CARs), sample collection forms, and audit reports will be maintained after the conclusion of the project by the LANLTC. Maintenance of records will entail transmittal, distribution, retention, access, protection, preservation, traceability, retrieval, and disposition.

6.0 COMPUTER HARDWARE AND SOFTWARE

6.1 HARDWARE AND SOFTWARE SELECTION

Hardware and software, including versions and file formats, used in the context of the NRDA should be agreed upon at the outset of data collection and information storage by the LANLTC, NRDA Contractor, Quality Assurance Manager and any participating Principal Investigators.

6.2 DATA AND INFORMATION STANDARDS

Trustees, contractors, field operations and laboratories, are required to submit deliverables in electronic format that will be compatible with LANLTC and Intellus requirements. Standards for submitting data and information will be documented in SOPs.

Project specific SOPs will describe how data security will be maintained as well as how the data will be reviewed and processed prior to making the information available to the Intellus database. The NRDA Contractor or designee will contact the data generator directly to resolve minor errors; however, the NRDA Contractor should consult with the QA Coordinator to resolve major reporting errors or omissions.

7.0 PLANNING AND IMPLEMENTATION

7.1 PARTICIPANTS

The planning process begins with the LANLTC, NRDA Contractor, and Principal Investigators.

7.2 DEVELOPMENT AND DOCUMENTATION OF QUALITY NEEDS

The assessment studies developed by the Principal Investigators shall be conducted pursuant to study-specific work plans. The work plans shall describe a systematic planning process (incorporating the EPA Data Quality Objectives Process), details of which will include a description of how, when, and where the data will be obtained and any constraints on data collection. The following are the steps described in Appendix A of the *Uniform Federal Policy for Implementing Environmental Quality Systems* (IDQTF 2005) for determining data quality needs:

A. Establish a Team-Based Approach to Planning

B. Description of the Project Goal, Objectives, and Questions and Issues to Be Addressed

C. Identification of Project Schedule, Resources (Including Budget), Milestones, and Any Applicable Requirements (e.g., Regulatory Requirements, Contractual Requirements)

D. Match the Data Collection and Analysis Process to Project Objectives

E. Identification of Collection and Analysis Requirements

   1. Determine how, when, and where data (including existing [*i.e.*, *historical*] data) will be obtained

   2. Determine the quantity of data needed and performance criteria for measuring quality

   3. Specify QA/QC activities needed to assess the quality performance criteria

F. Describe the Process for Generation, Evaluation, and Assessment of Collected Data

7.3 DEVELOPMENT AND APPROVAL OF WORK PLANS AND QAPPS

As shown in Exhibit 4, the Principal Investigator and QA Coordinator shall sign off on the work plan and associated QAPP. The NRDA Contractor shall submit these documents to the LANLTC, along with a formal recommendation to proceed (or not) with the described work, at least 60 days prior to the initiation of each data generation activity. The LANLTC will make a determination about whether to proceed with the described work.

EXHIBIT 4 WORK PLAN AND QAPP APPROVAL PROCESS

	ACTIVITY	IMPLEMENTED BY
1	Identify data gap as priority and define path forward for acquiring needed information.	LANLTC with NRDA Contractor
2	Prepare scope of work; contact prospective Principal Investigator(s) or prepare and release Request for Proposals.	NRDA Contractor
3	After contract award, prepare draft work plan and QAPP (with SOPs), coordinating with LANLTC ; include preliminary estimated budget and projected timeline as separate documents.[1]	Principal Investigator,[2] with input from QA Coordinator
4	Submit draft work plan, QAPP, estimated budget and projected timeline to the LANLTC, with recommendation to proceed to the peer review.	NRDA Contractor
5	Recommend to LANLTC to proceed with the peer review.	NRDA Contractor
6	Decide whether to approve the draft work plan/QAPP, whether or not to proceed with a peer review, and/or to request further changes.	LANLTC
7	Peer review:[3,4] select reviewers, manage review process, communicate results to Principal Investigator.	NRDA Contractor
8	Finalize work plan and QAPP in response to peer review. Revise estimated budget and projected timeline.	Principal Investigator
9	Submit final work plan and QAPP to the LANLTC, with recommendation about implementation.	NRDA Contractor
10	Decide whether to authorize funding for work plan implementation.	LANLTC

Notes:

[1] In some cases, this might be an iterative process, with submission and review of a preliminary work plan and budget (without QAPP), which is then cycled back to the Principal Investigator for preparation of a more detailed plan with QAPP.

[2] The Principal Investigator may be an employee of the selected organization (whether a Federal, state, or Tribal organization), or a contractor.

[3] The optional peer review may encompass the work plan, QAPP, and/or SOPs.

[4] Peer reviews can be accomplished by written review, or by conducting a review workshop.

8.0 MANAGEMENT OF THE WORK PROCESS IMPLEMENTATION

Work processes can vary substantially from one activity to another in terms of complexity, repetition, standardization, accuracy and precision requirements, and level of verification/validation required.

8.1 DEVELOPMENT OF STANDARD OPERATING PROCEDURES

LANL has developed a number of SOPs for activities expected to span multiple projects and that need uniformity across multiple cooperating parties. These activities may include but are not necessarily limited to: the process for maintaining proper chain of custody; coding for sample identification; sample location documentation; analytical chemistry measurements in various media; or procedures for collection of various field QC samples. SOPs will also be referenced in or developed for individual work plans (e.g., animal husbandry, toxicity testing procedures, necropsy methods, field survey methods). All SOPs will be reviewed and approved as described in Section 7.3.

Careful development and implementation of SOPs ensures that a project is conducted according to a defined process. As noted in Section 2.2.6, SOPs should be consistent with EPA Guidance for Preparing SOPs (QA/G-6).

8.2 IMPLEMENTATION OF THE WORK PLAN

The Principal Investigator shall work closely with the LANLTC to acquire all permissions that may be necessary to implement the work (e.g., acquisition of collection permits, DOE badge acquisition, acquisition of permission to conduct research on-site, etc.) in a timely fashion.

In addition, mechanisms for implementation of each work plan and QAPP are the responsibility of the Principal Investigator. These include oversight, monitoring, and inspection. Oversight and inspection are carried out by the QA Coordinator, as well as by the Principal Investigator, to check performance against technical and quality specifications.

8.3 PROJECT REPORT REVIEW

As noted previously, project reports that contain data or reporting the results of environmental data operations may also be subject to independent peer review to confirm that the data or results reflect appropriate scientific factual information and judgments. Once finalized, these documents will be maintained by the LANLTC.

9.0 QUALITY SYSTEM ASSESSMENT AND RESPONSE

9.1 IDENTIFICATION AND PLANNING OF QUALITY SYSTEM ASSESSMENTS

The QA Coordinator, or their designee, plans, conducts, and evaluates assessments of environmental data operations in order to measure the effectiveness of the implemented Quality System. Scheduling of assessments and allocation of resources are based on the status, risk, and complexity of sampling and analytical activities as described in individual work plans. Assessments include an evaluation to determine whether the technical requirements of activities are being effectively met.

The QA Coordinator should have sufficient authority, access, and organizational freedom to identify quality system problems; identify and cite noteworthy practices that may be shared with others to improve the quality of their operations and products; propose recommendations for resolving quality system problems; independently confirm implementation and effectiveness of solutions; and provide documented assurance to the LANLTC and NRDA Contractor that, when problems are identified, future work will be carefully monitored until problems are suitably resolved.

If, in the professional opinion of the QA Coordinator, the results of an audit indicate a compromise in the quality of the data, the QA Coordinator shall notify the NRDA Contractor immediately. The NRDA Contractor will have the responsibility of communicating audit results to the LANLTC.

9.2 QUALITY SYSTEM ASSESSMENT TOOLS

The type of assessment activity appropriate for particular projects will be determined during the planning process. Assessment tools include technical systems audits, laboratory and field audits, peer reviews, and data verification and validation. For evaluating particular activities, the work plan will describe the appropriate assessment tool and identify personnel responsibilities.

Data quality verification, validation, and assessment shall be consistent with EPA Guidance on Environmental Data Verification and Data Validation (QA/G-8).

9.3 QUALITY SYSTEM ASSESSMENT RESPONSE/CORRECTIVE ACTIONS

The QA Coordinator shall determine if appropriate actions have been implemented in response to assessment findings. The QA Coordinator, in a timely manner, shall determine the effectiveness of responses to assessments, and will maintain the documentation and correspondence relating to assessments and actions. Following any assessment event, a written summation of needed changes and actions taken will be prepared by the QA Coordinator and presented in a timely manner to the NRDA Contractor. The NRDA Contractor will have the responsibility of communicating any needed changes or actions to the LANLTC.

9.4 ANNUAL QUALITY SYSTEM MANAGEMENT REVIEW

The QA Coordinator will be responsible for conducting an annual review of the LANL NRDA quality systems to ensure their continuing suitability and effectiveness in meeting requirements and to introduce any necessary changes or improvements. The QA Coordinator shall present the findings of this review including recommendations for changes, if any, to the NRDA Contractor and the LANLTC, and to the Principal Investigator(s) and/or Laboratory Manager(s), as applicable.

10.0 QUALITY IMPROVEMENT

10.1 RESPONSIBILITY

The QA Coordinator will be responsible for identifying, planning, implementing, and evaluating the effectiveness of quality improvement activities.

10.2 CORRECTIVE ACTIONS

Whenever the procedures and guidelines established in this QMP or specific work plans are not implemented correctly, corrective action will be required to ensure that conditions adverse to data quality are identified promptly and corrected as soon as possible. Corrective actions may include identification of root causes of problems, determination of whether the problem is unique or has more widespread implications, and recommendations for preventing recurrence of the problem.

Corrective actions must be initiated if variances from proper protocols are noted. Reporting to the QA Coordinator ensures that early and effective corrective actions will be taken when data quality fails to meet acceptable limits. The responsibility to oversee and implement necessary corrective actions will rest with the Principal Investigator. The QA Coordinator will be informed of any corrective actions that are taken. Follow up evaluations will be conducted by the QA Coordinator to ensure effectiveness of the implemented corrective actions.

10.3 DOCUMENTATION OF CORRECTIVE ACTIONS

A Corrective Action Record (CAR) will be prepared by the QA Coordinator for documenting the non-compliance and submitted to the NRDA Contractor, the Principal Investigator, and the project personnel responsible for implementing the corrective action. The project personnel will describe the process that was implemented to correct the non-compliance, sign, date and return to the QA Coordinator and Principal Investigator within one week of submittal. If corrective action is found to be adequate, the completed CAR will then be signed off by the QA Coordinator. The CAR will be stored with the affected work plan or SOP.

REFERENCES

American National Standards Institute (ANSI). 1994. Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, ANSI/ASQC E4-1994.

DOE Oversight Bureau New Mexico Environment Department. 2009. Quality Assurance Project Plan for Environmental Monitoring Programs 2009, Rev. 4-30-09.

Intergovernmental Data Quality Task Force. 2005. Uniform Federal Policy for Implementing Environmental Quality Systems. Version 2. EPA-505-F-03-001. Washington, D.C.

Los Alamos National Laboratory Natural Resource Trustee Council. 2010. Preassessment Screen for Los Alamos National Laboratory.

U.S. Environmental Protection Agency (EPA).2002. EPA Guidance for Quality Assurance Project Plans(QA/G-5). EPA-240-R-02-009. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2001. EPA Requirements for Quality Management Plans (QA/R-2). EPA Requirements for Quality Management Plans (QA/R-2). EPA-240-B-01-002. Washington, D.C.

ATTACHMENT A

QA PROJECT PLAN REVIEW CHECKLIST

EXAMPLE OF A QA PROJECT PLAN REVIEW CHECKLIST

This is an example checklist based on the elements in *EPA Requirements for QA Project Plans (QA/R-5)* (EPA, 2001a). This checklist can be used to either write or review a QA Project Plan, especially those involving field sampling and laboratory analyses. The checklist has been streamlined/edited somewhat for the purposes of general NRDA QAPP generation. In addition, not all sections may apply to every study. Other documents may be referenced if the information is supplied elsewhere (e.g., project-specific Work Plan)

STUDY TITLE: ______________________________

Preparer: ______________________________ **Date Submitted for Review:** ______________

Reviewer: ______________________________ **Date of Review:** ______________________

Element	**Acceptable (Yes/No)**	**Page/ Section**	**Comments**
A1. Title and Approval Sheet			
Contains project title			
Indicates revision number, if applicable			
Indicates organizations name			
Dated signature of the Principal Investigator			
Dated signature of the QA Coordinator			
Other signatures, as needed			
A2. Table of Contents			
Lists QA Project Plan information sections			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Version number indicated			
A3. Distribution List			
Includes all individuals who are to receive a copy of the QA Project Plan and identifies their organization			
A4. Project/Task Organization			
Identifies key individuals involved in all major aspects of the project, including contractors			
Discusses their responsibilities			
QA Coordinator position indicates independence from unit generating data			
Organizational chart shows lines of authority and reporting responsibilities			
A5. Problem Definition/Background			
States decision(s) to be made, actions to be taken, or outcomes expected from the information to be obtained			
Clearly explains the reason (site background or historical context) for initiating this project			
Identifies regulatory information, applicable criteria, action limits necessary to the project, if any			

Element	Acceptable (Yes/No)	Page/ Section	Comments
A6. Project/Task Description			
Summarizes work to be performed, for example, measurements to be made, data files to be obtained that support the project goals			
Provides work schedule indicating critical project points, e.g., start and completion dates for activities such as sampling, analysis, data or file reviews, and assessments			
Details geographical locations to be studied, including maps where possible			
Discusses resource and time constraints, if applicable			
A7. Quality Objectives and Criteria			
Identifies performance/measurement criteria for all information to be collected and acceptance criteria for information obtained from previous studies, including any applicable threshold criteria and laboratory detection limits. And, if known, range of anticipated concentrations of each parameter of interest			
Discusses precision			
Addresses bias			
Discusses representativeness			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Identifies the need for completeness			
Describes the need for comparability			
Discusses desired method sensitivity			
A8. Special Training/Certifications (if applicable)			
Identifies any project personnel specialized training or certifications			
Discusses how this training will be provided			
Indicates personnel responsible for assuring these are satisfied			
Identifies where this information is documented			
B1. Sampling Process Design (Experimental Design)			
Describes and justifies design strategy, indicating size of the area, volume, or time period to be represented by a sample			
Details the type and total number of sample types/matrix or test runs/trials expected and needed			
Indicates where samples should be taken, how sites will be identified/located			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Discusses what to do if sampling sites become inaccessible			
Identifies project activity schedules such as each sampling event, times samples should be sent to the laboratory			
Specifies what information is critical and what is for informational purposes only			
B2. Sampling Methods			
Identifies all sampling SOPs by version number and date, indicating sampling options or modifications to be taken			
Indicates how each sample/matrix type should be collected			
If in situ monitoring, indicates how instruments should be deployed and operated to avoid contamination and ensure maintenance of proper data			
If continuous monitoring, indicates averaging time and how instruments should store and maintain raw data, or data averages			
Indicates how samples are to be homogenized, composited, split, or filtered, if needed			
Indicates what sample containers and sample volumes should be used			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Identifies whether samples should be preserved and indicates methods that should be followed			
Indicates whether sampling equipment and samplers should be cleaned and/or decontaminated, identifying how this should be done and by-products disposed of			
Identifies any equipment and support facilities needed			
Addresses actions to be taken when problems occur, identifying individual(s) responsible for corrective action and how this should be documented			
B3. Sample Handling and Custody			
States maximum holding times allowed from sample collection to extraction and/or analysis for each sample type and, for in-situ or continuous monitoring, the maximum time before retrieval of information			
Identifies how samples or information should be physically handled, transported, and then received and held in the laboratory or office (including temperature upon receipt)			
Discusses system for identifying samples			
Identifies chain-of-custody procedures and includes form to track custody			

Element	Acceptable (Yes/No)	Page/ Section	Comments
B4. Analytical Methods			
Identifies all analytical SOPs (field, laboratory and/or office) that should be followed by number and date, indicating options or modifications to be taken, such as sub-sampling and extraction procedures			
Identifies field equipment or instrumentation needed			
Specifies any specific method performance criteria			
Identifies procedures to follow when failures occur, identifying individual responsible for corrective action and appropriate documentation			
Identifies how long samples are to be stored and sample disposal procedures, if applicable			
Specifies laboratory turnaround times needed			
Provides method validation information and SOPs for nonstandard methods			
B5. Quality Control			
For each type of sampling, analysis, or measurement technique, identifies QC activities that should be used, for example, blanks, spikes, and duplicates, and at what frequency			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Details what should be done at the laboratory when control limits are exceeded, and how effectiveness of control actions will be determined and documented			
B6. Instrument/Equipment Testing, Inspection, and Maintenance			
References analytical laboratory(ies), QA Manual(s) and verifies that and equipment to be used for the study is included in the manuals. If equipment QA considerations are not in the QA Manual, then items listed below should be addressed in the QAPP.			
Identifies field equipment needing periodic maintenance, and the schedule for this			
Identifies testing criteria			
Notes availability and location of spare parts			
Indicates procedures in place for inspecting equipment before usage			
Identifies individual(s) responsible for testing, inspection and maintenance			
Indicates how deficiencies found should be resolved, re-inspections performed, and effectiveness of corrective action determined and documented			

Element	Acceptable (Yes/No)	Page/ Section	Comments
B7. Instrument/Equipment Calibration and Frequency			
Identifies equipment, tools, and instruments that should be calibrated and the frequency for this calibration			
Describes how calibrations should be performed and documented, indicating test criteria and standards or certified equipment			
Identifies how deficiencies should be resolved and documented			
B8. Inspection/Acceptance for Supplies and Consumables			
Identifies critical supplies and consumables for field and laboratory, noting supply source, acceptance criteria, and procedures for tracking, storing and retrieving these materials			
Identifies the individual(s) responsible for this			
B9. Non-direct Measurements			
Identifies data sources, for example, computer databases or literature files, or models that should be accessed and used			
Describes the intended use of this information and the rationale for their selection, i.e., its relevance to project			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Indicates the acceptance criteria for these data sources and/or models			
Identifies key resources/support facilities needed			
Describes how limits to validity and operating conditions should be determined, for example, internal checks of the program and Beta testing			
B10. Data Management			
Describes data management scheme from field to inclusion in Intellus			
Attaches any checklists and field forms that should be used			
C1. Assessments and Response Actions			
Lists the number, frequency, and type of assessment activities (e.g. field and laboratory audits) that should be conducted, with the approximate dates			
Identifies individual(s) responsible for conducting assessments, and any other possible participants in the assessment process			
Describes how and to whom assessment information should be reported			

Element	Acceptable (Yes/No)	Page/ Section	Comments
Identifies how corrective actions should be addressed and by whom, and how they should be verified and documented			
C2. Reports to Management			
Identifies what project QA status reports are needed and how frequently			
Identifies who should write these reports and who should receive this information			
D1. Data Review, Verification, and Validation			
Describes criteria that should be used for accepting, rejecting, or qualifying project data			
D2. Verification and Validation Methods			
Describes level of verification and validation to be performed for each type of data, and identifies who is responsible			
Identifies issue resolution process, and method and individual responsible for conveying these results to data users			
Attaches any work plan specific checklists, forms, and calculations			

APPENDIX C: INJURY DEFINITIONS

One essential component of injury assessment is the determination of injury. Because the LANLTC is conducting this NRDA in accordance with the DOI NRDA regulations at 43 C.F.R. Part 11, the LANLTC plans to make formal determinations of resource injury in a manner consistent with these regulations. Regulation definitions of what constitutes injury to categories of natural resources are provided below.

SURFACE WATER

Surface waters include both waterways and waterbodies as well as their associated bed and bank sediments. Injury to surface water:

"has resulted from the discharge of oil or release of a hazardous substance if one or more of the following changes in the physical or chemical quality of the resource is measured:

- *(i) Concentrations and duration of substances in excess of drinking water standards as established by sections 1411–1416 of SDWA* [Safe Drinking Water Act]*, or by other Federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the discharge or release;*
- *(ii) Concentrations and duration of substances in excess of water quality criteria established by section 1401(1)(D) of SDWA, or by other Federal or state laws or regulations that establish such criteria for public water supplies, in surface water that before the discharge or release met the criteria and is a committed use, as the phrase is used in this part, as a public water supply;*
- *(iii) Concentrations and duration of substances in excess of applicable water quality criteria established by section 304(a)(1) of the CWA, or by other Federal or state laws or regulations that establish such criteria, in surface water that before the discharge or release met the criteria and is a committed use, as that phrase is used in this part, as a habitat for aquatic life, water supply, or recreation. The most stringent criterion shall apply when surface water is used for more than one of these purposes;*
- *(iv) Concentrations of substances on bed, bank, or shoreline sediments sufficient to cause the sediment to exhibit characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act, 42 U.S.C. 6921; or*
- *(v) Concentrations and duration of substances sufficient to have caused injury as defined in paragraphs (c), (d), (e), or (f) of this section to ground water, air, geologic, or biological resources, when exposed to surface water,*

suspended sediments, or bed, bank, or shoreline sediments" (43 C.F.R. § 11.62(b)(1)).

Under DOI's NRDA regulations, the bed, bank, and shoreline sediments, including suspended sediments, are also considered to be part of the surface water resource. The LANLTC intends to evaluate the concentrations of chemicals of potential concern in sediments to assess the degree to which these substances may be causing adverse effects to exposed aquatic species.

The DOI NRDA regulations define injury to surface water sediments in several ways. In general, these sediments are determined to be injured when:

a) *"Concentrations of substances on bed, bank or shoreline sediments are sufficient to cause the sediment to exhibit characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act, 42 U.S.C. 6921; or*

b) *Concentrations and duration of substances sufficient to have caused injury as defined in paragraphs (c), (d), (e), or (f) of this section to ground water, air, geologic, or biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments."* (43 C.F.R. § 11.62(b)(1)(iv-v)).

GROUNDWATER

Injury to groundwater: "*has resulted from the discharge of oil or release of a hazardous substance if one or more of the following changes in the physical or chemical quality of the resource is measured:*

(i) Concentrations of substances in excess of drinking water standards, established by sections 1411–1416 of the SDWA, or by other Federal or state laws or regulations that establish such standards for drinking water, in ground water that was potable before the discharge or release;

(ii) Concentrations of substances in excess of water quality criteria, established by section 1401(1)(d) of the SDWA, or by other Federal or state laws or regulations that establish such criteria for public water supplies, in ground water that before the discharge or release met the criteria and is a committed use, as the phrase is used in this part, as a public water supply;

(iii) Concentrations of substances in excess of applicable water quality criteria, established by section 304(a)(1) of the CWA, or by other Federal or state laws or regulations that establish such criteria for domestic water supplies, in ground water that before the discharge or release met the criteria and is a committed use as that phrase is used in this part, as a domestic water supply; or

(iv) Concentrations of substances sufficient to have caused injury as defined in paragraphs (b), (d), (e), or (f) of this section to surface water, air,

geologic, or biological resources, when exposed to ground water (43 C.F.R. § 11.62(c)(1)).

GEOLOGICAL Soils are geologic resources. Injury to these resources occurs:

"if one or more of the following changes in the physical or chemical quality of the resource is measured:

(i) Concentrations of substances sufficient for the materials in the geologic resource to exhibit characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act, 42 U.S.C. 6921;

(ii) Concentrations of substances sufficient to raise the negative logarithm of the hydrogen ion concentration of the soil (pH) to above 8.5 (above 7.5 in humid areas) or to reduce it below 4.0;

(iii) Concentrations of substances sufficient to yield a salt saturation value greater than 2 millimhos per centimeter in the soil or a sodium adsorption ratio of more than 0.176;

(iv) Concentrations of substances sufficient to decrease the water holding capacity such that plant, microbial, or invertebrate populations are affected;

(v) Concentrations of substances sufficient to impede soil microbial respiration to an extent that plant and microbial growth have been inhibited;

(vi) Concentrations in the soil of substances sufficient to inhibit carbon mineralization resulting from a reduction in soil microbial populations;

(vii) Concentrations of substances sufficient to restrict the ability to access, develop, or use mineral resources within or beneath the geologic resource exposed to the oil or hazardous substance;

(viii) Concentrations of substances sufficient to have caused injury to ground water, as defined in paragraph (c) of this section, from physical or chemical changes in gases or water from the unsaturated zone;

(ix) Concentrations in the soil of substances sufficient to cause a toxic response to soil invertebrates;

(x) Concentrations in the soil of substances sufficient to cause a phytotoxic response such as retardation of plant growth; or

(xi) Concentrations of substances sufficient to have caused injury as defined in paragraphs (b), (c), (d), or (f), of this section to surface water, ground water, air, or biological resources when exposed to the substances" (43 C.F.R. § 11.62(e)).

BIOLOGICAL Injury to biological resources occurs:

"if concentration of the [hazardous] substance is sufficient to:

(i) *Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations; or*

(ii) *Exceed action or tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms; or*

(iii) *Exceed levels for which an appropriate state health agency has issued directives to limit or ban consumption of such organism"* (43 C.F.R. § 11.62(f)).

The methods used to determine injury to a biological resource need to satisfy several acceptance criteria:

(i) *"The biological response is often the result of exposure to oil or hazardous substances. This criterion excludes biological responses that are caused predominately by other environmental factors such as disturbance, nutrition, trauma, or weather. The biological response must be a commonly documented response resulting from exposure to oil or hazardous substances.*

(ii) *Exposure to oil or hazardous substances is known to cause this biological response in free-ranging organisms. This criterion identifies biological responses that have been documented to occur in a natural ecosystem as a result of exposure to oil or hazardous substances. The documentation must include the correlation of the degree of the biological response to the observed exposure concentration of oil or hazardous substances.*

(iii) *Exposure to oil or hazardous substances is known to cause this biological response in controlled experiments. This criterion provides a quantitative confirmation of a biological response occurring under environmentally realistic exposure levels that may be linked to oil or hazardous substance exposure that has been observed in a natural ecosystem. Biological responses that have been documented only in controlled experimental conditions are insufficient to establish correlation with exposure occurring in a natural ecosystem.*

(iv) *The biological response measurement is practical to perform and produces scientifically valid results. The biological response measurement must be sufficiently routine such that it is practical to perform the biological response measurement and to obtain scientifically valid results. To meet this criterion, the biological response measurement must be adequately documented in scientific literature, must produce reproducible and verifiable results, and must have well defined and accepted statistical criteria for interpreting as well as rejecting results."* (43 C.F.R. § 11.62(f)(2)).

Additionally, injury determination must:

> *(v)* *"be based upon the establishment of a statistically significant difference in the biological response between samples from populations in the assessment area and in the control area. The determination as to what constitutes a statistically significant difference must be consistent with the quality assurance provisions of the Assessment Plan. The selection of the control area shall be consistent with the guidance provided in §11.72 of this part."* (43 C.F.R. § 11.62(f)(3)).

Several specific biological responses already determined to meet the above criteria are identified in the regulations, and can be found at (43 C.F.R. § 11.62(f)(4)). These responses include the following (paraphrased):

(i) *Category of injury—death*. Five biological responses for determining when death is a result of exposure to the discharge of oil or release of a hazardous substance meet the acceptance criteria.

  (A) Brain cholinesterase (ChE) activity

  (B) Fish kill investigations

  (C) Wildlife kill investigations

  (D) *In situ* bioassay

  (E) Laboratory toxicity testing

(ii) *Category of injury—disease*. One biological response for determining when disease is a result of exposure to the discharge of oil or release of a hazardous substance has met the acceptance criteria.

  (A) *Fin erosion.*

(iii) *Category of injury—behavioral abnormalities.*

  (A) Clinical behavioral signs of toxicity.

  (B) Avoidance.

(iv) *Category of injury—cancer.* One biological response for determining when cancer is a result of exposure to the discharge of oil or release of a hazardous substance has met the acceptance criteria.

  (A) Fish neoplasm

(v) *Category of injury—physiological malfunctions.* Five biological responses for determining when physiological malfunctions are a result of exposure to the discharge of oil or release of a hazardous substance have met the acceptance criteria.

  (A) Eggshell thinning

  (B) Reduced avian reproduction

  (C) Cholinesterase (ChE) enzyme inhibition

(D) Delta-aminolevulinic acid dehydratase (ALAD) inhibition

(E) Reduced fish reproduction

(vi) *Category of injury—physical deformation.* Four biological responses for determining when physical deformations are a result of exposure to the discharge of oil or release of a hazardous substance have met the acceptance criteria.

(A) Overt external malformations

(B) Skeletal deformities

(C) Internal whole organ and soft tissue malformation

(D) Histopathological lesions.

AIR Injury to air resources occurs:

"*if one or more of the following changes in the physical or chemical quality of the resource is measured:*

(i) Concentrations of emissions in excess of standards for hazardous air pollutants established by section 112 of the Clean Air Act, 42 U.S.C. 7412, or by other Federal or state air standards established for the protection of public welfare or natural resources; or

(ii) Concentrations and duration of emissions sufficient to have caused injury as defined in paragraphs (b), (c), (e), or (f) of this section to surface water, ground water, geologic, or biological resources when exposed to the emissions." (43 C.F.R. § 11.62(d)).

APPENDIX D: POTENTIAL CONTAMINANTS OF CONCERN

Information on potential contaminants of concern for the assessment is detailed below. This list of potential contaminants of concern should be viewed as preliminary. Contaminants of concern for the assessment will be defined early on in the assessment and will be subject to change, if new information on contaminants becomes available.

RADIONUCLIDES

Radionuclides are a class of unstable elements that release energy through decomposition. They can cause injury to aquatic and terrestrial organisms by releasing that energy in the form of sub-atomic particles that can break chemical bonds and damage the cells within living tissues (USGS 2012)[26]. Organisms can be exposed to radionuclides through direct interaction with contaminated water, sediment or soil (i.e., bioconcentration), inhalation of contaminated air, or ingestion of contaminated food, water, sediment and soil (i.e., bioaccumulation; IAEA 1994; Till and Meyer 1983)[27]. The International Atomic Energy Agency suggests a dose of 0.1 rads/day is a safe exposure level for populations of terrestrial organisms and 1 rad/day is a safe exposure level for populations of aquatic organisms; however, individuals can experience adverse effects at doses between 0.01 and 1 rad/day (IAEA 1992).

Radionuclides originate from both natural and anthropogenic sources. Natural sources include the primordial decay chain[28], and atmospheric collisions[29], which have resulted in the worldwide presence of radionuclides such as uranium-238, uranium-235, thorium-232, tritium, beryllium-7, and carbon-14 in environmental media. Site specific naturally occurring background concentrations in water, groundwater, soil and sediment are a function of local geology, geochemistry and geographic location (USGS 2012, IAEA 2010, ENS 2012). In the 1960s, atmospheric nuclear weapon tests resulted in both immediate and long-term[30] distribution of radionuclides such as strontium-90, cesium-137, iodine-131, strontium-89, and carbon-14.

In the 1940s, radioactive liquid wastes were discharged directly into Acid Canyon, a tributary to Pueblo Canyon, as a result of operations associated with the Manhattan Project. Untreated discharges continued until 1951, when a wastewater treatment plant was constructed to manage liquid wastes for TA-51. After the completion of the wastewater treatment plant, discharges continued, though radiological contamination was

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[26] Energy is released in the form of gamma rays, alpha and beta particles.

[27] Bioconcentration is the direct accumulation of a contaminant from surrounding environmental media, whereas bioaccumulation is accumulation of a contaminant through a food chain. Biomagnification is the process by which contaminants increase in concentration at higher trophic (food chain) levels.

[28] The primordial decay chain consists of “Initial radionuclides existing since the earth was formed and which have not completely decayed due to their long half-life in addition to the radionuclides generated from the primordial radionuclides…associated decay chain”. Primordial radionuclides include Uranium-238, Uranium-235 and Thorium-232 (ENS 2012).

[29] Collisions between cosmic rays and atmospheric atoms (spallation) cause some radionuclides, such as tritium (3H), beryllium-7 (7Be) and carbon-14 (14C) to occur naturally in the atmosphere (IAEA 2012).

[30] Immediate distribution occurs within 24 hours, whereas long-term distribution occurs months, or years, later.

somewhat reduced because of the treatment process (LANL 1996). In addition to liquid waste disposal, radioactive and hazardous wastes were commonly buried on-site (e.g., Material Disposal Area F in TA-06; DOE and NNSA 2008). As on-site operations expanded, new facilities were constructed on adjacent mesa tops, creating new emissions sources. Air emissions of radionuclides also played a role at LANL. The bulk of LANL's radiological air emissions have been produced through operation of a linear proton accelerator in TA-53, constructed in the 1960s. The size and power of this facility was expanded on several occasions in the 1970s and 1980s.

Brief descriptions of some of the most commonly found radionuclides are below.

Strontium-90

Strontium is a hard, white-colored metal that is found in the minerals celestite ($SrSO_4$) and strontianite ($SrCO_3$). Strontium is chemically similar to calcium and exists as four stable isotopes in nature (Sr-84, Sr-86, Sr-87, and Sr-88). Strontium-90 is an artificial isotope formed in nuclear reactors or during the explosion of nuclear weapons. Terrestrial and aquatic organisms have a high potential to accumulate strontium-90 due to its propensity to accumulate in bone. In higher organisms, it is metabolized as if it were calcium and deposited in bone, and many of its associated adverse effects occur in that tissue (Agency for Toxic Substances and Disease Registry (ATSDR) 2004). Strontium is a beta emitter with a relatively high radiotoxicity and a low chemical toxicity. Plants (which depend less on calcium), have a low bioaccumulation potential (ATSDR 2004). Strontium-90 has a half-life[31] of approximately 29 years and decays by beta decay to yttrium-90, which is also radioactive. Yttrium-90 subsequently decays by beta decay to zirconium-90, which is stable (ATSDR 2004).

Cesium-137

Cesium is a soft metal element that exists as liquid at room temperature. Natural cesium (cesium-133) is not radioactive; however, the reactor-byproduct cesium-137, is considered "the most used and well-known" radioisotope of cesium (Butterman *et al.* 2005). Cesium is a beta emitter, with a high radiotoxicity and a low chemical toxicity. Once it is in the environment, biota are primarily exposed to it through ingestion of food and water[32] (NCRP 2007). Unlike most radionuclides, cesium-137 can bioconcentrate and has been shown to biomagnify in both terrestrial and aquatic food chains, concentrating in the soft tissues of higher trophic level organisms (NCRP 2007, ATSDR 2004). Cesium-137 has a half-life of about 30 years and decays by beta decay either to stable barium-137 or a meta-stable form of barium[33] (WHO 1983).

Tritium

Tritium is a radioactive isotope of hydrogen, which is produced naturally in the upper atmosphere by cosmic rays and in rocks from decay of other naturally occurring

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[31] The time required for half the amount of the radionuclide to be eliminated or disintegrated by natural processes (MWD 2012).

[32] An exception to this general rule is Cs-137 that is tightly bound to soil and sediment. When bound to soil and sediment, Cs-137 is generally not available to be transported across biological membranes.

[33] The meta-stable isotope (Ba-137m) has a half-life of about two minutes, and is rapidly converted to stable Ba-137 (ICRP 1983).

radioactive elements. It is also produced as a fission product in nuclear weapons tests, and in nuclear power reactors (NCRP 1979). Although pure tritium is a gas at room temperature, it is commonly occurs as part of a water molecule and generally has low radiotoxicity and no chemical toxicity (ANL 2005). Tritium is not typically thought to bioaccumulate[34]; it is a beta emitter, which decays to helium, and has a half-life of about 12 years (NCRP 1979, DOE Handbook 2008a).

Plutonium

Plutonium is largely produced during anthropogenic processes and its presence in the environment is usually a result of releases from research facilities, nuclear weapons testing, waste disposal, nuclear weapons production facilities, and accidents. Twenty isotopes of plutonium have been identified, the most common being plutonium-238 and plutonium-239 (ATSDR 2010). The chemical toxicity of plutonium is not well-studied because plutonium's radiotoxicity is so significant for most organisms (Driver 1994; Wildung and Garland 1982). Plutonium can bioconcentrate in aquatic organisms, but likely does not bioaccumulate or biomagnify in plants, higher aquatic organisms, animals or in terrestrial or aquatic food chains. Decay products and half-life vary by isotope (Exhibit D-1; ATSDR 2010).

EXHIBIT D-1 PLUTONIUM ISOTOPES AND HALF-LIVES (ATSDR 2010)*

RADIOISOTOPE	DECAY MODE(S)/ENERGY (MEV)	RADIOACTIVE HALF LIFE (YEARS)*	INITIAL DECAY PRODUCT(S)
Pu-238	Alpha/5.559	88	U-234
Pu-239	Alpha/5.244	2.1x10^4	U-235
Pu-240	Alpha/5.255	6.5 x10^3	U-236
Pu-241	Beta/0.02 (99+%)	14.3	Am-241
	Alpha/5.138 (0.002%)		U-237

Notes:
* Originally from Baum et al. 2002, ChemIDplus 2009, Clark et al. 2006; Lide 2008, as cited in ATSDR 2010.
* Two half-lives are provided because each isotope has two modes of decay: alpha decay and spontaneous fission. Spontaneous fission is very rare relative to alpha decay.
MEV=megaelectron volt, or one million electron volts (106 eV).

Uranium

Uranium occurs naturally in rocks and minerals as three isotopes: U-238, U-234 and U-235. Uranium is also produced intentionally for purposes of generating nuclear fuel for electric power generation. According to ATSDR:

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[34] Although it is rapidly taken up by organisms, it is also rapidly excreted and only a small fraction binds to tissues and gets incorporated into proteins and DNA (Blaylock et al. 1986).

> *The industrial process called enrichment is used to separate the uranium isotopes and increase the concentration of U-235; uranium with higher concentrations of U-235 than occurs in nature is called enriched uranium. The process also results in uranium with lower concentrations of U-235 than found in nature, which is called depleted uranium. The main civilian uses of enriched uranium are fuel for nuclear power plants; depleted uranium is used as a counterbalance on helicopters rotors and airplane control surfaces. Depleted uranium is used by the armed forces to increase the density of munitions to help them penetrate enemy armored vehicles and is also used as armor in some parts of military tanks* (ATSDR 2011, p. 2).

Uranium is both radiotoxic and chemically toxic. It bioconcentrates in lower trophic level organisms, such as bacteria and algae, but does not tend to bioaccumulate or biomagnify (Driver 1994). Uranium-234 has a half-life of 240,000 years, which is several orders of magnitude lower than that of uranium-238 and uranium-235, which have a half-lives of 4.5 billion and 700 million years, respectively (ATSDR 2013).

METALS

Metals occur naturally in the Earth's crust. At low doses, many metals are nutrients, and some are necessary for the proper functioning of metabolic processes. At elevated concentrations, however, metals can cause toxic effects to biota. Metals typically become an environmental concern when they are released from anthropogenic activities due to resulting changes in the distribution and chemical speciation (affecting bioavailability) of metals (EPA 2012). Natural weathering and microbial processes also contribute to the alteration of metals' bioavailability, and therefore toxicity.

Although not an exhaustive list of the metals released from operations at LANL, below we present information on arsenic, cadmium, chromium, copper, mercury, nickel, lead, and zinc. As discussed below, predominant sources of these contaminants include the former asphalt batch plant in TA-3, and explosives storage, processing, and detonation at firing sites.

Arsenic (As)

Arsenic occurs at elevated levels naturally in New Mexico. At LANL, firing sites in Pajarito Canyon, explosives storage and processing facilities in TA-16 (Water Canyon), Manhattan Project operations in TA-21 (Los Alamos watershed) and former TAs 1 and 45 (Pueblo Canyon), and releases of arsenic from TA-13 (P-Site) and the TA-16-340 Complex have resulted in areas with levels of arsenic elevated above background in sediment, soil, and groundwater (LANL 2004a, 2008, 2011). In addition, activities in TA-3 (e.g., liquid effluent releases, former asphalt batch plant; Sandia Canyon) have been correlated with levels of arsenic in sediment (LANL 2009d). Arsenic found at TA-48 and in the sand filter-bed outfall from TA-35 are understood to be the main sources of arsenic in Mortandad Canyon (LANL 2006b).

Arsenic can form both organic (less toxic) and inorganic (more toxic) compounds. Adverse effects to biota include dehydration, kidney and bladder failure, respiratory effects, and cardiovascular effects (ATSDR 2007a). Arsenic is not a known nutrient, and does not bioaccumulate through the foodweb (EPA 1984). Earthworms experienced up to 56 percent decreases in cocoon production as a result of exposure to 68 mg/kg arsenic in soil (Fischer and Koszorus 1992 as cited in Efroymson et al. 1997). Adverse effects on aquatic biota have been documented at levels as low as 1.3 mg/kg (Eisler 1988).

Cadmium (Cd)

Cadmium is rare in nature and does not serve any biological function, and is toxic in sufficient concentrations. At LANL, sources of cadmium releases include former landfills (TA-20), firing sites (TA-72), and the former asphalt batch plant in TA-03 (Sandia Canyon; LANL 2009d). Cadmium contamination is also associated with the 260 Outfall (HE-machining facility in TA-16) as well as the 300s Line Complex (LANL 2011d). In Pajarito Canyon, cadmium released in TA-09 (Anchor East site) and TA-08 (Anchor West Site) has traveled downstream to lower Pajarito Canyon and White Rock Canyon, and in Rendija Canyon, the former firing site and former asphalt batch plant have released cadmium to sediment and soil (LANL 2009c, 2008).

Although cadmium can exist at a number of oxidation states in terrestrial systems, in aquatic environments cadmium typically exists in its divalent oxidation state, and therefore its bioavailability is influenced by water hardness (increased water hardness decreases bioavailability). Cadmium can bioaccumulate in individual organisms and can biomagnify through food webs. Accumulating in all tissue types, excess cadmium can cause toxic effects such as decreased growth, inhibition of reproduction, immobility, and death to organisms at all trophic levels (Eisler 2000). Levels as low as 20 mg/kg in soil have been documented as causing adverse effects to earthworms (Malecki et al. 1982 as cited in Efroymson et al. 1997), and 4.98 mg/kg in sediment is the consensus-based probable effect concentration, above which adverse effects are expected to occur (MacDonald et al. 2000).

Chromium (Cr)

Chromium is usually released into the environment via the discharge of industrial effluents. At LANL, hexavalent chromium (as potassium dichromate) was used as descaler for purposes of maintenance of water cooling towers, and was known to have been released at the top of Sandia Canyon, resulting in a plume of hexavalent chromium in groundwater (Los Alamos Department of Public Utilities 2006).

Chromium typically exists either in a trivalent or hexavalent oxidation state. Although the trivalent form is considered a nutrient, and the hexavalent form is considered a toxicant, both forms can be toxic to biota at elevated concentrations. Toxic effects of chromium to aquatic organisms include adverse impacts on growth, enzymatic function, histopathology, and survival. Upper trophic level organisms such as birds and mammals can experience more severe effects, including mutagenic, teratogenic, and carcinogenic effects (Eisler 2000). Soil levels above 2 mg/kg can cause mortality in earthworms (Molnar et al. 1999 as cited in Efroymson et al. 1997), and levels above 111 mg/kg in sediment are likely to cause adverse impacts to aquatic biota (MacDonald et al. 2000).

Copper (Cu)

Storage of copper (along with other hazardous materials and wastes) at LANL facility 32-002 in Ancho Canyon, and Manhattan Project activities at former TAs 1 and 45 in Pueblo Canyon resulted in releases of copper to sediment, soil and groundwater (LANL 2009b and LANL 2004a). A radiochemistry and nuclear medicine research facility in TA-48 in Mortandad Canyon released copper to sediment, soil and groundwater (LANL 2006b), and explosives development, solid waste storage, and firing sites in TA-9 (Pajarito Canyon) resulted in elevated copper in sediment (LANL 2008b). Additional sources of copper at LANL include activities at TA-3 (e.g., liquid effluent releases, former asphalt batch plant); firing sites at TA-72 in Sandia Canyon; DHART and PHERMEX facilities in TA-15; and firing sites, explosives storage and processing facilities in TAs 16 and 36 (LANL 2011d, 2009a).

Copper, which is widely distributed in nature, exists in four oxidation states: Cu^0, Cu^{+1}, Cu^{+2}, and Cu^{+3}. Divalent copper (i.e., cuprous copper) is the most common in the terrestrial environment. Cu^{+1} is only found in water, and trivalent copper, does not occur naturally and only has a few known compounds that are not considered environmentally significant (Irwin 1997a). Copper is typically immobile in soils and shows relatively little variation in total content in different types of soils (Kabata-Pendais 2001, Eisler 1998). Copper is considered an essential nutrient, but can be toxic at elevated concentrations. Like other metals that form ions in water, copper is regulated in aquatic systems based on hardness. Whether exposed in the water column or sediment, aquatic organisms are generally more sensitive to the toxic effects of copper than are upper trophic level organisms; in fact, copper is considered to be one of the most toxic metals to aquatic organisms. Adverse effects include decreased growth, reproduction, and survival (Eisler 2000, 1998). MacDonald et al. 2000 reported a threshold effect concentration (below which adverse effects on aquatic biota are unlikely) as 31.6 mg/kg in sediment, and a probable effects concentration (above which adverse effects on aquatic biota are expected) as 149 mg/kg in sediment.

Mercury (Hg)

Mercury has been distributed widely globally due to a number of anthropogenic activities. Mercury does not serve any biological function, and is universally toxic in sufficient concentrations. At LANL, sources of mercury releases include Manhattan project operations in TA-21 (Los Alamos watershed), the radiochemistry and nuclear medicine research facility in TA-48 (Mortandad Canyon), a waste water treatment plant and municipal landfill and waste incinerator (TA-0, TA-73, Pueblo Canyon), and operations in former TAs 1 and 45, (Pueblo Canyon; LANL 2004a, 2006b). Activities at TA-3 (e.g., liquid effluent releases, asphalt batch plant), and firing sites (at TA-72 in Sandia Canyon; and in Canon de Valle and Rendija and Water Canyons) also apparently resulted in releases of mercury to sediment, soil, and groundwater (LANL 2011d, 2009a, 2009b).

Mercury is unique among metals because elemental mercury is a liquid at room temperature and readily volatilizes. In soils and aquatic systems, mercury predominantly exists in the mercuric (Hg^{+2}) and mercurous (Hg^{+1}) states, as ions with varying solubility

(MADEP 2012). Ionized forms of mercury are strongly adsorbed by soils. In acid soils, most mercury is adsorbed by organic matter, and microbial activity may then metabolize some part of the mercury, releasing it into the soil gas. When organic matter is not present, mercury becomes relatively more mobile in acid soils, causing it to evaporate or leach to groundwater (Mitra, 1986 as cited in MADEP 2012). In aquatic systems, forms of mercury with relatively low toxicity can be transformed into forms with high toxicity through biological and other processes. For example, methylmercury, produced mainly by bacteria, is the most toxic form of mercury, and is readily available for uptake and accumulation by biota. Mercury can also bioconcentrate through foodwebs, affecting higher trophic level organisms. A mutagen, teratogen, and carcinogen, at low concentrations mercury can cause adverse impacts to reproduction, growth, development, behavior, blood chemistry, vision, and metabolism, and at high concentrations is lethal (Eisler 2000). Levels as low as 0.02 mg/kg and as low as 0.22 mg/kg in the diet of piscivorous birds and mammals respectively, can have significant adverse effects on the development and reproduction of sensitivity species.

Nickel (Ni)

Although nickel is naturally distributed throughout the environment, sources of nickel releases at LANL include explosives storage, processing, and detonation, and asphalt processing. For example, in Rendija Canyon (TA-0) the former firing site and asphalt batch plant have released nickel in sediment and soil (LANL 2009c). In Water Canyon and Canon de Valle, firing sites, explosives storage and processing facilities in TA-16 have resulted in nickel in sediment and soil (LANL 2011d). Manhattan Project operations in TA-21 (Los Alamos watershed), former outfalls in TAs 1 and 45 (Pueblo Canyon), activities at TA-3 (e.g., liquid effluent releases, asphalt batch plant), and firing sites at TA-72 in Sandia Canyon have resulted in releases of nickel to sediment, soil, and groundwater (LANL 2009d, 2004).

The chemical forms of nickel, as well as environmental parameters, influence bioavailability and toxicity. In aquatic environments, nickel typically occurs in a divalent oxidation state, which allows it to interact with other compounds and become available for uptake in biota. Nickel is therefore regulated in aquatic systems based on hardness. Nickel is essential for the normal growth of many microorganisms and plants and several species of vertebrates (e.g., chickens, cows, and sheep). However, adverse effects at elevated exposures include decreased photosynthesis, growth, and metabolism in algae; convulsions and loss of equilibrium in fish; decreased growth, reduced bone densities, and metabolic inhibition in birds; and respiratory, immunological, developmental, and other effects in mammals. Chronic exposure to low doses of nickel or acute exposure to high doses can cause mortality in a wide range of organisms (Eisler 2000).

Lead (Pb)

Historical sources of lead in the environment include the use of leaded gasoline, and lead-based paints. At LANL, sources of lead releases include liquid effluent releases, asphalt batch plant operations (TA-3), firing sites (TA-10), nuclear test and processing facilities (including the mortar impact area in TA-0), explosives storage and processing, and the DHART and PHERMEX facilities (LANL 2011d, 2009a, 2009b, 2004). In addition, historically, Manhattan Project operations in TA-21 (Los Alamos watershed) and TAs 1 and 45 (Pueblo Canyon) and a radiochemistry and nuclear medicine research facility in TA-48 (Mortandad Canyon) resulted in the release of lead to sediment, soil, and groundwater (LANL 2006b, 2004).

In the environment, lead occurs mainly as Pb^{+2}, although its oxidation state Pb^{+4} is also known, and it can form inorganic and organic compounds and can be integrated into larger molecules (Kabata-Pendais 2001). Lead usually adheres to soil particles, so movement of lead from soil particles into underground water or drinking water is unlikely unless the water is acidic or soft. However, once it is released into aquatic ecosystems, dissolved cationic forms of lead and organic lead compounds are the most toxic forms. In freshwater systems, water hardness plays a key role in the bioavailability of lead, and as a result, water hardness is incorporated into water quality standards for lead (Eisler 2000). Elevated levels of lead may accumulate in plants and animals in areas where air, water, or soil are contaminated (Irwin 1997b). There are no known metabolic functions that require lead. In vertebrates, lead is deposited in bone and soft tissues, which can serve as continual sources of exposure. Enzymes involved in blood formation are affected by lead, and delta aminolevulinic acid dehydratase (ALAD) inhibition is a commonly measured response to lead exposure in organisms. Elevated concentrations of lead have also been shown to cause a variety of adverse health effects including neurological and reproductive effects (ATSDR 2007b, Eisler 2000). Although many organisms can bioaccumulate lead, it has not been shown to biomagnify through foodwebs (Eisler 2000). MacDonald et al. 2000 reported a threshold effect concentration (below which adverse effects on aquatic biota are unlikely) as 35.8 mg/kg in sediment, and a probable effects concentration (above which adverse effects on aquatic biota are expected) as 128 mg/kg in sediment.

Zinc (Zn)

Zinc is one of the most abundant metals on the planet, typically occurring in free and complex ions in soil solutions (Kabata-Pendais 2001). At LANL, firing sites, explosives storage and processing facilities in TA-16 (in Water Canyon and Canon de Valle), Manhattan Project operations in TA-21 (Los Alamos watershed), and the radiochemistry and nuclear medicine research facility in TA-48 (Mortandad Canyon) are known sources of zinc releases to sediment, soil and alluvial groundwater (LANL 2011d, 2006b, 2004). Explosives storage and firing sites in (TA6, TA-22, TA-42) in Pajarito and activities in TA-3 and TA-53 (e.g., liquid effluent releases, asphalt batch plant; Sandia Canyon) have also been correlated with elevated levels of zinc in sediment (LANL 2009d, 2008).

Clays and organic matter bind to zinc strongly, which means it is not readily labile in soil, and is not leached under most conditions (Eisler 2000). The primary factors affecting zinc availability are soil texture and phosphorus (Schulte 2004). Zinc is considered to be an essential nutrient, and is required for the proper functioning of some metabolic processes. However, excess exposure to zinc can cause cancer, adverse reproductive effects, and even mortality in organisms at varying concentrations, depending upon the sensitivities of the organism (ATSDR 2005, Eisler 2000). In general, aquatic organisms and birds are more sensitive to the toxicological effects of zinc than mammals. Although many organisms can bioconcentrate zinc, it does not appear to biomagnify through the food web. The probable effects concentration, above which adverse effects are expected for aquatic organisms, is 459 mg/kg (MacDonald et al. 2000).

PAHS

PAHs are organic compounds that consist of clusters of benzene rings with a variety of substituted groups. Examples include anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorine, naphthalene, phenanthrene, and pyrene. PAHs are typically of petrogenic or pyrogenic origin—that is, they occur in petroleum products but are primarily produced from the incomplete burning of organic matter (Kuzia and Black 1985). Petrogenic PAHs are concentrated in the refining process, so are prevalent at higher concentrations in refined petroleum products as compared to crude oil (Connell and Miller 1981). One potential source of pyrogenic PAHs at LANL may be wildfires and incinerators, both of which can produce PAHs as a result of burning natural organic matter. PAHs may have also been released at LANL through spills and releases of petroleum products.

Although PAHs can be mobilized atmospherically, once PAHs enter aquatic environments (usually through runoff from land or when oil is spilled) they are generally immobile and are typically adsorbed to particles that settle into the sediments (Eisler 2000). In the environment, PAHs are stable and persistent. They also partition into biological organisms and can accumulate in fatty tissues. As a result, they can bioconcentrate in an individual organism as well as biomagnify through food webs, depending on specific organisms' abilities to metabolize and excrete PAHs. For example, although fish species exhibit different rates of PAH metabolism, most fishes can readily metabolize PAHs, so tissue concentrations in fish are not typically elevated (Eisler 2000, EPA 2000). Several PAHs, including benzo(a)anthracene, benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene are some of the most potent carcinogens known to exist (Eisler 2000; ATSDR 1995a). Although the occurrence of cancer in aquatic organisms has not been definitively linked to PAHs, they have been implicated in causing a variety of developmental anomalies and tumors in fish and aquatic mammals. PAHs have also been shown to cause a variety of other toxicological responses in aquatic organisms, birds, and mammals, including inhibited survival, growth, and reproduction (Eisler 2000).

PCBS

PCBs are a class of man-made compounds that consists of 209 chlorinated hydrocarbon chemicals (individually known as PCB congeners). Primarily manufactured in mixtures that contained different concentrations of individual PCB congeners, the most common and well-known mixtures were produced by the Monsanto Company under the trade name Aroclor. PCBs were manufactured from the 1930s until their production was banned in the United States by EPA in 1979, at which time companies were required to phase out use of PCBs by 1985, except in cases where they were totally enclosed (EPA 1979). PCBs were used primarily as insulating materials for electrical transformers and capacitors given their chemical stability at high temperatures, but they were also used in such diverse products as paints and carbon copy paper. Like mercury, PCBs have been distributed widely globally due to their abundant historical use and persistence in the environment, resulting in their presence in animal tissues and environmental media around the world. PCBs are present in sediment, soil and groundwater across LANL property, with hotspots in Pajarito, Pueblo and Sandia Canyon. Major sources include discharges from the waste water treatment plant, municipal landfill and waste incinerator, and sanitary waste outfalls in Pueblo Canyon; as well as storage sites and firing sites in Sandia, Water, Ancho, Bayo, Chaquehui and Guaje Canyons (LANL 2011a, LANL 2009d, LANL 2009c, LANL 2009b, LANL 2008b, LANL 2004a).

The chemical structure of PCBs also allows these compounds to accumulate in the fatty tissues of organisms and bioaccumulate and biomagnify through food webs (Eisler 2000). In organisms, PCBs can cause a range of adverse health effects, including liver and dermal toxicity, teratogenic and other reproductive effects, and neurological effects. Responses depend on the exposed species and the particular congener mixture to which that species is exposed, and can therefore vary from subtle (e.g., induction of hepatic microsomal enzymes) to severe (e.g., impaired reproduction and death). In addition, toxic effects are likely to be more severe at higher trophic levels due to bioconcentration and biomagnification. For example, it is uncommon for environmental concentrations of PCBs to cause mortality to fish, but predatory birds are more susceptible to a variety of toxicological effects, ranging from beak deformities to retarded growth (Eisler 2000). Reproductive effects including reductions in the number of eggs hatched and young fledged have been documented in ring doves at 10 mg/kg PCBs in the diet (Peakall et al. 1972). Dietary concentrations between 0.72 mg/kg and 1 mg/kg in piscivorous mammals such as mink have been documented as causing up to 30 percent reductions in kit survival (Heaton et al. 1995, Wren et al. 1987).

EXPLOSIVES

Explosives (i.e., energetic materials) are a class of organic compounds that can undergo rapid chemical reactions to produce large amounts of heat and energy (Kalderis et al. 2011, LANLTC 2010). Based on their susceptibility of initiation, they are categorized as primary or secondary explosives, as described below.

- *Primary explosives* are highly susceptible to initiation and can detonate by ignition from a source such as a flame or spark. They are often used to ignite secondary explosives (Kalderis et al. 2011).
- *Secondary explosives* require a detonator or a supplementary booster to ignite. They include TNT (2,4,6-trinitrotoluene), RDX (1,3,5-trinitroperhydro-1,3,5-triazine), and HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocane; Exhibit 3-2; Kalderis et al. 2011p. 1407).

Explosives do not occur naturally in the environment; rather they are produced for military and civilian activities. Activities leading to the release of explosives to the environment include: explosives machining[35], casting and curing, laboratory testing, and open burning and open detonation of outdated munitions (Kalderis et al. 2011). On the

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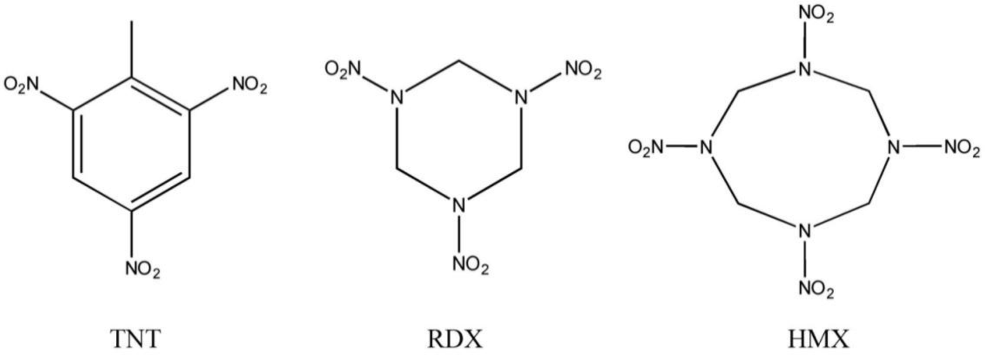
[35] Machining involves cutting, drilling, and/or sculpting of explosives or other materials for use in a specific process or application. (AHD 2000).

LANL site, test firing of high explosives (HE) and munitions have resulted in their release to surface water, groundwater, soils, and air. In particular, two key facilities have been responsible for the majority of explosives emissions. The High-Explosives Processing Facility, which is 115 acres in size and located in TA-08, TA-09, TA-11, TA-16, TA-22, and TA-37, has conducted processes such as machining, production, testing, and research of raw, powdered, and plasticized explosives and devices. Explosives disposal has also occurred within the High-Explosives Processing Facility. The High-Explosives Testing Facility (8691 acres; located in TA-14, TA-15, TA-36, TA-39, and TA-40) has consisted primarily of explosives research and munitions testing (DOE 1999, p. 2-73). As a result of activities in these areas, Water Canyon and its tributary, Canon de Valle, have received effluents produced by high explosives processing and experimentation (LANL 2007, p. 137).

As a result of their manufacture, disposal, storage and use, explosives enter the environment through air in volatile or particulate form. They then typically precipitate to the earth's surface where they can adsorb to soil and sediment. Explosives are not very soluble, so they release slowly into groundwater and surface water (Exhibit D-2). Dissolution into water is the primary mechanism for the transport and dissemination of explosives in the environment. Once explosives are present in environmental media, organisms become exposed through inhalation, ingestion, and dermal absorption (Kalderis et al. 2011). Of all explosives, TNT, RDX, and HMX are the most common as contaminants in the environment. Each of these is discussed in greater detail below.

EXHIBIT D-2 CHEMICAL STRUCTURE OF TNT, RDX AND HMX



TNT RDX HMX

Image adapted from Kalderis et al. 2011.

RDX

The ATSDR states:

> *RDX, also known as cyclonite or hexogen, is a highly explosive white powder that creates fumes when burned. It is a synthetic chemical that does not occur naturally in the environment. RDX particles can enter the air when disposed of by burning and can enter water from disposal of waste water from ammunition plants. RDX can enter water or soil from spills or leaks from improper disposal*

> *at plants or hazardous waste sites and at current and former military installations. In the environment, RDX dissolves slowly in water, and does not bind significantly to soils. It can leach to groundwater from soil. In water and air, RDX can break down in hours, but breaks down more slowly in soil. It does not build up in fish or people* (ATDSR 2012).

Toxic effects of RDX have been well-documented in various laboratory animals, including mammals and birds (Kalderis et al. 2011). For example,

> *Animals that had large amounts of RDX placed in the stomach with a tube or that ate food mixed with RDX for longer periods of time suffered seizures. Rats and mice that ate RDX for 3 months or longer had decreased body weights and slight liver and kidney damage* (ATSDR 2012).

RDX has a limited potential for accumulation in the aquatic environment, and more research is needed regarding accumulation in the terrestrial environment. However, the lowest 20 percent effect level (EC20) for earthworm production was reported as 1.2 mg/kg RDX in soil (Kuperman et al. 2006).

TNT

TNT is a yellow, odorless solid explosive used in military shells, bombs, and grenades, in industrial uses, and in underwater blasting. TNT enters the environment in waste waters and solid wastes resulting from the manufacture of the compound, the processing and destruction of bombs and grenades, and the recycling of explosives. The compound moves in surface water and through soils to groundwater. In surface water, TNT is rapidly broken down into other chemical compounds by sunlight. Microorganisms in water and sediment break down the compound more slowly. Small amounts of TNT can accumulate in fish and plants (ATSDR 1995b). TNT has been shown to cause a decrease in the hatching success of cricket eggs, as well as cardiovascular, gastrointestinal, hematological[36], hepatic[37], renal, immunological, neurological, reproductive, developmental, genotoxic, and carcinogenetic effects to mice, rats, and dogs (Kalderis et al. 2011). Levels as low as 3 mg/kg in soil may cause adverse effects to earthworms (EC20 value, Kuperman et al. 2006).

HMX

HMX is also known as octogen and cyclotetramethylenetetranitramine. It is a colorless solid that dissolves slightly in water. Only a small amount of HMX will evaporate into the air; however, it can occur in air attached to suspended particles or dust. HMX explodes violently at high temperatures. A small amount of HMX is also formed in making RDX. In surface water, HMX does not evaporate or bind to sediments to any large extent. Sunlight breaks down most of the HMX in surface water into other compounds, usually in a matter of days to weeks, so the amount of time HMX remains in

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[36] Pertaining to blood or blood-forming tissues (CED 2012).

[37] Of, or pertaining to the liver. (AHD 2012).

surface water depends on how much light-absorbing material is present. A small amount of HMX may also be broken down by bacteria in the water. Exactly how long HMX remains in the environment is not known; however, HMX in soil and groundwater may persist for extended periods of time. It is not known if plants, fish, or animals living in areas contaminated with HMX build up high levels of the chemical in their tissues (ATSDR 1977). High doses of HMX have been shown to adversely affect the gastrointestinal tract and kidneys in animals (Kalderis et al. 2011). Levels as low as 0.4 mg/kg in soil may cause adverse effects to earthworms (EC20 value, Kuperman et al. 2006).

DIOXINS AND FURANS

According to ATSDR, chlorinated dibenzo-p-dioxins, or CDDs, ("dioxins") are a family of 75 different compounds with varying harmful effects. The dioxin family is divided into eight groups of chemicals based on the number of chlorine atoms in the compound. Chlorinated dibenzofurans, or CDFs, ("furans") are a family containing 135 individual compounds (i.e., congeners) with varying harmful health and environmental effects. The most toxic and most well-studied chemical in the group of dioxins and furans is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD).

Dioxins and furans occur naturally from the incomplete combustion of organic material by forest fires or volcanic activity. They are also produced by human activities. In most instances they are produced unintentionally via industrial incineration and combustion processes, however, in some instances they are intentionally produced in small amounts for research purposes (ATSDR 1998; ATSDR 1994). At LANL, a former incinerator ash pond in TA-69 in Pajarito watershed (Twomile subwatershed) has been identified as a source for dioxins and furans (LANL 2008b). SWMU 73-002 is another ash pile from a former incinerator at TA-73 near the Los Alamos County Airport (DOE and NNSA 2008), which could have served as an additional source of dioxins and furans. Remediation of this ash pile has been completed and the Investigation Report for Consolidated Unit 73-002-099 and Corrective Action of SWMU 73-002 was submitted to and approved by NMED (NMED 2005). Dioxins and furans have been detected in surface water, groundwater, soil and springs on LANL property, however, the source of these furans is not always clear. Studies are underway to determine if dioxins and furans are from LANL historical releases or naturally produced as a result of historic fires (Gallaher and Koch 2004).

Dioxins and furans enter the environment as mixtures that are subject to atmospheric transport and deposition. Once in the environment, they adsorb strongly to soils, are generally immobile due to their low solubility, and can volatilize to the atmosphere from water and soil surfaces. Dioxins and furans are persistent and bioaccumulative, accumulating in both aquatic and terrestrial biota, and will bioaccumulate to a greater extent in organisms with a high fat content because they have a high affinity for lipids. In animals, these chemicals can cause problems with reproduction (e.g., abortions, reduced fertility, endometriosis), development (e.g., structural malformations, functional alterations, decreased growth), survival, and endocrine functions (ATSDR 1998; ATSDR

1994, EPA 2008). Dioxins and furans with chlorine atoms at the 2,3,7,8-positions of the parent molecule are especially harmful. The half-life of 2,3,7,8-TCDD ranges from nine to 15 years in surface soils, and 25 to 100 years in deeper soils (ATSDR 1994).

APPENDIX E: BACKGROUND VALUES USED AT LANL

SEDIMENT BACKGROUND CONCENTRATIONS		
CONTAMINANT	**RSRLs**	**CONSENT ORDER VALUES**
Inorganic Background Contaminants (mg/kg)		
Aluminum	15,560	15,400
Antimony	0.83	0.83
Arsenic	4.70	3.98
Barium	151	127
Beryllium	1.60	1.31
Cadmium	0.20	0.40
Calcium	4,620	4,420
Chloride		17.1
Chromium	12.0	10.5
Cobalt	5.60	4.73
Copper	12.0	11.2
Cyanide (total)		0.82
Iron	15,860	13,800
Lead	23.00	19.70
Magnesium	2,540	2,370
Manganese	635	543
Mercury	0.027	0.100
Nickel	11.00	9.38
Potassium		2,690
Selenium	0.30	0.30
Silver	0.23	1.00
Sodium	1,793	1,470
Sulfate		58.2
Tantalum		0.3
Thallium	0.73	0.73
Vanadium	23.0	19.7
Zinc	67.0	60.2
Radionuclide Background Contaminants (mg/kg)		
Thorium		14.6
Uranium		2.22
Radionuclide Background Contaminants (pCi/g)		
Americium-241	0.057	0.040
Cesium-137	0.57	0.90
Plutonium-238	0.010	0.006
Plutonium-239/240	0.018	0.068
Potassium-40		36.8
Radium-226		2.59
Radium-228		2.33
Strontium-90	1	1.04
Thorium-228		2.28
Thorium-230		2.29
Thorium-232		2.33
Tritium		0.93
Uranium-234	1.80	2.59
Uranium-235	0.077	0.200
Uranium-235/236		0.20
Uranium-238	1.60	2.29

SOIL BACKGROUND CONCENTRATIONS		
CONTAMINANT	**RSRLS**	**CONSENT ORDER VALUES**
Inorganic Background Contaminants (mg/kg)		
Aluminum	15,990	29,200
Antimony	0.27	0.83
Arsenic	5.45	8.17
Barium	217	295
Beryllium	1.20	1.83
Cadmium	0.32	0.40
Calcium	34,902	6,120
Chloride		231.0
Chromium	26.0	19.3
Cobalt	9.60	8.64
Copper	18.0	14.7
Cyanide (total)		0.50
Iron	19,990	21,500
Lead	18.26	22.30
Magnesium	5,014	4,610
Manganese	843	671
Mercury	0.039	0.100
Nickel	18.00	15.40
Potassium	3,729	3,460
Selenium	0.23	1.52
Silver	0.30	1.00
Sodium	83	915
Sulfate		293.0
Tantalum		0.3
Thallium	0.25	0.73
Vanadium	36.0	39.6
Zinc	69.0	48.8
Radionuclide Background Contaminants (mg/kg)		
Thorium		14.6
Uranium		1.82
Radionuclide Background Contaminants (pCi/g)		
Americium-241	0.019	0.013
Cesium-137	0.83	1.65
Plutonium-238	0.007	0.023
Plutonium-239/240	0.036	0.054
Potassium-40		36.8
Radium-226		2.59
Radium-228		2.33
Strontium-90	0.38	1.31
Thorium-228		2.28
Thorium-230		2.29
Thorium-232		2.33
Tritium		
Uranium-234	1.40	2.59
Uranium-235	0.110	0.200
Uranium-235/236		0.20
Uranium-238	1.40	2.29

RSRLS (Regional Statistical Reference Levels): Represent natural and fallout levels, and are the mean plus three standard deviations (=99% confidence level) of the average concentration for radionuclides and chemicals collected from soil and sediment at regional locations away from the influence of LANL over at least the)last five sampling periods. Sampling locations must be more than 20 miles away from LANL (LANL 2010).

LANL Consent Order: Background data collected for soils, canyon sediments, and Bandelier Tuff in the area of LANL, used in the Resource Conservation and Recovery Act corrective action process to distinguish between contaminated and uncontaminated media and to establish cleanup levels (Ryti et al. 1998).

APPENDIX F: COMMENT-RESPONSE LOG FOR PUBLIC COMMENTS RECEIVED ON THE DRAFT LANL NATURAL RESOURCE DAMAGE ASSESSMENT PLAN

Comments are organized by Chapter, and some comments have been paraphrased and/or grouped when appropriate. The comment # refers to numbers on the originally submitted comments found in Appendix G.

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
General Comments (do not refer to a specific chapter)			
Kathy Sanchez/ Beata Tsosie/ Marian Naranjo/ Jon Block/ J. Gilbert Sanchez	1	Numerous comments were received requesting that the comment period be extended.	The LANL Trustee Council extended the comment period through January 13th, 2014.
Kateri Pena	NA	I think that polluting should stop and there should be more recycling, and people should plant trees and flowers all over the world!	The Trustees agree that restoration of natural resources is important. The goal of NRDA is restoration of natural resources injured as a result of hazardous substance releases. For example, if there has been a loss of trees or flowers, the Trustees would consider replanting trees and flowers.
Gerald Maestas	NA	Fundamentally, I don't even agree an assessment is justified or justifiable. Much of what I read in the PAS (pre-assessment screen) goes against everything I heard from people on the ground at LANL during my many years on the DOE Citizens Advisory Board. LANL has spent many, many millions of dollars on environmental surveillance even before the 1980 trigger date for NRDA. There is no measurable damage to the resources and there is less risk from any contamination than from driving on any highway. Benefits from LANL to the surrounding area, including Native Americans, far and away outweigh any imaginary damage to the resource. "Compensation" for any damage which is in the offing is beyond the pale. My recommendation is ELIMINATE THE NRDA and transfer the people involved to useful work. Lacking that, A FULL ASSESSMENT IS NOT JUSTIFIED.	The LANL Trustees are following CERCLA and the guidelines provided in the Department of the Interior NRDA regulations, and completed a PAS determination before embarking on an assessment. As noted on page 42 of the PAS, the Trustees concluded that based on the criteria identified in the regulations a NRDA is warranted. The purpose of the assessment is to quantify injuries to natural resources as a result of hazardous substance releases. The LANL Trustees agree that a substantial amount of environmental surveillance has been completed at LANL to-date. As noted on page vii of the Draft Plan, evaluating this existing information is a priority for the Trustees, allowing the assessment to efficiently utilize existing information.

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
Kathy Roxlau	6	General – technically, the proper name is Cochiti Lake, not Cochiti Reservoir. Check with USACE for confirmation, if you like. While the difference at first glance appears superfluous, the two terms are functionally different and indicate two different types of bodies of water.	The LANL Trustee Council will make the necessary edit in the text of the Draft Plan.
Robert H. Gilkeson / Marian Naranjo (HOPE)	1	A series of comments including previous reports and discussion of the inadequacy of groundwater monitoring at LANL – please see original comments below for full comment.	The LANL Trustees will consider the comment and reports received as they move forward with the natural resource damage assessment.
Executive Summary and Chapter 1			
Kathy Sanchez	2, 3, 4	Please increase the trustee council to representation other than authority leadership who rep[resent] agency or tribe. Rights of Mother Earth needs representation - a voice for non human "sp[i]rit[e]d" life [g]ivers. Need to know how MOU to be on trustee council was extended to public entities, example why can't other pueblos be paralle[ll]y recognized council trustees?	As described on page i of the Draft Plan, only designated Trustees whose trust resources are potentially injured by LANL hazardous releases can participate in the LANL Trustee Council. CERCLA authorizes the Federal government, States, and Indian Tribes to recover, on behalf of the public, damages for injuries to natural resources belonging to, managed by, controlled by, or appertaining to them. Cities, environmental groups, and other organizations or individuals are not legally designated as Trustees, but are encouraged to comment on key documents during the NRDA process. Trustees are authorized pursuant to Section 307(f) of CERCLA, see Executive Order 12580, 52 Fed. Reg. 2923 (January 29, 1987); subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300.600 ff (as amended, 55 Fed. Reg. 8666, 8857-58, March 8, 1990).
Gerald Maestas	2	Secondly, why in the world does Jemez Pueblo, or any pueblo, have a full seat at the table with the State of NM, DOE, the forest service? Why not add San Juan, Cochiti, San Felipe, Isleta, Sandia, Santa Ana, Santo Domingo and even Taos Pueblo? Do the pueblos have a stake equal to that of non-Native Americans?	As described on page i of the Draft Plan, only designated Trustees whose trust resources are potentially injured by LANL hazardous releases can participate in the LANL Trustee Council. CERCLA authorizes the Federal government, States, and Indian Tribes to recover, on behalf of the public, damages for injuries to natural resources belonging to, managed by, controlled by, or appertaining to them. The Department of the Interior has promulgated regulations implementing CERCLA's NRD provisions that serve as guidance for damage assessments. Where a CERCLA damage assessment implicates multiple resource trustees, they are

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
			encouraged to work in coordination with one another through a trustee council to perform the assessment. Consistent with this, the LANL damage assessment is being conducted through the LANL Trustee Council whose members include the state of New Mexico, United States, and several Pueblos in the immediate area of the LANL facility. All decisions by the Council are made by consensus of the member trustees. Pueblo de Cochiti was invited to join the LANL Trustee Council but declined to participate in the NRDA.
Kathy Roxlau	NA	Role of DOE: As I am sure you have heard repeatedly, it is highly irregular to allow the PRP to have a position on the Trustee Council. This is further exacerbated by its role as Co-Lead Trustee. This seems to me to be a textbook case of Conflict of Interest, i.e., the body determining the damages is the body that did the damaging. This conflict of interest is further compounded by the very active role that DOE has in the NRDA process, preparing documents, determining process, and, I assume, conducting contracting with the firm who will be conducting the studies. This conflict of interest will taint every step of the NRDA process, and will subject every document and decision produced by the Trustee Council with suspicion. If DOE cannot be removed from the Trustee Council, then I would recommend that steps be taken to distance DOE from this active role as soon as possible.	40 CFR 300.600(b)(3) designates DOE as a Trustee among Federal agencies with trust authority as a land managing agency. In cases where the Trustee is also a potentially responsible party, they are often represented on the Trustee Council. Reconsideration of DOE's trust responsibility is outside the scope of the Trustee Council. DOE and other Federal agencies act on behalf of the public as Trustees for natural resources under Federal jurisdiction; specifically, DOE has trust responsibilities for natural resources that they manage. DOE's and the State’s co-lead administrative trusteeship was established by the LANL Trustee Council for administrative purposes only. DOE provides the funding for Trustee Council activities, but all decisions including document preparation and determinations as to processes are made by consensus of the member trustees.

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
Kathy Roxlau	General #1, #2	Due to the location of LANL adjacent to the Rio Grande, the potential for resource impacts downstream from LANL, and the use of the public lands surrounding LANL by members of the public from the State's major communities, concern for resource impacts exists beyond communities located adjacent to the DOE facility. As it is likely that the NRDA process for this facility is going to be fraught with contention, it would seem wise to start with a public involvement process that is very inclusive – i.e., to cast a wide net. I think it is reasonable for the Trustee Council to hold additional public meetings regarding this draft plan. I recommend holding at least one meeting each in Santa Fe and Albuquerque, as both of these communities are using the Rio Grande as a source of drinking water and community members make up a large number of visitors to the public lands surrounding LANL. / You have three Pueblos who have signed MOAs to be members of the Trustee Council and undertake a partnering role in the conduct of the NRDA. It would seem prudent to hold meetings for the Pueblo members at each of the Pueblos, so that they can understand what the study involves and provide meaningful comment... This is particularly important when you consider that you will need to involve the Pueblo members to ascertain the impact to Pueblo communities.	The LANL Trustee Council chose to hold the public meeting in a central location. In response to this comment, the LANL Trustee Council has uploaded the presentation given at the public meeting onto the LANL NRDA website (www.lanlnrda.org). There will be future opportunities for public involvement, including input on restoration planning. The LANL Trustee Council encourages the public to look for notices on the LANL NRDA website of future opportunities to participate. Members of the public may also sign up to receive future communications via e-mail on the website.
Ken LaGattuta	1	Neither the Department of the Interior (DOI) nor Cochiti Pueblo are included here [as Trustees], whereas they were included in the Preassessment Screen for Los Alamos National Laboratory (January 2010.)... Both of these omissions are troubling, albeit for different reasons: 1) In the case of the DOI, its omission from among the Trustees leads one to question the seriousness of the entire Natural Resource Damage Assessment Plan. Since the DOE has been recognized widely by the general public, as well as by the Trustees, as being the source of the resource damage being investigated and, presumably, will also be the source of any financial recompense made for damages, it behooves the Trustees to have explicitly included among themselves some other federal Executive Agency of equal or greater political weight than the DOE. The DOE has already been soundly criticized in the press and by the general public for its lack of diligence in the timely cleanup of the mess that it has created at the nuclear weapons factories and laboratories. To have assembled a group of Trustees, the most politically weighty of which is the DOE, when it is the DOE who is responsible for the toxic mess that has been created and will be responsible for its cleanup, is to tacitly agree to the perpetuation of the status quo; i.e., to a situation in which the DOE continues to mismanage the cleanup and continues to obfuscate the problems that it is experiencing along the way.	Each of the active Trustee agencies has an equal voice on the LANL Trustee Council, and all LANL Trustee Council decisions are made by consensus of the member Trustees. DOE and the U.S. Forest Service are two federal agencies on the LANL Trustee Council. As stated on page 3 of the Draft Plan, the Department of the Interior withdrew from the LANL Trustee Council citing lack of dedicated authorized financial support and resources. Separately, the Pueblo de Cochiti were invited to join the LANL Trustee Council but declined to participate in the NRDA.

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
Ken LaGattuta	2	In the case of Cochiti Pueblo, this is a troubling omission since, according to the Preassessment Screen, Cochiti Pueblo has suffered potentially serious resource damage due to past LANL operations; viz., quoting from the Preassessment Screen (January 2010)/ (p17): ...Plutonium deposits have been detected along the Rio Grande between Otowi and Cochiti Lake... Why has this... been omitted from the Draft Los Alamos National Laboratory Natural Resource Damage Assessment Plan? Why has Cochti Pueblo been excluded from the list of Trustees..? In my opinion, a public statement of the reasons for these omissions [s]hould be given now, and written into future versions of the Draft Plan. Quotes from Preassessment Screen: "> The DOE acts as trustee... has trusteeship for natural resources at LANL as a land management agency." "> The DOI acts as a trustee for natural resources... the [BIA], [USFWS], and [NPS] act on behalf of the Secretary of DOI... the BIA is delegated the authority to act on behalf of the Secretary and consults with, coordinates with, and obtains the concurrence of the USFWS and NPS." "> The USDA, acting through the Forest Service, has trusteeship... Santa Fe National Forest (40 CFR § 300.600)." "> The State of New Mexico... holds trusteeship for a range of natural resources potentially affected by releases from LANL (40 CFR § 600.605)." "> Four federally-recognized Pueblos have been identified as holding trusteeship..."	The Pueblo de Cochiti were invited to join the LANL Trustee Council but declined to participate in the NRDA. As to the information referenced from the Preassessment Screen, the LANL Trustee Council will utilize this information as part of the analysis of existing information to help determine and quantify injuries caused as a result of LANL hazardous releases.
Kathy Roxlau	1	I would like to see an explanation in this chapter of how the Trustee Council functions, namely, how decisions are arrived at. How is it determined what studies should be conducted, the methodologies for those studies, acceptance of results, determination of reasonable cost, and determination of reasonable restoration? Is it by vote? This needs to be made clear.	All LANL Trustee Council decisions including document preparation and determinations as to processes such as study methodologies, results, and restoration planning are made by consensus of the member trustees.
Kathy Roxlau	9	General – I recognize, as you do, the concern for safeguarding confidential information collected when assessing the loss to Pueblo services. There are many ways to address this concern, such as having the Pueblos themselves (with the assistance of their trusted contractors, with NRDA funding) conduct the studies, and the use of separate documentation, some of which is retained by the Pueblos and some of which is available to the public.	The LANL Trustee Council will continue to address confidentiality concerns of the Trustee Council members. As noted on page 84 of the Draft Plan in the "Approach" section, the Pueblos may conduct any required Pueblo loss studies.
Kathy Roxlau	3	(page 20) I recommend moving the footnote into the text, as it is very relevant.	The LANL Trustee Council will move the footnote into the text as suggested.

COMMENTER	COMMENT #	COMMENT	DRAFT RESPONSE
Kathy Roxlau	3	(page 20) You have Cochiti Reservoir and VCNP in your study area, yet the NPS, USACE, and Pueblo de Cochiti are not Trustees. How will you conduct these studies with them not on the Council?	If the LANL Trustee Council determines it is necessary to conduct on-site studies, the LANL Trustee Council will obtain all necessary permissions.
Kathy Roxlau	4	(page 21) I would like for the Council to prepare a comment response document that shows each comment received during public review of the Draft Plan and a response by the Council.	This comment response log will be posted on the LANL NRDA website (www.lanlnrda.org) and included as an appendix to the Final DAP.
Kathy Roxlau	2 & 3	(page 4) I disagree with the determination of study area as the Pajarito Plateau. I think that DOE should consider that there is a reasonable potential that impacts have "flowed downhill" to additional areas to the south, and extend the boundaries of the study area accordingly. Additionally, it is irresponsible to bound the study area with the Rio Grande to the east – I believe it is reasonable to assume that impacts may have occurred to resources on the banks on the east side of the Rio Grande. Since the USFS is already a Trustee, to extend to this side of the river should not cause undue angst. The geographic scope of the study should be extended downstream, past Cochiti Dam.	As stated on page 20 of the Draft Plan, the geographic scope of the assessment includes all locations where contaminants have come to be located. This geographic scope was determined using existing information on the likely extent of contamination resulting from LANL operational releases. If the LANL Trustee Council finds reason to believe injuries may have occurred on the east side of the Rio Grande or past Cochiti Dam, these areas will be included in the geographic scope of the assessment.

Chapter 4			
Kathy Roxlau	5, 7	(page 51, 60-61) I am concerned with the statement "Specifically, the assessment will need to determine if the people in these communities would be using the natural environment more or differently today if contaminants had not been released into the environment." What is the definition of use? It is important that the assessment include analysis not only of the physical interaction of Pueblo people with natural resources, but also of the more esoteric aspects.. between Puebloan people and these resources... resulting effects to the communities... secular/physical world is not separate from the traditional cultural/ceremonial/psychological/sacred world for these communities. Because everything is inter-related and associated, the "chain of effect" flows through all elements, and these indirect effects are significant... I appreciate that the approach described for "Assessment of Changes in Pueblo Services" makes an effort to be culturally relevant, but it is still lacking in acknowledging that efforts must also determine the effects to esoteric uses of the natural environment, as described in comment #5 above.	As noted on page 12 of the Draft Plan, the LANL Trustee Council agrees that Pueblo members have a unique connection to the natural world. The LANL Trustee Council plans to assess all lost or diminished Pueblo services that are linked to any injury to natural resources resulting from the release of hazardous substances from LANL operations.
Kathy Roxlau	8	(page 61-62) The approach described under "Habitat and Resource Equivalency" is wholly inappropriate for determining loss of Pueblo services, for the very reasons that you stipulate.	The Pueblos and the LANL Trustee Council have not yet decided on the specific methodology or methodologies for assessing Pueblo losses, but will attempt to utilize existing information as much as possible, collect new information as necessary, and develop assessment approaches that will provide the information needed to quantify Pueblo losses and scale necessary and appropriate restoration.

APPENDIX G: PUBLIC COMMENTS SUBMITTED ON THE DRAFT LANL NATURAL RESOURCE DAMAGE ASSESSMENT PLAN

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: Kathy Sanchez

Affiliation (optional):

Email: [redacted]

Phone:

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?
Please circle your answer: [✓ Yes] No.

Comment:

① Please extend the comment period

② Please increase the trustee council to representation other than authority leadership who rep. Agency or tribe.

③ Rights of Mother Earth needs representation - a voice for non human "spirited" life givers -

④ Need to know How MOU to be on trustee council was extended to public entities
example why can't other pueblos be
parallel-ly recognized council trustees

⑤

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: Beata Tsosie

Affiliation (optional): Tewa women United

Email: [redacted]

Phone: [redacted]

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?
Please circle your answer: [✓ Yes] No

Comment: Please extend comment period for beyond January.

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: Kateri peña

Affiliation (optional):

Email: ~~No Phone~~ No Email

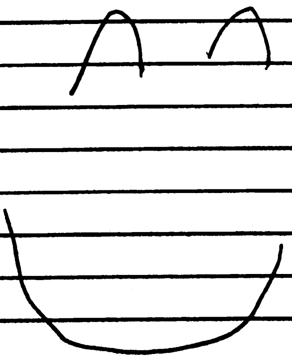
Phone: No phone

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?

Please circle your answer: Yes [✓ No]

Comment: I think that poluting should stop and there should be more [illegible] recycling, and people should plant trees and flowers all over the world!



Mkay Bye

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: Marian Naranjo

Affiliation (optional): Director Honor Our Pueblo Existence (HOPE)

Email: [redacted]

Phone: [redacted]

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?

Please circle your answer: [✓ Yes] No

Comment: I am formally asking for an extent of time to make substantival Comment. There are documents that need to be Reviewed & 30 days is NOT enough Time for this. Thank You

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: Jon Block

Affiliation (optional): NMELC

Email: [redacted]

Phone: [redacted]

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?

Please circle your answer: [✓ Yes] No

Comment: Extend comment period! 184 pages of documents to your plan + references — 3 days is not reasonable to make meaningful, substantive comments.

Los Alamos National Laboratory Natural Resource Damage Assessment
Draft Damage Assessment Plan

COMMENT FORM

Name: J Gilbert Sanchez

Affiliation (optional): Indigenous Peoples

Email:

Phone: [redacted]

(Contact information will only be used if the Trustees have questions about your comment)

Do you want to stay informed with e-mails regarding upcoming events?

Please circle your answer: Yes No

Comment:

Extend beyond Dec to Feb 14 due to the length of document and mostly due to Tribal activities at the end of Dec - Jan -

thank you

Gmail by Google

Trustees LANLTC <lanlnrda@gmail.com>

Draft NRDA Plan

1 message

[redacted] Thu, Nov 21, 2013 at 12:34 PM

To: lanlnrda@gmail.com

Fundamentally, I don't even agree an assessment is justified or justifiable. Much of what I read in the PAS(pre-assessment screen) goes against everything I heard from people on the ground at LANL during my many years on the DOE Citizens Advisory Board. LANL has spent many, many millions of dollars on environmental surveillance even before the 1980 trigger date for NRDA. There is no measurable damage to the resources and there is less risk from any contamination than from driving on any highway. Benefits from LANL to the surrounding area, including Native Americans, far and away outweigh any imaginary damage to the resource. "Compensation" for any damage which is in the offing is beyond the pale.

Secondly, why in the world does Jemez Pueblo, or any pueblo, have a full seat at the table with the State of NM, DOE, the forest service? Why not add San Juan, Cochiti, San Felipe, Isleta, Sandia, Santa Ana, Santo Domingo and even Taos Pueblo? Do the pueblos have a stake equal to that of non-Native Americans?

My recommendation is ELIMINATE THE NRDA and transfer the people involved to useful work. Lacking that, A FULL ASSESSMENT IS NOT JUSTIFIED.

gerald maestas
espanola, nm

Gmail by Google

Trustees LANLTC <lanlnrda@gmail.com>

Comments on the Draft NRDA Plan for LANL

1 message

Kathy Roxlau [redacted] Mon, Dec 9, 2013 at 12:04 PM

To: "lanlnrda@gmail.com" <lanlnrda@gmail.com>

New Mexico Office of Natural Resources Trustee,

I respectfully submit the following comments on the *Natural Resource Damage Assessment Plan for Los Alamos National Laboratory, Draft for Public Comment* (dated November 2013). I appreciate the amount of work that has been conducted thus far to develop the plan, and unfortunately, was unable to attend the one public meeting held for the Draft NRDA Plan to offer my comments verbally.

Regarding the role of DOE in the NRDA:

As I am sure you have heard repeatedly, it is highly irregular to allow the PRP to have a position on the Trustee Council. This is further exacerbated by its role as Co-Lead Trustee. This seems to me to be a textbook case of Conflict of Interest, i.e., the body determining the damages is the body that did the damaging. This conflict of interest if further compounded by the very active role that DOE has in the NRDA process, preparing documents, determining process, and, I assume, conducting contracting with the firm who will be conducting the studies. This conflict of interest will taint every step of the NRDA process, and will subject every document and decision produced by the Trustee Council with suspicion. If DOE cannot be removed from the Trustee Council, then I would recommend that steps be taken to distance DOE from this active role as soon as possible.

Regarding the public involvement effort being conducted for development of this plan, I have two recommendations:

(1) Due to the location of LANL adjacent to the Rio Grande, the potential for resource impacts downstream from LANL, and the use of the public lands surrounding LANL by members of the public from the State's major communities, concern for resource impacts exists beyond communities located adjacent to the DOE facility. As it is likely that the NRDA process for this facility is going to be fraught with contention, it would seem wise to start with a public involvement process that is very inclusive – i.e., to cast a wide net. I think it is reasonable for the Trustee Council to hold additional public meetings regarding this draft plan. I recommend holding at least one meeting each in Santa Fe and Albuquerque, as both of these communities are using the Rio Grande as a source of drinking water and community members make up a large number of visitors to the public lands surrounding LANL.

(2) You have three Pueblos who have signed MOAs to be members of the Trustee Council and undertake a partnering role in the conduct of the NRDA. It would seem prudent to hold meetings for the Pueblo members at each of the Pueblos, so that they can understand what the study involves and provide meaningful comment. DOE has a long history of working with the Pueblos, and should have figured out by now that involvement of the Pueblo-public in the project requires an extra, and important effort. Perhaps the project managers did not bother to consult with the DOE Public Affairs people at their disposal, to learn what should be done to involve the Pueblo-public. This is particularly important when you consider that you will need to involve the Pueblo members to ascertain the impact to Pueblo communities.

The following comments regard the Draft Plan itself:

1. Chapter 1 – I would like to see an explanation in this chapter of how the Trustee Council functions, namely, how decisions are arrived at. How is it determined what studies should be conducted, the methodologies for those studies, acceptance of results, determination of reasonable cost, and determination of reasonable restoration? Is it by vote? This needs to be made clear.

2. Page 4 – I disagree with the determination of study area as the Pajarito Plateau. I think that DOE should consider that there is a reasonable potential that impacts have "flowed downhill" to additional areas to the south, and extend the boundaries of the study area accordingly. Additionally, it is irresponsible to bound the study area with the Rio Grande to the east – I believe it is reasonable to assume that impacts may have occurred to resources on the banks on the east side of the Rio Grande. Since the USFS is already a Trustee, to extend to this side of the river should not cause undue angst.

3. Page 20

- I recommend moving the footnote into the text, as it is very relevant.
- The geographic scope of the study should be extended downstream, passed Cochiti Dam.
- You have Cochiti Reservoir and VCNP in your study area, yet the NPS, USACE, and Pueblo de Cochiti are not Trustees. How will you conduct these studies with them not on the Council?

4. Page 21 – I would like for the Council to prepare a comment response document that shows each comment received during public review of the Draft Plan and a response by the Council.

5. Page 51 – I am concerned with the statement "Specifically, the assessment will need to determine if the people in these communities would be using the natural environment more or differently today if contaminants had not been released into the environment." What is the definition of use? It is important that the assessment include analysis not only of the physical interaction of Pueblo people with natural resources, but also of the more esoteric aspects of the interaction between Puebloan people and these resources, and the resulting effects to the communities. Remember that the secular/physical world is not separate from the traditional cultural/ceremonial/psychological/sacred world for these communities. Because everything is inter-related and associated, the "chain of effect" flows through all elements, and these indirect effects are significant. "Use" of these resources needs to defined within the cultural framework of the Pueblos themselves.

6. General – technically, the proper name is Cochiti Lake, not Cochiti Reservoir. Check with USACE for confirmation, if you like. While the difference at first glance appears superfluous, the two terms are functionally different and indicate two different types of bodies of water.

7. Pages 60 and 61 – I appreciate that the approach described for "Assessment of Changes in Pueblo Services" makes an effort to be culturally relevant, but it is still lacking in acknowledging that efforts must also determine the effects to esoteric uses of the natural environment, as described in comment #5 above.

8. Pages 61 and 62 – the approach described under "Habitat and Resource Equivalency" is wholly inappropriate for determining loss of Pueblo services, for the very reasons that you stipulate.

9. General – I recognize, as you do, the concern for safeguarding confidential information collected when assessing the loss to Pueblo services. There are many ways to address this concern, such as having the Pueblos themselves (with the assistance of their trusted contractors, with NRDA funding) conduct the studies, and the use of separate documentation, some of which is retained by the Pueblos and some of which is available to the public.

Sincerely,

Kathy Roxlau

[redacted]

Trustees LANLTC <lanlnrda@gmail.com>

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critique of Draft Plan of Nov 2013

1 message

[redacted] Mon, Dec 9, 2013 at 3:06 PM
To: lanlnrda@gmail.com

Comments submitted to lanlnrda@gmail.com
by Ken LaGattuta
and lanl-the-back-story.blogspot.com
December 9, 2013

On page ii of the Executive Summary of the Draft Los Alamos National Laboratory Natural Resource Damage Assessment Plan (November 2013) the LANL Trustees are listed as:

> DOE.
> The U.S. Department of Agriculture, acting through the Forest Service.
> Pueblo of Jemez.
> Pueblo de San Ildefonso.
> Santa Clara Pueblo.
> The State of New Mexico, acting through the Natural Resources Trustee of the Office of Natural Resources Trustee.

However, neither the Department of the Interior (DOI) nor Cochiti Pueblo are included here, whereas they were included in the Preassessment Screen for Los Alamos National Laboratory (January 2010.) (See below)

Both of these omissions are troubling, albeit for different reasons:

1) In the case of the DOI, its omission from among the Trustees leads one to question the seriousness of the entire Natural Resource Damage Assessment Plan. Since the DOE has been recognized widely by the general public, as well as by the Trustees, as being the source of the resource damage being investigated and, presumably, will also be the source of any financial recompense made for damages, it behooves the Trustees to have explicitly included among themselves some other federal Executive Agency of equal or greater political weight than the DOE. The DOE has already been soundly criticized in the press and by the general public for its lack of diligence in the timely cleanup of the mess that it has created at the nuclear weapons factories and laboratories.

To have assembled a group of Trustees, the most politically weighty of which is the DOE, when it is the DOE who is responsible for the toxic mess that has been created and will be responsible for its cleanup, is to tacitly agree to the perpetuation of the status quo; i.e., to a situation in which the DOE continues to mismanage the cleanup and continues to obfuscate the problems that it is experiencing along the way.

2) In the case of Cochiti Pueblo, this is a troubling omission since, according to the Preassessment Screen, Cochiti Pueblo has suffered potentially serious resource damage due to past LANL operations; viz., quoting from the Preassessment Screen (January 2010)/ (p17):

"According to the 1999 SWEIS,"

"The major contributors to environmental impacts of operating LANL are wastewater discharges and radioactive air emissions."

"> Historic discharges to Mortandad Canyon from the RLWTF have resulted in above background residual radionuclide (americium, plutonium, strontium-90, and cesium-137) concentrations, as well as nitrates in alluvial groundwater and sediments."

"> Plutonium deposits have been detected along the Rio Grande between Otowi and Cochiti Lake."

.....

"Additionally, releases of plutonium have been detected in sediments within Cochiti Reservoir and below in the Rio Grande as far south as Albuquerque (Graf 1994). Once contaminants have been released to the environment, they can be remobilized and transported over distances or into new media. For example, storm events can redistribute sediment in stream beds, wind can shift contaminants in soil, and soil contamination can be relocated by percolation of precipitation and groundwater movement."

"(Graf, W. L., 1994. Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age. Oxford University Press. New York, New York. ISBN-13 978-0195089332.)"

....

Why has this important information, included in the Preassessment Screen, been omitted from the Draft Los Alamos National Laboratory Natural Resource Damage Assessment Plan?

Why has Cochti Pueblo been excluded from the list of Trustees in the Draft Los Alamos National Laboratory Natural Resource Damage Assessment Plan?

In my opinion, a public statement of the reasons for these omissions ahould be given now, and written into future versions of the Draft Plan.

....

Quoting from the Preassessment Screen (January 2010) / (p6)

"Natural resource Trustees for this site include the following."

"> The DOE acts as trustee for portions of LANL that are or have been owned and/or operated by the United States. As such, DOE has trusteeship for natural resources at LANL as a land management agency."

"> The DOI acts as a trustee for natural resources and supporting ecosystems that it manages or controls. In this matter, the Bureau of Indian Affairs (BIA), U.S. Fish and Wildlife Service (USFWS), and National Park Service (NPS) act on behalf of the Secretary of DOI as trustees for natural resources under the DOI's jurisdiction. As the authorized official for the LANL NRDA and Restoration

(NRDAR) effort, the BIA is delegated the authority to act on behalf of the Secretary and consults with, coordinates with, and obtains the concurrence of the USFWS and NPS."

"> The USDA, acting through the Forest Service, has trusteeship for various natural and cultural resources of the Santa Fe National Forest (40 CFR § 300.600)."

"> The State of New Mexico, acting through the Natural Resources Trustee and the Office of Natural Resources Trustee, and the Attorney General and the Attorney General's Office, holds trusteeship for a range of natural resources potentially affected by releases from LANL (40 CFR § 600.605)."

"> Four federally-recognized Pueblos have been identified as holding trusteeship over various resources that may have been injured as a result of releases from LANL. These include Pueblo de San Ildefonso, Jemez Pueblo, Santa Clara Pueblo, and Cochiti Pueblo."

....

H.O.P.E.
Honor Our Pueblo Existence

Honor Our Pueblo Existence's (H.O.P.E.) Public Comment on the November 14, 2013 DRAFT Los Alamos National Laboratory (LANL) Natural Resource Damage Assessment (NRDA) Plan to Bring Attention to the Many Problematic Errors About the Unreliable Monitoring Wells at the LANL. The LANL Monitoring Wells Do Not Provide the Data Required for Assessment of the Injury to the Precious Groundwater Resource.

Marian Naranjo, Executive Director
Honor Our Pueblo Existence (H.O.P.E.)
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Robert H. Gilkeson, Independent Registered Geologist
7220 Central Ave SE Apt 1043
Albuquerque, NM 87108
E-mail: rhgilkeson@aol.com

Foreword by Marian Naranjo, Executive Director, Honor Our Pueblo Existence (H.O.P.E.)

To: Natural Resources Damages Assessment (NRDA) Trustee Council,

Thank you for the opportunity to comment on the NRDA Process. HOPE participates in cultural activities as some of the members of the council do. The timeframe was just to short of a period to make substantial comments Cultural activities occurred before November 1, preparation during the Holidays, Thanksgiving, Christmas, New Years and the newly elected officials day of celebration, January 6th. Although we had asked for an extension of 30 days, we feel that a full 90 day comment period was necessary. Therefore, at this time, we are submitting only comments on the serious injury to the precious groundwater resourcd. Because of lack of time to submit comments on other important issues in the NRDA assessment process, we are asking for more time to submit more comments that will be accepted. Thank you for your consideration in this matter.

Sincerely,

Marian Naranjo, Executive Director, Honor Our Pueblo Existence (H.O.P.E.)

The public comments of Honor Our People Existence (H.O.P.E.) and Independent Registered Geologist Robert H. Gilkeson on the November 14, 2013 DRAFT Los Alamos National Laboratory Natural Resource Damage Assessment Plan are focused on the poor knowledge of groundwater contamination at the Los Alamos National Laboratory (LANL). The poor knowledge of groundwater contamination is because practically all of the LANL monitoring wells are badly flawed and do not provide reliable and representative water samples for the detection of groundwater contamination from past, present and future operations at LANL.

Approximately 50 of the monitoring wells at LANL are “characterization wells” installed for the 1998 LANL Hydrogeologic Workplan. The locations of 46 of the characterization wells are displayed on Figure 1. An important reason the characterization wells do not provide reliable and representative groundwater samples for the detection of LANL contaminants is because the drilling methods allowed organic drilling additives and/or bentonite clay drilling muds to flow into the geologic strata surrounding the well screens. Further, many of the characterization wells were constructed with multiple screens and groundwater samples were collected from the zone impacted with the drilling additives with no-purge sampling methods. In addition, many of the characterization wells were 1) not installed at appropriate locations. 2) were installed too deep below the water table, and 3) the well screens were installed in geologic strata with low hydraulic conductivity where contaminated groundwater is not expected to be present,

Table 1 describes the harmful drilling additives that were allowed to flow into the sampling zones for 36 of the LANL characterization wells.

Figure 2 is a display of the damaged sampling zone formed by the drilling additives in the geologic strata surrounding the well screens in the LANL characterization wells.

The LANL Natural Resource Trustee Council (LANL NRTC) is apparently uninformed about the large number of reports that document the unreliable monitoring wells at LANL that have produced a very large volume of unusable water quality data. The reports are listed below.

1) The report in 2004 by Independent Registered Geologist Robert H Gilkeson. The report was presented to a public meeting of the Northern New Mexico Citizens Advisory Board (NNMCAB) on June 9, 2004. In January 2005, the NNMCAB sent a letter to Region VI of the Environmental Protection Agency (EPA) with a request for groundwater experts in EPA to review the issues raised by Mr. Gilkeson about the unreliable monitoring wells that were being installed at LANL,

2) The EPA National Risk Management Research Laboratory (EPA Kerr Lab) issued four reports over the years 2006 to 2009 that described the properties of the organic drilling additives and bentonite clay drilling muds used in drilling the LANL characterization wells to conceal knowledge of groundwater contamination. The EPA Kerr Lab reports also documented the unscientific and badly flawed studies by the LANL scientists that claimed the majority of the LANL characterization wells produced reliable and representative groundwater samples because they had “cleaned up” from the deleterious effects of the bentonite clay drilling muds and organic drilling additives. The three unscientific and badly flawed LANL reports that described most of the LANL characterization wells as reliable monitoring wells were titled Well Screen Analysis Report (WSAR) and Revisions 1 and 2. Pertinent excerpts from the EPA Kerr Lab reports are included with this public comment.

3) At the request of DOE, the National Research Council (NRC) formed a committee of experts to review the issues raised by Mr. Gilkeson about the unreliable monitoring wells installed at LANL. The National Academies of Science (NAS) Division of the NRC issued a report in 2007 titled ***”Plans and Practices for Groundwater Protection at the Los Alamos National Laboratory: Final Report”*** **http://www.nap.edu/catalog/11883.html** The important conclusion is the 2007 NAS Report was that ***“Many if not all of the wells drilled into the regional aquifer under the [LANL] Hydrogeologic Workplan appear to be compromised in their ability to produce water samples that are representative of ambient groundwater for the purpose of monitoring.”*** Pertinent excerpts from the 2007 NAS report are included with this public comment.

4) The 2010 report about the unreliable LANL monitoring wells by the Internationally Recognized Professor Michael Barcelona in the Chemistry Department at Western Michigan University. The Barcelona report is in Appendix A.

5) The 2010 Response to Public Comment Report by the New Mexico Environment Department (NMED). The NMED 2010 report described the LANL characterization wells to not meet the requirements of monitoring wells. Pertinent excerpts from the NMED 2010 report are included with this public comment.

6) The September 2013 presentation by Dr. Patrick Longmire to the NNMCAB about the requirement for additional field studies for accurate knowledge of the nature and extent of the hexavalent chromium plume in the regional aquifer below Mortandad Canyon.

7). The October 2013 presentation by the DOE LANL Oversight Bureau (DOE OB) and the NMED to a national meeting of the Geological Society of America (GSA). The Report was titled “REDOX Chemistry of Aquifer Systems in the Presence of Residual Drilling Fluids by Patrick Longmire, Michael Dale, Kim Granzow and Stephen Yanicak. Pertinent excerpts from the Longmire et al October 2013 GSA report are included with this public comment.

All of the above reports describe the overall failure of the groundwater protection practices at LANL, and especially the overall failure to install reliable monitoring wells. There are many reasons for the failure to install reliable monitoring wells. An overarching reason is that organic drilling agents as foams or water-based fluids and/or bentonite clay drilling muds were allowed to flow into the groundwater zones that are sampled by the large number of badly flawed monitoring wells that were installed as characterization wells by the LANL 1998 Hydrogeologic Workplan. In addition, the 2013 report to the GSA describes the need to replace many of the LANL monitoring wells including wells that have screened intervals contaminated by hydraulic drilling oil.

The LANL NRTC cannot assess injury to the groundwater and the cost for restoration without a reliable network of monitoring wells. It is very important for the LANL NRTC to recognize that a reliable network of monitoring wells does not exist in the alluvial aquifers, the perched intermediate aquifers or the regional aquifer at the present time.

We are alarmed that the LANL NRTC has started the process of using the unreliable and unrepresentative water quality data in the LANL Intellus data base with the assumption that the Intellus water quality data are valid for identification of groundwater contamination from past, present and future LANL operations. However, there is much knowledge on record that all of the water quality data for water samples collected from the LANL characterization wells are not usable to assess groundwater contamination. This is also true for the many of the LANL monitoring wells installed as a requirement of the NMED Compliance Order On Consent (NMED Consent Order).

The NMED 2010 Response to Public Comment on the LANL proposed Resource Conservation and Recovery Act (RCRA) Permit

The National Academy of Sciences issued a report in 2007 that described the requirement to replace many and possibly all of the LANL characterization wells.
http://www.nap.edu/catalog.php?record_id=11883

<u>From page 49 in the 2007 NAS Report</u>:

> Many if not all of the wells drilled into the regional aquifer under the LANL Hydrogeologic Workplan appear to be compromised in their ability to produce water samples that are representative of ambient groundwater for the purpose of monitoring.

<u>From page 60 in the NAS 2007 Report</u>:

> **Findings and Recommendations on Monitoring and Data Quality**
>
> **General Findings**
> Any monitoring activity faces a conundrum: If little or no contamination is found, does it mean that there is in fact little or no contamination, or that the monitoring itself is flawed? <u>During this study the committee was presented a good deal of information suggesting that most or all wells into the regional aquifer at LANL (R-wells) are flawed for the purpose of monitoring. The committee did not disagree, but rather found a lack of basic scientific knowledge that could help ensure future success</u>. Evidence about the conditions prevalent around the screens in the compromised wells is indirect—relying on plausible but unproven chemical interactions, general literature data, analyses of surrogates, and apparent trends in sampling data that may not be statistically valid [Emphasis supplied].

All of the LANL characterization wells are compromised because the drilling methods introduced a large amount of bentonite clay drilling mud and/or organic drilling fluids into the aquifer strata where the well screens were installed. The drilling muds and organic drilling fluids formed a new chemistry in the zone surrounding the well screens with strong properties to remove LANL contaminants from the water samples collected from the characterization wells.

In November 2010, the NMED issued a report titled *General Response to Comment on the LANL Renewal RCRA Permit*. http://www.nmenv.state.nm.us/HWB/Permit.htm NOTE: On the NMED webpage under the heading Renewal Permit click on the topic "General Response to Comments."

In the above referenced NMED Report, the NMED agreed with the conclusions in the NAS 2007 Report about the ~50 LANL characterization wells installed for the LANL Hydrogeologic Work Plan. The NMED described the LANL characterization wells to not meet the requirement to be monitoring wells for the NMED 2005 Consent Order or the LANL 2010 Renewal of the Federal Resource Conservation and Recovery Act (RCRA) Permit.

For example, from page 31 of the NMED 2010 General Response to Comment:

> The Department agrees with many of the conclusions in the referenced National Academy of Sciences (NAS) Report; however the report is based on conditions at the time that the NAS conducted the evaluation. Since that time, the Permittees have installed, replaced and rehabilitated numerous wells completed in the intermediate perched aquifers and the regional aquifer at the Facility. The NAS report does not account for the additional groundwater characterization and actions taken to address deficient wells.
>
> The NAS report references wells that were installed as part of LANL's groundwater characterization efforts that were conducted in accordance with their Hydrogeologic Work Plan (1998). These [characterization] wells were not installed for contaminant detection or groundwater monitoring. Therefore, these wells have limited relevance to groundwater protection goals set forth by the March 1, 2005 Consent Order [Emphasis supplied].

Statement by H.O.P.E. and Robert H. Gilkeson: Despite the above description by NMED that the LANL characterization wells "have limited relevance to groundwater protection goals set forth by the March 1, 2005 Consent Order, practically all of the LANL characterization wells are now presented in the reports by NMED and LANL as reliable monitoring wells. The widespread use of the characterization wells is shown in Figure1 and Figures 6 through 13.

James Bearzi, the former Chief of the NMED Hazardous Waste Bureau (HWB) recommended for LANL to perform laboratory and field studies to determine the ability of each of the characterization wells to detect groundwater contamination from LANL operations. For example, from a letter to LANL by Mr. Bearzi dated May 25, 2007:

> NMED notes that the conclusions obtained in the Report [LANL Well Screen Analysis Report (WSAR), Revision 2] were derived mainly from analysis of extent data in the literature, possibly under conditions different from the Los Alamos National Laboratory's site (the site). The absence of critical site-specific data, such as adsorption properties, reaction kinetics and microbial activities, implies that there would be uncertainties and limitations in using the methodology developed in the [LANL WSAR] Report to assess the quality of groundwater samples collected from monitoring wells installed at this site. NMED is especially concerned about the uncertainty with respect to monitoring certain

> potential contaminants of concern, such as the highly adsorptive radionuclides. NMED therefore suggests that the Permittees consider conducting proper laboratory and field studies to address the uncertainty regarding whether or not the monitoring wells installed as the monitoring network are capable of providing reliable data to monitor potential releases of the highly adsorptive radionuclides from operation of the laboratory to groundwater [Emphasis supplied].

The US Environmental Protection Agency (EPA)National Risk Management Research Laboratory (EPA Kerr Lab) issued three reports over the years 2006 to 2009 with the conclusion that the study of water quality data alone in the LANL WSAR Reports could not determine that the LANL characterization wells were reliable to detect groundwater contamination from LANL operations. For example, from page 4 of the EPA Report issued on February 10, 2006:

> Relative to addressing the question of whether groundwater samples are representative of the undisturbed aquifer chemistry, water quality data alone provide an unreliable indication of whether there is sustained impact to sediment sorption characteristics. The margin of error of determining, through measurements of water chemistry, what sediment minerals exist at any given point in time at a well screen is comparable to the level of uncertainty in estimating the temperature of a glass of water solely through visual observations.

Unfortunately, the DOE, LANL, and the NMED continue to the present time to use only water chemistry from the LANL characterization wells to determine that the wells are reliable to detect groundwater contamination from LANL sources. The NMED should require LANL to perform field studies at each of the LANL characterization wells. The EPA Kerr Lab issued a report in 2009 that recommended for LANL to perform field studies in the LANL characterization wells. From page 5 in the EPA Kerr Lab 2009 Report:

> Ultimately, lines of evidence from field studies will be needed to reduce uncertainty in the validation of criteria used in the WSAR. Useful lines of evidence would include: characterization of aquifer solids obtained from impacted wells, evaluation of the effects of well purging prior to sampling of impacted wells, and push-pull tests to directly examine sorption properties at impacted wells. A primary line of evidence would also be the installation of new well(s) drilled without the use of additives in the screened zone near impacted well(s). A comparison of water quality data from the two wells would provide direct evidence of the degree of impact and the effects on water quality (Emphasis supplied).

The NMED should require LANL to perform the “push-pull tests” in the LANL characterization wells on Figure 1 and especially in the characterization wells that are in contaminant plumes or that are used to monitor groundwater contamination from the many large LANL Material Disposal Areas (MDAs). See Figures 6 through 13.

Figures 3, 4, 5 and 8 show characterization well R-28 is at an important location in the hexavalent chromium plume. The need for an additional monitoring well installed at the water table at the location of well R-28 is described on Figure 8. The push-pull trace test should be performed in well R-28 to evaluate the ability of the characterization well to produce reliable and representative groundwater samples.

From page 1 in the LANL Characterization Well R-28 Completion Report:

> [Characterization well] R-28 is located in Mortandad Canyon and will provide a contaminant analysis-and-monitoring point for comparison with regional [characterization] well R-15, located upstream; [characterization well] R-11, located to the northeast in Sandia Canyon; and [characterization well] R-13, located to the southeast, downstream in Mortandad Canyon. As indicated in the LANL-prepared Sampling and Analysis Plan (SAP) (LANL 2003, 03-8324), contaminants have been identified in alluvial and perched intermediate groundwater and in the regional aquifer within Mortandad Canyon. Historically, constituents that have been detected in surface water and alluvial groundwater include: americium-241; cesium-137; plutonium-238 and plutonium-239, 240; strontium-90; tritium; uranium-234, 235, 236, 238; nitrate; perchlorate; chloride; sulfate; fluoride; and total dissolved solids ([TDS] ESP 1999, 68661; ESP 2001, 73876; ESP 2002, 71301). Mortandad Canyon and its tributaries have received effluents from Los Alamos National Laboratory (LANL or the Laboratory) since the early 1950s. These effluents discharged from TA-3, TA-35, TA-48, and TA-50 have contained a variety of contaminants including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium (LANL 1997, 56835). Active outfalls at TA-3 and TA-50 discharged to Mortandad Canyon. Most contaminants found in Mortandad Canyon are associated with TA-50 discharges into Effluent Canyon except for sources of strontium-90 (LANL 1997, 56835), nitrate, and perchlorate. Strontium-90, nitrate, and perchlorate were discharged from TA-35 into Pratt Canyon; total masses of nitrate and perchlorate discharged are not known (Emphasis supplied).

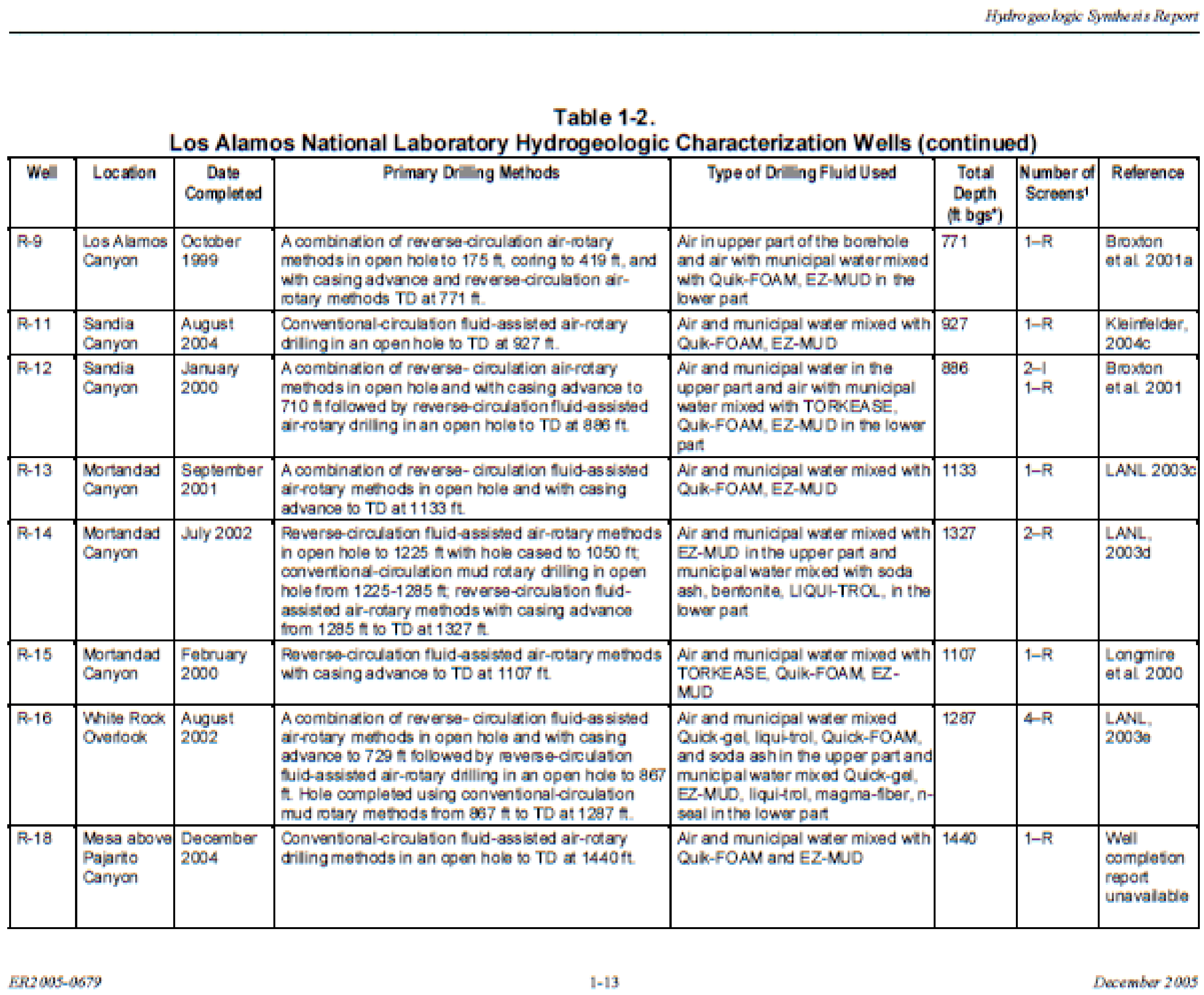
Statement by Hope and Gilkeson: Our review shows that there is an overall failure of LANL, DOE and the NMED to install reliable monitoring wells for the detection of groundwater contamination in the alluvial aquifers, the deeper perched aquifers, and the regional aquifer below Mortandad Canyon. This failure is illustrated by the large number of characterization wells on Figure 8. There is an immediate requirement to perform the push-pull tests recommended by the EPA Kerr Lab and the NMED in the characterization wells.

Table 1. A list of 36 of the characterization wells installed for the LANL Hydrogelogic Workplan. The table describes the types of drilling fluids used for the characterization wells. SOURCE. Table 1-2 in the LANL 2005 Hydrogeologic Synthesis Report.

Table 1-2.
Los Alamos National Laboratory Hydrogeologic Characterization Wells

Well	Location	Date Completed	Primary Drilling Methods	Type of Drilling Fluid Used	Total Depth (ft bgs*)	Number of Screens¹	Reference
R-1	Mortandad Canyon	November 2003	Conventional-circulation fluid-assisted air-rotary methods with casing advance to 90 ft followed by conventional-circulation fluid-assisted air-rotary drilling in an open hole to² TD at 1165 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1165	1–R	Kleinfelder, 2004e
R-2	Pueblo Canyon	October 2003	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to 403 ft followed by conventional-circulation mud rotary drilling to TD at 943 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD in the upper part and municipal water mixed with bentonite, soda ash, PAC-L in the lower part	943	1–R	Kleinfelder, 2004b
R-4	Pueblo Canyon	October 2003	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to 266 ft followed by conventional-circulation mud rotary drilling to TD at 844 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD in the upper part and municipal water mixed with bentonite, soda ash, PAC-L in the lower part	844	1–R	Kleinfelder, 2004a
R-5	Pueblo Canyon	June 2001	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 870 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 902 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	902	2–I 2–R	LANL, 2003a
R-6	Los Alamos Canyon	December 2004	Conventional-circulation air-rotary and fluid-assisted air-rotary drilling methods in an open hole to 945 ft followed by conventional-circulation mud rotary drilling in a cased hole (casing set to 815 ft depth) to TD at 1303 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD in the upper part and municipal water mixed with bentonite (Max-Gel and Quik-Gel), N-seal, Drispac, and soda ash in the lower part	1303	1–R	Well completion report unavailable
R-7	Los Alamos Canyon	February 2001	Reverse-circulation fluid-assisted air-rotary methods with casing advance to 290 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1097 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1097	2–I 1–R	Stone et al. 2002
R-8	Los Alamos Canyon	February 2002	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 809 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 880 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	880	2–R	LANL, 2003b

Table 1. (continued)



Hydrogeologic Synthesis Report

Table 1-2.
Los Alamos National Laboratory Hydrogeologic Characterization Wells (continued)

Well	Location	Date Completed	Primary Drilling Methods	Type of Drilling Fluid Used	Total Depth (ft bgs*)	Number of Screens¹	Reference
R-9	Los Alamos Canyon	October 1999	A combination of reverse-circulation air-rotary methods in open hole to 175 ft, coring to 419 ft, and with casing advance and reverse-circulation air-rotary methods TD at 771 ft.	Air in upper part of the borehole and air with municipal water mixed with Quik-FOAM, EZ-MUD in the lower part	771	1–R	Broxton et al. 2001a
R-11	Sandia Canyon	August 2004	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 927 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	927	1–R	Kleinfelder, 2004c
R-12	Sandia Canyon	January 2000	A combination of reverse- circulation air-rotary methods in open hole and with casing advance to 710 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 886 ft.	Air and municipal water in the upper part and air with municipal water mixed with TORKEASE, Quik-FOAM, EZ-MUD in the lower part	886	2–I 1–R	Broxton et al. 2001
R-13	Mortandad Canyon	September 2001	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to TD at 1133 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1133	1–R	LANL 2003c
R-14	Mortandad Canyon	July 2002	Reverse-circulation fluid-assisted air-rotary methods in open hole to 1225 ft with hole cased to 1050 ft; conventional-circulation mud rotary drilling in open hole from 1225-1285 ft; reverse-circulation fluid-assisted air-rotary methods with casing advance from 1285 ft to TD at 1327 ft.	Air and municipal water mixed with EZ-MUD in the upper part and municipal water mixed with soda ash, bentonite, LIQUI-TROL, in the lower part	1327	2–R	LANL, 2003d
R-15	Mortandad Canyon	February 2000	Reverse-circulation fluid-assisted air-rotary methods with casing advance to TD at 1107 ft.	Air and municipal water mixed with TORKEASE, Quik-FOAM, EZ-MUD	1107	1–R	Longmire et al. 2000
R-16	White Rock Overlook	August 2002	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 729 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to 867 ft. Hole completed using conventional-circulation mud rotary methods from 867 ft to TD at 1287 ft.	Air and municipal water mixed Quick-gel, liqui-trol, Quick-FOAM, and soda ash in the upper part and municipal water mixed Quick-gel, EZ-MUD, liqui-trol, magma-fiber, n-seal in the lower part	1287	4–R	LANL, 2003e
R-18	Mesa above Pajarito Canyon	December 2004	Conventional-circulation fluid-assisted air-rotary drilling methods in an open hole to TD at 1440 ft.	Air and municipal water mixed with Quik-FOAM and EZ-MUD	1440	1–R	Well completion report unavailable

ER2005-0679 1-13 December 2005

Table 1. (continued)

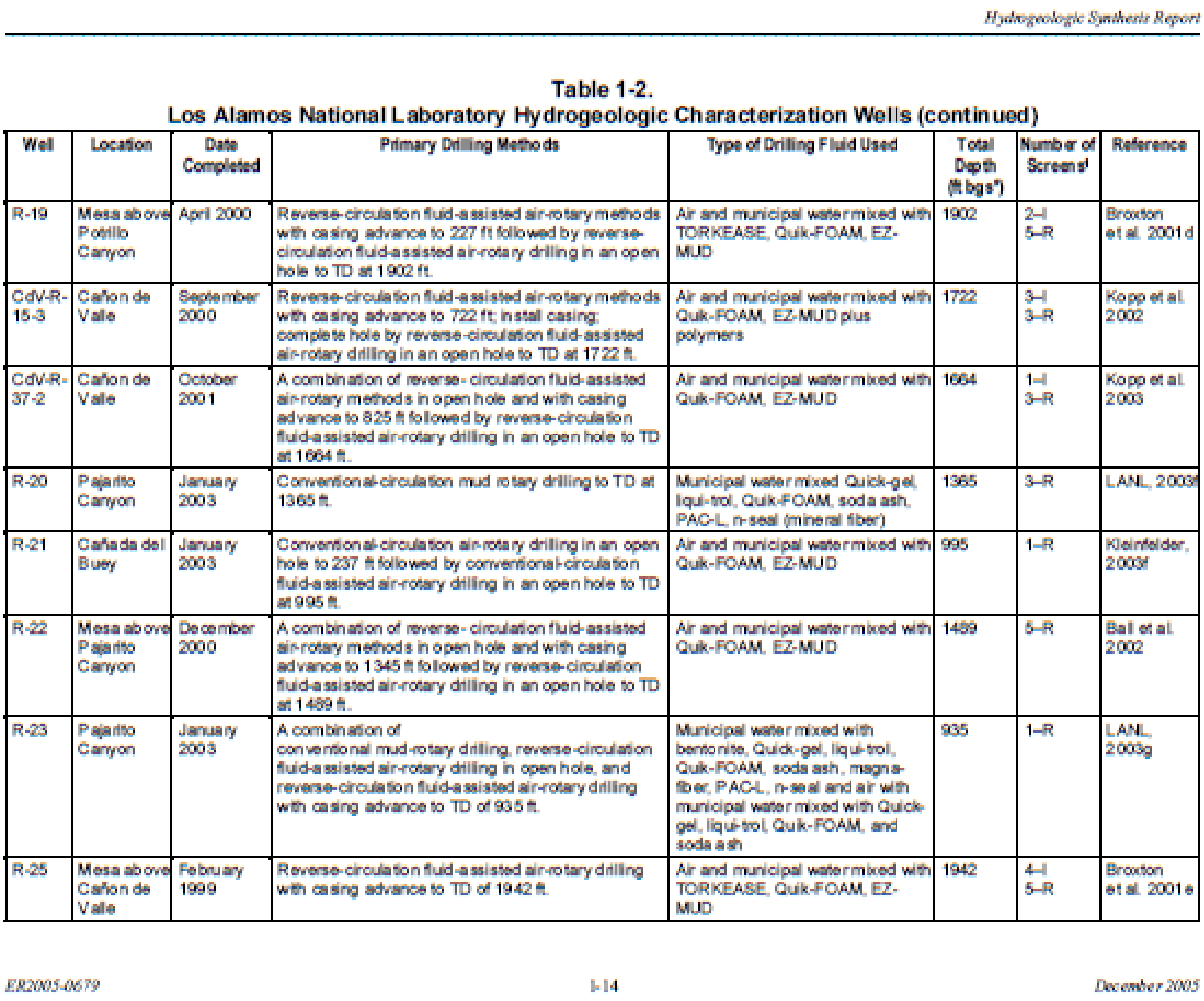


Table 1-2.
Los Alamos National Laboratory Hydrogeologic Characterization Wells (continued)

Well	Location	Date Completed	Primary Drilling Methods	Type of Drilling Fluid Used	Total Depth (ft bgs[*])	Number of Screens[1]	Reference
R-19	Mesa above Potrillo Canyon	April 2000	Reverse-circulation fluid-assisted air-rotary methods with casing advance to 227 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1902 ft.	Air and municipal water mixed with TORKEASE, Quik-FOAM, EZ-MUD	1902	2–I 5–R	Broxton et al. 2001d
CdV-R-15-3	Cañon de Valle	September 2000	Reverse-circulation fluid-assisted air-rotary methods with casing advance to 722 ft; install casing; complete hole by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1722 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD plus polymers	1722	3–I 3–R	Kopp et al. 2002
CdV-R-37-2	Cañon de Valle	October 2001	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 825 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1664 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1664	1–I 3–R	Kopp et al. 2003
R-20	Pajarito Canyon	January 2003	Conventional-circulation mud rotary drilling to TD at 1365 ft.	Municipal water mixed Quick-gel, liqui-trol, Quik-FOAM, soda ash, PAC-L, n-seal (mineral fiber)	1365	3–R	LANL, 2003f
R-21	Cañada del Buey	January 2003	Conventional-circulation air-rotary drilling in an open hole to 237 ft followed by conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 995 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	995	1–R	Kleinfelder, 2003f
R-22	Mesa above Pajarito Canyon	December 2000	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 1345 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1489 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1489	5–R	Ball et al. 2002
R-23	Pajarito Canyon	January 2003	A combination of conventional mud-rotary drilling, reverse-circulation fluid-assisted air-rotary drilling in open hole, and reverse-circulation fluid-assisted air-rotary drilling with casing advance to TD of 935 ft.	Municipal water mixed with bentonite, Quick-gel, liqui-trol, Quik-FOAM, soda ash, magna-fiber, PAC-L, n-seal and air with municipal water mixed with Quick-gel, liqui-trol, Quik-FOAM, and soda ash	935	1–R	LANL, 2003g
R-25	Mesa above Cañon de Valle	February 1999	Reverse-circulation fluid-assisted air-rotary drilling with casing advance to TD of 1942 ft.	Air and municipal water mixed with TORKEASE, Quik-FOAM, EZ-MUD	1942	4–I 5–R	Broxton et al. 2001e

Table 1. (continued)

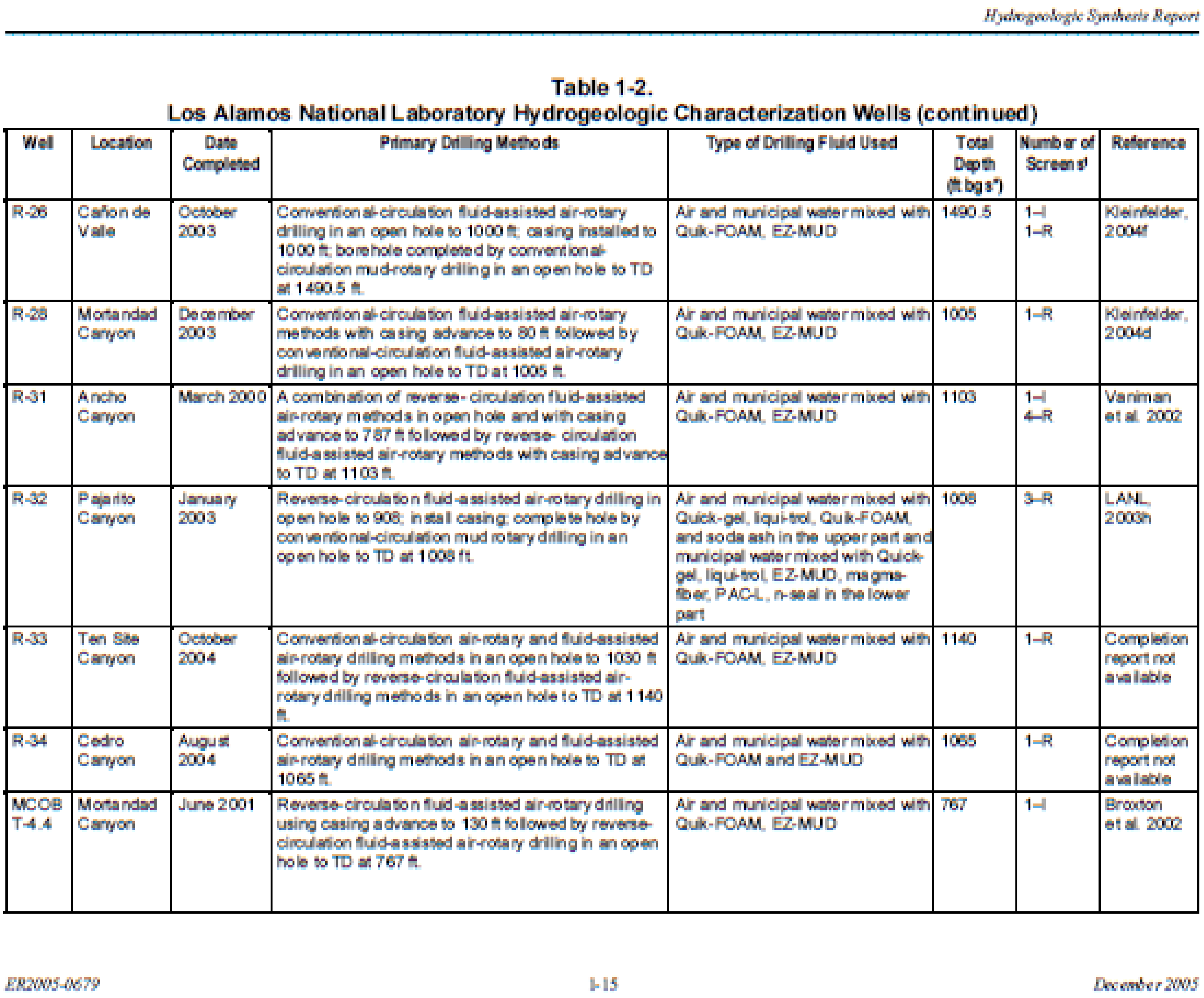


Table 1-2.
Los Alamos National Laboratory Hydrogeologic Characterization Wells (continued)

Well	Location	Date Completed	Primary Drilling Methods	Type of Drilling Fluid Used	Total Depth (ft bgs[*])	Number of Screens[†]	Reference
R-26	Cañon de Valle	October 2003	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to 1000 ft; casing installed to 1000 ft; borehole completed by conventional-circulation mud-rotary drilling in an open hole to TD at 1490.5 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1490.5	1–I 1–R	Kleinfelder, 2004f
R-28	Mortandad Canyon	December 2003	Conventional-circulation fluid-assisted air-rotary methods with casing advance to 80 ft followed by conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1005 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1005	1–R	Kleinfelder, 2004d
R-31	Ancho Canyon	March 2000	A combination of reverse- circulation fluid-assisted air-rotary methods in open hole and with casing advance to 787 ft followed by reverse- circulation fluid-assisted air-rotary methods with casing advance to TD at 1103 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1103	1–I 4–R	Vaniman et al. 2002
R-32	Pajarito Canyon	January 2003	Reverse-circulation fluid-assisted air-rotary drilling in open hole to 908; install casing; complete hole by conventional-circulation mud rotary drilling in an open hole to TD at 1008 ft.	Air and municipal water mixed with Quick-gel, liqui-trol, Quik-FOAM, and soda ash in the upper part and municipal water mixed with Quick-gel, liqui-trol, EZ-MUD, magma-fiber, PAC-L, n-seal in the lower part	1008	3–R	LANL 2003h
R-33	Ten Site Canyon	October 2004	Conventional-circulation air-rotary and fluid-assisted air-rotary drilling methods in an open hole to 1030 ft followed by reverse-circulation fluid-assisted air-rotary drilling methods in an open hole to TD at 1140 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1140	1–R	Completion report not available
R-34	Cedro Canyon	August 2004	Conventional-circulation air-rotary and fluid-assisted air-rotary drilling methods in an open hole to TD at 1065 ft.	Air and municipal water mixed with Quik-FOAM and EZ-MUD	1065	1–R	Completion report not available
MCOB T-4.4	Mortandad Canyon	June 2001	Reverse-circulation fluid-assisted air-rotary drilling using casing advance to 130 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 767 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	767	1–I	Broxton et al. 2002

Table 1. (continued)

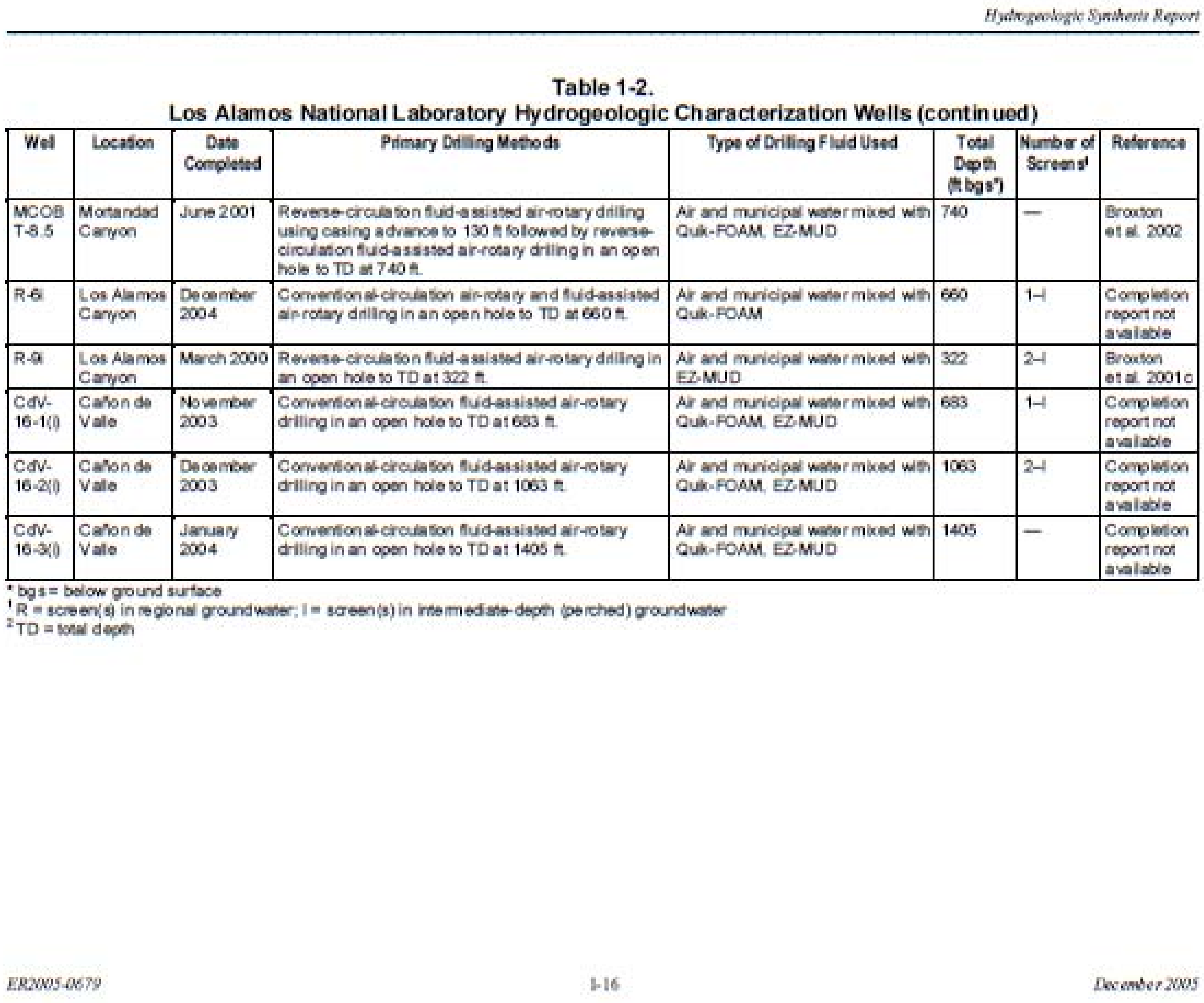


Table 1-2.
Los Alamos National Laboratory Hydrogeologic Characterization Wells (continued)

Well	Location	Date Completed	Primary Drilling Methods	Type of Drilling Fluid Used	Total Depth (ft bgs*)	Number of Screens¹	Reference
MCOB T-8.5	Mortandad Canyon	June 2001	Reverse-circulation fluid-assisted air-rotary drilling using casing advance to 130 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 740 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	740	—	Broxton et al. 2002
R-6i	Los Alamos Canyon	December 2004	Conventional-circulation air-rotary and fluid-assisted air-rotary drilling in an open hole to TD at 660 ft.	Air and municipal water mixed with Quik-FOAM	660	1-I	Completion report not available
R-9i	Los Alamos Canyon	March 2000	Reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 322 ft.	Air and municipal water mixed with EZ-MUD	322	2-I	Broxton et al. 2001c
CdV-16-1(i)	Cañon de Valle	November 2003	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 683 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	683	1-I	Completion report not available
CdV-16-2(i)	Cañon de Valle	December 2003	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1063 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1063	2-I	Completion report not available
CdV-16-3(i)	Cañon de Valle	January 2004	Conventional-circulation fluid-assisted air-rotary drilling in an open hole to TD at 1405 ft.	Air and municipal water mixed with Quik-FOAM, EZ-MUD	1405	—	Completion report not available

* bgs = below ground surface

[1] R = screen(s) in regional groundwater; I = screen(s) in intermediate-depth (perched) groundwater

[2] TD = total depth

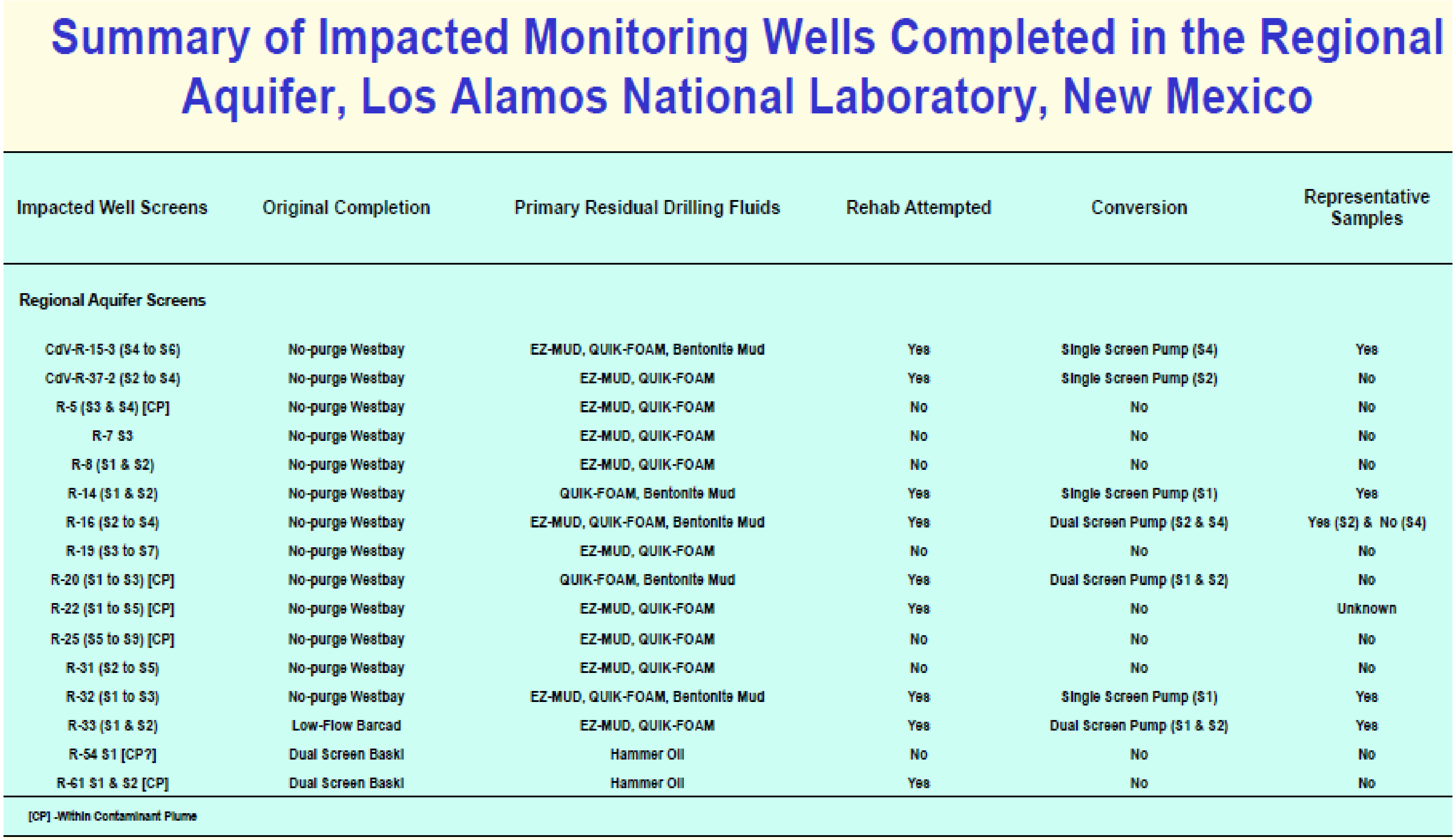
Table 2. Examples of Drilling Mud Invasion into LANL Monitoring Wells
Source: LANL *Well Screen Analysis Report – Revision 2*

Examples of Organic and Inorganic Drilling Fluids Used in Borehole Screen Intervals Drilled Primarily with Bentonite Mud

Well Screen	Screen Depth (ft)	Water (gal.)	Bentonite (lb)	PAC-L (lb)	N-SEAL (lb)	Soda Ash (lb)	MAGMA FIBER (lb)	QUIK-FOAM (gal.)	EZ-MUD (gal.)	LIQUI-TROL (gal.)
R-14 Screen 1	1205	14157	3836	95	247	0	292	23	0	3.2
R-14 Screen 2	1289	8485	2300	57	148	0	175	14	0	1.9
R-16 Screen 2	866	3120	2530	4	65	8	65	0	21	0.4
R-16 Screen 3	1018	2873	2330	4	60	8	60	0	19	0.4
R-16 Screen 4	1238	6550	5312	9	136	17	136	0	44	0.9
R-20 Screen 1	907	3253	614	17	9	0	54	0	0	7.7
R-20 Screen 2	1150	3361	634	18	9	0	56	0	0	8.0
R-20 Screen 3	1330	2784	525	15	8	0	46	0	0	6.5
R-32 Screen 1	871	7592	4234	8	135	0	135	0	4	0.7
R-32 Screen 3	976	7592	4234	8	135	0	135	0	4	0.7

Notes: This list is limited to screens in multiple-screen wells. It does not include the three single-screen wells drilled with bentonite mud (R-2, R-4, and R-6). This list does not include additional chemical treatments conducted after well installation. Information compiled by J. Pavletich from Well Completion Reports (LANL 2003, 076062; LANL 2003, 076061; LANL 2003, 079600; LANL 2003, 079602) and drillers' field logbooks. Quantities used in the interval are estimated from the total use by apportioning it according to the length of screen interval, including 10 ft above and below it. For example, if the total use over a 100-ft section is recorded as 90 gal. of Product X, and the screen interval is 10 ft, then the quantity used in that interval is estimated as 30-ft/100-ft = 0.33 x 90 gal. = 30 gal.

Table 3. List of LANL characterization wells and monitoring wells that do not provide representative groundwater samples SOURCE: Longmire et al (October 2013)



Summary of Impacted Monitoring Wells Completed in the Regional Aquifer, Los Alamos National Laboratory, New Mexico

Impacted Well Screens	Original Completion	Primary Residual Drilling Fluids	Rehab Attempted	Conversion	Representative Samples
Regional Aquifer Screens					
CdV-R-15-3 (S4 to S6)	No-purge Westbay	EZ-MUD, QUIK-FOAM, Bentonite Mud	Yes	Single Screen Pump (S4)	Yes
CdV-R-37-2 (S2 to S4)	No-purge Westbay	EZ-MUD, QUIK-FOAM	Yes	Single Screen Pump (S2)	No
R-5 (S3 & S4) [CP]	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-7 S3	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-8 (S1 & S2)	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-14 (S1 & S2)	No-purge Westbay	QUIK-FOAM, Bentonite Mud	Yes	Single Screen Pump (S1)	Yes
R-16 (S2 to S4)	No-purge Westbay	EZ-MUD, QUIK-FOAM, Bentonite Mud	Yes	Dual Screen Pump (S2 & S4)	Yes (S2) & No (S4)
R-19 (S3 to S7)	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-20 (S1 to S3) [CP]	No-purge Westbay	QUIK-FOAM, Bentonite Mud	Yes	Dual Screen Pump (S1 & S2)	No
R-22 (S1 to S5) [CP]	No-purge Westbay	EZ-MUD, QUIK-FOAM	Yes	No	Unknown
R-25 (S5 to S9) [CP]	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-31 (S2 to S5)	No-purge Westbay	EZ-MUD, QUIK-FOAM	No	No	No
R-32 (S1 to S3)	No-purge Westbay	EZ-MUD, QUIK-FOAM, Bentonite Mud	Yes	Single Screen Pump (S1)	Yes
R-33 (S1 & S2)	Low-Flow Barcad	EZ-MUD, QUIK-FOAM	Yes	Dual Screen Pump (S1 & S2)	Yes
R-54 S1 [CP?]	Dual Screen Baski	Hammer Oil	No	No	No
R-61 S1 & S2 [CP]	Dual Screen Baski	Hammer Oil	Yes	No	No

[CP] -Within Contaminant Plume

Table 4. “TABLE 3.2[*] Nine of 25 Principal Material Disposal Areas at LANL” ***in*** National Research Council 2007 Final Report ***Plans and Practices for Groundwater Protection at the Los Alamos National Laboratory***

Material **Disposal Area (MDA)**	**Location (Technical Area)**	**Period of Operation**	**Key Radionuclide Inventory**
- A	**21**	**1944-1978**	**Pu ~ 701 Ci, Am ~ 1.5 Ci**
- B	**21**	**1945-1952**	**Pu ~ 6.22 Ci, Sr-90 ~ 0.285 Ci, Cs ~ 0.005 Ci**
- T	**21**	**1945-1986**	**Pu ~ 182 Ci, Am ~ 3740 Ci, U ~ 6.9 Ci**
- U	**21**	**1948-1976**	**Unknown (Am, Cs, Pu, tritium, Sr, U)**
- V	**21**	**1945-1961**	**Unknown (Am, Cs, Pu, Sr-90, U, tritium)**
- AB	**49**	**1959-1961**	**Pu ~ 23,000 Ci (includes ~ 20,600 Ci of Pu- 241, which has a 14.4-year half-life, and ~ 2300 Ci of Pu-239, which has a 24,000-year half-life), U ~ 0.246 Ci**
- C	**50**	**1948-1974**	**Tritium ~ 20000 Ci, Sr-90 ~ 21 Ci, U ~ 25 Ci, Pu ~ 26 Ci, Am ~ 145 Ci**
- G	**54**	**1957-1997**[**]	**Am ~ 2360 Ci, Cs ~2810 Ci, Tritium ~ 3,610,000 Ci, Pu ~ 16,000 Ci, Sr-90 ~ 3500 Ci, U ~ 124 Ci**
- H	**54**	**1960-1986**	**Tritium ~ 240 Ci, Pu ~ 0.0267 Ci, U ~ 75.2 Ci**

[*] **Table 3.2 is from the NAS 2007 Final Report on the LANL Groundwater Protection Practices**

[**] **(Parts of MDA G remain active today for disposal of radioactive wastes as “Area G”)**

- **Ci = Curies of radioactivity**
- **Pu = plutonium, Am = americium, Sr = strontium, Cs = Cesium, U = uranium**

Table 5. Table 4-14 in DOE LANL 2008 Performance Assessment Composite Analysis (PACA) Report for Area G

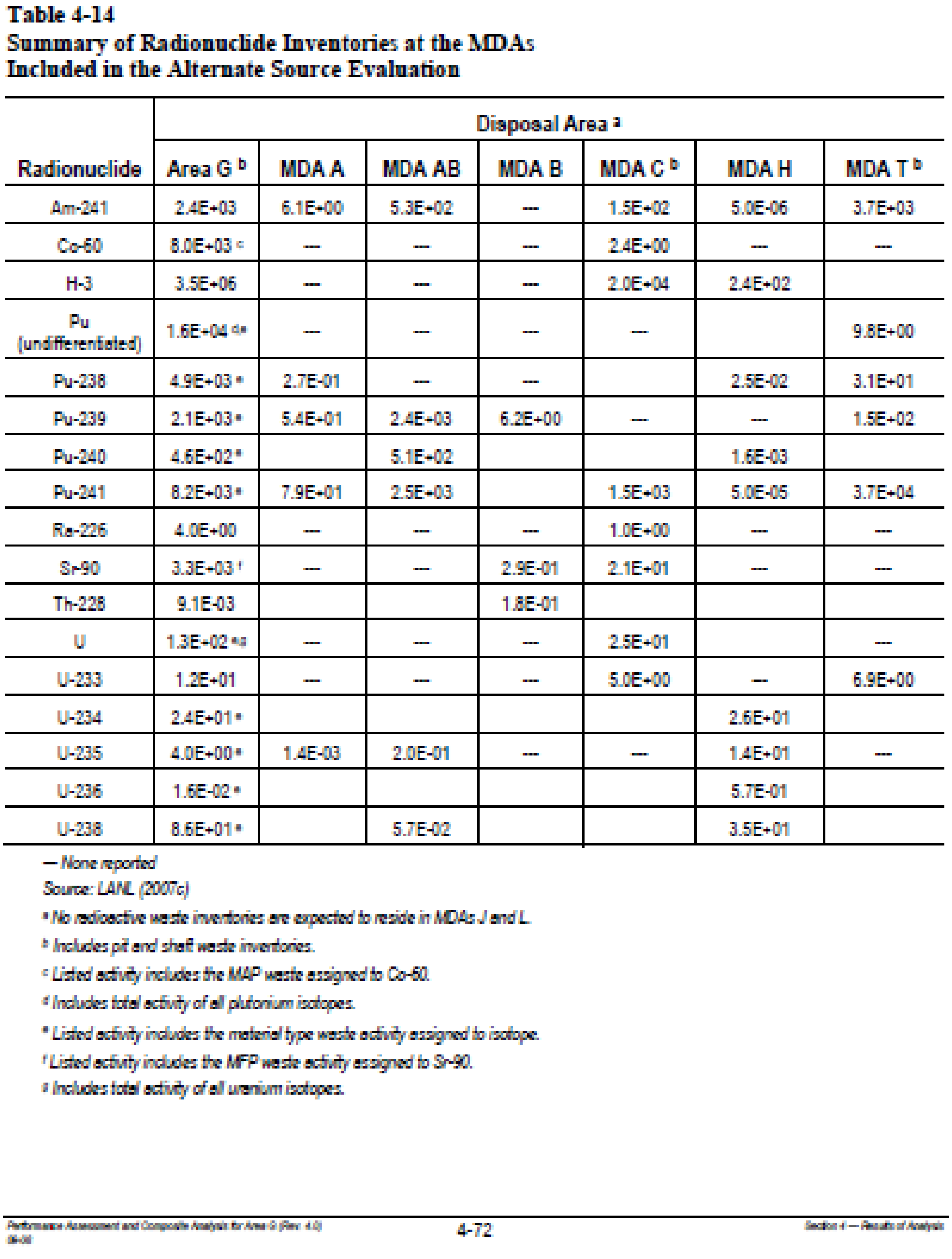


Table 4-14
Summary of Radionuclide Inventories at the MDAs Included in the Alternate Source Evaluation

Radionuclide	Disposal Area [a]						
	Area G [b]	MDA A	MDA AB	MDA B	MDA C [b]	MDA H	MDA T [b]
Am-241	2.4E+03	6.1E+00	5.3E+02	---	1.5E+02	5.0E-06	3.7E+03
Co-60	8.0E+03 [c]	---	---	---	2.4E+00	---	---
H-3	3.5E+06	---	---	---	2.0E+04	2.4E+02	
Pu (undifferentiated)	1.6E+04 [d,e]	---	---	---	---		9.8E+00
Pu-238	4.9E+03 [e]	2.7E-01	---	---		2.5E-02	3.1E+01
Pu-239	2.1E+03 [e]	5.4E+01	2.4E+03	6.2E+00	---	---	1.5E+02
Pu-240	4.6E+02 [e]		5.1E+02			1.6E-03	
Pu-241	8.2E+03 [e]	7.9E+01	2.5E+03		1.5E+03	5.0E-05	3.7E+04
Ra-226	4.0E+00	---	---	---	1.0E+00	---	---
Sr-90	3.3E+03 [f]	---	---	2.9E-01	2.1E+01	---	---
Th-228	9.1E-03			1.8E-01			
U	1.3E+02 [e,g]	---	---	---	2.5E+01		---
U-233	1.2E+01	---	---	---	5.0E+00	---	6.9E+00
U-234	2.4E+01 [e]					2.6E+01	
U-235	4.0E+00 [e]	1.4E-03	2.0E-01	---	---	1.4E+01	---
U-236	1.6E-02 [e]					5.7E-01	
U-238	8.6E+01 [e]		5.7E-02			3.5E+01	

— None reported

Source: LANL (2007c)

[a] *No radioactive waste inventories are expected to reside in MDAs J and L.*

[b] *Includes pit and shaft waste inventories.*

[c] *Listed activity includes the MAP waste assigned to Co-60.*

[d] *Includes total activity of all plutonium isotopes.*

[e] *Listed activity includes the material type waste activity assigned to isotope.*

[f] *Listed activity includes the MFP waste activity assigned to Sr-90.*

[g] *Includes total activity of all uranium isotopes.*

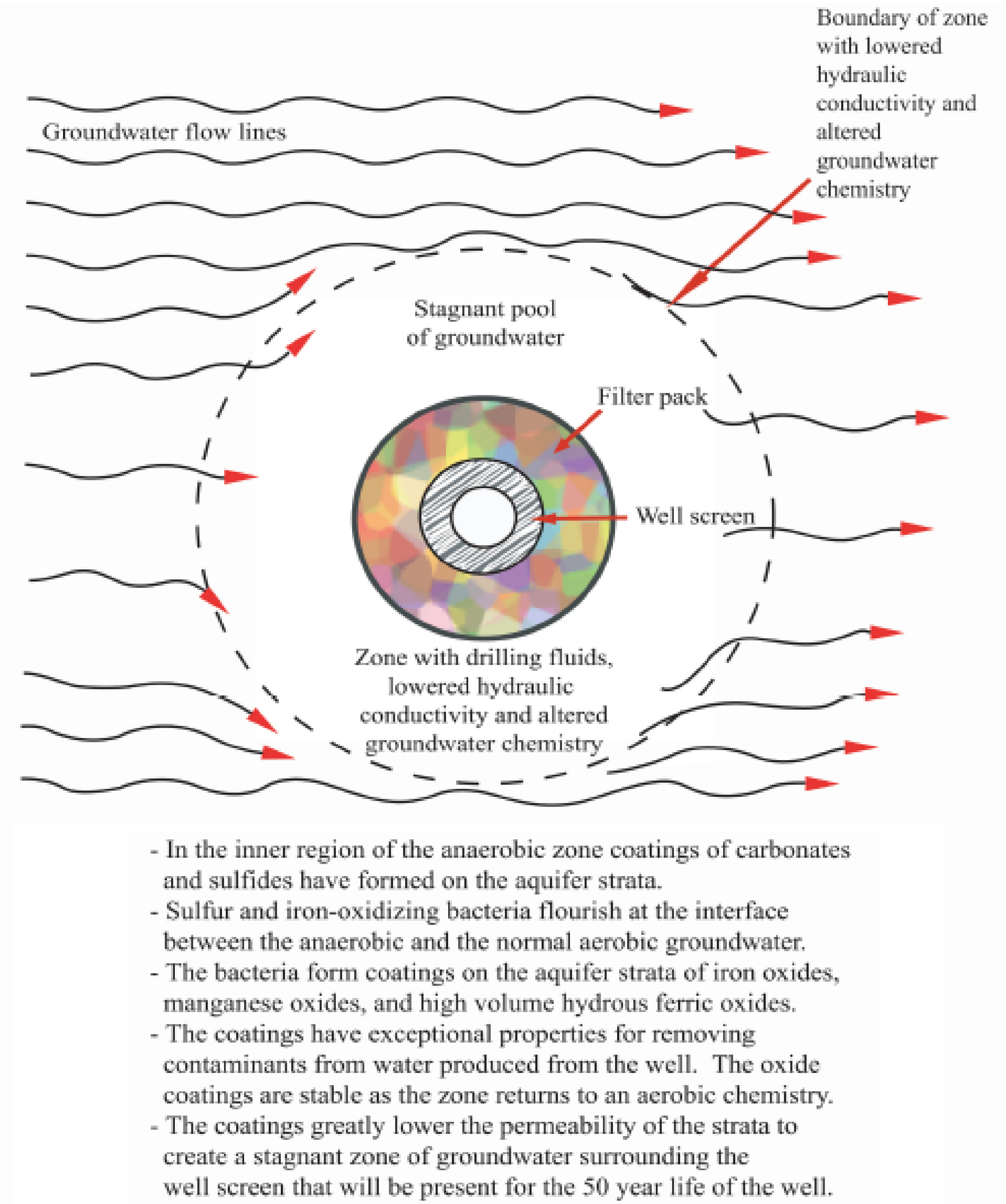
Performance Assessment and Composite Analysis for Area G (Rev. 4.0)
08-08
4-72
Section 4 — Results of Analysis

Figure 1. *"Figure 1-1. Map showing the location of wells and Rio Grande springs referenced in this report"* ***in*** Well Screen Analysis Report, Revision 1 (LA-UR-07-0873, Feb 2007)

NOTE: The figure displays 42 characterization wells installed for the LANL Hydrogeologic Workplan

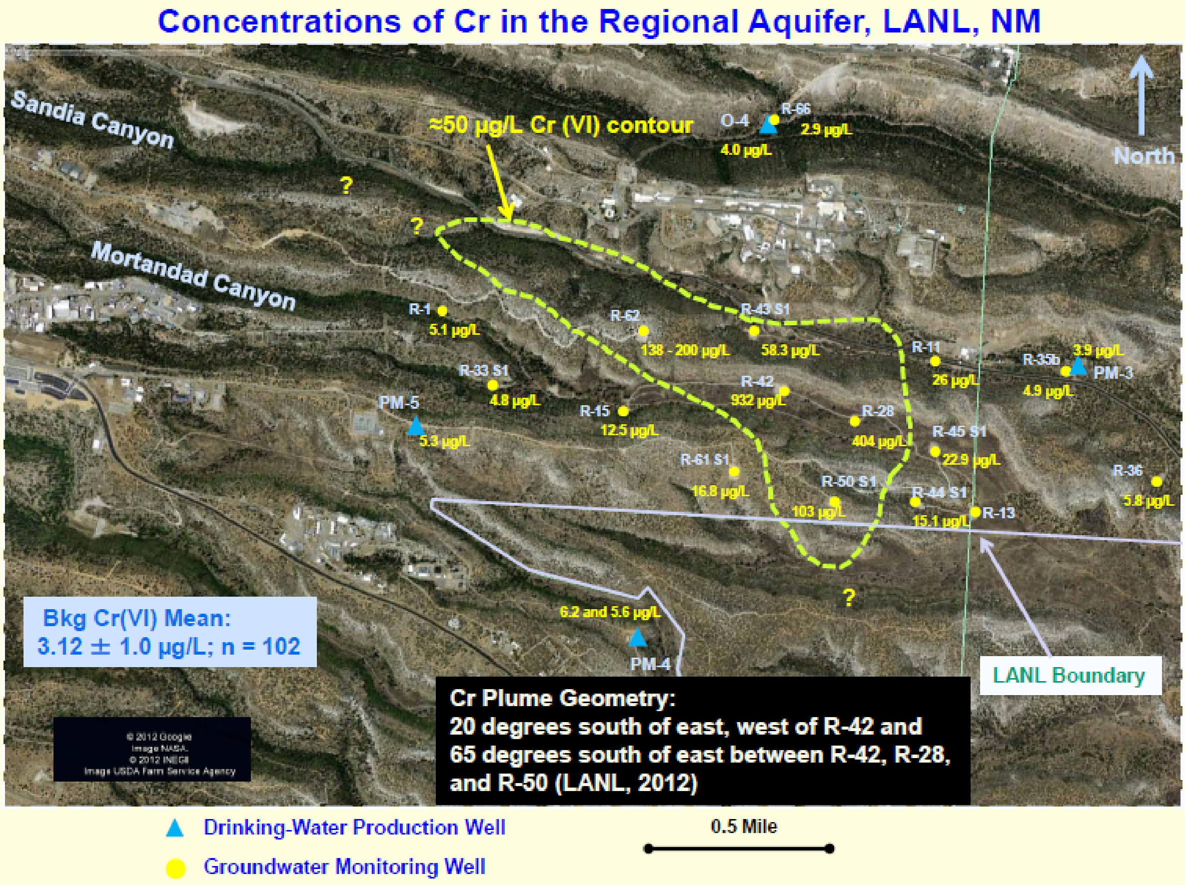
Figure 2. The figure below from the NAS 2007 report shows the properties of the new zone surrounding the well screens in the LANL characterization wells displayed on Figure 1 that was caused by the drilling fluids.

Figure 5.2 *in* the NAS 2007 Report. “Reactive contaminant capture barrier. Geologist Robert Gilkeson described concepts of how drilling fluids could form a zone that removes contaminants from sampled groundwater. This would invalidate affected well screens as sampling points. SORCE: Adapted from Gilkeson, 2006a.”



- In the inner region of the anaerobic zone coatings of carbonates and sulfides have formed on the aquifer strata.
- Sulfur and iron-oxidizing bacteria flourish at the interface between the anaerobic and the normal aerobic groundwater.
- The bacteria form coatings on the aquifer strata of iron oxides, manganese oxides, and high volume hydrous ferric oxides.
- The coatings have exceptional properties for removing contaminants from water produced from the well. The oxide coatings are stable as the zone returns to an aerobic chemistry.
- The coatings greatly lower the permeability of the strata to create a stagnant zone of groundwater surrounding the well screen that will be present for the 50 year life of the well.

Figure 3. Three PowerPoint Slides from Longmire et al September 2013



Concentrations of Cr in the Regional Aquifer, LANL, NM

Bkg Cr(VI) Mean:
3.12 ± 1.0 μg/L; n = 102

LANL Boundary

Cr Plume Geometry:
20 degrees south of east, west of R-42 and 65 degrees south of east between R-42, R-28, and R-50 (LANL, 2012)

▲ Drinking-Water Production Well

● Groundwater Monitoring Well

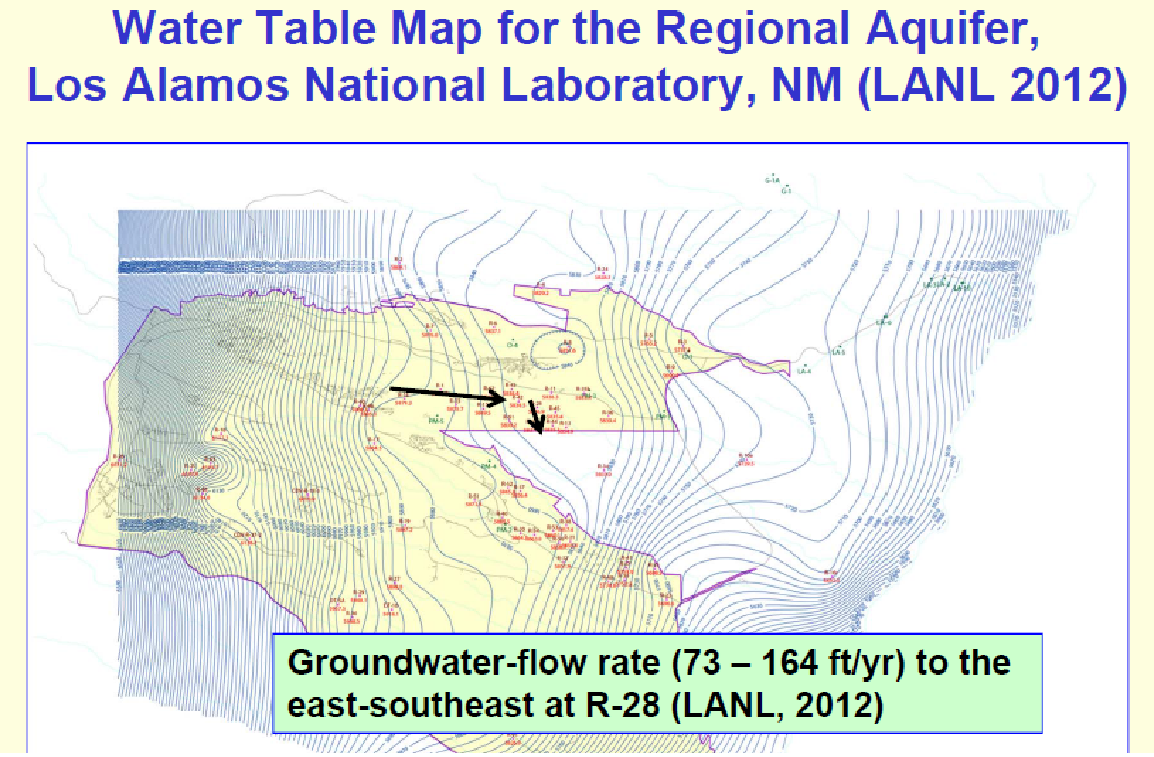
The above map shows the best information on the boundary of the hexavalent chromium plume below the LANL Facility and the property of the Pueblo de San Ildefonso. The dashed yellow contour line is for hexavalent chromium in the regional aquifer at 50 ug/L (50 parts per billion).

The Power Point slide on the next page shows the belief by the DOE Oversight Bureau and the NMED Hazardous Waste Bureau that the flow direction of the hexavalent chromium plume and also the perchlorate plume (see Figure 3 below) is onto the property of the Pueblo de San Ildefonso at a flow rate of up to 164 feet per year.

Important conclusions in Longmire et al (September 2013) include 1) the dissolved hexavalent chromium will not be removed by natural attenuation and 2) there is not sufficient knowledge of the nature and extent of the hexavalent chromium plume in the regional aquifer at the present time (see the Summary and Conclusions slide on the next page).

An additional important conclusion in Longmire et al (September 2013) is that 11 of the monitoring wells installed in the regional aquifer (a total of 27 screened zones) do not produce representative groundwater samples for accurate knowledge of groundwater contamination (see Table 3 in this Public Comment).

Figure 3 (continued). PowerPoint slide from Longmire et al September 2013



Water Table Map for the Regional Aquifer, Los Alamos National Laboratory, NM (LANL 2012)

Groundwater-flow rate (73 – 164 ft/yr) to the east-southeast at R-28 (LANL, 2012)

Figure 3 (continued). Summary and Conclusions in Longmire et al September 2013

Summary and Conclusions

- **Soluble chromium(VI) is stable in the regional-aquifer system characterized by strongly oxidizing conditions with respect to iron, dissolved oxygen, and manganese.**
- **Chromium is migrating at nearly the same rate of groundwater flow within the regional aquifer (Puye Formation and Miocene pumiceous sediments).**
- **The mass, nature, and extent of chromium contamination in the vadose zone and regional aquifer is not completely known.**
- **Natural attenuation of chromium(VI) is not an effective process taking place in the regional-aquifer system.**
- **Successful aquifer remediation of chromium in the regional aquifer requires complete understanding of:**
  - **Nature and extent of contamination and**
  - **Geochemical, biochemical, and hydrologic characteristics.**

Figure 4. Figure 1.0-2 in Interim Measures Work Plan for the Evaluation of Chromium Mass Removal (LA-UR-13-22534 April 2013)

NOTE: See caption for Figure 1.0-2 below,

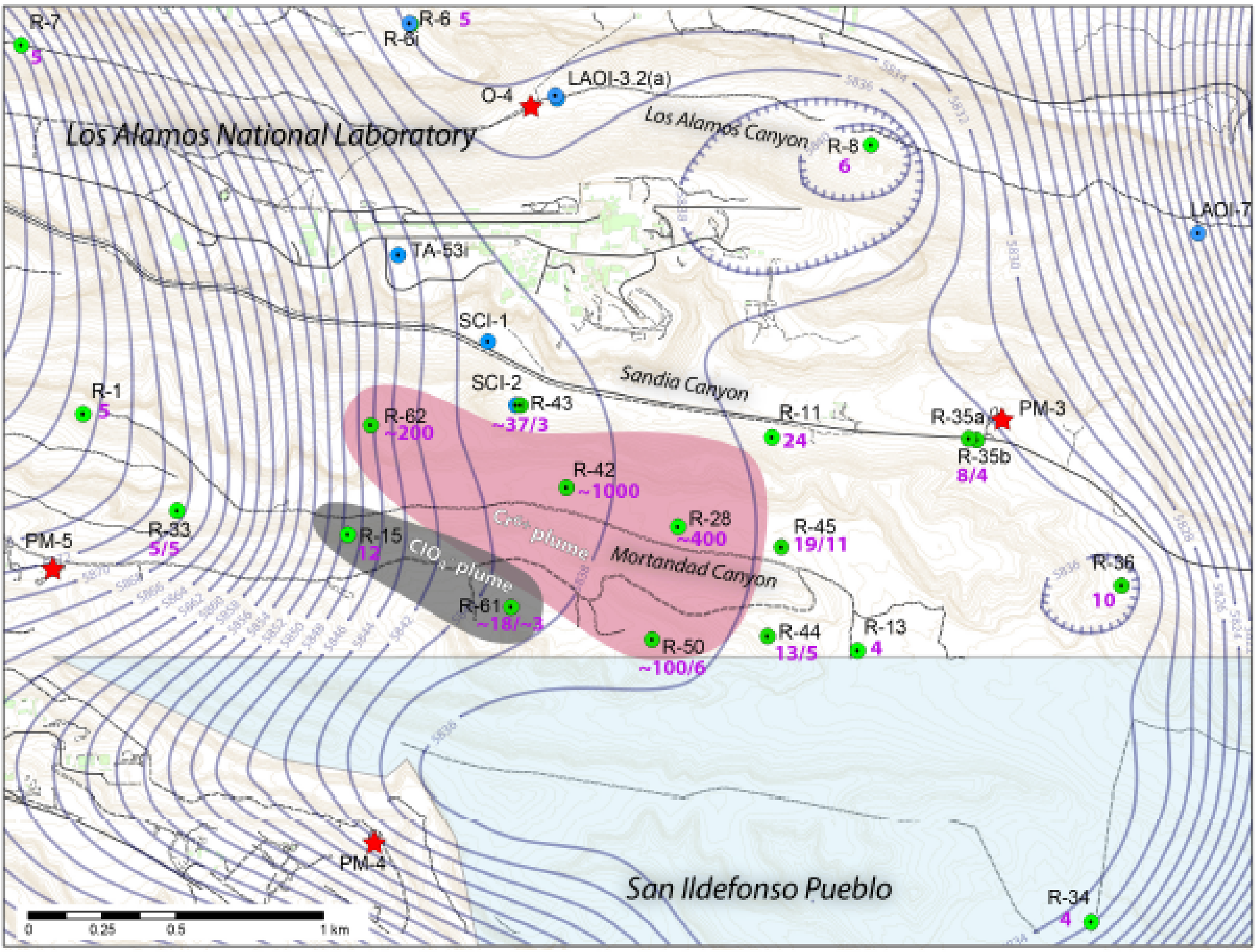


Figure 1.0-2 Plan view of the Cr(VI) plume (>50 ppb contour shown in pink) in the regional aquifer with nearby regional monitoring wells (green circles), perched-intermediate monitoring wells (blue circles), and water-supply wells (red stars). Contour lines (2-ft intervals) represent the regional water table elevations. The approximate area of perchlorate contamination greater than approximately 2 ppb in the regional aquifer is shown in grey. Numbers beneath the well names refer to the approximate chromium concentrations. Two numbers represent concentrations for upper and lower screens.

Figure 4 shows the concentration of dissolved hexavalent chromium in well R-50 a short distance north of the Pueblo de San Ildefonso is 100 ug/L (100 parts per billion). An important issue for the LANL NRDA TC to be aware of is that California is in the process of promulgation a Drinking Water Standard for hexavalent chromium of 10 ug/L (10 parts per billion) http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx

Figure 4 shows the concentration of dissolved perchlorate in regional aquifer monitoring well R-61 is 18 ug/L. It is important to note that the perchlorate contamination in well R-61 may be much greater than 18 ug/L because the two well screens are contaminated with hammer oil introduced during the drilling operations. Longmire et al (September 2013) identified well R-61 to not produce representative groundwater samples (see Table 3).

Figure 5. Figure 1.0-1 in Interim Measures Work Plan for the Evaluation of Chromium Mass Removal (LA-UR-13-22534 April 2013)

Figure 1.0-1. Conceptual three dimensional representation of surface-water and groundwater flow paths that influence chromium migration

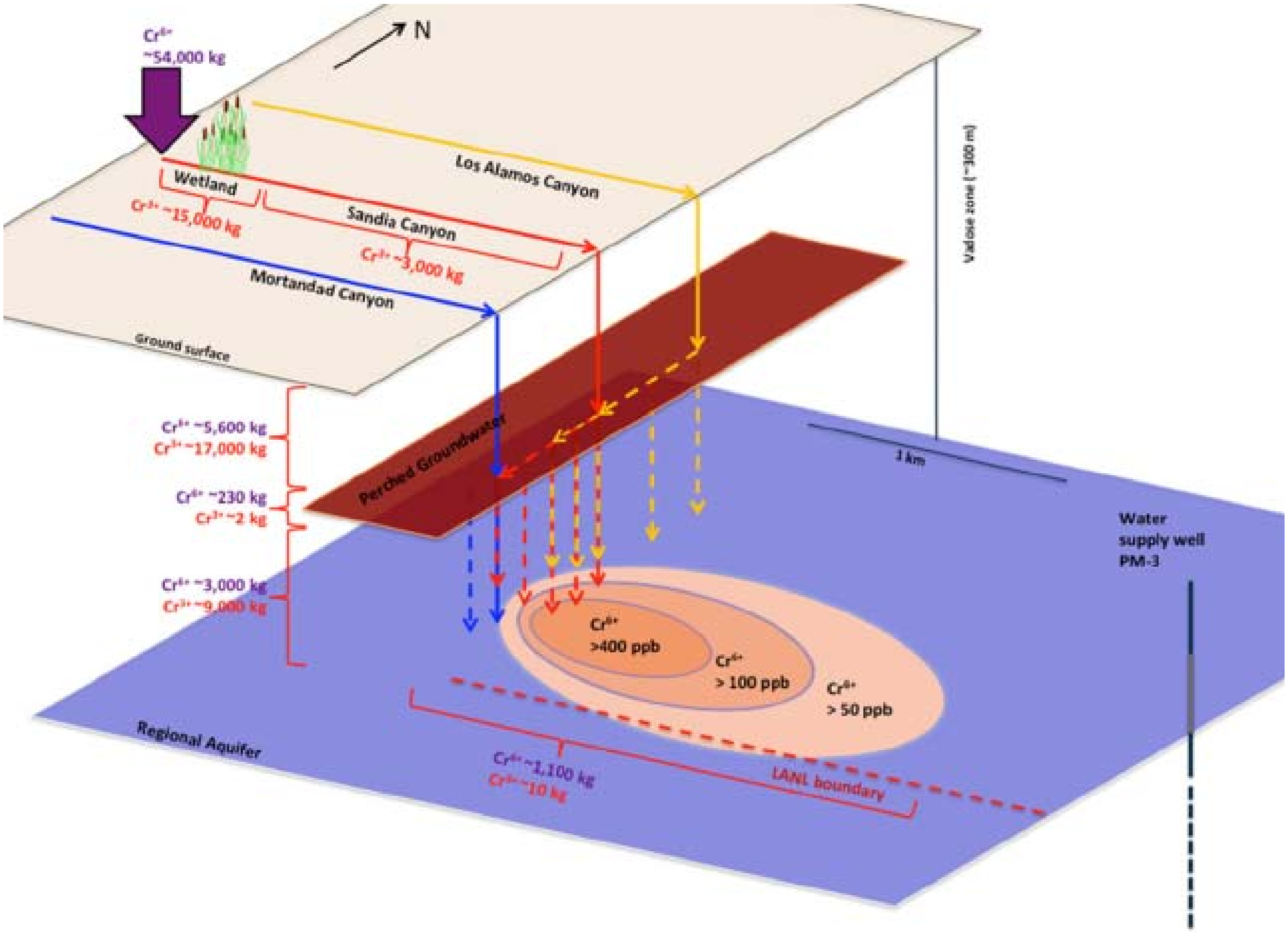


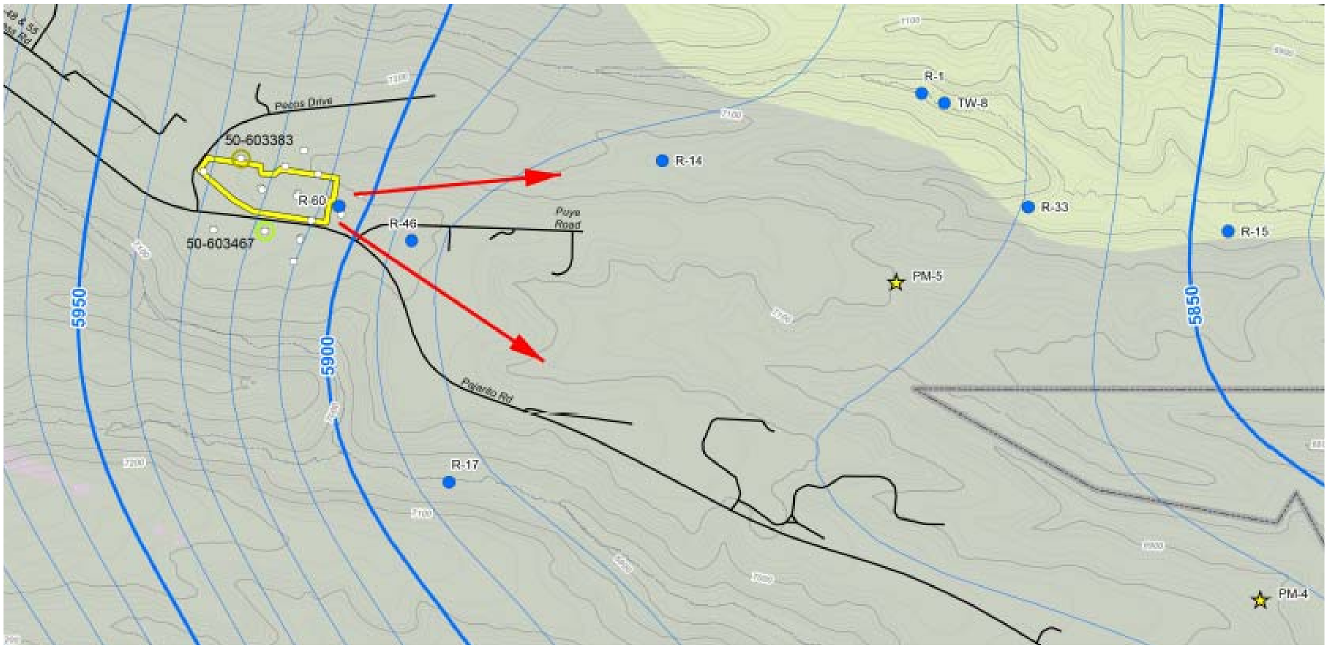
Figure 1.0-1. Conceptual three dimensional representation of surface-water and groundwater flow paths that influence chromium migration

The above figure shows the groundwater contaminated with hexavalent chromium has flowed downward from perched zones to the water table of the regional aquifer below Mortandad Canyon.

The figure shows that the flow of the hexavalent chromium plume and also the perchlorate plume (see Figure 3 above) is onto and across the property of the Pueblo de San Ildefonso to the highly productive Los Alamos County Supply Well PM-4. The hydraulic flow field in the regional aquifer toward well PM-4 is because of the highly productive aquifer strata and the very large withdrawal of groundwater that has occurred over the many decades of pumping at well PM-4.

The LANL NRDA requires accurate knowledge of the flow of the hexavalent chromium plume and the perchlorate plume onto and across the property of the Pueblo de San Ildefonso to Los Alamos County Supply Well PM-4. This knowledge does not exist at this time and requires installation of many monitoring wells and the performance of pumping tests.

Figure 6. Expanded view of "Figure F-1.0-1 Locations of the existing regional monitoring wells near MDA C, including the elevation of the regional water table representative of September 2010, the hydrostratigraphic units along the regional water table near MDA C, and two potential source areas" ***in*** Corrective Measures Evaluation Report for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50 (LA-UR-12-24944 September 2012).



Scale 0---------------1,500 feet

The yellow line is the boundary of MDA C

R-60 and R-46 are regional aquifer monitoring wells installed for the NMED Consent Order

R-17, R-14, R-1, R-33, and R-15 are regional aquifer characterization wells installed for the LANL Hydrogeologic Workplan

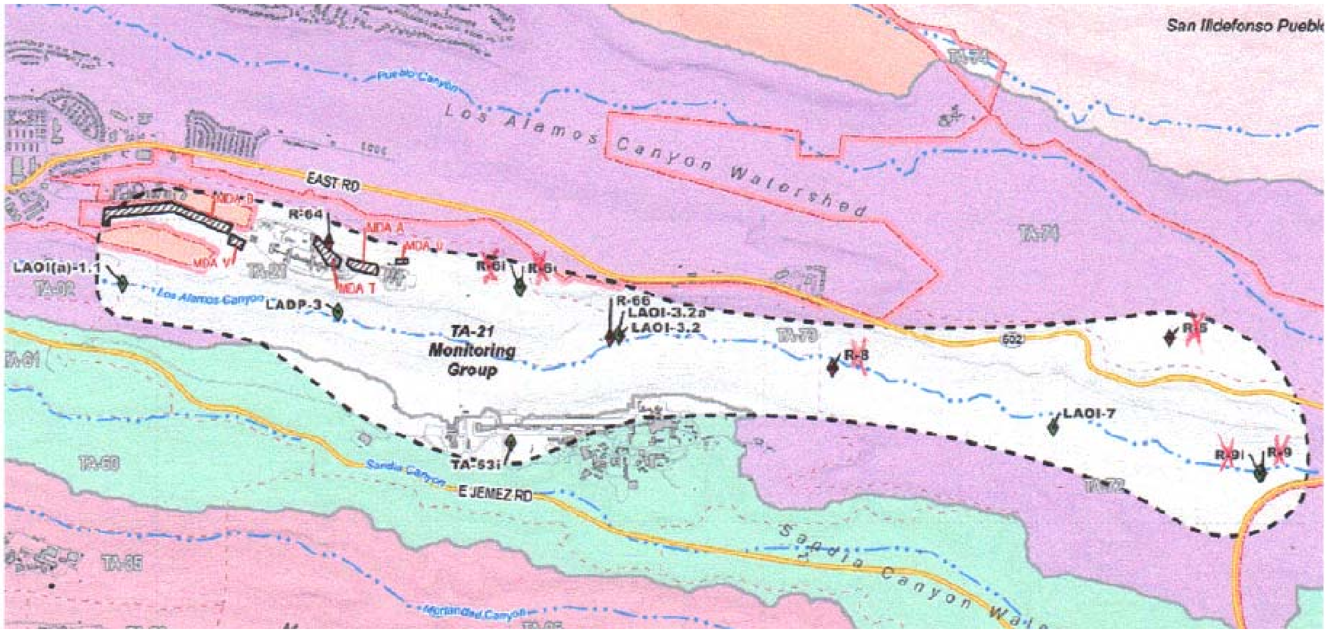
TW8 is an old unreliable test well in Mortandad Canyon that was installed in 1960 to a total depth of 1,065 ft below ground surface. The screened interval was formed by cutting slots in the bottom 112 feet of the steel casing. Well TW8 does not produce representative groundwater samples for detection of groundwater contamination. Well TW8 should have been plugged and abandoned fifty years ago.

PM-5 and PM-4 are Los Alamos County drinking water supply wells. PM-4 is located south of the Pueblo de San Ildefonso.

The red arrows pointing away from MDA C display the great uncertainty in the direction of groundwater flow away from MDA C because there are not a sufficient number of monitoring wells installed in the regional aquifer. For example from page F-2 of the LANL 2012 MDA C CME Report:

> However, the groundwater flow directions in the regional aquifer beneath MDA C are uncertain because of the low density of existing wells in the vicinity of MDA C; more specifically, the water-level data for defining regional flow directions west and north of MDA C are limited.

Figure 7. “Figure 2.1-1 TA-21 Monitoring Group” ***in*** LANL Monitoring Year 2014 Interim Facility-Wide Groundwater Monitoring Plan (LANL MY2014 IFWGMP)



Scale 0--------------½------------1 mile

The monitoring well network at TA-21 is insufficient for 1. accurate knowledge of the direction of groundwater travel in the regional aquifer, 2. the speed of groundwater travel and 3. the detection of groundwater contamination for the wastes buried in the unlined trenches and shafts at TA-21. <u>There is an immediate need to install additional monitoring wells.</u>

The 2007 NAS Report lists a large inventory of radionuclides in the waste buried in the unlined MDAs A, B, T, U and V at TA-21. See Table 4 in these public comments.

Well R-64 is the only monitoring well installed close to the TA-21 MDAs. However, this well requires replacement because the bentonite clay grout used to seal the borehole flowed into the sampling zone during the well development. From an NMED letter dated March 30, 2012:

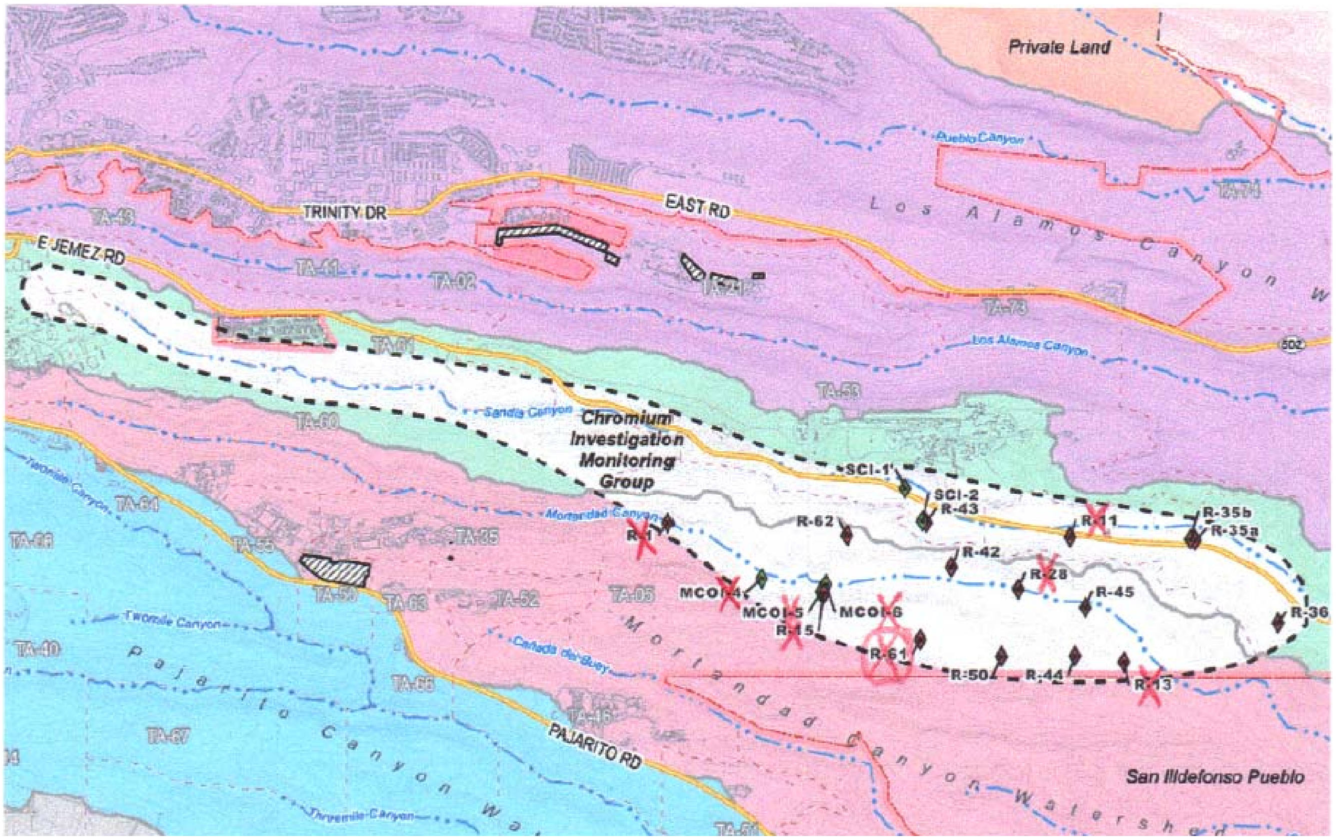
> “Purge water extracted in excess of six casing volumes from R-64 during the last two sampling events, conducted on December 8, 2011 and March 26,2012, contained significant amounts of fme-grained solid material. An aliquot of the solid material collected during the December sampling event was analyzed by the Permittees using xray diffraction. X-ray analysis indicated that the solid material was bentonite, indicative of backfill-sealant material used at R-64,”

There is an immediate requirement to perform the push-pull tracer tests recommended by the NMED and the EPA Kerr Lab to determine the ability of well R-64 to provide reliable and representative groundwater samples for contaminants of concern at the MDAs at TA-21.

Besides unreliable well R-64, on the above figure, there are six unreliable characterization wells used for monitoring groundwater contamination from the MDAs at TA-21.

An additional very serious issued is that the LANL MY2014 IFWGMP states on page 10 that ***“Shallow regional groundwater in the vicinity of TA-21 generally flows to the east-northeast.”*** However, the above figure shows that there are **<u>no</u>** monitoring wells located northeast of TA-21.

Figure 8. “Figure 3.1-1 Chromium Investigation Monitoring Group” *in* LANL 2014 Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan



Scale 0-----------½----------1 mile

The network of monitoring wells in the “Chromium Investigation Monitoring Group“ is insufficient for the required knowledge of the nature and extent of the hexavalent chromium plume.

There is a special concern for the nature and extent of the hexavalent chromium plume and the parallel perchlorate plume on the property of the Pueblo de San Ildefonso (see Figures 2, 3 and 3 above.) No monitoring wells have been installed on the property of the Pueblo de San Ildefonso to determine the southward extent of the two plumes.

A very serious issue is that the 7 characterization wells on the above figure are not reliable to detect groundwater contamination from the large volume of liquid radioactive wastes that were discharged to Mortandad Canyon for greater than the past 50 years. The contaminants of concern in Mortandad Canyon were described as follows on page 1 in the LANL Well Completion Report for Characterization Well R-28:

> R-28 is located in Mortandad Canyon and will provide a contaminant analysis-and-monitoring point for comparison with regional well R-15, located upstream; R-11, located to the northeast in Sandia Canyon; and R-13, located to the southeast, downstream in Mortandad Canyon. . . Contaminants have been identified in alluvial and perched intermediate groundwater and in the regional aquifer within Mortandad Canyon. Historically, constituents that have been detected in surface water and alluvial

> groundwater include: americium-241; cesium-137; plutonium-238 and plutonium-239, 240; strontium-90; tritium; uranium-234, 235, 236, 238; nitrate; perchlorate; chloride; sulfate; fluoride; and total dissolved solids. . . Mortandad Canyon and its tributaries have received effluents from Los Alamos National Laboratory (LANL or the Laboratory) since the early 1950s.These effluents discharged from TA-3, TA-35, TA-48, and TA-50 have contained a variety of contaminants including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium (LANL 1997, 56835). Active outfalls at TA-3 and TA-50 discharged to Mortandad Canyon. Most contaminants found in Mortandad Canyon are associated with TA-50 discharges into Effluent Canyon except for sources of strontium-90, nitrate, and perchlorate. Strontium-90, nitrate, and perchlorate were discharged from TA-35 into Pratt Canyon; total masses of nitrate and perchlorate discharged are not known.

Characterization Well R-28 does not produce representative groundwater samples for detection of groundwater contamination with the large list of radionuclides in the above excerpt. The organic drilling additives QUIK-FOAM AND EZ-MUD were allowed to flow into the aquifer zone surrounding the well screen.

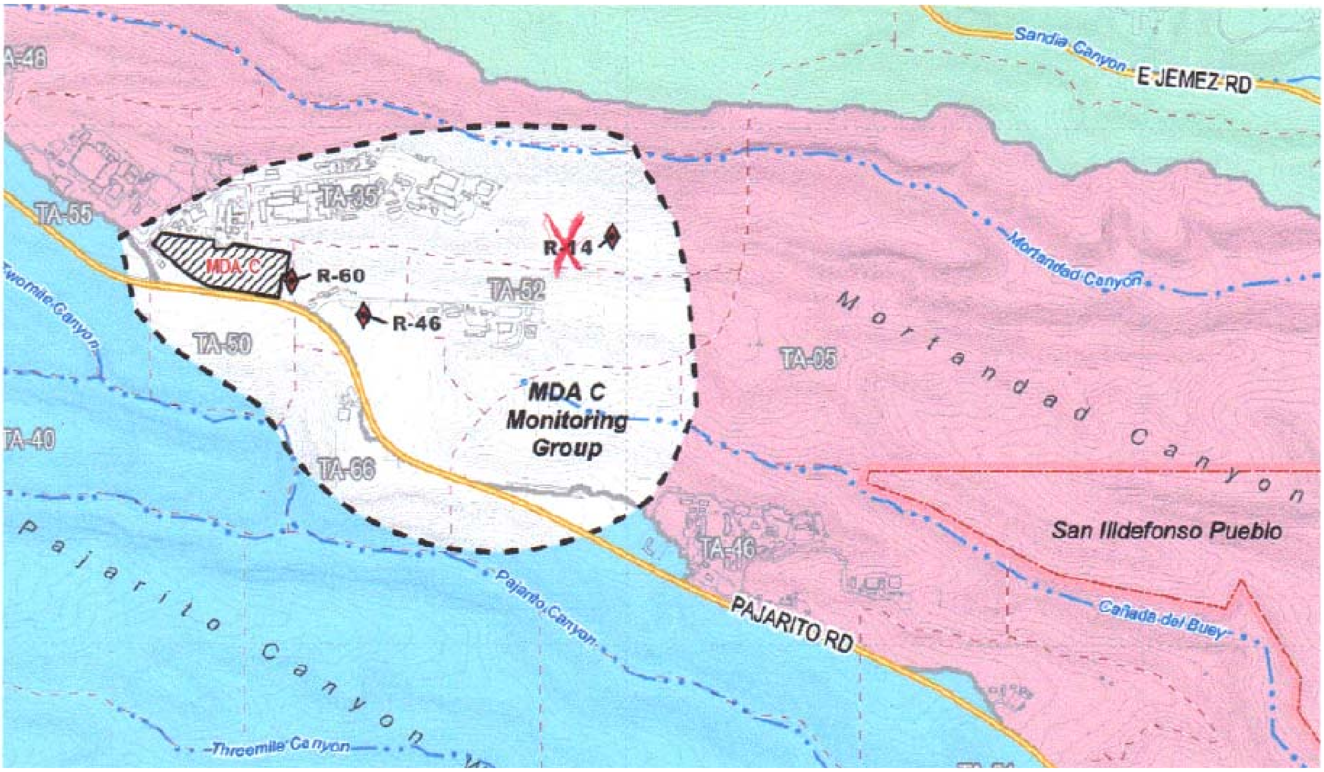
An additional very serious issue for well R-28 is that the top of the 24-foot long well screen is installed greater than 40 feet below the water table of the regional aquifer. Figure 3 shows that well R-28 is locacted in the hexavalent chromium plume. The highest concentrations of hexavalent chromium are expected to be close to the water table (see Figure 4 above).

- There is an immediate need to install a new monitoring well near the location of well R-28 with the well screen installed at the water table of the regional aquifer.

- There is an immediate need to perform the push-pull tracer tests recommended by the EPA Kerr Lab and the NMED to determine the ability of well R-28 to produce reliable and representative groundwater samples for the contaminants of concern in Mortandad Canyon (see the discussion of the push-pull tracer tests in these public comments.)

The push-pull tracer test should be performed in all of the characterization wells marked with red X’s on Figure 8 and also in the two screens in well R-61 because of drilling mistakes that contaminated the screened zones with hammer oil. The study by Longmire et al (October 2013) determined that the two screened zones in well R-64 do not produce representative ground water samples (see Table 3).

Figure 9. “Figure 4.1-1 MDA C Monitoring Group” ***in*** LANL 2014 Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan

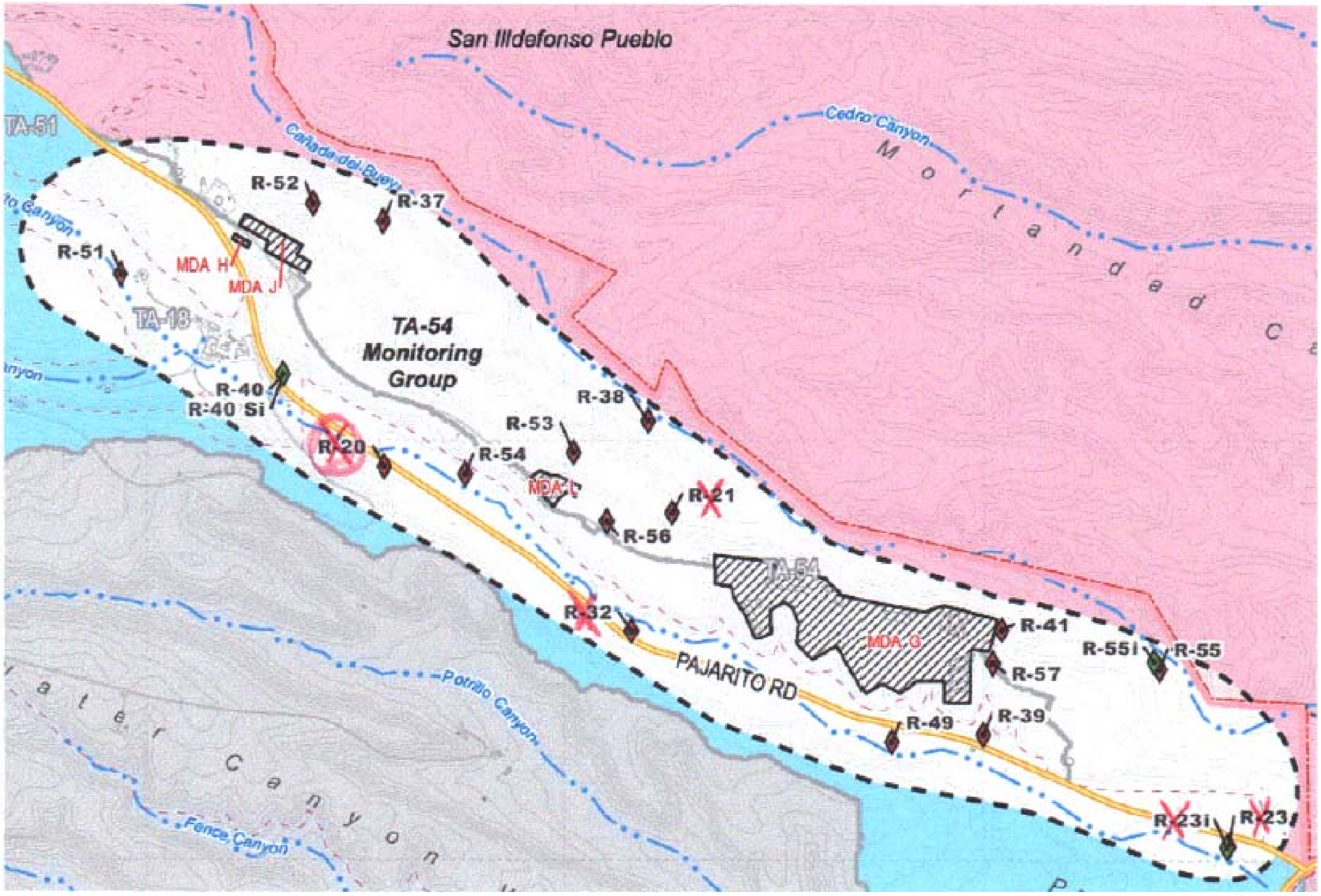


Scale 0---------------------½---------------------1 mile

The monitoring well network at MDA C is insufficient for 1. accurate knowledge of the direction of groundwater travel in the regional aquifer, 2. the speed of groundwater travel and 3. the detection of groundwater contamination for the wastes buried in the unlined trenches and shafts at MDA C. Table 4 describes the large inventory of radionuclides in the waste buried at MDA C

The immediate need for the installation of additional monitoring wells in the region of MDA C is described above on Figure 5 and in Appendix D.

Figure 10. “Figure 5.1-1 Monitoring well network for TA-54 MDAs H, L, and G” *in* LANL 2014 Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan



Scale 0---------------½---------------1 mile

The monitoring well network at the TA-54 MDAs G, L and H is insufficient for 1) accurate knowledge of the direction of groundwater travel in the regional aquifer, 2) the speed of groundwater travel and 3) the detection of groundwater contamination for the wastes buried in the unlined trenches and shafts at MDA G, H and L.

Table 4 shows the large inventory of radionuclides buried in the unlined trenches and shafts at MDA G and MDA H. A very large inventory of solvent wastes are buried in the unlined shafts and pits at MDA L.

- A very serious issue is the ***glaringly incorrect statement*** on page 19 of the LANL MY2014 IFWGMP as follows:

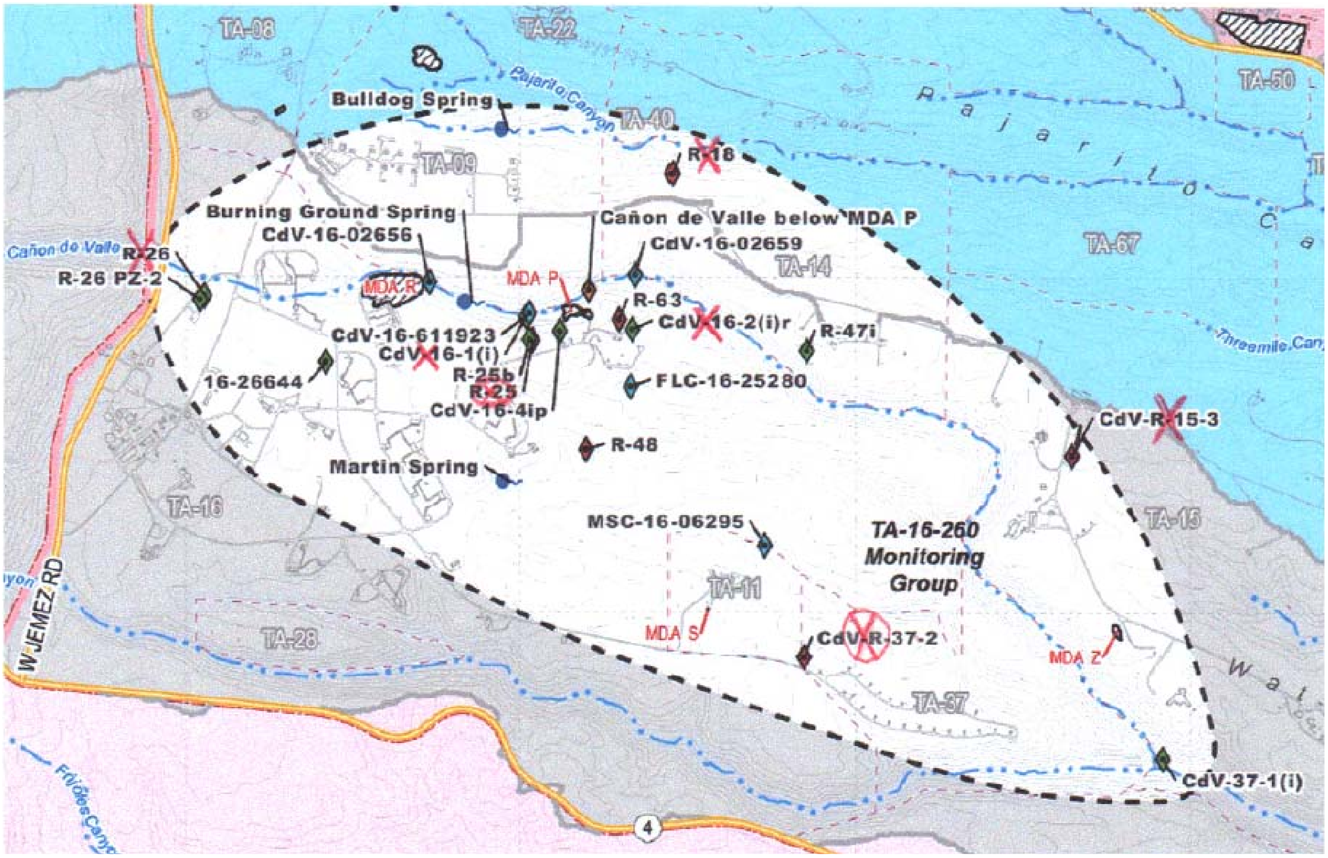
> The regional monitoring-well network downgradient of the MDAs in TA-54 is a system that includes redundancy and is designed to provide reliable detection of potential contaminants reaching the regional aquifer. The wells are located both near the facility boundary and at more distal locations along the dominant regional flow direction as well as along potential local flow directions to the northeast. The locations of wells also address potential complex pathways for contaminants in the vadose zone.

In fact, Figure 9 shows that there are **no** monitoring wells installed close to MDAs L and H. The three MDAs G, L and H are RCRA “regulated units”. RCRA requires the installation of a minimum of three monitoring wells close to the hydraulic downgradient boundary of disposal facilities. The RCRA required network of monitoring wells are not installed at MDA L and H.

Figure 4 shows monitoring wells R-39, R-57, and R-41 installed close to the eastern boundary of MDA G. However, the screens in wells R-41 and R-39 are installed too deep below the water table of the regional aquifer to provide accurate knowledge of the elevation of the water table along the eastern region of MDA G. Accurate knowledge of the elevation of the water table below and away from MDA G is essential but does not exist because of the many mistakes in the placement of the screens in the monitoring wells.

The overall failure of the monitoring well network at MDA G is described in Appendix B.

Figure 11. “Figure 6.1-1 TA-16 260 Outfall Monitoring Group” *in* LANL Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan

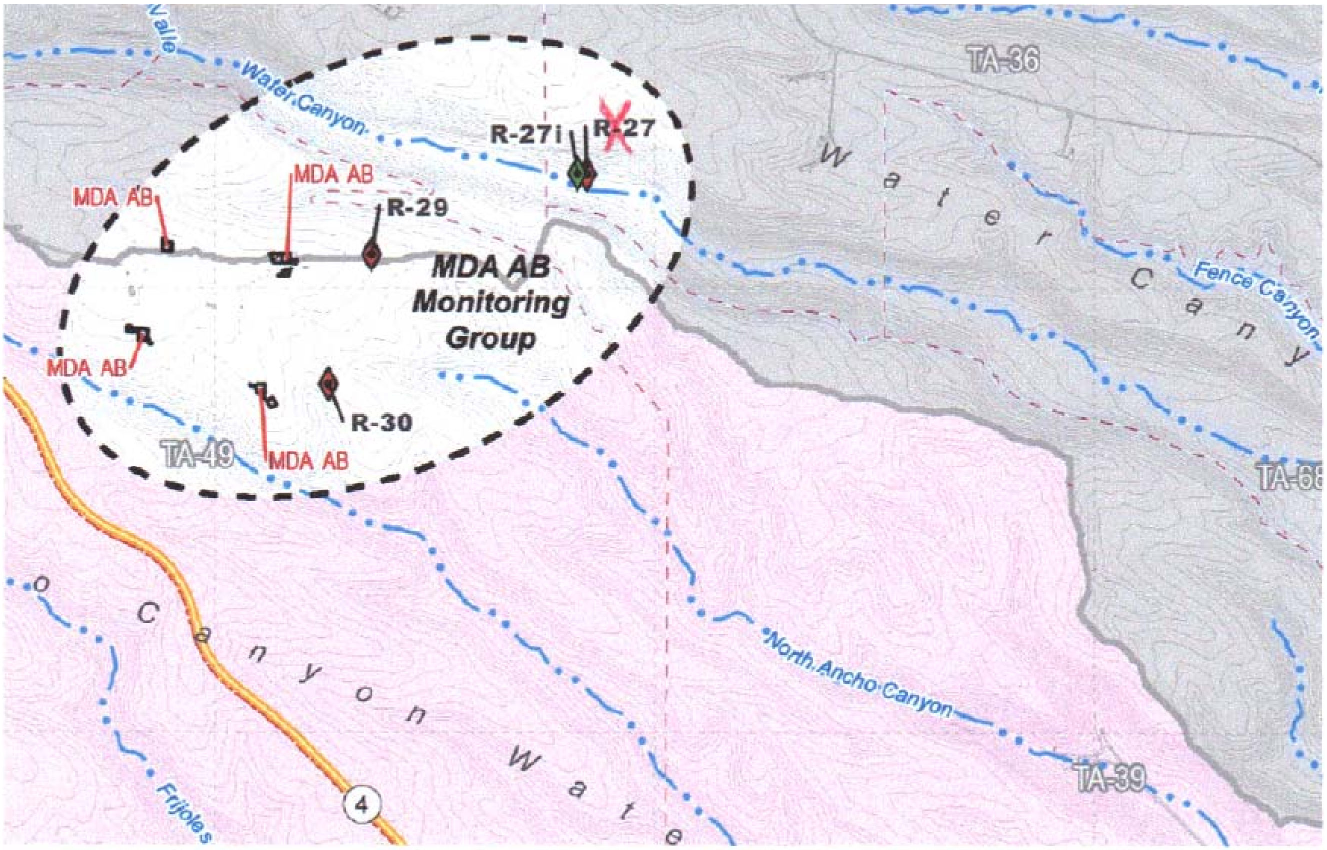


Scale 0----------------½--------------1 mile

The monitoring well network at the TA-60 260 Outfall is insufficient for 1) accurate knowledge of the direction of groundwater travel in the regional aquifer, 2) the speed of groundwater travel and 3) the detection of groundwater contamination.

The monitoring well network includes many characterization wells. The report by Longmire et al 2013) determined that the multiple-screen characterization wells CdV-R-37-2 and R-25 do not produce representative groundwater samples (see Table 3).

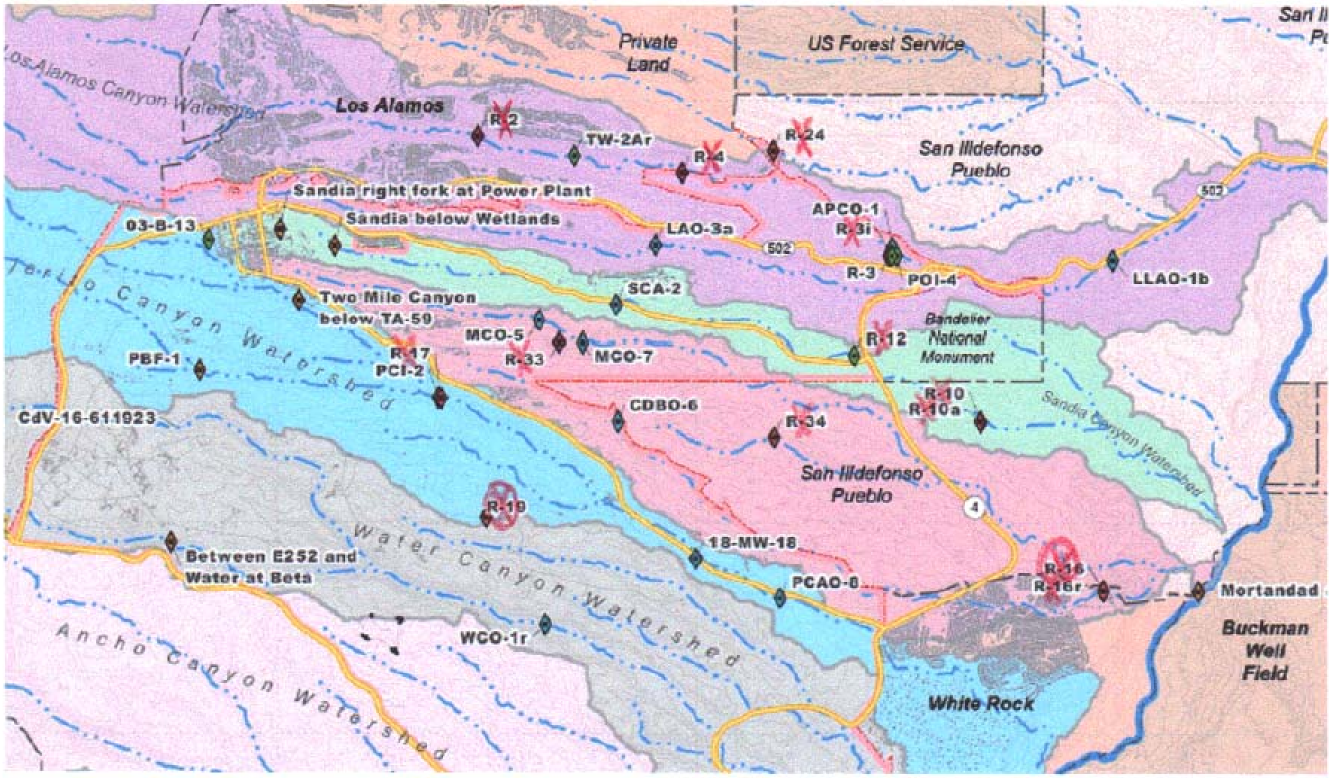
Figure 12. “Figure 7.1-1 MDA AB Monitoring Group” ***in*** LANL 1014 Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan



Scale 0-------------------½-------------------1 mile

The monitoring well network at MDA AB is insufficient for 1. the detection of perched zones of saturation below the four hydronuclear test sites, 2. accurate knowledge of the direction of groundwater travel in the regional aquifer, 3. the speed of groundwater travel and 4. the detection of groundwater contamination from the wastes buried in the many unlined shafts where the hydronuclear tests were performed. Tables 4 and 5 describes the large inventory of radionuclides in the waste buried at MDA C

Figure 13. “Figure 8.1-1 General Surveillance Monitoring Group” *in* LANL 2014 Monitoring Year Interim Facility-Wide Groundwater Monitoring Plan



Scale 0---------1--------2 miles

The network of monitoring wells for *“General Surveillance”* across the 43-square mile LANL Facility is insufficient for detection and accurate knowledge of groundwater contamination at the water table of regional aquifer and in deeper productive zones in the regional aquifer.

The “General Surveillance Monitoring Group” includes only13 wells in the regional aquifer. However, 12 of the 13 wells are “characterization wells” installed for the LANL Hydrogeologic Workplan. The 12 characterization wells are marked with a **red X** on the above figure and include starting from the top of the figure wells R-2, R-4, R-24, R-17, R-33, R-12, R-34, R-10, R-10a, R-19, R-16, and R-16r.

The NMED issued a report in 2010 that stated the LANL characterization wells did not meet requirements to be RCRA monitoring wells (See discussion in the text section).

The DOE Oversight Bureau and the NMED Hazardous Waste Bureau issued a report in October 2013 (Longmire et al, October 2013) with a table (table 3 in this public comment) that that identified screen 4 in well R-16 and screens 3 to 7 (five screens) in well R-19 to not provide representative groundwater samples.