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# Environmental Surveillance at Los Alamos during 2002



## **Enhancing Our Stewardship of the Environment**

**The Laboratory places a priority on simultaneously fulfilling our mission responsibilities and our environmental stewardship responsibilities. The overall goal of our stewardship efforts is to minimize negative impacts and ensure a healthy environment. We monitor our performance to demonstrate the fulfillment of these responsibilities. This annual environmental report describes the 2002 successes of our environmental stewardship. The monitoring information focuses on operations. The monitoring program addresses changes from baseline conditions before the Cerro Grande fire of 2000 and will aid in evaluating any future impacts the Laboratory may have, especially those resulting from contaminant transport off-site.**

**The program involves a number of different organizations within the Laboratory, as well as coordination with outside organizations and agencies. The primary Laboratory organizations involved are the Meteorology and Air Quality Group (RRES-MAQ), the Water Quality and Hydrology Group (RRES-WQH), the Solid Waste Regulatory Compliance Group (RRES-SWRC), the Ecology Group (RRES-ECO), and the Environmental Restoration Project (RRES-RS).**

**The Risk Reduction and Environmental Stewardship (RRES) is incorporated to strengthen the Laboratory's commitment to managing the entire life-cycle of nuclear materials from generation to permanent disposal as well as to understanding and safeguarding the natural environment on a local to global scale. Over the next two decades, billions of dollars will be invested globally in managing nuclear materials and waste, cleaning up the environment, and protecting and restoring the natural environment. To this end, RRES has highlighted the following strategic environmental science program thrust areas:**

- Natural Resources Protection and Restoration,**
- Nuclear Waste and Materials Management, and**
- Repository Science.**

**The role of this new division is to reduce the risk of current and historic Laboratory activities to the public, workers, and the environment through natural and cultural resource protection, pollution prevention, waste disposition, and remediation activities. The new division will serve as the steward of the Laboratory reservation by developing and implementing integrated natural and cultural resource management.**

**This report summarizes the results of the ongoing routine environmental monitoring and surveillance program, for which the Laboratory collects more than 12,000 environmental samples each year from more than 450 sampling stations in and around the Laboratory. In addition, we have summarized results from sampling for effects of the Cerro Grande fire, especially where the fire has resulted in alterations of trends in environmental conditions seen in past years. We will continue to follow the alterations resulting from the wild-fire over the next few years to determine if conditions return to pre-fire levels.**

**In the aftermath of the events of September 11, 2001, enhanced security actions by the Department of Energy resulted in the removal of many environmental World Wide Web pages from public access. At this writing, it is unknown how many pages these actions have affected and when the pages will be accessible again to the general public. If you have difficulty reaching the sites referenced in this document, please contact me, Lars F. Soholt, Ph.D., at [soholt@lanl.gov](mailto:soholt@lanl.gov) or 505/667-2256. We will make every attempt to get you the information that you desire.**

*Environmental Surveillance at Los Alamos during 2002*

*Environmental Surveillance Program:*

*Meteorology and Air Quality (Group RRES-MAQ)  
505-665-8855*

*Water Quality and Hydrology (Group RRES-WQH)  
505-665-0453*

*Solid Waste Regulatory Compliance (Group RRES-SWRC)  
505-665-9527*

*Ecology (Group RRES-ECO)  
505-665-8961*









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*Environmental Surveillance at Los Alamos* reports are prepared annually by the Los Alamos National Laboratory (the Laboratory), Risk Reduction and Environmental Stewardship, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 2002. Chapter 3 provides a summary of the maximum radiological dose a member of the public could have potentially received from Laboratory operations. The environmental data are organized by environmental media (Chapter 4, air; Chapters 5 and 6, water; Chapter 7, soils; and Chapter 8, foodstuffs and biota) in a format to meet the needs of a general and scientific audience. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, and Appendix C describes the Laboratory's technical areas and their associated programs.

We've also enclosed a disk with detailed tables of data from 2002.

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**This report is also available on the World Wide Web at  
<http://www.airquality.lanl.gov/pdf/ESR/LA-14085-ENV.pdf>  
and the supplemental data tables are available at  
<http://www.airquality.lanl.gov/ESRIndex.htm>**

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# EXECUTIVE SUMMARY ENVIRONMENTAL SURVEILLANCE—2002



LA-14085-ENV

Table ES-1. Environmental Statutes under which LANL Operates

<i>Federal Statute</i>	<i>What it Covers</i>	<i>Status</i>
<b>Resource Conservation and Recovery Act (RCRA)</b>	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites	The Laboratory is operating under an extension of the previous permit while seeking to renew its RCRA permit. The state issued a compliance order requiring extensive site investigation and monitoring. Negotiations are continuing in both of these issues. Two other compliance orders were resolved in 2003.
<b>Emergency Planning and Community Right to Know Act (EPCRA)</b>	The public's right to know about chemicals released into the community	As required, the Laboratory reported releases and disposal totaling 9,913 lb of lead and 183 lb of mercury.
<b>Clean Air Act (CAA)</b>	Air quality and emissions into the air from facility operations	The Laboratory met all limits for emissions to the air. Nitrogen oxide emissions declined by 30% facility-wide from 2001. The dose to the Maximum Exposed Individual (MEI) from LANL air emissions was 1.69 mrem, much less than the annual limit of 10 mrem. The principal contributor to the dose was the Los Alamos Neutron Science Center (LANSCE). Independent auditors found LANL fully compliant with radiological air emissions requirements.
<b>Clean Water Act (CWA)</b>	Water quality and liquid discharges to US waters	Discharges met requirements in 100% of samples from sanitary effluent outfalls, 99.8% of samples from industrial effluent outfalls, and 100% of water quality parameter samples at both types of outfalls.
<b>Safe Drinking Water Act (SDWA)</b>	Drinking water supplies	Los Alamos County provides the Laboratory's drinking water supply. During 2002, drinking water met all limits for chemicals, radiological materials, and bacteria.
<b>Toxic Substances Control Act (TSCA)</b>	Chemicals such as polychlorinated biphenyls (PCBs)	The Laboratory disposed of 380 kg of capacitors, more than 2,400 kg of PCB-containing liquids, and 4,100 kg of fluorescent light ballasts in off-site, EPA-permitted treatment and disposal facilities.
<b>Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)</b>	Storage and use of pesticides	The Laboratory's storage and use of pesticides remained in compliance with regulatory requirements.
<b>Endangered Species Act (ESA)</b>	Rare species of plants and animals	The biology team reviewed more than 2,000 new projects to ensure the protection of threatened and endangered species on Laboratory lands.
<b>National Historic Preservation Act (NHPA) and others</b>	Cultural resources	The Laboratory's cultural resources team evaluated more than 1,000 new actions to ensure compliance and identified 297 archaeological sites and 75 historical buildings on DOE land.
<b>National Environment Policy Act</b>	Consideration of potential environmental impacts in deciding on new operations	In 2002, LANL personnel conducted 68 reviews of proposed projects to ensure compliance; NNSA issued 8 findings of no significant impact (FONSIs).



## EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) is managed by the University of California under a contract administered by the National Nuclear Security Administration (NNSA) of the Department of Energy (DOE). This report (1) presents environmental data and analyses that characterize performance in 2002 and (2) addresses compliance with environmental regulations. Using comparisons with standards and regulations, this report concludes that the environmental effects from Laboratory operations are small and do not pose a threat to human health or the environment.

### **Environmental Compliance at Los Alamos in 2002 (See Chapter 2.)**

Many activities at LANL use or produce materials that are radioactive or otherwise hazardous. Laboratory policy implements DOE requirements by directing employees to protect the environment and meet compliance requirements of applicable state and federal environmental-protection regulations.

Federal and state regulations provide specific requirements and standards to implement these statutes and maintain environmental qualities. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. The DOE and its contractors are also subject to the energy department's requirements for control of radionuclides. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations.



Table ES-2. Where are the Sources of Radiological Doses?

<i>Pathway</i>	<i>Dose</i>	<i>Location</i>	<i>Trends</i>
Air	1.7 mrem/yr	East Gate	None; remains well below regulatory limits
Direct Irradiation	1 mrem/yr	Technical Area (TA)-18, Pajarito Road	None
Food	<0.1 mrem/yr	All sites	None
Drinking Water	<0.1 mrem/yr	All sites	None
Background	300 to 500 mrem/yr	All Sites	N/A
Dose to wildlife	<0.1 rad/day	All sites	None

Table ES-3. Where Can We See LANL Impacts on Air (AIRNET)?

<i>Radionuclide</i>	<i>On Site</i>	<i>Off Site</i>	<i>Off-Site Significance (% of the EPA Standard)</i>
Tritium	Yes, found in most samplers	Yes, measurable at many perimeter samples	1%
Gross alpha beta	Yes, found in 1997 and 2002 at Area G from transuranic releases	No	Not applicable
Uranium	Yes, increasing number of locations found with measurable depleted transuranic uranium	Yes, increased frequency of depleted uranium found at perimeter locations after the Cerro Grande fire	Less than 1%
Americium and plutonium	Yes, found mostly at TA-21 and Area G	Yes, found in 2002 first quarter in White Rock; plutonium-239 found near TA-1 and occasionally at other perimeter samplers	2%
Beryllium	Yes, short-term concentrations above background	No, off-site concentrations all appeared to be natural beryllium, not Laboratory-caused.	No standard
Volatile organic compounds and other metals	No, on-site measurements comparable to background levels.	No, off-site measurements comparable to background levels	No standard

## Environmental Radiological Dose Assessment (See Chapter 3.)

Table ES-2 shows the sources and locations of radiological doses.

We calculated potential radiological doses to members of the public that resulted from LANL emissions. During 2002, the population within 80 km of LANL received a collective dose of 1.4 person-rem. The maximum off-site radiation dose to a member of the public was at East Gate and was 1.7 mrem. These values are similar to previous ones from recent years. Background radiological doses in this area range from about 300 to 500 mrem/yr. No health effects are expected from doses attributable to Laboratory emissions. Calculated doses to nonhuman biota remained below DOE established limits for aquatic and terrestrial systems.

## Air Surveillance (See Chapter 4.)

### *Ambient Air Sampling*

The radiological air-sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides that may be released from Laboratory operations. These radionuclides include plutonium, americium, uranium, and tritium. Ambient concentrations during 2002 were generally comparable to concentrations in 2001. Measurable concentrations of tritium were found at most on-site locations and at off-site locations near the perimeter of the Laboratory. Plutonium and americium were occasionally found on site, primarily near decontamination and decommissioning operations and at Technical Area (TA)-54, Area G, the Laboratory's low-level radioactive waste disposal site. Low concentrations of americium and plutonium were also detected in several perimeter samples. Depleted uranium was detected on site and near the perimeter of the Laboratory. Concentrations at no off-site location exceeded more than several percent of the EPA public dose limit. No detectable concentrations of any radionuclides attributable to LANL were detected at regional samplers in Santa Fe, Española, or El Rancho.

Three significant investigations took place in 2002 and revealed the following.

- The number of samples with depleted uranium has increased since the Cerro Grande fire—a catastrophic wildfire that burned almost 50,000 acres within and around LANL— at both on-site and perimeter samplers.
- Tritium emissions increased at TA-21 because decontamination and decommissioning (D&D) activities caused measurable increases in tritium in the eastern part of the Los Alamos town site.
- A soil-screening operation at TA-54 resuspended plutonium and americium contamination that caused measurable first-quarter concentrations at Area G and in White Rock.

Three nonradioactive air-monitoring stations were operated during 2002 to evaluate air concentrations of metals, volatile organic compounds, and particulate matter. The monitoring stations were designed and located to establish background levels of constituents/pollutants in the surrounding communities and, if possible, to determine any Laboratory impacts. The metals data were consistent with expected values that would occur because of the resuspension of local soils. Volatile organic compound data were consistent with those taken in 2001. Total suspended-particulate-matter measurements were consistent with historical measurements. Correlations with wind speed and large-scale regional events (e.g., forest fires) could be readily observed.

Quarterly concentrations of beryllium were similar to those of 2001. Concentrations were consistent with values expected because of resuspension of naturally occurring beryllium in soils. The dustiest locations—the Los Alamos County Landfill, Jemez Pueblo, and TA-54—had the highest measured concentrations. Special short-term beryllium samples were taken to monitor several test shots with high explosives (HEs). A few on-site air samples contained elevated beryllium and uranium, based on comparisons with average air concentrations measured on non-test-shot days. Table ES-3 shows locations where radionuclides from LANL impacted the air.

Table ES-4. Where Can We See Radiological Stack Emissions into the Air?

<i>Radionuclide</i>	<i>Maximum Off-site Impact (Location)</i>	<i>Emission Trend</i>
<b>Tritium</b>	<b>0.03 mrem (airport)</b>	<b>None</b>
<b>Uranium, plutonium, americium</b>	<b>&lt;0.01 mrem (all)</b>	<b>None</b>
<b>Carbon-11, oxygen-15, nitrogen-13, argon-41 (LANSCE emissions)</b>	<b>1.7 mrem (East Gate)</b>	<b>Decreasing</b>



## ***Meteorology***

Los Alamos weather for 2002 continued a 5-year trend of warm temperatures and a dryer-than-normal climate. The average annual temperature in 2002 of 49.3°F exceeded the normal annual average of 48.2°F by 1.1 degree. The total precipitation in 2002 of 11.7 in. was 62% of normal (18.95 in.). The current drought is similar in severity to droughts during the late 1930s, early-to-mid 1950s, and late 1970s.

## ***Air Emissions***

Emissions from tritium-handling facilities in 2002 were relatively consistent with emissions from 1998 through 2000. Tritium emissions were much lower in 2002 than in 2001, because of a single unplanned release in January 2001. Emissions from plutonium and uranium isotopes have remained approximately the same since 2000. Emissions from LANSCE were somewhat reduced from 2001 levels during 2002 because of the installation of a delay line system.

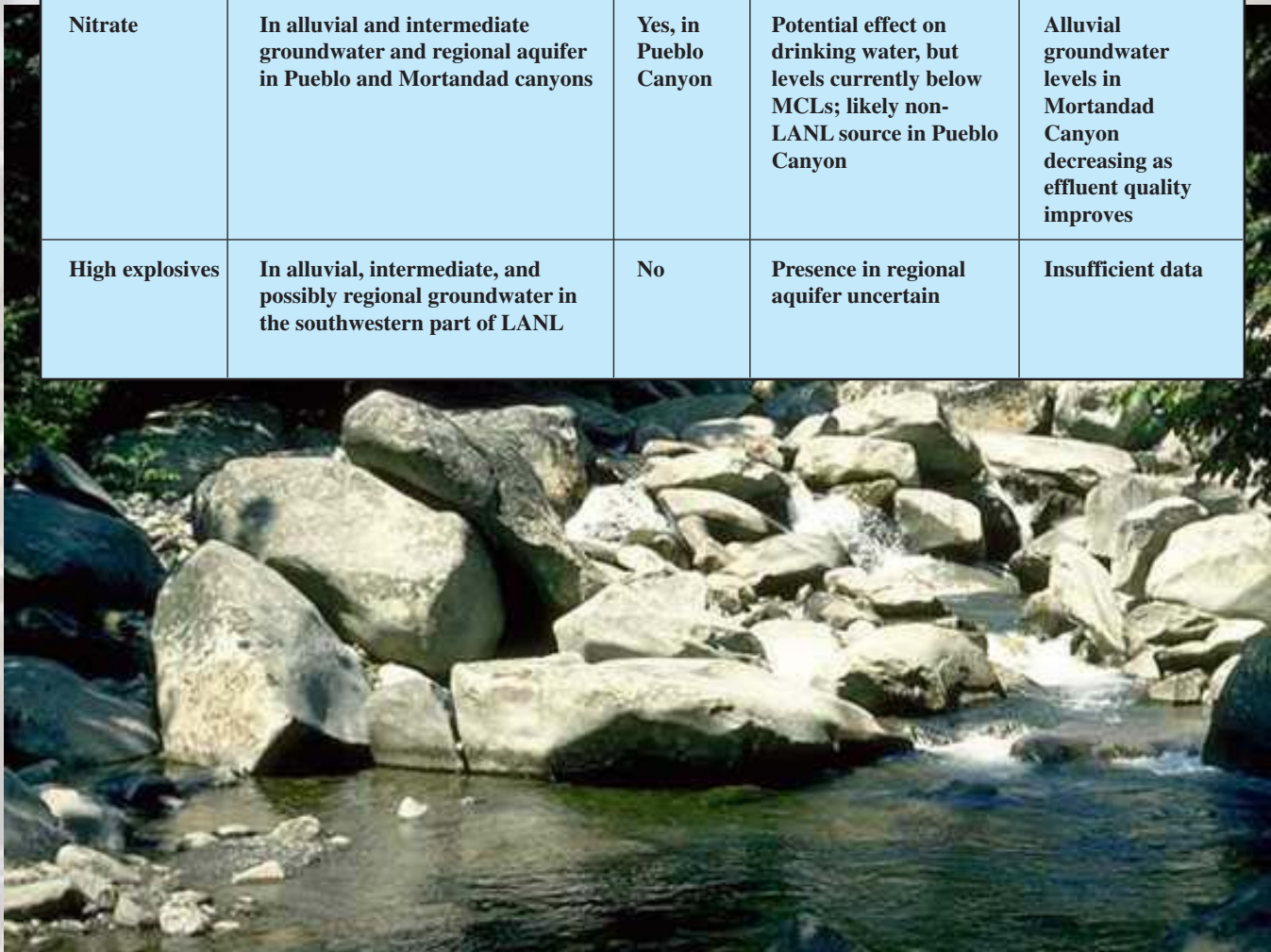
No air releases occurred during 2002 that required reporting to the National Response Center. Table ES-4 presents the locations of stack-emission sampling.

## ***Direct Penetrating Radiation***

During 2002, measurements of direct penetrating radiation at most LANL locations were similar to 2001 measured values. The public dose is < 1 mrem/yr. Highest doses were measured at locations on Pajarito Road adjacent to Pajarito Laboratory (TA-18) and on site at the Waste Disposal Site (TA-54), Area G. Measurements showed that at some TA-54, Area G, locations, radiation levels were up to 25% higher because of an increase in radioactive waste awaiting shipment to the Waste Isolation Pilot Plant (WIPP); but the average dose rate at Area G has not changed significantly.

Table ES-5. Where Can We See LANL Impacts on Groundwater?

<i>Chemical</i>	<i>On Site</i>	<i>Off Site</i>	<i>Significance</i>	<i>Trends</i>
<b>Tritium</b>	Near MCLs in alluvial and intermediate groundwater because of LANL discharges into Mortandad Canyon	No	Not used as a drinking water supply	Decreasing as effluent quality improves
<b>Other radionuclides</b>	Above DOE and EPA drinking water limits because of LANL discharges to alluvial water in DP, Los Alamos, and Mortandad canyons	No	Not used as a drinking water supply; radionuclides have not penetrated to deeper groundwater	Some constituents are fixed in location; some decreasing as effluent quality increases
<b>Perchlorate</b>	In alluvial and intermediate groundwater of Mortandad Canyon; possible detection in regional aquifer in Mortandad Canyon; found in regional aquifer in Pueblo Canyon	Yes, in Pueblo Canyon	No established regulatory standard; values exceed provisional risk level in alluvial groundwater and are near them in deeper groundwater	Decreasing in Mortandad Canyon alluvial groundwater as effluent quality improves; insufficient data for other groundwater
<b>Nitrate</b>	In alluvial and intermediate groundwater and regional aquifer in Pueblo and Mortandad canyons	Yes, in Pueblo Canyon	Potential effect on drinking water, but levels currently below MCLs; likely non-LANL source in Pueblo Canyon	Alluvial groundwater levels in Mortandad Canyon decreasing as effluent quality improves
<b>High explosives</b>	In alluvial, intermediate, and possibly regional groundwater in the southwestern part of LANL	No	Presence in regional aquifer uncertain	Insufficient data



## Groundwater Monitoring (See Chapter 5.)

Table ES-5 shows a summary of LANL impacts on groundwater.

Groundwater at the Laboratory occurs as a regional aquifer at depths ranging from 600 to 1200 ft and as perched groundwater of limited thickness and horizontal extent, either in canyon alluvium or at intermediate depths of a few hundred feet. In some canyons, 5 decades of liquid-effluent disposal by LANL have degraded groundwater quality in the alluvium. Because flow through the underlying approximately 900-ft-thick zone of unsaturated rock is slow, the impact of effluent disposal is seen to a lesser degree in intermediate-depth perched groundwater and is seen in some samples from the regional aquifer. All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate aquifers.

Elevated alluvial-groundwater concentrations of strontium-90, plutonium, americium, tritium, nitrate, perchlorate, HEs, barium, and molybdenum in recent years have approached or exceeded drinking water standards or risk-based drinking water levels in a few locations and over a limited area on site. Similarly, intermediate groundwater concentrations of HEs, chlorinated solvents, tritium, perchlorate, and nitrate levels exceed or approach drinking water standards or risk-based drinking water levels in a few locations on site. The regional aquifer shows traces of tritium, nitrate, and perchlorate that are below drinking water risk levels. A former supply well in Pueblo Canyon shows tritium at 1/500th of the drinking water Maximum Contaminant Level (MCL) established by the EPA, nitrate at about three times background or 1/10th of the MCL, and perchlorate, which has no standard, at possibly 2 parts per billion (ppb).

One regional aquifer well (R-25) may show HEs and chlorinated solvents near drinking water risk levels, but the results appear to be caused by well construction problems rather than indicating regional aquifer contamination. Thus, the HEs and solvents at R-25 are probably restricted to the perched zone that lies at the 750-ft depth and have not reached the regional aquifer.

LANL has shut off or significantly improved the water quality of most liquid effluent discharges (High-Explosive Wastewater Treatment Facility [HEWTF], Radioactive Liquid Waste Treatment Facility [RLWTF]); and, with some exceptions (strontium-90), water quality in shallow groundwater has improved rapidly as a result of these Laboratory actions. In one example, the RLWTF has sharply reduced tritium activity in its discharge since 2000 to below 20,000 picocuries per liter (pCi/L), with a corresponding decrease in tritium in the alluvial groundwater since then.



Table ES-6. Where Can We See LANL Impacts on Surface Water and Sediments?

<i>Chemical</i>	<i>On Site</i>	<i>Off Site</i>	<i>Significance</i>	<i>Trends</i>
<b>Radionuclides</b>	Higher than background in sediments because of LANL contributions in Pueblo, Los Alamos, and Mortandad canyons	Yes, in Los Alamos/ Pueblo canyons; slightly elevated in the Rio Grande and Cochiti Reservoir	Sediments below health concern; elevated radionuclides a short distance in Mortandad Canyon but exposure potential is limited	Increased transport in Pueblo Canyon in response to post-fire flooding
	Higher than background in runoff in Pueblo and Los Alamos canyons because of LANL contributions	Yes, in Los Alamos/ Pueblo canyons	Minimal exposure potential because events are sporadic	Flows in Pueblo Canyon occurring more often after fire
<b>Polychlorinated biphenyls (PCBs)</b>	Detected in sediment in nearly every canyon	Yes, particularly in the Los Alamos/ Pueblo canyons	Minimal exposure potential; may accumulate in Rio Grande fish; findings include non-Laboratory and Laboratory sources.	None
	Detected occasionally in Sandia Canyon runoff	No		None
<b>High explosive residues</b>	Detections above background in Cañon de Valle and Water Canyon runoff (likely in water only)	No	Minimal potential for exposure	None
<b>Polycyclic aromatic hydrocarbons (PAHs)</b>	Detections near or above applicable risk-based screening levels in Sandia and Mortandad canyons	Yes, in Pueblo/ Los Alamos canyons	Origins uncertain; probably multiple source	None



## Watershed Monitoring (See Chapter 6.)

Table ES-6 shows the locations of LANL-impacted surface water and sediments.

Watersheds that drain the Laboratory are dry for most of the year. No perennial surface water extends completely across the Laboratory in any canyon. Storm runoff occasionally extends across the Laboratory but is short-lived. Wildlife drink from the stream channels when water is present.

LANL activities have caused contamination of sediments in several canyons, mainly because of industrial effluent discharges. These discharges and contaminated sediments also affect the quality of storm runoff, which carries much of this sediment for short periods of intense flow. In some cases, sediment contamination lingers from Laboratory operations conducted more than 50 years ago.

Sediment radioactivity levels are above fallout background but substantially lower than screening action levels (SALs) in Los Alamos and Pueblo canyons. Cesium-137 in Mortandad Canyon sediments are at elevated levels in an approximately 1.5-mile-long reach on site and some samples exceed industrial-site screening levels. Plutonium-239, -240 in sediments extend off site down Los Alamos Canyon into the Rio Grande; but levels remain well below the screening levels for unrestricted use of the land. PCBs are present in sediments in the northernmost watercourses that drain the Laboratory and are at concentrations below EPA industrial soil-screening levels in Sandia Canyon sediments, where the highest levels occur. Channel sediments in Pueblo, Los Alamos, Sandia, and Mortandad canyons contain polycyclic aromatic hydrocarbons (PAHs) of uncertain origin with maximum concentrations near or above applicable EPA soil-screening levels.

After the Cerro Grande fire, runoff volumes that leave the downstream boundary of LANL have increased by 2 to 4 times, and peak flows have increased by 10 to 100 times. There are signs that watersheds are recovering from the fire, but storm runoff in Pueblo Canyon remains very dynamic. Several large runoff events from Pueblo Canyon in 2002 carried contaminated sediments downstream directly into the Rio Grande. The overall pattern of radioactivity in channel sediments, such as along lower Los Alamos Canyon, has not greatly changed. Radioactivity in bottom sediments in Cochiti Reservoir have increased slightly but remain well below health-based screening levels.

Individual storm runoff events in Pueblo Canyon sometimes contained elevated plutonium-239,-240 levels. However, the average concentration on an annual basis is approximately 5% of the 100-mrem DOE Derived Concentration Guideline (DCG) for public exposure. All samples of base flow (persistent surface waters) collected near the Laboratory or from the Rio Grande in 2002 met the New Mexico stream standards for livestock-watering or wildlife habitat. A small number of the short-lived storm-runoff events contained concentrations of some metals, gross alpha, PCBs, and HEs above the state standards or above background levels. Several Los Alamos area watersheds were recently added to the State of New Mexico's water-quality-impaired list for gross alpha activity and total selenium concentrations. Our review indicates that these high values appear to be related to high natural sediment concentrations in the runoff samples, rather than caused by Laboratory operations. The dissolved concentrations of barium, copper, zinc, and chromium exceed state acute wildlife habitat standards in some samples.



Table ES-7. Where Can We See LANL Impacts on Mesa-Top Soils?

<i>Chemical</i>	<i>On Site</i>	<i>Off Site</i>	<i>Significance</i>	<i>Trends</i>
<b>Tritium</b>	<b>Yes, at most because of LANL contributions</b>	<b>Yes, in a few areas on the perimeter of LANL</b>	<b>Far below screening level, except at Area G, TA-54, where one sample exceeded screening level; no health risk because public is not allowed in area</b>	<b>Increasing at Area G, TA-54</b>
<b>Other radio-nuclides</b>	<b>Yes, mostly plutonium-239, -240 at Area G and TA-21</b>	<b>Yes, in a few LANL perimeter areas</b>	<b>Far below screening levels; no health risk</b>	<b>Plutonium-239,-240 showed a small spike</b>
<b>Metals</b>	<b>Few detections: lead, mercury, barium, beryllium</b>	<b>No</b>	<b>Far below screening levels; no health risk</b>	<b>Decreasing</b>

## Soil Monitoring (See Chapter 7.)

Table ES-7 shows Laboratory impacts on mesa-top soils.

The soils-monitoring team collected soil surface samples within and around the perimeter of the Laboratory to help determine the impacts of Laboratory operations on human health and the environment. We compared these samples to soil samples collected from regional (background) areas located a great distance away to the north, south, and southwest of the Laboratory. Also, we compared these samples, which represent the third collection after the Cerro Grande fire, with samples collected before the fire.

The mean concentrations (using detectable and nondetectable values) of tritium; uranium; plutonium-238; plutonium-239,-240; and americium-241 in soils collected from LANL and perimeter areas were statistically higher ( $\alpha = 0.05$ ) than the mean concentrations of these radionuclides in soils collected from regional areas, primarily caused by increasing levels of fallout at higher elevations. Only tritium and plutonium-239,-240 were attributable to Laboratory operations. Although these radionuclides were statistically higher than regional areas, the concentrations in soils from individual sites within and around the perimeter of LANL were still very low (pCi/g dry range) and were far below screening levels. Therefore, the concentrations and distributions of tritium and plutonium-239,-240, in soils from LANL and perimeter sites are of no significant health concern.

Samples of radionuclides taken after the Cerro Grande fire show that, with the exception of tritium, most concentrations in soils collected from perimeter and LANL areas after the fire were statistically similar to soils collected before the fire. The higher tritium levels were attributed to Laboratory operations and were not a result of the fire. The mean concentrations of beryllium, mercury, and lead in soils collected from on-site areas were statistically ( $\alpha = 0.05$ ) higher than concentrations from regional soils. However, the differences between the two sites were very small; and the amounts were still within upper-level regional concentrations and far below applicable EPA screening levels. Moreover, all of the metals analyzed in soils collected from perimeter and on-site areas after the Cerro Grande fire were statistically similar to soils collected before the fire.

The facility-monitoring program included collection of soils within and around the perimeter of Area G and the Dual Axis Radiographic Hydrotest Facility (DARHT), the Laboratory's primary explosive test site. Results of soil-sampling at Area G show that tritium; plutonium-238; plutonium-239,-240; and americium-241 concentrations were significantly higher than in regional areas. One area (southwestern corner of Area G), in particular, exceeded the tritium-screening levels and showed increasing concentrations over time. Results of soil- and sediment-sampling at DARHT showed that most radionuclides and nonradionuclides were within baseline statistical reference levels developed as part of the preoperational baseline study.

In a soil-and-lichen study in the Valles Caldera, both media showed no discernable trend of higher-to-lower concentrations of most radionuclides with distance from LANL.

A special study showed that trace amounts of total PCBs measured in soil appear to be mostly from background global atmospheric sources.

Table ES-8. Where Can We See LANL Impacts on Foodstuffs?

<i>Media</i>	<i>Chemical</i>	<i>On Site</i>	<i>Off Site</i>	<i>Significance</i>	<i>Trends</i>
Produce	Tritium	Slightly higher than background	Yes, in a few areas on the perimeter of LANL	Dose <0.1 mrem/yr; no health risk	None
Produce	Other radionuclides	Indistinguishable from background	No	Dose <0.1 mrem/yr; no health risk	None
Produce, milk, honey	Metals	Few detections	No	No health risk	None
Fish	Polychlorinated biphenyls	Not applicable (N/A)	Mixed results	Cannot distinguish LANL contributions	None
Fish	Radionuclides, metals	N/A	No	Dose <0.1 mrem/yr; no health risk	None
Vegetation	Tritium	Higher than background, especially at Area G	No	Below DOE dose limits for terrestrial plants	None
Vegetation	Other radionuclides	Indistinguishable from background	No	Below DOE dose limits for terrestrial plants	None

## Foodstuffs and Biota Monitoring (See Chapter 8.)

Table ES-8 presents a summary of Laboratory impacts on foodstuffs.

The foodstuffs-monitoring team collected foodstuff and non-foodstuff biota within and near LANL property to help determine the impacts of Laboratory operations on human health, through the food chain, and to the environment. Also, we collected non-foodstuff biota at Area G and at DARHT.

Produce, milk, and honey were analyzed for radionuclides and metals; and the fish were analyzed for radionuclides, metals, and PCBs. Findings included the following.

- The concentrations of most radionuclides and metals in areas analyzed were indistinguishable from worldwide fallout and/or natural sources.
- Tritium concentrations in produce and honey from perimeter areas were higher than such concentrations in regional areas; but the differences were very small.
- No increase occurred in contaminants in produce, milk, and honey as a result of the Cerro Grande fire.
- The concentrations of mercury in fish collected downstream of LANL in the Rio Grande and Cochiti reservoir were similar to concentrations upstream of LANL.
- The analytical results for PCBs in fish were mixed: catfish contained higher PCBs upstream than downstream and carp contained higher PCBs downstream than upstream. Our analysis does not indicate a distinct contribution of PCBs from LANL.



Non-foodstuff biota test results from on-site locations show that most radionuclides, with the exception of tritium, were similar to regional areas. Tritium in vegetation from on-site areas was significantly higher than in regional areas. These results are similar to past years and agree with the tritium concentrations in soil from on-site areas. As noted previously, these results remain well below levels that would exceed limits for the protection of nonhuman biota.

At Area G, most radionuclides, with the exception of tritium and plutonium-239,-240, in vegetation, bees, and small mammals were within upper-level regional concentrations. Tritium and plutonium-239,-240 were both significantly higher in vegetation, bees, and small mammals from both on-site and off-site areas surrounding Area G.



These data are similar to findings of past years and the radionuclide concentrations in biota are not increasing over time. At DARHT, all radionuclides, with the exception of tritium, and metals in vegetation, bees, and small mammals were within baseline statistical reference levels (BSRLs). All radionuclides and metals in birds at DARHT were within BSRLs.





# 1. Introduction







## A. Laboratory Overview

### 1. Introduction to Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. Although planners originally expected that the task would require only 100 scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. The Laboratory is managed by the Regents of the University of California (UC) under a contract that is administered by the National Nuclear Security Administration (NNSA) of the Department of Energy (DOE) through the Los Alamos Area Office (LAAO) and the Albuquerque Operations Office.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, US priorities, and the world community have changed. Los Alamos National Laboratory enhances global security by

- ensuring the safety and reliability of the US nuclear deterrent;
- reducing the global threat of weapons of mass destruction; and
- solving national problems in energy, infrastructure, and health security (LANL 2001a).

In the "Strategic Plan (2001–2006)," Los Alamos National Laboratory personnel explain LANL's vision and role as follows: "We serve the nation by applying the best science and technology to make the world a better and safer place . . . . Inseparable from its commitment to excellence in science and technology is LANL's commitment to completing all endeavors in a safe, secure, and cost-effective manner" (LANL 2001b).

### 2. Geographic Setting

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 40-square-mile Laboratory is situated

on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west-oriented canyons cut by streams. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft above the Rio Grande Canyon. Most Laboratory and community developments are confined to the mesa tops. The surrounding land is largely undeveloped; and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, the Bandelier National Monument, the US General Services Administration, and the Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east.

The Laboratory is divided into technical areas (TAs) that are used for building sites, experimental areas, support facilities, roads, and utility rights-of-way. (See Appendix C and Figure 1-2.) However, these uses account for only a small part of the total land area; much land provides buffer areas for security and safety and is held in reserve for future use.

### 3. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major local faults constitute the modern rift boundary, and each is potentially seismogenic. Recent studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al. 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-3) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains' volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

Surface water in the Los Alamos area occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez

# 1. Introduction

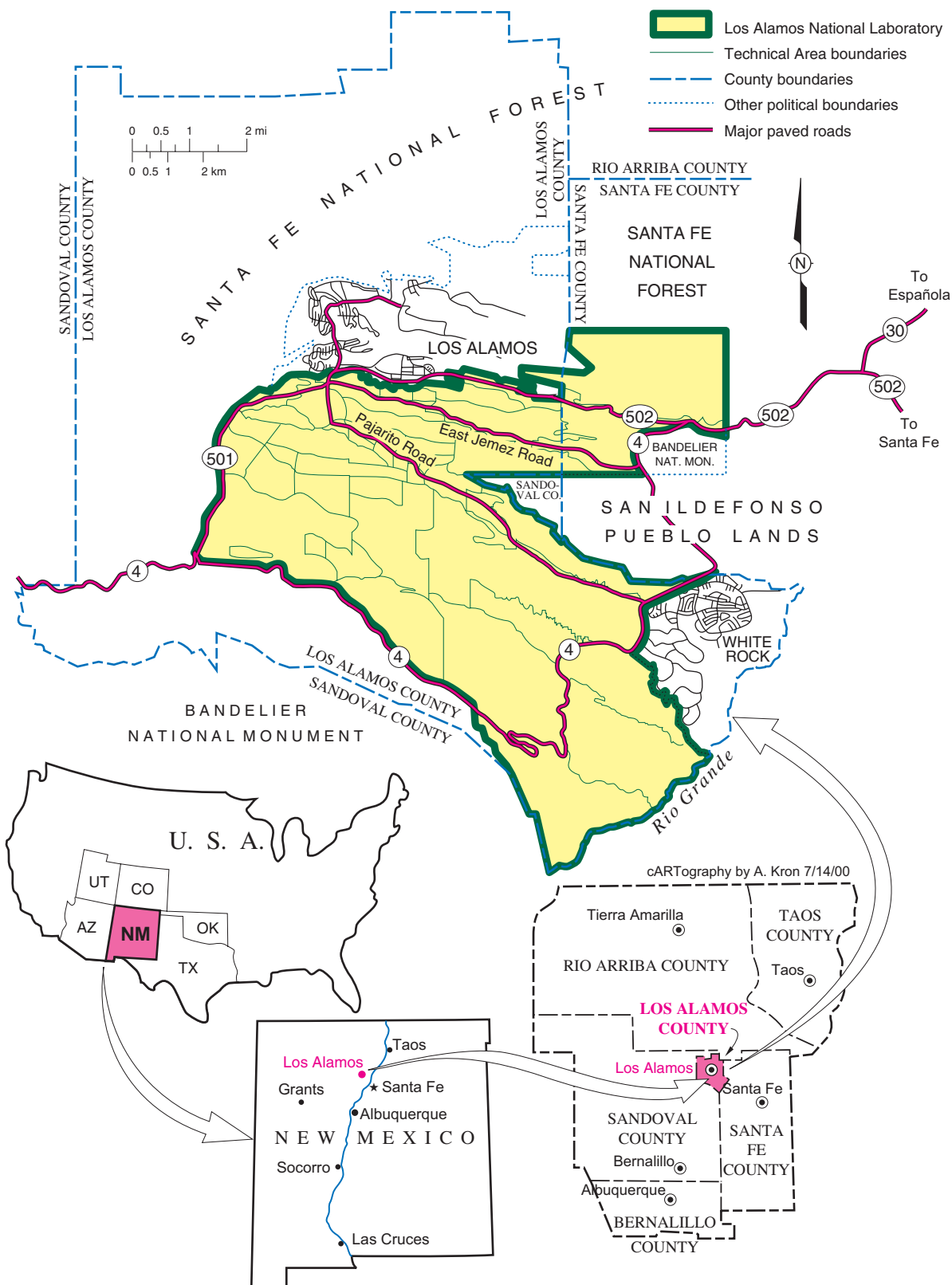


Figure 1-1. Regional location of Los Alamos National Laboratory.

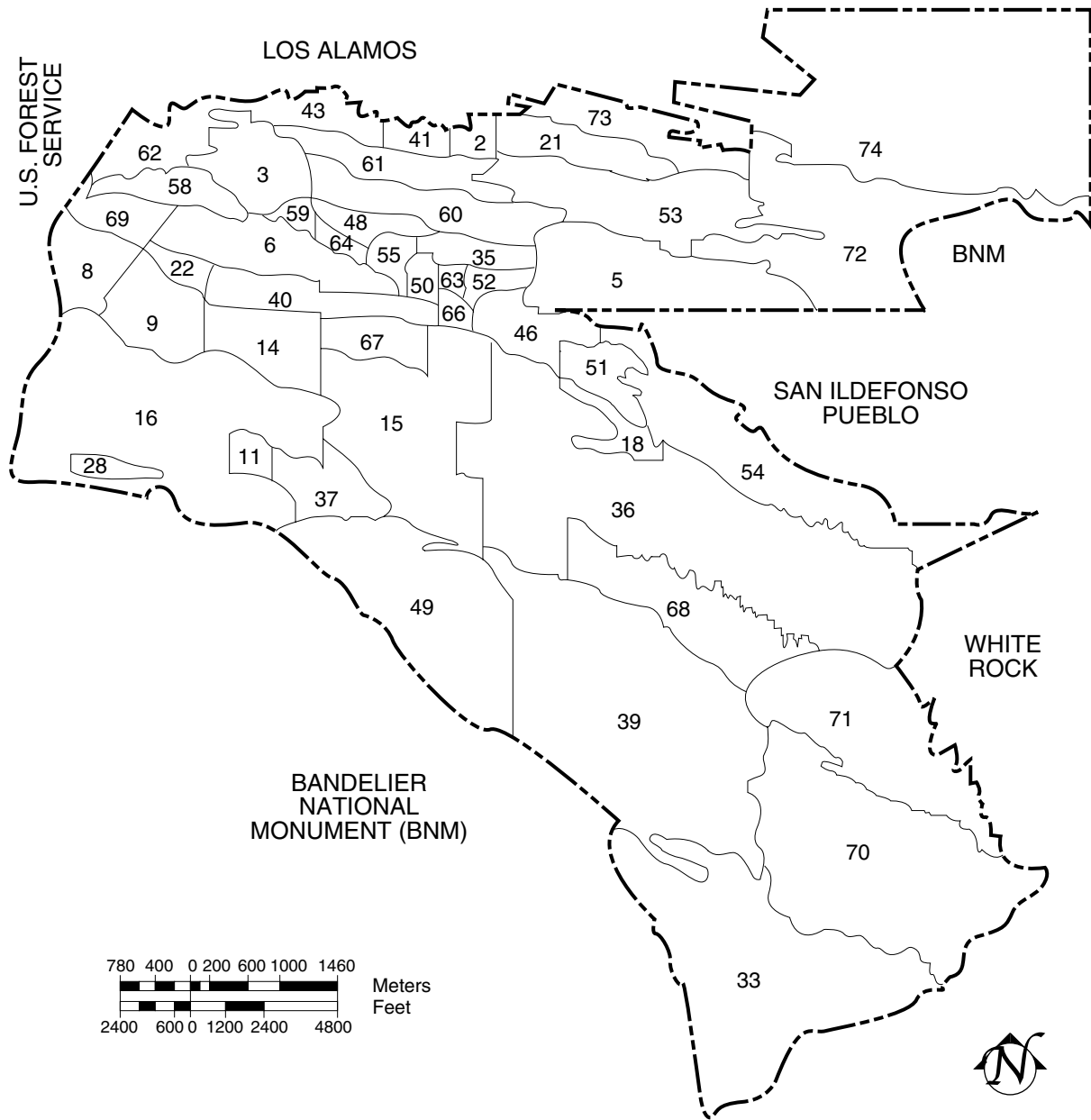


Figure 1-2. Technical Areas of Los Alamos National Laboratory in relation to surrounding landholdings.



# 1. Introduction

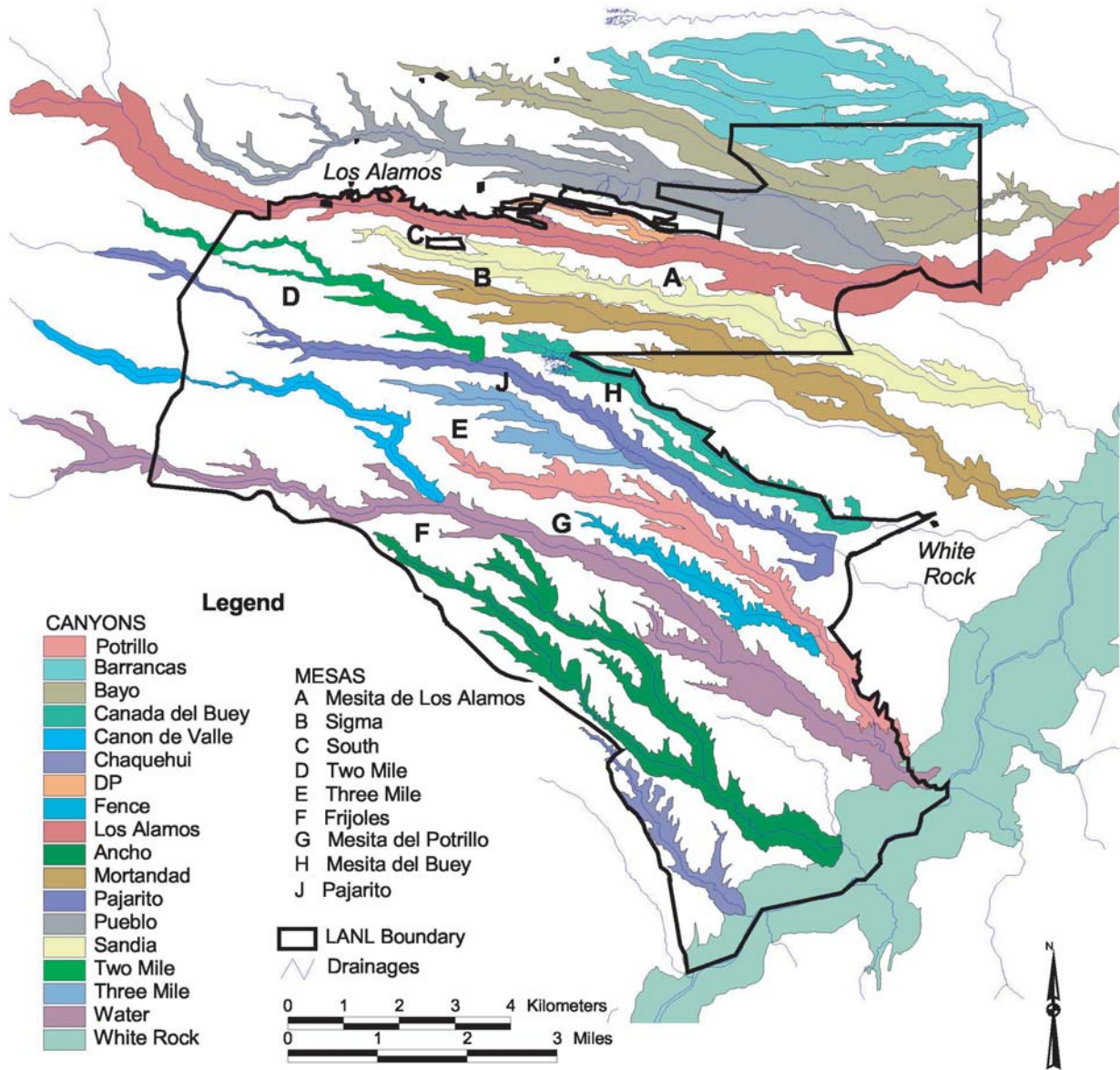


Figure 1-3. Major canyons and mesas.

Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before the water is depleted by evaporation, transpiration, and infiltration.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer of the Los Alamos area, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is in artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of most recharge to the aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. The regional aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mile reach of the river in White Rock Canyon, between Otowi Bridge and the mouth of Rito de los Frijoles, receives an estimated 4,300–5,500 acre-feet of water annually from the aquifer.

#### 4. Biology and Cultural Resources

The Pajarito Plateau is a biologically diverse and archaeologically rich area. This diversity is illustrated by the presence of more than 900 species of plants; 57 species of mammals; 200 species of birds, including 112 species known to breed in Los Alamos County; 28 species of reptiles; 9 species of amphibians; over 1,200 species of arthropods; and 12 species of fish (primarily found in the Rio Grande, Cochiti Reservoir, and the Rito de los Frijoles). No fish species have been found within LANL boundaries. Roughly 20 of these plant and animal species are designated as threatened species, endangered species, or species of concern at the federal and/or state level.

Approximately 80% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1800 sites have been recorded. More than 85% of the ruins date from the 14th and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100<sup>o</sup>ft. Almost three-quarters of all ruins are found on mesa tops. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places.

## B. Management of Environment, Safety, and Health

### 1. Integrated Safety Management

Throughout the Laboratory, the goal of Integrated Safety Management (ISM) is the systematic integration of environment, safety, and health (ES&H) considerations into work practices at all levels. The term “integrated” indicates that the safety management system is a normal and natural element in performing the work. Safety and environmental responsibility involve every worker. Management of ES&H functions and activities is an integral, visible part of the Laboratory’s work-planning and work-executing processes.

The Laboratory is committed to achieving excellence in environmental, safety, health, and security performance. Then Laboratory Director John C. Browne said in 1999, “We will never compromise safety or security for programmatic or operational needs.” Having zero environmental incidents means (1) complying with all applicable environmental laws and regulations; (2) adopting practicable proactive approaches to achieve environmental excellence (minimizing waste generation, wastewater discharges, air emissions, ecological impacts, cultural impacts, etc.); (3) preventing unnecessary adverse environmental impacts; and (4) enhancing environmental protection (LANL 1999).

### 2. Risk Reduction and Environmental Stewardship Division

The Risk Reduction and Environmental Stewardship (RRES) Division is primarily a Laboratory support organization that provides a broad range of technical expertise and assistance in areas such as environmental protection, pollution prevention, National Environmental Policy Act (NEPA) requirements, wildfire protection, and natural and cultural resources management. RRES Division is in charge of performing environmental monitoring, surveillance, and compliance activities to help ensure that Laboratory operations do not adversely affect human health and safety or the environment.

The Laboratory conforms to applicable environmental regulatory and reporting requirements of DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 231.1 (DOE 1995). RRES Division has the responsibility and the authority for serving as the central point of institutional contact, coordination, and support for interfaces with regulators, stakeholders, and the public,

# 1. Introduction

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including the DOE/NNSA, the US Defense Nuclear Facilities Safety Board, the New Mexico Environment Department, and the Environmental Protection Agency.

RRES Division provides line managers with assistance in preparing and completing environmental documentation. Such documentation includes reports required by (1) NEPA of 1969 and (2) the federal Resource Conservation and Recovery Act (RCRA) and (3) its state counterpart, the New Mexico Hazardous Waste Act, as documented in Chapter 2 of this report. With assistance from Laboratory legal counsel, RRES Division helps to define and recommend Laboratory policies for applicable federal and state environmental regulations and laws and DOE orders and directives. RRES Division is responsible for communicating environmental policies to Laboratory employees and makes appropriate environmental training programs available.

The Environmental Surveillance Program resides in four RRES Division groups—Meteorology and Air Quality (RRES-MAQ), Water Quality and Hydrology (RRES-WQH), Solid Waste Regulatory Compliance (RRES-SWRC), and Ecology (RRES-ECO). These

groups initiate and promote Laboratory programs for environmental assessment and are responsible for environmental surveillance and regulatory compliance under the auspices of the division's Environmental Protection Program (RRES-EP).

RRES Division uses approximately 600 sampling locations for routine environmental monitoring. The maps in this report present the general location of monitoring stations. For 2002, Laboratory personnel performed more than 250,000 routine analyses for chemical and radiochemical constituents on more than 12,000 routine environmental samples. Laboratory personnel also collected many additional samples in continuing efforts to monitor the effects of the Cerro Grande fire that occurred in 2000, burning more than 7,500 acres of Laboratory property. Samples of air particles and gases, water, soils, sediments, foodstuffs, and associated biota are routinely collected at monitoring stations and then analyzed. These analyses help identify impacts of LANL operations on the environment. RRES personnel collect and analyze additional samples to obtain information about particular events, such as major surface-water runoff events, nonroutine radiation releases, or special studies.

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## 2. Compliance Summary









## 2. Compliance Summary

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### A. Introduction

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. Laboratory policy implements Department of Energy (DOE) requirements by directing employees to protect the environment and meet compliance requirements of applicable federal and state environmental-protection regulations. Federal and state environmental laws address (1) handling, transporting, releasing, and disposing of contaminants, pollutants, and wastes; (2) protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and (3) conducting environmental-impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental qualities. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. DOE and its contractors are also subject to DOE-

administered requirements for control of radionuclides. Table 2-1 presents the environmental permits or approvals these organizations issued that the Laboratory operated under in 2002 and the specific operations and/or sites affected.

### B. Compliance Status

#### 1. Resource Conservation and Recovery Act

**a. Introduction.** The Laboratory produces a variety of hazardous wastes, mostly in small quantities relative to industrial facilities of comparable size. The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and state regulations of New Mexico Administrative Code, Title 20, Chapter 4,

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2002

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA <sup>a</sup> Hazardous Waste Facility	Hazardous- and mixed-waste storage and treatment permit	November 1989	November 1999 Administratively continued	NMED <sup>b</sup>
	RCRA General Part B renewal application	submitted January 15, 1999		
	Request for supplemental information	submitted October 2000		NMED
	RCRA mixed-waste Revised Part A application	submitted April 1998	---	NMED
	TA-50/TA-54 permit renewal application	submitted January 15, 1999		
	TA-54 Characterization, High-Activity Processing, and Storage Facility	submitted September 19, 2000		NMED
	TA-16 permit renewal application	submitted September 2000		NMED
	TA-55 Revisions to permit application	January 2002	---	NMED
	TA-50 Revisions to permit application	August 2002	---	NMED
HSWA <sup>c</sup>	RCRA corrective activities	March 1990	December 1999 Administratively continued	NMED
TSCA <sup>d</sup>	Disposal of PCBs <sup>e</sup> at TA-54, Area G	June 25, 1996	June 25, 2001 Administratively continued	EPA <sup>f</sup>
CWA <sup>g</sup> /NPDES <sup>h</sup>	Outfall permit for the discharge of industrial and sanitary liquid effluents	February 1, 2001	January 31, 2005	EPA
	MSGP <sup>i</sup> for the discharge of storm water from industrial activities	December 23, 2000	December 23, 2005*	EPA
	General permits (13) for the discharge of storm water from construction activities	varies	July 1, 2003**	EPA
NPDES Storm Water Permit for Construction Activity	DARHT Facility Project	October 2, 1998	July 7, 2003	EPA
	Guaje Well Field Improvements Project	October 2, 1998	July 7, 2003	EPA
	Fire Protection Improvements Project	October 2, 1998	July 7, 2003	EPA
	Strategic Computing Complex Project	May 21, 1999	July 7, 2003	EPA
	Norton Power Line Project	June 1, 1999	July 7, 2003	EPA
	TA-9 to TA-15 Gas Pipeline Replacement Project	August 22, 1999	July 7, 2003	EPA
	Flood Mitigation Project	July 25, 2000	July 7, 2003	EPA
	Nuclear Materials Safeguards and Security Upgrade Project	February 25, 2000	July 7, 2003	EPA
	TA-3 Revitalization Project	March 22, 2001	July 7, 2003	EPA
	TA-55 Fireloop Constructional Project	August 18, 2001	July 7, 2003	EPA
	EOC	January 27, 2002	July 7, 2003	EPA
	DX Strategic Plan	July 18, 2002	July 7, 2003	EPA
D&D	August 10, 2002	July 7, 2003	EPA	

**Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2002 (Cont.)**

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401	Individual dredge and fill permits (29)	varies	varies	COE/NMED
Groundwater Discharge Plan, Fenton Hill	Discharge to groundwater	June 5, 2000	June 5, 2005	NMOCD <sup>k</sup>
Groundwater Discharge Plan, TA-46 SWS Facility <sup>l</sup>	Discharge to groundwater	January 7, 1998	January 7, 2003	NMED
Groundwater Discharge Plan, Sanitary Sewage Sludge Land Application	Land application of dry sanitary sewage sludge	June 30, 1995	June 30, 2000 Administratively extended	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid-Waste Treatment Facility	Discharge to groundwater	submitted August 20, 1996 approval pending		NMED
Air Quality Operating Permit (20.2.70 NMAC <sup>m</sup> )	LANL air emissions	not yet issued		NMED
Air Quality (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	TA-3 Steam Plant-flue gas recirculation	September 27, 2000	None	NMED
	Generator at TA-33	October 10, 2002	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
Air Quality (NESHAP) <sup>n</sup>	Beryllium machining at TA-3-39	March 19, 1986	Surrendered on October 22, 2002	NMED
	Beryllium machining at TA-3-102	March 19, 1986	None	NMED
	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED
Open Burning	Burning of jet fuel and wood for ordnance testing, TA-11 Burning of HE <sup>o</sup> -contaminated materials, TA-14 Burning of HE-contaminated materials, TA-16 Burning of scrap wood from experiments, TA-36 Fuel fire burn of wood or propane, TA-16	August 18, 1997	December 31, 2002	NMED

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**Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2002 (Cont.)**


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Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Open Burning (20.2.60 NMAC)	Air-curtain destructors Burning of wood and wood slash from fire-mitigation activities on LANL property	June 20, 2001	September 30, 2003	NMED

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<sup>a</sup>Resource Conservation and Recovery Act

<sup>b</sup>New Mexico Environment Department

<sup>c</sup>Hazardous and Solid Waste Amendments

<sup>d</sup>Toxic Substances Control Act

<sup>e</sup>Polychlorinated biphenyls

<sup>f</sup>Environmental Protection Agency

<sup>g</sup>Clean Water Act

<sup>h</sup>National Pollutant Discharge Elimination System

<sup>i</sup>Multi-Sector General Permit

<sup>j</sup>US Army Corps of Engineers

<sup>k</sup>New Mexico Oil Conservation Division

<sup>l</sup>Sanitary Wastewater Systems Facility

<sup>m</sup>New Mexico Administrative Code

<sup>n</sup>National Emission Standards for Hazardous Air Pollutants

<sup>o</sup>High-explosive

\*MSGP expiration date

\*\*Construction General Permit (CGP) expiration date

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## 2. Compliance Summary

Part 1, as revised January 1, 1997 (20 NMAC 4.1). Federal and state laws regulate management of hazardous wastes based on a combination of the following: the facility's status; large- or small-quantity generation; and types of treatment, storage, and disposal conducted by the facility. Certain operations may require an operating permit, called a Hazardous Waste Facility permit or a RCRA permit.

**b. Resource Conservation and Recovery Act Permitting Activities.** The Laboratory's original RCRA permit did not include the open burning and open detonation (OB/OD) units that continue to operate under interim status. The original permit expired in 1999 but was administratively continued beyond the expiration date (as allowed by the permit and by 20 NMAC 4.1, Subpart IX, 270.51), because the Laboratory submitted new permit renewal applications before the expiration date.

To support renewal of the permit, the Laboratory has since responded to numerous information requests from the NMED. These responses provide additional information or detail about RCRA waste-management practices at the Laboratory and are part of the public administrative record the NMED keeps for the permit. In 2002, the Laboratory received or responded to six additional requests for facility information. In August, the Laboratory's Solid Waste Regulatory Compliance Group (RRES-SWRC) personnel submitted a response to an NMED request for site-wide information contained in the permit applications. In February and August, Laboratory personnel submitted two responses regarding Technical Area (TA) 16 waste-management practices. In April, July, and August, respectively, we submitted responses for TA-50, TA-54, and TA-55 (Los Alamos Plutonium Facility) information and procedures.

In 2002, Laboratory personnel revised permit applications to include the additional information requested by the NMED, to incorporate new formats or language suggested by the NMED, or to upgrade descriptions of waste-management procedures or units that had changed after the original applications were developed. In January and August, Laboratory employees submitted new revisions to the TA-55 and TA-50 (LANL Waste Management Site) applications. In late 2002, work began on new revisions to the TA-16 and TA-54 permit applications.

Three active RCRA waste-management units were closed in 2002, including TA-50-1-Room 59, TA-50-114, and the TA-54 Area L treatment tanks. The TA-16-88 container storage area was withdrawn

from the Laboratory's permit in October because it had never managed waste. In July, personnel submitted closure plans for TA-50-37 storage areas and, in August, for the TA-55-PF4-B38 storage area. All closure activities are awaiting final approval by the NMED.

**c. Resource Conservation and Recovery Act Corrective Action Activities.** Solid-waste management units (SWMUs) are subject to the HSWA Permit Module VIII corrective action requirements. See previous LANL Environmental Surveillance Program (ESP) reports (ESP 2002, ESP 2001, ESP 2000, ESP 1999, ESP 1998, ESP 1997) for the history of RCRA closures and other corrective actions.

LANL's Remediation Services (RRES-RS) conducted an interim action to remove contaminated soil from the two northern wastewater lagoons at the Los Alamos Neutron Science Center (LANSCE, TA-53). The wastewater came from various LANSCE activities and septic tank sludge from other Laboratory activities. The lagoons operated until 1998, when the southern lagoon was replaced by a new liquid wastewater treatment facility at TA-53.

The two northern lagoons were 210 ft long, 210 ft wide, and 6 ft deep; each could store 1.6 million gal. The radioactive wastewater was first pumped into storage tanks to allow short-lived radioisotopes to decay away; and then was pumped into the lagoons to evaporate.

Approximately 5,000 yd<sup>3</sup> of contaminated material (sludge and clay liner) from the two northern lagoons was removed in 2002. The sludge and clay liners contained radioisotopes (e.g., cobalt-60 and cesium-134) and carcinogens (e.g., Aroclor-1260) at levels exceeding the target levels. Approximately 90 yd<sup>3</sup> of soil were removed from the lagoons outfall area located on the eastern side. Miscellaneous debris, from a previous interim action, filled three waste bins.

The completion of remediation activities at Area P was a major accomplishment. Area P is located at TA-16 on the south rim of Cañon de Valle on the western edge of the Laboratory. The Area P landfill began receiving waste from the S-Site burning grounds in 1950 and operated until 1984. Remediation personnel began the closure process at the landfill in 1997. The presence of detonable high explosives in the landfill required the use of a robotic excavator. Remote excavation of the landfill was completed on May 3, 2000, just before the Cerro Grande fire. Excavation of contaminated soil beneath the landfill with nonremote excavation methods resumed after the



## 2. Compliance Summary

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fire and was completed in March 2001. Phase II confirmatory sampling and geophysics measurements began in June 2001. During Phase II sampling, workers found additional contamination, which was excavated and shipped off-site for disposal. All waste-disposal activities and confirmation sampling were completed at Area P in February 2002. Waste material included hazardous and industrial waste and recycled material. Waste types and amounts generated included

- 387 lb of detonable high explosive;
- 820 yd<sup>3</sup> of hazardous waste with residual levels of radioactive contamination;
- 6,600 lb of barium nitrate;
- 2,605 lb of asbestos;
- 200 lb of mixed waste;
- 235 ft<sup>3</sup> of low-level radioactive waste; and
- 888 containers that contained materials and waste that were characterized as hazardous.

RRES-RS continued investigations in several areas during fiscal year (FY) 2002, including the following:

- completed four rounds of well sampling and two rounds of biota sampling to monitor natural attenuation and to support the RRES-RS collaboration with San Ildefonso Pueblo;
- completed well installation and hydrological testing for well CdV-R-37-2 at TA-16; and
- completed sediment, alluvial, and surface-water field investigations in LA/Pueblo Canyon.

**d. Other Resource Conservation and Recovery Act Activities.** In 1995, RRES-SWRC began a waste-management program in cooperation with waste-management coordinators to assess the Laboratory's performance in managing hazardous and mixed waste in a way that would meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. RRES-SWRC communicates findings from individual self-assessments to waste generators, waste-management coordinators, and managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In 2002, RRES-SWRC completed 1,426 self-assessments.

**e. Resource Conservation and Recovery Act Compliance Inspection.** On June 10–12, 2002, the NMED conducted a hazardous-waste-compliance inspection at TA-54 and TA-55. To date, the state has

identified no issues or deficiencies found in those inspections (Table 2-2).

**f. Site Treatment Plan.** The Laboratory met all 2002 Site Treatment Plan (STP) deadlines and milestones. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order (CO) to both the DOE and the University of California (UC), requiring compliance with the STP. The plan documents the use of off-site facilities for treating mixed waste generated at LANL and stored more than one year. Through 2002, the Laboratory treated and disposed of more than 685 m<sup>3</sup> of STP mixed waste.

**g. Underground Storage Tanks.** The Laboratory had two underground storage tanks (USTs), as defined by 40 Code of Federal Regulations (CFR) 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks," in operation at the beginning of 2002.

- TA-16-197 is a 10,000-gal. UST for unleaded gasoline at a single-pump station that was used for fueling Laboratory service vehicles located at and near TA-16. The tank was removed from service in July 2002 by pumping out the tank contents. The NMED inspected the TA-16-197 UST during 2001. The inspector noted a record-keeping deficiency that LANL corrected. Final decommissioning of the tank will occur in 2003.
- TA-15-R312-DARHT is a 10,000-gal. UST that captures and stores any accidental releases from an equipment room located at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility. This tank is normally empty and is only used as a secondary containment system during an accidental spill. Substances that could enter the tank are mineral oil and glycol. A review of this tank operation indicated the use of the tank for possible spill containment is not a regulated use under the New Mexico Petroleum Tank regulations. TA-15-R312-DARHT is a fiberglass tank that does not require a corrosion protection system. The Laboratory requested the NMED to rescind the tank registration. The NMED concurred, and this tank is no longer a regulated tank.

Because Laboratory personnel discovered low levels of total petroleum hydrocarbons (TPHs) and polychlorinated biphenyls (PCBs) in soil samples collected directly underneath three USTs at the main

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**Table 2-2. Environmental Inspections and Audits Conducted at the Laboratory during 2002**

Date	Purpose	Performing Agency
4/12/02	Asbestos inspection at TA-53, Bldgs. 61, 62, 53	NMED <sup>a</sup>
6/02	Audit of compliance with NESHAP <sup>b</sup> radionuclide emission limits	RAC <sup>c</sup>
6/10/02–6/12/02	RCRA <sup>d</sup> compliance inspection at TA-54 and TA-55	NMED
8/20/02	Clean Air Act Title 6 compliance refrigerant	Independent assessor management survey (Donald Unser, Environmental Solutions, Inc., Tempe, Arizona)
9/4/02	Asbestos inspection at TA-41, Bldg.30	NMED
9/5/02	401 Inspection	NMED
9/13/02	Asbestos inspection at TA-2, Bldg. 1	NMED
12/11/02	Asbestos inspection at TA-16, Bldgs. 220–239	NMED

(No NPDES<sup>e</sup> Outfall, Storm Water, FIFRA<sup>f</sup>, SDWA<sup>g</sup>, 404, Ground Water Discharge Plan, PCB<sup>h</sup>, or Area J inspections were conducted in 2002. Also no beryllium inspections were conducted.)

<sup>a</sup>New Mexico Environment Department

<sup>b</sup>National Emission Standards for Hazardous Air Pollutants

<sup>c</sup>Risk Assessment Corporation

<sup>d</sup>Resource Conservation and Recovery Act

<sup>e</sup>National Pollutant Discharge Elimination System

<sup>f</sup>Federal Insecticide, Fungicide, and Rodenticide Act

<sup>g</sup>Safe Drinking Water Act

<sup>h</sup>polychlorinated biphenyl

LANL technical area (TA-3) during tank removal in 2001, LANL conducted an extent-of-contamination investigation at the site. They completed this investigation in 2002. Five boreholes were drilled to depths of 30 ft in the center and around the perimeter of the former location of the USTs. Low concentrations of TPH and PCBs were detected in the center borehole at a depth of 10 ft below ground surface (which also was at or near the depth and the location of the original samples collected during UST removal). No contaminants were detected in soil samples collected from all depths at the four perimeter boreholes and at depths

greater than 10 ft in the center borehole. Based on that information, in a June 2002 letter to the NMED, analysts proposed no further action for this site. The NMED has not responded to that proposal.

The NMED did not perform any formal inspections of USTs at the Laboratory during 2002.

**h. Solid-Waste Disposal.** The Laboratory closed an on-site landfill that had been used to dispose of solid waste and New Mexico (NM) special waste. Material Disposal Area J, located at TA-54, was subject to NM Solid Waste Management Regulations

## 2. Compliance Summary

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The Laboratory submitted a closure plan for Area J to the NMED in May 1999. LANL completed the physical closure of Area J in 2002 by placing cover material over the filled pits and reseeded the site. Personnel from the NMED Solid Waste Bureau did not inspect Area J closure activities during 2002.

LANL sends sanitary solid waste (trash), concrete/rubble, and construction and demolition debris for disposal to the Los Alamos County Landfill on East Jemez Road. The DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County owns and operates this landfill and is responsible for obtaining all related permits for this activity from the state. The landfill is registered with the NMED Solid Waste Bureau. The Laboratory contributed 12% (7,380 tons) of the total volume of trash deposited at this site during 2002, an increase from last year's total volume of 5,110 tons. Residents and businesses in Los Alamos County contributed the remaining 88% of the total waste volume. Laboratory trash placed in the landfill included 1,917 tons of trash; 4,547 tons of concrete/rubble; and 630 tons of construction and demolition debris. During 2002, the Laboratory also sent to the county landfill 261 tons of brush for composting and 24 tons of metal for recycling.

**i. Waste Minimization and Pollution Prevention.** The year 2002 was a great one for pollution prevention at the Laboratory.

- More than 40 teams and individuals were recognized for their successful projects at the annual pollution prevention award ceremony.
- One of the most impressive projects involved the creation of a system for recycling more than 99% of the nitric acid used at TA-55, avoiding treatment costs of more than \$1 million annually. This project also received a White House Closing the Circle Award, the nation's most prestigious pollution-prevention prize.
- The Pollution Prevention Group (RRES-PP) granted Generator Set-Aside Fee funds to 19 projects designed to reduce waste generation at the Laboratory. The average financial return on investment for these projects was more than 200%.
- Ongoing projects diverted more solid waste than ever before. Paper, cardboard, magazines, and office supplies, such as toner cartridges, are recycled through the MS A1000 program. More

than 120 metric tons (tonnes) of material were recycled through this program in 2002.

- More than 2,700 tonnes of clean fill from construction projects was diverted from the Los Alamos County Landfill to the municipal golf course for field improvements through the Truck Turn-Around program.

**j. Resource Conservation and Recovery Act Training.** The RCRA training program is a required component of, and is described in, the RCRA Hazardous Waste Facility Permit. Laboratory training is in compliance with regulatory and permit requirements.

During 2002, 141 workers completed RCRA Personnel Training; and 812 workers completed Waste Generation Overview, reflecting the increased number of new hires in 2002. Of the 573 workers who received credit for RCRA Refresher Training during 2002, 469 met this requirement through completing Hazardous Waste Operations (HAZWOPER) Refresher for Treatment, Storage, and Disposal Facility Workers, a course that includes the RCRA Refresher as part of its 8-hour requirement.

The LANL Environment, Safety, and Health Training Group (PS-13) offers Waste Generation Overview Refresher, a Web-based course. People whose work generates waste are required to take this course every 3 years. In 2002, 736 such Laboratory workers received credit for this course. This number is down from more than 1,000 workers the year before. The Web-based refresher course was first offered in the year 2001, and many employees took advantage of the ease of updating their training on the Web.

PS-13 updated the following RCRA courses during 2002:

- RCRA Refresher Training;
- HAZWOPER: Refresher for Environmental Restoration Workers;
- HAZWOPER: Refresher for Treatment, Storage, and Disposal Facility Workers;
- Waste Documentation Forms; and
- Waste Generation Overview.

### **2. Comprehensive Environmental Response, Compensation, and Liability Act**

As part of the Conveyance and Transfer project, the Ecology Group (RRES-ECO) prepared environmental baseline survey documents for nine subparcels of land

## 2. Compliance Summary

during 2002. These documents contain the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120(h) information required to transfer these properties to private ownership and indicate that “no hazardous substances exist on these sites,” that “all remedial action necessary to protect human health and the environment has been taken,” or that certain restrictions on use are required. These documents provide sufficient information to demonstrate that no environmental impacts exist that would trigger actions under CERCLA.

The nine tracts for which surveys were completed include

A-12	LAAO-1 (East),
A-17	TA-74-1 (West),
A-19	White Rock-1,
A-3	Airport-1 (East),
A-6	Airport-4 (West),
A-9	DP Road-2 (North) (Tank Farm),
C-1	White Rock,
C-2	White Rock “Y”-1, and
C-3	White Rock “Y”-3.

### 3. Emergency Planning and Community Right-to-Know Act

**a. Introduction.** The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order (EO) 12856.

**b. Compliance Activities.** In 2002, the Laboratory submitted two annual reports and one notification to fulfill its requirements under EPCRA, as shown on Table 2-3 and described here.

**Emergency Planning Notification.** Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees (1) of any changes at the Laboratory that might affect the local emergency plan or (2) if the Laboratory’s emergency planning coordinator changes. No updates to this notification were made in 2002.

**Emergency Release Notification.** Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment, if these chemicals exceed specified reporting quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. Although the Laboratory

exceeded no reporting thresholds in 2002, we made an informational notification to the National Response Center and the NMED concerning a chlorine release from TA-54 in January 2002. Approximately 8.5 lb of chlorine gas were released when an experimental apparatus exploded. The reportable quantity for chlorine is 10 lb. No one was injured in the explosion.

**Material Safety Data Sheet/Chemical Inventory Reporting.** Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals that are above specified thresholds present at the facility. The inventory includes the material safety data sheet for each chemical. The Laboratory submitted a report to the state emergency-response commission and the Los Alamos County fire and police departments listing 50 chemicals and explosives at the Laboratory that exceeded threshold limits during 2002.

**Toxic Release Inventory Reporting.** EO 12856 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases of listed toxic chemicals that exceed activity thresholds. Beginning with reporting year 2000, new and lower chemical-activity thresholds are in place for certain persistent, bioaccumulative, and toxic (PBT) chemicals and chemical categories. The thresholds for PBTs range from 0.1 g to 100 lb. Until this change went into effect, the lowest threshold was 10,000 lb. LANL exceeded two thresholds in 2002 and, therefore, was required to report the uses and releases. The reported materials were lead and mercury, with reporting-threshold quantity of 100 lb and 10 lb respectively. The largest use of reportable mercury is at the reservoirs of mercury that LANSCE uses as shields on the neutron beam shutter system. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. The following releases of lead were reported: 13.3 lb of air emissions, 106 lb of water releases, 9,794 lb of on-site land releases from the shooting range, and 467 lb of lead waste shipped off site for disposal. Reported releases for mercury were as follows: 0.72 lb of air emissions, 0.6 lb of water releases, and 182 lb of mercury waste shipped off site for disposal.

### 4. Toxic Substances Control Act

Because the Laboratory’s activities are research and development (R&D) and do not involve making chemicals to sell, the PCB regulations have been the Laboratory’s main concern under the Toxic Substances Control Act (TSCA). The PCB regulations govern substances including, but not limited to, dielectric fluids,



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**Table 2-3. Compliance with Emergency Planning and Community Right-to-Know Act during 2002**

Statute	Brief Description	Compliance
EPCRA <sup>a</sup> Sections 302-303 Planning Notification	Requires emergency-planning notification to state and local emergency-planning committees	LANL sent notification to appropriate agencies (July 30, 1999) informing officials of the presence of hazardous materials in excess of specific threshold planning quantities and of the current facility emergency coordinator. An additional update adding sodium cyanide to the list was provided in 2000.
EPCRA Section 304 Release Notification	Requires reporting of releases of certain hazardous substances above specific thresholds to state and local emergency-planning committees and to the NRC <sup>b</sup>	No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2002. A courtesy notification to the NRC was made regarding a chlorine release in January 2002 that was below the 10-1b reportable quantity.
EPCRA Sections 311-312 MSDSs and Chemical Inventories	Requires facilities to provide appropriate emergency-response personnel with an annual inventory and other specific information for any hazardous materials present at the facility that are above specified thresholds	The presence of 50 hazardous materials stored at LANL above specified quantities in 2002 required submittal of a hazardous chemical inventory to the state emergency-response commission and the Los Alamos County fire and police departments.
EPCRA Section 313 Annual Releases	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds	Use of lead and mercury exceeded the reporting thresholds in 2002, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the state emergency-response commission.

<sup>a</sup>Emergency Planning and Community Right-to-Know Act

<sup>b</sup>National Response Center

contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soils, and materials contaminated by spills.

During 2002, the Laboratory had 96 off-site shipments of PCB waste. The quantities of waste disposed of include 380 kg of capacitors; 5 kg of laboratory waste; 2,428 kg of PCB-contaminated liquids; and 4,156 kg of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 CFR 761 manifesting, record-keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and

treatment facilities. Light ballasts go off-site for recycling. The primary compliance document related to 40 CFR 761.180, is the annual PCB report that the Laboratory submits to the EPA, Region 6.

The Laboratory disposes of nonliquid wastes that contain PCB and are contaminated with radioactive constituents at its TSCA-authorized landfill located at TA-54, Area G. Radioactively contaminated PCB liquid wastes are stored at the TSCA-authorized storage facility at TA-54, Area L. Some of these items have exceeded TSCA's 1-year storage limitation and

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are covered under the Final Rule for the Disposal of PCB, dated August 28, 1998.

The 5-year letter of authorization to use Area G for PCB disposal expired in July 2001, and the EPA granted an administrative extension to LANL for continued use of Area G during the review process. Approval of a renewal request is expected to occur in 2003. The EPA did not perform any PCB inspections in 2002.

### 5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides and the protection of workers who use these chemicals. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture (NMDA) has the primary responsibility to enforce pesticide use under the FIFRA. The New Mexico Pesticide Control Act applies to the Laboratory's licensing and certifying of pesticide workers, record keeping, applying of pesticides, inspecting of equipment, storing of pesticides, and disposing of pesticides.

The NMDA and the DOE's Los Alamos Area Office (LAAO) did not conduct assessments or inspections of the Laboratory's pesticide application program in 2002. Johnson Controls Northern New Mexico (JCNNM) conducted an annual inspection of the Laboratory's pesticide storage area in 2002 and found that the storage area was being maintained in accordance with NMDA Regulations.

Amount of pesticides used during 2002 included the following:

- |                                   |            |
|-----------------------------------|------------|
| • VELPAR L (herbicide)            | 172.5 gal. |
| • 2-4-D Amine (herbicide)         | 11 gal.    |
| • TELAR (herbicide)               | 27 g       |
| • PT110 RESMITHERIN (insecticide) | 48 oz      |
| • TEMPO (insecticide)             | 354.37 g   |
| • STINGER WASP (insecticide)      | 22 oz      |

### 6. Clean Air Act

The NMED or the EPA regulates Laboratory operations and air emissions. The Meteorology and Air Quality Group's (RRES-MAQ) Quality Assurance (QA) Project Plan for the Operating Permit Project, <http://www.lanl.gov/orgs/rres/maq/QA.htm>, presents a complete description of air quality requirements

applicable to the Laboratory. A summary of the major aspects of the Laboratory's air quality compliance program is presented here.

In December 1995, LANL submitted to the NMED an operating permit application as required under Title V of the Clean Air Act (CAA) and Title 20 of the New Mexico Administrative Code, Chapter 2, Part 70—Operating Permits (20.2.70 NMAC). In February, the NMED contacted LANL with the intent to review the application and issue a permit. Considering the changes that had occurred at LANL since the application was initially submitted, both organizations agreed that it would be appropriate to update the application. In November, LANL submitted an updated application. The application is available at <http://www.airquality.lanl.gov/OpPermitLANL.htm>. On December 18, the NMED issued a letter stating that the application was ruled complete and that sufficient information was provided for a review of the application to begin. The NMED plans to issue an operating permit in 2003. When issued, the permit will specify the operational terms and limitations imposed on LANL to continue to ensure that all federal and state air quality standards are being met. In the interim, LANL continues to operate under the provisions of source-specific permits and to comply with applicable sections of the state and federal air quality regulations.

LANL is a major source under the operating permit program based on the potential to emit for nitrogen oxides ( $\text{NO}_x$ ), carbon monoxide, and volatile organic compounds (VOCs). The TA-3 power plant boilers have the greatest potential to emit for  $\text{NO}_x$  and carbon monoxide emissions. The air-curtain destructors (ACDs) have the greatest potential to emit VOC emissions. In 2002, LANL completed a project to install flue gas recirculation (FGR) equipment on the boilers at the TA-3 power plant to reduce the  $\text{NO}_x$  emissions. A source test conducted in September confirmed that FGR reduces  $\text{NO}_x$  air emissions by 70%.

LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to revise the operating permit application, to apply for construction permits, or to submit notifications to the NMED. During 2002, the Laboratory performed approximately 300 air quality reviews. Two of the reviewed projects, installation of a generator and the installation of a new asphalt plant, required permitting actions (20.2.72 NMAC). See the following paragraph on Construction Permits. A Notice of Intent application (20.2.73

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NMAC) was submitted for a pugmill to support an environmental restoration project that was planned for TA-21. NMED determined that a permit was not required for the equipment to solidify and stabilize contaminated soil. Twenty sources, including natural-gas-fired boilers, hot water heaters, generators and other equipment, were exempt from construction permitting but required written notification to NMED (20.2.72 NMAC).

As part of the Operating Permit Program, the NMED collects annual fees (20.2.71 NMAC) from facilities that are required to obtain an operating permit. For LANL, the fees are based on the allowable emissions from activities and operations as reported in the 1995 operating permit application. LANL's fees for 2002 were \$12,761.25.

LANL reports emissions for sources—including multiple boilers, two steam plants, a paper shredder, a carpenter shop, three degreasers, a rock crusher, multiple storage tanks, and an asphalt-production facility. In addition to these point-source emissions, LANL reports emissions from chemical use associated with research and development activities, three ACDs used to burn wood and slash from forest-thinning activities, and permitted beryllium activities. Emissions reported for 2002 are shown in Table 2-4.

Smaller sources of air pollutant emissions, such as nonregulated boilers, emergency generators, and space heaters, are located throughout LANL. The NMED considers these smaller sources insignificant. Therefore, these sources are not required to be included in the annual emissions inventory.

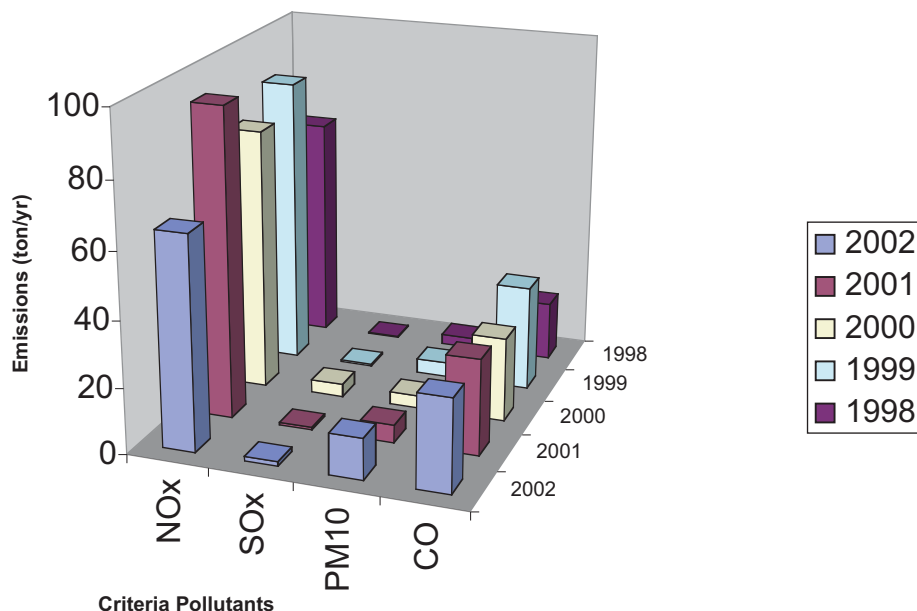
LANL staff calculates air emissions using emission factors from source tests, manufacturer data, and EPA documentation. Calculated emissions are based on actual production rates or fuel or material throughput rates. LANL's combustion units and ACDs were the primary sources of criteria pollutants ( $\text{NO}_x$ , sulfur oxides [ $\text{SO}_x$ ], particulate matter less than  $10\ \mu$  [ $\text{PM}_{10}$ ], and carbon monoxide emissions). Of all combustion units, the TA-3 steam plant was the largest source of criteria pollutants.

Figure 2-1 provides a comparison among recent emissions inventories reported to the NMED.  $\text{NO}_x$  emissions were reduced in 2002 because of lower seasonal heat demand and start-up of pollution control equipment at the TA-3 power plant. FGR equipment became operational in October 2002 and, based on stack testing, this equipment is reducing  $\text{NO}_x$  emissions by approximately 70%.  $\text{NO}_x$  emissions from the TA-3 power plant were 40 tons in 2002, compared to 73.8 tons reported in 2001.  $\text{PM}_{10}$  and VOC emissions

**Table 2-4. Calculated Actual Emissions for Regulated Pollutants (Tons) Reported to NMED**

Emission Units	Pollutants					
	PM	CO	$\text{NO}_x$	$\text{SO}_x$	VOC	HAP
Asphalt Plant	0.17	1.4	0.09	0.02	0.03	0.03
TA-3 Steam Plant	2.34	12.3	40.3	0.27	1.69	0.56
TA-16 Boilers	0.05	0.26	0.26	0.004	0.04	0.01
TA-21 Steam Plant	0.13	1.43	1.7	0.01	0.09	0.03
TA-48 Boilers	0.1	1.15	1.4	0.01	0.07	0.03
TA-53 Boilers	0.08	0.9	1.1	0.006	0.06	0.02
TA-55 Boilers	0.27	0.73	2.6	0.012	0.11	0.03
TA-59 Boilers	0.06	0.69	0.82	0.004	0.04	0.02
Air-Curtain Destructors	9.2	9.3	16.4	1.0	22.9	2.1
Carpenter Shop	0.08	NA	NA	NA	NA	NA
Degreasers	NA	NA	NA	NA	0.01	0.01
Paper Shredder	0.001	NA	NA	NA	NA	NA
Rock Crusher	0	0	0	0	0	0
R & D	NA	NA	NA	NA	14.9	7.72
Storage Tanks	NA	NA	NA	NA	0.05	NA
Total	12.4	28.2	64.7	1.34	40.0	10.6

NA = not applicable.



**Figure 2-1.** Criteria pollutant emissions from LANL from 1998 to 2002.

were higher in 2002 because of extensive use of the ACDs. These ACDs produce much lower emissions than open burning or prescribed burning. However some emissions are associated with these operations. The ACDs contributed 16 tons of  $\text{NO}_x$ , 9 tons of carbon monoxide, 9 tons of  $\text{PM}_{10}$ , and 23 tons of VOC. An assessment of the ambient impacts of air pollutant emissions, presented in the Site-Wide Environmental Impact Statement (SWEIS) Yearbook for 2001, indicates that all emissions are less than the amounts evaluated in the SWEIS. In addition, the ambient impacts of emissions from the ACDs were assessed in 2002, as required by the air-permitting for these units. Based on the results of the dispersion-modeling, we expect no adverse air quality impacts from emissions from these units.

The ACDs and chemical use associated with R&D activities were the primary sources of VOC and hazardous air pollutant (HAP) emissions. Detailed analysis of chemical tracking and procurement records indicates that LANL procured approximately 15 tons of VOCs, lower than the 19 tons reported for 2001. For a conservative estimate of air emissions, we assumed the total quantity of VOCs purchased to be emitted. The ACDs also contributed significant amounts of VOCs in 2002. As reported in the annual

emission inventory, VOC emissions from the ACDs were 23 tons.

The HAP emissions reported from R&D activities generally reflect the quantities procured during the calendar year. In a few cases, we evaluated procurement values and operational processes in more detail so we could report actual emissions in place of the procured value. The total quantity of HAP emissions based on chemical procurements for 2002 was 7.7 tons, similar to the 7.4 tons reported in 2001. In previous years, LANL only reported HAP emissions from chemical use associated with R&D activities. For 2002, LANL reported HAP emissions from all sources included in the emission inventory. Sources contributing to the HAP emissions included the following: R&D activities, 7.7 tons; ACDs, 2.1 tons; TA-3 steam plant, 0.56 tons; and numerous small boilers, 0.16 tons.

### a. New Mexico Air Quality Control Act.

**Construction Permits.** LANL currently operates under the air permits listed in Table 2-1. Table S2-1 summarizes allowable emissions from 20.2.72 NMAC construction permits. In 2002, the Laboratory submitted two permit applications under 20.2.72 NMAC. The first addressed the installation of a diesel-fired generator to provide stand-alone power to support research activities conducted by LANL's

## 2. Compliance Summary

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Nonproliferation and International Security (NIS) Division. The second application addressed the installation of a new asphalt plant that can produce up to 80 tons per hour. This new asphalt plant will replace the existing one. NMED issued both permits in October 2002.

**Open Burning.** LANL has an open burning permit (20.2.60 NMAC) for operational burns conducted to thermally treat or dispose of high explosives and material contaminated with high explosives and to test accident scenarios involving fire. All operational burns for 2002 were conducted within the terms specified in the permit. The results of these operations are reported annually to the NMED to document compliance with permit requirements.

In addition to operational burns, the Laboratory also conducted prescribed burning to assist with fire-mitigation activities that were needed after the Cerro Grande fire. On June 20, 2001, LANL was granted an open-burn permit to operate three ACDs within the Laboratory boundaries. These special units were chosen instead of traditional open-air burning because the ACDs have ability to operate with very little visible smoke emissions. These ACDs were installed in 2001 and continued to operate during 2002. During 2002 operations, nearly 12,000 tons of slash from fire-mitigation activities were burned. This is a significant increase over the 2001 operations, which burned approximately 1,200 tons of slash. This increase is primarily attributable to increased operating experience and obtaining NMED approval to conduct 24-hour operations. Operations are expected to continue through September 2003, when the permit for the ACDs expires. In November 2002, the Laboratory conducted its annual compliance test for opacity for each of these units. All three met the opacity limitations outlined in 40 CFR 60, Subpart CCCC.

The Open Burn permit for the operational burns expires on December 31, 2002. LANL prepared new open burn permit applications for the Dynamic Experimentation (DX) Division and Engineering Sciences and Application (ESA) Division activities. The application for DX was submitted to NMED in November 2002 and the ESA application was submitted in December. On December 27, 2002, NMED issued one permit for each area performing open burns (TA-11, 14, 16, and 36).

**Asbestos.** The National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos requires that LANL provide advance notice to the NMED for large renovation jobs that involve asbestos and for all demolition projects. The Asbestos NESHAP

further requires that all activities that involve asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed of properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the Asbestos NESHAP. Major activities in 2002 included eight large renovation jobs and demolition projects in which the NMED received advance notice. These projects, combined with other smaller activities, generated approximately 350 m<sup>3</sup> of asbestos waste. During 2002, asbestos waste amounts were more consistent with past levels and represent a significant decrease compared to the 2,070 m<sup>3</sup> generated in 2001. During that year, more than 1,800 m<sup>3</sup> of asbestos waste came from fire recovery efforts at DF-Site (TA-40). All asbestos wastes were properly packaged and disposed of at approved landfills.

To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly. In addition, four inspections by NMED during the year identified no violations. RRES-MAQ has placed its "QA Project Plan" for the Asbestos Report Project at <http://www.airquality.lanl.gov/QA.htm> on the World Wide Web.

**Degreasers.** The halogenated solvent-cleaning NESHAP requires that all solvent-cleaning machines that contain any of the six listed halogenated solvents be registered with the NMED. The Laboratory now operates two regulated solvent-cleaning machines that are registered with the NMED.

### b. Federal Clean Air Act.

**Ozone-Depleting Substances.** Title VI of the CAA contains specific sections that establish regulations and requirements for ozone-depleting substances (ODSs), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting an ODS into the atmosphere during maintenance, repair, service, or disposal of halon fire-suppression systems and air-conditioning or refrigeration equipment. All technicians who work on refrigerant systems must be EPA-certified and must use certified recovery equipment. The Laboratory is required to maintain records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants. The Laboratory's standards for refrigeration work are covered under Criterion 408, "EPA Compliance for Refrigeration Equipment," of the *Operations and Maintenance* manual.



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LANL contracts with other outside contractors to maintain, service, repair, and dispose of halon fire-suppression systems and air-conditioning and refrigeration equipment. LANL also contracts with qualified local automotive repair shops for automotive repair work, including motor-vehicle air-conditioning work.

During 2002, LANL contracted for an independent external audit of its CAA Title VI compliance program. The auditor found the Laboratory to be substantially in compliance with the requirements of Title VI. The auditor did identify opportunities for improvement in the Laboratory's compliance efforts, such as (1) improving processes for small-appliance disposals at salvage, (2) obtaining better service records from outside contractors, and (3) ensuring that all refrigerants are stored in appropriate cylinders.

In addition to routine compliance demonstration, DOE has established two goals to eliminate usage of class 1 refrigerants at DOE sites:

- retrofit or replace by the year 2005 all chillers with greater than 150 tons of cooling capacity and manufactured before 1984 that use class 1 refrigerants, and
- eliminate the use of the remaining equipment that uses class 1 refrigerants by 2010.

Figure 2-2 shows the decrease in total refrigerants used from 2001 to 2002, for all equipment and for equipment to be phased out by 2005. As the trend shows, LANL is making progress toward achieving these goals and anticipates meeting the DOE expectations. More detailed information on progress toward these phase-out goals is included in the Data Supplement.

**Radionuclides.** Under the National Emission Standard for Hazardous Air Pollutants for Radionuclides (Rad NESHAP), the EPA limits the effective dose equivalent (EDE) of radioactive airborne releases from a DOE facility, such as LANL, to any member of the public to 10 mrem/yr. The 2002 EDE (as calculated using EPA-approved methods) was 1.69 mrem. The location of the highest dose was at East Gate. Operations at LANSCE made the principal contribution to that highest dose. The RRES-MAQ QA Project Plan for the Rad NESHAP Compliance Project is available at <http://www.lanl.gov/orgs/rres/maq/QA.htm> on the World Wide Web.

LANL reviews plans for new and modified projects, activities, and operations to identify the need for emissions monitoring and prior approval from the EPA. During 2002, more than 100 reviews involved the evaluation of air-quality requirements associated with

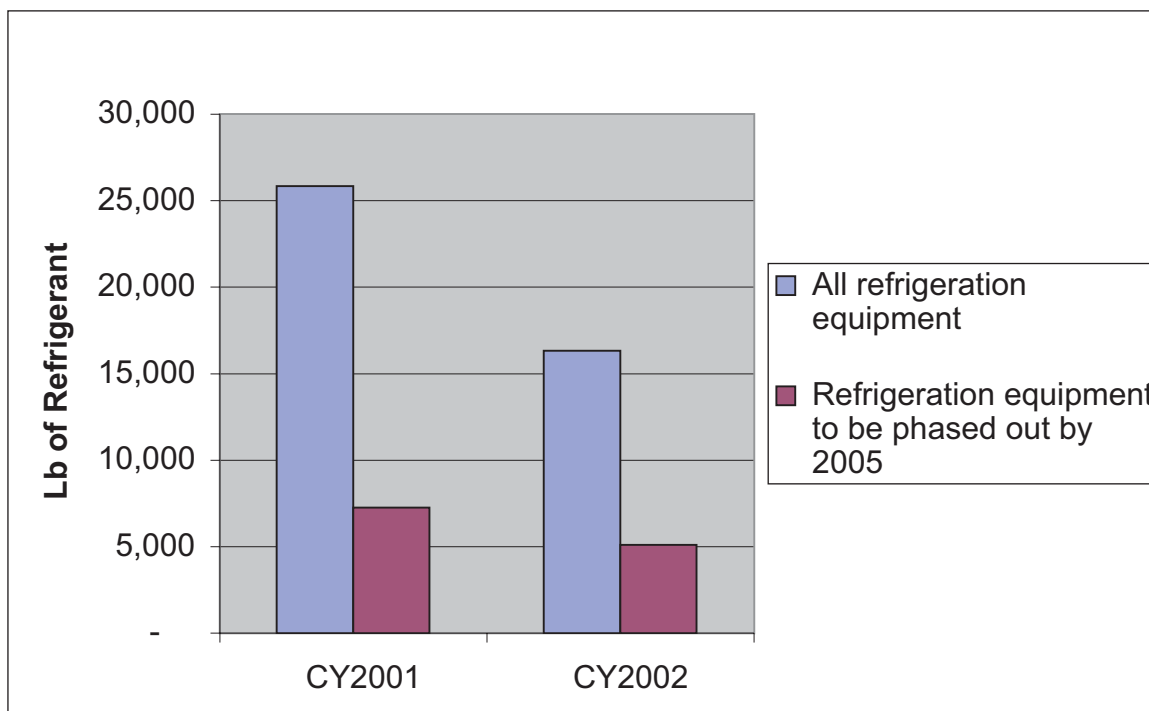


Figure 2-2. LANL refrigeration systems containing Class 1 refrigerants.

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the use of radioactive materials. One of these proposed projects that involves repackaging of radioactive waste met the criteria requiring EPA pre-approval. LANL submitted the approval application in January 2002, and approval was granted in March 2002. However, changes in scope and project delays on this activity will require the pre-approval application to be resubmitted in 2003 after plans are finalized.

During 2002, independent auditors conducted the third audit of the Laboratory's Rad NESHAP program. This audit began in June 2002 and evaluated the Laboratory's compliance for calendar year (CY) 2001. The audit found the Laboratory in full compliance with Rad-NESHAP regulations.

### 7. Clean Water Act

**a. National Pollutant Discharge Elimination System Industrial Point Source Outfall Self-Monitoring Program.** The primary goal of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for National Pollutant Discharge Elimination System (NPDES) permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

UC and the DOE are copermittees of the NPDES permit covering Laboratory operations. The EPA Region 6 in Dallas, Texas, issues and enforces the permit. The NMED certifies the EPA-issued permit and performs some compliance-evaluation inspections and monitoring for the EPA. The Laboratory's current industrial point-source NPDES permit contains 21 permitted outfalls that include 1 sanitary outfall and 20 industrial outfalls.

During the past 5 years, the Laboratory has achieved a reduction in outfalls by removing process flows at industrial outfalls and completing the transfer of the drinking-water system to Los Alamos County. No NPDES outfalls were deleted in CY 2002; however, a July 2002 request to the EPA Region 6 to delete two NPDES outfalls is still pending. Long-term objectives require that outfall owners continue evaluating outfalls for possible elimination and that new construction designs and modifications to existing facilities provide for reduced or no-flow effluent discharge systems.

Under the Laboratory's NPDES industrial point-source outfall permit, personnel collect samples

weekly, monthly, and quarterly to analyze for effluent quality limits. These regular analyses are specified by the permit. The Laboratory also annually collects water-quality samples for analysis at all outfalls. The Laboratory reports results to the EPA and the NMED at the end of the monitoring period for each respective outfall category. During CY 2002, 2 of the 1,084 samples collected from the industrial outfalls exceeded effluent limits. In the 129 samples collected from the Sanitary Wastewater Systems (SWS) Facility outfall, no samples exceeded effluent limits. To view the Laboratory's NPDES permit go to <http://wqdbworld.lanl.gov> on the World Wide Web.

The following is a summary of the corrective actions the Laboratory took during 2002 to address permit noncompliances at two industrial outfalls.

- **TA-3 Power Plant.** On March 6, 2002, a total residual chlorine (TRC) concentration of 0.5 mg/L exceeded the NPDES monthly average and daily maximum permit limit of 0.011 mg/L (counts as two instances of exceedance). The cause of this noncompliance was a malfunction of the pump that injects chlorine neutralizer into the waste stream before discharge to the outfall. The pump was immediately reprimed, an action that brought the effluent back into compliance. An additional pump was installed on March 13, 2002, and is in continuous operation along with the original pump. If either pump fails, the remaining pump will continue to pump neutralizer into the effluent.
- **TA-21 Steam Plant.** On December 17, 2002, a pH result of 9.6 standard units (s.u.) exceeded the maximum permit limit of 9. The cause of this noncompliance was a defective pH probe inside the environmental tank. The automatic control system that releases the contents of the environmental tank has been taken offline, and the pH is checked by the plant operator before the contents of the tank are manually released.

**b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program.** The Laboratory's WA-Site (TA-46) SWS Facility is an extended-aeration, activated-sludge sanitary wastewater treatment plant. The activated-sludge treatment process requires periodic disposing of excess sludge (waste-activated sludge) from the plant's clarifiers to synthetically lined drying beds. After air-drying for a minimum of 90 days to reduce pathogens, the dry sludge is removed and disposed of as a New Mexico Special Waste. During 2002, the SWS Facility

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generated approximately 24 dry tons (48,267 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

**c. National Pollutant Discharge Elimination System Permit Compliance Evaluation Inspection.** The NMED did not conduct an NPDES Outfall Compliance Evaluation Inspection during 2002. (See Table 2-2.)

**d. National Pollutant Discharge Elimination System Storm Water Construction Program.** The NPDES permit program regulates storm water discharges from identified construction activities. During 2002, the Laboratory's 13 active construction projects were permitted under the July 6, 1998, EPA Region 6 NPDES General Permit for Storm Water Discharges from Construction Activities. Under the Construction Regulations, all construction sites disturbing five or more acres, including those that are part of a larger plan of development collectively disturbing five or more acres, are required to have an NPDES Construction Permit. The NPDES Construction Permit regulates storm water discharges from construction sites. At most LANL construction sites, the Facility Manager and the General Contractor are co-permittees for the site.

Like the MSGP Permit, the NPDES Construction Permit requires each construction site to develop and implement a Storm Water Pollution Prevention (SWPP) Plan. A SWPP Plan describes the management practices used to reduce the pollutants in storm water discharges associated with the construction activity and assure compliance with the terms and conditions of the NPDES Construction Permit. These practices include the installation, inspection, and maintenance of structural and vegetative erosion and sediment controls, post-construction storm water management controls, and other controls to limit off-site sediment tracking and the contamination of run-off with other potential pollutants. Furthermore, each SWPP Plan must describe and implement measures necessary to protect listed endangered or threatened species and critical habitat. In 2002, the Laboratory implemented and maintained 44 SWPP Plans.

Construction sites with SWPP Plans are inspected in accordance with NPDES Construction Permit Regulations. Inspection reports document the condition of the site and the site's storm water controls and give recommendations to ensure NPDES Construction Permit compliance. In 2002, LANL performed 435 storm water inspections at construction sites. To track

NPDES Construction Permits, the Laboratory has developed a geographic information system-based tracking system. The system maintains records for each site, such as:

- SWPP Plan inspections,
- the condition of best management practices,
- deficiencies, and
- the date the deficiencies were corrected

General Permit information for the Laboratory is accessible to the public through postings in the Laboratory's Community Involvement Office Reading Room.

**e. National Pollutant Discharge Elimination System Storm-Water Program.** The NPDES Storm Water Permit Program regulates storm-water discharges from identified industrial activities. The UC and the DOE are copermittees under the NPDES Multi-Sector General Permit 2000 (MSGP-2000) for LANL. The permit regulates storm-water discharges from LANL industrial activities.

The permit requires the development and implementation of a Storm Water Pollution Prevention (SWPP) Plan. Currently, LANL maintains and implements 18 SWPP plans for its industrial activities.

LANL is currently conducting stream-monitoring and storm-water monitoring (1) at the confluence of the major canyons, (2) in certain segments of these canyons, and (3) at a number of site-specific facilities. In addition, LANL conducts voluntary monitoring in the major canyons that enter and leave LANL property. The flow-discharge information for the preceding period is reported in Shaull 2003 and in discharge-monitoring reports.

Compliance with the permit may be evaluated in two different ways: (1) surface waters that receive storm-water runoff should meet state water-quality standards; and (2) for certain types of industries, including industries found at LANL, federal regulations require that "benchmark parameter monitoring," or "sector-specific monitoring," be conducted under the storm-water permit.

The current strategy for implementation of the MSGP-2000 at LANL includes the following elements: (1) development and implementation of SWPP plans at 18 industrial activity locations; (2) development and implementation of a Storm-Water Monitoring Plan that provides detail on collecting storm-water runoff at watershed-based and site-specific facilities gauging stations; and (3) development and implementation of a

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best management practice installation, inspection and maintenance program.

**f. National Pollutant Discharge Elimination System Storm-Water Program Inspection.** No inspections were conducted by either the NMED or the EPA at MSGP-regulated facilities during 2002.

**g. Spill Prevention Control and Countermeasures Program.** The Laboratory's Spill Prevention Control and Counter Measures (SPCC) Program, as required by the CWA (40 CFR 112, Oil Pollution Prevention), develops comprehensive plans to meet EPA requirements that regulate water pollution from oil spills. Table S2-2 in the Data Supplement shows the SPCC plans and tanks regulated by this program at the Laboratory for 2002. The DX SPCC Plan from 2001 was separated into four separate SPCC plans in 2002. In 2002, LANL personnel revised and implemented three previously implemented SPCC plans at TA-50 and TA-21.

The NMED is in the process of combining above-ground-storage-tank (AST) and UST regulations under the new NMAC Petroleum Storage Tank (PST) Regulation 20 NMAC 5. The revised PST regulations have been filed for publication in the *New Mexico Register*. Parts 1, 2, 3, and 17 of the revised PST regulations became effective in June 2002.

On February 21, 2002, the Laboratory notified the EPA, the NMED, and the National Response Center (NRC) of a discharge of approximately 48,000 gal. of diesel fuel into the environment from the TA-21-57 AST. Soil removal and sampling were performed in accordance with Laboratory and regulatory requirements to determine the extent of the leak. The Laboratory is working with the EPA, the DOE, and the NMED on corrective actions.

**h. Dredge and Fill Permit Program.** Section 404 of the CWA requires the Laboratory to obtain permits from the US Army Corps of Engineers (COE) to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the CWA requires states to certify that Section 404 permits issued by COE will not prevent attainment of state-mandated stream standards. The NMED reviews Section 404/401 joint permit applications and then issues separate Section 401 certification letters, which may include additional permit requirements to meet state stream standards for individual Laboratory projects.

During 2002, 29 Section 404/401 permits were issued to the Laboratory for projects including utility lines, road crossings (including fire roads), headwaters

and isolated waters, and wetland/riparian areas. Because of the increased runoff from the Cerro Grande fire, LANL undertook more Section 404/401 projects during 2001 and 2002 than in prefire years. Many of the projects consist of strengthening road crossings or removing sediment that has built up behind culverts. The removal of sediment at these road crossings is required to keep the water from backing up at the culverts and eroding the surface of the road. The Laboratory has initiated numerous fire-road projects requiring 404/401 permits to ensure access to Laboratory areas during a large-scale fire.

On September 5, 2002, the NMED inspected seven sites permitted under the Section 401 regulations. No findings were noted during this inspection.

### 8. Safe Drinking Water Act

**a. Introduction.** Los Alamos County, as owner and operator of the Los Alamos Water Supply System, is responsible for compliance with the requirements of the federal Safe Drinking Water Act (SDWA) and the New Mexico Drinking Water Regulations (NMEIB 2002). The SDWA requires Los Alamos County to collect samples from various points in the water-distribution systems at the Laboratory, Los Alamos County, Bandelier National Monument, and from the water-supply wellheads to demonstrate compliance with SDWA maximum contaminant levels (MCLs). The EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The state has adopted these standards in the New Mexico Drinking Water Regulations. The EPA has authorized the NMED to administer and enforce federal drinking-water regulations and standards in New Mexico. This section presents the results from SDWA compliance monitoring conducted by Los Alamos County in 2002. Also in 2002, the Laboratory conducted additional, noncompliance monitoring of the Los Alamos Water Supply System for QA purposes. These data are presented in Chapter 5.

Staff from the NMED performed all chemical and radiological sampling for Los Alamos County, with the exception of total trihalomethane (TTHM) sample collection, which JCNNM and Los Alamos County staff conducted. The New Mexico Health Department's Scientific Laboratory Division in Albuquerque and the New Mexico State University's Soil and Water Testing Laboratory in Las Cruces received the samples for analysis. The JCNNM Health and Environmental (HENV) laboratory performs



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microbiological sampling and analysis. The NMED has certified the HENV laboratory for microbiological compliance analysis.

**b. Radiochemical Analytical Results.** In 2002, the NMED conducted no radiochemical sampling for SDWA compliance purposes.

**c. Nonradiological Analytical Results.** In 2002, Los Alamos County collected TTHM samples during each quarter from seven locations in the Laboratory and Los Alamos County water distribution systems. As shown in Data Supplement Table S2-3, the annual average for samples in 2002 was 4.9  $\mu\text{g}$  of TTHM per liter of water, less than the SDWA MCL of 80  $\mu\text{g}$  of TTHM per liter of water. In 2002, the NMED Drinking Water Bureau also sampled for total haloacetic acids (HAA5) at four TTHM sites. Like TTHMs, total haloacetic acids are byproducts from the disinfection of drinking water. As shown in Data Supplement Table S2-4, the annual average for samples in 2002 was 2.1  $\mu\text{g}$  of total haloacetic acids per liter of water, less than the SDWA MCL of 60  $\mu\text{g}$  of total haloacetic acids per liter of water.

In 2002, the NMED Drinking Water Bureau collected samples for nitrate/nitrite (as nitrogen), fluoride, cyanide, the 10 SDWA Group I metals in drinking water at the 3 entry points to the distribution system. As shown in Data Supplement Table S2-5, all concentrations at all locations were less than SDWA MCLs.

In 2002, Los Alamos County collected lead and copper samples at residential drinking water taps. Under the SDWA, if more than 10% of the samples collected from selected residential sites exceed the action levels for lead or copper, then the water supplier must take prescribed actions to monitor and control the corrosiveness of the water supplied to customers. Additionally, if 90% of the sample sites are below the action levels for lead and copper, then the water system is in compliance without the need to implement corrosion controls. As shown in Data Supplement Table S2-6, all 31 samples collected were below EPA action levels for lead and copper.

**d. Microbiological Analyses of Drinking Water.** Each month during 2002, Los Alamos County collected an average of 46 samples from the water distribution systems of the Laboratory, Los Alamos County, and Bandelier National Monument to determine the free-chlorine residual available for disinfection and the microbiological quality of the drinking water. Of the 556 samples analyzed during 2002, none indicated the presence of total or fecal coliforms.

Noncoliform bacteria were present in only 11 of the microbiological samples. Noncoliform bacteria are not regulated, but their repeated presence in samples may serve as an indicator of stagnation and biofilm growth in water pipes. Data Supplement Table S2-7 presents a summary of the monthly analytical data.

**e. Los Alamos County Consumer Confidence Report.** More information on the quality of the drinking water from the Los Alamos Water Supply System is in Los Alamos County's annual Consumer Confidence Report, available on-line at: <http://www.lac-nm.us/>.

**f. Drinking-Water Inspection.** The NMED did not conduct an inspection of the drinking-water system in 2002.

### 9. Groundwater

**a. Groundwater Protection Compliance Issues.** DOE Order 5400.1 requires the Laboratory to prepare a groundwater protection management program plan to protect groundwater resources in and around the Los Alamos area and ensure that all groundwater-related activities comply with the applicable federal and state regulations. Task III of Module VIII of the RCRA Hazardous Waste Facility Permit, the HSWA Module, requires the Laboratory to collect information about the environmental setting at the facility and to collect data on groundwater contamination.

The Hydrogeologic Workplan (LANL 1998) (Figure 2-3) happened in 1997—proposes a multiyear drilling and hydrogeologic analysis program to characterize the hydrogeologic setting of the Pajarito Plateau and to assess the potential for groundwater contamination from waste-disposal operations. The goal of the project is to develop greater understanding of the geology, groundwater flow, and geochemistry beneath the 43-square-mile Laboratory area and to assess any impacts that Laboratory activities may have had on groundwater quality.

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in New Mexico. Under the regulations, when required by the NMED, a facility must submit a groundwater discharge plan and obtain NMED approval (or approval from the Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan.

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The Laboratory has three approved groundwater discharge plans to meet NMWQCC regulations (Table 2-1): one for TA-57 (Fenton Hill), one for the SWS Facility, and one for the land application of dried sanitary sewage sludge from the SWS Facility. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. As of December 31, 2002, NMED approval of the plan was still pending.

**b. Compliance Activities.** Hydrogeologic Workplan activities during 2002 lead to the following key conclusions.

- Major ion chemistry of the regional aquifer varies from a calcium-sodium-bicarbonate to a sodium-calcium-bicarbonate ionic composition.
- Total dissolved solids (TDSs) generally increase along groundwater flow paths in the regional aquifer.
- Measurable activities of tritium observed in wells R-9, R-9i, R-12, R-15, and R-22 suggest that a component of groundwater is less than 60 years old. Well R-19 does not have detectable tritium, and the age of groundwater at this well probably ranges between 3,000 and 10,000 years.
- Mobile (nonadsorbing) solutes, including tritium, nitrate, and perchlorate, have migrated hundreds of feet within the subsurface during the past 60 years. Concentrations and activities of these chemicals are below regulatory standards and/or health advisory limits in the regional aquifer at R-wells.

The Laboratory's "Groundwater Annual Status Summary Report" (Nylander et al. 2003) provides more detailed information on newly collected groundwater data. Additionally, sample, water-level, well-construction, and other programmatic data can be reviewed online on the Laboratory's Water Quality Database (<http://wqdbworld.lanl.gov/>).

### 10. National Environmental Policy Act

**a. Compliance Activities.** In 2002, LANL sent 68 National Environmental Policy Act (NEPA) Environmental Review Forms to the National Nuclear Security Administration (NNSA), compared with 45 in 2001. The NNSA excluded 33 new actions and amended the exclusion for another 21 approved actions. LANL applied the NNSA "umbrella" exclusion (prior) determinations for 605 actions in 2002, compared with 122

actions in 2001. Use of the LANL SWEIS and prior environmental assessments (EAs) and environmental impact statements (EISs) accounts for 80 of the previous NEPA reviews. The NNSA made eight EA determinations and issued six findings of no significant impact (FONSI) in 2002. The increased number of overall reviews is caused by reviewing excavation permits in 2002 to assist LANL with compliance on its ground-disturbing activities.

**b. Environmental Impact Statements, Supplement Analyses, and Special Environmental Analyses.** Two EISs were begun and one EIS was completed in 2002: in addition, one record of decision (ROD) was amended and one Supplement Analysis (SA) was completed in 2002. All of these deal with operations or projects at LANL. No Special Environmental Analyses (SEA) were initiated at LANL in 2002.

*Supplemental Programmatic Environmental Impact Statement on Stockpile Stewardship and Management for a Modern Pit Facility.* A Notice of Intent (NOI) to prepare a supplemental programmatic EIS was published in the Federal Register on September 23, 2002. This notice is a major step forward in carrying out recommendations to develop a modern capability to manufacture plutonium pits. Pit production was shut down in 1989 at the Rocky Flats Plant, and no pits have been produced since. The NNSA's strategy calls for a new facility to be in production by approximately 2020. This supplement to the Programmatic EIS will support two decisions: (1) whether to proceed with a Modern Pit Facility and, (2) if so, where to locate it.

*Environmental Impact Statement for the Proposed Chemistry and Metallurgy Research Building Replacement Project.* An NOI to prepare an EIS was published in the Federal Register on July 23, 2002 (67 FR 48160). This EIS will analyze the environmental impacts that could result from the consolidation and relocation of mission-critical chemistry and metallurgy research capabilities at LANL from aging facilities at the current Chemistry and Metallurgy Research (CMR) Building at TA-3. The alternatives include

- relocate CMR capabilities from TA-3 to new facilities at TA-55 near the existing Plutonium Facility (proposed action);
- relocate CMR capabilities from TA-3 to new facilities built on undisturbed land in or near TA-55;

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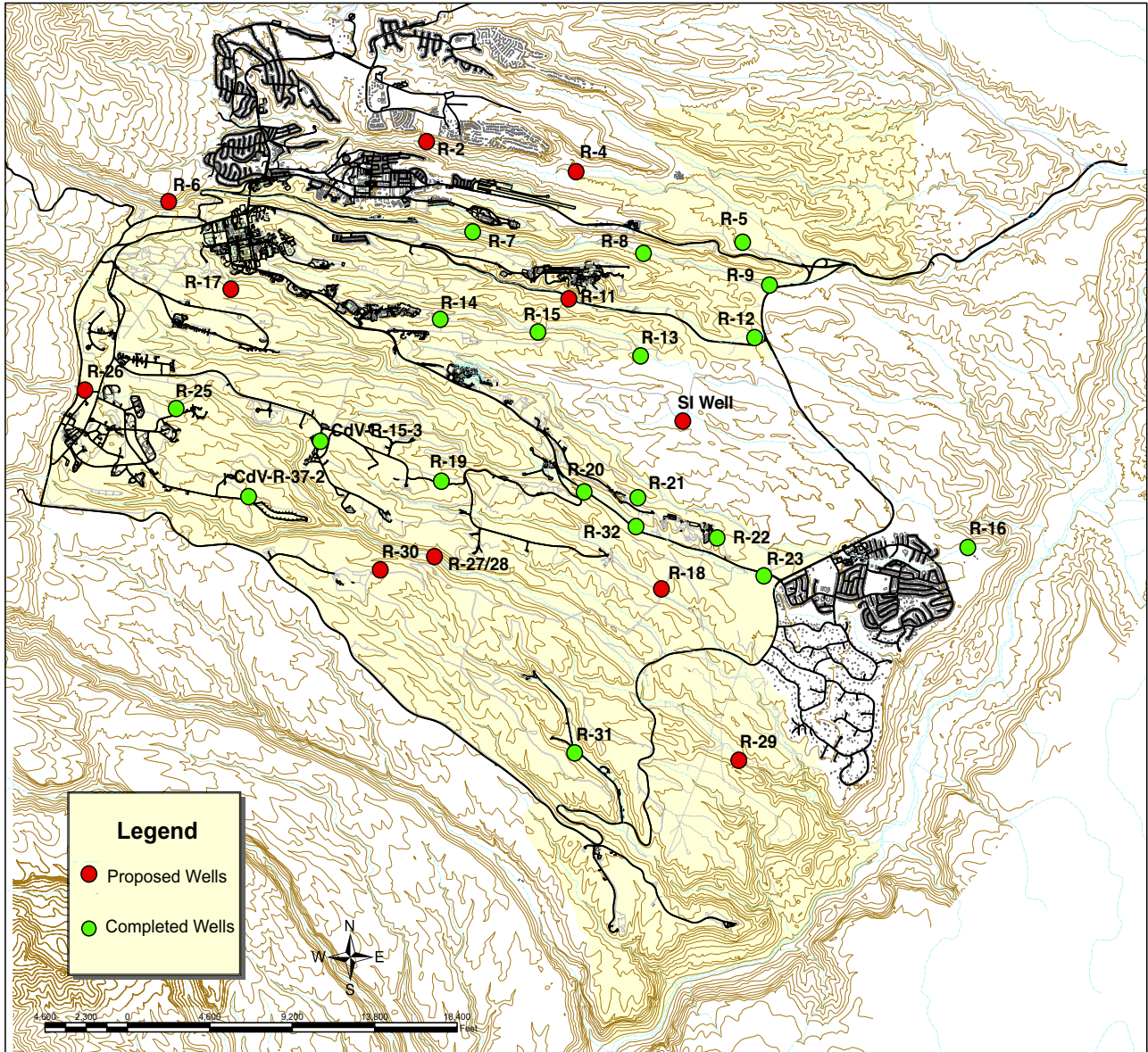


Figure 2-3. Map of hydrogeologic workplan regional aquifer characterization wells.



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- retain limited office functions and light laboratory operations at the existing CMR facility and move analytical-chemistry and materials-characterization capabilities to new facilities in or near TA-55; or
- continue CMR mission activities at the current location and do not construct new facilities (no-action alternative).

***Environmental Impact Statement for the Proposed Relocation of TA-18 Capabilities and Materials at the Los Alamos National Laboratory.*** The NNSA issued a final EIS for the proposed relocation of certain Pajarito Laboratory (TA-18) missions at LANL to another location by the end of 2004. The preferred alternative has been changed to reflect the Nevada Test Site as the relocation site for certain operations (Hazard Categories I and II). Additional NEPA reviews may be required for relocating the remaining operations. Relocating the TA-18 missions will enable the DOE to conduct its nuclear criticality studies in a more efficient and cost-effective manner.

***Environmental Impact Statement for Conveyance and Transfer of Certain Land Tracts Administered by the Department of Energy and Located at Los Alamos National Laboratory, Los Alamos and Santa Fe Counties, New Mexico.*** The ROD was amended on July 9, 2002. The amended ROD reflects changes in the need to retain certain portions of land tracts withheld earlier because of potential national security mission requirements for health and safety buffer areas relating to ongoing and future operations. Specifically, the DOE and the NNSA have reassessed the need for certain portions of tracts to serve as health and safety buffer areas. The DOE and the NNSA would no longer need to retain an 8-acre portion located at the western end of the Airport Tract. Additionally, two portions of the White Rock Y Tract that comprise about 74 acres of highway easement are no longer required as health and safety buffer areas.

***Supplemental Assessment of the LANL Site-Wide Environmental Impact Statement for Modification of Management Methods for Transuranic-Waste Characterization.*** On August 12, 2002, the Area Manager of the LAAO issued a final SA to determine whether the existing LANL SWEIS adequately encompasses the environmental effects of a proposal to modify management methods for transuranic-waste characterization at LANL or whether additional documentation is required under the NEPA. This SA specifically compares key impact assessment parameters of the waste-management program evaluated in

the SWEIS with a proposal that would change the approach of a portion of this management program. The SA also provides an explanation of any differences between the proposed action and activities described in the previous SWEIS analysis.

**c. Environmental Assessments Completed during 2002.** LANL personnel prepared seven EA-level NEPA documents in 2002. A brief description of each EA follows.

***Environmental Assessment for the Proposed Construction and Operation of a Biosafety Level 3 Facility at LANL, Los Alamos, New Mexico.*** The BSL-3 facility would be used for biological research in areas that are critical to the NNSA's national security mission. Bioscience research at LANL would be aimed at strengthening the ability to protect people against emerging infectious disease and the effects of biological agents that might be introduced into an environment, either by accident or with harmful intent. The NNSA issued a FONSI for this EA on February 26, 2002.

***Environmental Assessment for the Proposed Disposition of the Omega West Facility at LANL, Los Alamos, New Mexico.*** LANL proposes to decontaminate and demolish (D&D) the Omega West Facility and its associated structure, TA-2, Building 1, including the Omega West Reactor reactor vessel. Low levels of contamination are widespread throughout the main floor of the building with the highest levels occurring in the reactor room. The NNSA issued a FONSI for this EA on March 28, 2002.

***Environmental Assessment for the Proposed Refurbishment and Consolidation of the TA-16 Engineering Complex at LANL, Los Alamos, New Mexico.*** Most TA-16 buildings and support shops have exceeded their design life and are expensive to maintain. The Engineering Sciences and Applications Division proposes to D&D a number of these buildings, consolidate operations into other existing buildings, and construct several new facilities at TA-16. The NNSA issued a FONSI for this EA on April 23, 2002.

***Environmental Assessment for the Proposed Issuance of an Easement to Public Service Company of New Mexico for Installation and Operation of a 12-inch Natural Gas Transmission Line in Los Alamos Canyon at Los Alamos, New Mexico.*** A 50-ft right-of-way would be cleared along the length of the pipeline. Analyses performed in the EA allowed the NNSA to conclude that potential adverse effects of the proposed action, under normal conditions, would be minimal. The NNSA issued a FONSI for this EA on July 30, 2002.



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***Environmental Assessment for the Future Disposition of Certain Cerro Grande Fire Flood and Sediment Retention Structures at LANL, Los Alamos, New Mexico.*** In 2002, these structures were constructed by the NNSA, with assistance of the COE in the aftermath of the Cerro Grande fire. The NNSA issued a FONSI for this EA on August 7, 2002.

***Environmental Assessment for Proposed Access Control and Traffic Improvements at LANL, Los Alamos, New Mexico.*** Effects on traffic flow would be a concern, as would the proposed crossing of floodplain and wetland areas in upper Sandia and Mortandad canyons. The NNSA issued a FONSI for this EA on August 23, 2002.

***Environmental Assessment for the Proposed Installation and Operation of Combustion Turbine Generators at LANL, Los Alamos, New Mexico.*** The project would include installing the turbine, constructing electrical and natural-gas tie-ins, and demolishing an existing cooling tower. Waste management, air quality, surface-water quality, and wetlands are potential issues of concern about this project. The NNSA issued a FONSI for this EA on December 11, 2002.

**d. Environmental Assessments and Supplement Analyses in Progress during 2002.** Six EAs and one SA were in various stages of development during 2002:

- EA for the proposed consolidation of certain DX Division activities at the Two-Mile-Mesa Complex;
- EA for the proposed renovation of Building 55-41 and the subsequent installation and operation of radiographic equipment therein;
- EA for the proposed establishment and maintenance of certain hiking trails and closing and reclamation of certain other hiking trails within the boundaries of LANL;
- EA for the proposed lease of land to the incorporated County of Los Alamos for a new distribution center at LANL;
- EA for the proposed Los Alamos County Landfill at LANL;
- EA for the proposed remediation of the Area H at TA-54 at LANL; and
- SA for the Security Perimeter Project.

**e. Mitigation Action Plans.** Mitigation Action Plans (MAPs) may apply to individual or site-wide projects, are generally project-specific, and are designed to (1) document potentially adverse environmen-

tal impacts of a proposed action, (2) identify impact mitigation commitments made in the final NEPA documents (FONSIs or RODs), and (3) establish action plans to carry out each commitment.

***Site-Wide Environmental Impact Statement.*** Mitigations include specific measures

- to further minimize the impacts, identified in the SWEIS, that result from operations (e.g., electrical power and water supply, waste management, and wildfire) and
- to take measures to enhance existing programs to improve operational efficiency and minimize future potential impacts on cultural resources, traditional cultural properties, and natural resources.

The DOE expects LANL to complete specific measures by FY 2006, and the enhancement of existing programs should be implemented by FY 2003. A Mitigation Action Plan Annual Report is prepared annually.

***Dual Axis Radiographic Hydrodynamic Test Facility Mitigation Action Plan.*** The scope of operations-related mitigation measures included ongoing environmental chemistry baseline monitoring, ongoing monitoring of the Nake'muu cultural resource site, and human health and safety mitigations for operations.

***Low-Energy Demonstration Accelerator Mitigation Action Plan.*** The NNSA has determined that the Low-Energy Demonstration Accelerator Low-Energy Demonstration Accelerator (LEDA) project is to be terminated; and the facility has been placed in a safe, secure storage mode until further uses can be identified. Based on a thorough evaluation of the status of the facility and the remaining mitigation measures, the NNSA determined that implementation of the MAP is no longer required.

***Special Environmental Analysis of Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory, Los Alamos, New Mexico.*** As part of the SEA, the NNSA identified various mitigation measures that must be implemented as an extension of the fire-suppression, erosion, and flood-control actions. Monitoring results of the mitigation effectiveness and the environmental effects of the emergency actions recognized after the measures are in operation are to be made available to the public through an annual mitigation tracking report. The NNSA will issue the second annual report covering the fiscal year beginning October 1, 2001, and ending on September 30, 2002.

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*Other Studies Completed in 2002.* The LANL NEPA team prepared one other NEPA-related study in 2002. This study supports the proposed Advanced Hydrotest Facility project. (See LANL 2002.)

### 11. Cultural Resources

**a. Compliance Overview.** The National Historic Preservation Act requires federal agencies to evaluate the impact of proposed actions on cultural resources. Federal agencies must consult with the State Historic Preservation Officer (SHPO) and/or the Advisory Council on Historic Preservation about possible adverse effects on resources eligible for designation in the National Register of Historic Places.

During fiscal year 2002, the Laboratory cultural resources team evaluated 1,124 Laboratory-proposed actions and conducted 2 new field surveys to identify cultural resources. The team identified 297 archaeological sites and 75 historic buildings. The DOE sent 11 survey results to the SHPO for concurrence in findings of effects and determinations of eligibility for National Register inclusion of cultural resources located during the survey. The governors of San Ildefonso, Santa Clara, Cochiti, and Jemez pueblos and the president of the Mescalero Apache Tribe received for comment copies of six reports to identify any traditional cultural properties that a proposed action could affect. We identified adverse effects to 25 historic buildings that were decommissioned and decontaminated in 2002 and prepared 5 Memorandums of Agreement to support documentation and interpretation of these buildings to resolve the adverse effects. Then the team prepared a programmatic agreement to support the Land Conveyance and Transfer Project, as will be discussed.

The American Indian Religious Freedom Act of 1978 stipulates that federal policy protect and preserve the right of American Indians to practice their traditional religions. Tribal groups must receive notification of possible alteration of traditional and sacred places.

The Native American Grave Protection and Repatriation Act (NAGPRA) of 1990 states that if burials or cultural objects are inadvertently disturbed by federal activities, work must stop in that location for 30 days and the closest lineal descendant must be consulted for disposition of the remains. No discoveries of burials or cultural objects occurred in 2002. The Archaeological Resources Protection Act (ARPA) of 1979 (Public Law 96-95) provides protection of cultural resources and sets penalties for their damage or removal from federal

land without a permit. The team recorded no ARPA violations on DOE land in 2002.

### b. Compliance Activities.

**Nake'muu.** As part of the DARHT MAP, the cultural resource team is conducting a long-term monitoring program at the ancestral pueblo of Nake'muu. Nake'muu is the only pueblo on Laboratory property that still contains its original standing walls. As such, it represents one of the best-preserved ruins on the Pajarito Plateau. The year 2002 witnessed the lowest loss rate for chinking stones (0.5%) and masonry blocks (0.2%) during the 5-year monitoring period. The fact that 2002 was an extreme drought year would support the contention that natural processes have had a great effect on the deterioration of the site.

**Traditional Cultural Properties Consultation Comprehensive Plan.** In 2002, the cultural resources team continued to assist the DOE/LAAO in implementing the Traditional Cultural Properties Consultation Comprehensive Plan. This plan provides the framework to open government-to-government consultations between the DOE/LAAO and interested Native American tribal organizations on identifying, protecting, and gaining access to traditional cultural properties, while maintaining confidentiality of sensitive information. Laboratory personnel held consultation meetings with San Ildefonso Pueblo and with the Hopi Tribe in 2002.

**Land Conveyance and Transfer.** In 2002, the Advisory Council on Historic Preservation and the New Mexico SHPO, Los Alamos County, and the San Ildefonso Pueblo implemented a programmatic agreement for the transfer of lands from federal ownership. In support of this effort, the cultural resources team finalized a data-recovery plan for excavations at selected archaeological sites on lands being transferred to the County of Los Alamos and prepared a cultural affiliation study of LANL lands, as required under the NAGPRA. The team also prepared, in consultation with San Ildefonso Pueblo representatives, an Intentional Excavation Comprehensive Agreement in support of NAGPRA. With the assistance of tribal monitors from San Ildefonso Pueblo, Laboratory personnel also performed archaeological data-recovery excavations at eight sites.

**Cerro Grande Fire Recovery.** The cultural resources team finalized a report assessing fire damage of approximately 7,500 acres of LANL property burned during the May 2000 Cerro Grande fire. The team field-assessed 470 historic properties, both ancient and historic, within the burned area: fire-related damage

## 2. Compliance Summary

occurred on 340 of them. A team from the pueblos of San Ildefonso and Santa Clara selected 116 of the most heavily impacted ancient sites for rehabilitation evaluation. The LANL pueblo rehabilitation assessment team recommended a number of specific treatments, including placing of wattles, filling of stump holes, removing and slashing of hundreds of trees and snags, reseeded with native vegetation, and constructing fences around sites vulnerable to normal and emergency Laboratory operations. The team also assessed and documented some historic buildings and structures that would be scheduled for decontamination and decommissioning activities in support of the Cerro Grande Rehabilitation Project.

### 12. Biological Resources including Floodplain and Wetland Protection

**a. Compliance Activities.** During 2002, the RRES biology team reviewed 1,098 proposals and 922 excavation-permit proposals for Laboratory activities and projects that have potential impact on biological resources, including federally listed threatened and endangered (T&E) species. These reviews evaluate the amount of previous development or disturbance at the site, determine the presence of wetlands or floodplains in the project area, and determine whether habitat evaluations or species-specific surveys are needed. Of the total reviews, we identified 275 projects that required habitat-evaluation surveys to assess whether the appropriate habitat types and parameters were present to support any threatened or endangered species. The team identified 109 projects as having floodplains or wetlands issues. As part of the standard surveys associated with the Threatened and Endangered Species Habitat Management Plan, the biology team conducted approximately 30 species-specific surveys to determine the presence or absence of threatened or endangered species at LANL.

**b. Biological Resource Compliance Documents.** In 2002, the biology team prepared 15 biological resource documents, such as biological assessments, biological evaluations, floodplains and wetlands assessments, and other compliance documents. Compliance packages were written in support of the original Security Bypass Road Project, the Los Alamos Gas Line Project, and the Pajarito Gas Line Project. The team determined that all projects may affect, but are not likely to adversely affect, the Mexican spotted owl and the bald eagle and will have no effect on any other T&E species. In addition to the

compliance packages, the Laboratory produced four independent floodplains/wetlands assessments for the TA 18-22 Bypass Road Project, the Disposition of the Cerro Grande Fire Flood and Sediment Retention Structure Project, the installation of a multiple permeable reactive barrier in Mortandad Canyon, and an access-control and traffic-improvement project. Site plans were successfully used to further evaluate and manage the threatened and endangered species that occupy DOE/Laboratory property.

**c. Effects of the Drought.** During 2002, the continuing effects of the Cerro Grande fire of 2000 were dramatically worsened by the effects of a regional drought. Specifically, in late 2002 bark-beetle infestations killed large numbers of ponderosa pine and piñon pine trees throughout the Southwest, including on LANL property. In some stands, more than 90% of the pines were lost. At this time, biology team personnel can only speculate on the ecological consequences of this drought-induced tree loss; but with our enhanced monitoring capability, analysts will be more able to evaluate the effects on sensitive species.

### C. Current Issues and Actions

#### 1. Compliance Agreements

**a. New Mexico Hazardous-Waste-Management-Regulations Compliance Orders.** On June 25, 1998, the Laboratory received CO-98-02 that alleged two violations of the NM Hazardous-Waste-Management Regulations. The disputed matter involved storage of gas cylinders at LANL's TA-21. The NMED proposed civil penalties of more than \$950,000. The Laboratory filed its answer to the CO on August 10, 1998, meeting the compliance schedule by demonstrating that all gas cylinders had been disposed of properly. This CO was resolved during 2002 with a negotiated settlement of \$165,000.

On December 21, 1999, the Laboratory received CO-99-03. This CO dealt with alleged deficiencies the NMED Hazardous and Radioactive Materials Bureau discovered during a 5-month inspection that took place in 1997. The inspection was called "wall-to-wall" because NMED personnel walked every space at the Laboratory—storage areas, laboratories, hallways, stairwells, and areas surrounding buildings—looking for improperly stored hazardous chemicals. Twenty-nine deficiencies were alleged with more than \$1 million in proposed penalties. During the year 2000, the Laboratory prepared and submitted its response to the

## 2. Compliance Summary

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CO and requested a hearing. Negotiations continued during 2001 and 2002. Agreement was reached on a \$190,200 penalty, and the CO was resolved in December 2002.

The Laboratory received CO-99-01 on December 28, 1999, in response to an NMED inspection conducted August 10–September 18, 1998. The inspection team visited approximately 544 sites at the Laboratory. The CO alleged 30 violations. Total penalties proposed were almost \$850,000. In 2000, the Laboratory prepared and submitted its response to the CO and requested a hearing. Negotiations to resolve this CO were expected to begin in 2003.

**b. Notice of Violation.** On October 9, 2001, the NMED issued a Notice of Violation (NOV) to UC and DOE. This NOV arrived after a 2001 RCRA hazardous-waste-compliance inspection (April 23 to the end of August 2001). The NOV identified 18 categories of violations, each with 1 or more instances of alleged noncompliance. The types of issues described ranged from waste determinations, generator's control of waste, excessive waste storage time, incompatible chemical storage, training, emergency response, waste manifesting, mixed-waste management under the site treatment plan, waste piles, and release prevention. The response of the UC and the DOE to the NOV was provided to the NMED on February 4, 2002.

**c. NMED Order.** The NMED issued a draft order to UC/DOE in May 2002 requiring extensive site investigating and monitoring based on allegations

of imminent and substantial endangerment. The UC and the DOE provided extensive comments on the draft by July 31, 2002. The NMED issued a final order in November 2002, and negotiations are ongoing.

### D. Consent Decree

#### 1. Clean Air Act Consent Decree/Settlement Agreement

During 1997, the DOE and the Laboratory entered into a consent decree and a settlement agreement to resolve a lawsuit that the Concerned Citizens for Nuclear Safety had filed. The lawsuit, filed in 1994, alleged that the Laboratory was not in full compliance with the CAA Radionuclide NESHAP, 40 CFR 61, Subpart H. The third independent audit of the Laboratory's radionuclide NESHAP program was conducted in 2002. The auditor found the Laboratory in compliance with the radionuclide NESHAP standard for 2001. The auditor also concluded that there were no substantive deficiencies requiring corrective actions that justified having a fourth audit under the consent decree. Therefore, the auditor determined that the audit requirements under the consent decree had been met and were concluded. This was the final action required under the consent decree and settlement agreement, so the Laboratory's responsibilities in this matter were completed in 2002. The provisions of the decree and agreement are described in detail at <http://www.lanl.gov/orgs/rres/maq/ConsentDecree.htm>.

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### E. References

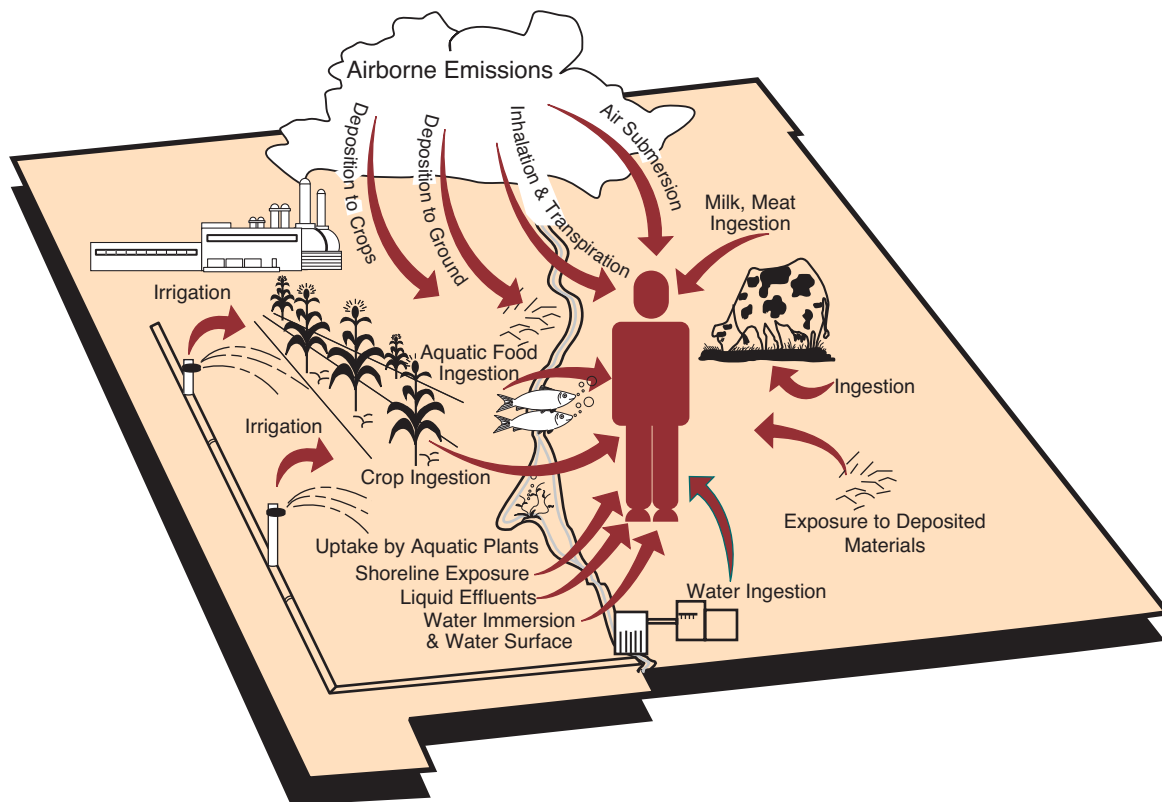
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# 3 Environmental Radiological Dose Assessment







### 3. Environmental Radiological Dose Assessment

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#### A. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented here are calculated using standard methods. The “effective dose equivalent” (EDE), referred to here as “dose,” is calculated using “radiation weighting factors” and “tissue weighting factors” to adjust for the various types of radiation and the various tissues in the body. The final result, measured in mrem, is a measure of the overall risk to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium.

Federal government standards limit the dose that the public may receive from Los Alamos National Laboratory (LANL or the Laboratory) operations. The Department of Energy (DOE) (DOE 1993) public dose limit to any individual is 100 mrem/year received from all pathways (i.e., all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct radiation). The dose received from airborne emissions of radionuclides is further restricted by the dose standard of the Environmental Protection Agency (EPA) of 10 mrem/year, which is codified in the Code of Federal Regulations (40 CFR 61, EPA 1986). These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from public water supplies are also limited according to the Clean Water Act, either by established maximum contaminant levels for some radionuclides or by dose (4 mrem/year for man-made radionuclides, beta/photon emitters) (EPA 2000). (See Appendix A.)

#### B. Public Dose Calculations

##### 1. Scope

The objective of our dose calculations is to report incremental (above background) doses caused by LANL operations. Therefore, we don’t include dose

contributions from radionuclides present in our natural environment or from radioactive fallout. Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

- (1) the entire population within 80 km of the Laboratory;
- (2) the maximally exposed individual (MEI) who is not on LANL/DOE property (referred to as the off-site MEI);
- (3) the on-site MEI, defined as a member of the public who is on LANL/DOE property, such as Pajarito Road;
- (4) residences in Los Alamos and White Rock; and
- (5) firewood released from LANL.

The doses for cases 1 and 2 for the past 5 years are shown in Figures 3-1 and 3-2.

##### 2. General Considerations

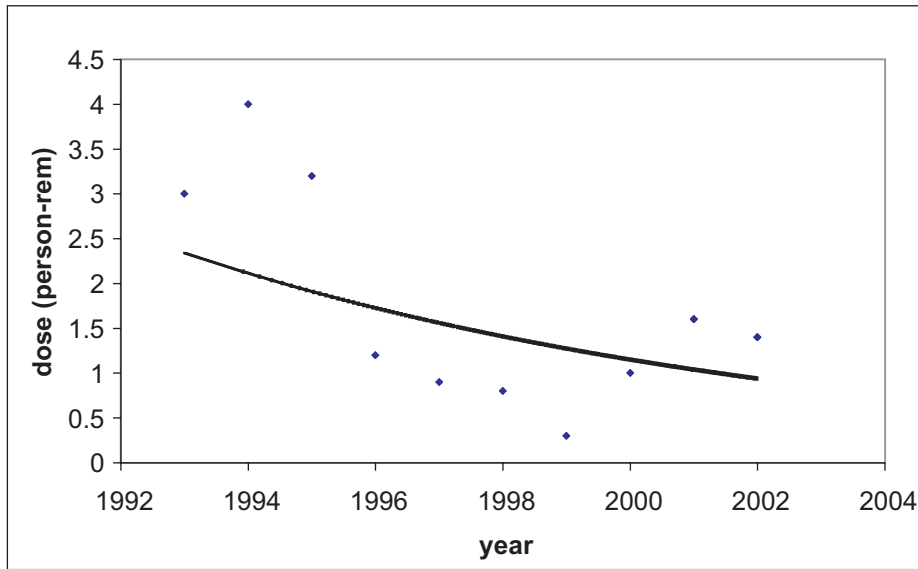
We use the standard methods recommended by federal agencies to determine radiation doses (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997; and NRC 1977). We begin with measurements and extend these with calculations using the standard methods that are used worldwide.

As we discuss in Section D, the dose rate from naturally occurring radioactivity is about 400 mrem/year. It is extremely difficult to measure doses from LANL that are less than 0.1% of natural doses. As the dose rates become smaller, the estimates become less certain and less significant. Generally, we conclude that a dose rate less than 0.1 mrem/year is essentially zero.

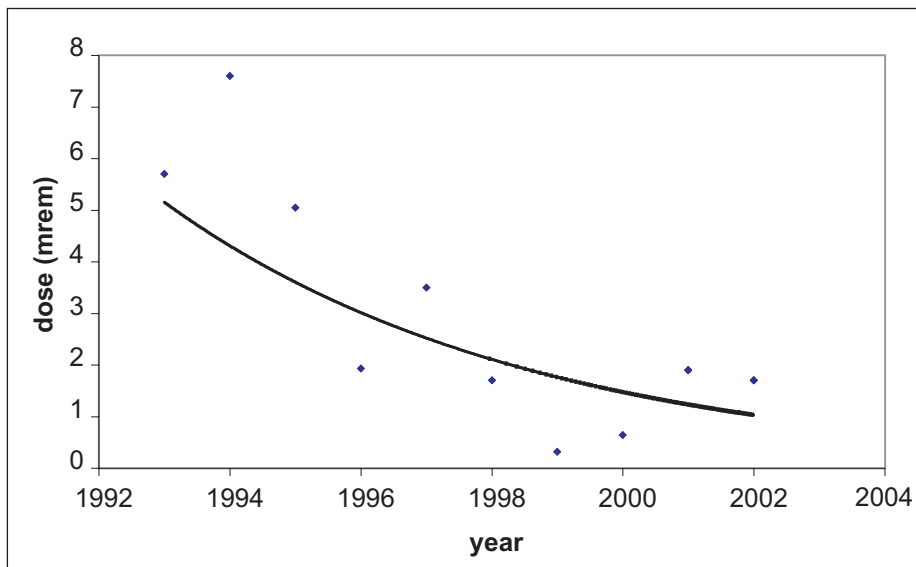
**a. Direct Radiation Exposure.** Direct radiation from gammas or neutrons is measured at more than 100 locations near LANL (Chapter 4 Section C). Doses

### 3. Environmental Radiological Dose Assessment

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**Figure 3-1.** Trend of collective dose (person-rem) to the population within 80 km of LANL.



**Figure 3-2.** Trend of dose (mrem) to the maximally exposed individual (MEI).



### 3. Environmental Radiological Dose Assessment

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above natural background were observed near TA-18, TA-53, and TA-54.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source, e.g., on Pajarito Road. At distances more than 1 km, the inverse-square law combined with scattering and attenuation in the air reduces the dose to much less than 0.1 mrem/year, which cannot be distinguished from natural background radiation. In practice, this means the only significant dose from direct radiation is on Pajarito Road near TA-18 (Section C.3 of this chapter.)

To estimate the dose to the public, we combine the measurements of gamma and neutron dose with an occupancy factor. The measurements reported in Chapter 4 would apply to an individual who is at the particular location continuously, i.e., 24 hours/day and 365 days/year. We follow standard guidance and assume continuous occupancy for residences and places of business. For locations such as Pajarito Road, we multiply the measured dose by an occupancy factor of 1/16 (NCRP 1976).

**b. Airborne Radioactivity (Inhalation Pathway).** At distances more than a few hundred meters from LANL sources, the dose to the public is almost entirely from airborne radioactive material. Whenever possible, we use the direct measurements of airborne radioactivity concentrations measured by AIRNET and reported in Chapter 4 Section A. All of these measurements result in an annual dose to a member of the public that is 0.1 mrem or less. Where local concentrations are too small to measure, we calculate the doses using the standard model CAP88 that combines source-term information with meteorological data to estimate where the released radioactive material went.

Some of the nuclide emissions from Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These are measured at the stacks (Chapter 4, Section B) and the resulting doses are calculated by CAP88 (Chapter 3, Section C). Because the radioactive half-lives are short, these doses decrease steeply with distance; e.g., the annual dose is 1.7 mrem at East Gate 1 km to the north of LANSCE and is less than 0.01 mrem at a location in Los Alamos 5 km to the west-north-west.

**c. Water (Ingestion Pathway).** We report measurements of radionuclide concentrations in ground water in Chapters 5 and surface water and sediments in Chapter 6. For all radionuclides except

uranium, the doses were less than 0.1 mrem/year. Natural uranium in the drinking water contributes a dose of about 0.1 mrem/year in Los Alamos County and more in parts of the Rio Grande valley. We conclude that the LANL contribution to the drinking-water dose is too small to measure and is much less than 0.1 mrem/year.

**d. Soil (Direct Exposure Pathway).** We report measurements of radionuclide concentrations in surface soil in Chapter 7. The dose from the cesium-137 and strontium-90 concentrations is on the order of 0.1 mrem/year, but all or almost all are from global fallout and not from LANL. The tritium is mainly from three sources: cosmic rays, nuclear weapons testing, and LANL; however, the total dose from tritium is about 0.01 mrem/year. Similarly, the transuranics may include a small contribution from LANL, but the dose is much less than 0.01 mrem/year. Finally, the isotopic mixture of uranium is consistent with natural uranium. In summary, we conclude that the LANL contribution to dose from soil is too small to measure and is less than 0.1 mrem/year.

**e. Food (Ingestion Pathway).** We report measurements of the radioactive content of foods in Chapter 8. The results are similar to those reported in previous years. Tritium concentrations near the LANL perimeter are measurably higher than regional concentrations, but the resulting doses are far below 0.1 mrem/year. The concentrations of other nuclides are consistent with global fallout, and the resulting doses are also far below 0.1 mrem/year. We conclude that the LANL contribution to the food dose is too small to measure and is much less than 0.1 mrem/year.

**f. Release of Items.** The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public. The requirements for release of such items are found in Laboratory Implementation Requirement LIR-402-700-01.0, "Occupational Radiation Protection. Chapter 14, Part 3. Releasing Items." In keeping with the principle of maintaining radiation dose levels to "As Low As Reasonably Achievable," it is Laboratory policy to not release any items with residual radioactivity. According to the best of our knowledge, there is no additional dose to the general public through the release of items for uncontrolled use by the general public.

On a related topic, in Section C.5 we calculate the dose to users of firewood released from LANL and conclude it is essentially zero.

## 3. Environmental Radiological Dose Assessment

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### C. Dose Calculations and Results

#### 1. Population within 80 Kilometers

We used the local population distribution to calculate the dose from Laboratory operations during 2002 to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. We used county population estimates provided by the University of New Mexico Bureau of Business and Economic Research. These statistics are available at <http://www.unm.edu/~bber/>.

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL; for example, if two persons each receive 3 mrem the collective dose is 6 person-mrem. This dose results from airborne radioactive emissions; other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88, an atmospheric dispersion and dose calculation computer code.

The 2002 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 1.4 person-rem, which compares with 1.6 person-rem reported for 2001. Tritium contributed about 70% of the dose and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 25%.

No observable health effect is expected from these doses.

#### 2. Off-Site Maximally Exposed Individual

The off-site maximally exposed individual (MEI) is a hypothetical member of the public who, while not on DOE/LANL property, received the greatest dose from LANL operations. The location of the off-site MEI was at East Gate along State Road 502 entering the east side of Los Alamos County. East Gate is normally the location of greatest exposure because of its proximity to LANSCE. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

We modeled the dose from LANSCE and from the LANL stacks using CAP88, an atmospheric dispersion and dose calculation computer code. The CAP88-modeled doses were 1.3 mrem from the LANSCE

stack, 0.1 mrem from LANSCE diffuse emissions, and 0.2 mrem from other LANL stacks. To this total, we add 0.1 mrem from the radionuclides measured at the AIRNET station, primarily from tritium (Jacobson 2003).

The total annual dose, 1.7 mrem, is far below the applicable standards; and we conclude it causes no observable health effects.

#### 3. On-Site Maximally Exposed Individual

The on-site MEI is a member of the public on Pajarito Road who passes LANL TA-18.

Dosimeters that are sensitive to neutron and photon radiation are located on Pajarito Road. We collected data continuously throughout 2002 (Chapter 4, Section C), and these data allow us to calculate doses that might have been received by members of the public. After subtracting the dose from natural background, the total dose (during 24 hours a day and 365 days a year) was 16 mrem. Following the guidance of the NCRP (NCRP 1976) we multiplied this total by 1/16 to account for occupancy (an occupancy factor of 1/16 corresponds to an average of half an hour of exposure every 8-hour workday). This calculation indicates a dose of 1 mrem to a member of the public on Pajarito Road during 2002. All other pathways, including CAP88 calculations for the air pathway, add less than 0.1 mrem to the calculated dose. This dose is about 1% of the DOE public all-pathway dose limit of 100 mrem.

#### 4. Doses in Los Alamos and White Rock

We used the AIRNET data (reported in Chapter 4, Section A) to calculate the average air concentrations for the 21 perimeter stations near Los Alamos and White Rock and subtracted the concentrations at the 4 regional stations. These concentrations were converted to doses using the factors in DOE 1988b. To these doses, we added the contributions from LANSCE, calculated using CAP88 for 2 representative locations: 5 km west-north-west of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

**a. Los Alamos.** During 2002, the measurable contributions to the dose at an average Los Alamos residence were as follows: 0.007 mrem from LANSCE, 0.007 mrem from plutonium, 0.000 mrem from americium, and 0.003 mrem from tritium. These add to 0.017 mrem. All other nuclides contribute less than 0.001 mrem.

### 3. Environmental Radiological Dose Assessment

**b. White Rock.** During 2002, the measurable contributions to the dose at an average White Rock residence were as follows: 0.006 mrem from LANSCE, 0.013 mrem from plutonium, 0.006 mrem from americium, and 0.001 mrem from tritium. These add to 0.026 mrem. All other nuclides contribute less than 0.001 mrem.

The contributions from direct radiation, food, water, and soil were discussed in Chapter 3, Section B.2; each was too small to measure. In summary, the total annual dose from all pathways was less than 0.1 mrem. No observable health effect is expected from these doses.

#### 5. Firewood from Laboratory Property

In this section, we discuss the doses to users of the firewood that was cut as part of the LANL tree-thinning and fire-prevention project. The distribution of firewood is subject to LANL 2001. According to the procedure, all potentially contaminated trees are retained on LANL property.

We have measured the potential contamination in LANL trees. The most recent LANL report is Gonzales et al. 2001, which finds that the highest concentrations of contamination occur in wood ash because the ashing process concentrates some elements by about a factor of 100. The cesium-137 concentrations of approximately 1–10 pCi/g ash are typical worldwide and are a result of global fallout. We conclude that all or almost all the radioactivity reported in the table below is from global fallout.

Table 3-1 summarizes the typical concentrations and doses from burning the firewood, spreading the wood ash on agricultural land, and eating the food grown on this land according to a standard residential farmer scenario.

Thus, the dose associated with firewood and wood ash is about 0.1 mrem/year or less, and almost none is a result of LANL operations.

#### D. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section we discuss the LANL contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from radionuclides naturally in the environment. Doses from cosmic radiation range from 50 mrem/year at lower elevations near the Rio Grande to about 90 mrem/year in the mountains. Doses from terrestrial radiation range from about 50 to 150 mrem/year depending on the amounts of natural uranium, thorium, and potassium in the soil.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products, which contribute about 200 mrem/year. An additional 40 mrem/year results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and in all living cells.

In addition, members of the US population receive an average dose of 50 mrem/year from medical and dental uses of radiation, 10 mrem/year from man-made products such as stone or adobe walls, and less than 1 mrem/year from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the total annual dose from sources other than LANL approximately 300–500 mrem. The estimated LANL-attributable 2002 dose to the MEI, 1.7 mrem, is about 0.5% this dose.

**Table 3-1. Radionuclide Concentrations and Potential Doses for Wood Ash**

Radionuclide	Wood-Ash Concentration	Potential Dose
<sup>40</sup> K (natural)	100 pCi/g	0.1 mrem/yr
<sup>137</sup> Ce	10 pCi/g	0.01 mrem/yr
<sup>90</sup> S	4 pCi/g	0.01 mrem/yr
<sup>241</sup> Am	0.2 pCi/g	0.001 mrem/yr
<sup>239</sup> Pu	0.5 pCi/g	0.0001 mrem/yr
<sup>238</sup> Pu	0.03 pCi/g	0.00001 mrem/yr
<sup>238</sup> U	0.1 pCi/g	0.00001 mrem/yr

### 3. Environmental Radiological Dose Assessment

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#### E. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem). However, doses to the public from LANL operations are much smaller. According to the 1996 Position Statement of the Health Physics Society (HPS 1996) “Below 10 rem, risks of health effects are either too small to be observed or are nonexistent.” Therefore, the doses reported here are not expected to cause observable health effects.

#### F. Biota Dose Assessment

In 2002, the DOE established radiological dose rate limits for the protection of non-human biota: 0.1 rad/day for terrestrial wildlife and 1 rad/day for terrestrial plants and aquatic organisms (DOE 2002). At the same time, the department published Biota Concentration Guides (BCGs) for individual

radionuclides; the BCGs represent environmental media concentrations that are equivalent to the dose rate limits. For multiple radionuclides, the sum of the ratios of measured values to the corresponding BCGs is computed, and, if this sum of the ratios exceeds 1, the limit is exceeded. We calculated a sum of ratios for terrestrial wildlife of 0.02 in the areas of highest soil concentration measured in 2002 (Supplemental Data Table S3-1). This is well below the target value of 1. For aquatic organisms, we calculated a value of about 1. The measured values used here were in samples taken immediately below the TA-50 outfall, which discharges radioactive liquid waste. Water concentrations are much smaller elsewhere, and the outfall area does not provide good habitat for aquatic life. We conclude that environmental concentrations of radionuclides pose no threat to the health of nonhuman biota inhabiting the Laboratory’s environs.

### 3. Environmental Radiological Dose Assessment

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## 4. Air Surveillance







## 4. Air Surveillance

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### A. Ambient Air Sampling (Craig Eberhart)

#### 1. Introduction

The radiological air-sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and activation products, that may be released from Los Alamos National Laboratory (LANL or the Laboratory) operations. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the Laboratory's air-sampling program. Most of the regional airborne radioactivity come from the following sources: (1) fallout from past atmospheric nuclear weapons tests conducted by several countries, (2) natural radioactive constituents in particulate matter (such as uranium and thorium), (3) terrestrial radon diffusion out of the earth and its subsequent decay products, and (4) material formation from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and common atmospheric gases). Table 4-1 summarizes regional levels of radioactivity in the atmosphere for the past 5 years, which can be useful in interpreting current air sampling data.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days can increase soil entrainment, but precipitation (rain or snow) can wash particulate matter out of the air. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Natural events

can also have major impacts: during 2000, the Cerro Grande fire dramatically increased short-term ambient concentrations of particulate matter (ESP 2001).

Risk Reduction and Environmental Stewardship Division Meteorology and Air Quality Group (RRES-MAQ) personnel compare ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental-compliance standards or workplace-exposure standards, depending on the location of the sampler. The group usually compares annual concentrations in areas accessible to the public with the 10 mrem equivalent concentration established by the Environmental Protection Agency (EPA) (EPA 1989). Concentrations in controlled access areas are usually compared with Department of Energy (DOE) Derived Air Concentrations (DACs) for workplace exposure (DOE 1988a) because access to these areas is generally limited to workers with a need to be in the controlled area.

#### 2. Air-Monitoring Network

During 2002, the Laboratory operated approximately 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as follows: (1) regional, (2) pueblo, (3) perimeter, (4) decontamination and decommissioning (D&D) samplers (for areas where the sources are primarily D&D operations), (5) Technical Area (TA) -15 and TA-36, (6) TA-54, or (7) other on-site locations.

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**Table 4-1. Average Background Concentrations of Radioactivity in the Regional<sup>a</sup> Atmosphere**

	Units	EPA Concentration Limit <sup>b</sup>	Annual Averages <sup>c</sup>				
			1998	1999	2000	2001	2002
Gross Alpha	fCi/m <sup>3</sup>	NA <sup>d</sup>	0.8	1.0	1.0	0.8	0.8
Gross Beta	fCi/m <sup>3</sup>	NA	12.4	13.4	13.0	13.9	13.3
Tritium <sup>e</sup>	pCi/m <sup>3</sup>	1,500	0.5	0.5	0.8	-0.1	-0.1
<sup>90</sup> Sr	fCi/m <sup>3</sup>	19					0.004
<sup>238</sup> Pu	aCi/m <sup>3</sup>	2,100	0.1	-0.2	0.0	0.0	0.0
<sup>239,240</sup> Pu	aCi/m <sup>3</sup>	2,000	0.4	0.1	0.0	0.1	0.3
<sup>241</sup> Am	aCi/m <sup>3</sup>	1,900	0.3	-0.2	0.3	-0.2	0.3
<sup>234</sup> U	aCi/m <sup>3</sup>	7,700	12.9	16.1	17.1	17.9	21.7
<sup>235</sup> U	aCi/m <sup>3</sup>	7,100	0.9	1.2	0.9	1.3	2.4
<sup>238</sup> U	aCi/m <sup>3</sup>	8,300	12.8	15.2	15.9	17.7	21.8

<sup>a</sup>Data from regional air-sampling stations operated by LANL during the last 5 years (Locations can vary by year.)

<sup>b</sup>Each EPA limit equals 10 mrem/yr.

<sup>c</sup>Gross alpha and beta annual averages are calculated from gross air concentrations. All other annual averages are calculated from net air concentrations.

<sup>d</sup>NA = not available.

<sup>e</sup>Tritium annual averages have been corrected for the tritium lost to bound water in the silica gel media.

### 3. Sampling Procedures, Data Management, and Quality Assurance

**a. Sampling Procedures.** Generally, each AIRNET sampler continuously collects particulate matter and water-vapor samples for approximately 2 weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m<sup>3</sup> per minute. The vertically mounted canisters each contain about 135 g of silica gel with an airflow rate of about 0.0002 m<sup>3</sup> per minute; the gel collects the water-vapor samples. This silica gel is dried in a drying oven to remove most residual water before being used in the field. The gel is a desiccant that removes moisture from the sampled air; the moisture is then distilled, condensed, collected as a liquid, and shipped to the analytical laboratory. The AIRNET project plan (ESH-17 2000) and the numerous procedures through which the plan is implemented provide details about the sample collection, sample management, chemical analysis, and data management activities.

**b. Data Management.** Using a palm-held microcomputer, RRES-MAQ personnel recorded electronically in the field the 2002 sampling data, including timer readings, volumetric airflow rates at the start and stop of the sampling period, and comments pertaining to these data. We later transferred these data to an electronic table format within the AIRNET Microsoft Access database.

**c. Analytical Chemistry.** A commercial laboratory analyzed each 2002 particulate-matter filter for gross alpha and gross beta activities. These filters were also grouped across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. For 2002, clumps ranged from six to nine filters. Gamma-emitting radionuclides were also measured at each Federal Facilities Compliance Agreement station by grouping the filters collected each quarter. To prepare a quarterly composite for isotopic analyses for each AIRNET station, the group combined half-filters from the six or seven sampling periods at each site during the quarter.



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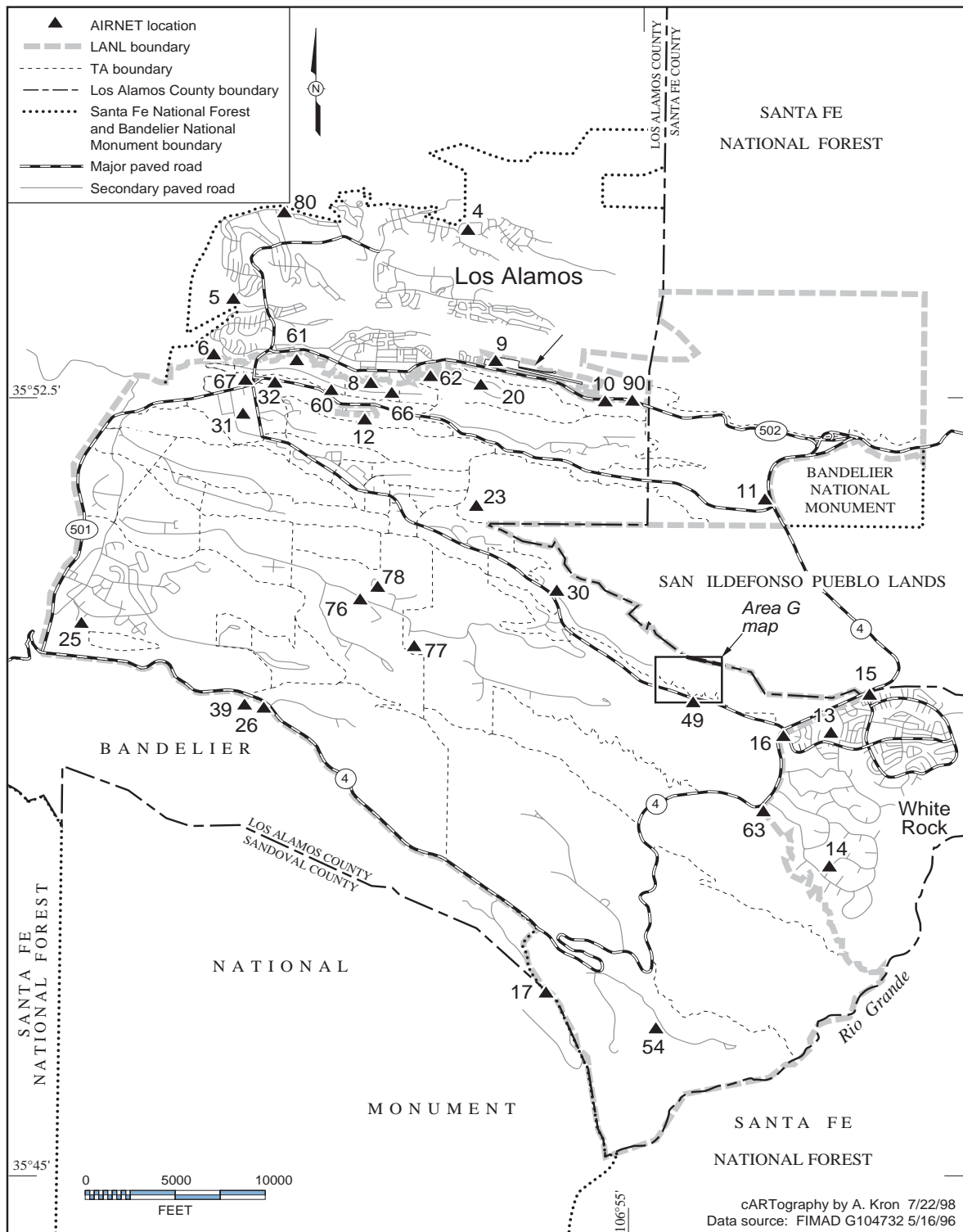


Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

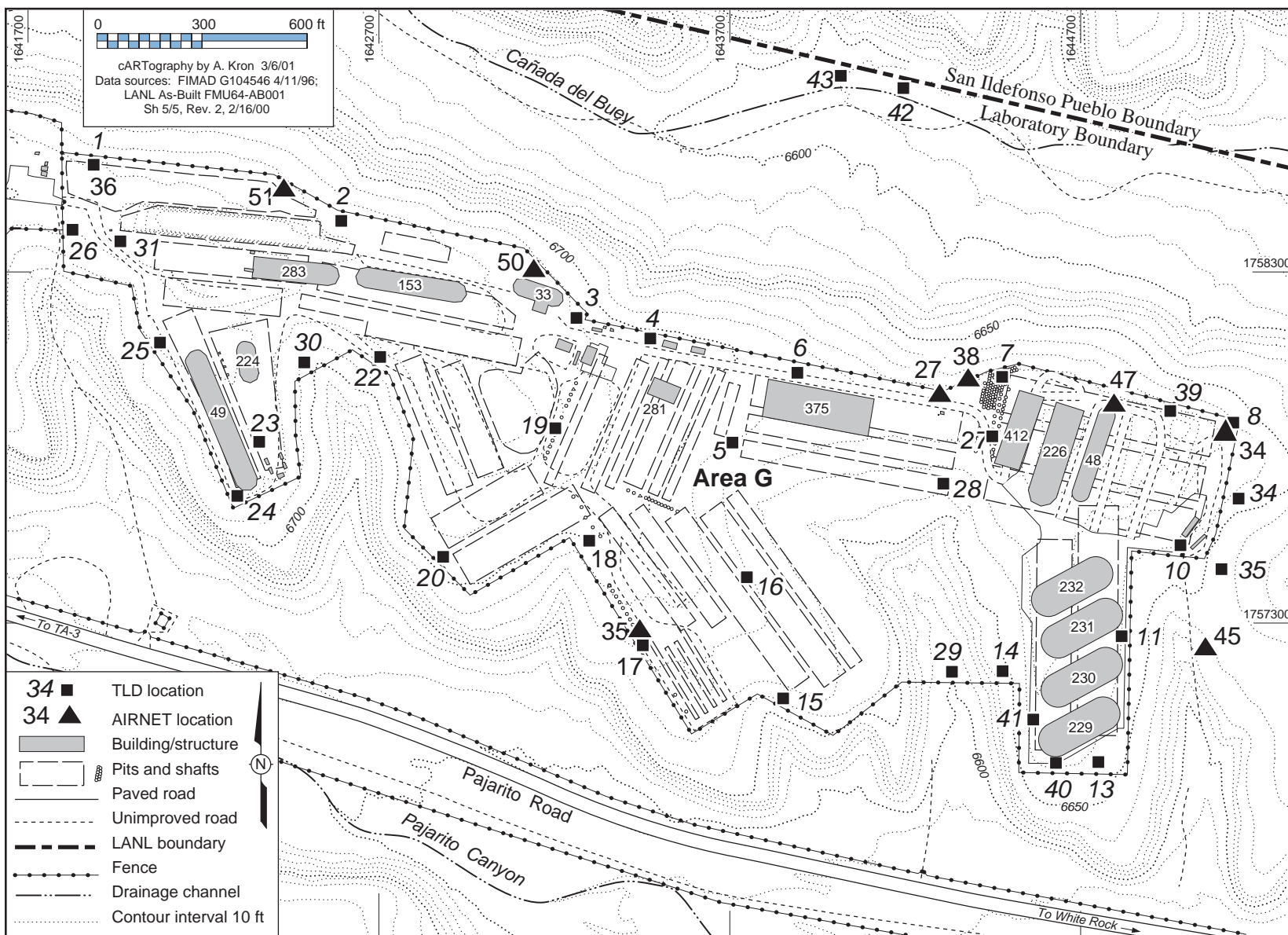


Figure 4-2. Technical Area 54, Area G, map of AIRNET and TLD locations.

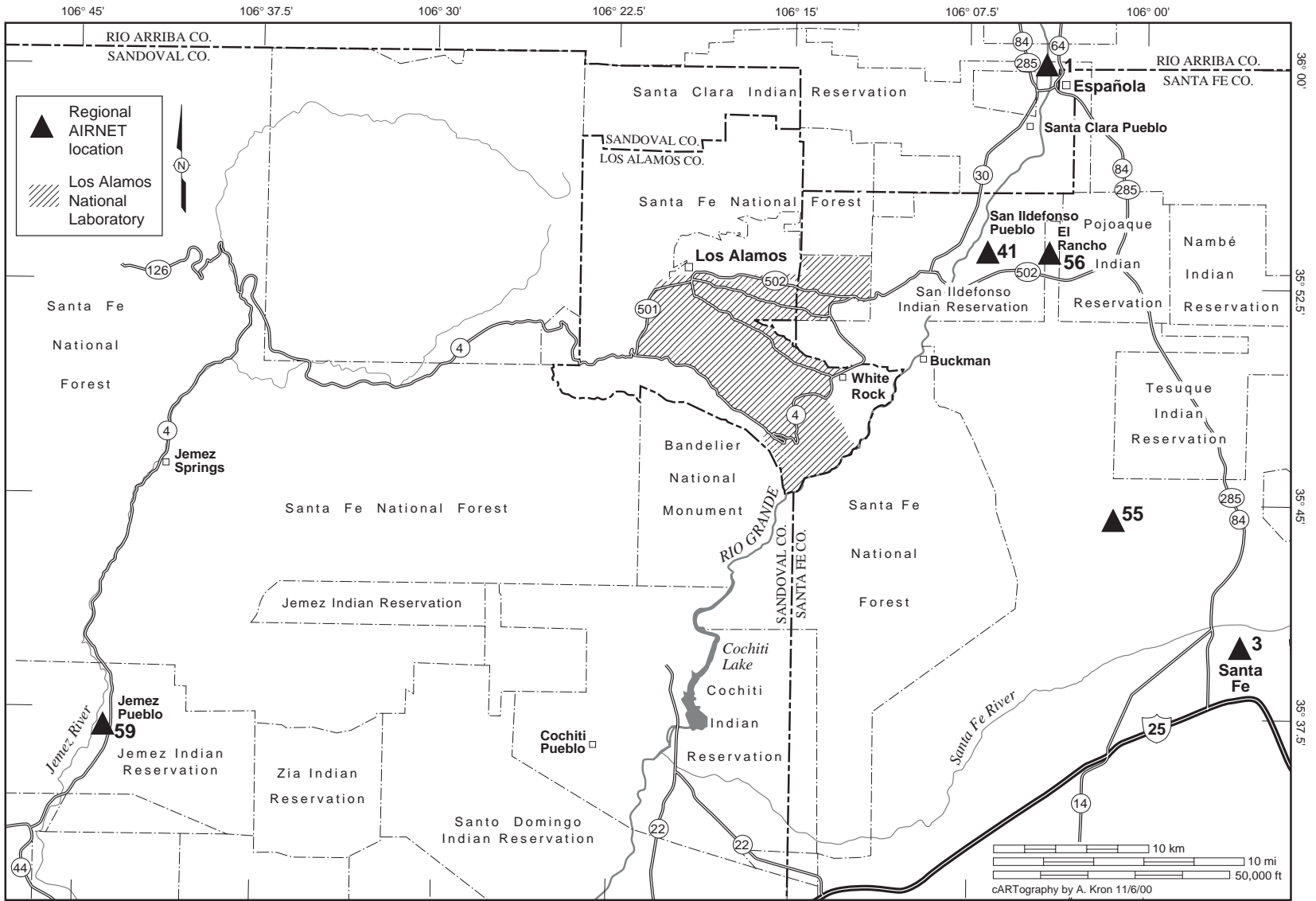


Figure 4-3. Regional and pueblo AIRNET locations.

## 4. Air Surveillance

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Analysts dissolved these composites, separated them chemically, and then analyzed for isotopes of americium, plutonium, and uranium using alpha spectroscopy. Every 2 weeks, water was distilled from the silica gel that had been used to collect water vapor in the field. A commercial laboratory used liquid scintillation spectrometry to analyze this distillate for tritium. All analytical procedures meet the requirements of 40 Code of Federal Regulations (CFR) 61, Appendix B. The AIRNET project plan provides a summary of the target minimum detectable activity (MDA) for the biweekly and quarterly samples.

**d. Laboratory Quality Control Samples.** For 2002, the RRES-MAQ and the contractor analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical chemistry laboratories. The chemistry met the quality assurance (QA) requirements for the AIRNET program.

### 4. Ambient Air Concentrations

#### a. Explanation of Reported Concentrations.

Tables 4-2 through 4-13 summarize the ambient air concentrations calculated from the field and analytical data. Data from individual sites are given in Tables S4-1 through S4-10 in the Data Supplement. The number of measurements is normally equal to the number of samples analyzed. The number of measurements less than the uncertainty is the number of calculated net air concentrations that are less than their individual propagated net 2 standard deviations (std dev) analytical uncertainties. These concentrations are defined as “not having measurable amounts of the material of interest.” The MDAs are the levels that the instrumentation could detect under ideal conditions. All AIRNET concentrations and doses are total measurements without any type of regional background subtractions. However, the air concentrations include corrections for radioactivity from the filter material and the analytical process. The net concentrations are usually somewhat lower because small amounts of radioactivity are present in the filter material, the acids used to dissolve the filter, and the tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or

minus ( $\pm$ ) another value represent a 95% confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement and analytical errors but also seasonal and spatial variations. As such, the calculated 95% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals that approach 100%. All ambient concentrations are activity concentrations per actual cubic meter of sampled air. It should be noted that some values in the tables are negative. See Appendix B for an explanation of negative values.

#### b. Gross Alpha and Gross Beta Radioactivity.

We use gross alpha and gross beta analyses primarily (1) to evaluate general radiological air quality, (2) to identify potential trends, and (3) to detect sampling problems. If the gross analytical results appear to be elevated, then immediate analyses for specific radionuclides may be performed to investigate a potential problem, such as an unplanned release.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air to be 2 femtocuries (fCi)/m<sup>3</sup>. The primary alpha activity is caused by polonium-210 (a decay product of radon) and other naturally occurring radionuclides (NCRP 1975, NCRP 1987). The NCRP also estimated national average concentration levels of long-lived gross beta activity in air to be 20 fCi/m<sup>3</sup>. The presence of lead-210 and bismuth-210 (also decay products of radon) and other naturally occurring radionuclides is the primary cause of this activity.

In 2002, we collected and analyzed more than 1,300 air samples for gross alpha and gross beta activity. The annual means for all of the stations are less than half of the NCRP's estimated average (2 fCi/m<sup>3</sup>) for gross alpha concentrations (Table 4-2). At least two factors contribute to these seemingly lower concentrations: the use of actual sampled air volumes instead of standard temperature and pressure (STP) volumes and the burial of alpha emitters in the filter that are not measured by front-face counting. Gross alpha activity is dependent on variations in natural conditions, such as atmospheric pressure, atmospheric mixing, temperature, and, soil moisture.

Table 4-3 shows gross beta concentrations within and around the Laboratory. These data show variability similar to the gross alpha concentrations. All of the annual averages are below 20 fCi/m<sup>3</sup>, the NCRP-

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**Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m <sup>3</sup> )	Minimum (fCi/m <sup>3</sup> )	Mean (fCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	98	0	1.52	0.31	0.75	±0.05
Pueblo	51	0	1.51	0.46	0.77	±0.07
Perimeter	673	0	1.79	0.22	0.70	±0.02
TA-15 and TA-36	78	0	1.63	0.23	0.67	±0.06
D and D	85	0	1.33	0.32	0.75	±0.05
TA-54 Area G	234	0	7.43	0.34	0.84	±0.07
Other on-site	128	0	1.71	0.25	0.72	±0.04

### Concentration Guidelines

Concentration guidelines are not available for gross alpha concentrations.

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

**Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m <sup>3</sup> )	Minimum (fCi/m <sup>3</sup> )	Mean (fCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	98	0	25.5	8.1	13.3	±0.6
Pueblo	51	0	25.9	5.1	13.2	±1.0
Perimeter	673	0	22.5	2.6	12.0	±0.2
TA-15 and TA-36	78	0	17.8	9.0	12.2	±0.5
D and D	85	0	19.1	5.3	12.6	±0.5
TA-54 Area G	234	0	21.5	2.6	12.1	±0.4
Other on-site	128	0	19.3	8.2	12.1	±0.4

### Concentration Guidelines

Concentration guidelines are not available for gross beta concentrations.

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.



## 4. Air Surveillance

estimated national average for beta concentrations, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. We also calculate the gross beta measurements on the actual sampled air volumes instead of STP volumes. The primary source of measured gross beta activity in the particulate matter samples is the bismuth-210 in the radon-222 decay chain.

Gross alpha and beta activities in air exhibit considerable temporal variability as shown in Figures 4-4 and 4-5. Variability among sites within AIRNET is usually much less than variability over time. However, as shown in Figure 4-4, Site 45 at the eastern side of Area G had much higher gross alpha measurements during February and March 2002. These high concentrations led the team to believe that a release may have occurred at this active waste disposal area. Further investigation indicated that the likely source was material-screening to separate larger rocks from crushed tuff that had been used to bury transuranic (TRU) waste. A detailed discussion of this investigation is included in Section A.5.

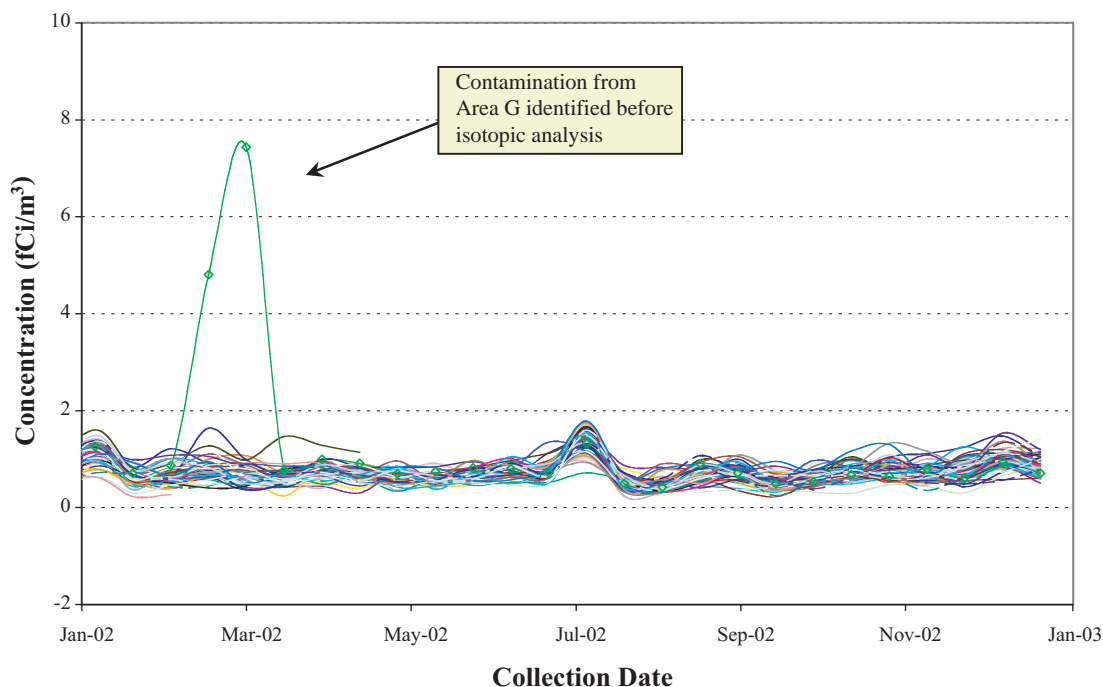
**c. Tritium.** Tritium is present in the environment primarily as the result of nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure the tritium

in water (HTO or T<sub>2</sub>O) because the dose impact is about 14,000 times higher than if it were hydrogen gas (DOE 1988b).

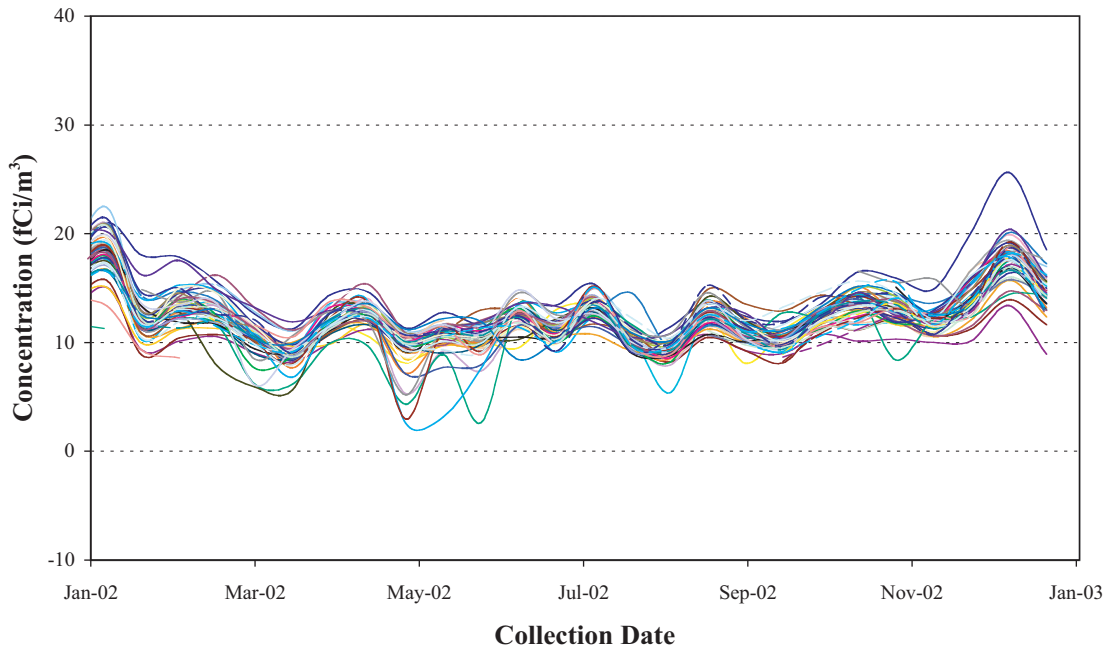
Water-vapor concentrations in the air and tritium concentrations in the water vapor were used to calculate ambient levels of tritium. Corrections for blanks, bound water in the silica gel, and isotopic distillation effects are included in this calculation (ESP 2002).

The annual concentrations for 2002 at the regional and pueblo stations were not significantly different from zero (Table 4-4). The average concentration for the perimeter samplers was significantly greater than zero as were the average concentrations for all of the on-site groups. The highest concentrations were measured at TA-54, Area G. These data indicate that the Laboratory does produce measurable amounts of tritium. All annual mean concentrations at all sampling sites were well below the applicable EPA and DOE guidelines.

The highest off-site annual concentration, 13.2 picocuries (pCi)/m<sup>3</sup>, was at the Los Alamos Airport, which is close to TA-21. This concentration is equivalent to about 1% of the EPA public dose limit. Emissions from TA-21 were higher in 2002 and regularly caused concentrations to exceed investigation levels as described in section A.5 of this chapter.



**Figure 4-4.** Gross alpha measurements (fCi/m<sup>3</sup>) by sampling site.



**Figure 4-5.** Gross beta measurements (fCi/m<sup>3</sup>) by sampling site.

**Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (pCi/m <sup>3</sup> )	Minimum (pCi/m <sup>3</sup> )	Mean (pCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	98	97	1.9	-3.0 <sup>b</sup>	-0.1	±0.2
Pueblo	52	52	1.5	-3.4	-0.1	±0.3
Perimeter	676	233	30.9	-1.9	4.0	±0.3
TA-15 and TA-36	78	35	10.7	-0.1	2.8	±0.5
D and D	81	7	58.1	1.1	14.6	±2.7
TA-54 Area G	240	0	3380.1	3.7	123.7	±56.5
Other on-site	130	37	408.2	-1.2	12.4	±6.5

**Concentration Guidelines**

DOE Derived-Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

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The RRES-MAQ Group measured elevated concentrations at a number of on-site stations, with the highest annual concentration at TA-54, Area G. This annual mean concentration, 963 pCi/m<sup>3</sup>, is only 0.005% of the DOE DAC for worker exposure and is measured at a location near shafts containing tritium-contaminated waste.

**d. Plutonium.** While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), this element is not naturally present in measurable quantities in the ambient air. All measurable sources are from plutonium research-and-development activities, nuclear-weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air.

The high concentrations for the plutonium isotopes in Area G and Rocket Park in White Rock are probably related to the soil-screening operations at TA-54, as described in section A.5 of this chapter.

The RRES-MAQ environmental air monitoring team found no detectable concentrations of plutonium-238 at any of the regional or pueblo sampling sites, but one perimeter quarterly concentration was above its uncertainty level (Table 4-5). This detection of plutonium-238, 2.2 attocuries (aCi)/m<sup>3</sup>, was measured

the first quarter of 2002 at Rocket Park. As a single measurement only 13% higher than its uncertainty, analytical variability may have caused the detection; but elevated concentrations of americium-241 and plutonium-239 in the same sample corroborate that the measurement is real. Nine on-site quarterly concentrations were above their uncertainties, with all nine being at TA-54, Area G. Three of the measurements were at the station located at the northeast corner of Area G, which indicates that the concentrations at this location are quantitative and above background levels. For the past 3 years, this site has had the highest concentration of plutonium-238, but site 45 was higher in 2002 with an annual mean activity of 20.4 aCi/m<sup>3</sup>, which corresponds to 0.001% of the DOE DAC for worker exposure.

No detectable concentrations of plutonium-239 were found at any of the regional or pueblo samplers, but 12 perimeter quarterly concentrations were above their uncertainty levels (Table 4-6). The highest off-site annual mean was at Los Alamos Inn-South, with a concentration of 33 aCi/m<sup>3</sup> or about 2% of the EPA public dose limit. These higher ambient concentrations are from historical activities at LANL's Old Main Technical Area (TA-1) that deposited plutonium on the hillside below the Los Alamos Inn. We recorded the highest annual on-site concentration for plutonium-239,-240 at Area G. The concentration was

**Table 4-5. Airborne Plutonium-238 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	15	0.6	-0.8 <sup>b</sup>	0.0	±0.2
Pueblo	8	8	0.2	-0.3	-0.1	±0.2
Perimeter	104	103	2.2	-0.9	-0.1	±0.1
TA-15 and TA-36	12	12	0.5	-0.6	-0.2	±0.2
D and D	17	17	1.1	-0.7	0.1	±0.3
TA-54 Area G	36	27	77.0	-0.4	3.5	±4.3
Other on-site	20	20	1.8	-0.6	0.0	±0.2

### Concentration Guidelines

DOE Derived-Air Concentration (DAC) Guide for workplace exposure is 3,000,000 aCi/m<sup>3</sup>. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

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**Table 4-6. Airborne Plutonium-239,-240 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	15	1.4	-0.7 <sup>b</sup>	0.3	±0.3
Pueblo	8	8	0.9	-0.6	0.2	±0.5
Perimeter	104	92	88.4	-1.1	2.6	±2.3
TA-15 and TA-36	12	12	0.9	-0.6	-0.1	±0.4
D and D	17	13	16.2	-0.5	3.1	±2.4
TA-54 Area G	36	15	2460.2	-0.2	99.8	±138.8
Other on-site	20	20	1.3	-0.8	0.1	±0.2

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

**Table 4-7. Airborne Americium-241 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	15	1.5	-1.8 <sup>b</sup>	0.25	±0.5
Pueblo	8	8	1.7	-1.1	0.01	±0.9
Perimeter	104	102	28.1	-1.7	0.40	±0.6
TA-15 and TA-36	12	12	2.5	-1.4	0.02	±0.6
D and D	17	16	4.5	-1.4	0.66	±0.8
TA-54 Area G	36	21	1340.4	-1.1	52.03	±75.6
Other on-site	20	20	1.6	-1.2	0.08	±0.4

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

## 4. Air Surveillance

643 aCi/m<sup>3</sup>, which is about 0.03% of the DOE DAC for workplace exposure.

**e. Americium-241.** As with the plutonium isotopes, americium is present in very low concentrations in the environment (Table 4-7). No detectable concentrations of americium-241 were measured at any of the regional or pueblo sampling stations, but two perimeter quarterly concentrations were above their uncertainty levels. The highest off-site annual mean was at Rocket Park, which showed a concentration of 7 aCi/m<sup>3</sup> or about 0.4% of the EPA public dose limit.

Fifteen of the 16 on-site quarterly samples with detectable concentrations of americium-241 were measured at Area G. The overall concentration at Area G was almost 100 times higher than for any other group of sampling sites, with an average of 52 aCi/m<sup>3</sup>. The highest annual on-site concentration was 342 aCi/m<sup>3</sup> at station 45 in Area G. This concentration is about 0.02% of the DOE DAC for worker exposure.

**f. Uranium.** Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. Relative isotopic abundances are constant and well characterized. Uranium-238 and uranium-234 are essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (as calculated from Walker et al. 1989). Because known LANL uranium emissions are enriched (excess uranium-234 and -235)

or depleted (excess uranium-238), we can use comparisons of isotopic concentrations to estimate LANL contributions. Using excess uranium-234 to detect the presence of enriched uranium may not seem suitable because the enrichment process is usually designed to increase uranium-235 concentrations. However, the enrichment process normally increases uranium-234 at a faster rate than uranium-235, and the dose, in natural uranium, is about an order of magnitude higher for uranium-234 than for uranium-235.

All annual mean concentrations of the three uranium isotopes were well below the applicable EPA and DOE guidelines (Tables 4-8 through 4-10). The maximum annual uranium concentrations were at locations with high dust levels from local soil disturbances such as dirt roads at the Los Alamos County Landfill and LANL's TA-54, Area G. Both the regional and pueblo groupings had higher average concentrations of uranium-234 and uranium-238 than the perimeter group. The higher concentrations for the regional and pueblo groups result from increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, and other soil disturbances such as construction activities and grazing—but not any known man-made sources of uranium.

During 2002, 25 sites had at least one quarter with excess uranium-238 as shown in Figure 4-6. We measured no excess uranium-234 during 2002. These excess uranium concentrations were identified by statistically comparing the uranium-234 and

**Table 4-8. Airborne Uranium-234 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	1	60.3	2.3	21.7	±9.4
Pueblo	8	0	56.7	8.6	28.2	±12.4
Perimeter	104	18	64.5	1.1	11.8	±1.9
TA-15 and TA-36	12	2	29.7	0.2	11.6	±5.6
D and D	17	7	21.9	2.6	8.1	±3.0
TA-54 Area G	36	2	94.3	0.5	26.5	±7.7
Other on-site	20	2	23.9	1.7	11.0	±2.8

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m<sup>3</sup>. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.



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**Table 4-9. Airborne Uranium-235 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	11	10.1	-0.6 <sup>b</sup>	2.4	±1.7
Pueblo	8	7	3.7	-0.1	1.9	±1.2
Perimeter	104	93	8.3	-1.2	0.9	±0.3
TA-15 and TA-36	12	10	3.9	-2.4	1.1	±1.2
D and D	17	17	2.0	-2.9	0.2	±0.6
TA-54 Area G	36	27	6.1	-1.2	1.9	±0.6
Other on-site	20	18	4.1	-1.4	1.0	±0.6

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

**Table 4-10. Airborne Uranium-238 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m <sup>3</sup> )	Minimum (aCi/m <sup>3</sup> )	Mean (aCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
Regional	15	1	48.3	3.6	21.8	±7.5
Pueblo	8	0	61.7	17.6	33.6	±12.2
Perimeter	104	2	72.0	0.6	15.1	±2.1
TA-15 and TA-36	12	0	79.7	9.5	25.7	±13.4
D and D	17	5	23.0	-0.4 <sup>b</sup>	10.8	±3.4
TA-54 Area G	36	0	99.9	11.1	31.7	±7.1
Other on-site	20	2	27.3	2.3	15.5	±3.6

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

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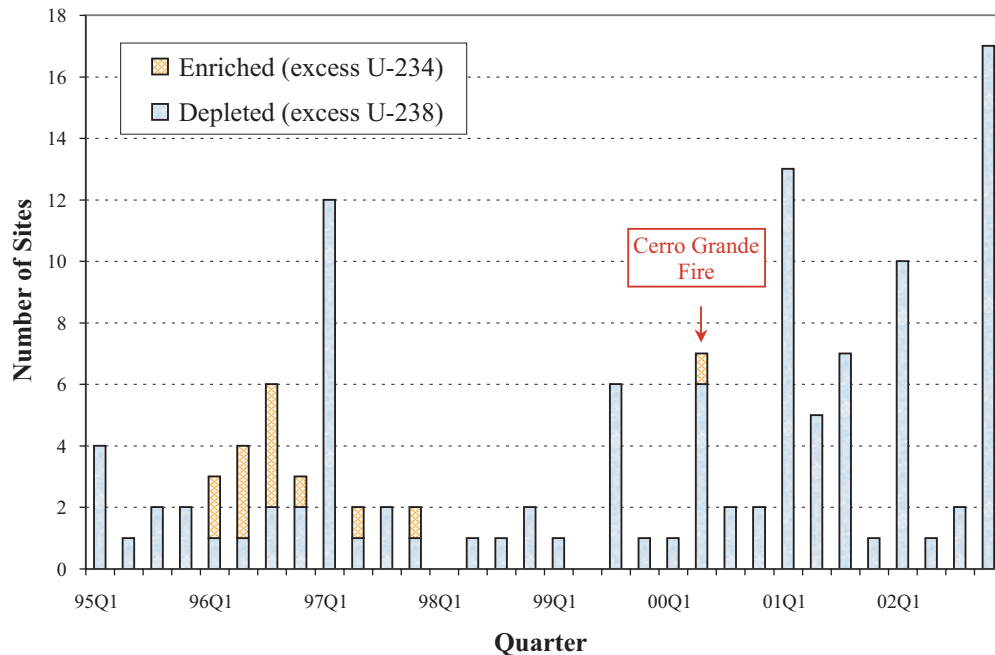


Figure 4-6. AIRNET sites with excess isotopic uranium.

uranium-238 concentrations. If the concentrations in a sample were more than three standard deviations apart, the sample was considered to have excess enriched or depleted uranium. (See Section A.6.)

**g. Strontium-90.** Strontium-90 is present worldwide from atmospheric weapons testing and locally from the historical experiments and nuclear reactor operations. We began measuring strontium-90 on a select set of quarterly composites with the first quarter of 2002. None of the 87 samples collected in 2002 had any detectable concentrations (Table 4-11).

**h. Gamma Spectroscopy Measurements.** In 2002, RRES-MAQ personnel conducted gamma spectroscopy measurements on groups of filters including analyses of “clumps” (biweekly filters grouped across sites for a single sampling period) and quarterly composites (biweekly filters grouped across time for a single site). We investigated any measurement other than beryllium-7, potassium-40, and lead-210) above the MDA because the existing data indicate that such a measurement is highly unlikely except after an accidental release. The beryllium-7 and lead-210 measurements were the only radionuclides above their MDAs. (See Tables 4-12 and 4-13.)

## 5. Investigation of Elevated Air Concentrations

Two action levels have been established to determine the potential occurrence of an unplanned release: investigation and alert. Investigation levels are based on historical measurements and are designed to indicate that an air concentration is higher than expected. Alert levels are based on dose and require a more thorough, immediate follow-up.

In 2002, a number of air sampling values exceeded action levels. When a measured air concentration exceeds an action level, the RRES-MAQ Group verifies that the calculations were done correctly and that the sampled air concentrations are likely to be representative, i.e., that no cross contamination has taken place. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations.

Three significant investigations occurred in 2002 and dealt with the following: (1) the number of samples with depleted uranium (DU) has increased since the Cerro Grande fire as described in Section A.6; (2) tritium emissions increased at TA-21 because of D&D activities; and (3) a soil-screening operation at TA-54 resuspended plutonium and americium contamination in the air.

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**Table 4-11. Airborne Strontium-90 Concentrations for 2002 — Group Summaries**

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m <sup>3</sup> )	Minimum (fCi/m <sup>3</sup> )	Mean (fCi/m <sup>3</sup> )	95% Confidence Interval <sup>a</sup>
<b>Regional</b>	15	15	0.068	-0.061 <sup>b</sup>	0.004	±0.018
<b>Pueblo</b>	8	8	0.067	-0.003	0.021	±0.011
<b>Perimeter</b>	32	32	0.057	-0.044	0.005	±0.010
<b>TA-15 and TA-36</b>	4	4	0.032	-0.068	-0.003	±0.071
<b>D and D</b>	8	8	0.040	-0.114	-0.026	±0.053
<b>TA-54 Area G</b>	8	8	0.037	-0.024	0.002	±0.016
<b>Other on-site</b>	12	12	0.052	-0.041	0.002	±0.016

### Concentration Guidelines

DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 fCi/m<sup>3</sup>. See Appendix A, “Table A-2. Department of Energy’s Derived Concentration Guides for Water and Derived-Air Concentrations.”

<sup>a</sup>95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

<sup>b</sup>See Appendix B for an explanation of negative values.

**Table 4-12. Airborne Gamma-Emitting Radionuclides that are Potentially Released by LANL Operations**

Gamma-Emitting Radionuclide	Number of Measurements	Number of Measurements ≤MDA <sup>a</sup>	Mean (fCi/m <sup>3</sup> )	Measured Average MDA as a Percent of the Required MDA
<sup>73</sup> As	200	200	<<0.81	0.1
<sup>74</sup> As	200	200	<<0.55	0.5
<sup>109</sup> Cd	200	200	<<0.03	0.1
<sup>57</sup> Co	200	200	<<0.14	0.2
<sup>60</sup> Co	200	200	<<0.28	33.2
<sup>134</sup> Cs	200	200	<<0.25	18.8
<sup>137</sup> Cs	200	200	<<0.23	24.4
<sup>54</sup> Mn	200	200	<<0.27	2.0
<sup>22</sup> Na	200	200	<<0.29	22.2
<sup>83</sup> Rb	200	200	<<0.52	3.1
<sup>86</sup> Rb	200	200	<<4.38	15.6
<sup>103</sup> Ru	200	200	<<0.25	0.2
<sup>75</sup> Se	200	200	<<0.23	2.7
<sup>65</sup> Zn	200	200	<<0.58	12.8

<sup>a</sup>Minimum detectable amounts

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**Table 4-13. Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities**

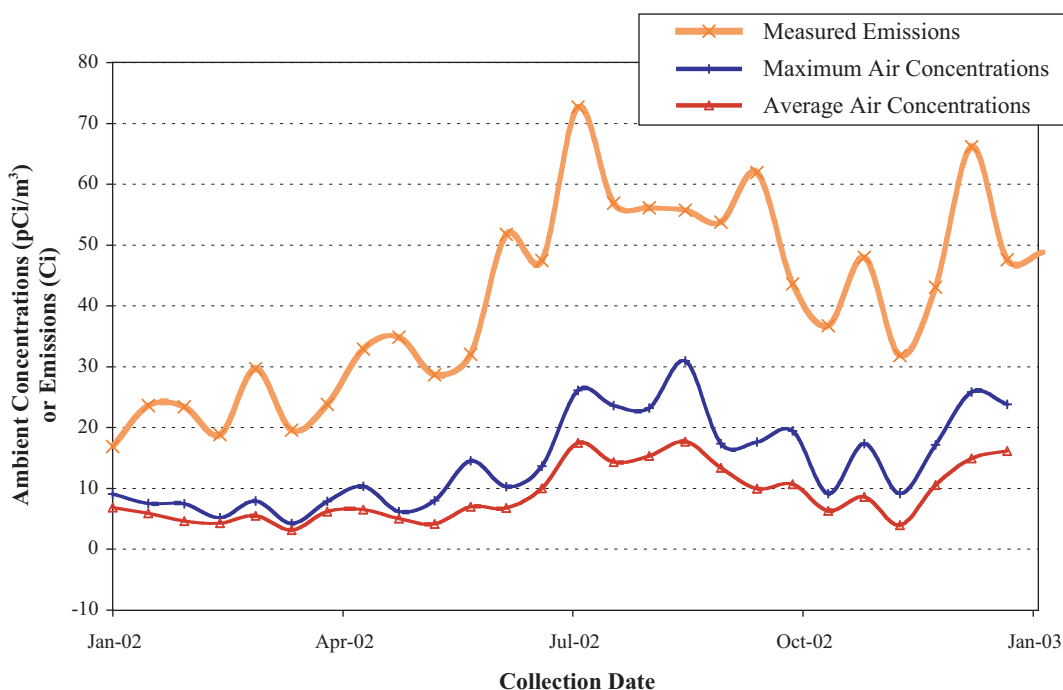
Gamma-Emitting Radionuclide	Number of Measurements	Number of Measurements $\leq$ MDA <sup>a</sup>	Mean <sup>b</sup> (fCi/m <sup>3</sup> )
<sup>7</sup> Be	200	0	79.0
<sup>210</sup> Pb	200	3	12.6

<sup>a</sup>Minimum detectable amounts

<sup>b</sup>Measurements that are less than the MDA are not included in the mean.

**a. Sites near TA-21 with Tritium Investigations.** During the entire year of 2002, various planned operations at TA-21 emitted larger-than-normal quantities of tritium. The two primary facilities, TA-21-155 and TA-21-209, together emitted slightly more than 1,000 curies (Ci) of tritiated water (HTO) during 2002. This quantity is roughly one and one-half to three times the typical annual HTO emissions for these facilities in recent years. Consequently, beginning with the biweekly sample period ending May 27, when biweekly TA-21 HTO emissions began consistently to exceed 30 Ci, AIRNET stations near or in the

prevalent wind directions of TA-21 detected slightly elevated levels of airborne tritium that exceeded investigation levels. This pattern persisted throughout the year (Figure 4-7). This figure shows the 2-week HTO emissions from TA-21 and the maximum and average tritium concentrations as measured by nearby AIRNET samplers. Both maximum and average ambient tritium concentrations were strongly correlated with TA-21 emissions, indicating that the samplers provided sufficient coverage and that TA-21 was the primary source.



**Figure 4-7.** Tritium oxide emissions at TA-21 and nearby ambient concentrations in the Los Alamos townsite.

**b. Soil Screening at TA-54.** In February and March 2002, soil-sifting activities at Area G caused a release of measurable quantities of plutonium and americium into the atmosphere. This soil or overburden had been used to bury TRU waste drums. After the drums had been exhumed, this soil was sampled for possible contamination. Apparently pockets of contamination were not detected by the soil-sampling. These releases were first detected by the high gross alpha measurements that were about three times higher than the action level (Figure 4-4).

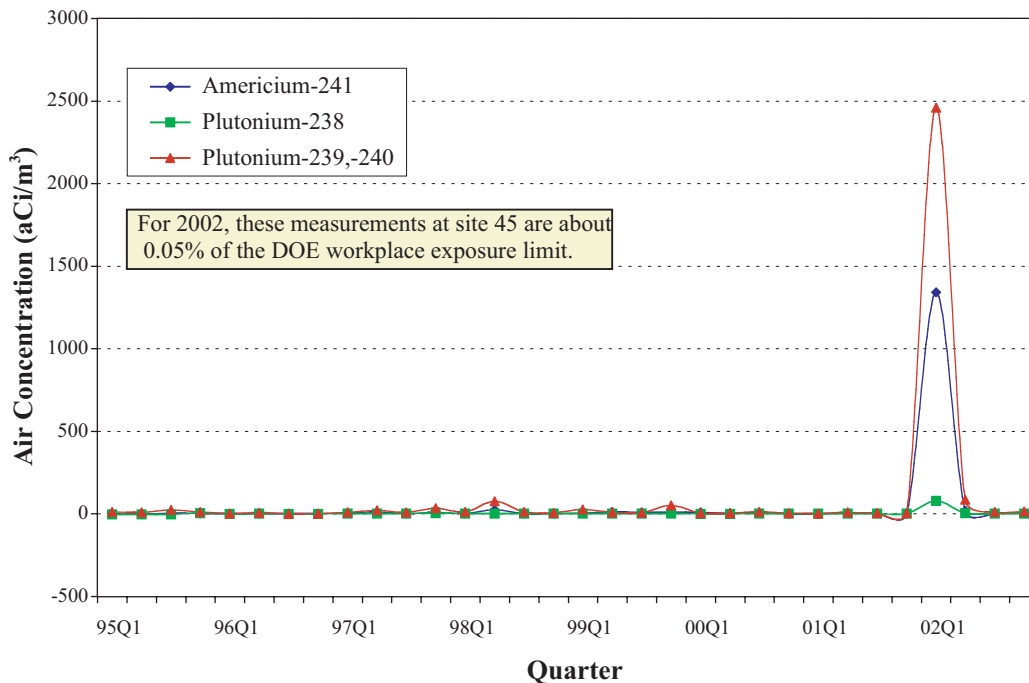
The suspected contamination was confirmed by subsequent alpha spectroscopy of the quarterly composites and individual half filters (Figure 4-8). All three quarterly measurements of the transuranic radionuclides were the highest concentrations ever measured on a quarterly AIRNET sample. These values and smaller increases at other Area G samplers caused upward spikes in the TA-54 concentration trends (Figure 4-9). In addition to impacting nearby samplers, the emissions were measured off-site at the Rocket Park sampling station in White Rock as shown in Figure 4-10. These measurements are among the highest ever measured off-site, but summed together they still only represent about 1.4% of the EPA public dose limit. Several other detectable concentrations

were above their uncertainties in White Rock, but at much lower concentrations.

### 6. Long-Term Trends

**a. Uranium.** Even though the annual and quarterly concentrations of uranium isotopes vary, peak concentrations for all three isotopes occur during the second quarter of each year (Figure 4-11). Furthermore, since the first quarter of 1998, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations, indicating the presence of DU in some samples. The station at TA-36 was not included in these averages because of the persistent and known presence of DU in the samples, as discussed following.

As shown in Figure 4-6, DU has usually been detected in at least one sample per quarter—most notably the first quarters of 1997, 2001, and 2002 and the fourth quarter of 2002 when significant differences (3 std dev) were detected in about 25% or more of the samples. All of the samples with DU were collected on LANL property or within Los Alamos County. In the 6 years before 2001, we collected only 15 quarterly composite samples with excess uranium-238 off-site. During 2001 and 2002, 18 off-site samples with



**Figure 4-8.** Site 45 Area G quarterly transuranic concentrations.



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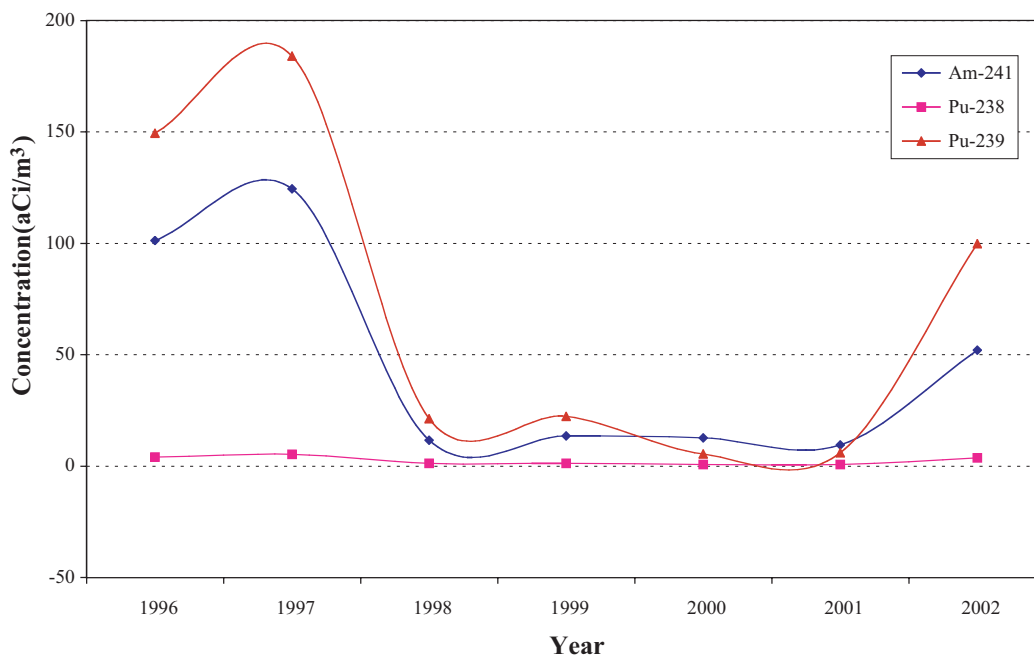


Figure 4-9. Americium and plutonium concentration trends for TA-54, Area G.

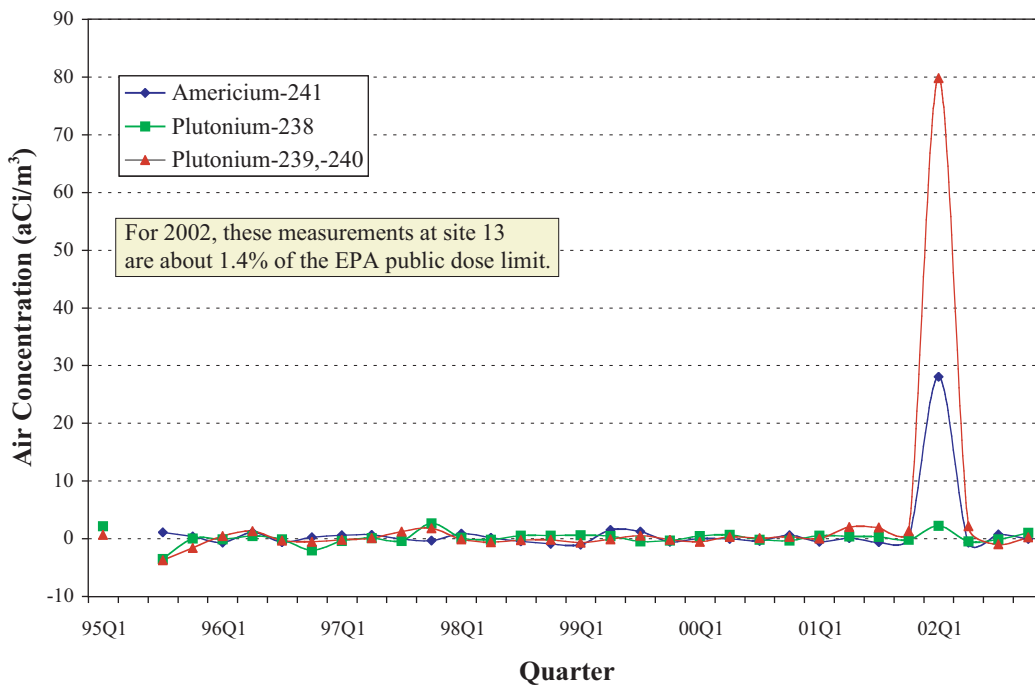
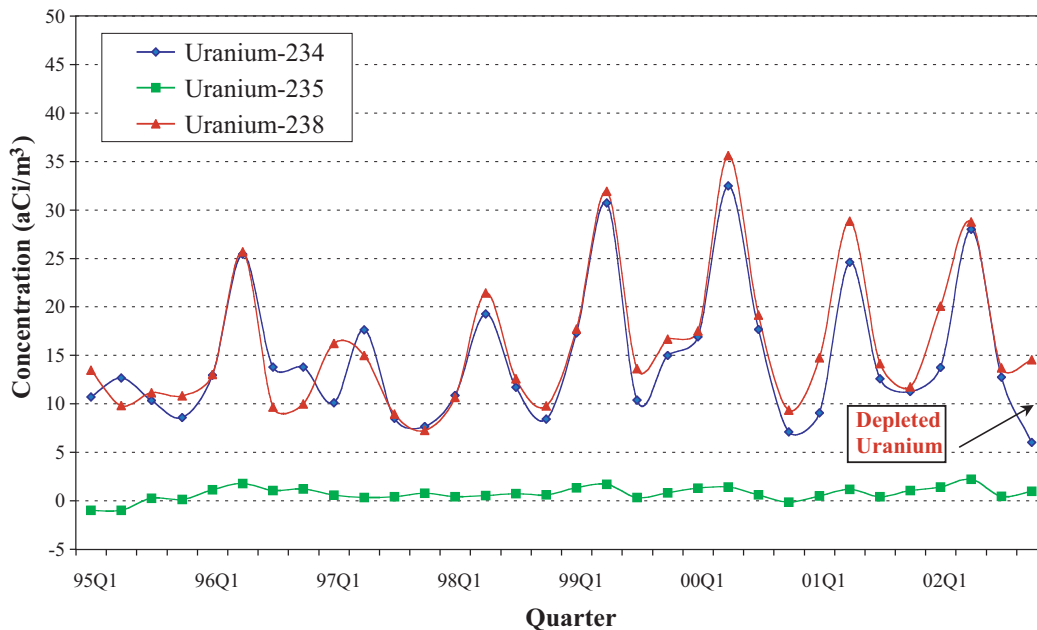


Figure 4-10. Site 13, Rocket Park (White Rock), quarterly transuranic concentrations.



**Figure 4-11.** AIRNET quarterly uranium concentrations (network-wide concentrations excluding site 77).

excess uranium-238 were collected. In addition, the number of quarterly composites with DU was higher in 2002 than in 2001—higher than that of any of the years since isotopic measurements began. Possible contributing causes include below-average rainfall, less vegetation and ground cover because of the fire, fire-mitigation activities, and/or tree-thinning operations. It should be noted that the off-site concentrations of DU are comparable to or less than historical natural uranium concentrations.

Only a few samples show excess enriched uranium, and most of these occurred in 1996. Some evidence indicates that these samples were contaminated in a laboratory, but this contamination has not been proved, and the concentrations are still considered valid environmental measurements.

Station 77 (Figure 4-12) at TA-36 is located in a posted radiation-control area where DU is still present as surface contamination from explosive tests. This location has been previously identified with measured excess ambient concentrations of uranium-238 (Eberhart et al. 1999, ESP 1999, ESP 2000, and ESP 2001). Of the 32 quarterly composites analyzed for isotopic uranium at this site, 28 have had excess uranium-238. The 2002 uranium-238 and -234 concentrations at this site were 43 and 14 aCi/m<sup>3</sup> respectively. These concentrations were lower than in

2001, but comparable to most previous years. If we assume that about 15% of the activity in DU is uranium-234, the calculated LANL contributions at this location were about 6 aCi/m<sup>3</sup> of uranium-234 and 35 aCi/m<sup>3</sup> of uranium-238. Therefore, the combined estimated LANL contribution at this on-site controlled-access location is about 0.0002% of the DOE DAC for workplace exposure.

**b. Plutonium and Americium.** Only one quarterly measurement during the last 7 years for the regional and pueblo samples was above its 2 std dev analytical uncertainty. However, on-site measurements of plutonium-238, plutonium-239 and americium-241 are clearly higher for the TA-21 and for the TA-54, Area G, sampling stations where about one-third of the measurements are detectable concentrations of these radionuclides. Perimeter samplers are somewhere in between, with occasional samples having measurable concentrations. Graphs of the annual concentrations by isotope and general station locations are shown in Figures 4-13, 4-14, and 4-15. Annual average concentrations for plutonium-238,-239 and americium-241 are above zero for the TA-54, Area G, sampling stations. Concentrations at the TA-54 samplers had been decreasing for several years, but the high concentrations from the soil-screening

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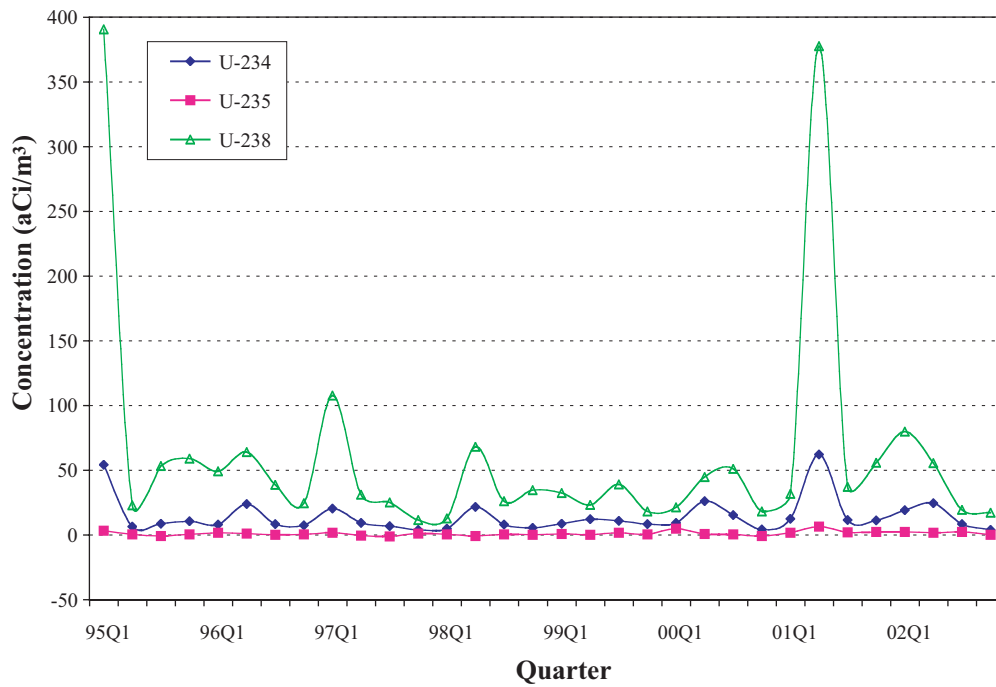


Figure 4-12. Uranium concentrations at site 77.

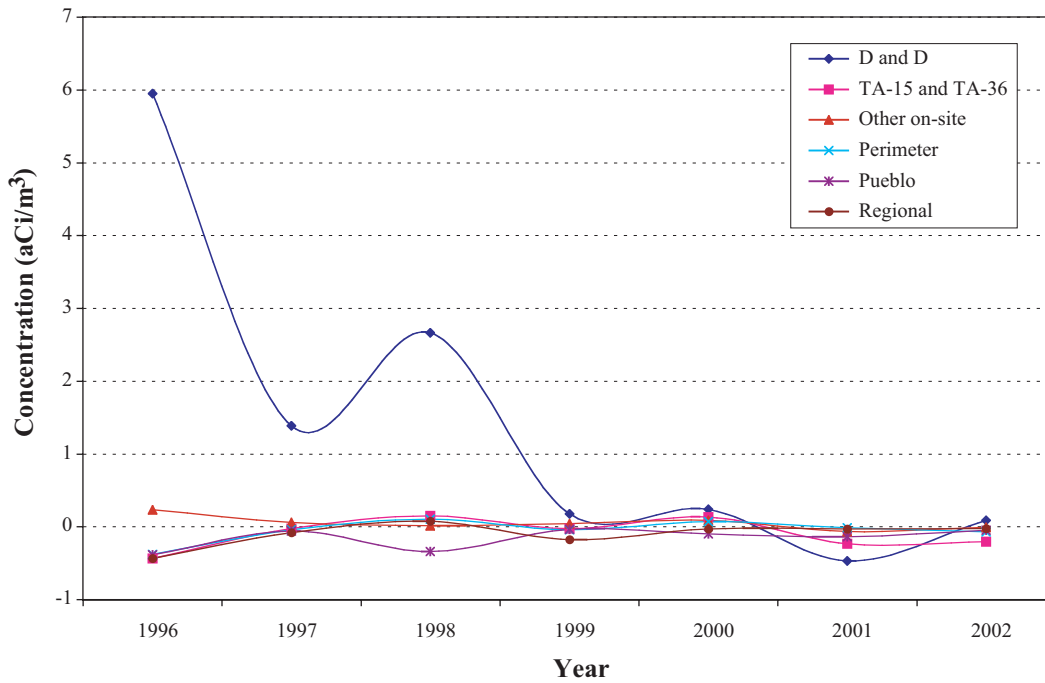


Figure 4-13. Plutonium-238 concentration trends.

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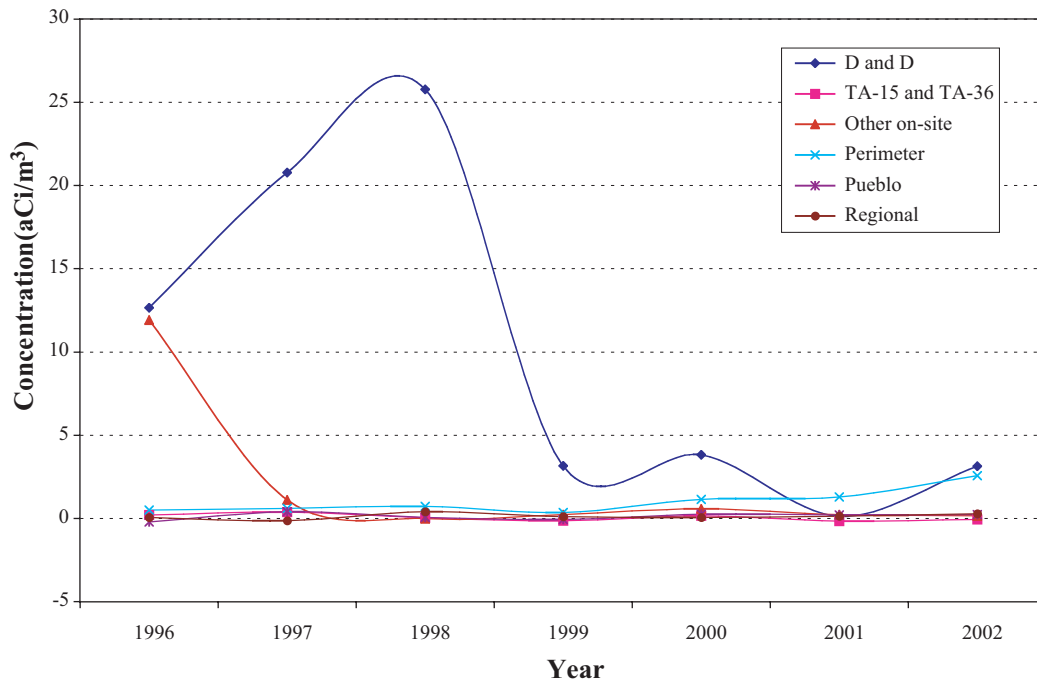


Figure 4-14. Plutonium-239,-240 concentration trends.

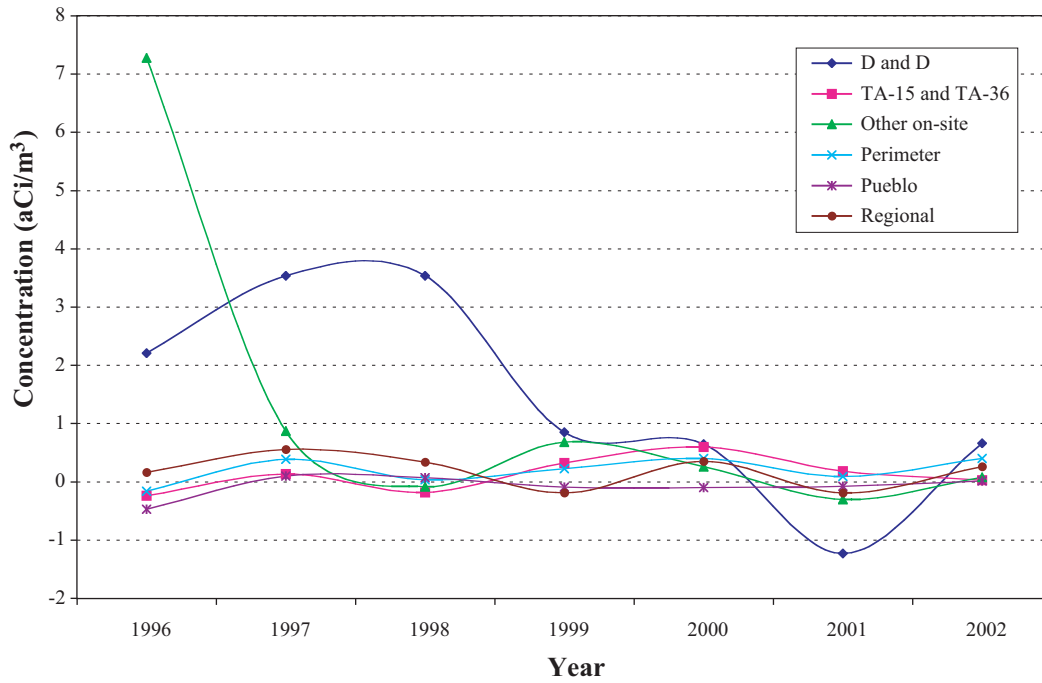


Figure 4-15. Americium-241 concentration trends.

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operation caused all three radionuclides to increase in 2002 (Figure 4-12). The average concentrations for the other sample groupings vary but remain near zero, with occasional samples and/or locations having detectable concentrations.

**c. Tritium.** Unlike other contaminants, tritium concentrations are strongly influenced by current operations and emissions with no distinctive trends over this period (Figure 4-16).

### B. Stack Sampling for Radionuclides

#### 1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory. Some operations that involve these materials may be vented to the environment through a stack or other forced-air release point. RRES-MAQ Group personnel evaluate these operations to determine impacts on the public and the environment. If this evaluation shows that emissions from a stack may result in a member of the public receiving as much as 0.1 mrem in a year, the Laboratory must sample the stack in accordance with Title 40, CFR 61, Subpart H (EPA 1989). During 2002, we identified 28 stacks as meeting this criterion. Two additional sampling systems were in place to meet DOE requirements for nuclear facilities prescribed in

their respective technical or operational safety requirements. Where sampling is not required, personnel use engineering calculations and radionuclide-materials-usage information to estimate emissions. Note that the sampling systems on two tritium-handling facilities were shut down in late 2002. The sampling at TA-33-86 was discontinued when the building power was cut during D&D activities in November 2002. The sampling system at TA-41-4 was shut down in December 2002, following source-term removal in late June 2002 and monitoring of negligible emissions for 5 months.

#### 2. Sampling Methodology

In 2002, LANL personnel continuously sampled 30 stacks for the emission of radioactive material to the ambient air. The Laboratory categorizes its radioactive stack emissions into four types: (1) particulate matter, (2) vaporous activation products (VAPs), (3) tritium, and (4) gaseous mixed-activation products (GMAPs). For each of these emission types, the Laboratory employs an appropriate sampling method, as described here.

Personnel use a glass-fiber filter to sample emissions of radioactive particulate matter generated by operations at facilities, such as the Chemistry and Metallurgy Research (CMR) Building and the TA-55

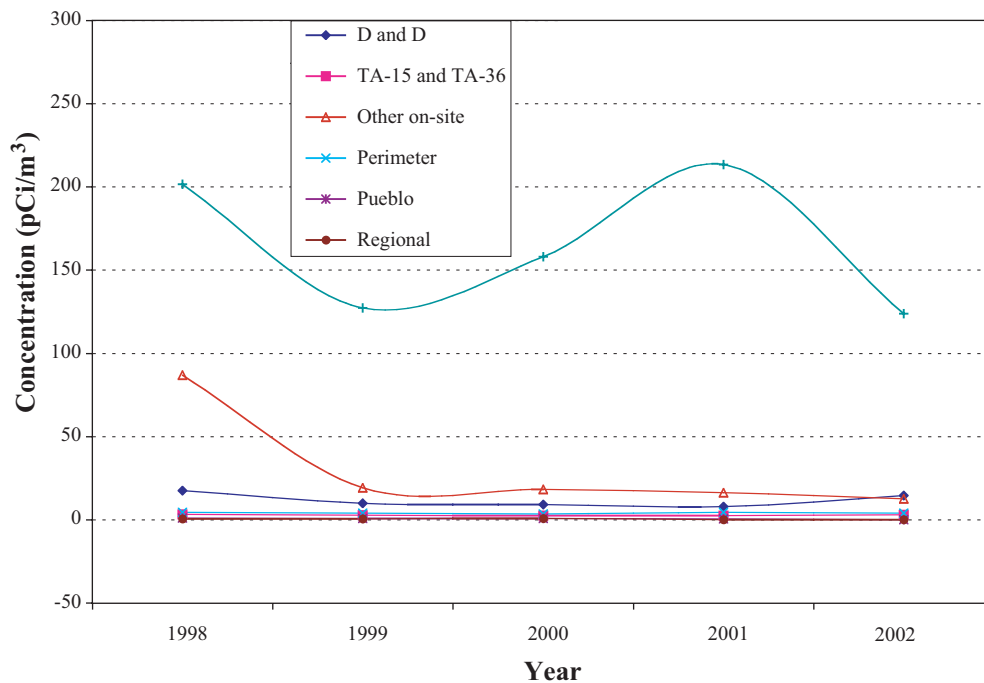


Figure 4-16. Tritium concentration trends.



Plutonium Facility. A continuous sample of stack air is pulled through the filter that captures small particles of radioactive material. Workers analyze these samples weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every 6 months, RRES-MAQ Group personnel composite these samples for shipment to an off-site commercial laboratory. The commercial laboratory analyzes these composited samples to determine the total activity of materials, such as uranium-234, -235, and -238; plutonium-238 and -239, -240; and americium-241. These data are then used to calculate emissions.

A charcoal cartridge samples VAP emissions, such as selenium-75 and bromine-77 generated by Los Alamos Neutron Science Center (LANSCE, TA-53) operations and by hot-cell activities at the CMR and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. We use gamma spectroscopy to determine the amount and identity of the radionuclide(s) present on the filter.

We use a collection device known as a bubbler to measure tritium emissions from the Laboratory's tritium facilities. This device enables the Laboratory to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler operates by pulling a continuous sample of air from the stack, which is then "bubbled" through three sequential vials that contain ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). After "bubbling" through these three vials, essentially all HTO is removed from the air, leaving only HT. The sample that contains the HT is then passed through a palladium catalyst that converts the HT to HTO. The sample is then pulled through three additional vials that contain ethylene glycol; these vials collect the newly formed HTO. Personnel use liquid scintillation counting (LSC) to analyze the ethylene/glycol for the presence of tritium and determine the amount of HTO and HT.

In previous years, stacks at LANSCE were monitored for tritium. After a historical evaluation of HTO emissions from LANSCE in 2001 showed low historical emissions and low relative contribution of tritium to the off-site dose from TA-53 emissions, we discontinued sampling of tritium from TA-53 after the

July 2001 report period. Emissions of tritium reported in 2002 from LANSCE are based on 2001 tritium-generation rates.

We measure GMAP emissions that result from activities at LANSCE by using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample. We use gamma spectroscopy and decay curves to identify specific radioisotopes.

### 3. Sampling Procedures and Data Analysis

**a. Sampling and Analysis.** We chose analytical methods to comply with EPA requirements (40 CFR 61, Appendix B, Method 114). See Section F in this chapter for the results of analytical QA measurements. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

**b. Particulate Matter Emissions.** We generally removed and replaced weekly the glass-fiber filters used to sample facilities with significant potential for radioactive particulate emissions and transported them to the LANL Health Physics Analysis Laboratory (HPAL). Before screening the samples for the presence of alpha and beta activity, HPAL personnel allowed approximately 72 h for the short-lived progeny of radon to decay. These initial screening analyses ensured that potential emissions were within normal values. The HPAL performed final analyses after the sample had been allowed to decay for approximately 1 week. In addition to alpha and beta analyses, the HPAL used gamma spectroscopy to identify the energies of gamma-ray emissions from the samples. Because the energy of decay is specific to a given radioactive isotope, the HPAL could determine the identity of any isotopes detected by gamma spectroscopy. The amount, or activity, of an isotope could then be found by noting the number of photons detected during analysis. We analyzed LANSCE glass-fiber filters using only gamma spectroscopy.

Because gross alpha/beta counting cannot identify specific radionuclides, an off-site commercial laboratory performed radiochemical analysis on the composited glass-fiber filters every 6 months. We used the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. To ensure that the analyses requested (e.g., uranium-234, -235, and -238

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and plutonium-238 and -239,-240, etc.) identified all significant activity in the composites, RRES-MAQ Group personnel compared the results of the isotopic analysis to gross activity measurements.

**c. Vaporous Activation Product Emissions.** We generally removed and replaced on a weekly basis the charcoal canisters that collect samples at facilities with the potential for significant VAP emissions. These samples were transported to the HPAL where gamma spectroscopy, as described previously, was used to identify and quantify the presence of vaporous radioactive isotopes.

**d. Tritium Emissions.** Tritium bubbler samples used to collect samples at facilities with the potential for significant elemental and oxide tritium emissions were generally collected and transported to the HPAL on a weekly basis. HPAL personnel added an aliquot of each sample to a liquid scintillation cocktail and by LSC determined the amount of tritium in each vial.

**e. Gaseous Mixed-Activation Product Emissions.** For two reasons, we used continuous monitoring, rather than offline analysis, to record and report GMAP emissions. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed offline. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma-spectroscopy system. Total GMAP emissions were measured with the ionization chamber. The real-time current measured by this ionization chamber was recorded on a strip chart, and the total amount of charge collected in the chamber throughout the entire beam-operating cycle was integrated on a daily basis. The composition of these GMAP emissions was analyzed with the gamma-spectroscopy system. Using decay curves and energy spectra to identify the various radionuclides, RRES-MAQ Group personnel determined the relative composition of the emissions. Decay curves were typically taken one-to-three times per week, based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

### 4. Analytical Results

Measurements of Laboratory stack emissions during 2002 totaled approximately 6,150 Ci. Of this total,

tritium emissions contributed approximately 1,890 Ci, and air-activation products from LANSCE stacks contributed nearly 4260 Ci. Combined airborne emissions of materials, such as plutonium, uranium, americium, and particulate/vapor activation products, were less than 1 Ci.

Table 4-14 provides detailed emissions data for Laboratory buildings with sampled stacks. Table 4-15 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and particulate/vapor activation products (P/VAPs). Table 4-16 presents the half-lives of the radionuclides emitted by the Laboratory. During 2002, nonpoint-source emissions of activated air from the LANSCE facility comprised approximately 140 Ci carbon-11 and 6 Ci argon-41, whereas TA-18 contributed 0.16 Ci argon-41.

### 5. Long-Term Trends

Figures 4-17 through 4-20 present radioactive emissions from sampled Laboratory stacks. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, tritium emissions were down dramatically from 2001 (but relatively consistent with levels in the year 2000); and GMAP emissions decreased slightly from 2001. Emissions from plutonium and uranium isotopes have stayed relatively steady since 2000.

Emissions from tritium-handling facilities were much lower in 2002 than in 2001. This emission reduction is caused by emissions in 2001 being dominated by a single release of 7,600 Ci of tritium on January 31, 2001. No such large-scale accidental releases occurred in 2002. Emissions from other tritium-handling facilities, notably TA-21-209 and TA-21-155, increased because of cleanup operations in preparation for the D&D of these areas. In these facilities, we expect increased emissions from activities, such as disassembly of equipment and opening pipes and containers, to demonstrate that all significant tritium has been removed. TA-21-209 is transferring its tritium operations to the Weapons Engineering Tritium Facility (WETF, TA-16) and TA-21-209 is being prepared for D&D. As tritium-contaminated systems are dismantled and prepared for removal and disposal, increased releases of tritium are expected. However, overall long-term emissions from these facilities will decrease following such D&D preparation.

Stack-sampling systems at two tritium-handling facilities were shut down in 2002. TA-33-86, which

**Table 4-14. Airborne Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 2002 (Ci)**

TA-Building	<sup>3</sup> H <sup>a</sup>	<sup>241</sup> Am	Pu <sup>b</sup>	U <sup>c</sup>	Th	P/VAP <sup>d</sup>	G/MAP <sup>e</sup>
TA-03-029		$1.86 \times 10^{-6}$	$1.91 \times 10^{-5}$	$5.61 \times 10^{-6}$	$3.37 \times 10^{-7}$		
TA-03-102			$3.92 \times 10^{-10}$	$9.60 \times 10^{-8}$	$7.96 \times 10^{-10}$		
TA-16-205	$4.02 \times 10^2$						
TA-21-155	$5.18 \times 10^2$						
TA-21-209	$6.05 \times 10^2$						
TA-33-086	$2.61 \times 10^2$						
TA-41-004	$3.40 \times 10^1$						
TA-48-001			$1.73 \times 10^{-9}$			$1.04 \times 10^{-2}$	
TA-50-001		$1.31 \times 10^{-8}$	$4.75 \times 10^{-8}$	$2.54 \times 10^{-8}$			
TA-50-037 <sup>f</sup>		$5.83 \times 10^{-10}$	$8.90 \times 10^{-10}$				
TA-50-069		$1.65 \times 10^{-10}$	$9.26 \times 10^{-10}$	$3.28 \times 10^{-10}$			
TA-53-003	$5.68 \times 10^{-1}$						$1.66 \times 10^0$
TA-53-007	$4.40 \times 10^0$					$6.15 \times 10^{-1}$	$4.26 \times 10^3$
TA-55-004	$6.07 \times 10^1$	$1.55 \times 10^{-8}$	$9.52 \times 10^{-8}$	$2.31 \times 10^{-7}$	$1.18 \times 10^{-7}$		
<b>Total<sup>f</sup></b>	$1.89 \times 10^3$	$1.89 \times 10^{-6}$	$1.93 \times 10^{-5}$	$5.96 \times 10^{-6}$	$4.55 \times 10^{-7}$	$6.25 \times 10^{-1}$	$4.40 \times 10^3$ <sup>g</sup>

<sup>a</sup>Includes both gaseous and oxide forms of tritium.

<sup>b</sup>Includes <sup>238</sup>Pu, <sup>239</sup>Pu, and <sup>240</sup>Pu.

<sup>c</sup>Includes <sup>234</sup>U, <sup>235</sup>U, and <sup>238</sup>U.

<sup>d</sup>P/VAP—Particulate/vapor activation products.

<sup>e</sup>G/MAP—Gaseous/mixed activation products.

<sup>f</sup>Some differences may occur due to rounding.

<sup>g</sup>Total for G/MAP includes 146 curies released from diffuse sources at TA-53.

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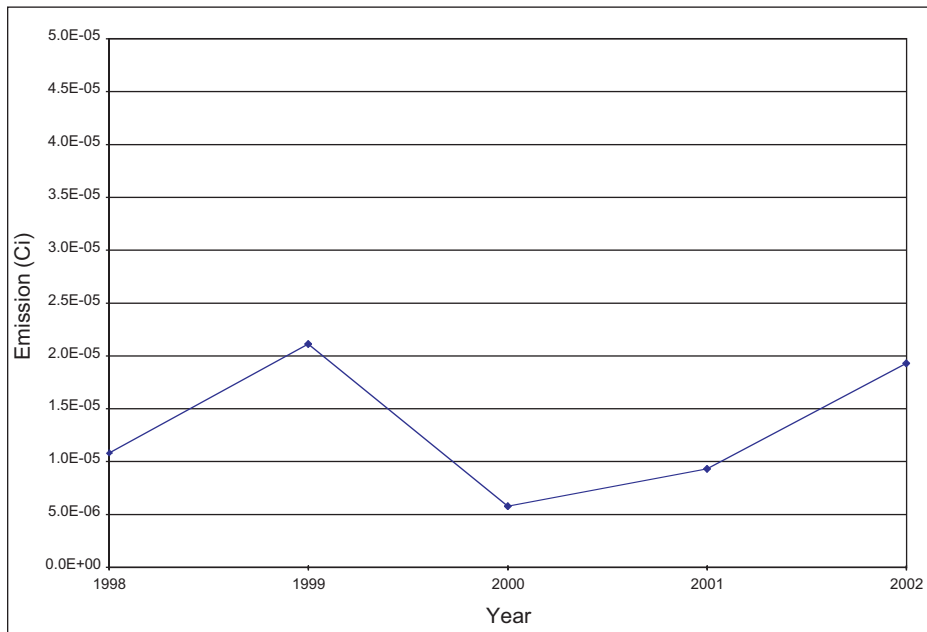
**Table 4-15. Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 2002 (Ci)**

TA-Building	Radionuclide	Emission
TA-48-001	<sup>73</sup> As	$2.31 \times 10^{-3}$
TA-48-001	<sup>74</sup> As	$1.21 \times 10^{-3}$
TA-48-001	<sup>68</sup> Ga	$3.45 \times 10^{-3}$
TA-48-001	<sup>68</sup> Ge	$3.45 \times 10^{-3}$
TA-48-001	<sup>75</sup> Se	$3.85 \times 10^{-7}$
TA-53-003	<sup>10</sup> C	$1.80 \times 10^{-3}$
TA-53-003	<sup>11</sup> C	$1.66 \times 10^0$
TA-53-007	<sup>41</sup> Ar	$1.92 \times 10^1$
TA-53-007	<sup>82</sup> Br	$5.96 \times 10^{-3}$
TA-53-007	<sup>10</sup> C	$7.27 \times 10^{-1}$
TA-53-007	<sup>11</sup> C	$2.62 \times 10^3$
TA-53-007	<sup>193</sup> Hg	$4.38 \times 10^{-1}$
TA-53-007	<sup>193m</sup> Hg	$4.72 \times 10^{-4}$
TA-53-007	<sup>195m</sup> Hg	$7.98 \times 10^{-3}$
TA-53-007	<sup>197</sup> Hg	$1.62 \times 10^{-1}$
TA-53-007	<sup>197m</sup> Hg	$3.99 \times 10^{-4}$
TA-53-007	<sup>203</sup> Hg	$6.19 \times 10^{-4}$
TA-53-007	<sup>13</sup> N	$1.23 \times 10^2$
TA-53-007	<sup>16</sup> N	$4.73 \times 10^{-1}$
TA-53-007	<sup>14</sup> O	$1.49 \times 10^1$
TA-53-007	<sup>15</sup> O	$1.48 \times 10^3$

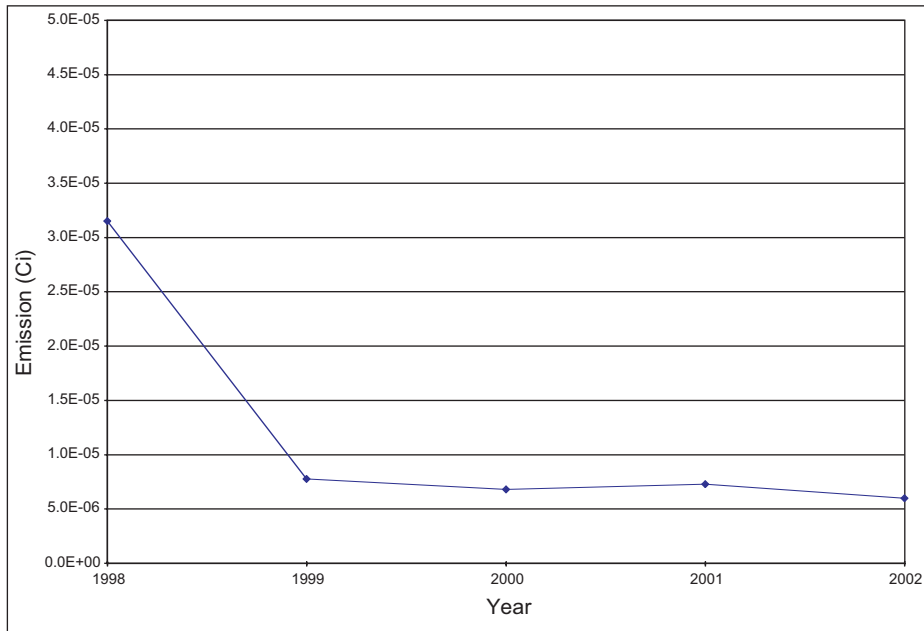
**Table 4-16. Radionuclide: Half-Life Information**

Nuclide	Half-Life
<sup>3</sup> H	12.3 yr
<sup>7</sup> Be	53.4 d
<sup>10</sup> C	19.3 s
<sup>11</sup> C	20.5 min
<sup>13</sup> N	10.0 min
<sup>16</sup> N	7.13 s
<sup>14</sup> O	70.6 s
<sup>15</sup> O	122.2 s
<sup>22</sup> Na	2.6 yr
<sup>24</sup> Na	14.96 h
<sup>32</sup> P	14.3 d
<sup>40</sup> K	1,277,000,000 yr
<sup>41</sup> Ar	1.83 h
<sup>54</sup> Mn	312.7 d
<sup>56</sup> Co	78.8 d
<sup>57</sup> Co	270.9 d
<sup>58</sup> Co	70.8 d
<sup>60</sup> Co	5.3 yr
<sup>72</sup> As	26 h
<sup>73</sup> As	80.3 d
<sup>74</sup> As	17.78 d
<sup>76</sup> Br	16 h
<sup>77</sup> Br	2.4 d
<sup>82</sup> Br	1.47 d
<sup>75</sup> Se	119.8 d
<sup>85</sup> Sr	64.8 d
<sup>89</sup> Sr	50.6 d
<sup>90</sup> Sr	28.6 yr
<sup>131</sup> I	8 d
<sup>134</sup> Cs	2.06 yr
<sup>137</sup> Cs	30.2 yr
<sup>183</sup> Os	13 h
<sup>185</sup> Os	93.6 d
<sup>191</sup> Os	15.4 d
<sup>193</sup> Hg	3.8 h
<sup>195</sup> Hg	9.5 h
<sup>195m</sup> Hg	1.67 d
<sup>197</sup> Hg	2.67 d
<sup>197m</sup> Hg	23.8 h
<sup>234</sup> U	244,500 yr
<sup>235</sup> U	703,800,000 yr
<sup>238</sup> U	4,468,000,000 yr
<sup>238</sup> Pu	87.7 yr
<sup>239</sup> Pu	24,131 yr
<sup>240</sup> Pu	6,569 yr
<sup>241</sup> Pu	14.4 yr
<sup>241</sup> Am	432 yr

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**Figure 4-17.** Plutonium emissions from sampled Laboratory stacks since 1998.

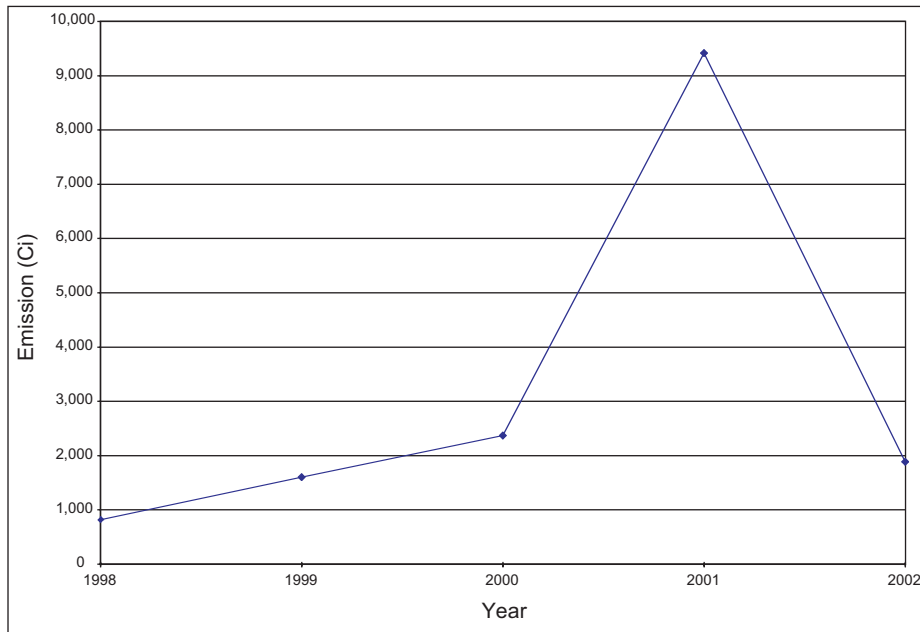


**Figure 4-18.** Uranium emissions from sampled Laboratory stacks since 1998.

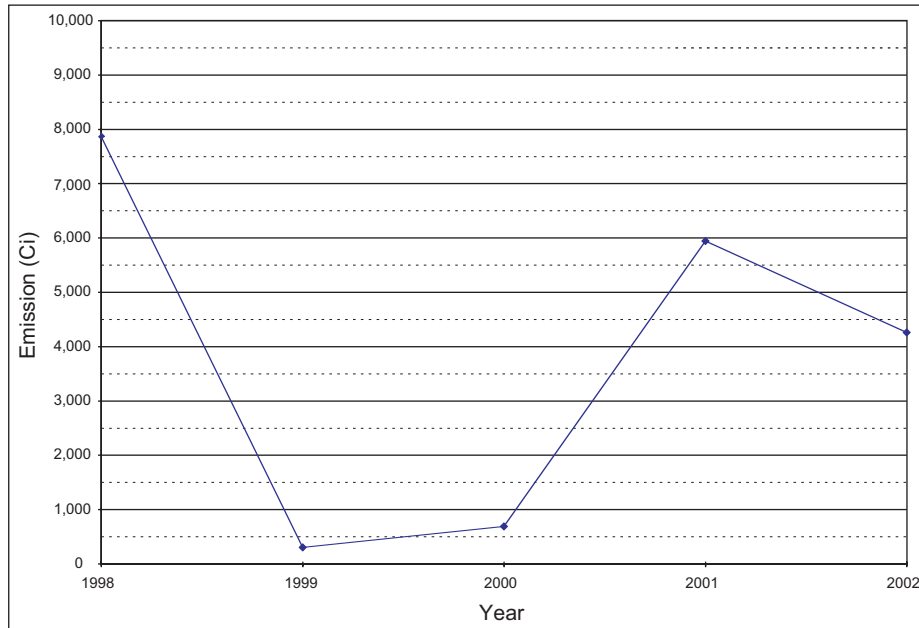


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**Figure 4-19.** Tritium emissions from sampled Laboratory stacks since 1998.



**Figure 4-20.** G/MAP emissions from sampled Laboratory stacks since 1998.

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originally housed the High-Pressure Tritium Laboratory (HPTL), has been shut down for several years, and formal D&D operations began in 2002. The power to TA-33 was cut in November 2002, eliminating a source of stack emissions and completing the stack-sampling process for that facility.

TA-41-4 likewise has ceased operations, and D&D began in 2002. The source term was removed in June 2002, and sampling continued for 5 months to verify low emissions. In December 2002, sampling at TA-41-4 ceased. As mentioned, all releases in 2002 were well below regulatory limits.

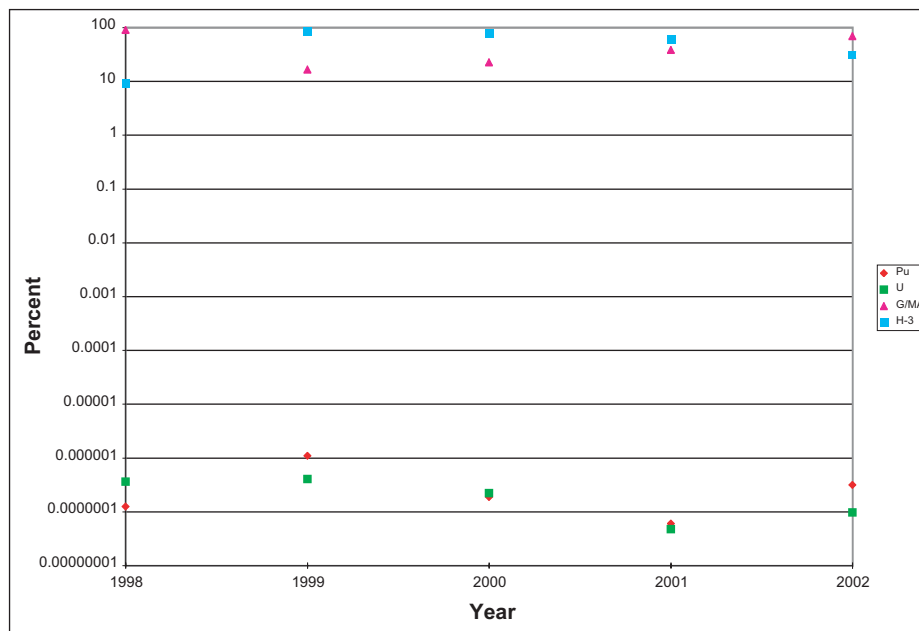
In 2002, the LANSCE operated in the same configuration as 2001, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center, causing the majority of radioactive air emissions. The rate of emissions from the facility was similar to the 2001 rate at the beginning of the year. In early October 2002, however, a delay line system was installed in the 1L Target area, a move that reduced the emissions rate from this facility by more than 60% for the last 3 months of 2002. As a result, total emissions from the TA-53-7 stack decreased from 2001 to 2002, while the facility still maintained high-power beam operations. The emissions from 2002 remained well below any regulatory limits.

Figure 4-21 shows the individual contribution of each of these emission types to the total Laboratory emissions. Clearly, GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. However, this plot does not directly relate to offsite dose, because some radionuclides have a higher impact per curie released than others do. GMAP and tritium, emissions that are not easily removed from an exhaust-stack air stream, remain the highest contributors to the total curies released. Because of the close proximity of the LANSCE facility with the Laboratory site boundary, GMAP emissions remain the greatest source of offsite dose from the airborne pathway.

### C. Gamma and Neutron Radiation Monitoring Program (*Michael McNaughton*)

#### 1. Introduction

The RRES-MAQ group monitors gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000). Naturally occurring radiation originates from terrestrial and cosmic sources. Because the natural radiation doses are generally much larger than those from man-made sources, it is



**Figure 4-21.** Fraction of total stack emissions that resulted from Laboratory plutonium, uranium, tritium, and G/MAP since 1998.

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extremely difficult to distinguish man-made sources from the natural background.

The dose rate from natural terrestrial and cosmic sources varies from approximately 100 to 200 mrem/yr. In publicly accessible locations, the dose rate from man-made radiation is much smaller than, and difficult to distinguish from, natural radiation.

### 2. Monitoring Network

**a. Dosimeter Locations.** In an attempt to distinguish any impact from Laboratory operations, the RRES-MAQ Group has located 119 thermoluminescent dosimeter (TLD) stations around the Laboratory and in the surrounding communities (Figure 4-22).

**b. Neutron Dosimeters.** We monitor potential neutron doses with 62 albedo TLD stations. Albedo dosimeters are sensitive to neutrons and use a hydrogenous material to simulate the human body that causes neutron backscatter.

**c. Neutron Background.** Natural cosmic rays result in a background dose of approximately 10 mrem/yr. However, at stations with no LANL contribution, the neutron dosimeters record a dose of approximately 2 mrem/yr, because the dosimeter zero is established with reference to dosimeters in a shielded vault. The 2-mrem neutron dose reported at the background stations is the difference between approximately 10 mrem in the field and approximately 8 mrem in the vault.

### 3. Quality Assurance

RRES Division operating procedures outline the quality assurance/quality control (QA/QC) protocols. The Health Physics Measurements Group (HSR-4) calibration lab calibrates the dosimeters every calendar quarter. The DOE Laboratory Accreditation Program has accredited the dosimeters that HSR-4 provides, and HSR-4 provides QA for the dosimeters. We estimate the uncertainty in the TLD data from the standard deviation of data from dosimeters exposed to the same dose. The overall 1-std-dev uncertainty is similar to previous data and is 8%.

### 4. Results

The annual dose equivalents at almost all stations are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Data Supplement Table S4-11 and at <http://www.airquality.lanl.gov/DPRNET.htm>.

The locations with a measurable contribution from Laboratory operations are at Omega Site (TA-2), Pajarito Laboratory (TA-18), TA-21, LANSCE, and TA-54, Area G.

TA-2 is the site of the Omega-West reactor, which is being decontaminated and decommissioned. As activated shielding is removed from the reactor building, it is stored near the TLD station before being transferred to Area G. As a result, the dose at station 120 was 164 mrem during 2002 compared with 146 mrem in 2001. TA-2 is a controlled area, so the extra 18 mrem is an occupational dose, not a public dose. RRES-MAQ personnel calculated that the public dose at the nearest public location 300 m to the north was 0.1 mrem in 2002.

At TA-18, most of the dose is from neutrons; the gamma dose is too small to distinguish from the natural background radiation. The largest neutron dose, 42 mrem in the TA-18 parking lot, was not a public dose because the parking lot was closed to the public throughout 2002. At Pajarito Road next to TA-18, the annual dose was 17 mrem. This dose must be multiplied by an occupancy factor to account for the small fraction of time an individual member of the public spends at this location. Using the nominal occupancy factor of 1/16, the maximum dose was 1.1 mrem.

TA-21, Area T, is contaminated with 50 pCi/g of cesium-137 (LANL 1991, pp. 16–124). The calculated dose rate from this contamination is 200 mrem/yr. Considering that the dosimeter is on the boundary fence of Area T, the calculation is in reasonable agreement with the measurement, which is about 100 mrem/yr above background. Area T is not accessible to the public.

At the TA-53 lagoons activated material, such as cobalt-60, has accumulated. As a result, the annual dose is 184 mrem, which is approximately 50 mrem above background. Access to TA-53 is restricted so the dose measured at station 116 is not a public dose.

Figure 4-2 shows the locations of the stations at TA-54, Area G. Figure 4-23 shows the trend of the average dose rate that results from transuranic waste awaiting shipment to the Waste Isolation Pilot Plant (WIPP). Near individual buildings, such as # 49, # 230, and # 375, the dose rate is higher; but Area G is a controlled-access area, so most Area G data are not representative of a potential public dose. The maximum public dose is at station 42, where the dosimeter measures 12 mrem and the individual dose (assuming

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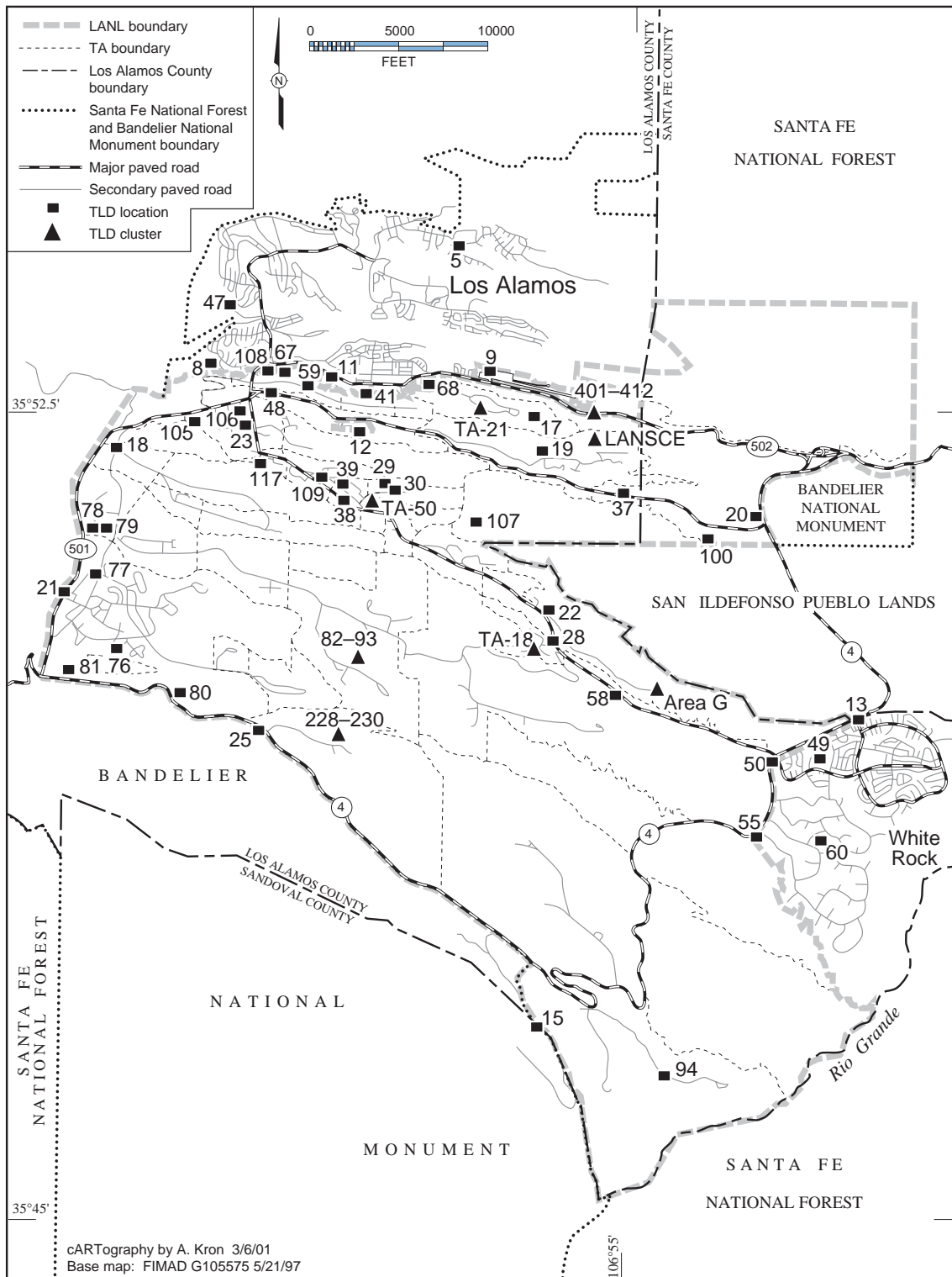


Figure 4-22. Off-site perimeter and on-site Laboratory TLD locations.

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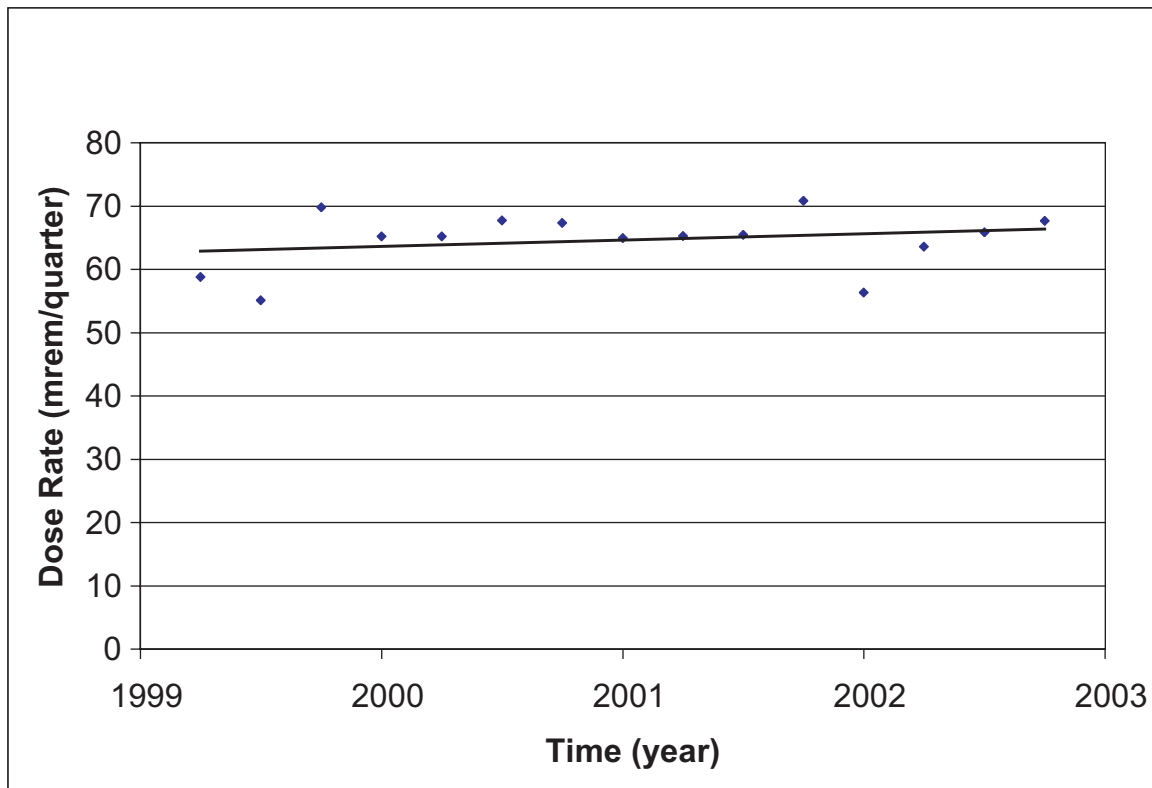


Figure 4-23. Trend of average dose rate measured by TLDs at Area G.

an occupancy factor of 1/16 or less) is less than 1 mrem.

### D. Nonradioactive Ambient Air Monitoring (*Ernie Gladney, Craig Eberhart, and Jean Dewart*)

#### 1. Introduction

During 2002, the RRES-MAQ continued and completed the short-term nonradiological monitoring (NonRadNet) air-monitoring program implemented in 2001 to provide baseline nonradiological data under normal conditions. The objectives of NonRadNet are to

- develop the capability for collecting nonradiological air-monitoring data,
- conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest the Laboratory, and
- measure LANL's potential contribution to nonradiological air pollution in the surrounding communities.

#### 2. Air-Monitoring Network

During 2002, the Laboratory continued to conduct NonRadNet. Simultaneous monitoring took place in the same three locations as in 2001—two in Los Alamos and one in White Rock. The White Rock sampling is collocated with the existing AIRNET station at the White Rock Fire Station. One Los Alamos station is collocated with the existing AIRNET station at the Los Alamos Medical Center. The other Los Alamos station is located near the intersection of Diamond Drive and East Jemez Road, between the main technical area of the Laboratory and the population center of the Los Alamos town site.

Species monitored include the following: total suspended particulate matter (TSP), particles with diameters of 10 micrometers ( $\mu\text{m}$ ) or less (PM-10), and particles with diameters of 2.5  $\mu\text{m}$  or less (PM-2.5), volatile organic compounds (VOCs), and inorganic elements on particulate matter. In 2002, the VOCs included up to 160 compounds, and the inorganics included up to 20 elements (arsenic, antimony, barium,



beryllium, cadmium, cerium, chromium, cobalt, copper, iron, lead, manganese, neodymium, nickel, selenium, silver, strontium, thallium, vanadium, and zinc).

We use existing meteorological data collected through LANL's current monitoring network to help interpret the data and evaluate their impact. PM-10 and PM-2.5 concentrations are measured continuously and averaged over 1-hour, 3-hour, and 24-hour time periods. VOC and TSP/inorganics sampling takes place on every 12th day to coincide with the EPA's national ambient air-monitoring schedule, with each sampling period lasting 24 hours.

### 3. Sampling Procedures, Data Management, and Quality Assurance

Anderson GV-2360 volumetric-flow-controlled high-volume sampling apparatus collected samples for 24-hour time-integrated TSP on Whatman cellulose 8 in. × 10 in. filters. All filters are placed in the sampler less than 48 hours before the start of a sampling run and are recovered from the samplers within 24 hours of the end of a sampling period. RRES-MAQ personnel weigh all filters before deployment and again after collection. All weighing activities take place in a humidity-conditioning chamber, and filters are equilibrated for at least 24 hours before each weighing in an attempt to achieve consistent absorbed water levels. LANL personnel then send these TSP filters to a commercial-environmental-analytical-chemistry laboratory in glassine envelopes under chain-of-custody procedures. The laboratory uses EPA Methods SW 6010 and SW 6020 to analyze up to 20 inorganic elements with both inductively coupled plasma emission spectrometry (ICPES) and inductively coupled plasma mass spectrometry (ICPMS) respectively.

A Rupprecht & Patashnick Co., Inc. tapered-element oscillating microbalance (TEOM) Series 1400a ambient particulate monitor fitted with either PM-10 or PM-2.5 sample inlets collects continuous PM-10 and PM-2.5 concentrations (micrograms per cubic meter). The collecting instruments record the data automatically and save them electronically for subsequent downloading and transfer to a MAQ-maintained database. RRES-MAQ personnel use these data as an indicator of natural dust-loading in the atmosphere and to aid in interpreting the inorganic-elemental-concentration data determined on the large TSP filters.

A ThermoAnderson Ambient Volatile Organic Collection System collects samples of ambient air in

15-liter SUMMA Canisters owned by LANL. Before each sampling operation, all canisters are precleaned and monitored for residual levels of all VOCs. After collecting an integrated 24-hour sample, taken simultaneously at all sites every 12th day per EPA procedure, RRES-MAQ personnel send all canisters to Severn-Trent Laboratories (STL) in Austin, Texas, under chain-of-custody for VOC determination with EPA Compendium Method TO-15. STL reports up to 160 organic compounds to the RRES-MAQ Group, and these data are stored within the existing AIRNET database for subsequent evaluation and interpretation.

RRES-MAQ personnel enter field-sampling data manually on paper forms and key them into an existing database. Using calibration procedures provided by each sampling system's manufacturer, we calculate the net air volumes sampled. We then use these volumes to calculate net ambient-air concentrations of TSP, VOCs, and inorganic elements.

### 4. Ambient Air Concentrations

Tables S4-12 through S4-16 in the Data Supplement summarize the ambient-air concentrations calculated from field and analytical data, inorganic elements, and VOCs.

**a. Particulate Matter.** Several previous environmental surveillance reports (ESP 1971a, ESP 1971b, ESP 1986, ESP 1987, ESP 1988, and ESP 1989) include limited local TSP data. These data show annual geometric means for both Los Alamos and White Rock to be in the 20–30  $\mu\text{g}/\text{m}^3$  range, with the maximum value observed to be 242  $\mu\text{g}/\text{m}^3$  during those time periods.

The change to Whatman cellulose paper from Dynaweb at the beginning of 2002 has been successful. Our 2002 TSP data, shown in Table 4-17, are much improved over our initial efforts in 2001, when we observed many samples with both negative values and concentrations up to three times the previously reported maximum. The 2002 TSP data summary follows.

Among the rejected data, one was negative and the remainder had measured TSP that was less than the measured PM-10 on the same day. The overall station means were somewhat higher than historical measurements. More than 80% of the individual-station TSP values exceeded the PM-10 average for the same date, most by a factor of 1.5 to 2. These considerations lead RRES-MAQ analysts to believe that the 2002 data are

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**Table 4-17. Total Suspended Particulate Matter Data Summary for 2002**

Station Location	Number of Measurements	Number Rejected	Range ( $\mu\text{g}/\text{m}^3$ )	Mean ( $\mu\text{g}/\text{m}^3$ )	Standard Deviation ( $\mu\text{g}/\text{m}^3$ )
<b>Diamond Drive</b>	32	5	9.7 – 114	47	27
<b>Los Alamos Medical Center</b>	32	7	9.8 – 140	37	26
<b>White Rock Fire Station</b>	32	7	16.0 – 300	72	63

largely valid, and they are accepted as being representative of actual atmospheric conditions for this year.

We have achieved largely complete collection of PM-2.5 and PM-10 data for the entire year on TEOM sampling units at one or more sites as shown in Table 4-18. The following summarizes our observations for 2002.

The PM-10 measurements had concentrations up to almost 1,000  $\mu\text{g}/\text{m}^3$ , whereas PM-2.5 exhibited a maximum of 450  $\mu\text{g}/\text{m}^3$ , after the rejection of invalid data. Average data are consistent with the historical TSP levels of 20–30  $\mu\text{g}/\text{m}^3$  and PM-2.5 ranging over 3–8  $\mu\text{g}/\text{m}^3$ .

Two different particulate interaction situations are readily illustrated in Figure 4-24. During high wind periods (6/20/2002), PM-10 particulate matter levels rise dramatically by factors of 10 or more, while the PM-2.5 particulate matter levels increase significantly, but more modestly. However, when some regional source of small particulate impacts our airshed, as it did during the 2002 Arizona fires (6/23 through 6/26/2002), both PM-10 and PM-2.5 reach similar

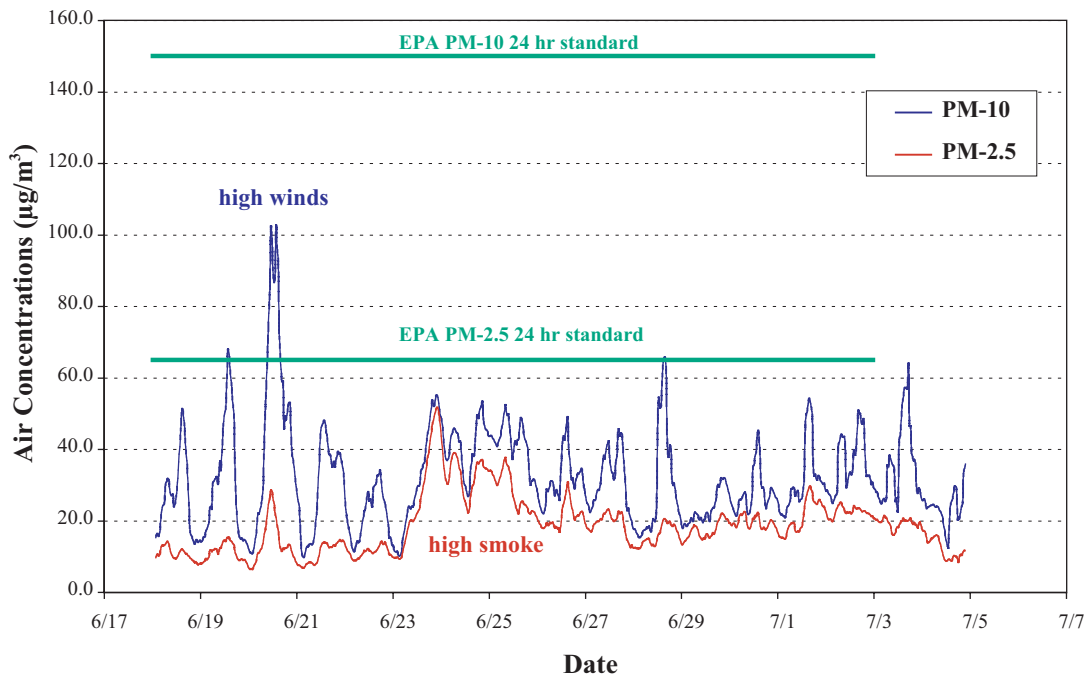
concentrations and co-vary equally, indicating that essentially all the particulate being detected is PM-2.5.

**b. Inorganic Elements.** RRES-MAQ analysts have calculated a set of mean elemental ratios to barium from our summary of the on-site soil data from the 2000 Environmental Surveillance Report shown in Table S4-17. The 2002 air sample data are internally very consistent and in good agreement with our estimates from local soils. This agreement suggests no evidence for any non-soil-derived enhancement to the soil background levels of these trace elements except for copper, iron, manganese, antimony, and zinc. Copper is strongly enhanced, and this enhancement probably results from contributions from the high-volume pump in the sampling equipment. This effect was documented in 1970 during sampling for metals in clean marine and continental environments (Hoffman 1971). The results for antimony, iron, manganese, and zinc are not so readily understood and require further study and source evaluation before we can draw firm conclusions. It is possible that the average concentrations used for local soils are in error, particularly for

**Table 4-18. PM-2.5 and PM-10 Data Summary for 2002**

Station Location	Constituent	Number of Valid 30 Minute Average Measurements	Range ( $\mu\text{g}/\text{m}^3$ )	Annual Mean ( $\mu\text{g}/\text{m}^3$ )	Standard Deviation ( $\mu\text{g}/\text{m}^3$ )
<b>Diamond Drive</b>	PM-10	Not Sampled	NA <sup>a</sup>	NA	NA
	PM-2.5	17179	0.1 – 93	8.5	5.5
<b>Los Alamos Medical Center</b>	PM-10	11815	0.1 – 447	19.0	18.0
	PM-2.5	13508	0.1 – 1161	8.7	22.0
<b>White Rock Fire Station</b>	PM-10	15922	0.1 – 984	19.0	25.0
	PM-2.5	16842	0.1 – 56	8.2	4.9

<sup>a</sup>NA = not available



**Figure 4-24.** Particulate matter concentrations observed in Los Alamos County during the 2002 fire in Arizona (4-hr averages).

antimony, a difficult element to determine at natural abundance levels in soils. We observe excess zinc in our air samples, relative to local soil data, which may be influenced by the exposure to significant vehicle traffic at all three sites. Zinc has been shown to be in unusually high concentrations in vulcanized rubber tires, which abrade readily in normal use.

**c. Volatile Organic Compounds.** Tables S4-13 through S4-16 present summary data for 160 compounds at 3 stations. These tables represent 20 additional compounds that were detected during 2002 as compared with the initial startup of this program in the final quarter of 2001.

Determining background levels for these compounds is not as easy as making such determinations is for inorganics. Organic compounds have a variety of natural and anthropogenic sources, and many of these compounds are well mixed in the troposphere. As our program matures, we hope to be able to group this large number of compounds into major source groups (e.g., fuel hydrocarbons, refrigerants, paint solvents, natural vegetation emissions, etc.) to help provide a simpler basis for evaluating seasonal variations and potential impacts from Laboratory operations.

### 5. Detonation and Burning of Explosives

**a. Total Quantities.** The Laboratory tests explosives by detonating them at firing sites operated by the Dynamic Experimentation Division. The Laboratory maintains monthly shot records that include the type of explosives used and other material expended at each site. Table S4-18 summarizes the amounts of expended materials for calendar year (CY) 2001 and CY 2002. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2002, the Laboratory burned 2.5 tons of high explosives.

An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicates that high-explosives testing produces no adverse air-quality impacts. The quantities of materials detonated during 2002 were less than the amounts for which impacts are analyzed in the DOE (1999).

### 6. Beryllium Sampling

**a. Routine Sampling.** New Mexico no longer has an ambient-air-quality standard for beryllium to compare with AIRNET measurements. Therefore, we selected another air-quality standard to use for

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comparison purposes: the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard of 10 nanograms (ng)/m<sup>3</sup> (40 CFR Part 61), can be, with EPA approval, an alternative to meeting the emission standard for beryllium. LANL is not required to use this alternative standard because the permitted sources meet the emission standards, but it is used in this case for comparative purposes.

We continued to analyze quarterly composite samples from 29 sites for beryllium during 2002. These sites are located near potential beryllium sources at LANL or in nearby communities. Our previous results indicate that the source of beryllium in our AIRNET samples was naturally occurring beryllium in resuspended dust. Dust may be resuspended mechanically, by vehicle traffic on dirt roads or construction activities, or by the wind in dry weather periods.

Air concentrations for 2002, shown in Table S4-19, remain very similar to those measured during 2000 and 2001. All values are 2% or less than the NESHAP standard.

The highest measured beryllium concentrations in air occur at TA-54, Area G, the Los Alamos County Landfill, the Jemez Pueblo Visitor's Center, the San Ildefonso Pueblo Plaza, and in Santa Fe. Since none of these sites have any beryllium-handling operations, the source of the beryllium is most likely from naturally occurring beryllium in the soils, resuspended by the wind, by vehicles on dirt roads, or by earth-moving/construction operations. TA-54, Area G, is located in the drier portion of the Laboratory, making wind resuspension a more important contributor to air-particle concentration than at other Laboratory locations. Resuspension of fine dust particles is also a common occurrence during trucking operations at the county landfill. Jemez and San Ildefonso pueblos have reported significant levels of blowing dust, especially during the spring season.

The ratio of beryllium to other elements present in the soil should be relatively constant if the local sources of particulate matter are similar and if the composition of the soil is relatively consistent over LANL property. Beginning with the second quarter of 2001, we added manganese and strontium analyses in order to examine the elemental ratio of beryllium to each of these common rock-forming elements. Even though manganese and strontium air concentrations never approached their respective analytical detection limits, we observed significant variability in the

strontium relative abundance in soils taken from such a wide area as covered by our AIRNET network.

A summary of 7 quarters of data is shown in Table S4-20. The manganese ratio is different at a particular set of sites. The Los Alamos County Landfill and all four TA-54 sampling stations where inorganic analyses were done now show a potential enrichment of beryllium relative to manganese by about a factor of two. While this difference is not yet statistically significant at either 2 std dev or 3 std dev, all these sites are consistently noticeably higher than all other regional, perimeter, or LANL sites.

Using this elemental ratio approach to assess potential Laboratory impact is difficult, and the statistical significance of this observation remains to be substantiated. The areas where we observe potentially enhanced beryllium air concentrations relative to manganese may have higher natural beryllium abundances in their soils.

**b. Special Sampling.** During 2002, the RRES-MAQ Group performed short-term ambient-air sampling for two high-explosives test shots at TA-15 (Dual Axis Radiographic Hydrodynamics Test [DARHT] and Phermex), taking TSP matter samples at 10–13 locations during the test. One test shot included beryllium and the other did not. In general, the samplers ran for 24 hours. We analyzed samples for beryllium and uranium isotopes. Samples were also analyzed for three inorganic soil elements: cerium, manganese, and strontium. These elements are not found in LANL emissions and so are useful in distinguishing the impacts of high-explosives tests from soils resuspended by winds. We used the TA-49 and TA-6 meteorological-tower wind-direction data to identify air-sample locations downwind of the tests at the time of the test shots.

Based on 7 or 8 days of 24-hour sampling on non-high-explosives test-shot days (during 2002), the average beryllium concentration at the short-term sampling locations was 0.035 ( $\pm 0.00033$ ) ng/m<sup>3</sup>. The standard deviation of these 99 samples was 0.029 ng/m<sup>3</sup>. The average value was somewhat higher, but consistent with, quarterly average beryllium concentrations measured at AIRNET stations. The higher concentration may reflect sampling locations near areas where beryllium has been used historically or near areas where soil-disturbing activities (other than high-explosive testing) occur.

RRES-MAQ personnel reviewed the 24-hour beryllium concentrations for the two shot events. Two



measurements demonstrated elevated beryllium and uranium concentrations and were in the downwind direction from the shot. These samples also did not have high inorganic soil elements, indicating that the elevated beryllium was not produced by wind resuspension of local soils.

These beryllium air concentrations were 0.402 ( $\pm 0.009$ ) ng/m<sup>3</sup> and 0.096 ( $\pm 0.003$ ) ng/m<sup>3</sup>. These beryllium concentrations in air were measured at TA-51 and TA-36, respectively.

### E. Meteorological Monitoring (*Scot Johnson*)

#### 1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, the meteorology team of the RRES-MAQ Group measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Baars et al. 1998) provides details of the meteorological monitoring program. An electronic copy of the "Meteorological Monitoring Plan" is available on the Internet at <http://www.weather.lanl.gov/monplan/mmp1998.pdf>.

#### 2. Climatology

Los Alamos has a temperate, semiarid mountain climate. However, large differences in locally observed temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site. Four distinct seasons occur in Los Alamos. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses provided in Bowen (1990 and 1992) and from historical meteorological databases maintained by the meteorology team of the RRES-MAQ Group.

Temperatures at Los Alamos have wide daily variations (a 23°F range on average) because of the semiarid climate. Atmospheric moisture levels are low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and long-wave radiative cooling of the earth at night.

This radiative cooling is not ameliorated by downward long-wave radiation that would occur in the presence of clouds and water vapor. Communities nearby, such as White Rock and Española, see even greater fluctuations because they receive a cool nighttime flow that drains from the Pajarito Plateau as it slopes downward to the east toward the Rio Grande and a nighttime flow southward down the Rio Grande valley itself.

Winter temperatures range from 30°F to 50°F during the daytime and from 15°F to 25°F during the nighttime, with a record low temperature of -18°F recorded in 1963. The Sangre de Cristo Mountains to the east of the Rio Grande Valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. Winds during the winter are relatively light, so extreme wind chills are uncommon. Summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime, with a record high temperature of 95°F recorded in 1998.

The average annual precipitation (which includes both rain and the water equivalent for frozen precipitation) from 1971 to 2000 is 18.95 in. The average annual snowfall is 58.7 in. By convention, the 30-yr period of 1971 to 2000 is used to determine climatological averages. However, decadal variability in precipitation produces considerable variation in precipitation-related averages depending on the 30-year period chosen. During the 1980s, for example, the annual average snowfall was 77 in. compared with the annual average snowfall since 1931 (including the 1980s) of 52.3 in.

Winter precipitation in Los Alamos is often caused by storms approaching from the Pacific Ocean or by cyclones forming and/or intensifying leeward of the Rocky Mountains. The snow is usually a dry fluffy powder, with an equivalent water-to-snowfall ratio of about 1:20. Large snowfalls may occur locally as a result of orographic lifting of the storms by the Jemez Mountains (i.e., higher snowfall occurs when storms come from lower elevations south and east of Los Alamos). The record single-day snowfall is 22 in., which occurred once in 1978 and once in 1987. The record single-season snowfall is 153 in. set in 1986–87.

The 2 months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in late June and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning. Local



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lightning density, among the highest in the USA, is estimated at 7 to 22 strikes per square mile per year. The RRES-MAQ Group began measuring lightning activity in 1998, and, according to this small sample set, 54% of the detected local lightning activity occurred during July and August. Lightning is most commonly observed during warmer months; 93% of the lightning activity counted since 1998 occurred between the months of June and September.

The complex topography of Los Alamos influences local wind patterns, notable in the absence of large-scale disturbances. Often a distinct diurnal cycle of winds occurs. As air close to the ground is heated during the day, it tends to be displaced by cooler air from aloft and tends to rise and flow upslope along the ground. This is called “anabatic” flow. During the night, cool air that forms close to the ground tends to flow downslope and is known as “katabatic” flow. Daytime upslope (anabatic) flow of heated air on the Pajarito Plateau adds a southerly component to the winds on the plateau as it flows up the Rio Grande valley. Nighttime downslope (katabatic) flow of cooled air from the mountains and plateau adds a light westerly-to-northerly component to local winds. Flow in the east-west-oriented canyons that interrupt the Pajarito Plateau is often aligned with the canyons, so winds are usually from the west at night as katabatic flow and from the east during the day.

### 3. Monitoring Network

A network of six towers gathers meteorological data (winds, atmospheric state, precipitation, and fluxes) at the Laboratory (See Figure 4-25 and the Meteorological Monitoring Plan [Baars et al., 1998]). Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), one is in a canyon (TA-41), and one is on top of Pajarito Mountain. The TA-6 tower is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is located adjacent to the TA-6 meteorological tower. Precipitation is also measured at TA-16, TA-74, and in North Community of the Los Alamos town site.

### 4. Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects (from trees and structures) on wind and

precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers. The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects.

Data loggers at the tower sites sample most of the meteorological variables at 0.33 hertz (Hz), store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation by telephone or cell phone. The workstation automatically edits measurements that fall outside of allowable ranges. Time-series plots of the data are also generated for a meteorologist’s data-quality review. Daily statistics of certain meteorological variables (i.e., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. During the past 45 years, a similar once-daily set of statistics has been telephoned to the National Weather Service. Observers log cloud type and percentage cloud cover three times daily.

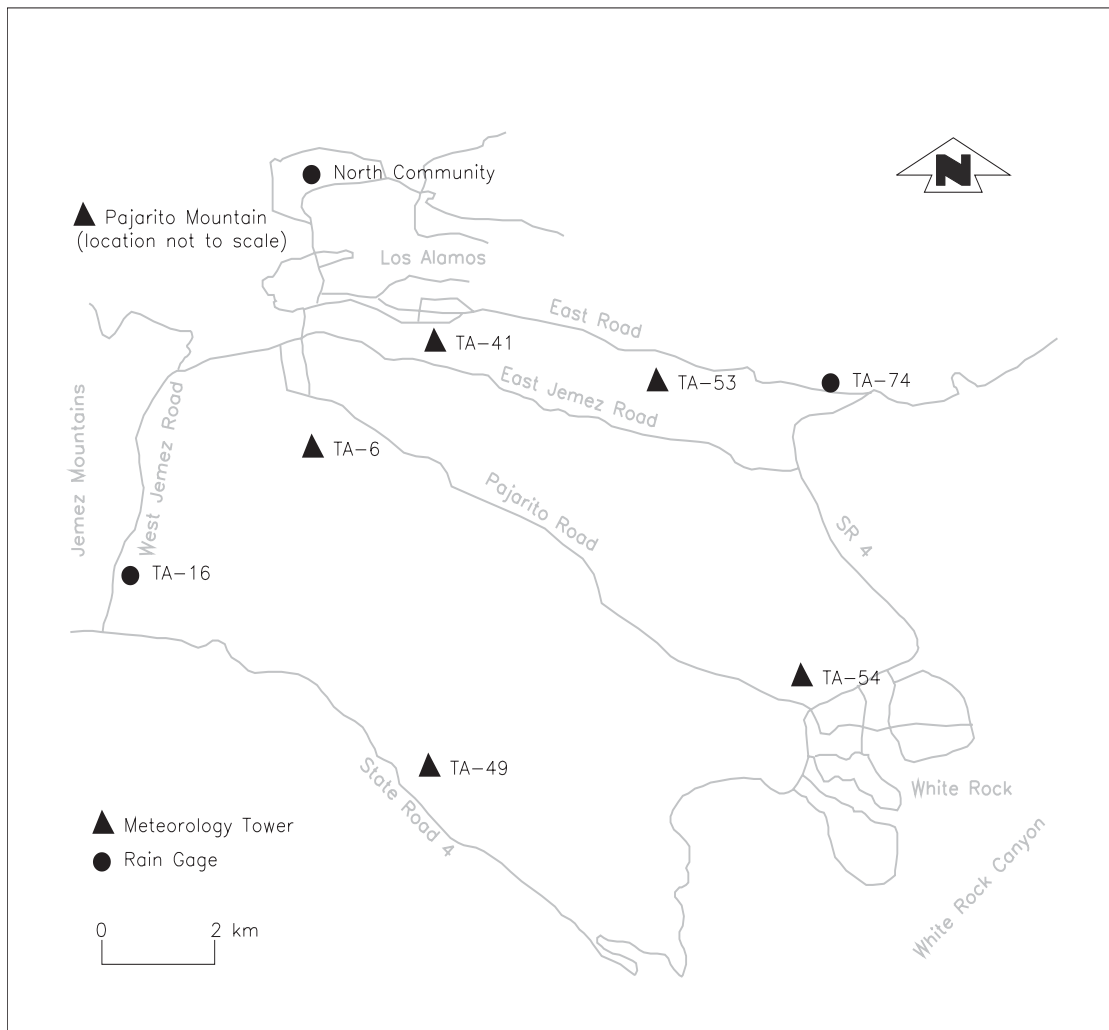
All meteorological instruments are annually refurbished and calibrated during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify that they remained in calibration while in service. All instrument calibrations are traceable to the National Institute of Standards and Technology. An external audit is typically performed once every 2–3 years, with the most recent audit being performed during the summer of 1999. Results indicated no significant anomalies with the instruments in the network.

### 5. 2002 in Perspective

Figure 4-26 presents a graphical summary of Los Alamos weather for 2002. The figure depicts the year’s monthly average temperature ranges, monthly precipitation, and monthly snowfall totals, compared with monthly normals (averages for each of 12 calendar months during the 1971–2000 time period).

Climatologically, Los Alamos weather during 2002 continued a 5-year trend of warm temperatures and a dryer-than-normal climate. From September to the end of 2002, however, temperatures and precipitation returned to near-normal values. The average annual temperature in 2002 of 49.3°F exceeded the normal

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**Figure 4-25.** Meteorological network.

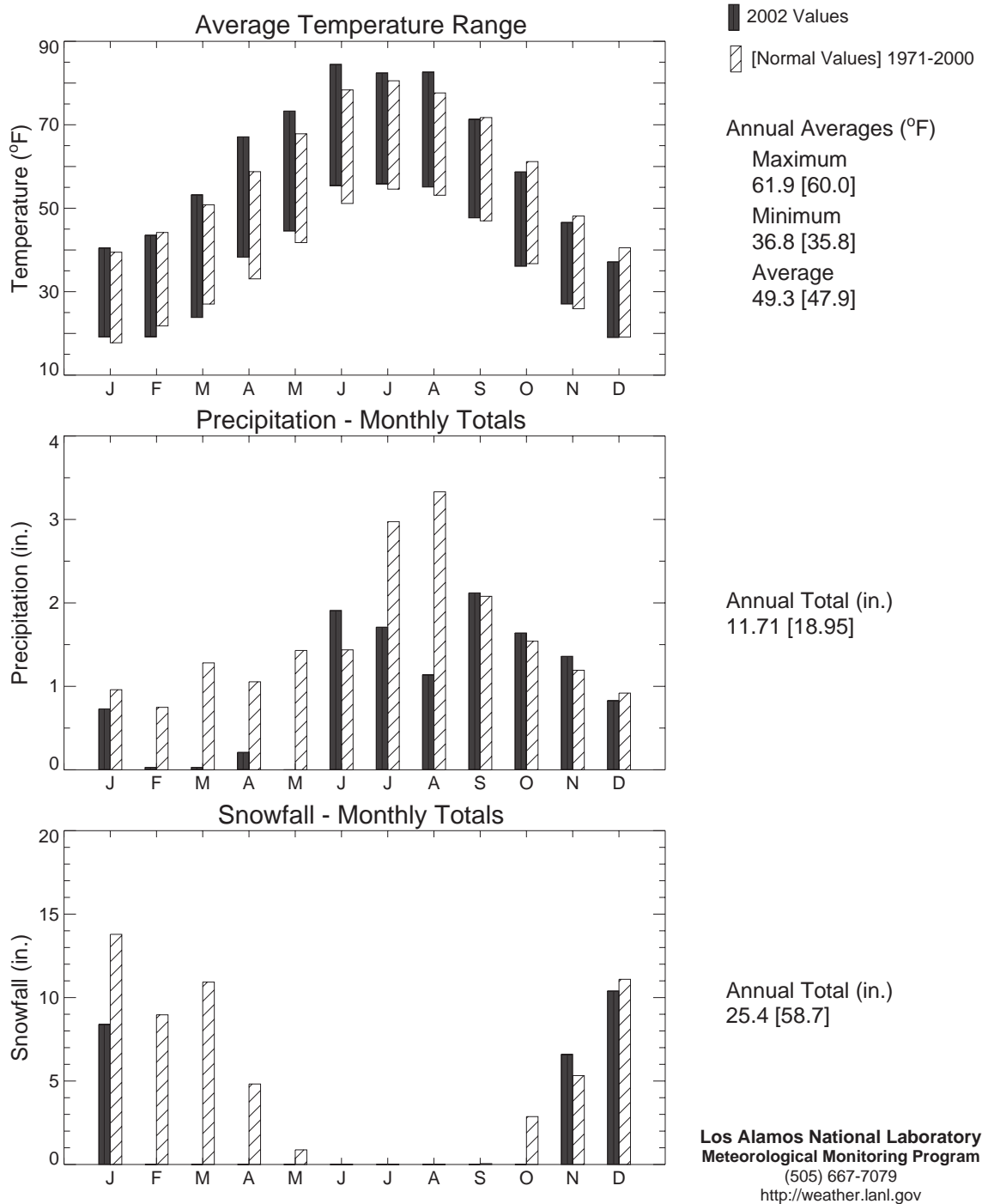
annual average of 48.2°F by 1.1 degree. The total precipitation in 2002 of 11.71 in. was 62% of normal (18.95 in.). Monthly precipitation totals were well below normal early in the year, below average during the main portion of the rainy season (July–August), and nearly normal from September through the remainder of the year. The annual snowfall total of 25.4 in. was only 43% of normal (58.7 in.).

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-27 shows the historical record of temperatures in Los Alamos from 1924 through 2002. The data prior to 1924 are sparse and, therefore, omitted. The annual average temperature is not the average temperature per se, but rather the midpoint between daily high and low

temperatures, averaged over the year. One-year averages are shown in blue in Figure 4-27. The years 1953, 1954, and 1956 all had higher temperatures than any year during the 5 warmer-than-normal years from 1998 to 2002. To aid in showing longer-term trends, the running mean for 5-year and 9-year spans is also shown in Figure 4-27. In all cases, the early-to-mid 1950s were clearly warmer than recent years have been.

Figure 4-28 shows the historical record of the annually-summed total precipitation. As with the historical temperature profile, 5-year and 9-year running means are shown in addition to the plot of totals for each year. Although 2002 was indeed a very dry year, about half-a-dozen other years during the

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**Figure 4-26.** 2002 weather summary for Los Alamos at TA-6 station, elevation 7,424 ft. (Numbers in brackets are normal temperatures, and nonbracketed numbers are for 2002.)

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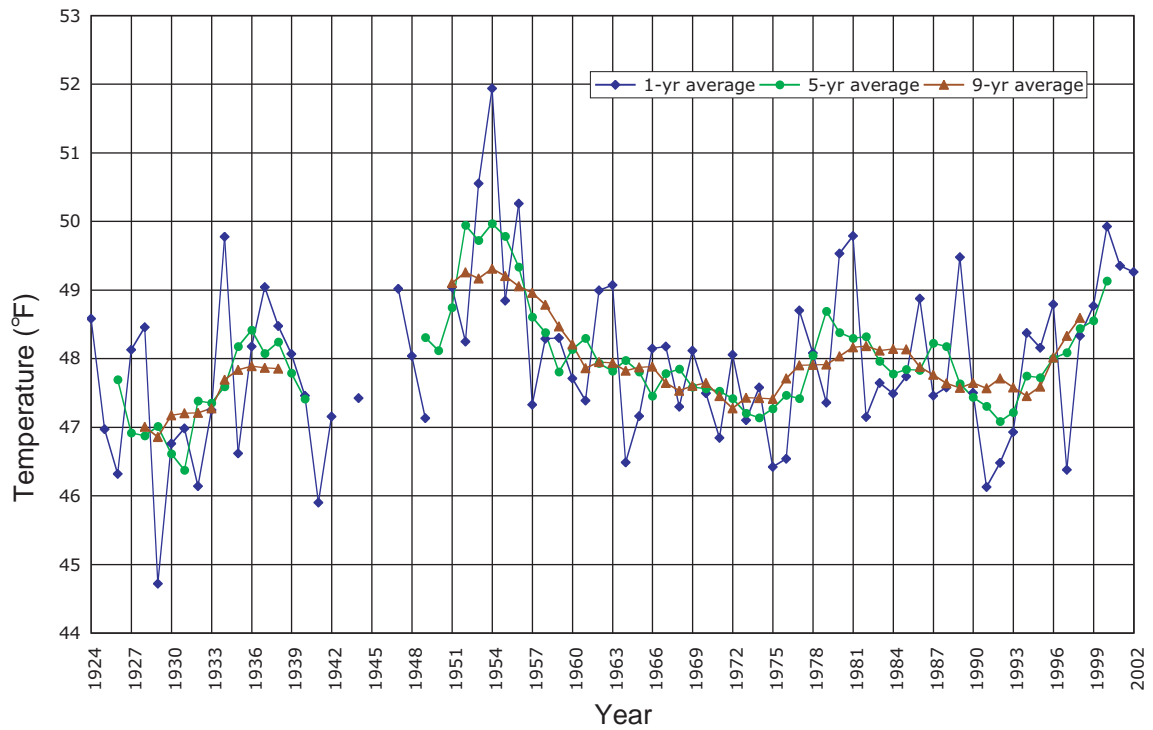


Figure 4-27. Temperature history for Los Alamos.

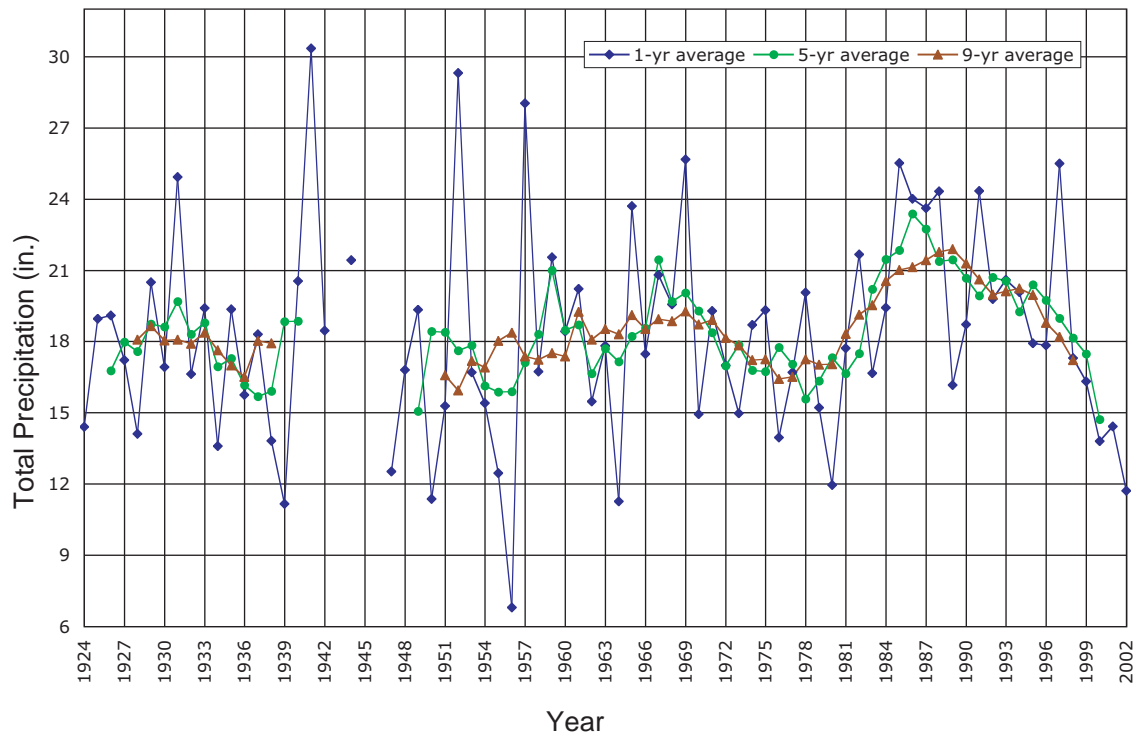


Figure 4-28. Total precipitation history for Los Alamos.

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79-year record had comparable precipitation, and 1956 was clearly drier. By all measures, the current drought appears to be similar in severity to droughts during the late 1930s, early-to-mid 1950s, and late 1970s. Note that from about 1982 until the beginning of the current drought, Los Alamos enjoyed greater-than-normal annual precipitation. This is particularly apparent in the 5-year and 9-year means.

Wind statistics, based on 15-minute-averaged wind observations for 2002 at the four Pajarito Plateau towers and the Pajarito Mountain tower, are shown in the form of wind roses (Figure 4-29). The wind roses depict the percentage of time that the wind blows from each of 16 compass rose points and the distribution of wind speed for each of the 16 directions, represented by shaded wind-rose barbs.

Daytime winds (sunrise to sunset) measured by the four Pajarito Plateau towers were predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley (See Figure 4-30.). Nighttime winds (sunset to sunrise) on the Pajarito Plateau were lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope katabatic flow of cooled mountain air. (See Figure 4-31.) Winds atop Pajarito Mountain are more representative of upper-level flows and primarily ranged from the northwest to the southwest, mainly because of the prevailing westerly winds. Wind roses are remarkably constant from one year to the next. In contrast to temperature and precipitation-related variables, one has to look closely at the wind roses to see changes from year to year.

### F. Quality Assurance Program in the Air Quality Group *(Ernest Gladney and Terrance Morgan)*

#### 1. Quality Assurance Program Development

During 2002, the RRES-MAQ Group revised two quality plans that affect collection and use of air-quality-compliance data. We also revised approximately 37 implementing procedures to reflect the constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that RRES-MAQ processes perform satisfactorily. All current quality-related documents are available on the RRES-MAQ public (Green) Web site ([www.airquality.lanl.gov](http://www.airquality.lanl.gov)).

#### 2. Field-Sampling Quality Assurance

Overall quality of this portion of the program is maintained through the rigorous use of carefully documented procedures that govern all aspects of the sample-collection program.

Particulate and water-vapor samples are (1) taken on commercially available media of known performance, (2) collected under common EPA chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and (3) prepared in a secure and radiologically clean laboratory for shipment. They are then delivered to internal and external analytical laboratories under full chain-of-custody using secure FedEx shipment to all external vendors, and tracked at all stages of their collection and analysis through the AIRNET and RADAIR relational databases.

All NonRadNet program samples are tracked within the AIRNET database. A complete suite of blanks is also taken with each set of samples, to include matrix blanks, trip blanks, and process blanks (where applicable). All blanks are submitted to analytical suppliers for chemical measurements.

Field-sampling completeness is assessed every time the AIRNET biweekly gross alpha/beta data are returned from the analytical laboratory. RADAIR field-sampling completeness is evaluated each week upon receipt of the gross alpha/beta and tritium bubbler data. NonRadNet field-sampling completeness is determined each 12-day sampling period upon receipt of the inorganic or VOC data sets. All these calculations are performed for each ambient-air and stack-sampling site and are included in the quality-assessment memo that is prepared by RRES-MAQ staff to evaluate every data group received from a supplier.

#### 3. Analytical Laboratory Quality Assessment

Specific statements of work (SOWs) are written to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified our program objectives. These SOWs are sent to potentially qualified suppliers who then undergo pre-award on-site assessment by experienced and trained RRES-MAQ quality systems and chemistry-laboratory assessors. SOW specifications, professional judgement, and quality-system performance at each lab (including recent past performance on nationally conducted performance-evaluation programs) are primarily used



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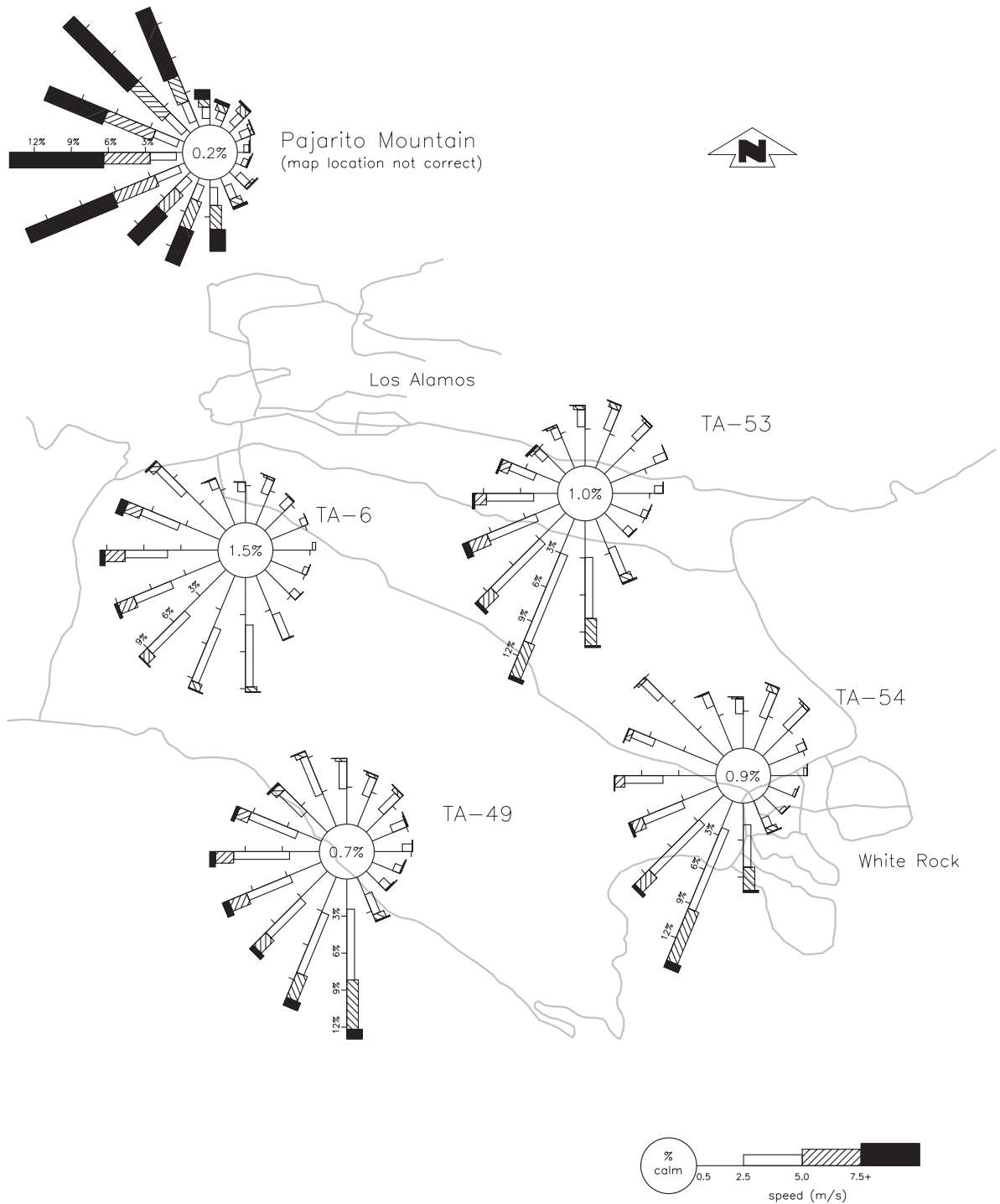


Figure 4-29. Total wind roses, 2002.

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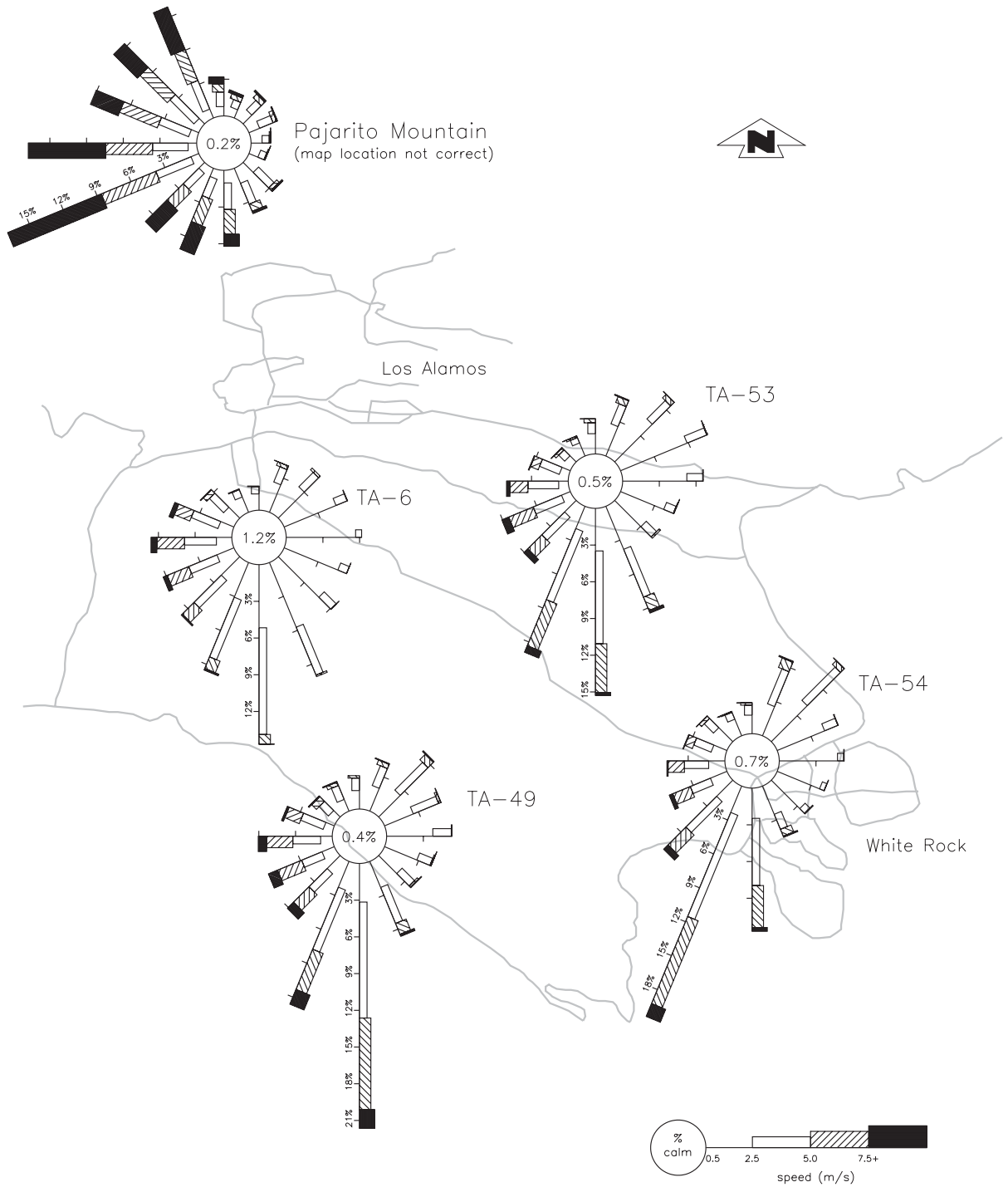


Figure 4-30. Daytime wind roses, 2002.

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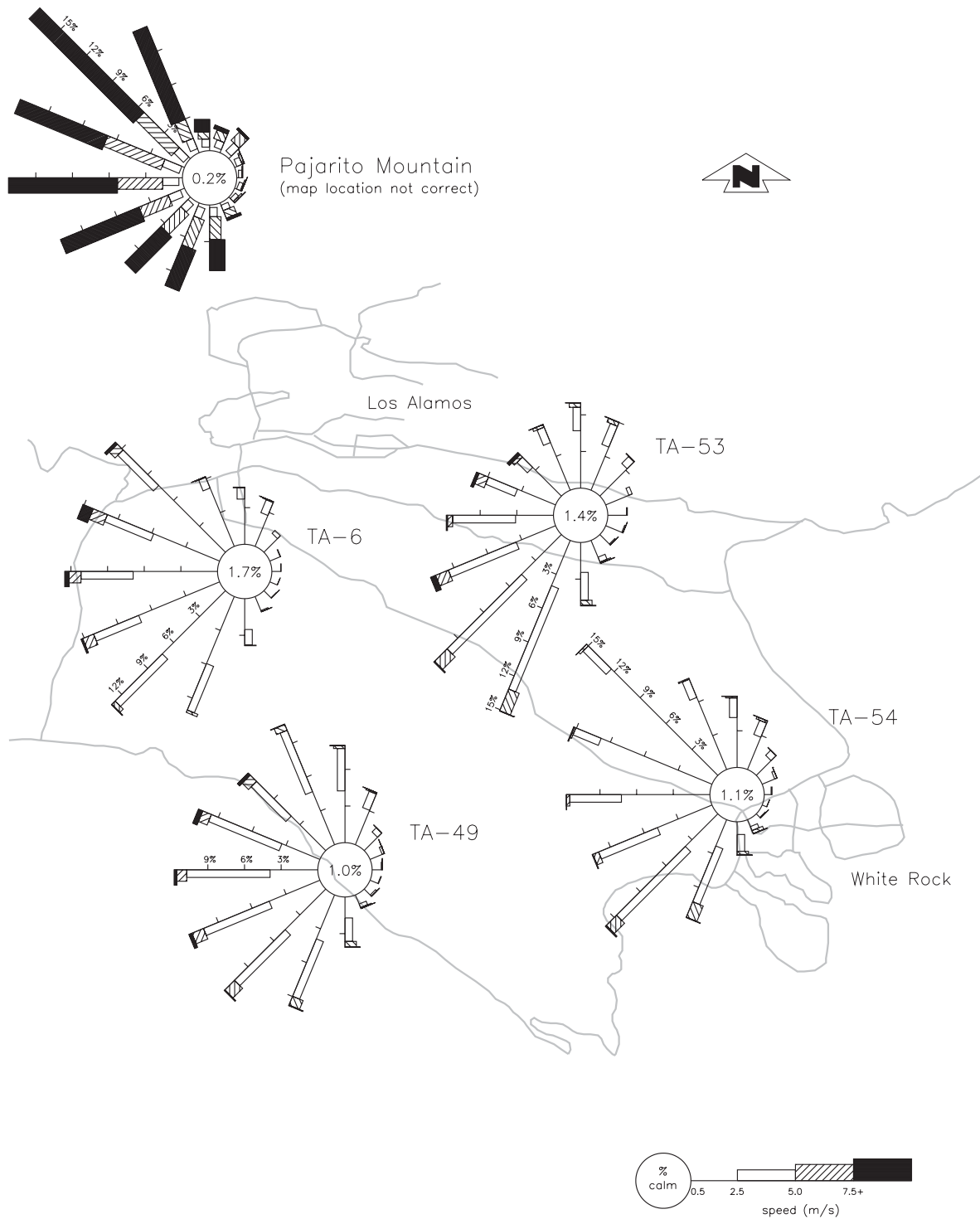


Figure 4-31. Nighttime wind roses, 2002.

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to award contracts for specific types of radiochemical and inorganic analyses. Twelve of these SOWs were reissued as controlled documents in 2002.

Each laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The RRES-MAQ Group submits independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned to the RRES-MAQ Group by e-mail in an electronic data deliverable of specified format and content. Each set of samples contains all the internal QA/QC data generated by the analytical laboratory during each phase of chemical analysis (including laboratory control standards, VOC surrogate compounds, process blanks, matrix spikes, duplicates, and replicates, when applicable). All data are electronically uploaded into either the AIRNET or RADAIR databases (NonRadNet data are stored within AIRNET.) and immediately subjected to a variety of quality and consistency checks. Analytical completeness is calculated, tracking and trending of all blank and control-sample data is performed, and all are included in the quality-assessment memo mentioned in the field-sampling section. All parts of the data-management process are tracked electronically in each database and periodic reports to management are prepared.

### 4. Field-Data Quality-Assessment Results

Field data completeness for AIRNET, NonRadNet, and Stacks was 100%. Sample run time was greater than 95% for each network.

### 5. Analytical-Data Quality-Assessment Results

Analytical-data completeness for all three sampling programs was 100%. The Clean Air Act (CAA) requires an EPA-compliant program of QC samples be included as an integral part of the sampling and analysis process. RRES-MAQ sample- and data-management procedures document the specific evaluations of each type of QC sample for each analytical measurement. The evaluation criteria and overall outcome of these QC tests are shown in the detailed QC evaluation tables contained in the Data Supplement. All QC data are tracked, trended, and reported in specific QC evaluation memos that are submitted to project staff along with each set of analytical data received from our chemistry laboratories. The overall results of our 2002 program of quality monitoring indicates that all

analytical laboratories maintained the same high level of control that the RRES-MAQ Group has observed in the past several years.

### 6. Analytical-Laboratory Assessments

During 2002, one internal and three external laboratories performed all chemical analyses reported for AIRNET, NonRadNet, and RADAIR samples.

- The Wastren-Grand Junction analytical laboratory (associated with the DOE's Grand Junction Project Office) provided biweekly gross alpha, gross beta, and isotopic gamma analytical services for AIRNET.
- Paragon Analytics, Inc., Fort Collins, Colorado, provided biweekly AIRNET tritium and weekly RADAIR stable beryllium analytical services.
- Wastren-Grand Junction provided analytical-chemistry services for alpha-emitting isotopes (americium, plutonium, polonium, thorium, and uranium), beta-emitting isotopes (lead-210), and stable beryllium on AIRNET quarterly composite samples.
- Wastren-Grand Junction also provided all inorganic elemental analyses for the AIRNET and NonRadNet programs.
- STL-Austin performed all VOC analyses on the Summa Cannisters collected for the NonRadNet program.
- LANL's on-site Health Physics Analytical Laboratory in HSR-4 performed all instrumental analyses (gross alpha, gross beta, isotopic gamma, and tritium) reported for stack emissions and in-stack samples.
- Wastren-Grand Junction also analyzed semester composites of in-stack filters for alpha- and beta-emitting isotopes (lead-210 and strontium-90).

RRES-MAQ personnel performed formal on-site assessments at all laboratories except STL-Austin during 2002. The STL-Austin lab was not visited since the NonRadNet program ended in December 2002. All of these analytical laboratories participated in national performance-evaluation studies during 2002. The detailed results of these performance evaluations are included in each assessment report (Gladney and Luedeker 2001; Gladney and Morgan 2002; Gladney and Morgan 2003a, 2003b, and 2003c). Overall, the study sponsors judged the analytical labs

that participated in these national studies to have acceptable performance for almost all analytes attempted in all matrices.

### G. Unplanned Releases

During 2002, the Laboratory reported two instances of increased airborne emissions to the New Mexico Environment Department (NMED) Air Quality Bureau. Both were exceedences of opacity limits, and we reported them to NMED using the Excess Emission Form (20NMAC 2.7).

On September 5, 2002, the TA-03-22 power plant exceeded the stack-emission opacity limit of 20%. The excess emission was caused by boiler-control tuning for fuel-oil firing to ensure readiness for flue gas recirculation operational initiation. When the exceedence occurred, plant engineers were adjusting fuel-oil and air ratios for optimum combustion conditions. The problem was corrected by changing the fuel from oil to natural gas.

On August 13, 2002, a spark from the air curtain destructor (ACD) ignited a small smoldering fire in a container of straw located about 30 ft from the ACD. The operators sprayed water on the straw; however, the straw continued to smolder. The operator then used heavy equipment to transfer the smoldering straw into the ACD; opacity limits for the ACD were approached or exceeded when wet straw was

transferred into the ACD. The emissions for the ACD returned to allowable opacity levels within 30 min.

Although no reporting thresholds were exceeded on January 8, 2002, a courtesy notification was made to the National Response Center and the NMED concerning a chlorine release from TA-54. Approximately 8.5 lb of chlorine gas were released when an experimental apparatus exploded. The reportable quantity for chlorine is 10 lb, therefore no notification was required. No one was injured in the explosion.

### H. Special Studies—Neighborhood Environmental Watch Network Community Monitoring Stations

Neighborhood Environmental Watch Network (NEWNET) is a LANL program for radiological monitoring in local communities. It establishes gamma-radiation monitoring stations in local communities and near radiological sources. The data are available to the public, usually with less than 20-min delay.

The station measures gross gamma radiation, using a pressurized ion chamber. The radiation sensors are sampled at 1-second intervals, averaged every 15 min. The data are presented on the World Wide Web in both English and Spanish.

More information about NEWNET and the data are available at <http://newnet.LANL.gov/> on the World Wide Web.



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# 5. Groundwater Monitoring



IM-4: CN81-1657







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*David B. Rogers, Robert S. Beers, and William R. Turney*

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### A. Introduction

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples from the Pajarito Plateau and surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the Department of Energy (DOE) Orders and New Mexico and federal regulations. The objectives of the Laboratory's groundwater programs are to determine compliance with waste-discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources. This program addresses environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1996, 1998).

Groundwater resource management and protection efforts at the Laboratory focus on (1) the regional aquifer underlying the region and include (2) the perched groundwater found within canyon alluvium and (3) the perched groundwater at intermediate depths above the regional aquifer. The Los Alamos public water supply comes from supply wells that draw water from the regional aquifer, which lies at a depth of 600 to 1,200 feet.

Since the 1940s, liquid effluent disposal by the Laboratory has degraded water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. These water quality impacts extend in a few cases to perched groundwater at depths of a few hundred feet beneath these canyons. The contaminated perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so

recharge from the shallow perched groundwater occurs slowly. As a result, little contamination reaches the regional aquifer from the shallow perched groundwater bodies, and water quality impacts on the regional aquifer, though present, are low. With one exception (perchlorate in well O-1 in Pueblo Canyon) drinking water in the Los Alamos area has not been adversely impacted by Laboratory actions. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water requirements.

The Groundwater Protection Program (RRES-GPP) and the Water Quality and Hydrology Group (RRES-WQH) implement the Laboratory's groundwater monitoring program. The RRES-WQH Group collects groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby San Ildefonso Pueblo.

### B. Hydrogeologic Setting

Additional information on groundwater studies at Los Alamos and a more detailed discussion of the Laboratory's hydrogeologic conceptual model appear in the Laboratory's annual groundwater status report (Nylander et al. 2003).

#### 1. Geologic Setting

Los Alamos National Laboratory is located in northern New Mexico on the Pajarito Plateau, which extends eastward from the Sierra de los Valles (the eastern range of the Jemez Mountains) (Figure 5-1). The Rio Grande borders the Laboratory on the east.

## 5. Groundwater Monitoring

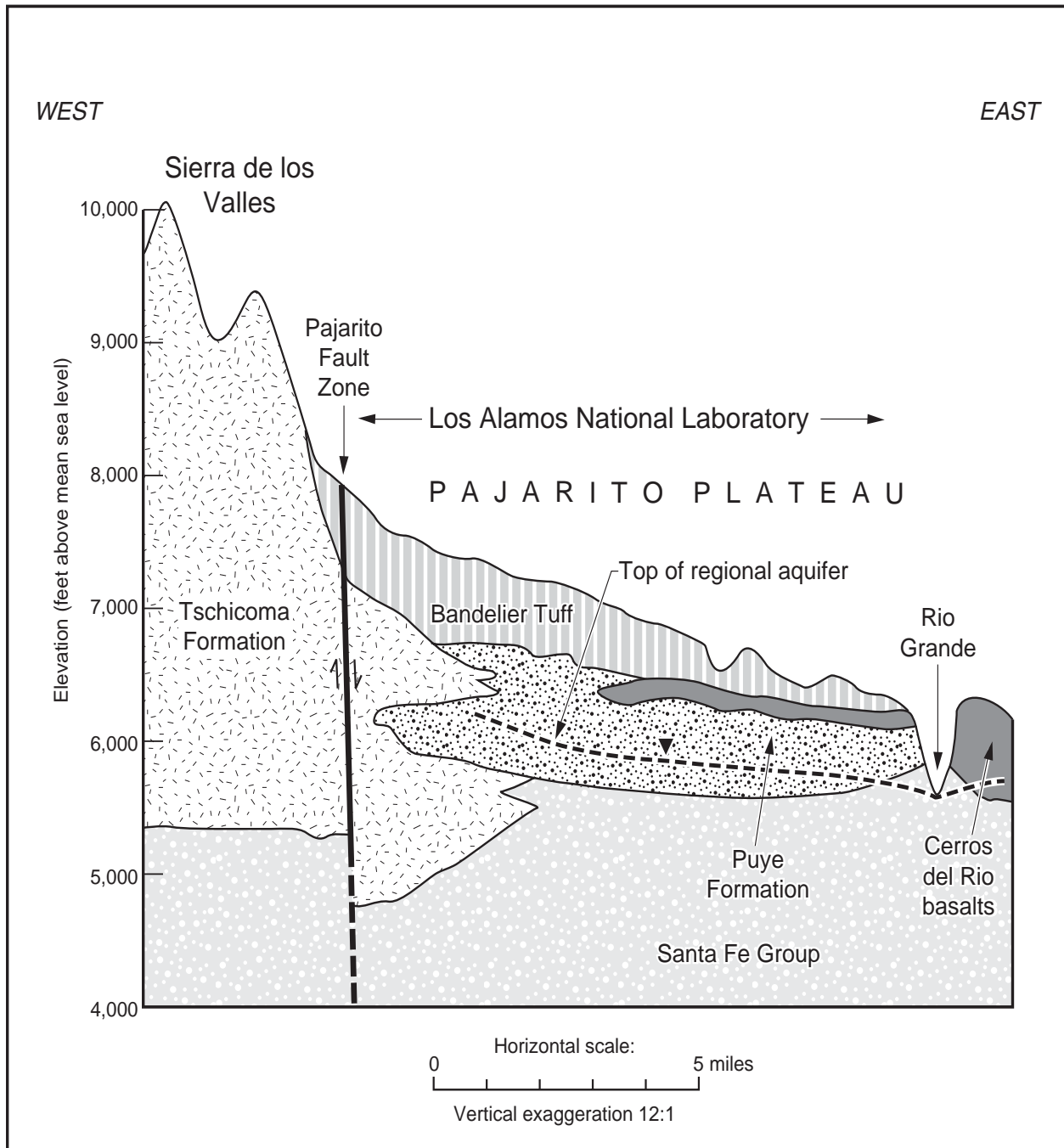


Figure 5-1. Generalized geologic cross section of the Pajarito Plateau.

## 5. Groundwater Monitoring

Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff formed from volcanic ashfall deposits and pyroclastic flows erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (Figure 5-1). The Puye Formation conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

### 2. Groundwater Occurrence

Los Alamos has a semiarid climate with average rainfall approximately 18.7 in./yr. The plateau has ponderosa forest at higher elevations that gives way to

piñon-juniper woodlands as elevation decreases. The plateau is separated into finger mesas by east-west oriented canyons. These contain riparian vegetation and small streams that for the most part have short-lived or intermittent flow.

Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is retained above a less permeable layer and separated from underlying groundwater by an unsaturated zone. The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by subsurface changes in rock type and permeability, and (3) the regional aquifer beneath the Pajarito Plateau.

Streams have filled some parts of canyon bottoms with alluvium up to 100 ft thick. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. In wet canyons, stream runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff, maintaining shallow bodies of perched groundwater within the alluvium. Evapotranspiration and infiltration into

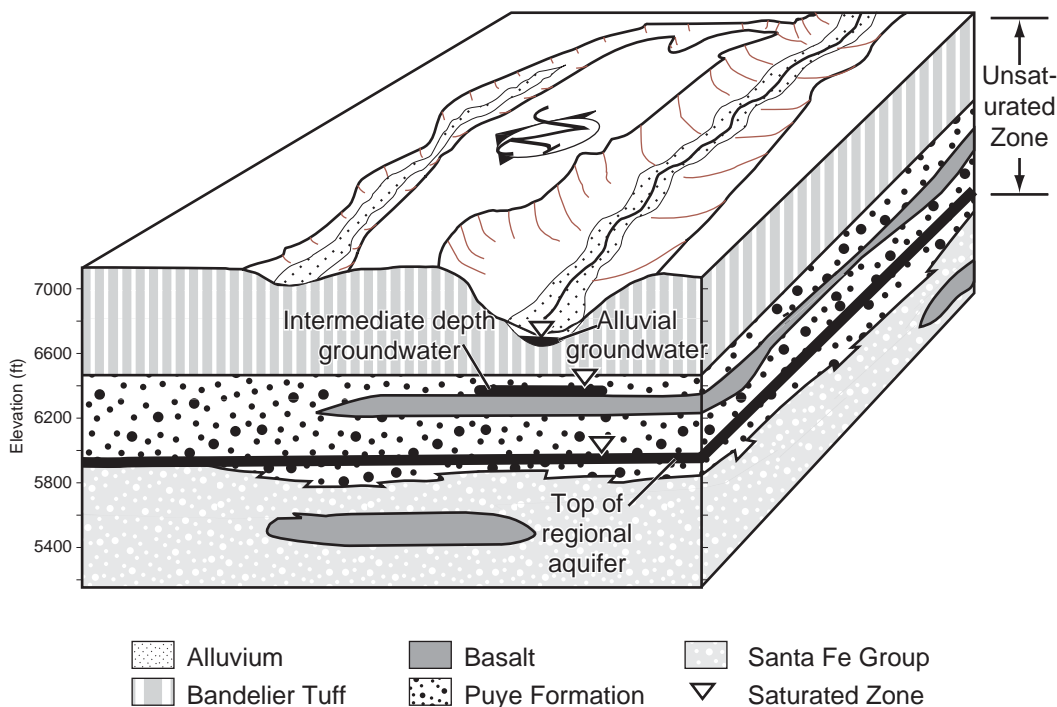


Figure 5-2. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

## 5. Groundwater Monitoring

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underlying rocks deplete the alluvial groundwater as it moves down the canyon. The chemical quality of some of the alluvial groundwater shows the effects of Laboratory discharges.

Underneath portions of Pueblo, Los Alamos, Mortandad, and Sandia canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and within the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. Intermediate groundwater occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary: approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched water occurs in volcanics on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon. Intermediate perched water also occurs within the Laboratory border just east of the Sierra de los Valles, in the Bandelier Tuff at a depth of approximately 700 ft. The source of this perched water may be infiltration from streams that discharge from canyons along the mountain front and underflow of recharge from the Sierra de los Valles. The intermediate groundwater shows localized radioactive (tritium), organic (high explosives [HEs] cyclonite [RDX] and trinitrotoluene [2,4,6-TNT] and degradation products), and inorganic (perchlorate and nitrate) contamination from Laboratory operations.

The regional aquifer of the Los Alamos area occurs at a depth of 1,200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). The regional aquifer lies about 1,000 ft beneath the mesa tops in the central part of the plateau. This aquifer is the only aquifer in the area capable of serving as a municipal water supply. Water in the aquifer flows generally east or southeast toward the Rio Grande, and underflow of groundwater from the Sierra de los Valles appears to be the main source of recharge for the regional aquifer. Groundwater velocities vary spatially but are typically 30 ft/yr.

The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation, part of the Santa Fe Group (Figure 5-1). Underneath the central

and western part of the plateau the aquifer rises farther into the Cerros del Rio basalt and the lower part of the Puye Formation.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 620 ft of unsaturated tuff, basalt, and sediments with low (<10%) moisture content. Percolation losses from alluvial and intermediate groundwater occur through unsaturated flow. This percolation is a significant source of contaminants that may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, limit their volumetric contribution to recharge reaching the regional aquifer.

### C. Groundwater Standards

Concentrations of radionuclides in groundwater samples may be evaluated by comparison with the derived concentration guides (DCGs) for ingested water calculated from DOE's 100-mrem public dose limit. (See Appendix A for a discussion of standards.) The New Mexico Water Quality Control Commission (NMWQCC) has also established standards for groundwater quality (NMWQCC 2002). Concentrations of radioactivity in drinking water samples from the water supply wells, which draw water from the regional aquifer, are compared with New Mexico drinking water regulations and Environmental Protection Agency (EPA) maximum contaminant levels (MCLs) or to the 4-mrem DOE DCGs that apply to drinking water. The DCG for gross alpha assumes that the radioactivity comes solely from americium-241 and plutonium-239,-240, thus is conservative.

The concentrations of nonradioactive chemical quality parameters may be evaluated by comparing them with NMWQCC groundwater standards (NMWQCC 2002) and with the New Mexico drinking water regulations and EPA MCLs, although these latter standards technically apply only to the public water supply. EPA Region 6 tap water screening levels are used for comparison for some compounds ([http://www.epa.gov/earth1r6/6pd/rcra\\_c/pd-n/screen.htm](http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm)). Although not a source of municipal or industrial water, perched alluvial groundwater is a source of return flow to surface water and springs used by wildlife. (No livestock are allowed on the Laboratory.) The standards for groundwater or the NMWQCC's (NMWQCC 2000) surface water livestock watering

## 5. Groundwater Monitoring

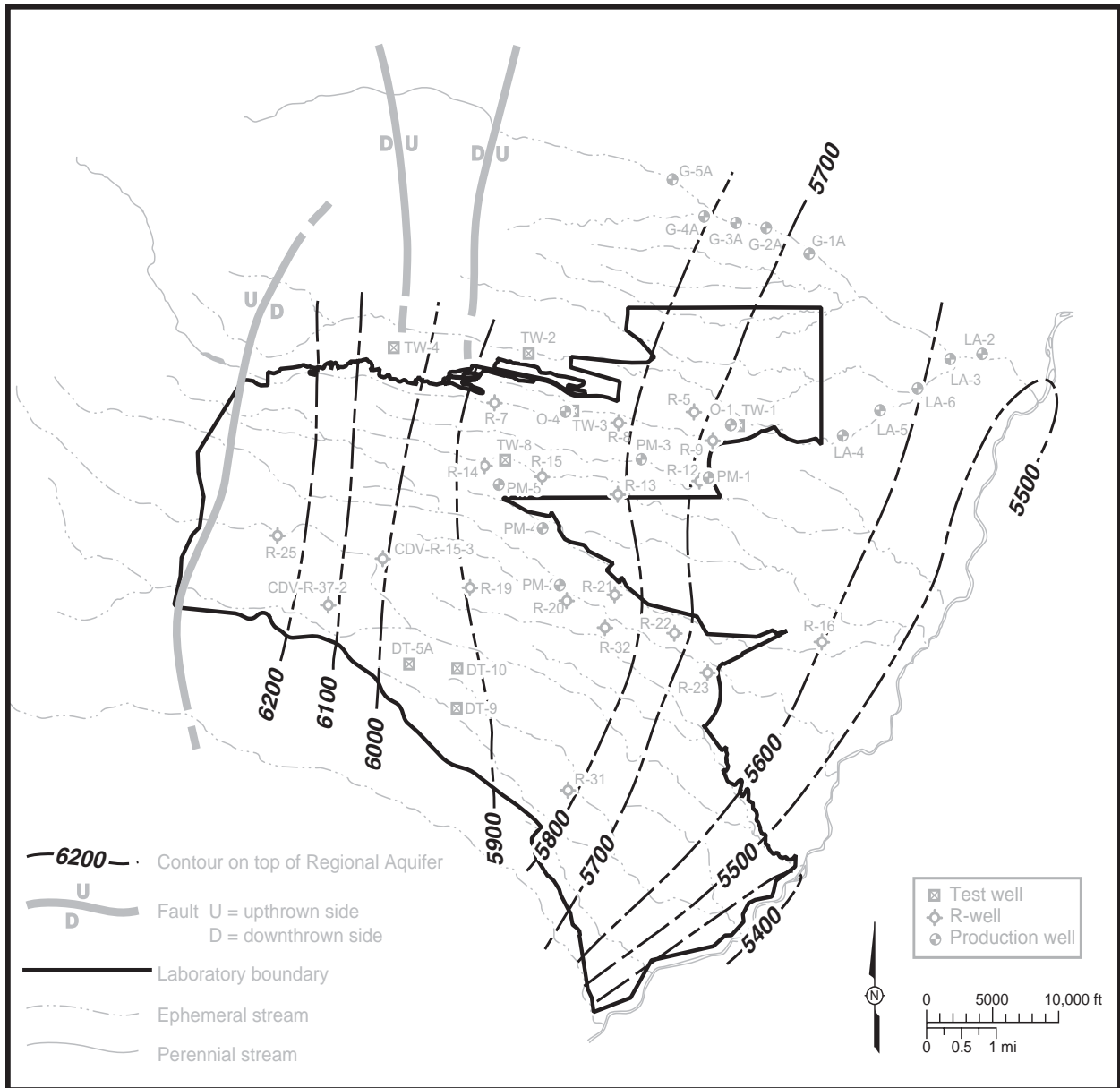


Figure 5-3. Generalized water-level contours for the regional aquifer (Nylander et al. 2003).



## 5. Groundwater Monitoring

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and wildlife habitat water quality standards may be used as a basis for comparison; however, these standards are for the most part based on dissolved concentrations. Many of the results reported here are total concentrations (that is, they include both dissolved and suspended solids concentrations), which may be higher than dissolved concentrations alone.

### D. Overview of Groundwater Quality

#### 1. Groundwater Contaminant Sources

Liquid effluent disposal is the primary means by which Laboratory contaminants have had a limited effect on the regional aquifer. In most cases where Laboratory contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged. The discharge of effluents to canyons or mesa-top locations in the Laboratory's semiarid setting initiates or increases downward percolation of water. Even under unsaturated flow conditions, this percolation may move significant volumes of water to the regional aquifer within a few decades.

Liquid effluent disposal at the Laboratory has significantly affected the quality of alluvial groundwater in some canyons (Figure 5-4). These effluents have affected deeper intermediate perched groundwater and the regional aquifer to a lesser degree. Drainages that received liquid radioactive effluents include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon. Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

Water Canyon and its tributary Cañon de Valle have received effluents produced by HE processing and experimentation (Glatzmaier 1993, Martin 1993). Over the years, Los Alamos County has operated three sanitary treatment plants in Pueblo Canyon (ESP 1981). Only the Bayo plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

#### 2. Radioactive Liquid Waste Treatment Facility Discharges

Mortandad Canyon presently receives radioactive effluents from the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) from its tributary Effluent Canyon. Since the RLWTF began operating in 1963, the

radionuclides in the RLWTF effluent have often exceeded the 100-mrem DOE public dose limit. The effluent also contains nitrate that has caused perched alluvial groundwater concentrations to exceed the New Mexico groundwater standard of 10 mg/L (nitrate as nitrogen). In April 1999, the RLWTF began operating a reverse osmosis and ultrafiltration system. This system removes additional radionuclides and nitrate from the effluent, and discharges from the plant now meet the New Mexico groundwater standards for nitrate and fluoride. The RLWTF effluent has met the 100-mrem DOE DCGs continuously since December 10, 1999.

Perchlorate was measured in RLWTF effluent at annual average concentrations of 254 parts per billion (ppb) in 2000 and 169 ppb in 2001. The RLWTF started operating a system for removing perchlorate from the plant effluent on March 26, 2002. The annual average RLWTF effluent perchlorate concentration for 2002 was 16 ppb, with none detected in the effluent after March 31, 2002.

### E. Groundwater Contaminant Distribution at Los Alamos

The following sections provide an overview of the extent of groundwater contamination at the Laboratory. More detail on sources, contaminant history, and current monitoring results for each location is given in later sections of this chapter. The discussion accompanying the maps serves as a general overview to introduce groundwater contaminants, sources, and locations.

The accompanying maps represent a synthesis of the last several years of groundwater data collected for Laboratory environmental monitoring and characterization programs.

The maps show contaminant locations extrapolated beyond the area covered by monitoring wells. This extrapolation takes into account the location of contaminant sources and direction of groundwater flow. Question marks on the maps indicate where contaminant extent is inferred, but not confirmed by monitoring coverage, or indicate locations where analytical measurements suggest detections that are contradicted by other measurements. Along canyons, the extent of contamination lateral to the canyon is not to scale: contamination is confined to the alluvium within the canyon bottom and is quite narrow at the map scale.

## 5. Groundwater Monitoring

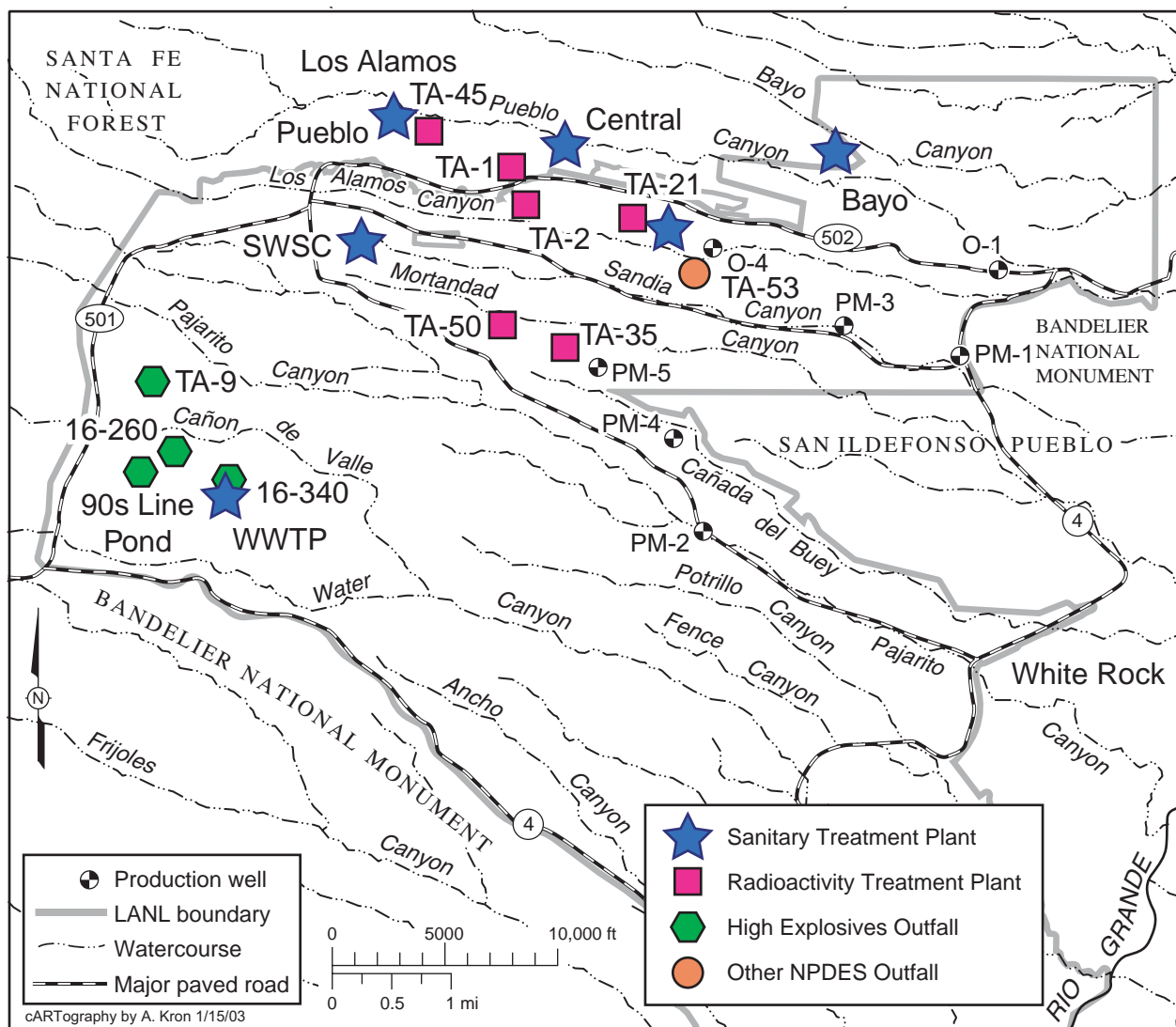


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. (Most sources shown are inactive.)

### 1. Strontium-90 and Transuranics

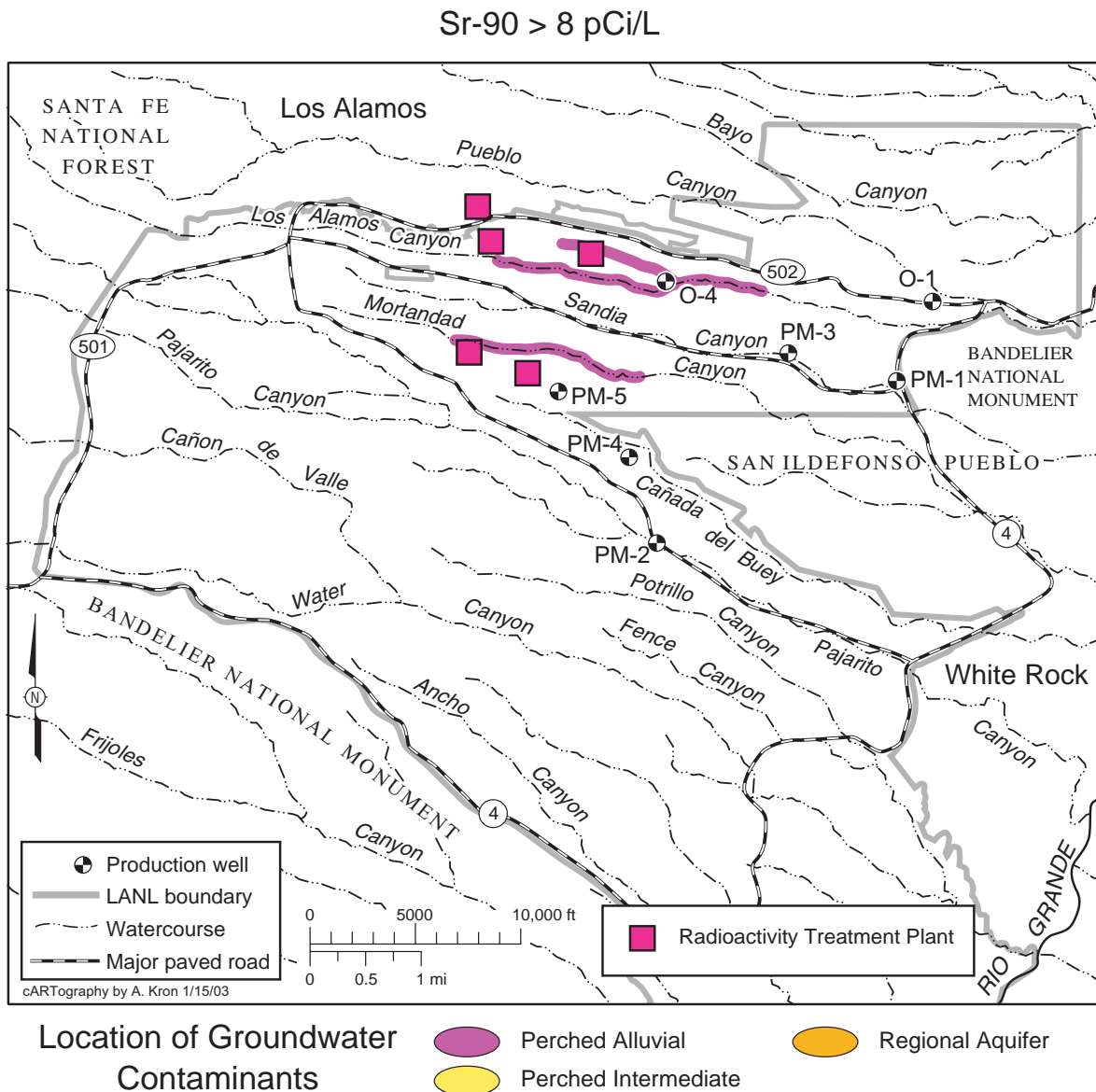
Release of radioactive liquid effluents into DP Canyon, Los Alamos Canyon, and Mortandad Canyon has introduced strontium-90 into the alluvial groundwater that persists at levels above the 8-pCi/L EPA drinking-water MCL, as indicated in Figure 5-5 (Rogers 2001). Strontium-90 has not been found in deeper groundwater. In almost every intermediate perched or regional aquifer sample, no strontium-90 is detected; the occasional detections are analytical outliers and not repeatable. The discharge from the RLWTF into Mortandad Canyon creates a localized area of alluvial groundwater with plutonium-238;

plutonium-239,-240; and americium-241 measured above the 4-mrem DOE DCG for drinking water (although this water is not used for drinking). (See Figure 5-6.)

### 2. Nitrate and Perchlorate

Until recently, the RLWTF discharge also contained perchlorate and nitrate at high levels. The discharge has caused nitrate (as nitrogen) levels in alluvial and intermediate perched groundwater in Mortandad Canyon to exceed 10 mg/L, the New Mexico groundwater standard (Figure 5-7). Perchlorate concentrations in these groundwater zones have reached

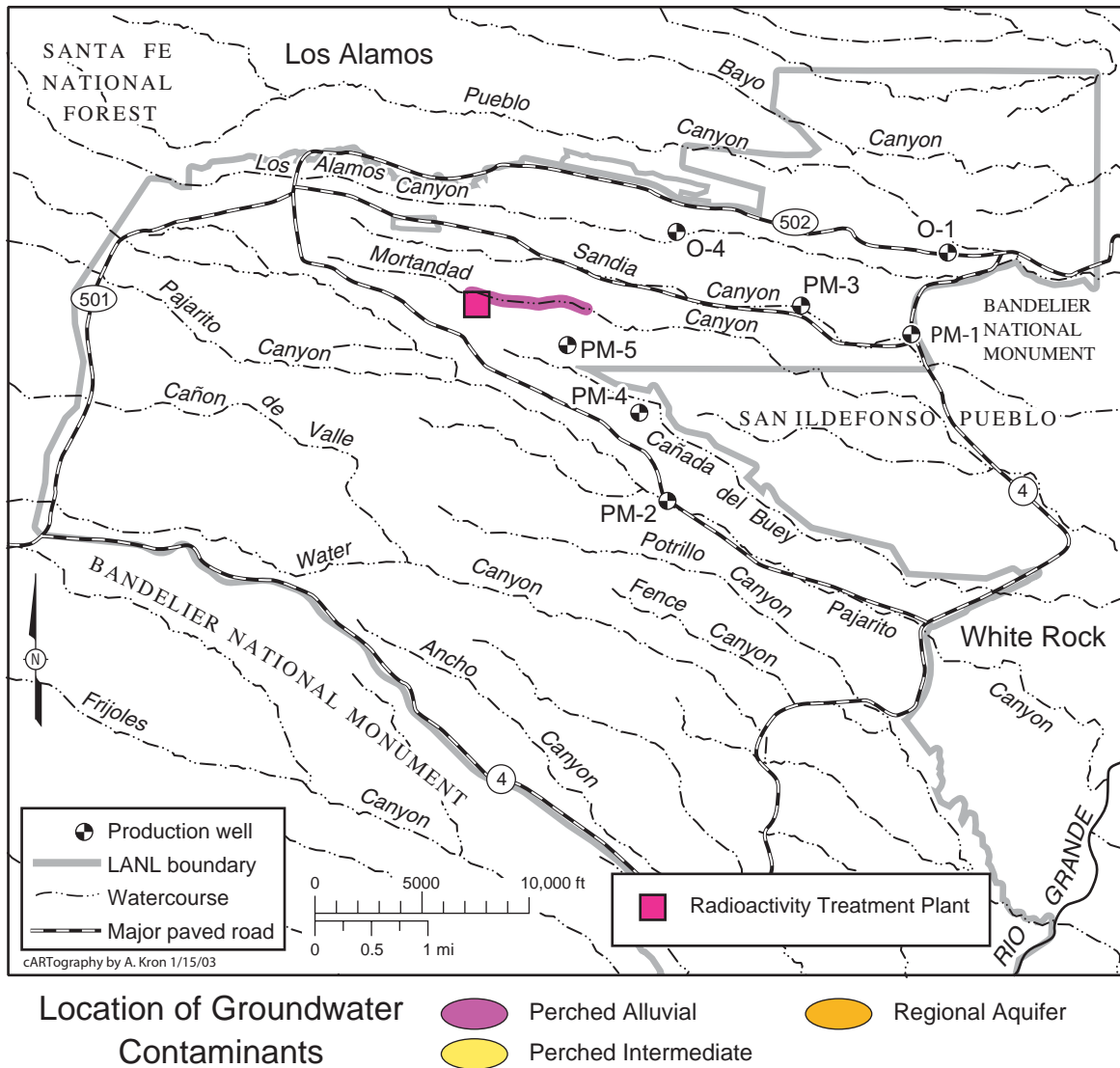
## 5. Groundwater Monitoring



**Figure 5-5.** Location of groundwater contamination by strontium-90 above the 8 pCi/L EPA MCL. The maximum 2002 values in Mortandad and Los Alamos Canyon alluvial groundwater were 7.8 and 3.6 times the MCL, respectively. Different colors indicate the affected groundwater zones. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale: contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

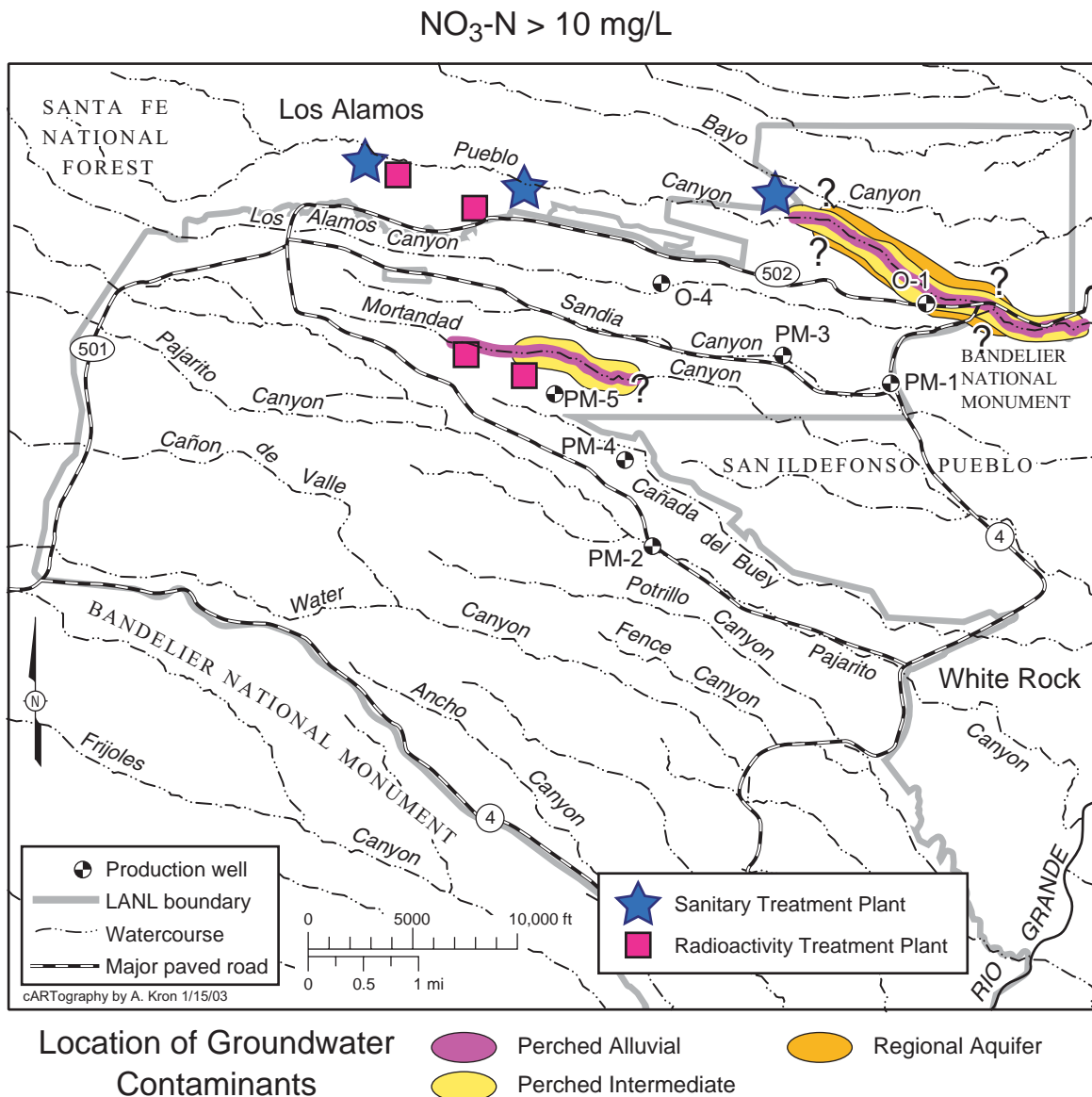
## 5. Groundwater Monitoring

Pu-238, Pu-239,240, and Am-241 > 4 mrem



**Figure 5-6.** Location of groundwater contamination by plutonium-238; plutonium-239,-240; and americium-241 above the 4-mrem DOE DCG for drinking water. The 2002 maximum values in Mortandad Canyon alluvial groundwater for plutonium-238; plutonium-239,-240; and americium-241 were 1.4, 1.1, and 3.3 times the 4-mrem limit, respectively. Different colors indicate the affected groundwater zones.

## 5. Groundwater Monitoring



**Figure 5-7.** Location of groundwater contamination by nitrate (as nitrogen) above the 10 mg/L EPA MCL. Maximum 2002 values in Mortandad Canyon alluvial and intermediate groundwater were 77% and 132% of the MCL. In Pueblo Canyon maximum values in alluvial and intermediate groundwater and the regional aquifer were 18%, 56%, and 53% of the MCL. Pueblo Canyon values have ranged to 100% of the MCL in recent years. Different colors indicate the affected groundwater zones. The extent of intermediate groundwater and regional aquifer contamination is based on a limited number of wells: question marks on the maps indicate where contaminant extent is inferred, not necessarily substantiated.



## 5. Groundwater Monitoring

200 ppb, well above provisional risk-based levels of 1 ppb. Perchlorate has possibly been detected in regional aquifer monitoring wells in Mortandad Canyon (values below the 4 ppb detection limit), but subsequent samples have not substantiated this finding. Our current detection limit for perchlorate, using the EPA-approved ion chromatography (IC) method, is 4 ppb. Perchlorate was also found in alluvial groundwater in Cañon de Valle in 2000 (Figure 5-8).

In Pueblo Canyon, nitrate (as nitrogen) is found above 10 mg/L in alluvial and intermediate perched groundwater. Samples in one regional aquifer monitoring well consistently show nitrate at approximately 5 mg/L. The nitrate is likely from the Bayo Canyon sanitary wastewater treatment plant, but it may also have come from past Laboratory radioactive effluent discharges into Acid Canyon. Discharges into Acid Canyon probably contained large concentrations of perchlorate, based on a similarity of past Laboratory activities to those programs that currently process effluent through the RLWTF. Perchlorate is found within the regional aquifer in Pueblo Canyon, notably in water supply well O-1. Although a few perchlorate values from this well reach 5 ppb, most are slightly below the 4-ppb detection limit. The number and consistency of the perchlorate results in O-1 support its presence at that level, however. O-1 also contains a consistent 30-40 pCi/L of tritium and higher nitrate (as nitrogen) than any other regional aquifer well. O-1 nitrate (as nitrogen) has been about 1.3 mg/L compared with approximately 0.5 mg/L in other water supply wells.

### 3. Tritium

During the last 10 years, tritium has been found above the 20,000 pCi/L EPA MCL at the Laboratory only in alluvial groundwater in Mortandad Canyon (Figure 5-9). Radioactivity trends in Mortandad Canyon groundwater are discussed in further detail in section F of this chapter. At the end of 2000, the RLWTF adopted a voluntary goal of having tritium activity in its effluent below 20,000 pCi/L. Average annual tritium activity in the RLWTF effluent dropped below 20,000 pCi/L to 9,300 pCi/L in 2001 and 7,200 pCi/L in 2002. Tritium activity in alluvial groundwater downstream has dropped correspondingly with maximum values 6,700 pCi/L in 2001 and 8,400 pCi/L in 2002. Underlying intermediate perched groundwater shows tritium at nearly 15,000 pCi/L at a 500-ft depth. In the regional aquifer, the source of drinking

water, wells have shown tritium at up to 80 pCi/L, well below the EPA MCL.

Elsewhere in the Laboratory, tritium has been found in the intermediate perched groundwater and the regional aquifer at trace levels in locations that include Pueblo, Los Alamos, and Sandia canyons, and TA-16 in the southwest portion of the Laboratory. In the past, alluvial groundwater in Los Alamos Canyon has shown significant tritium levels from effluent discharges and the Omega West Reactor leak, but tritium activity has fallen below a few hundred pCi/L in recent years. Rogers (1998) summarized the occurrence of tritium in groundwater at the Laboratory.

### 4. Molybdenum

A short section of alluvial groundwater in Los Alamos Canyon has molybdenum concentrations near or above the New Mexico groundwater standard of 1,000 µg/L (Figure 5-10). The source of this molybdenum is sodium molybdate, a water-treatment chemical commonly used in cooling towers. Historically, sodium molybdate was used as a tracer in managing water chemistry in three cooling towers at TA-53. These cooling towers have recently been replaced with two new cooling towers. The Laboratory discontinued use of sodium molybdate in June 2002.

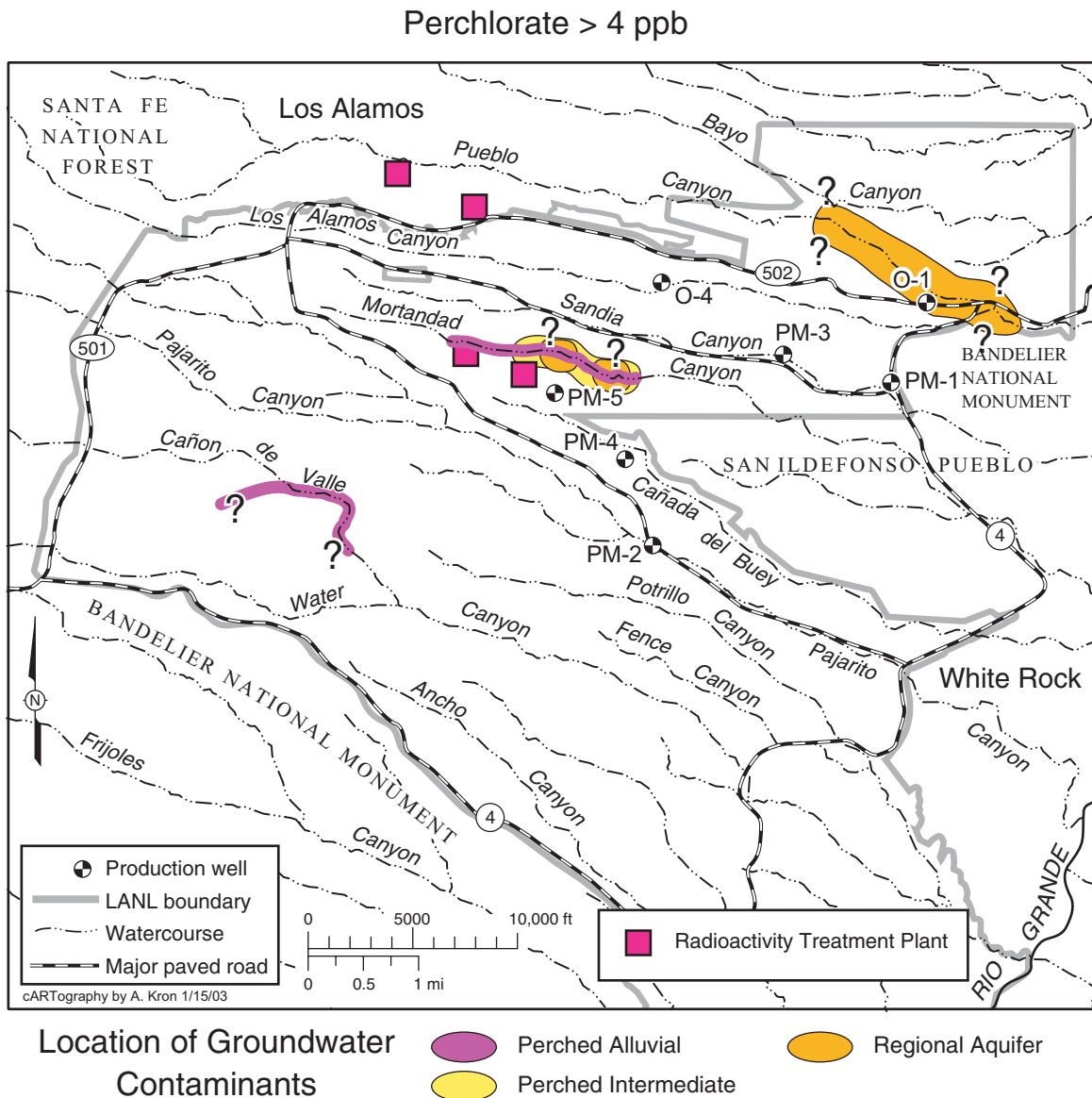
### 5. High Explosives and Barium

The Laboratory formerly released wastewater from several HE processing sites in TA-16 and TA-9 into Water Canyon and Cañon de Valle (a tributary). Alluvial groundwater in Cañon de Valle shows barium above 1 mg/L, the New Mexico groundwater standard (Figures 5-11 and 5-12) and RDX above 2 ppb, an EPA risk-based groundwater action level. A more recent EPA tap water screening level of RDX at 0.61 ppb corresponds to a  $10^{-6}$  excess cancer risk. Intermediate perched groundwater and the regional aquifer in this area show RDX above 2 ppb and TNT above 20 ppb.

### F. Monitoring Network

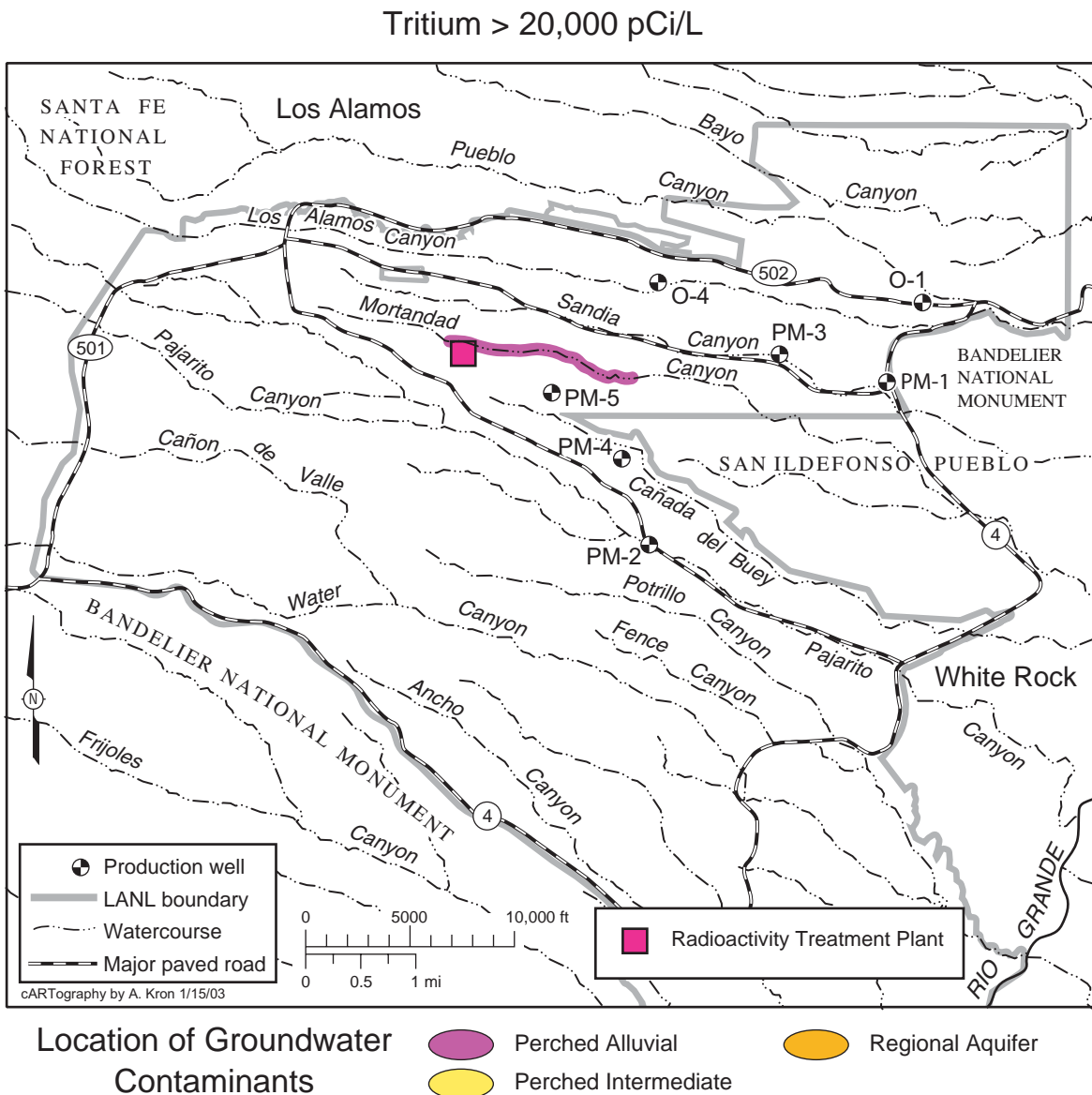
Groundwater sampling locations are divided into three principal groups, related to the three modes of groundwater occurrence: the regional aquifer, perched alluvial groundwater in the bottom of some canyons, and localized intermediate-depth perched groundwater systems (Figures 5-13 and 5-14). The springs and wells are described by Purtymun (1995) and Nylander et al. (2003). To document the potential impact of

## 5. Groundwater Monitoring



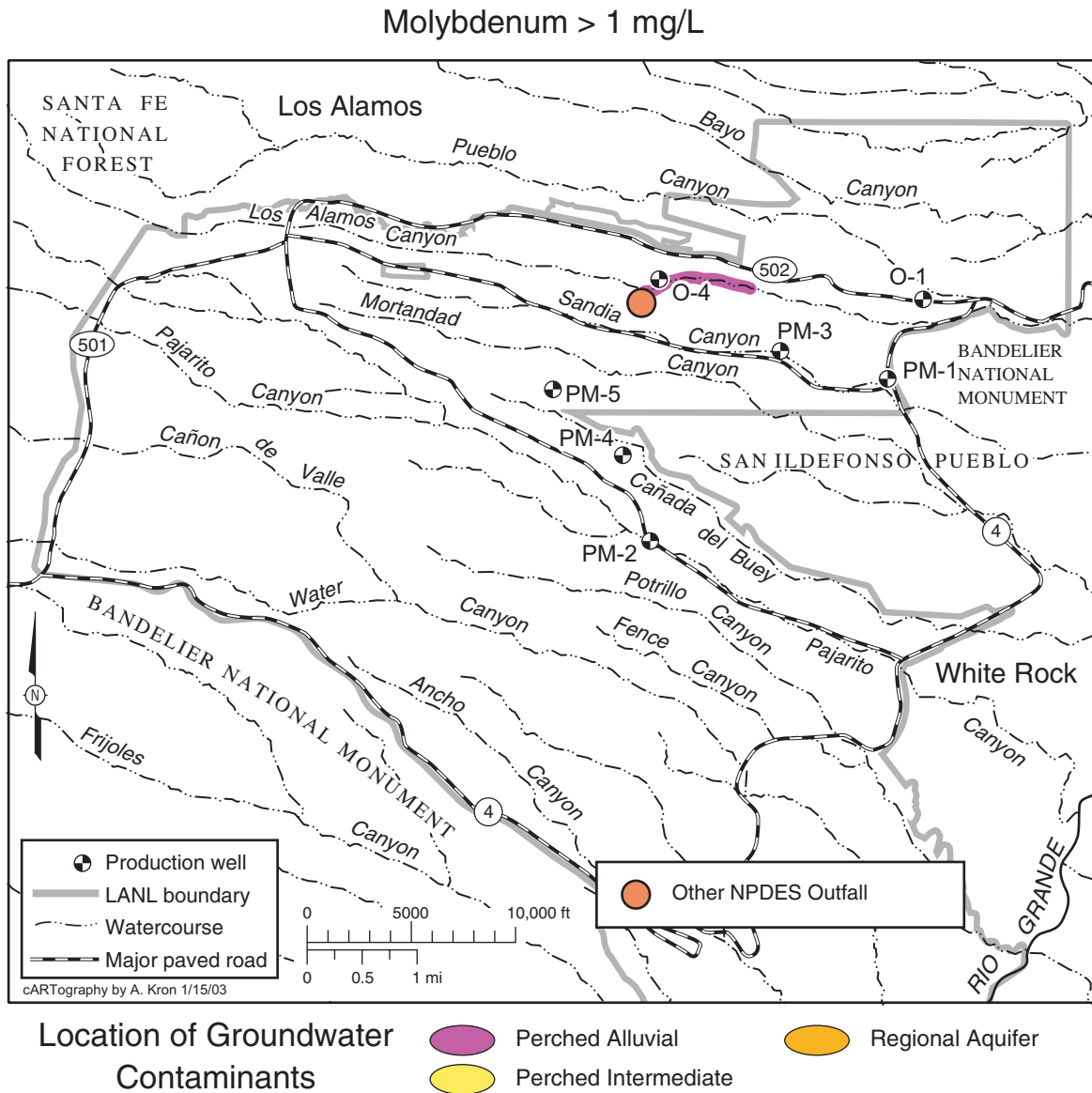
**Figure 5-8.** Location of groundwater contamination by perchlorate above the 4-ppb method detection limit (most risk-based screening levels are 4-18 ppb). Maximum 2002 values in Mortandad Canyon alluvial and intermediate groundwater were 143 ppb and 142 ppb respectively; in Pueblo Canyon regional groundwater the maximum was 3 ppb, just below the MDL. Different colors indicate the affected groundwater zones.

## 5. Groundwater Monitoring



**Figure 5-9.** Location of groundwater contamination by tritium near the 20,000 pCi/L EPA MCL. Maximum 2002 values in Mortandad Canyon alluvial and intermediate groundwater were 42% and 65% of the MCL, respectively. Mortandad Canyon alluvial groundwater values exceeded the MCL prior to 2001. Different colors indicate the affected groundwater zones.

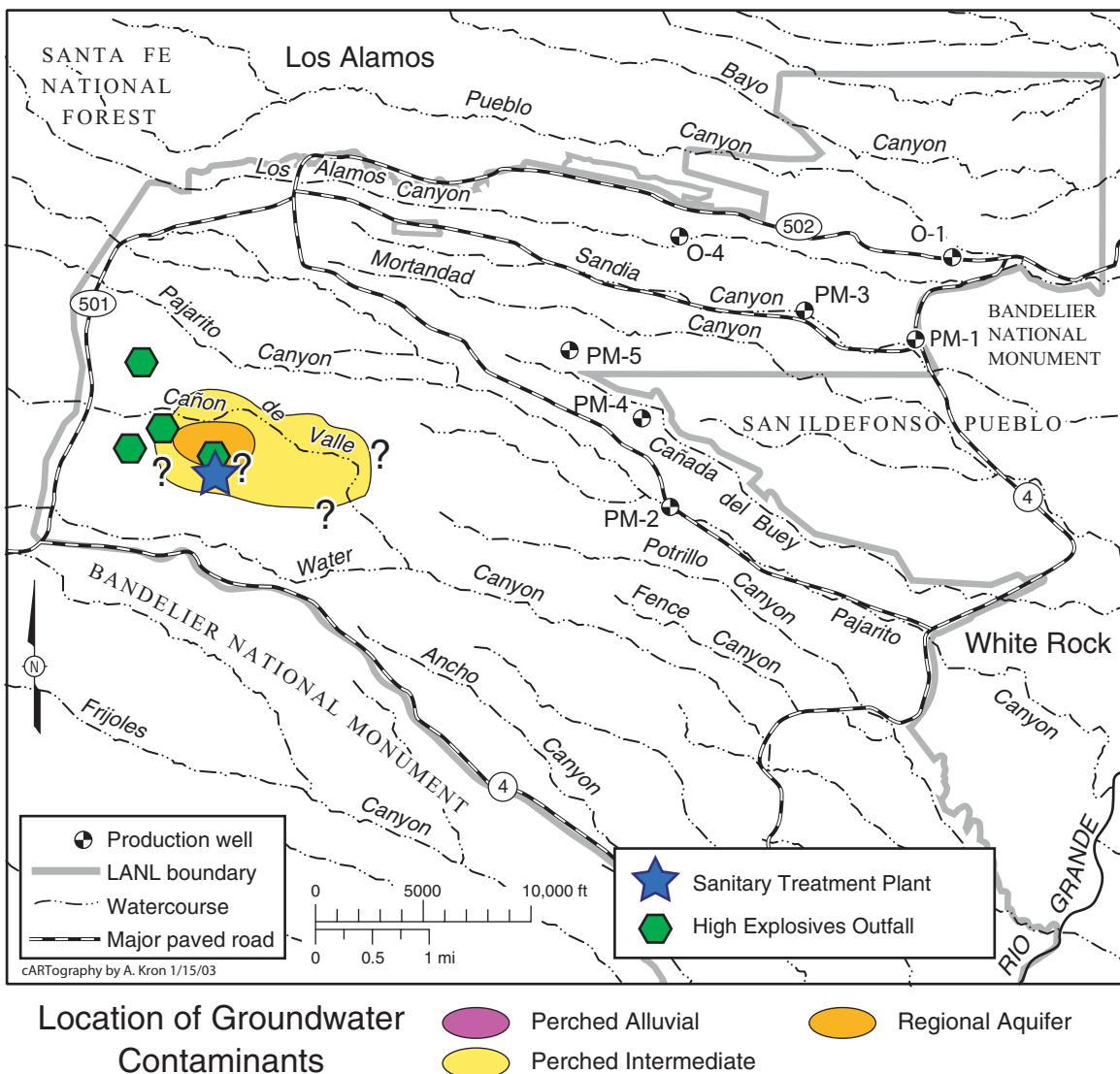
## 5. Groundwater Monitoring



**Figure 5-10.** Location of groundwater contamination by molybdenum above the 1 mg/L New Mexico Groundwater Standard for Irrigation Use. The maximum 2002 value in Los Alamos Canyon alluvial groundwater was 2.5 times the groundwater standard. Different colors indicate the affected groundwater zones.

## 5. Groundwater Monitoring

High Explosives (RDX > 2 ppb, TNT > 20 ppb)

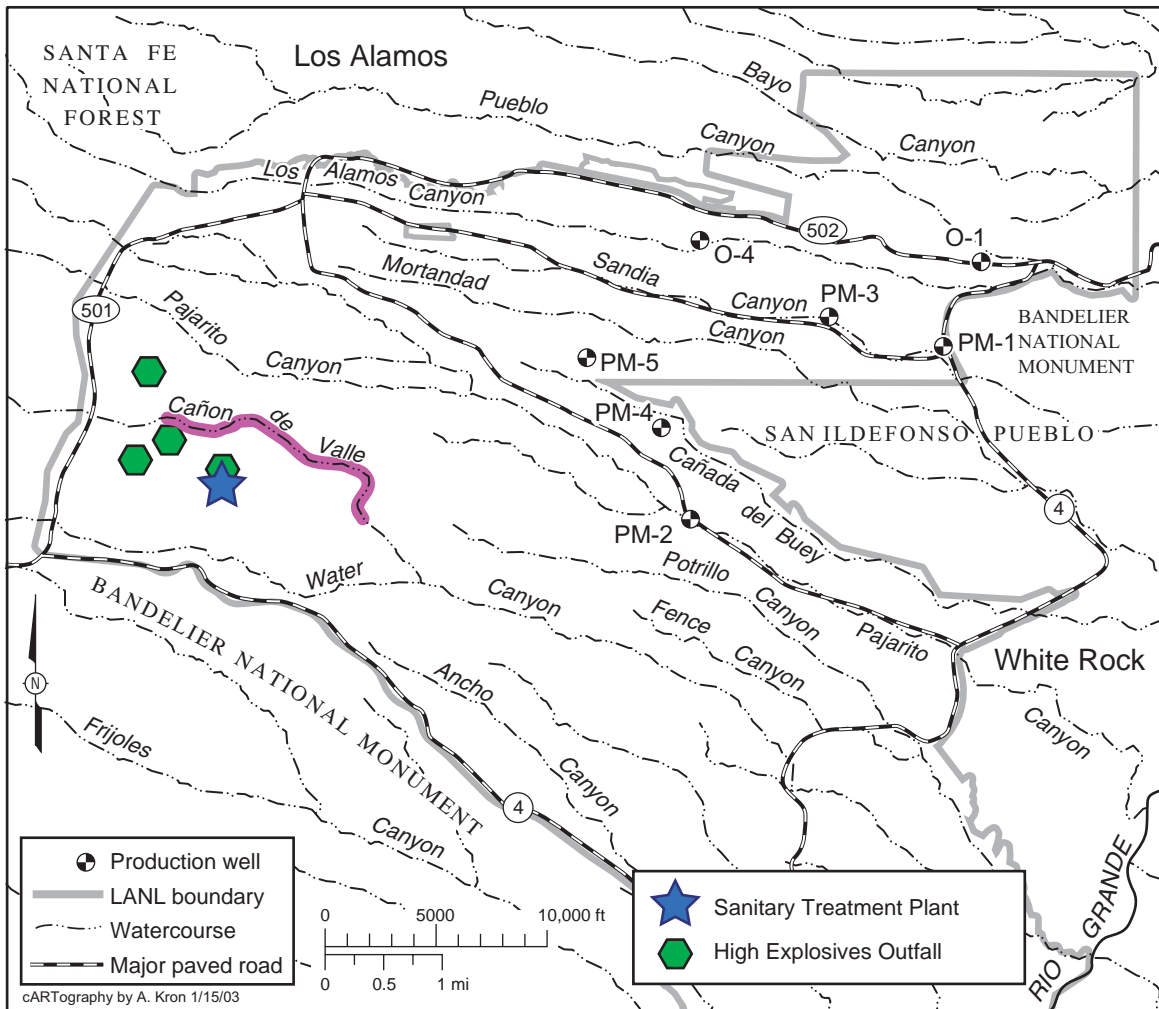


**Figure 5-11.** Location of groundwater contamination by RDX and TNT above EPA screening levels of 2 ppb and 20 ppb, respectively, in perched intermediate groundwater and the regional aquifer. Maximum 2002 values for RDX in intermediate groundwater and the regional aquifer at well R-25 were 30 and 1.7 times the 2 ppb screening level. For TNT, the maximum intermediate groundwater value was 10% of the 20 ppb screening level. Many values also exceeded more recent EPA Region 6 tap water screening levels that correspond to a  $10^{-6}$  excess cancer risk: for RDX, 0.61 ppb and for TNT, 2.24 ppb. Different colors indicate the affected groundwater zones.



## 5. Groundwater Monitoring

High Explosives (RDX > 2 ppb) and Barium > 1 mg/L

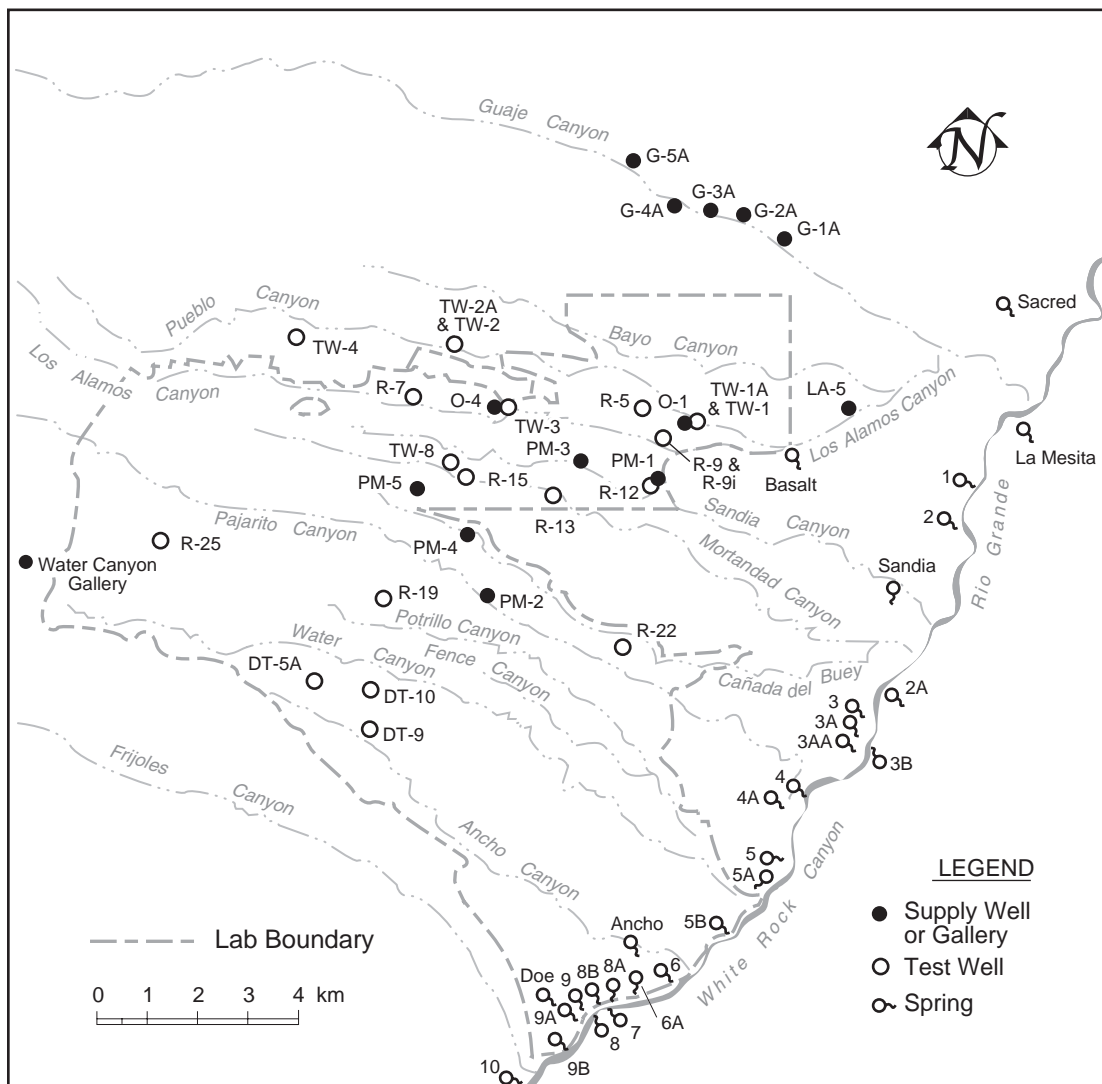


Location of Groundwater Contaminants

- Perched Alluvial
- Regional Aquifer
- Perched Intermediate

**Figure 5-12.** Location of groundwater contaminant by RDX above 2 ppb and barium above 1 mg/L in perched alluvial groundwater. This map is based on data obtained by the Environmental Restoration Project. Different colors indicate the affected groundwater zones.

## 5. Groundwater Monitoring



**Figure 5-13.** Springs and wells used for intermediate perched and regional aquifer groundwater monitoring.

Laboratory operations on San Ildefonso Pueblo land, the DOE entered into a Memorandum of Understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on pueblo land. Groundwater monitoring stations at San Ildefonso Pueblo sample the regional aquifer (except Basalt Spring, an intermediate groundwater sampling point) and are shown in Figure 5-15.

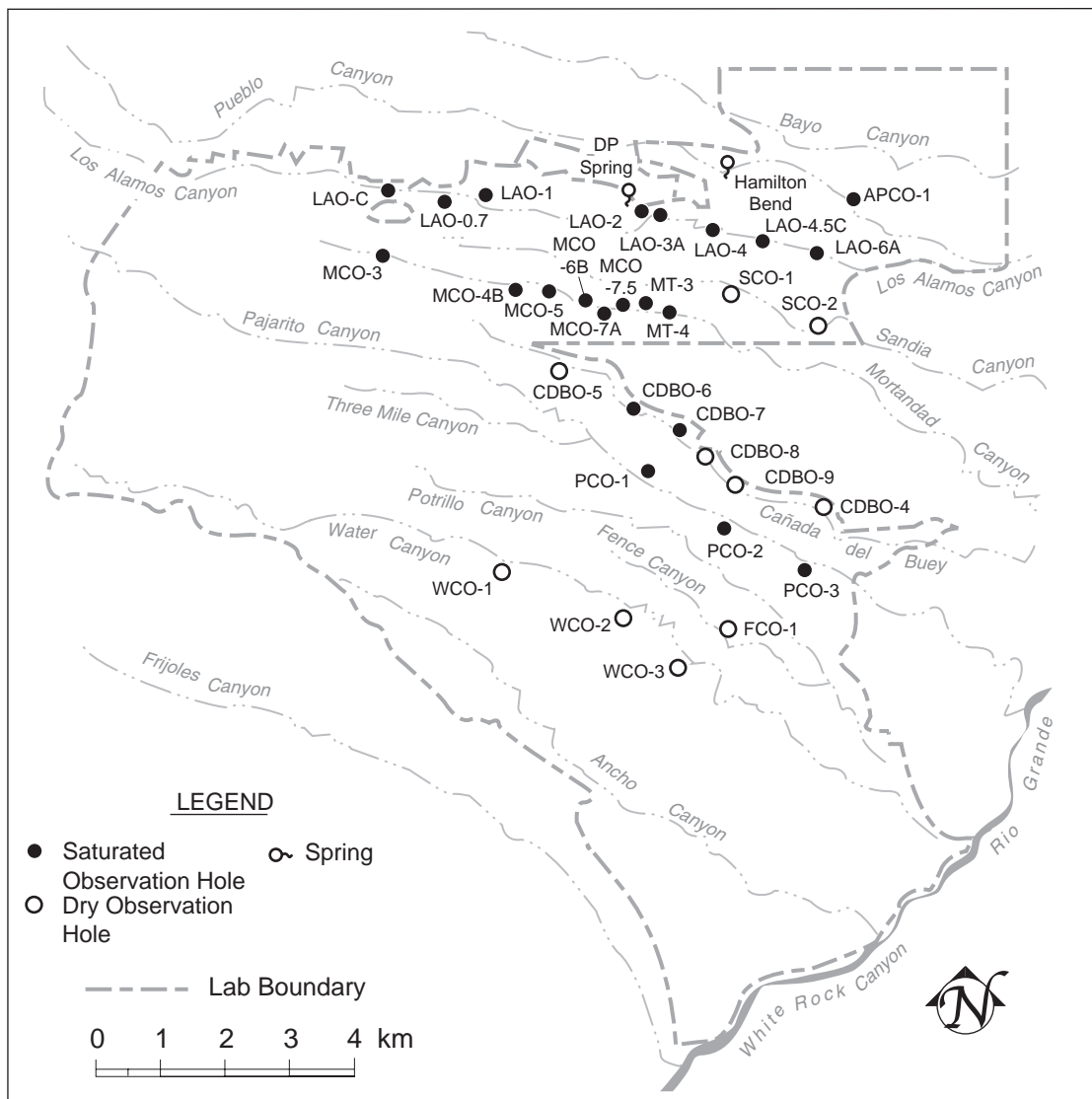
### 1. Regional Aquifer and Intermediate Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring (test) wells, supply wells, and springs. New wells,

constructed under the Hydrogeologic Workplan, are intended for additional groundwater characterization efforts and to extend the Laboratory's groundwater monitoring system. Several of these wells were added to the monitoring well network in 2002.

Early on, the Laboratory located monitoring wells where they might detect contaminants infiltrating from areas of effluent disposal or underground weapons-testing operations. These wells penetrate only a few tens or hundreds of feet into the upper part of the regional aquifer. The casings are not cemented, which would seal off surface infiltration along the boreholes. The newer characterization wells were installed beginning in 1998 (Nylander et al. 2003). Some of

## 5. Groundwater Monitoring



**Figure 5-14.** Springs and wells used for alluvial groundwater monitoring.

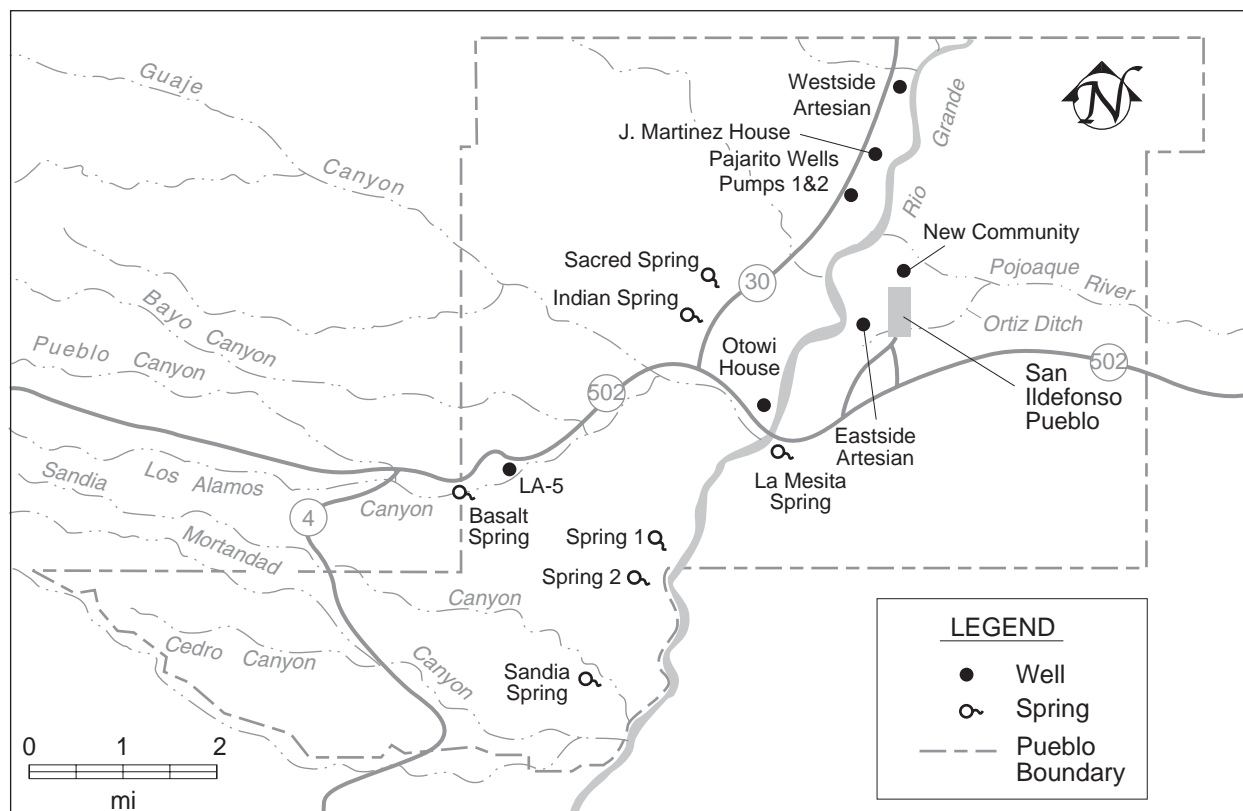
these newer wells penetrate down to 600 ft into the regional aquifer, and several have multiple sampling ports within intermediate perched zones and the regional aquifer. Table S5-1 in the Data Supplement identifies the groundwater zones sampled by different ports of these wells.

The RRES-WQH Group collects samples from 12 deep water supply wells in 3 well fields that produce water for the Laboratory and the community. The County of Los Alamos owns and operates these wells. The county is responsible for demonstrating that the supply system meets Safe Drinking Water Act (SDWA) requirements. This chapter reports on supplemental

SDWA sampling carried out by the RRES-WQH Group. Koch and Rogers (2003) summarized operation of the water supply system for the years 1998–2001. The water supply wells are screened up to 1,600 ft within the regional aquifer, and the wells draw samples that integrate water over a large depth range. Additional regional aquifer samples come from wells located on San Ildefonso Pueblo and from the Buckman well field operated by the City of Santa Fe.

We sample numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al. 1980). The springs serve to detect possible discharge of contaminated

## 5. Groundwater Monitoring



**Figure 5-15.** Springs and wells used for groundwater monitoring on San Ildefonso Pueblo.

groundwater from underneath the Laboratory into the Rio Grande. Larger White Rock Canyon springs and springs on San Ildefonso Pueblo lands are sampled annually, with the remainder scheduled for sampling in alternate years.

### 2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, the RRES-WQH Group uses shallow wells to sample the perched alluvial groundwater in five canyons (Pueblo, Los Alamos, Mortandad, and Pajarito canyons, and Cañada del Buey). In any given year, some of these alluvial observation wells may be dry; and water samples cannot be obtained. Observation wells in Water, Fence, and Sandia canyons have been dry since their installation in 1989. All but two of the wells in Cañada del Buey are generally dry. Many alluvial wells that might ordinarily hold water could not be sampled in 2002 because of the particularly dry conditions during the winter and summer.

### G. 2002 Groundwater Sampling Results

Table S5-2 in the Data Supplement lists the results of radiochemical analyses of groundwater samples for 2002. The table also lists the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity, where available. Uranium was analyzed by isotopic methods; total uranium was calculated from these values using specific activities for each isotope. Table S5-3 shows low-detection-limit tritium results from analyses done by the University of Miami.

To emphasize analytical results that are detections, Table S5-4 in the Data Supplement lists radionuclides detected in groundwater samples. Detections are defined as values that exceed both the analytical method detection limit (where available) and three times the individual measurement uncertainty. Qualifier codes are shown in Table S5-4 because some analytical results that meet the detection criteria are not detections: in some cases, for example, the analyte was found in the laboratory blank. In others, the result was below the method detection limit, but the analyti-

## 5. Groundwater Monitoring

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cal result was reported as the minimum detectable activity (MDA). The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7 in the Data Supplement).

Because gross alpha and gross beta are usually detected, Table S5-4 indicates occurrences of these measurements only above threshold values. The specific levels are 5 pCi/L for gross alpha and 20 pCi/L for gross beta and are lower than the EPA MCLs or screening levels. The right-hand columns of Table S5-4 indicate radiochemical detections that are greater than one-half of either the 100-mrem DOE DCGs for public dose for ingestion of environmental water or the standards shown. The DCGs assume that the radioactivity comes solely from americium-241 and plutonium-239,-240 for gross alpha, or from strontium-90 for gross beta, and are thus conservative.

Table S5-8 in the Data Supplement lists the results of general chemical analyses of groundwater samples for 2002. Table S5-9 lists groundwater perchlorate results. The value for the perchlorate method detection limit (MDL) is 4 ppb according to our independent analytical laboratory, although the table gives smaller values. The results of trace metal analyses appear in Table S5-10.

In 2002 RRES-WQH personnel analyzed samples from selected springs and monitoring wells for organic constituents (Table S5-11 in the Data Supplement). Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and HEs. Analytical methods are given in Appendix A, Table A-4; and analytes for each suite are listed in Appendix A, Tables A-5 through A-8. RRES-WQH personnel rejected many of the possible organic detections the analytical laboratory reported because the compounds were either detected in method blanks (that is, they were introduced during laboratory analysis) or were detected in field quality-control samples, including equipment and trip blanks. Equipment blanks use distilled water in which sampling equipment is rinsed before sampling to check for organic contamination acquired during sampling. Trip blanks go along during sampling to determine if organic constituents come from sample transportation and shipment. Table S5-12 in the Data Supplement shows organic compounds detected above the analytical laboratory's reporting level in 2002, as well as results from field quality-control (QC) samples.

In the following sections, we discuss the results for each of the three groundwater modes in the major watersheds that encompass the Laboratory.

### 1. Overview of Radioactivity in Groundwater

The main radioactive element detected in the regional aquifer is naturally occurring uranium, found in springs and wells throughout the Rio Grande Valley. Values that exceeded half the DOE public dose DCG values in 2002 were gross alpha values in San Ildefonso Pueblo springs and water supply wells and in City of Santa Fe water supply wells. The gross alpha in these springs and wells is from the decay of naturally occurring uranium in the water. The EPA MCL for gross alpha does not include the contribution to gross alpha by uranium.

None of the radionuclide activities in perched alluvial groundwater were above the 100-mrem DOE DCG for public dose for ingestion of environmental water, although the gross alpha value at MCO-3, a monitoring well in Mortandad Canyon, reached 40% of the public dose DOE DCG. Except for americium-241, strontium-90, plutonium-238, and plutonium-239,-240 values from Mortandad and Los Alamos canyons and uranium-234 and uranium-238 values in Buckman well No. 2, none of the radiochemical measurements exceeded the 4-mrem DOE DCGs applicable to drinking water. Strontium-90 exceeds the 8-pCi/L EPA MCL in alluvial groundwater by a factor of 3.5 in Los Alamos Canyon and by a factor of 8 in Mortandad Canyon.

### 2. Guaje Canyon (Includes Rendija and Barrancas)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities. The Guaje well field, located northeast of the Laboratory, contains five water supply wells. No tritium was detected in low-detection-limit (1 pCi/L) analyses of samples from these wells (Table S5-3). Groundwater with a tritium activity below approximately 1.6 pCi/L is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but large dating uncertainties may be associated with small tritium activities (Blake et al. 1995).

Neither strontium-90 nor perchlorate was detected during sampling. Each supply well was tested at least twice for HE. RDX (Table S5-12) was detected in a



## 5. Groundwater Monitoring

sample from supply well G-1A taken August 24. This compound was not detected in a field duplicate on the same date or in a sample from February 23, indicating a possible analytical error.

### 3. Los Alamos Canyon (Includes Bayo, Acid, Pueblo, and DP Canyons)

**a. Pueblo Canyon.** Pueblo Canyon receives effluent from Los Alamos County's Bayo sewage treatment plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity shows up in groundwater at this time. Seventeen low-detection-limit tritium results for supply well O-1 averaged 33 pCi/L, indicating a subdued effect of surface water recharge on tritium activity at the regional aquifer. As described earlier, O-1 also shows perchlorate just at the 4-ppb detection limit and above-background nitrate. Because of a leaking fuel tank at TA-21 in 2002, well O-1 was tested monthly for diesel-range organic compounds (DROs); none were detected. Test Well 1 showed nitrate (as nitrogen) at 53% of the 10-mg/L EPA MCL in the regional aquifer. This well and Test Well 4 had levels of iron, lead, and manganese in the range of the EPA MCLs. These levels were related to aging steel and galvanized well components.

Results for intermediate well POI-4 were incomplete. Alluvial well APCO-1 has plutonium-239,-240 at 5% of the 4-mrem DCG and strontium-90 at 10% of the 8-pCi/L EPA MCL. The Cerro Grande fire impacted the Pueblo Canyon watershed heavily, causing high manganese, aluminum, and iron concentrations in the range of EPA MCLs in many surface water and shallow perched alluvial groundwater samples. Alluvial well APCO-1 again had elevated manganese and iron concentrations in the range of EPA MCLs.

**b. Los Alamos Canyon.** Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at TA-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. From 1952 to 1986, a liquid-waste treatment plant discharged effluent that contained radionuclides from the old plutonium-processing facility at TA-21 into DP Canyon, a tributary to Los Alamos Canyon. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center (LANSCE) at TA-53.

In the regional aquifer sample from monitoring well R-7, americium-241 was in one of three duplicate

analyses, a finding that suggests that the detection is a false positive. This well showed tritium at 2.3 pCi/L, suggesting marginal impact of recent surface recharge (Blake et al. 1995). An equipment blank from intermediate well R-9i showed plutonium-239,-240, suggesting contamination of the sampling equipment. The two intermediate horizons in this well had tritium values of about 250 and 127 pCi/L, indicating a subdued impact from surface recharge. Supply well O-4 had a nondetection for tritium, below the MDA of 1 pCi/L. Basalt Spring had plutonium-239,-240 at approximately 3% of the 4-mrem DOE DCG. This spring may represent intermediate groundwater, but as it discharges near the stream in Los Alamos Canyon, the plutonium result might also reflect surface contamination of the sample during collection.

Basalt Spring also had nitrate (as nitrogen) at 56% of the 10-mg/L EPA MCL, possibly reflecting sanitary discharges from the Bayo sewage treatment plant. Wells R-7 and R-9i showed high levels of iron and manganese in the range of EPA MCLs. These metal concentrations are a temporary effect of well construction (Longmire 2002a, Longmire and Goff 2002). As with other older monitoring wells, Test Well 3 has high iron, lead, and manganese in the range of EPA MCLs because of aging steel and galvanized well components. Isopropyl benzene was detected in one sample at R-7 at less than 0.01% of the EPA Region 6 screening level. This compound was also detected during characterization sampling of the well and may be a temporary result of drilling fluids (Longmire and Goff 2002). Supply well O-4 was tested twice for HE and monthly for DRO; none of these compounds were detected.

Alluvial groundwater in Los Alamos Canyon showed strontium-90 at 1.3 to 3.6 times the 8-pCi/L EPA MCL. Tritium was barely detectable at a 150-pCi/L detection limit, in contrast to values of 10,000 to 100,000 pCi/L in previous decades (Rogers 1998). Americium-241 and plutonium-239,-240 were detected at 3% of the 4 mrem DCG in the mouth of DP Canyon. Monitoring well LAO-3A showed fluoride at about half the New Mexico groundwater standard. High manganese, aluminum, and iron concentrations (in the range of EPA MCLs) reflect Cerro Grande fire effects on water quality; aluminum and iron also correlate to turbidity in the water samples (Riebsomer 2003).

Molybdenum reached the highest levels ever in alluvial groundwater: 90% of the 1-mg/L New Mexico

## 5. Groundwater Monitoring

groundwater standard in monitoring well LAO-2 and 250% of the limit in LAO-3A (Figure 5-16). The molybdenum comes from cooling towers at TA-53 (LANSCE). Use of sodium molybdate was discontinued in June 2002.

### 4. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives water from the cooling tower at the TA-3 power plant. Treated effluents from the TA-46 Sanitary Wastewater Systems (SWS) Facility are rerouted to Sandia Canyon.

Well R-12 at the eastern Laboratory boundary had low levels of tritium in two intermediate zones and the regional aquifer, indicating a slight effect on these horizons by recent recharge. Samples from nearby supply well PM-1 showed tritium near the 1 pCi/L detection limit, but no tritium was detected in PM-3 samples.

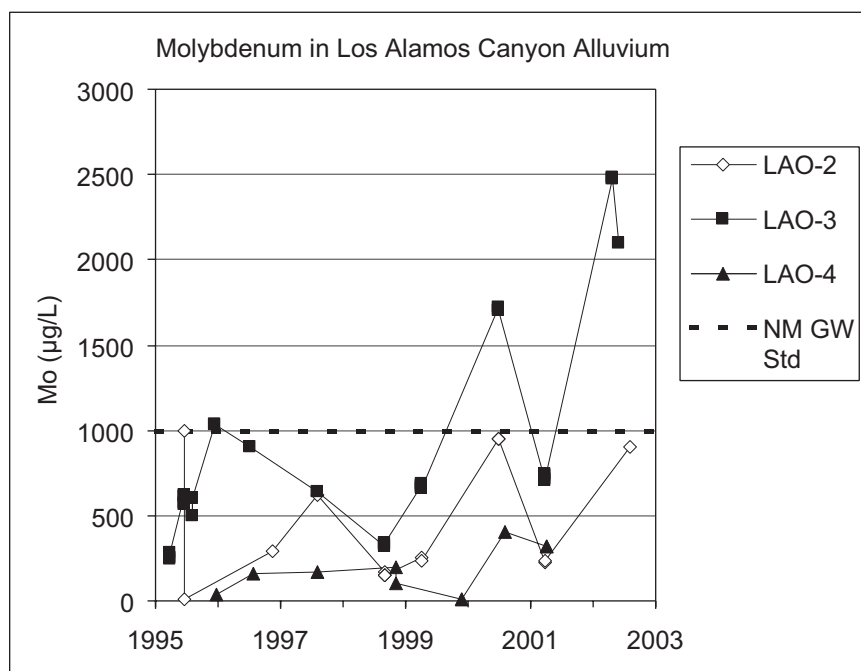
One of four PM-3 perchlorate analyses from samples on January 16 was an apparent detection; the result was below the 4-ppb MDL and was the only detection among the 17 analyses from this well during all of 2002. Several R-12 samples had high manganese (in the range of EPA MCLs), a temporary result

of well construction (Longmire 2002b). The supply wells were tested monthly for DROs and less frequently for HE; no such compounds were detected except in a field blank.

### 5. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of National Pollutant Discharge Elimination System (NPDES) outfalls, including one from the RLWTF at TA-50. Past discharges into tributary Ten Site Canyon included a previous radioactive-effluent treatment plant at TA-35.

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two observation wells here have ever contained water. Because treated effluent from the Laboratory's SWS Facility may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture-monitoring holes was installed during the early summer of 1992 within the upper and middle reaches of the drainage.



**Figure 5-16.** Molybdenum histories in Los Alamos Canyon alluvial groundwater compared with the New Mexico groundwater standard.

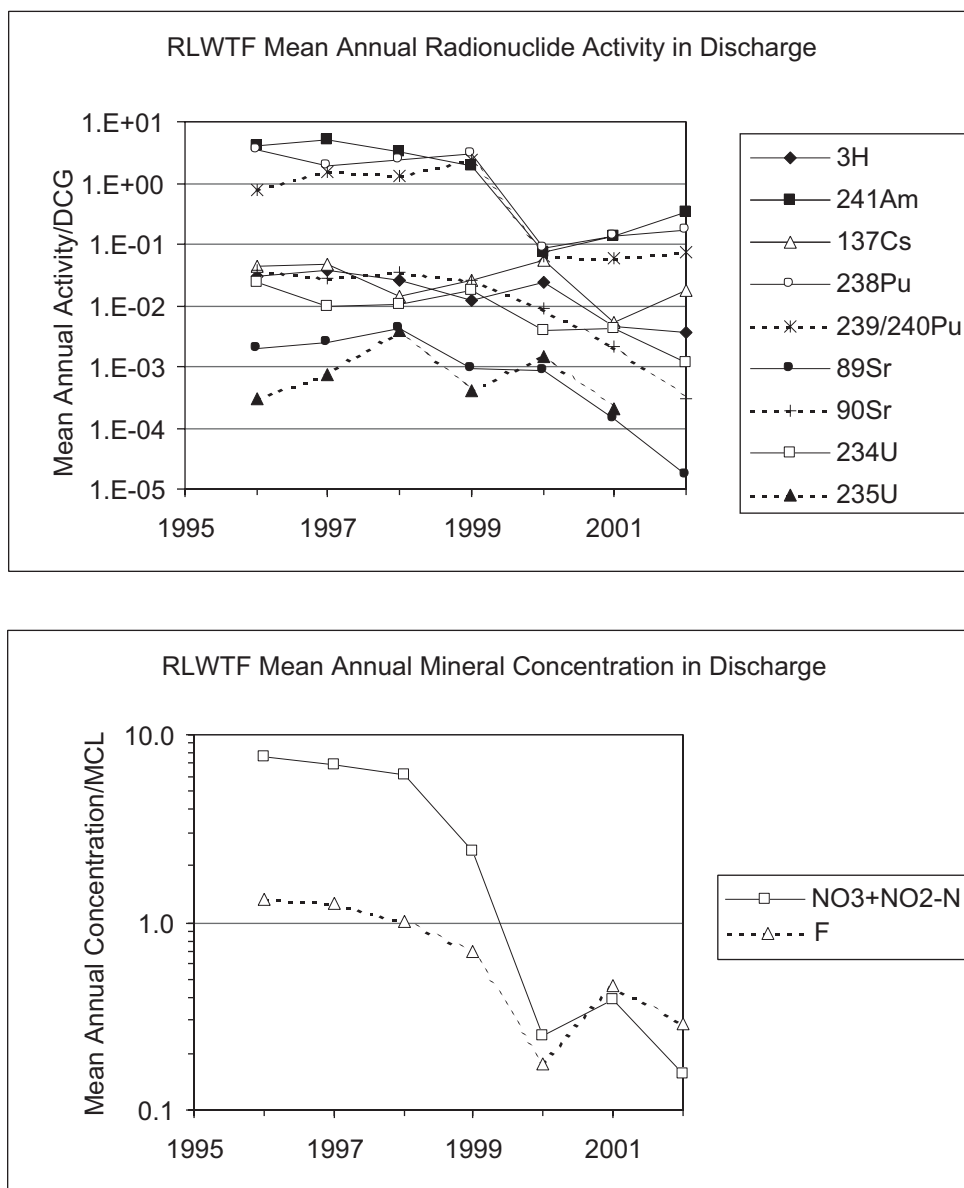
## 5. Groundwater Monitoring

Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

**a. 2002 Radioactive Liquid Waste Treatment Facility Discharges.** The cumulative discharge of radionuclides from the RLWTF into Mortandad Canyon between 1963 and 1977 and yearly discharge data for 2000 through 2002 appear in Table S5-13 in the Data Supplement. Table S5-13 also shows mean annual levels in effluent for each radionuclide and the

ratio of this to the 100-mrem DOE DCG for public dose. Figure 5-17 shows the relationship of RLWTF average annual radionuclide activities and mineral concentrations in discharges to DOE DCGs or New Mexico groundwater standards since 1996.

The new reverse osmosis and ultrafiltration system began operating at the RLWTF in April 1999. This system is designed to remove additional radionuclides from the effluent and to ensure that the discharges meet the DOE DCGs for public dose. Americium-241;



**Figure 5-17.** Ratio of average annual radionuclide activity and mineral concentration in RLWTF discharges to 100-mrem DOE DCGs or New Mexico groundwater standards for 1996 to 2002.

## 5. Groundwater Monitoring

plutonium-238; and plutonium-239,-240 in the discharge have not exceeded the public dose DCGs since December 1999. At the end of 2000, the RLWTF adopted a voluntary goal of tritium activity below 20,000 pCi/L in its effluent. Whenever possible, effluent with tritium above 20,000 pCi/L is segregated and trucked to the TA-53 RLWTF evaporation basins for evaporation. Since 2000, tritium activity in the effluent has fallen below 20,000 pCi/L.

During 2002, the nitrate (as nitrogen) concentrations of all effluent discharges from the RLWTF were less than 10 mg/L. The average 2002 effluent nitrate concentration (value of 1.54 mg/L) was below the New Mexico groundwater standard of 10 mg/L and was much lower than the values for previous years. In 2002, the nitrate concentration in Mortandad Canyon base flow at the surface water station Mortandad below Effluent Canyon was 0.5 mg/L.

The fluoride concentration in the discharge also has declined over the last few years. The 2002 effluent fluoride concentration (average value of 0.46 mg/L) was below the New Mexico groundwater standard of 1.6 mg/L. In 2002, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.53 mg/L.

RLWTF annual perchlorate discharges in 2000, 2001, and 2002 were 4.74 kg, 2.29 kg, and 0.175 kg, respectively. The resulting annual average effluent concentrations in 2000, 2001, and 2002 were 254 µg/L, 169 µg/L, and 16 µg/L, respectively. The new system at the RLWTF for removing perchlorate from the effluent became operational on March 26, 2002; no perchlorate was detected in the effluent after this date. The average figure of 16 µg/l for 2002 reflects an average of samples from the beginning of the year with nondetects after March.

**b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer.** In 2002, Test Well 8 was the only regional aquifer well in Mortandad Canyon sampled for environmental surveillance, and results were incomplete because of sample loss. Neither strontium-90 nor perchlorate was detected in samples collected from this well on three dates.

Initial results from new well MCOBT-4.4, drilled to an intermediate perched zone, showed several contaminants at concentrations of concern (Broxton et al. 2002a). The 500-ft-deep intermediate perched zone sample found about 13,000 pCi/L of tritium (MCL of 20,000 pCi/L), 13.2 mg/L of nitrate (as nitrogen, MCL

10 mg/L), and 142 µg/L of perchlorate (no MCL, provisional EPA level of 1 µg/L).

**c. Alluvial Groundwater.** Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest nearest to the TA-50 RLWTF outfall at well MCO-3 and decrease down the canyon. The levels of strontium-90, gross beta, and (until 2000) tritium usually exceed EPA drinking water criteria in many of the wells. In some years, the levels exceed the 4-mrem DOE drinking water DCGs, but the levels do not exceed the 100-mrem DOE DCGs for public dose for ingestion of environmental water.

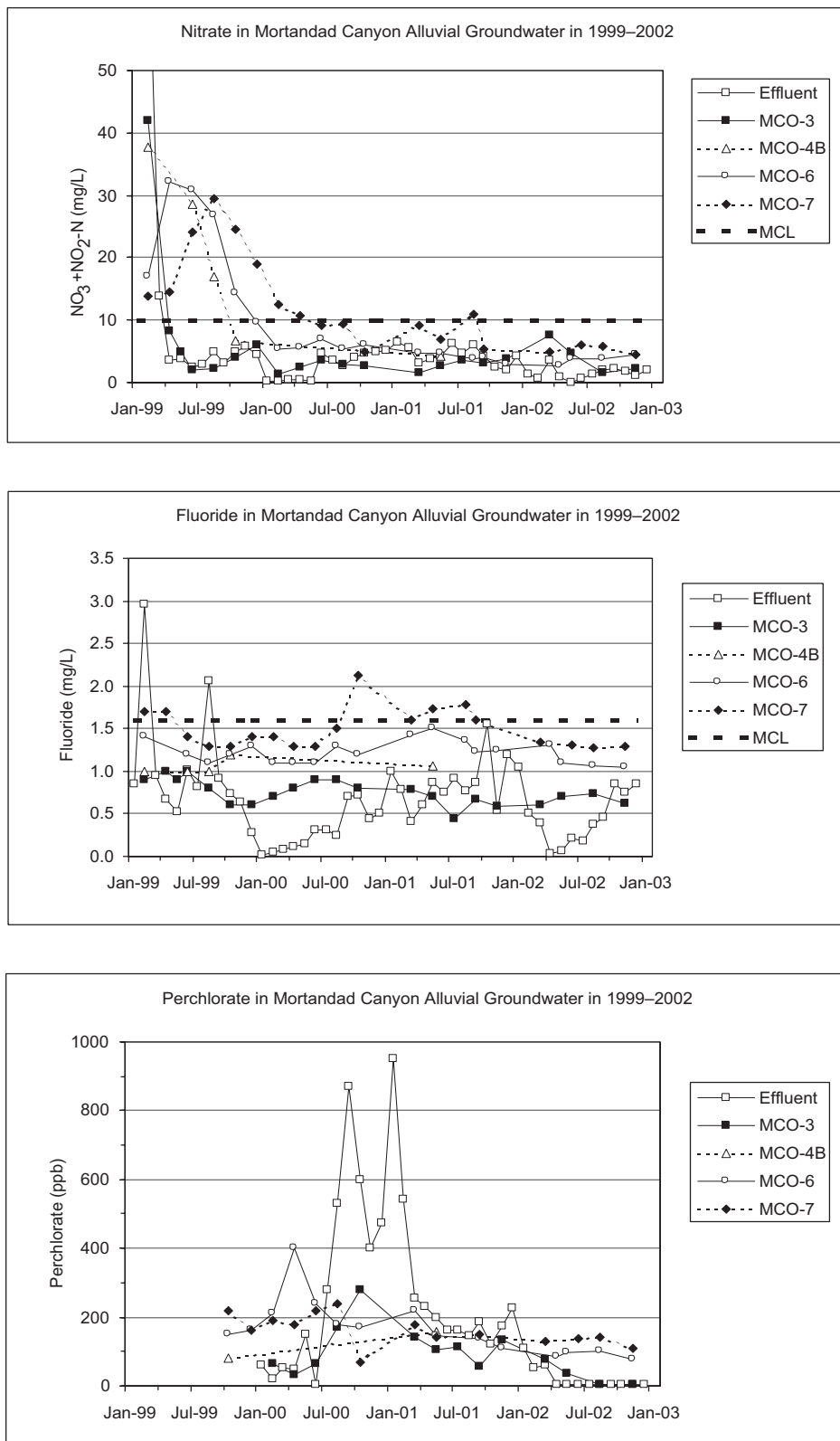
In 2002, americium-241 at MCO-3 was more than 300% of the 4-mrem DCG but was 44% of the DCG at MCO-5 and decreased to 12% at MCO-7. Gross beta values ranged from more than 100% to 340% of the EPA screening level in alluvial groundwater samples. Tritium was found at activities ranging from 3,200 pCi/L to 8,400 pCi/L (in the range of the MCL of 20,000 pCi/L). Plutonium-238 and plutonium-239,-240 at MCO-3 were at 140% and 110%, respectively, of the 4-mrem DOE DCGs. Plutonium-238 was also found at MCO-5 at 3% of the 4-mrem DCG.

Under the Laboratory's groundwater discharge plan application for the RLWTF, the RRES-WQH Group during 2002 collected separate quarterly samples for nitrate, fluoride, perchlorate, and total dissolved solids from three alluvial monitoring wells in Mortandad Canyon: MCO-3, MCO-6, and MCO-7. Many of the Mortandad Canyon alluvial groundwater samples had fluoride and nitrate concentrations greater than half the New Mexico groundwater standards. As shown in Figure 5-18, the nitrate (nitrate as nitrogen) concentration of effluent discharge from the RLWTF after March 1999 has been less than 10 mg/L. The concentration of fluoride in the RLWTF effluent after August 1999 has been less than the 1.6 mg/L standard.

During 2002, nitrate concentrations in Mortandad Canyon alluvial groundwater were below the NMWQCC groundwater standard of 10 mg/L (nitrate as nitrogen) (Figure 5-14). During 2002, fluoride concentrations were below the NMWQCC groundwater standard of 1.6 mg/L.

Perchlorate was detected in groundwater during 2002 at every alluvial groundwater well sampled in Mortandad Canyon. Perchlorate concentrations increased down canyon from some nondetect values near the RLWTF outfall to 143 µg/L at downstream well MCO-7. The increase of perchlorate down canyon indicates that the concentrations in alluvial groundwater are decreasing in response to improved effluent quality.

## 5. Groundwater Monitoring



**Figure 5-18.** Fluoride, nitrate, and perchlorate in RLWTF effluent and Mortandad Canyon groundwater from 1999 through 2002.



## 5. Groundwater Monitoring

**d. Long-Term Radioactivity Trends.** Figure 5-19 depicts long-term trends of radionuclide concentrations in surface water and shallow perched alluvial groundwater in Mortandad Canyon downstream from the RLWTF outfall at TA-50. Because of its strong adsorption to sediments, cesium-137 is not detected in groundwater samples. The figure shows only radionuclide detections. If more than one sample was collected in a year, the average value for the year is plotted. The surface water samples are from the station below Effluent Canyon, a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending on whether individual samples are collected after a release from the RLWTF. These samples also vary in response to changing amounts of runoff from other sources in the drainage. The groundwater samples are from observation well MCO-5 in the middle reach of the canyon. Groundwater radioactivity at MCO-5 is more stable than surface water sampled at Mortandad below Effluent Canyon because groundwater responds more slowly to variations in runoff water quality.

Chemical reactions such as adsorption do not delay tritium transport, and high tritium activities are found throughout the groundwater within the Mortandad Canyon alluvium (Figure 5-19). Average annual tritium activity in the RLWTF effluent dropped below 20,000 pCi/L in 2001 and 2002, and tritium activity has consequently dropped in surface water and alluvial groundwater in those 2 years.

Americium-241 activity has not been measured regularly at monitoring stations in Mortandad Canyon. For most years up to 1999, the americium-241 activity of RLWTF discharges exceeded the 100-mrem DOE DCG for public dose of 30 pCi/L. In the last few years, americium-241 in surface water and alluvial groundwater nearest the outfall has been just below the 100 mrem DOE DCG. Americium-241 in alluvial groundwater downstream at MCO-5 has been below the 4-mrem DOE DCG.

In 2002, RRES-WQH personnel detected strontium-90 in surface water at Mortandad below Effluent Canyon and in all sampled perched alluvial groundwater observation wells. The activities remain at values in the range of the EPA drinking water standard (8 pCi/L) and the 4-mrem DOE DCG for drinking water (40 pCi/L). It appears that strontium-90 has been retained by adsorption or mineral precipitation within the upstream portion of the alluvium. The level of strontium-90 has risen gradually at downstream wells MCO-5 and MCO-6 during the last 20 years, suggest-

ing that the mass of the radionuclide is moving slowly downstream.

RRES-WQH personnel detected both plutonium isotopes at Mortandad below Effluent Canyon and at MCO-3, but only plutonium-238 at MCO-5 in 2002. Both isotopes have been detected at Mortandad below Effluent Canyon and at MCO-3 at levels near the 100-mrem DOE public dose DCGs (30 pCi/L for plutonium-239,-240 and 40 pCi/L for plutonium-238), but the levels have decreased during the past few years. Values at other alluvial observation wells, except for MCO-4 and MCO-7.5, were near the detection limit in the 1990s. Plutonium has, in general, been detected in all alluvial observation wells in Mortandad Canyon but appears to be decreasing in activity at downstream locations.

**e. Cañada del Buey.** Water supply wells PM-4 and PM-5 are on the mesa top just south of Cañada del Buey. In 2002, neither of the wells had tritium detectable by the low-detection-limit method (MDA about 1 pCi/L). PM-4 did not operate much during 2002 and had few sample events. PM-5 had 14 perchlorate analyses from monthly samples with no detections. No HE compounds were detected in samples from these wells.

In 2002, americium-241 at alluvial well CDBO-6 was just over the detection limit at 2% of the 4-mrem DCG; but it was not detected in a duplicate sample, suggesting a false positive. CDBO-6 had a gross alpha result of 3.4 pCi/L in 2002. The well had gross alpha results of 3.7 pCi/L and 19.3 pCi/L on separate dates in 2001 and has shown higher values in 1993, 1994, 1997, and 1998. Other radioactivity has not usually been detected in CDBO-6 or -7. These wells often are dry and produce turbid samples. CDBO-6 had high aluminum and iron values, probably related to a high turbidity of about 25 nephelometric turbidity units and total suspended solids of 28 mg/L (Riebsomer 2003).

### 6. Pajarito Canyon (Includes Twomile and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles west of the Laboratory. In lower Pajarito Canyon near the eastern Laboratory boundary, saturated alluvium occurs but does not extend beyond that boundary. Some firing sites border portions of Twomile and Threemile canyons. A nuclear materials experimental facility at TA-18 occupies the floor of Pajarito Canyon. Areas used for disposal of organic solvents and low-level radioactive waste occupy the

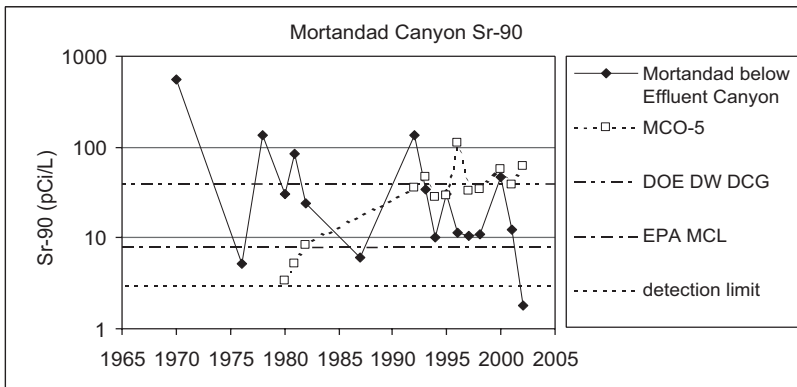
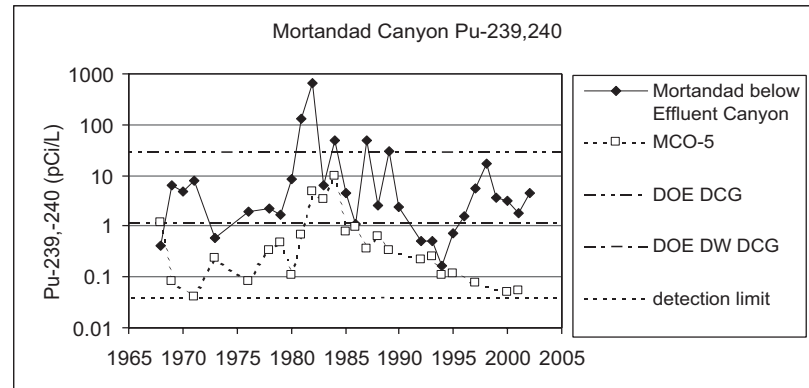
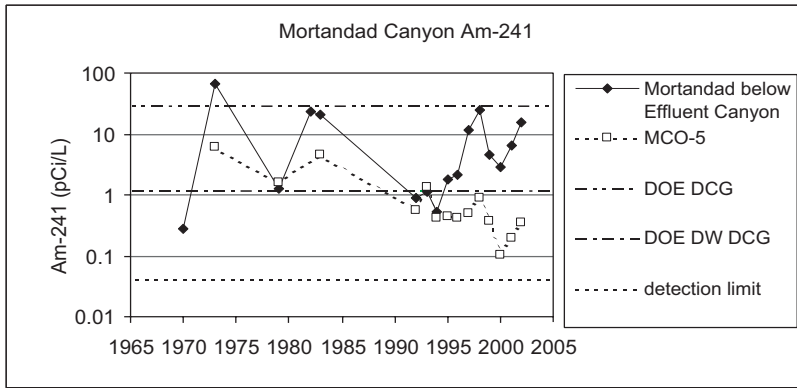
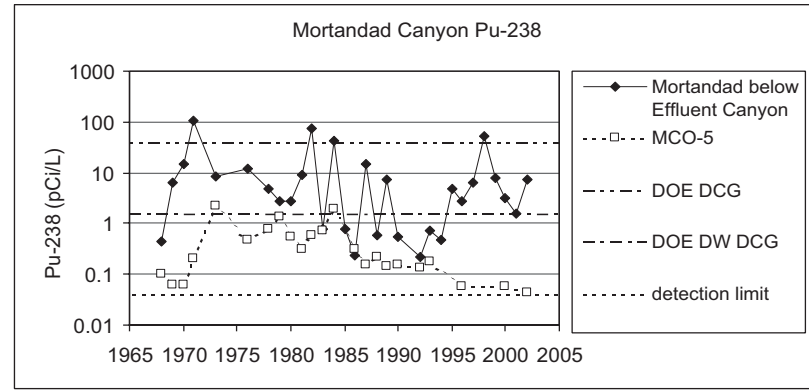
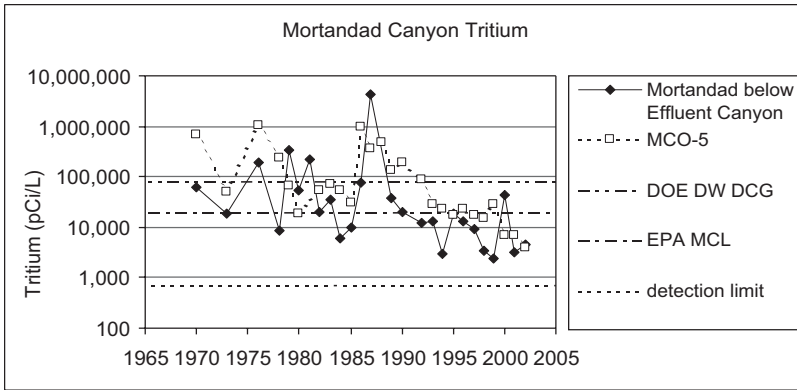


Figure 5-19. Average annual radioactivity in Mortandad Canyon surface water and alluvial groundwater.

## 5. Groundwater Monitoring

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mesa north of the lower part of the canyon. Three shallow observation wells were constructed in 1985 as part of a compliance agreement with the State of New Mexico to determine whether technical areas in the canyon or solid-waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater. No effects were observed.

In 2002, supply well PM-2 did not have tritium detectable by the low-detection-limit method (MDA about 1 pCi/L). RDX was detected at a low level on May 18 but not found in four samples collected on three other dates, suggesting a false positive. The analytical laboratory assigned a data qualifier ("P" flag) to the RDX result for poor precision (> 25% difference between two analytical columns).

Technetium-99 was detected in regional aquifer-monitoring well R-22 ports 3 and 4 during the first of four sampling rounds, but it was not detected during subsequent sampling (Longmire 2002c). The values were just above the detection limit, casting uncertainty on the results. The 2002 sampling found technetium-99 in only 2 of 12 analyses: these samples were the equipment blank and field blank collected during sampling of port 1 (Table S5-14, in the Data Supplement). The analytical results were just above the detection limit. The results, if true detections of technetium-99, suggest that the field-sampling equipment might initially have been contaminated by dust or another source at the sampling site.

R-22 also showed tritium at 2-to-3 pCi/L in the uppermost port and 13 pCi/L in the deepest port. The three intermediate ports showed no tritium detections. Tritium was detected during previous characterization samples at similar levels in the top and bottom ports. Tritium detections in other ports did not continue past the first sampling events, suggesting that the tritium was introduced during well construction (Longmire 2002c).

High concentrations of iron and manganese (in the range of EPA MCLs) in R-22 are a temporary effect of well construction (Longmire 2002c). Sampling for VOCs and SVOCs found only one compound, isopropyl benzene, in port 1. This compound was found in port 1 during the third and fourth characterization sampling rounds, and in port 5 on the fourth round. Isopropyl benzene may be a temporary result of drilling fluids used (Longmire and Goff 2002).

No alluvial wells were sampled in Pajarito Canyon in 2002 because of lack of water in the alluvium.

### 7. Water Canyon (Includes Cañon de Valle, Potrillo and Fence, Indio canyons)

Water Canyon and Cañon de Valle (a tributary) pass through the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE-processing sites in TA-16 and TA-9. In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall for the High Explosives Wastewater Treatment Facility. The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for open-air testing of weapons systems.

Of the seven sampled ports of monitoring well R-19, the upper port is dry, the second port is within a perched zone, and the remaining five ports are in the regional aquifer. No tritium was detected in any of the six sampled ports of R-19 at a detection limit of about 1 pCi/L, consistent with characterization sampling results (Longmire 2002d). Groundwater with such tritium is probably older than 3,000 years and is not affected by recent surface recharge. Several ports showed high levels of iron and manganese (relative to EPA MCLs), a temporary effect of well construction (Longmire 2002d). Arsenic in the deepest port occurred at 53% of the EPA MCL; values during characterization sampling in the three deepest ports ranged from 30% to 150% of the MCL. Most volatile and semivolatile organic compounds found in R-19 samples were also found in associated equipment, trip, or field blanks. These findings suggest that the results are false positives or chemicals inadvertently added during analytical laboratory analysis.

R-25 has four ports in a large intermediate perched zone and four in the regional aquifer (Broxton et al. 2002b). Port 5 at a depth of 1,309 ft is the uppermost regional aquifer port. The intermediate port at 1,063 ft only yielded water during the first of four characterization-sampling events. The Laboratory completed installation of the well casing in May 1999 and installed the Westbay packer system in October 2000. During the intervening 17 months, the well casing stayed open, allowing commingling of water between the eight screens. This mixing of water from different groundwater zones has temporarily obscured the original water quality differences between the zones. Several key constituents (tritium, chlorinated solvents, and HE compounds) were introduced into regional aquifer screens during the 17 months before packer installation. Concentration histories for the ports from

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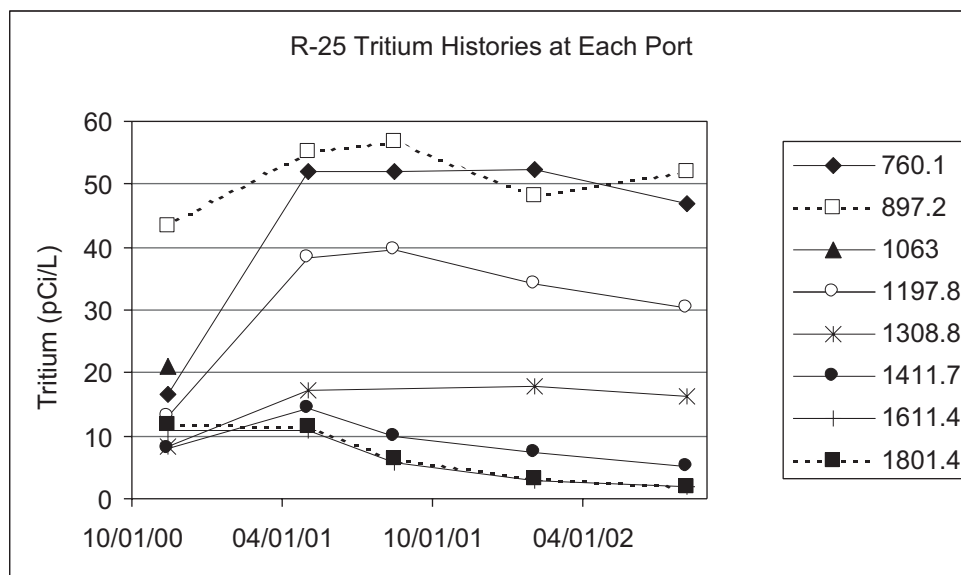
five sampling episodes indicate that concentrations for several analytes are decreasing and stabilizing over time. These concentration results indicate that several of these constituents are present in the regional aquifer only at very low levels, if at all.

Four main constituents of concern were found in the latest (August 2002) sampling of R-25 and during previous characterization sampling (Longmire 2003). Two constituents were the HE compounds RDX and TNT, and two were the organic chlorinated solvents tetrachloroethene (tetrachloroethylene, perchloroethylene, or PERC) and trichloroethene (trichloroethylene or TCE). RRES-WQH personnel found these constituents at several depths at concentrations near or above EPA MCLs or EPA Region 6 tap water screening levels.

Tritium histories for the ports (Figure 5-20) indicate that tritium activities in the intermediate perched zone have stabilized at values ranging from 30 pCi/L to 55 pCi/L, following the first sample round. This suggests that tritium activity in the groundwater surrounding these ports is no longer affected by groundwater mixing during construction and that the well casing has isolated the groundwater zones from each other. The tritium activity in the uppermost regional port at 1,309 ft has stabilized at approximately 17 pCi/L, and activities in the deepest three regional aquifer ports continue to fall. The

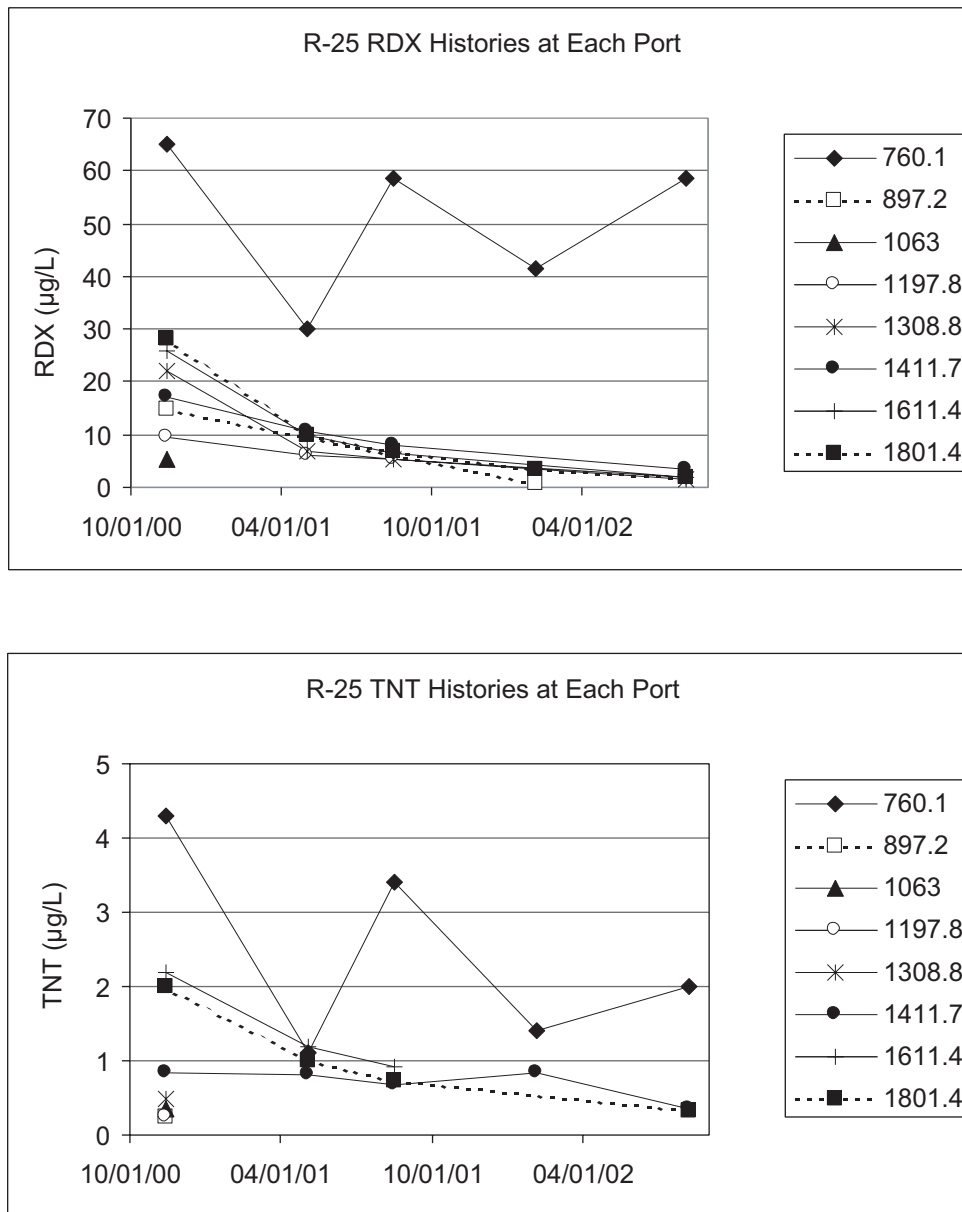
tritium activity in the uppermost regional port shows the effect of recharge from the overlying intermediate perched groundwater.

We found HE constituents and their degradation products during drilling of R-25 and subsequent sampling (Broxton et al. 2002b). RDX occurs in the upper port of the intermediate perched zone at an average concentration of 50 µg/L (Figure 5-21), compared to an EPA tap water screening level of 0.61 µg/L (corresponding to  $10^{-6}$  excess cancer risk). Concentrations of RDX at other ports in the first characterization-sampling event ranged from 5 µg/L to 28 µg/L and have declined to 1.9 µg/L to 3.3 µg/L in the deeper ports where RDX is still detected. The sampling results do not yet rule out the presence of RDX in the regional aquifer ports. However, the concentration histories suggest that RDX is present in large amounts only in groundwater near the upper port and was introduced into the other ports by groundwater mixing during well construction. TNT concentration histories (Figure 5-21) lead to a similar conclusion: TNT is present in the upper intermediate perched zone port at an average concentration of 2.4 µg/L, compared to an EPA tap water screening level of 2.24 µg/L. Concentrations (where detected) in regional aquifer ports are steadily decreasing, averaging 0.34 µg/L in the two ports where it was detected in August 2002.



**Figure 5-20.** Tritium histories at R-25 ports. (Characterization data were provided by P. Longmire.)

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**Figure 5-21.** RDX and TNT histories at R-25 ports. (Characterization data were provided by P. Longmire.)



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Two chlorinated solvents, PERC and TCE, were found in samples from several ports at R-25 throughout their sampling history. Both solvents have EPA MCLs of 5 µg/L. PERC was detected in three of five samples in the upper port at an average concentration of 1.2 µg/L (EPA tap water screening level of 1.08 µg/L). This compound was detected in two of five sampling events at two other intermediate perched ports, including the most recent two samples at the 1,197-ft port 4 at the base of the perched zone. The average of these results was 0.8 µg/L. TCE was found in all five samples from the upper port at an average concentration of 1.5 µg/L (EPA tap water screening level of 1.63 µg/L). The two most recent analytical results were 1.7 µg/L. TCE was detected in the two most recent (2002) samples at port 4 (as was PERC) and also one time in each of three other ports (Figure 5-22). The analytical results for PERC and TCE indicate that the chlorinated solvents are present at screening levels and at 30% to 40% of the MCL.

Several R-25 ports showed levels of iron and manganese (EPA MCLs), a temporary effect of well construction found in other recently drilled wells (Longmire 2002d). Nickel and chromium occurred at levels above EPA MCLs, possibly another temporary effect of well construction. Boron in port 2 was 77% of the New Mexico groundwater standard and was above background in port 1. Boron may be the result of infiltration of Laboratory effluents. In addition to analyzing samples for HE compounds, RRES-WQH personnel analyzed samples for SVOC and VOC compounds. Other than the compounds previously discussed, no compounds were detected that were not also found in field, trip, or equipment blanks.

Samples from the Water Canyon gallery, which came from intermediate perched groundwater flowing from volcanics in the Sierra de los Valles west of the Laboratory boundary, contained no detected radionuclides or constituents above drinking water standards.

### 8. Ancho Canyon

Area AB at TA-49 was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved HEs and fissionable material insufficient to produce a nuclear reaction. In 1960, the US Geological Survey drilled three deep wells to monitor regional aquifer water quality. No radionuclides were detected in these wells in 2002 and no other inorganic constituents except aluminum (related to turbidity)

exceeded regulatory standards. All three wells were sampled for HE compounds, with no HE compounds detected. Monitoring well DT-9 was sampled for other organic compounds. Only methylene chloride was detected: this is a common analytical laboratory contaminant and was detected in a trip blank at a similar level.

### 9. White Rock Canyon Springs

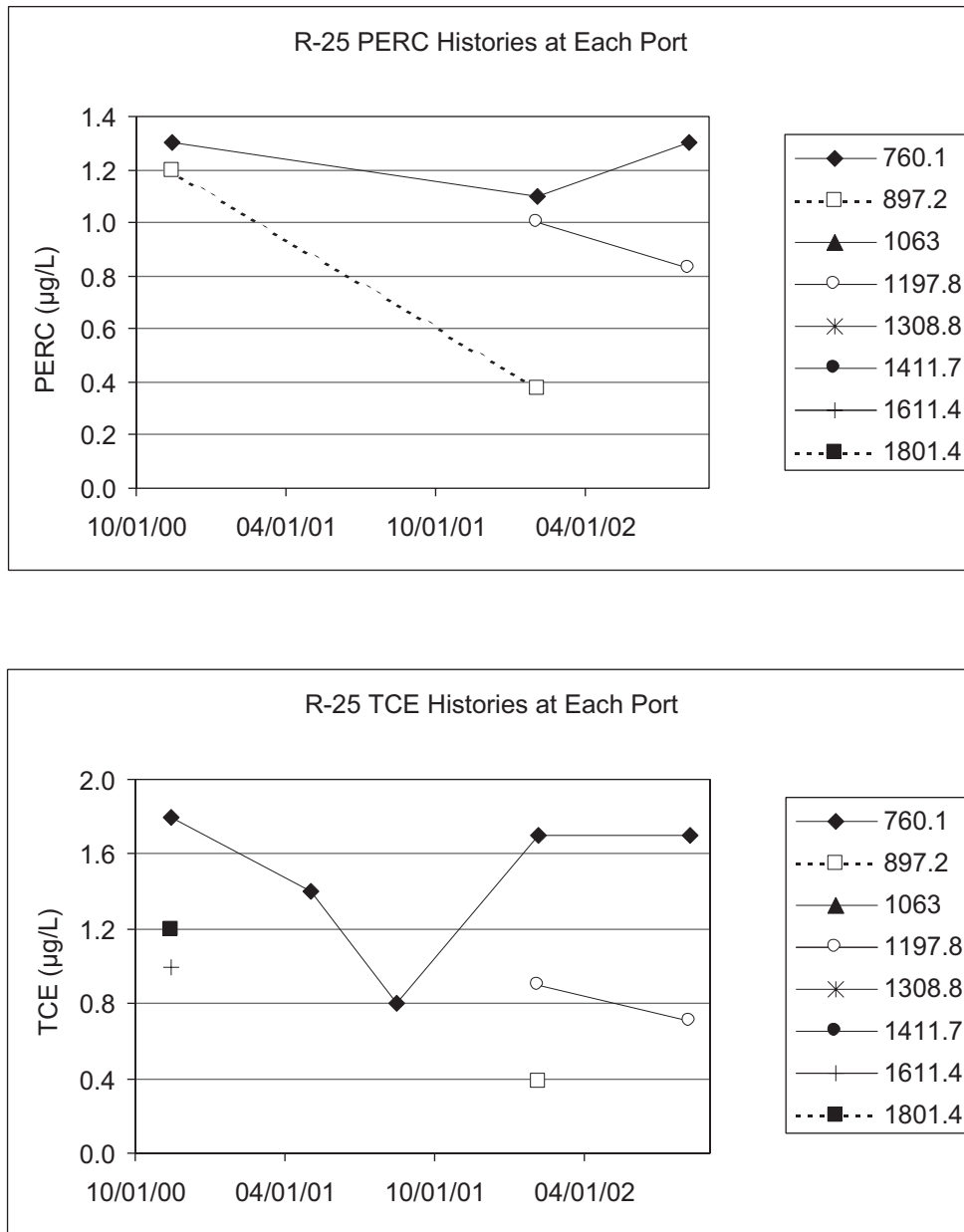
The springs that issue along the Rio Grande in White Rock Canyon represent the principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al. 1980). The springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer. Other than very low levels of tritium, the only radionuclide detections in White Rock Canyon springs were uranium in La Mesita Spring and plutonium-238 in Spring 2. Naturally occurring uranium is commonly detected in La Mesita Spring. The plutonium-238 value was just above the detection limit and is likely a false positive.

The RRES-WQH Group analyzed several springs using the low-detection-limit tritium method. Except where impacted by effluent discharge, activities of tritium in the regional aquifer in other parts of the Laboratory range between 1 and 3 pCi/L. Tritium concentrations in northern New Mexico surface water and rainwater range from 30 to 40 pCi/L. Rainfall around the Laboratory may have higher tritium activity (Adams et al. 1995). Most of the springs had tritium values ranging between nondetection (less than about 1 pCi/L) and 3 pCi/L. Three springs (4, 4B, and 4C) issue within a few hundred feet of each other near the Rio Grande. Spring 4B had tritium values near 45 pCi/L, while the other two springs had tritium values near 10 pCi/L. Spring 4B has a low flow rate and all the spring samples may be affected to some degree by rainfall. The largest spring in the area, Spring 4A, had a nondetect for tritium.

Perchlorate was not detected in 2002 in any springs at the 4 µg/L detection limit of the IC method. Two analyses of a sample from Spring 4 had results of 12 µg/L. However, the analyst apparently spiked the original sample (as a matrix spike); multiple reanalyses of the sample resulted in nondetects.

Tetryl, an HE compound, was found at Spring 6. Several semivolatile compounds were found in the Spring 4 sample. Bis (2-ethylhexyl) phthalate is a plastics component; it and di-n-butylphthalate are

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**Figure 5-22.** PERC and TCE histories at R-25 ports. (Characterization data were provided by P. Longmire.)

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often found as a result of contamination during analytical laboratory organic analysis. Diphenylhydrazine is unlikely to be detected in spring samples as it rapidly oxidizes in water under aerobic conditions. In the past, it was used in dye production, but now it is used in manufacturing arthritic drugs. The detection is likely a false positive. Bromomethane is used as a fumigant and is another compound used in analytical chemistry.

### 10. San Ildefonso Pueblo

The groundwater data for San Ildefonso Pueblo indicate the widespread presence of naturally occurring uranium at levels approaching the EPA MCL of 30 µg/L. Naturally occurring uranium concentrations near the EPA MCL are prevalent in well water throughout the Pojoaque area and San Ildefonso Pueblo. The high gross alpha readings for these wells are related to uranium occurrence. In 2002, New Community well had the highest total uranium of 23 µg/L, and Westside Artesian well had 21 µg/L. The uranium concentration at Pajarito Well Pump 1 was approximately 8 µg/L. These measurements are consistent with the levels in previous samples.

The gross alpha values in New Community well and Westside Artesian well exceeded half the 100-mrem DOE public dose DCG values in 2002. The uranium-234 values in these wells exceeded half the 4-mrem DOE DCG for drinking water. The gross alpha levels in these wells are attributable to the presence of uranium. The DCG for gross alpha assumes that the radioactivity comes solely from americium-241 and plutonium-239,-240, and, as such, the DCG is conservative. The gross alpha values in some wells were also above the EPA primary drinking water standard of 15 pCi/L. The EPA MCL for gross alpha, however, does not include the contribution to gross alpha by radon or uranium.

Strontium-90 seemed to be detected in two wells, LA-5 and Westside Artesian. We obtained six total analyses from three samples at each well. Several reanalyses and analysis of follow-up samples did not confirm these detections, which appear to be false positives. Westside Artesian well had a nondetect for low-detection-limit tritium, and LA-5 had a low value of 0.86 pCi/L. These values indicate substantial age for this water, or a lack of influence from recent surface recharge.

Several of the San Ildefonso Pueblo wells have levels of sodium, chloride, fluoride, and total dis-

solved solids near or above New Mexico groundwater standards or EPA health advisory levels. Perchlorate was not detected in 2002 in any San Ildefonso Pueblo wells at the 4-µg/L detection limit of the IC method.

The boron value in the Westside Artesian well was 240% of the NMWQCC groundwater standard of 750 µg/L. This value was similar to the values of past years. The J. Martinez House Well had arsenic near the EPA MCL and lead near the EPA screening level. No PCBs, SVOCs, or VOCs were found in San Ildefonso Pueblo well samples.

### 11. Buckman Well Field

In 2002, we sampled three wells in the City of Santa Fe's Buckman Field for radionuclides and general inorganic chemistry constituents, with two rounds of samples for strontium-90, perchlorate, tritium, and HEs.

One sample from Buckman well No. 2 contained about 248 µg/L of uranium compared with the EPA MCL of 30 µg/L, a value in line with earlier values obtained for that well. Buckman No. 1 had 16 µg/L of uranium and Buckman No. 8 had 14 µg/L.

The gross alpha value in Buckman well No. 2 exceeded the 100-mrem DOE public dose DCG values in 2002, and the gross alpha values in Buckman No. 1 and Buckman No. 8 were about half the DCG. The gross alpha levels in these wells are attributable to the presence of uranium. The DCG for gross alpha assumes that the radioactivity comes solely from americium-241 and plutonium-239,-240, and, as such, the DCG is conservative. The uranium-234 and uranium-238 values in Buckman well No. 2 well exceeded the 4-mrem DOE DCG for drinking water, and the uranium-234 values for Buckman No. 1 and Buckman No. 8 were about 40% of the DCG. The gross alpha values in these wells were also above the EPA primary drinking-water standard of 15 pCi/L. The gross alpha values for Buckman No. 1 and No. 8 were 105% of the MCL and for Buckman No. 2 was 1,200% of the MCL. The EPA MCL for gross alpha, however, does not include the contribution to gross alpha by radon or uranium.

No tritium was detected in Buckman well No. 1 at a detection limit of about 1 pCi/L. On October 10, 2002, duplicate samples were collected from Buckman well No. 2: one showed 1.4 pCi/L, the other was a nondetect. A reanalysis confirmed both results (detection and nondetection), with the first sample producing a second value of 1.76 pCi/L. Four analyses

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from two samples at Buckman well No. 8 produced three nondetects and one detection of 3.5 pCi/L. Any tritium impact on the water in these wells from recent recharge (in the past 50 years) appears to be minimal.

No perchlorate was found in samples from the Buckman wells, at the IC method 4- $\mu\text{g/L}$  detection limit. Arsenic in the wells ranged from 7 to 11  $\mu\text{g/L}$ , compared with the EPA MCL of 10  $\mu\text{g/L}$ . The wells were each sampled twice for HE compounds; none were detected.

### H. Special Drinking Water Sampling Program

#### 1. Introduction

On September 5, 2001, DOE completed the transfer of ownership of the Los Alamos water supply system to Los Alamos County. Since September 1998, Los Alamos County has operated the water supply system under a lease agreement. Under this 1998 agreement, the Laboratory retained responsibility for operating the distribution system within the Laboratory's boundaries, whereas the county assumed full responsibility for operating the water system, including ensuring compliance with the requirements of the federal SDWA (40 Code of Federal Regulations 141) and the New Mexico Drinking Water Regulations (NMEIB 2002). To demonstrate compliance with MCLs, the SDWA requires Los Alamos County to collect samples from the water supply wellheads and from various points in the water distribution systems of the Laboratory, Los Alamos County, and Bandelier National Monument.

Beginning in 1998, the Laboratory instituted its Special Drinking Water Sampling Program. Under this program, the Laboratory conducts supplemental monitoring of the water supply wells to provide quality assurance (QA), not for SDWA compliance purposes. This section presents the results from the Special Drinking Water Sampling Program's QA monitoring conducted during 2002.

In 2002, the Laboratory's monitoring network for the Special Drinking Water Sampling Program consisted of the following 11 water supply wells in operation at the time of sampling: Guaje wells G-1A, G-2A, G-3A, G-4A, G-5A; Pajarito Mesa wells PM-1, PM-2, PM-3, PM-5; and Otowi wells O-1, O-4. LANL's sample collection, preservation procedures, and analytical methods follow the requirements specified in federal and state drinking water regulations. Laboratory staff performed chemical and radiological sampling and submitted the samples for analysis to the

New Mexico Health Department's Scientific Laboratory Division in Albuquerque. The RRES-WQH Group has staff certified to perform drinking water sampling and maintains both electronic and hard-copy files of all data collected from QA testing.

#### 2. Radiochemical Analytical Results

In 2002, RRES-WQH staff collected samples from 11 of the 12 supply wells to determine the radiological quality of the drinking water. As shown in Table S5-15 in the Data Supplement, the concentrations of gross alpha and gross beta activity were less than the EPA screening levels.

#### 3. Nonradiological Analytical Results

In 2002, RRES-WQH personnel collected samples from 11 water supply wells for inorganic constituents in drinking water. As shown in Table S5-16 all inorganic constituents at all locations were less than the EPA MCLs with the exception of arsenic in water supply well G-1A. The concentration of arsenic in two samples collected in 2002 from G-1A was 0.010 mg/L and 0.011 mg/L. The MCL for arsenic in drinking water is 0.010 mg/L. (On January 22, 2001, EPA adopted a new standard for arsenic of 0.010 mg/L and all public water systems must comply beginning January 23, 2006.) Drinking water produced from water supply well G-1A is blended with the other four Guaje water supply wells (G-2A, G-3A, G-4A, G-5A) prior to distribution to consumers. The concentration of arsenic in a blended-water sample (Guaje Booster Station # 2) collected by the New Mexico Environment Department for SDWA compliance purposes in 2002 was 0.0076 mg/L.

No VOCs were detected with concentrations greater than the analytical laboratory's MDL at any of the sample locations.

### I. Unplanned Releases

#### 1. Radioactive Liquid Materials

No unplanned radioactive liquid releases occurred in 2002.

#### 2. Nonradioactive Liquid Materials

There were seven unplanned releases of non-radioactive liquid in 2002. The following is a summary of these discharges.

- Two unplanned releases of potable water:  
Area of Concern (AOC) 3-047(d).

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Potential Release Site (PRS) 46-003(g) and 46-006(g).

- One unplanned release of sanitary sewage from TA-46 SWS Facility's collection system.
- One organic chemical release discovered at TA-48 RC-89.
- One unplanned diesel release from an aboveground storage tank (AST) at TA-21-57.
- One unplanned mineral oil release at TA-53-80.
- One acid waste line liquid release at TA-21.

RRES-WQH investigated all unplanned releases of liquids as required by the NMWQCC Regulations 6.2 NMAC 1203. Upon cleanup, personnel from NMED and NMED-DOE Oversight Bureau (DOB) inspect the unplanned release sites to ensure adequate cleanup. The diesel release at the TA-21-57 AST in 2002 is currently under investigation and characterization activities continue. The organic chemical release discovered at TA-48 RC-89 is under negotiations with NMED-HWB, as well. It is anticipated that these two unplanned releases will be closed-out when corrective actions and negotiations are completed and NMED/NMED-DOB personnel become available for final closeout assessments. The Laboratory is in the process of administratively closing out all other releases for 2002 with NMED-DOB. The laboratory anticipates these unplanned release investigations will be closed out when NMED-DOB personnel become available for final inspections.

### J. Quality Assurance

#### 1. Introduction

RRES-WQH personnel conducted QA activities in 2002 in accordance with DOE Order 414.1A, which prescribes a risk-based, graded approach to QA. This process promotes the selective application of QA and management controls based on the risk associated with each activity to maximize effective resource use.

#### 2. Analytical Laboratories

The RRES-WQH Group is responsible for acquiring analytical services that support monitoring activities. The RRES-WQH Group Statement of Work (SOW) follows the DOE-Albuquerque Operations Office Analytical Management Program's Model Statement of Work (Model SOW) for analytical services. The RRES-WQH SOW provides contract

laboratories the general QA guidelines specified in the Model SOW and also includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

#### 3. Analytical Quality Assurance Activities

The RRES-WQH Group is responsible for verifying that analytical data used to support monitoring activities are defensible and of known quality. Analytical data packages undergo a rigorous review and validation process following the guidelines set in the DOE-AL Model standard operating procedure (SOP) for Data Validation, which includes review of the data quality and the documentation's correctness and completeness. Tables S5-5, S5-6, and S5-7 in the Data Supplement list qualifier and validation flag codes that accompany 2002 sediment and water data.

When staff members identify documentation or contract-compliance problems during validation, they contact the analytical laboratory and attempt to resolve or clarify the problem. In 2002, this process required RRES-WQH Group's largest analytical services provider to issue about 150 package-specific nonconformance reports (NCRs). Most of the NCRs written in response to these problems concerned minor documentation and paperwork errors or typographical errors on individual data reports.

In addition to routine review of data packages, analytical laboratory oversight includes audits, site visits, and conference calls to review general laboratory quality practices. Problems identified during these processes normally require the laboratory to take a formal corrective action. All requested corrective actions for 2002 were completed.

#### 4. Radiological Data

Negative values are sometimes reported in radiological measurements. (See Appendix B.) Although negative values do not represent a physical reality, we report them as they are received from the analytical laboratory, as required by the "Environmental Regulation Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991).

The precision of radiological analytical results is reported as the 1 standard deviation (1 sigma) total propagated uncertainty. The RRES-WQH Group reports radiochemical detections as analytical results that are greater than both the sample-specific minimum detected activity and three times the reported uncertainty.



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### 5. Nonradiological Data

Nonradiological results are reported at levels down to the laboratory-derived MDL. Data between the MDL and practical quantitation limit are qualified as estimated by the analytical laboratory. The analytical laboratory reports results below the MDL as nondetections.

### 6. Detection-Limit Issues

During review of MDL studies, RRES-WQH personnel encountered incorrectly calculated MDLs, typically resulting from (1) the use of analytical standards that have inappropriately high concentrations that result in false negative results and (2) a combination of extraction methods and analytical techniques that result in false positive results. The RRES-WQH Group SOW requires that analytical laboratories verify their calculated MDLs empirically.

A particular issue regards perchlorate. The EPA's recommended analytical method for perchlorate is Method 314. The single laboratory MDL given in Method 314 is 0.53 µg/L. MDL verification studies conducted at General Engineering Laboratory of Charleston, South Carolina, have shown that in real (that is, groundwater) samples, spikes at the MDL cannot reliably be detected. In addition, using an MDL of about 1 µg/L has been shown to produce an unacceptable number of false positives in the range of 1 µg/L to 4 µg/L. From these studies and similar studies conducted at the DOE Pantex Plant Site in Amarillo, Texas, the DOE-AL AMP Analytical Management Program recommended a 4-µg/L detection limit for Method 314 in groundwater.

### 7. Participation in Laboratory Intercomparison Studies

The RRES-WQH Group SOW requires that analytical laboratories participate in several independent national performance evaluation (PE) programs. These include the Environmental Measurement Laboratory Quality Assessment Program and the DOE Mixed Analyte Performance Evaluation Program (MAPEP) for radiochemistry analysis and the EPA Water Supply, the EPA Water Pollution, the EPA NPDES Discharge Monitoring Report-Quality Assurance Study, and the MAPEP programs for organic and inorganic constituents.

Results for these PE programs are categorized as (1) acceptable (result within the 2-sigma acceptance

range), (2) acceptable with warning (result within the 3-sigma acceptance range), and (3) not acceptable (result outside the 3-sigma acceptance range). Participating analytical laboratories are required to initiate internal corrective actions when PE results are categorized as not acceptable, and those corrective actions are spot-checked during various analytical laboratory oversight activities.

### 8. Quality Control Samples

The required analytical laboratory batch QC is defined by the analytical method, the SOW, and generally accepted laboratory practices. The laboratory batch QC is used in the data-validation process to evaluate the quality of individual analytical results, to evaluate the appropriateness of the analytical methodologies, and to measure the routine performance of the analytical laboratory.

In addition to batch QC performed by laboratories, the RRES-WQH Group submitted field QC samples to test the overall sampling and analytical laboratory process and to spot-check for analytical problems. These samples included equipment blanks, field blanks (deionized water), and field duplicates.

On the whole, the equipment and field blanks, field duplicates, and laboratory duplicates were satisfactory, indicating no significant handling issues from sampling and analyses. Results of equipment and field blanks, along with performance evaluation blanks (deionized water) are shown in Tables S5-17, S5-18, and S5-19 in the Data Supplement. Detections in the blanks are shown in Tables S5-20, S5-21, and S5-22, also in the Data Supplement.

**a. Equipment and Field Blanks.** Equipment and field blanks were submitted for metals, organic, general inorganic, and radiochemistry analyses to monitor for contamination during sampling and decontamination of equipment. Except for one sample mix-up at the laboratory, all reported results were at or near the detection limit.

**b. Field Duplicates.** Field duplicate samples are distinct samples of the same matrix collected as closely as possible to the same point in space and time. Duplicate samples processed and analyzed by the same analytical laboratory provide intralaboratory information about the precision of the entire measurement system, including sample acquisition, homogeneity, handling, shipping, storage, preparation, and analysis. Duplicate samples may also be used to

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identify errors such as mislabeled samples or data-entry errors. Duplicates were collected and submitted for general inorganic, metals, and radiochemistry analysis for groundwater, storm water, surface water, and sediment samples.

Duplicate analyte results were evaluated for the metals and inorganic fractions for pairs in which both results were greater than the MDL; that is, both results were detections. The general criterion used is consistent with that used in the data-validation SOP for validation of duplicates. The duplicate relative percent difference (RPD) was used as the measure of precision for organic (volatile and semivolatile) and inorganic constituents.

All radiochemistry duplicate result pairs were evaluated against the calculated replicate error ratio. Gross gamma measurements have inherently high variability and were not evaluated.

**c. Laboratory Duplicate Analyses.** Laboratory duplicate samples are splits of samples processed and analyzed by the laboratory that provide information about the precision of the measurement system, including sample homogeneity, preparation, and analysis. Laboratory duplicates can indicate analytical techniques with poor reproducibility. Comparison of laboratory duplicates and field duplicates can be used to evaluate the sampling system and general environmental homogeneity at the time of sampling. Duplicates are required as routine batch QC for general inorganic, metals, and radiochemistry.

Duplicate analyte results were evaluated for the metals and inorganic fractions for pairs in which both results were greater than the MDL; that is, both results were detections. The RPD was used as the measure of precision for organic and inorganic constituents. All radiochemistry duplicate result pairs were evaluated against the calculated replicate error ratio.

## 5. Groundwater Monitoring

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## 5. Groundwater Monitoring

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## 6. Watershed Monitoring







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### A. Introduction

Los Alamos National Laboratory (LANL or the Laboratory) monitors surface water and stream sediments in northern New Mexico and southern Colorado to evaluate the potential environmental effects of Laboratory operations. The Laboratory analyzes samples for several parameters including radionuclides, high explosives, metals, a wide range of organic compounds, and (for surface water) general chemistry. In this chapter, we assess effects of Laboratory operations and evaluate any trends over time. We also compare the monitoring results with criteria established to protect human health and the aquatic environment.

The Cerro Grande fire in May 2000 caused chemical and hydrologic changes that have complicated our interpretation of the monitoring results. In the absence of forest cover, runoff from the burned areas above the Laboratory is now greater and occurs more rapidly. The runoff contains concentrations of fallout radionuclides, metals, and solutes that are higher than concentrations measured before the fire (Gallaher et al. 2002, Koch et al. 2001, Johansen et al. 2001, Katzma et al. 2001). Because post-fire runoff has carried sediment and ash from the burned areas onto LANL lands, we continue to consider how the fire has influenced surface water and sediment monitoring results. We expect that as burned areas become more and more thickly revegetated, stormwater runoff and sediment transport will increasingly diminish.

### B. Hydrologic Setting

Watersheds that drain Laboratory land are dry for most of the year. No perennial surface water extends completely across Laboratory land in any canyon.

To aid in water quality interpretation, we divide stream flow into three types or matrices. Each of the

three flow types might be collected at a single location within a time span of as little as a week, depending on weather conditions. At times, the flow might represent a combination of several of these components. The three types are

- base flow—persistent stream flow, but not necessarily perennial water (This stream flow is present for periods of weeks or longer. The water source may be effluent discharge or shallow groundwater that discharges in canyons.);
- snowmelt—flowing water that is present because of melting snow (This type of water often may be present for a week or more and in some years may not be present at all.); and
- storm runoff—flowing water that is present in response to rainfall (These flow events are generally very short lived, with flows lasting from less than an hour to several days.).

Because snowmelt and base flow are present for extended periods of time, they pose similar potentially longer-term exposure concerns, such as wildlife watering. We thus discuss snowmelt and base flow together, separate from storm runoff. While runoff may provide a short-term water source for wildlife, that water is a principal agent for moving Laboratory-derived constituents off-site and possibly into the Rio Grande.

Since the Cerro Grande fire, total volumes of runoff and peak rates of discharge have increased in Pajarito Plateau drainages. Even with the increased flows, however, none of the canyons on Laboratory lands average annually more than 1 cubic foot per second (cfs) of flow. By comparison, flows in the Rio Grande commonly average approximately 1,000 cfs (USGS 2003). Post-fire peak flows greater than 1,000 cfs have been recorded in several canyons

## 6. Watershed Monitoring

that drain burned areas (Shaull et al. 2003). Although most of the watercourses are dry throughout the year, occasional floods can redistribute sediment in a streambed to locations far downstream from where a release or spill occurs.

Severe drought conditions in the Los Alamos vicinity continued in 2002 for the fourth consecutive year. The snowmelt runoff in 2002 was virtually nonexistent, partially because of the lowest seasonal precipitation for the 8-year period from 1995 through 2002 (Koch et al. 2003). Fewer summer storm runoff events occurred at LANL in 2002, and most of those were considerably less intense than the ones in 2000 and 2001. Nonetheless, significant runoff events occurred on June 21, August 28, and September 10, 2002. Total runoff volume at downstream gauges in 2002 was about 2.8 times higher than the prefire average, indicating that the Cerro Grande wildfire is still affecting the hydrology of the area (Figure 6-1). This situation was particularly true in Pueblo Canyon, where a single runoff event on June 21, 2002, resulted in a peak runoff of 582 cfs and yielded about one-half of the total runoff volume measured in the canyon that year (Koch et al. 2003).

### C. Surface Water and Sediment Standards

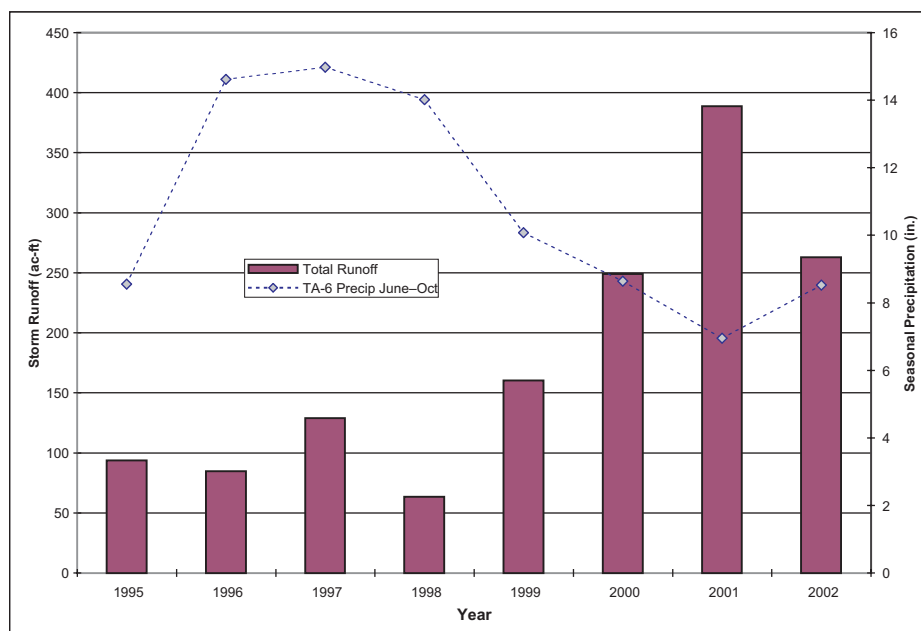
To evaluate Laboratory impacts, we compare analytical results for surface water and sediment

samples to regulatory standards or to health-based screening levels.

The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. We compare activities of radionuclides in surface water samples with either the 100-mrem Department of Energy (DOE) Derived Concentration Guides (DCGs) for public dose or the New Mexico Water Quality Control Commission (NMWQCC) (NMWQCC 2002a) stream standards, whichever is most restrictive. The DCGs for gross alpha and gross beta are conservative. For gross alpha the DCG assumes that the radioactivity comes solely from americium-241 and plutonium-239,-240. The DCG for gross beta assumes that the radioactivity comes solely from strontium-90.

We compare concentrations of nonradioactive constituents to the NMWQCC General, Wildlife Habitat, Livestock Watering, and Human Health Standards (NMWQCC 2002b). Surface water quality results are also compared to the NMWQCC groundwater standards to evaluate the potential for stream flows to impact underlying groundwater bodies.

Evaluation of storm runoff results is complicated by several factors. Runoff events are short-lived, so they do not result in long-term exposure. The higher concentrations of many compounds found in runoff



**Figure 6-1.** Annual seasonal precipitation and storm runoff at downstream gauges located on LANL land.

samples reflect constituents that are part of the large suspended sediment load of runoff, rather than dissolved constituents. A runoff event carrying a high sediment load might seem to be greater than water quality standards for gross alpha, for example. The gross alpha might be completely caused by sediments that contain background amounts of naturally occurring uranium.

To evaluate storm runoff results, we developed preliminary threshold values for some metals and radioactivity parameters. A value is greater than the threshold if it is greater than the upper 95% prediction limit for concentrations measured at background locations in 2001 and 2002 samples. The thresholds are used to identify data that signify possible effects from Laboratory operations. Above-background results merit further investigation to determine whether they are from Laboratory sources.

We screen sediment results to screening action levels to identify concentrations of a constituent that may require further assessment (ER 2001). The Laboratory's Remediation Services Project (RRES-R) uses residential screening levels (SALs) to identify radionuclide activity levels of interest (ER 2001). Industrial worker screening levels for radionuclides (Perona et al. 1998) are applicable on Laboratory land because it is not available for residential development. Concentrations of nonradioactive compounds in sediments may be compared with residential and industrial outdoor worker soil-screening levels developed by Environmental Protection Agency (EPA) Region 6 (EPA 2000). All of these screening levels are conservative (protective) because they are calculated based on the assumption that humans will be continually exposed to the chemicals or radionuclides. We can also compare sediment data to background levels of metals or background activities of radionuclides that are naturally occurring or result from atmospheric fallout (Ryti et al. 1998; McLin and Lyons 2002).

### D. Overview of Surface Water and Sediment Quality

#### 1. Contaminant Sources

The overall quality of most surface water in the Los Alamos area is very good, with very low levels of dissolved solutes. Of the more than 100 analytes tested for in sediment and surface water within the Laboratory, most are within normal ranges or at concentrations far below regulatory standards or health-based advisory levels. However, nearly every major watershed shows

indications of some effect from Laboratory operations, often for just a few analytes.

Although many of the above-background results in sediment and surface water are from the major liquid effluent discharges (shown in Figure 5-4 in Chapter 5), other possible sources include isolated spills, photographic-processing facilities, highway runoff, and residual Cerro Grande ash. At monitoring locations below other industrial or residential areas, particularly in the Los Alamos and Pueblo canyon watersheds, above-background contaminant levels reflect contributions from non-Laboratory sources, such as urban runoff.

#### 2. Contaminant Maps

We reviewed recent watershed monitoring results to develop a preliminary picture of key analytes that reflect possible effects from Laboratory operations. Most of the above-background results for surface water were found in storm runoff samples. We prepared a series of maps (Figures 6-2 through 6-15) to show general patterns of where potential contamination from Laboratory operations was measured in surface water or sediment during 2001 or 2002. Few runoff events have occurred during the last 2 years because of extended drought, so we based the maps on 2 years of data to include more samples in each watershed. When the same pattern showed up in several samples within part of a canyon, we highlighted that area on the maps.

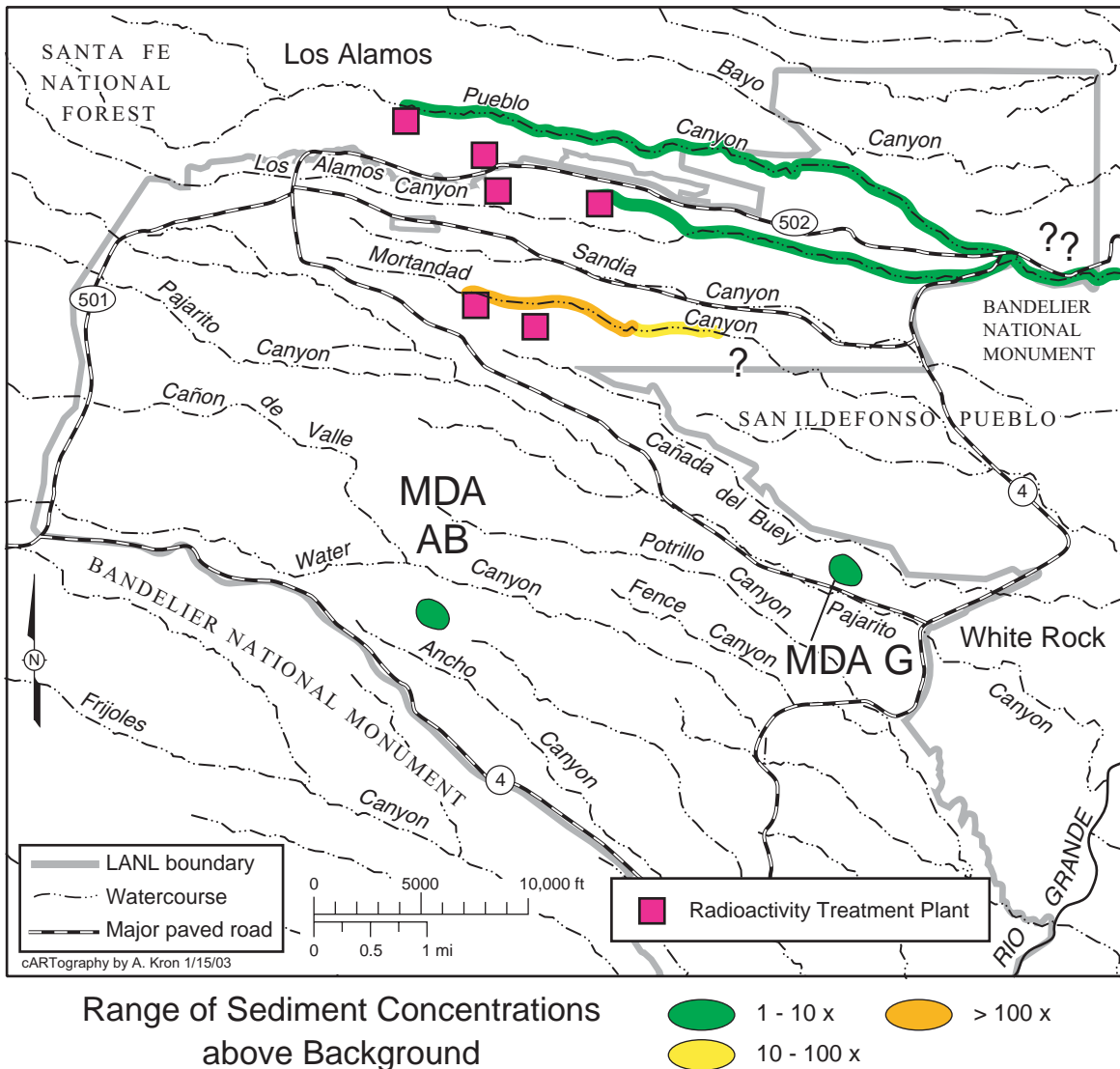
We prepared separate maps for sediments and for storm runoff, although they often show similar distribution for a constituent. Because of the lack of flow, storm runoff data are sparse in some parts of the Laboratory. The maps show analytes that are widely distributed, possibly affecting an entire watershed, and may not show localized contamination.

The maps show contaminant distributions extrapolated beyond the area covered by monitoring locations. This extrapolation takes into account the location of contaminant sources and direction of sediment and surface water movement. Question marks on the maps indicate where contaminant extent is inferred, but not confirmed by monitoring coverage; or they indicate locations where analytical measurements suggest detections that are contradicted by other measurements. Along canyons, the extent of contamination lateral to the canyon is diagrammatic: contamination is confined to the alluvium within the canyon bottom and is quite narrow at the map scale.



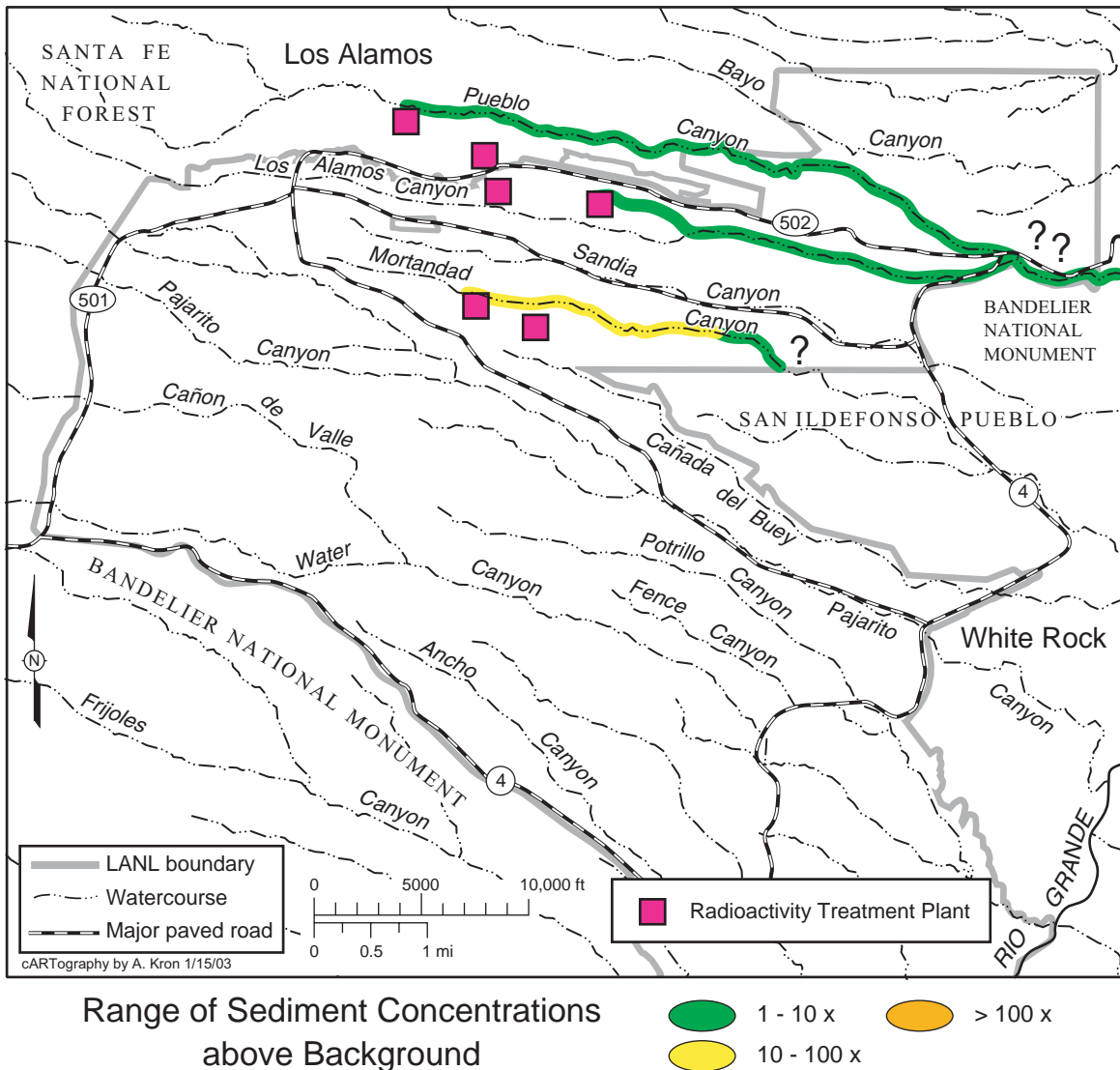
## 6. Watershed Monitoring

### Above-background Americium-241 in Sediments



**Figure 6-2.** Location of the active stream channel sediment with americium-241 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). The highest value in 2002 was in Mortandad Canyon, at 134 times background, 26% of the SAL, and 18% of the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

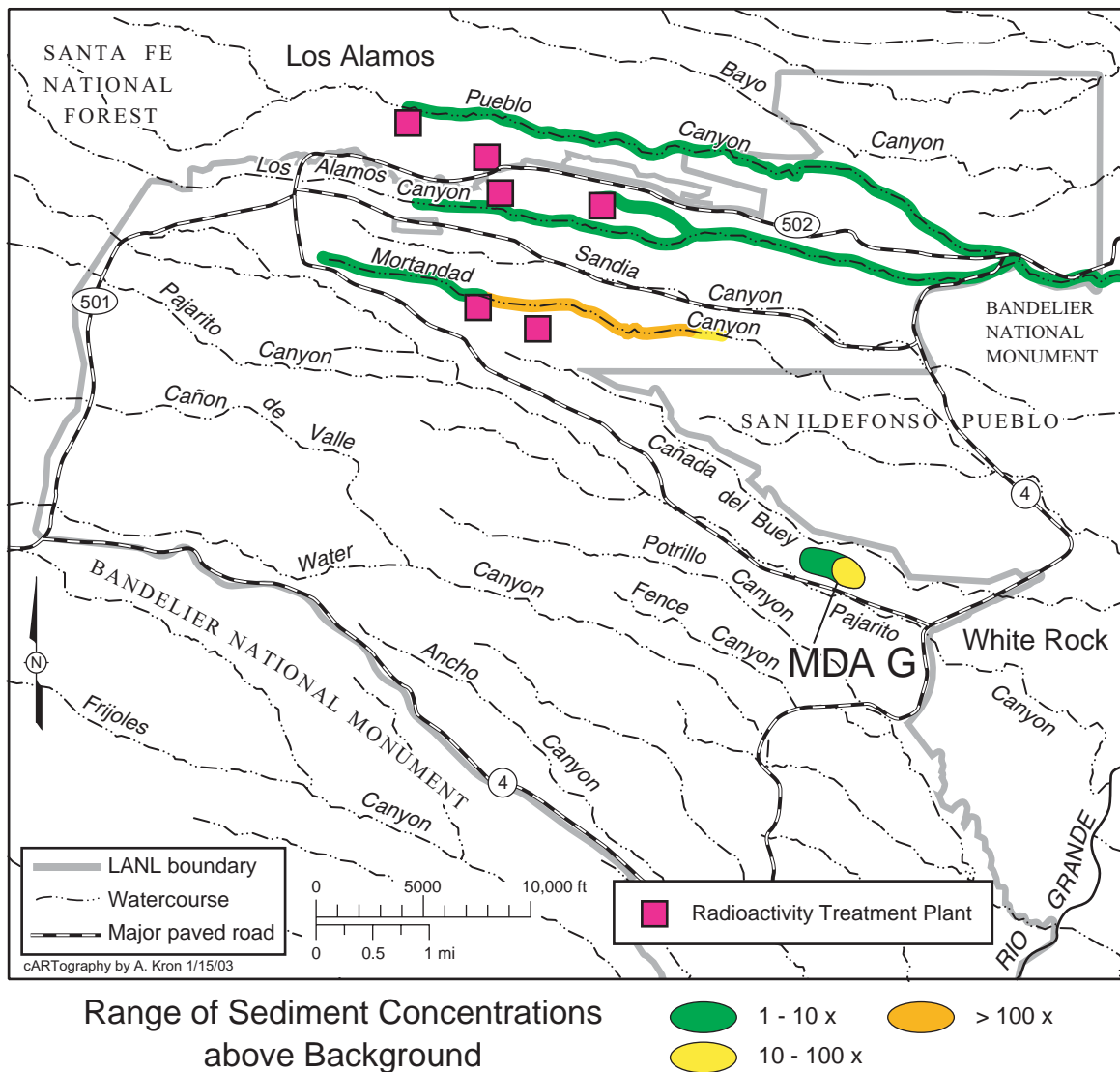
### Above-background Cesium-137 in Sediments



**Figure 6-3.** Location of the active stream channel sediment with cesium-137 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. All values larger than 10 times background are above the SAL. The highest value in 2002 was in Mortandad Canyon, at 51 times background, 5.4 times the SAL, and 1.5 times the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

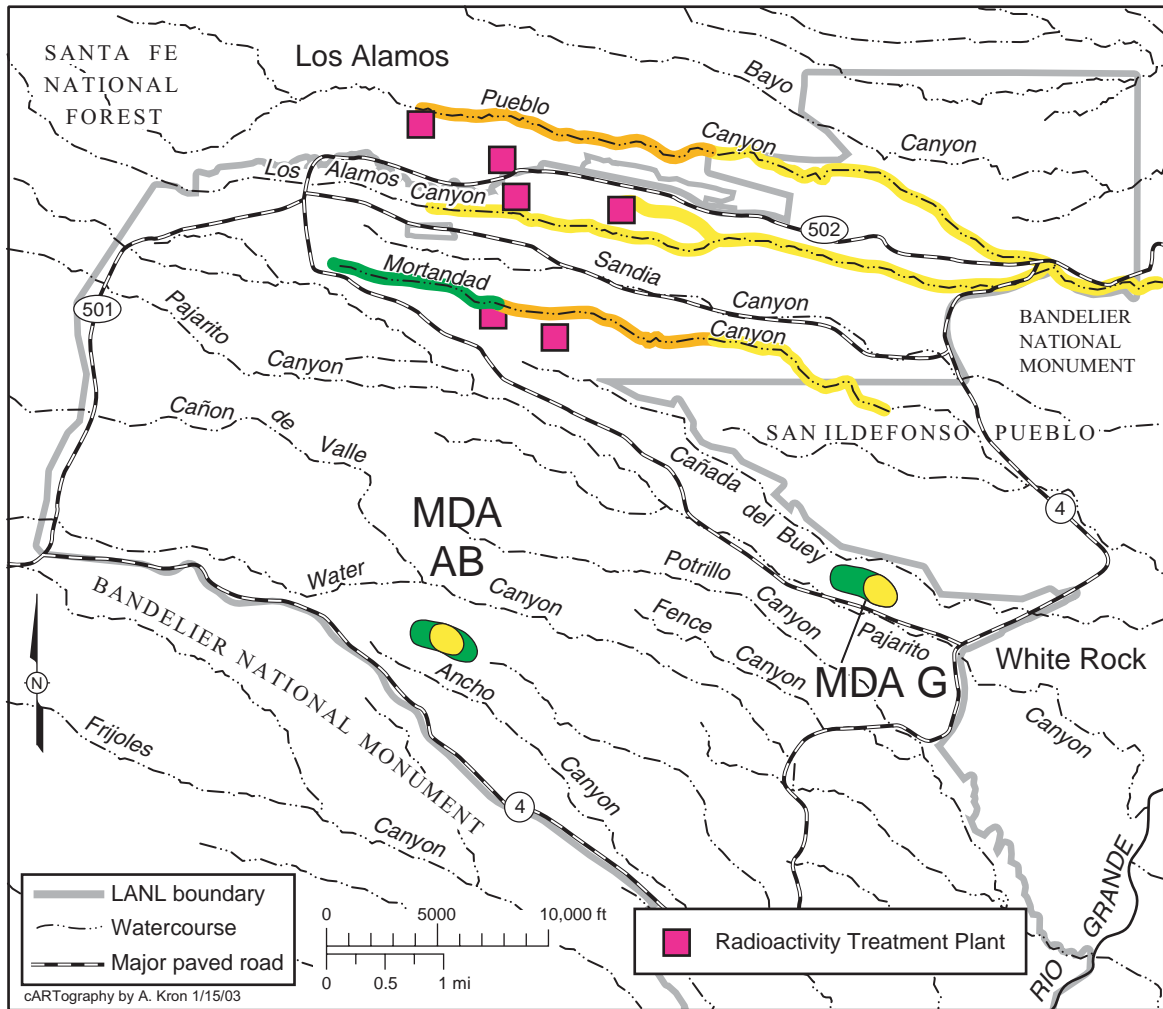
## 6. Watershed Monitoring

### Above-background Plutonium-238 in Sediments



**Figure 6-4.** Location of the active stream channel sediment with plutonium-238 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. The highest value in 2002 was in Mortandad Canyon, at 423 times background, 8% of the SAL, and 6% of the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

Above-background Plutonium-239,-240 in Sediments



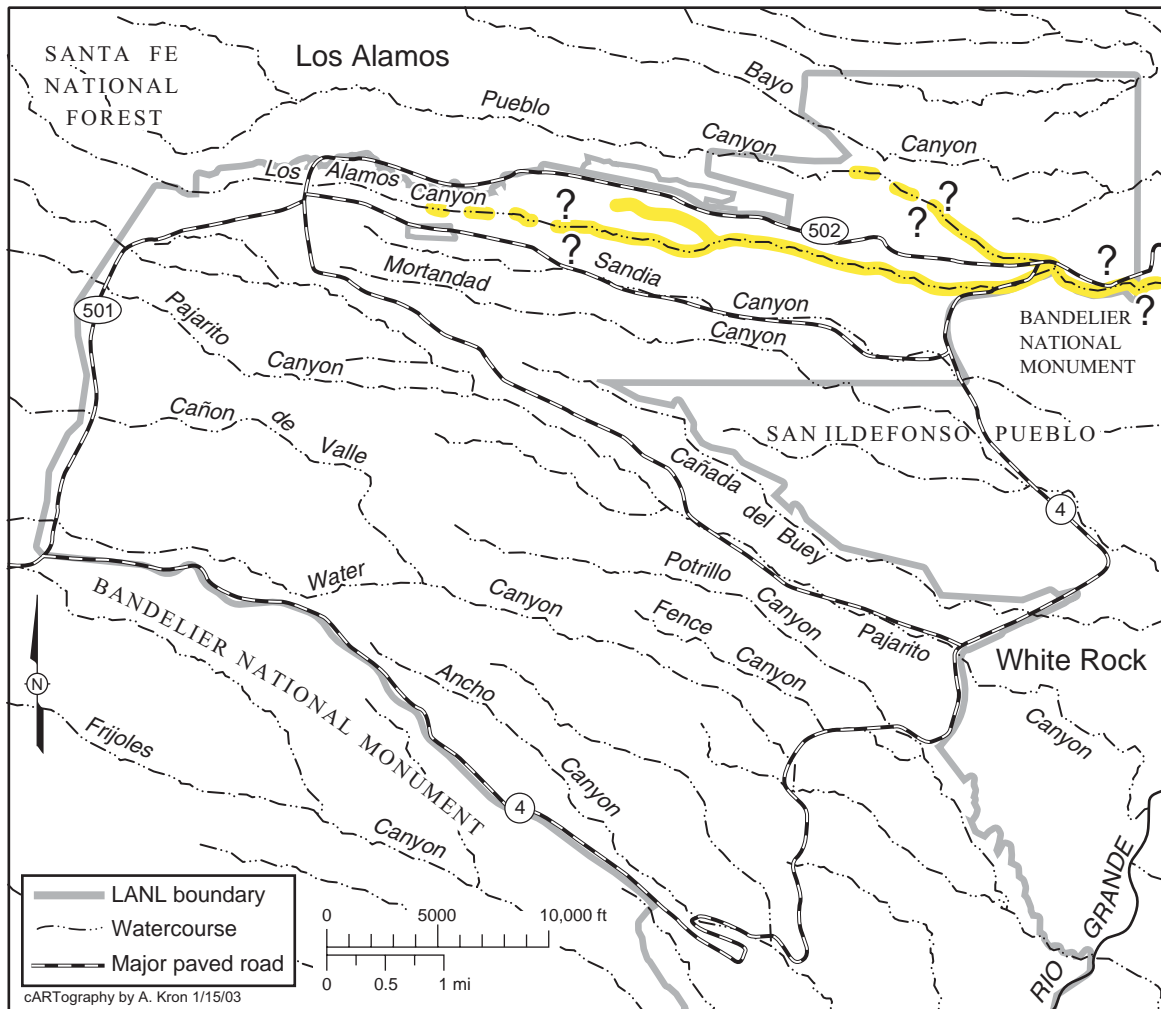
Range of Sediment Concentrations above Background

- 1 - 10 x
- 10 - 100 x
- > 100 x

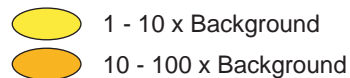
**Figure 6-5.** Location of the active stream channel sediment with plutonium-239,-240 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. The highest values in 2002 were in Acid Canyon, at 612 times background, 18% of the SAL, and 13% of the industrial worker screening level; and in Mortandad Canyon, at 545 times background, 16% of the SAL, and 12% of the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

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Total Plutonium-238 in Storm Runoff > Background



Range of Storm Runoff Concentrations  
Compared to Background

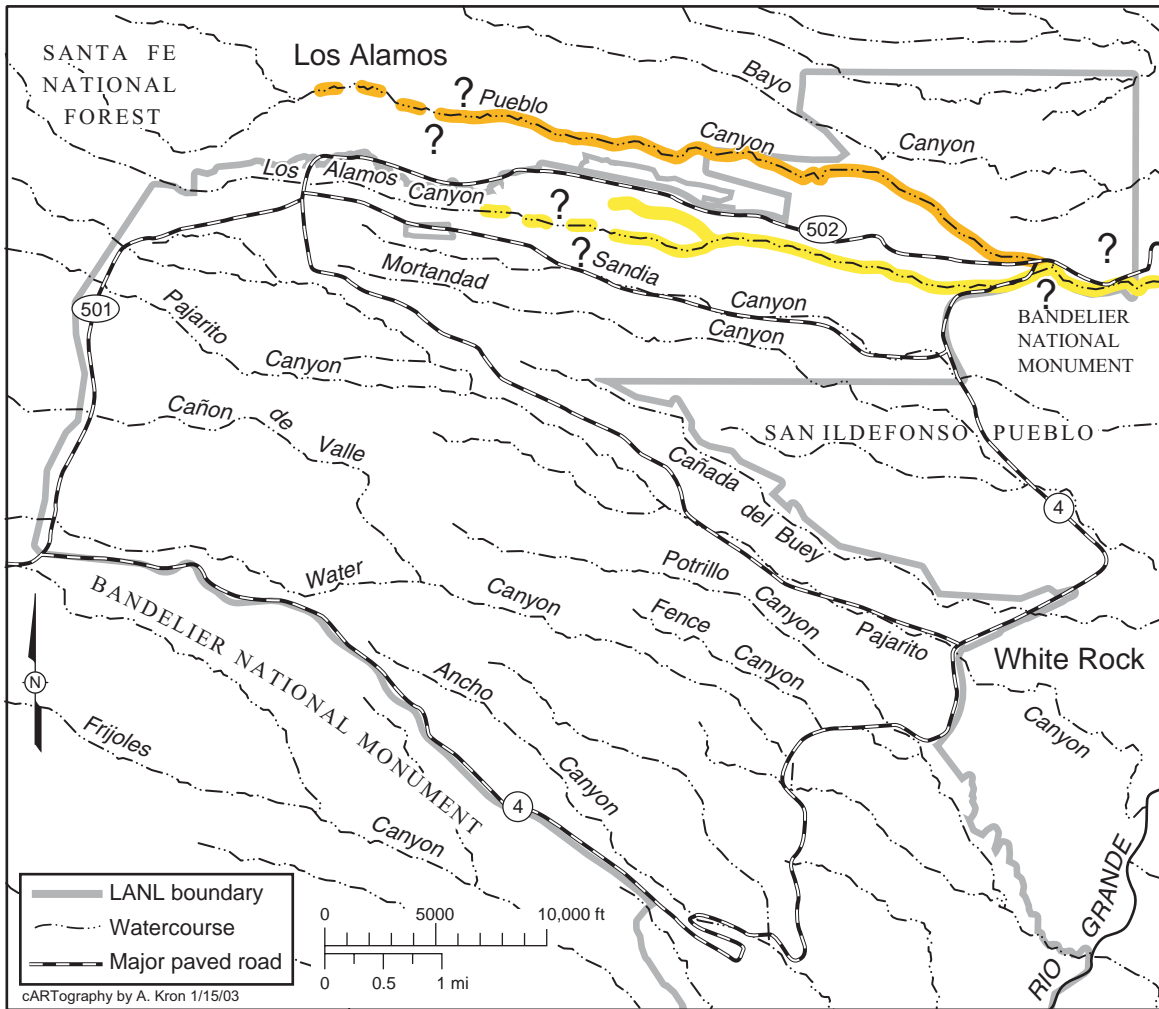


**Figure 6-6.** Location of storm runoff with plutonium-238 activity above background levels. Different colors indicate the proportion of concentration to the background level. The highest recent plutonium-238 activity in runoff was in DP Canyon in 2001, at 6.2 times background. There is minimal opportunity for exposure to the runoff, as flow is short-lived and not used as a drinking water source.



## 6. Watershed Monitoring

### Total Plutonium-239,-240 in Storm Runoff > Background

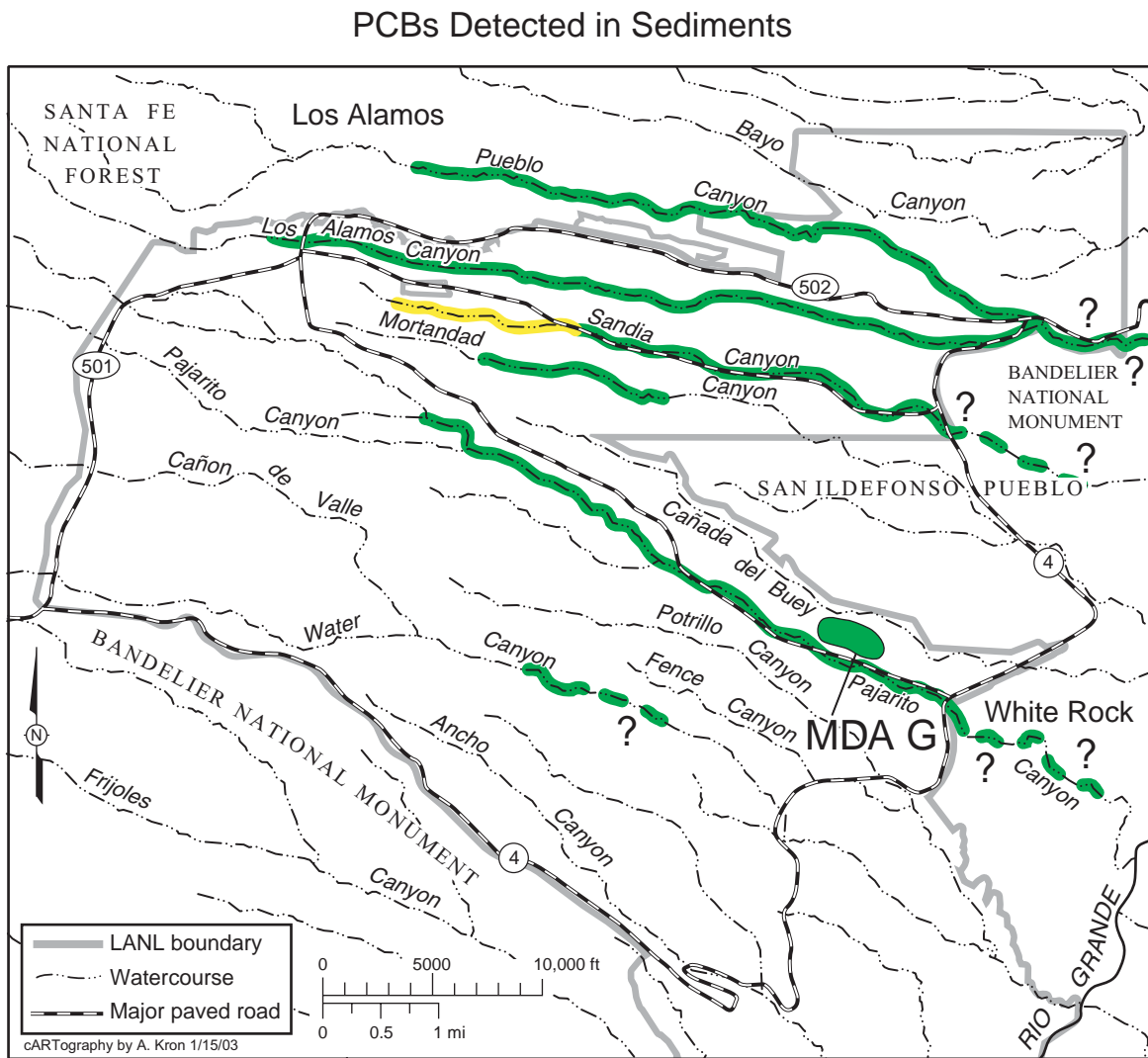


#### Range of Storm Runoff Concentrations Compared to Background

- 1 - 10 x Background
- 10 - 100 x Background

**Figure 6-7.** Location of storm runoff with plutonium-239,-240 activity above background levels. Different colors indicate the proportion of concentration to the background level. The highest plutonium-239,-240 activity in a recent surveillance sample was in Pueblo Canyon in 2001, at 25 times background. The Laboratory's Environmental Restoration Project measured Pu-239,-240 in a 2002 Pueblo Canyon sample at 170 times the background. There is minimal opportunity for exposure to the runoff as flow is short-lived and not used as a drinking water source.

## 6. Watershed Monitoring

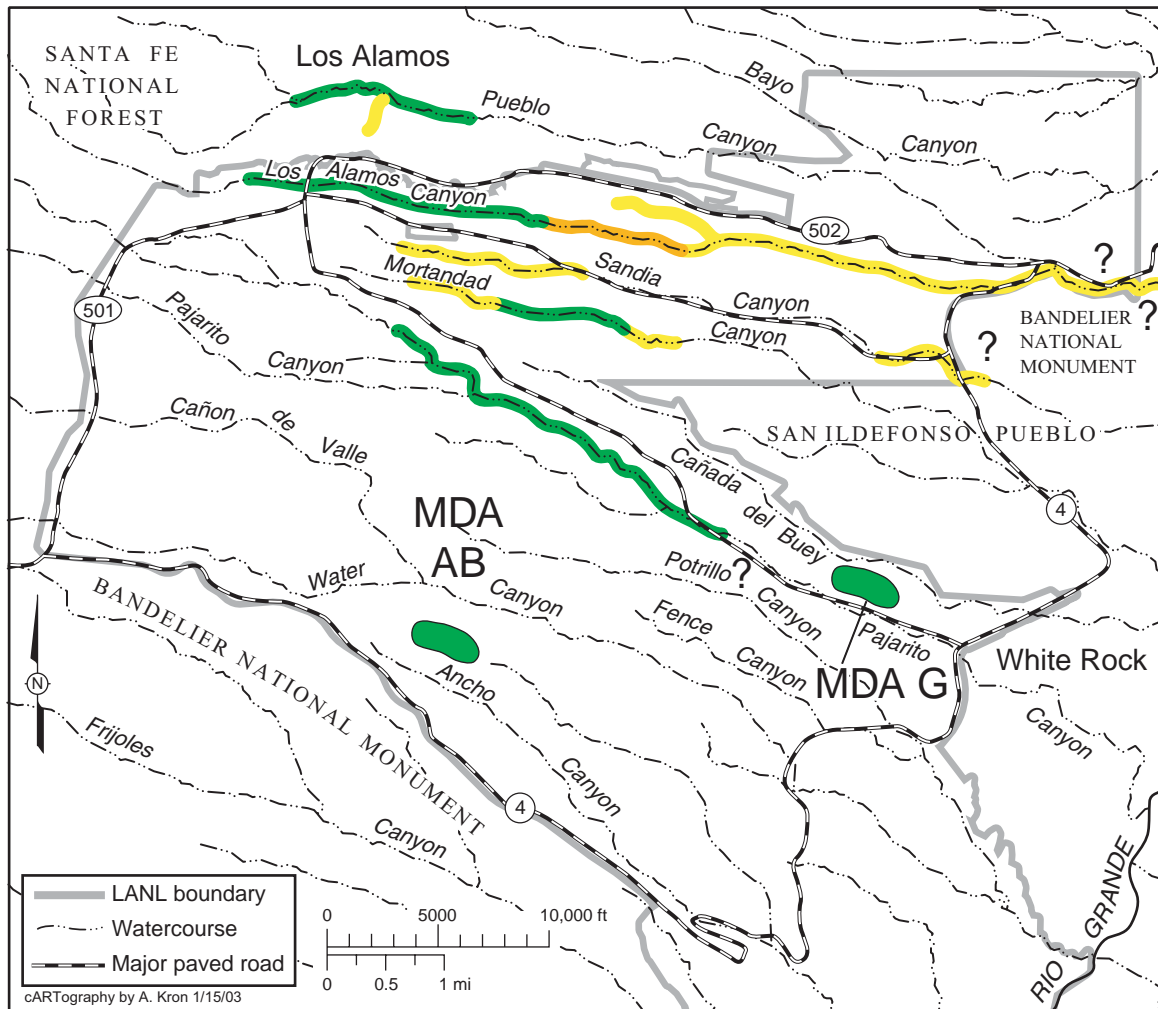


Range of Sediment Concentrations Compared  
to EPA Residential and Industrial Outdoor  
Worker Soil Screening Levels

- detected but < RSSL
- near or > RSSL
- > IOWSSL

**Figure 6-8.** Location of sediment with PCBs detected or above screening levels. Different colors indicate where PCBs are detected or are above the EPA Region 6 residential soil screening level (no values were above the industrial screening level). The highest value in 2002 was in Sandia Canyon, at 97% of the residential soil screening level and 26% of the industrial outdoor worker soil screening level.

PAHs (Benzo(a)pyrene) Detected in Sediments



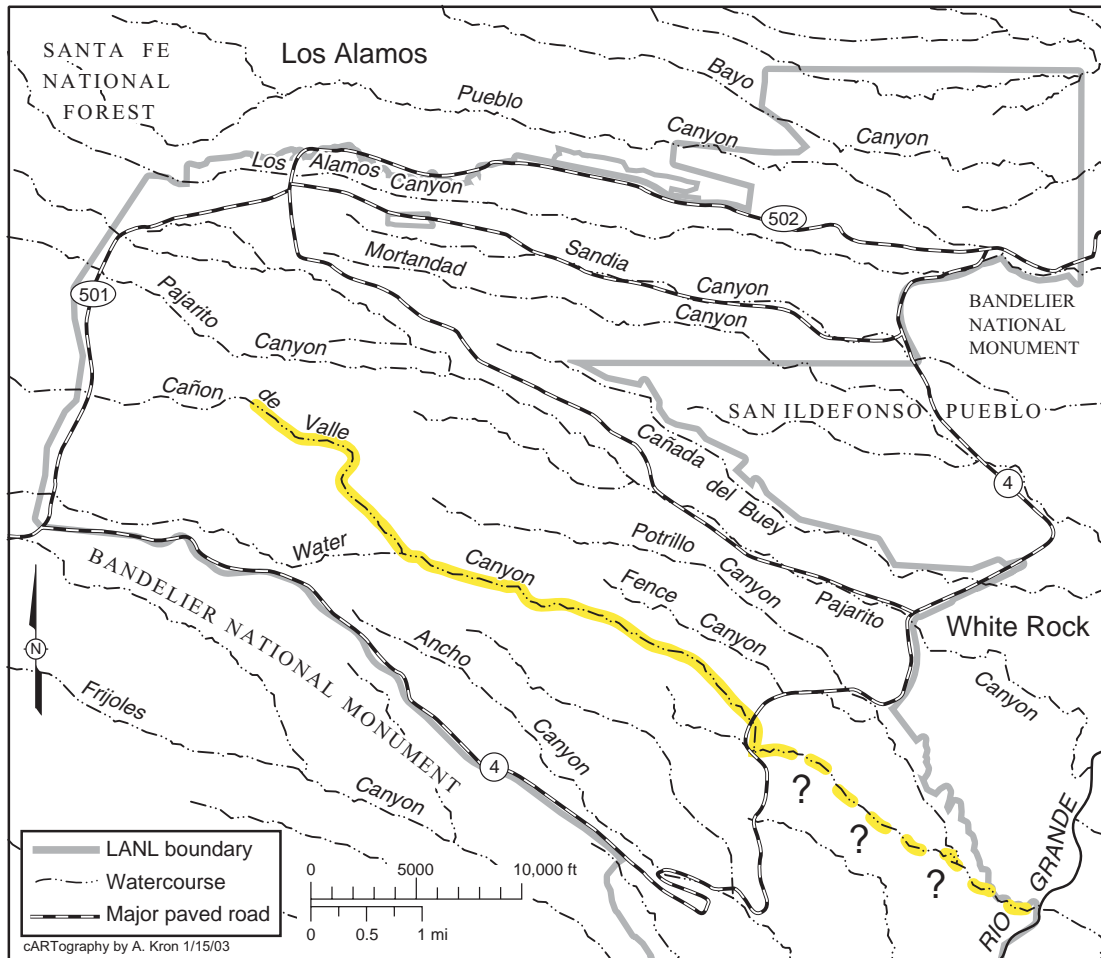
Range of Sediment Concentrations Compared to EPA Residential and Industrial Outdoor Worker Soil Screening Levels

- detected but < RSSL
- near or > RSSL
- > IOWSSL

**Figure 6-9.** Location of sediment with benzo(a)pyrene, a PAH, detected or above screening levels. Different colors indicate where benzo(a)pyrene was detected or was above the EPA Region VI residential or industrial soil screening levels. The highest value in 2002 was in Sandia Canyon, at 2.5 times the residential soil screening level and 65% of the industrial outdoor worker soil screening level. In 2001 maximum values in Los Alamos Canyon were more than 15 times the residential soil screening level and 4 times the industrial outdoor worker soil screening level.

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Total Barium > Background and RDX near Tap Water Health Advisory in Storm Runoff



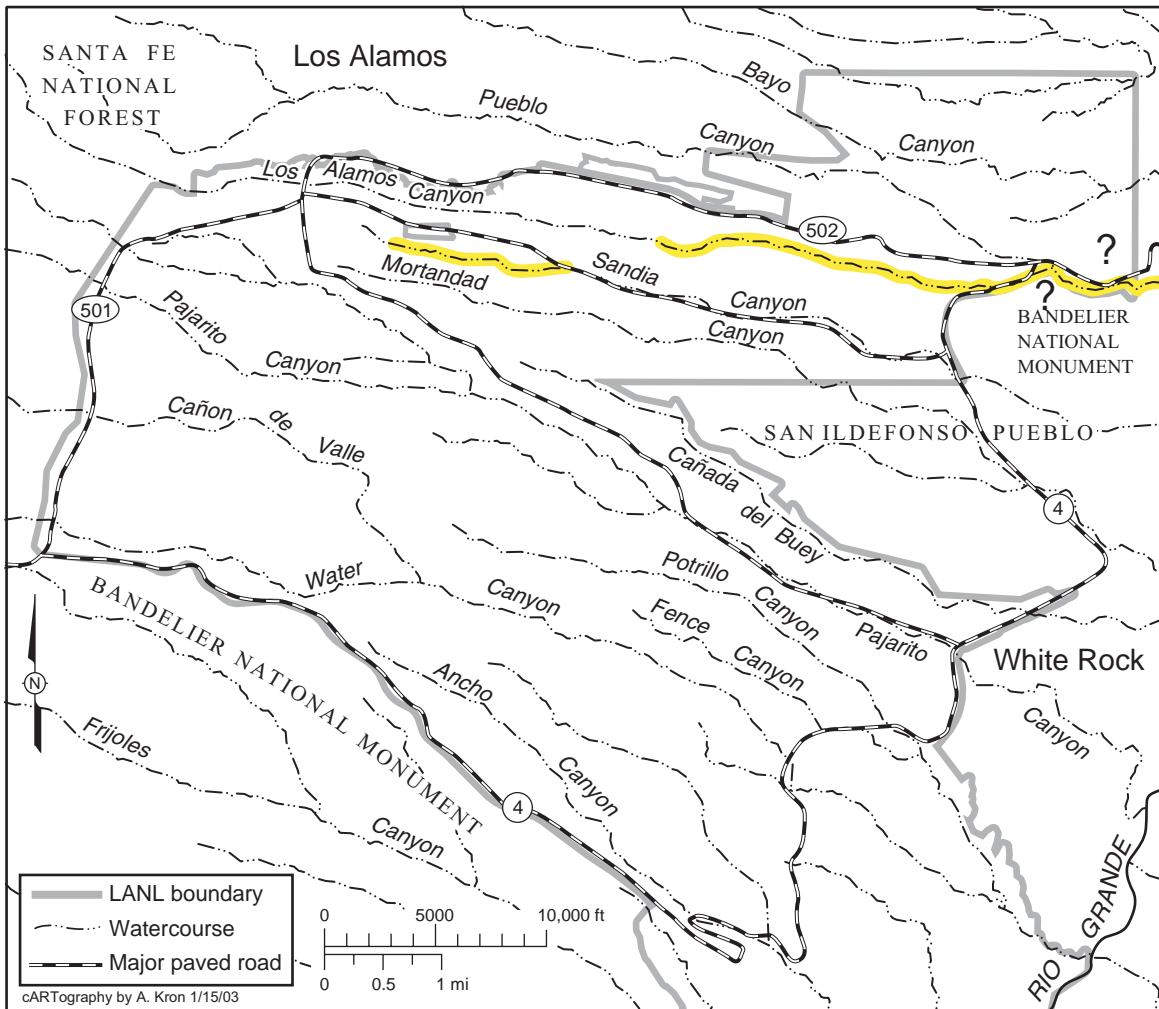
Range of Storm Runoff Concentrations  
Compared to Background or Standard

- 1 - 10 x Screening Level
- 10 - 100 x Screening Level

**Figure 6-10.** Location of storm runoff with total barium above background levels and RDX above or near the 2 ppb EPA risk-based groundwater action level. A more recent 0.61 ppb RDX EPA tap water screening level corresponds to a  $10^{-6}$  excess cancer risk. Different colors indicate the proportion of concentration to the screening level. The highest 2002 total barium concentration was in Water Canyon, at 2.1 times the calculated background level. A 2001 storm runoff sample in Water Canyon contained RDX at a concentration 75% of the groundwater action level and 2.6 times the EPA's tap water screening level. Dissolved barium was detected at concentrations above the 1000  $\mu\text{g/L}$  New Mexico Groundwater Standard in Water Canyon, Cañon de Valle (upstream of LANL), and Guaje Canyon (north of LANL), at levels up to 6.1 times the groundwater standard. These streams are not a drinking water source.

## 6. Watershed Monitoring

### Total Zinc in Storm Runoff > Background



### Range of Storm Runoff Concentrations Compared to Background

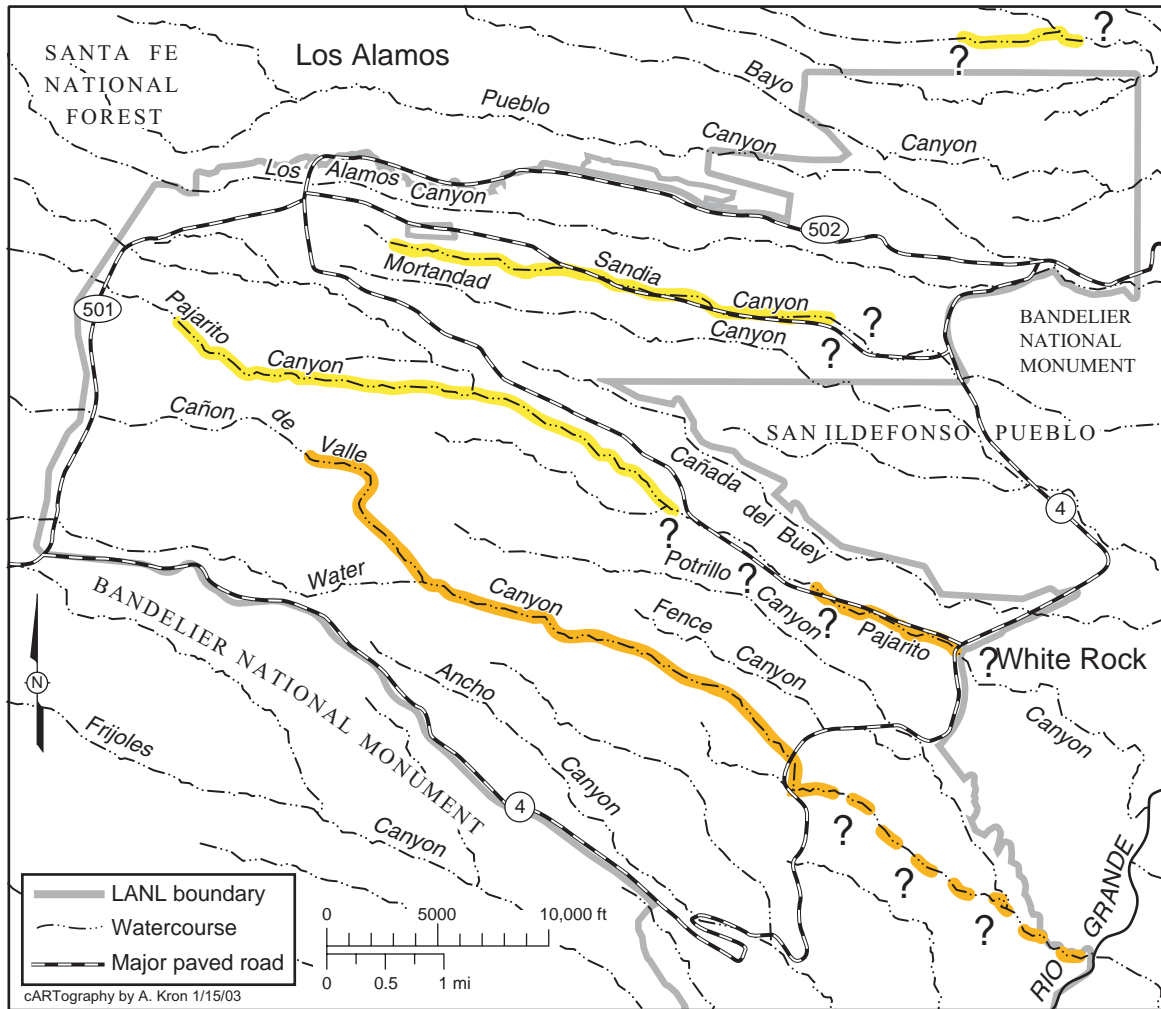
- 1 - 10 x Background
- 10 - 100 x Background

**Figure 6-11.** Location of storm runoff with total zinc above background levels. Different colors indicate the proportion of concentration to the background level. The highest total zinc concentrations were in Sandia Canyon (2001) and Twomile Canyon (2002), at 3.4 times background. Dissolved zinc was detected at concentrations above the New Mexico short-term (acute) aquatic life stream standard in several canyons including Sandia, Water, and Guaje (north of LANL), at levels up to 22 times the standard. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande, while streams within LANL do not have fish.



## 6. Watershed Monitoring

### Total Silver in Storm Runoff > Background



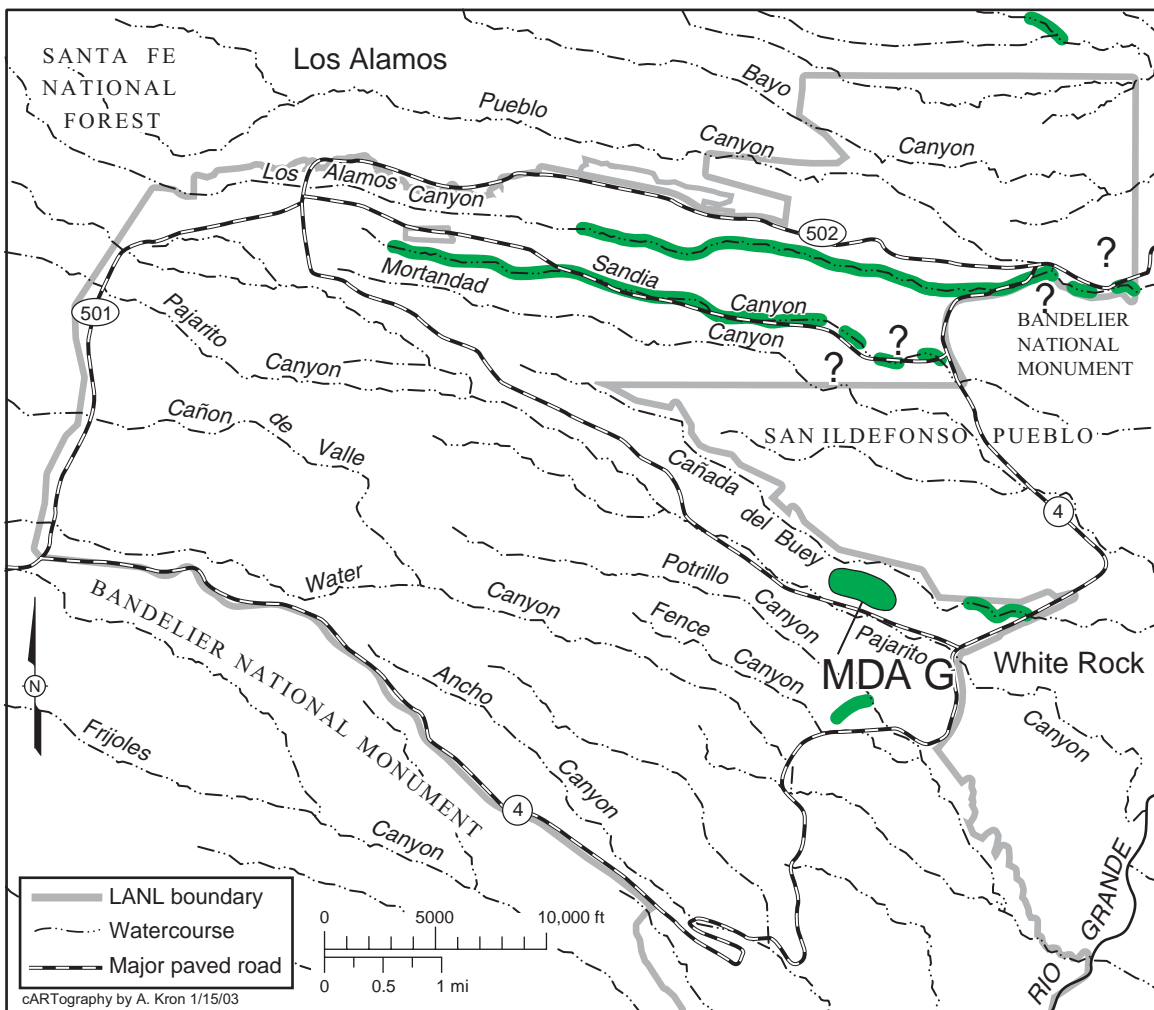
#### Range of Storm Runoff Concentrations Compared to Background

- Detected but < Background
- 1 - 10 x Background
- 10 - 100 x Background

**Figure 6-12.** Location of storm runoff with total silver above the detection limit of  $1 \mu\text{g/L}$  (silver is rarely detected in surface water). Different colors indicate the proportion of concentration to the detection limit. The highest recent value was in Water Canyon in 2001, at approximately 300 times the detection limit. Two 2002 dissolved silver values were above the NMWQCC acute aquatic life stream standard, but these values have not been found consistently at any location. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande, while streams within LANL do not have fish.

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### Total Mercury in Storm Runoff Compared to New Mexico Acute Aquatic Life Stream Standard (2.4 µg/L)



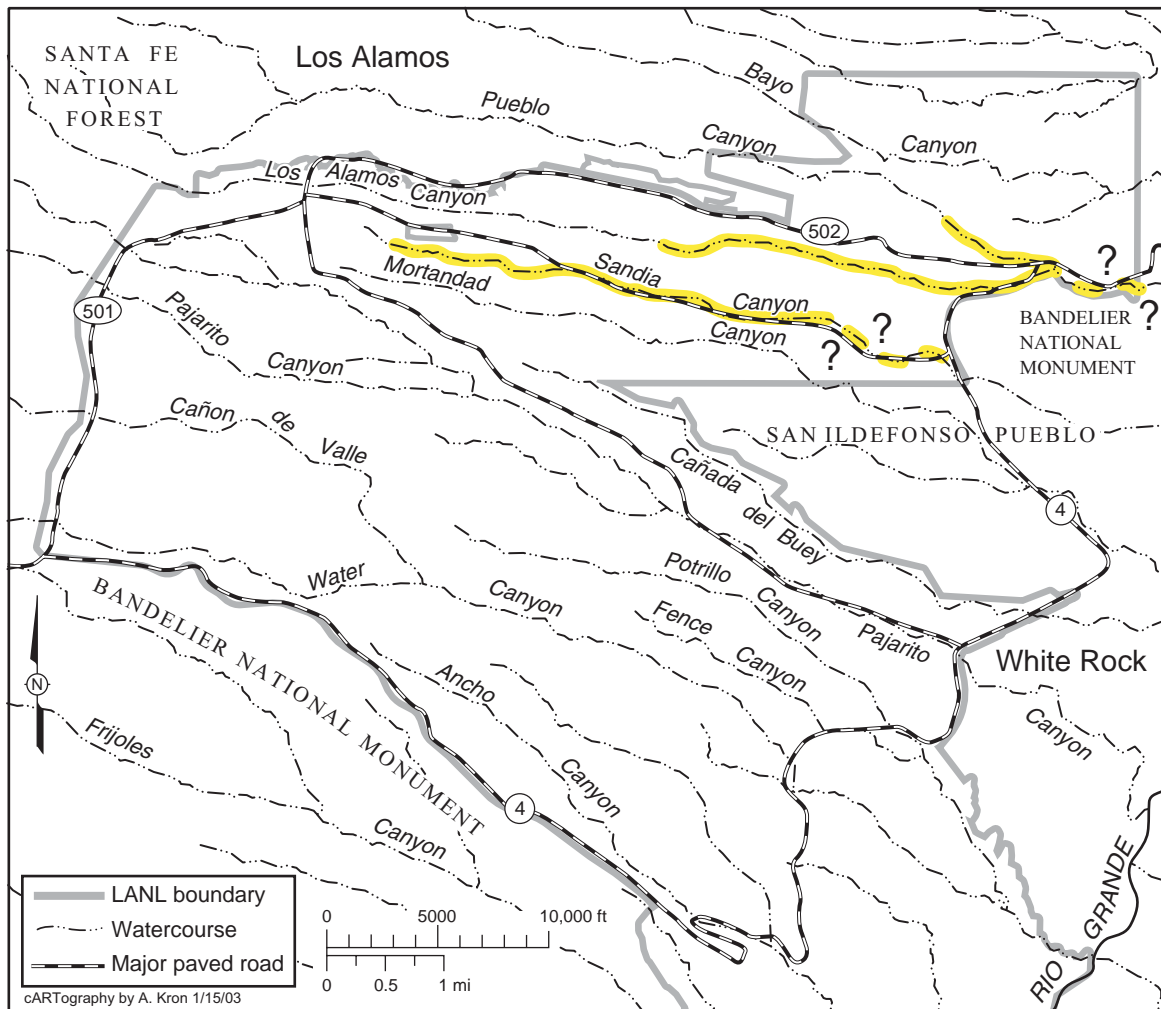
#### Range of Storm Runoff Concentrations Compared to Standard

- Detected but < Standard
- 1 - 10 x Standard

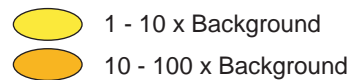
**Figure 6-13.** Location of storm runoff with total mercury above the New Mexico Acute Aquatic Life stream standard. Different colors indicate the proportion of concentration to the standard. The highest recent value was in Los Alamos Canyon in 2001, at 71% of the Acute Aquatic stream standard. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande, while streams within LANL do not have fish.

## 6. Watershed Monitoring

Total Chromium in Storm Runoff > Background

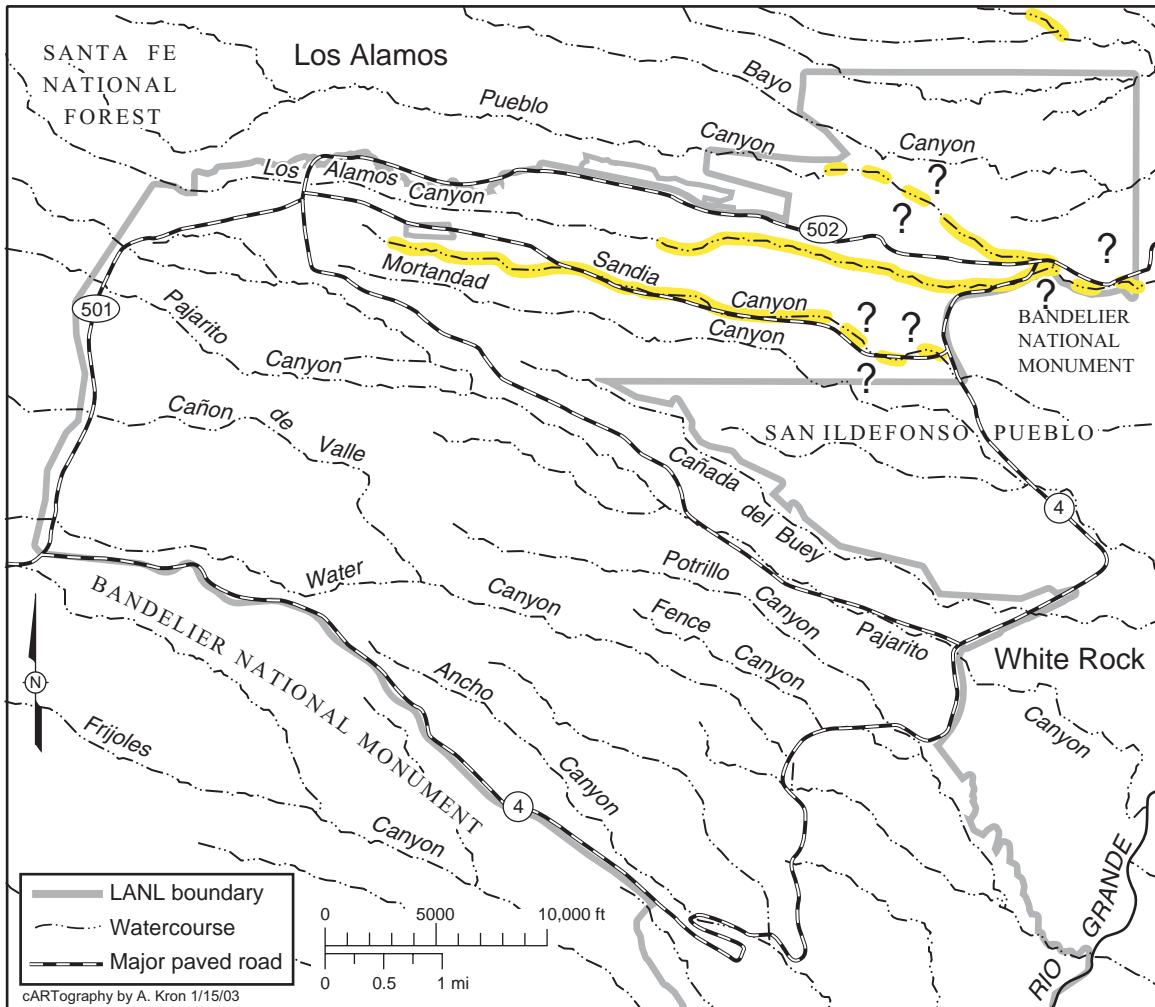


Range of Storm Runoff Concentrations  
Compared to Background



**Figure 6-14.** Location of storm runoff with total chromium above background levels. Different colors indicate the proportion of concentration to the background level. The highest total chromium concentration was in Sandia Canyon in 2002, at 8 times background. Dissolved chromium was detected at concentrations above the New Mexico Groundwater Standard in Water Canyon and Guaje Canyon (north of LANL). The highest concentration was 4.7 times the standard. These streams are not a drinking water source.

Total Copper in Storm Runoff > Background



Range of Storm Runoff Concentrations Compared to Background

- 1 - 10 x Background
- 10 - 100 x Background

**Figure 6-15.** Location of storm runoff with total copper above background levels. Different colors indicate the proportion of concentration to the background level. The highest total copper concentration was in Sandia Canyon in 2002, at 1.7 times background. Dissolved copper was detected at concentrations above the New Mexico short-term (acute) aquatic life standard in Water and Guaje Canyons (north of LANL), at levels up to 20 times the standard. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande while streams within LANL do not have fish.

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Table 6-1 lists representative highest values measured for key analytes in sediment and storm runoff samples in 2001 and 2002. The table also lists the location and year the values were measured and provides a comparison of the results to screening values or regulatory standards.

**a. Radionuclides.** Past release of radioactive liquid effluents into Pueblo, DP, and Los Alamos canyons and current releases into Mortandad Canyon have introduced americium-241, cesium-137, plutonium-238, and plutonium-239,-240, among other radionuclides, into canyon bottoms. These radionuclides bind to stream sediments and persist at levels several orders of magnitude above worldwide fallout levels.

Beginning with Manhattan Project operations in the 1940s, surface water and storm runoff have transported plutonium bound to sediments off site in the Los Alamos Canyon drainage. Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, and into the Rio Grande (Graf 1993, 1997). Plutonium-239,-240 is found in active channel sediments in Pueblo Canyon at levels more than 100 times above fallout levels (Figures 6-4 and 6-5) but remain below SALs. Sediments containing plutonium-239,-240 at levels more than 10 times fallout background extend off site down Los Alamos Canyon onto San Ildefonso Pueblo land. Individual storm runoff events in Pueblo Canyon sometimes contain plutonium-239,-240 levels above the 100-mrem DOE DCG for public exposure (based on water ingestion). However, flows for the entire year average approximately 5% of the DCG (Figures 6-6 and 6-7), and storm runoff is not a source of drinking water. Downstream of the Laboratory, plutonium-239,-240 levels have risen recently by 2 to 18 times in Cochiti Reservoir bottom sediments, reflecting accelerated erosion of Laboratory-derived plutonium from Pueblo Canyon after the Cerro Grande fire. The plutonium activity in these sediments, however, remains below a level that would pose a threat to health and the environment.

In Mortandad Canyon, cesium-137 activities are greater than SALs (ER 2001) for active channel sediment by up to five times in many samples (Figure 6-3). These cesium-137 values also were up to 1.5 times the industrial worker screening level. Americium-241 activities in Mortandad Canyon sediments are more than 100 times fallout levels. Plutonium-239,-240 is found in Mortandad Canyon sediments at levels more than 100 times above fallout levels (Figure 6-5), but those levels remain below SALs. Some sediment radioactivity

at levels slightly above fallout extends beyond the San Ildefonso Pueblo boundary for possibly up to 2 miles (Gallaher et al. 1997).

Above-background radioactivity in sediments also occurs in the vicinity of two material disposal areas. Sediments near Area G (TA-54) show americium-241 at less than 10 times fallout levels, and plutonium-238 and plutonium-239,-240 at more than 10 times fallout levels. Area AB (TA-49) has sediments with americium-241 at less than 10 times fallout levels, and plutonium-239,-240 at more than 10 times fallout levels. Storm runoff near Area G carries similarly elevated levels of these radionuclides.

**b. Polychlorinated Biphenyls.** Polychlorinated biphenyls (PCBs) are synthetic organic chemicals that are used in a variety of industrial applications such as electrical transformers. We have detected PCBs in sediments in nearly all the major canyons that flow across Laboratory land. The highest concentrations are in upper Sandia Canyon near the Laboratory's main technical area, where concentrations are near EPA residential soil-screening levels and 26% of the industrial outdoor worker screening level (Figure 6-8). There are numerous potential PCB sources in upper Sandia Canyon. Health standards and the water quality standards for PCBs are concerned with long-term exposure. Runoff events in Los Alamos are typically short in duration and give minimal exposure to PCBs. To assess the levels of PCBs in the northern Rio Grande watershed, LANL is participating in a special study with state, local, and tribal government agencies.

**c. Perchlorate.** Several Laboratory discharges contained perchlorate at significant levels until March 2002. In 2002, we did not detect the chemical in any surface water samples on the Pajarito Plateau, except in Mortandad Canyon below the Radioactive Liquid Waste Treatment Facility (RLWTF).

**d. Polycyclic Aromatic Hydrocarbons in Sediment.** Polycyclic aromatic hydrocarbons (PAHs) are complex hydrocarbons formed by incomplete combustion of petroleum products or organic matter or are in products such as asphalt or tar. PAHs are commonly found in urban runoff. PAHs—benzo(a)pyrene, benzo(b)fluoranthene, and benzo(a)anthracene—at levels near or well above the EPA residential soil-screening levels are present in the following canyons—Acid, DP, Los Alamos, Sandia, Pajarito, and Mortandad—and are found at Areas G and AB (Figure 6-9). Values for benzo(a)pyrene in Los Alamos Canyon in 2001 were



Table 6-1. Representative Highest Values in Sediment and Storm Runoff Samples Compared to Screening Levels

Analyte	Location	Year	Result	Background Screening Level <sup>1</sup>			
				Units	Type	Value <sup>2</sup>	Result+Screen
<b>Sediment</b>							
<sup>241</sup> Am	Mortandad at MCO-5	2002	10.2	pCi/g	Fallout Background	0.076	134.21
<sup>137</sup> Cs	Mortandad at MCO-5	2002	28.6	pCi/g	Fallout Background	0.56	51.07
<sup>238</sup> Pu	Mortandad below Effluent Canyon	2002	3.68	pCi/g	Fallout Background	0.0087	422.99
<sup>239, 240</sup> Pu	Acid above Pueblo	2002	7.96	pCi/g	Fallout Background	0.013	612.31
<sup>239, 240</sup> Pu	Mortandad below Effluent Canyon	2002	7.09	pCi/g	Fallout Background	0.013	545.38
Aroclor-1260 (PCB)	Sandia below Wetlands	2002	213	µg/kg			
Benzo(a)pyrene (PAH)	Los Alamos at LAO-1	2001	915	µg/kg			
Benzo(a)pyrene (PAH)	Los Alamos at Upper GS	2001	938	µg/kg			
Benzo(a)pyrene (PAH)	Sandia rt fork at Power Plant	2002	149	µg/kg			
<b>Runoff</b>							
<sup>238</sup> Pu (total)	DP above LA	2001	1.4	pCi/L	Runoff background	NA	6.21
<sup>239,240</sup> Pu (total)	Pueblo above SR-502	2001	80	pCi/L	Runoff background	NA	25
Barium (dissolved)	Water at SR-4	2001	6,100	µg/L			
Barium (dissolved)	Canon de Valle above SR-501	2001	5,210	µg/L			
Barium (dissolved)	Guaje above Rendija	2001	4,150	µg/L			
Barium (total)	Water at SR-4	2002	9,520	µg/L	Runoff background	NA	2.1
RDX (total)	Water below SR-4	2001	1.5	µg/L			
Zinc (dissolved)	Sandia Tributary at Heavy Equipment	2001	2,600	µg/L			
Zinc (dissolved)	Water at SR-4	2001	1,020	µg/L			
Zinc (dissolved)	Guaje above Rendija	2001	958	µg/L			
Zinc (total)	Sandia Tributary at Heavy Equipment	2001	2,770	µg/L	Runoff background	NA	3.4
Zinc (total)	Twomile tributary at TA-3	2002	2,840	µg/L	Runoff background	NA	3.4
Chromium (dissolved)	Water at SR-4	2001	235	µg/L			
Chromium (dissolved)	Guaje above Rendija	2001	86	µg/L			
Chromium (dissolved)	Water at SR-4	2002	74.6	µg/L			
Chromium (total)	Sandia below Wetlands	2002	478	µg/L	Runoff background	NA	8
Copper (dissolved)	Water at SR-4	2001	262	µg/L			
Copper (dissolved)	Guaje above Rendija	2001	122	µg/L			
Copper (dissolved)	Water at SR-4	2002	82.6	µg/L			
Copper (total)	Sandia below Wetlands	2002	184	µg/L	Runoff background	NA	1.68
Silver (total)	Water below SR-4	2001	307	µg/L	MDL	1.00	307
Mercury (total)	Los Alamos above SR-4	2001	1.69	µg/L			

**Table 6-1. Representative Highest Values in Sediment and Storm Runoff Samples Compared to Screening Levels (Cont.)**

Analyte	Location	Year	Result	Units	Residential Screening Level or Standard <sup>1</sup>			Industrial Screening Level or Standard <sup>1</sup>		
					Type	Value	Result+Screen	Type	Value	Result+Screen
<b>Sediment</b>										
<sup>241</sup> Am	Mortandad at MCO-5	2002	10.2	pCi/g	Residential SAL	39	0.26	Industrial	56	0.18
<sup>137</sup> Cs	Mortandad at MCO-5	2002	28.6	pCi/g	Residential SAL	5.3	5.4	Industrial	19	1.48
<sup>238</sup> Pu	Mortandad below Effluent Canyon	2002	3.68	pCi/g	Residential SAL	49	0.08	Industrial	65	0.06
<sup>239,-240</sup> Pu	Acid above Pueblo	2002	7.96	pCi/g	Residential SAL	44	0.18	Industrial	60	0.13
<sup>239,-240</sup> Pu	Mortandad below Effluent Canyon	2002	7.09	pCi/g	Residential SAL	44	0.16	Industrial	60	0.12
Aroclor-1260 (PCB)	Sandia below Wetlands	2002	213	pCi/g	EPA RSSL	220	0.97	EPA IOWSSL	830	0.26
Benzo(a)pyrene (PAH)	Los Alamos at LAO-1	2002	915	pCi/g	EPA RSSL	60	15.25	EPA IOWSSL	230	3.98
Benzo(a)pyrene (PAH)	Los Alamos at Upper GS	2002	938	pCi/g	EPA RSSL	60	15.63	EPA IOWSSL	230	4.08
Benzo(a)pyrene (PAH)	Sandia rt fork at Power Plant	2002	149	pCi/g	EPA RSSL	60	2.48	EPA IOWSSL	230	0.65
<b>Runoff</b>										
<sup>238</sup> Pu (total)	DP above LA	2002	1.4	pCi/g				DCG	40	0.04
<sup>239,-240</sup> Pu (total)	Pueblo above SR-502	2002	80	pCi/g				DCG	30	2.67
Barium (dissolved)	Water at SR-4	2002	6,100	pCi/g	NM Groundwater	1,000	6.1			
Barium (dissolved)	Canon de Valle above SR-501	2002	5,210	pCi/g	NM Groundwater	1,000	5.21			
Barium (dissolved)	Guaje above Rendija	2002	4,150	pCi/g	NM Groundwater	1,000	4.15			
Barium (total)	Water at SR-4	2002	9,520	pCi/g						
RDX (total)	Water below SR-4	2002	1.5	pCi/g	Tap Water	0.61	2.62			
Zinc (dissolved)	Sandia Tributary at Heavy Equip.	2002	2,600	pCi/g	Aquatic Life (acute)	117	22.22			
Zinc (dissolved)	Water at SR-4	2002	1,020	pCi/g	Aquatic Life (acute)	117	8.72			
Zinc (dissolved)	Guaje above Rendija	2002	958	pCi/g	Aquatic Life (acute)	117	8.19			
Zinc (total)	Sandia Tributary at Heavy Equip.	2002	2,770	pCi/g						
Zinc (total)	Twomile tributary at TA-3	2002	2,840	pCi/g						
Chromium (dissolved)	Water at SR-4	2002	235	pCi/g	NM Groundwater	50	4.7			
Chromium (dissolved)	Guaje above Rendija	2002	86	pCi/g	NM Groundwater	50	1.72			
Chromium (dissolved)	Water at SR-4	2002	74.6	pCi/g	NM Groundwater	50	1.49			
Chromium (total)	Sandia below Wetlands	2002	478	pCi/g						
Copper (dissolved)	Water at SR-4	2002	262	pCi/g	Aquatic Life (acute)	13.4	19.55			
Copper (dissolved)	Guaje above Rendija	2002	122	pCi/g	Aquatic Life (acute)	13.4	9.1			
Copper (dissolved)	Water at SR-4	2002	82.6	pCi/g	Aquatic Life (acute)	13.4	6.16			
Copper (total)	Sandia below Wetlands	2002	184	pCi/g						
Silver (total)	Water below SR-4	2002	307	pCi/g						
Mercury (total)	Los Alamos above SR-4	2002	1.69	pCi/g	Aquatic Life (acute)	2.4	0.70			

<sup>1</sup>Sources of screening levels for sediment: Fallout Background: from McLin and Lyons 2002; Residential SAL: Screening Action Level from ER 2001; RSSL: EPA Region 6 Residential Soil Screening Level; IOWSSL: EPA Region 6 Industrial Outdoor Worker Soil Screening Level; Industrial: Industrial worker screening level: for an industrial scenario at 15 mrem/y dose, (Perona et al, 1998).

<sup>2</sup>Sources of screening levels for storm runoff: Runoff Background: Background concentration in storm runoff varies for each sample depending on suspended sediment concentration. MDL: As it is rarely detected, the background concentration in runoff for silver is assumed to be the typical analytical detection limit of 1 ug/L. NM Groundwater: New Mexico Water Quality Control Commission groundwater standards (NMWQCC 2002a). Tap Water: EPA Region 6 Tap Water Screening Level. Aquatic Life (acute): New Mexico Water Quality Control Commission stream standards (NMWQCC 2002b); (We assumed 100 mg/L hardness to calculate screening levels for zinc, copper). Wildlife Habitat: NMWQCC stream standard for total mercury. DCG: DOE 100 mrem public dose Derived Concentration Guide.

<sup>3</sup>NA: For storm runoff, analysts used to calculate a linear regression fit to a large group of samples for each sample based on suspended sediment concentration.

4 times the EPA industrial outdoor worker soil screening level, and a 2002 value in Sandia Canyon was 65% of this screening level. Sources of the PAHs are not clear, but the Cerro Grande fire is a likely contributor. The proximity of some of the higher concentrations to developed areas indicates that highway runoff is also a major contributor.

**e. High Explosives, Barium, and Silver.** The Laboratory formerly released wastewater containing high levels of several high explosives (HEs) and barium from processing sites in TA-16 and TA-9 into Water Canyon and Cañon de Valle. For many decades, the Laboratory also discharged spent photographic solutions that contained silver into a tributary of Cañon de Valle. The occasional storm runoff event contains cyclonite (RDX, an HE compound) above 2 ppb, an EPA risk-based tap water action level, and total barium up to 10 times background (Figures 6-10 through 6-13). Silver is rarely detected in water samples. However, in Cañon de Valle, silver is often detected at levels more than 100 times analytical detection limits. Because storm runoff occurs infrequently and for short durations, there is little opportunity for direct exposure. Although a large portion of the barium carried by storm runoff is in particulate form, dissolved concentrations up to 6 times larger than the New Mexico groundwater standard were measured in several canyons. Because some of these higher dissolved barium values were found upstream and north of the Laboratory, it is uncertain to what extent they are due to LANL operations. Two 2002 dissolved silver values were above the NMWQCC acute aquatic life stream standard, but these values have not been found consistently at any location. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande, while streams within LANL are not designated as fisheries.

**f. Mercury.** About 20% of storm runoff samples contain detectable levels of mercury, but at levels below acute aquatic life standards. Laboratory spills of mercury have occurred in the past, but it is uncertain if the mercury in the runoff is from LANL operations. Background levels of mercury in waters and sediments are appreciable, and we have measured mercury in runoff and sediment samples from Guaje Canyon at a background location far from Laboratory operations. Mercury in runoff is a concern because it can enter the Rio Grande and accumulate in fish. The contribution of Los Alamos-area mercury into the Rio Grande and

Cochiti Reservoir cannot be differentiated from other possible contributors in sediment or water samples.

**g. Chromium, Copper, Lead, and Zinc.** In Sandia Canyon, chromium levels in storm runoff samples exceed average background levels by as much as 4 to 10 times (Figures 6-12 and 6-13). A potential source of this chromium is a water treatment biocide chemical formerly used in cooling towers at LANL throughout the 1980s. Storm runoff in Pueblo and Los Alamos canyons contains slightly elevated levels of chromium, copper, lead, and zinc (Figures 6-14 and 15), all of uncertain origin. While most of the metals carried by the storm runoff are associated with the sediment, dissolved chromium concentrations up to 5 times larger than the New Mexico groundwater standard were measured in several canyons. Dissolved copper and zinc concentrations were larger than short-term (acute) aquatic life standards by up to approximately 20 times. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande while streams within LANL are not designated as fisheries. Because some of the higher dissolved chromium, copper, and zinc values were found north of the Laboratory, it is uncertain to what extent they are due to LANL operations.

### E. Monitoring Network

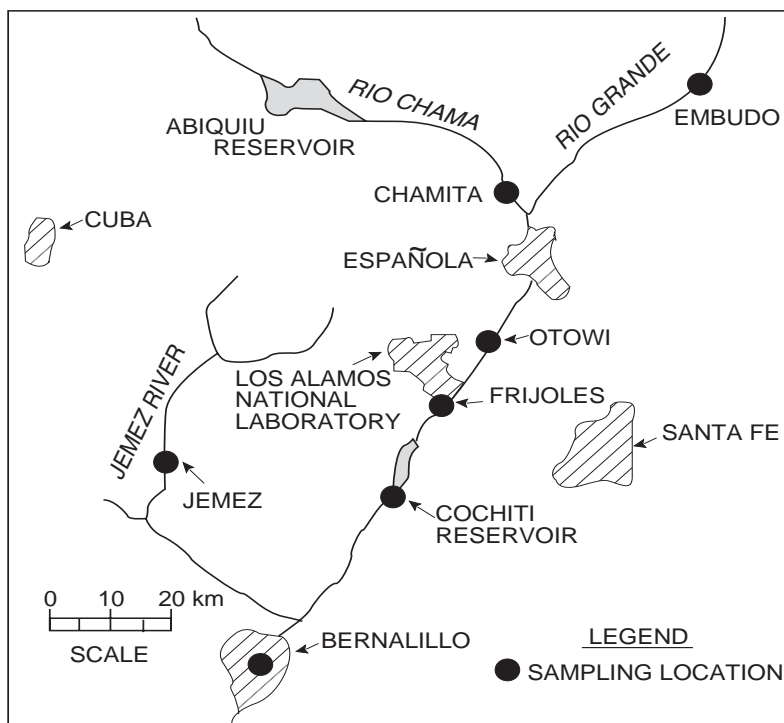
#### 1. Regional Monitoring Locations

Regional base flow and sediment-sampling stations (Figure 6-16) are located in northern New Mexico and southern Colorado. Samples from regional stations provide a basis for estimating background concentrations of nonradioactive compounds and background activities of radionuclides that are naturally occurring or result from atmospheric fallout. We obtained regional sediment samples from reservoirs on the Rio Grande and the Rio Chama and at stations on the Rio Grande and the Jemez River. Sampling stations in the Rio Grande drainage system are located up to 200 km upstream and 60 km downstream of the Laboratory.

#### 2. On-Site and Perimeter Monitoring Locations

We sample surface water and sediments in all major canyons that cross Laboratory land, including those canyons with either persistent or brief flows. We sample stream sediments to evaluate any accumulation of undissolved contaminants in the aquatic environment (DOE 1991). During 2002, we reevaluated the locations of base flow and sediment stations. In many cases, we

## 6. Watershed Monitoring



**Figure 6-16.** Regional base-flow and sediment-sampling locations.

consolidated station locations with nearby gauging stations, to collect surface water and sediment samples at the same location. In other cases, sediment stations were adjusted to reflect current channel locations or to move the station above effects of disturbance by construction or post-Cerro Grande fire mitigation activity.

We collect base-flow samples from Pajarito Plateau stations within and near the Laboratory and snowmelt at upstream and downstream gauging stations at the Laboratory boundary. We collect base-flow grab samples annually from locations where effluent discharges or natural runoff maintains persistent stream flow (Figure 6-17).

After 1996, we have collected storm runoff samples using stream-gauging stations with automated samplers (Figure 6-18). The stream-gauging stations collect samples when a significant rainfall causes flow in a monitored portion of a drainage. Many gauging stations are located where drainages cross the Laboratory's boundaries. We also sample storm runoff at several mesa-top sites that allow us to target specific industrial activities. These sites have negligible runoff from other sources.

Sediment stations on the Pajarito Plateau (Figure 6-19) are located within approximately 4 km of Laboratory boundaries, with the majority located within

Laboratory boundaries. Many of the sediment-sampling stations on the Pajarito Plateau are located within canyons to monitor sediment contamination in the active channel related to past and/or present effluent release sites. We sampled three major canyons (Pueblo, Los Alamos, and Mortandad) that have experienced past or present liquid radioactive releases from upstream of the Laboratory to their confluence with the Rio Grande.

We also collected sediments from drainages downstream of two material disposal areas. Material disposal area G at TA-54 is an active waste storage and disposal area. Nine sampling stations were established outside its perimeter fence in 1982 (Figure 6-20) to monitor possible transport of radionuclides from the area.

Area AB at TA-49 was the site of underground nuclear weapons testing from 1959 to 1961 (Purtyum and Stoker 1987, ESP 1988). The tests involved HEs and fissionable material insufficient to produce a nuclear reaction. We established 11 stations in 1972 to monitor surface sediments in drainages adjacent to Area AB (Figure 6-21).

We also sample surface water and sediments at several locations on San Ildefonso Pueblo lands. DOE entered into a Memorandum of Understanding with

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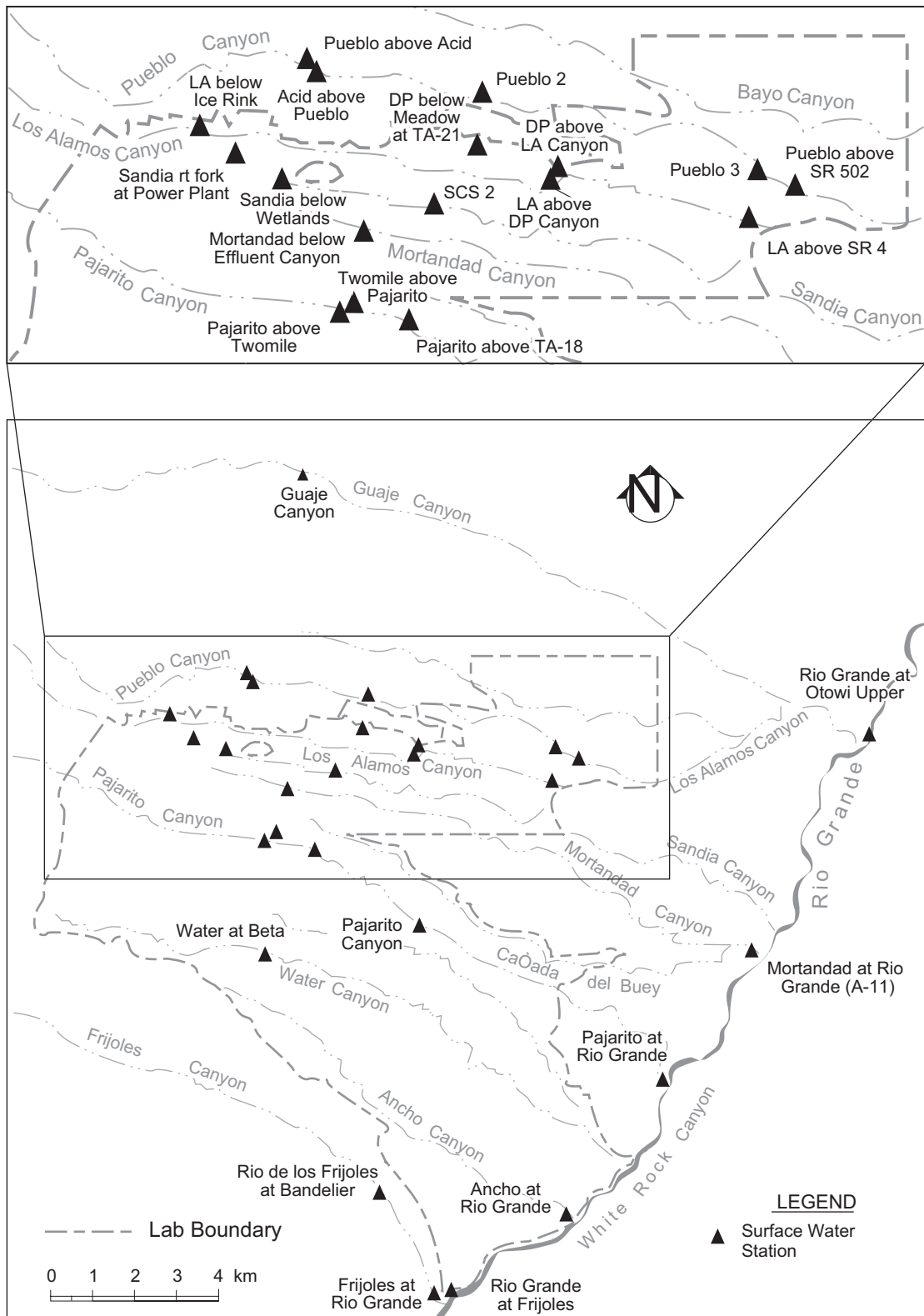


Figure 6-17. Base-flow sampling locations in the vicinity of Los Alamos National Laboratory.



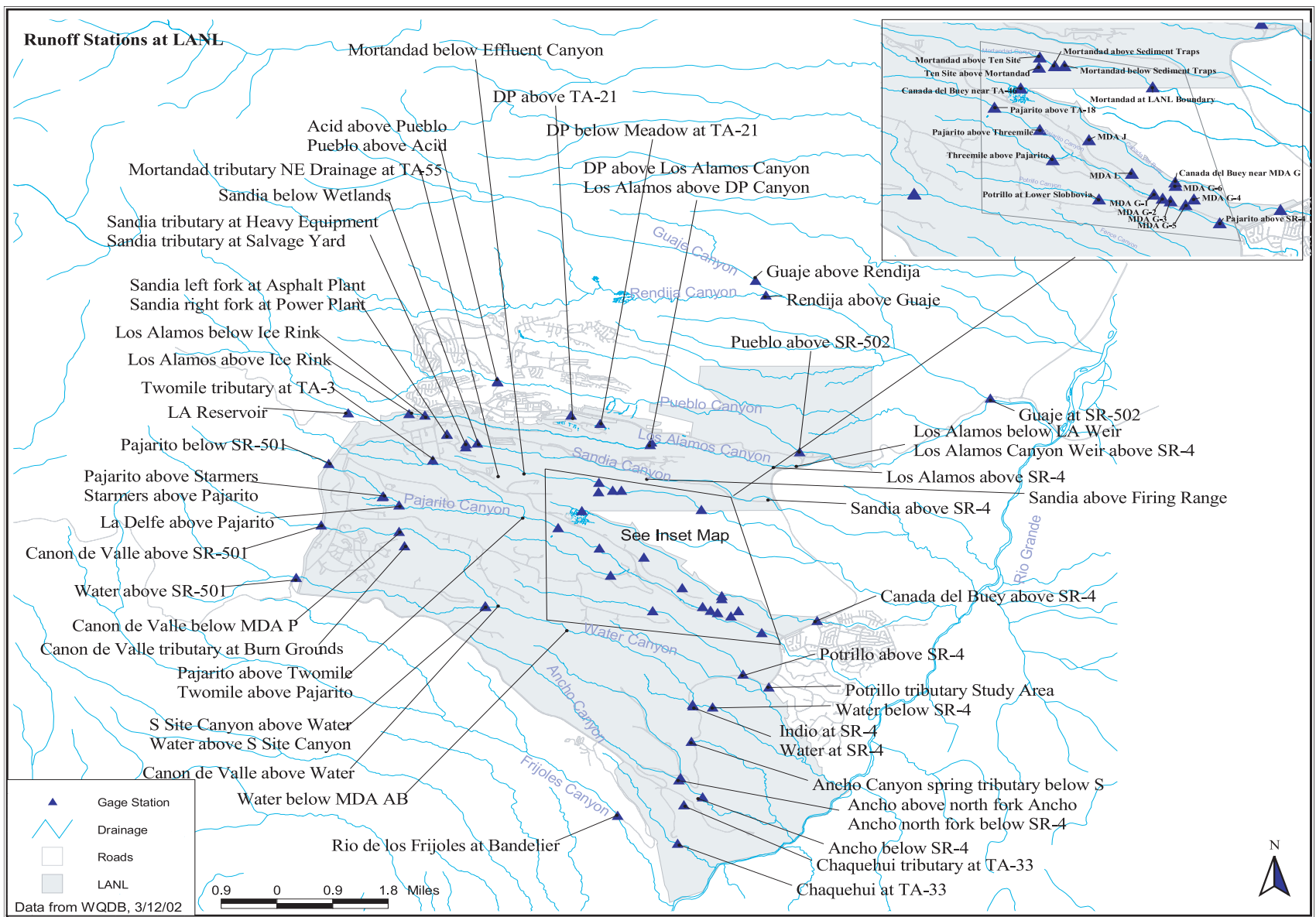
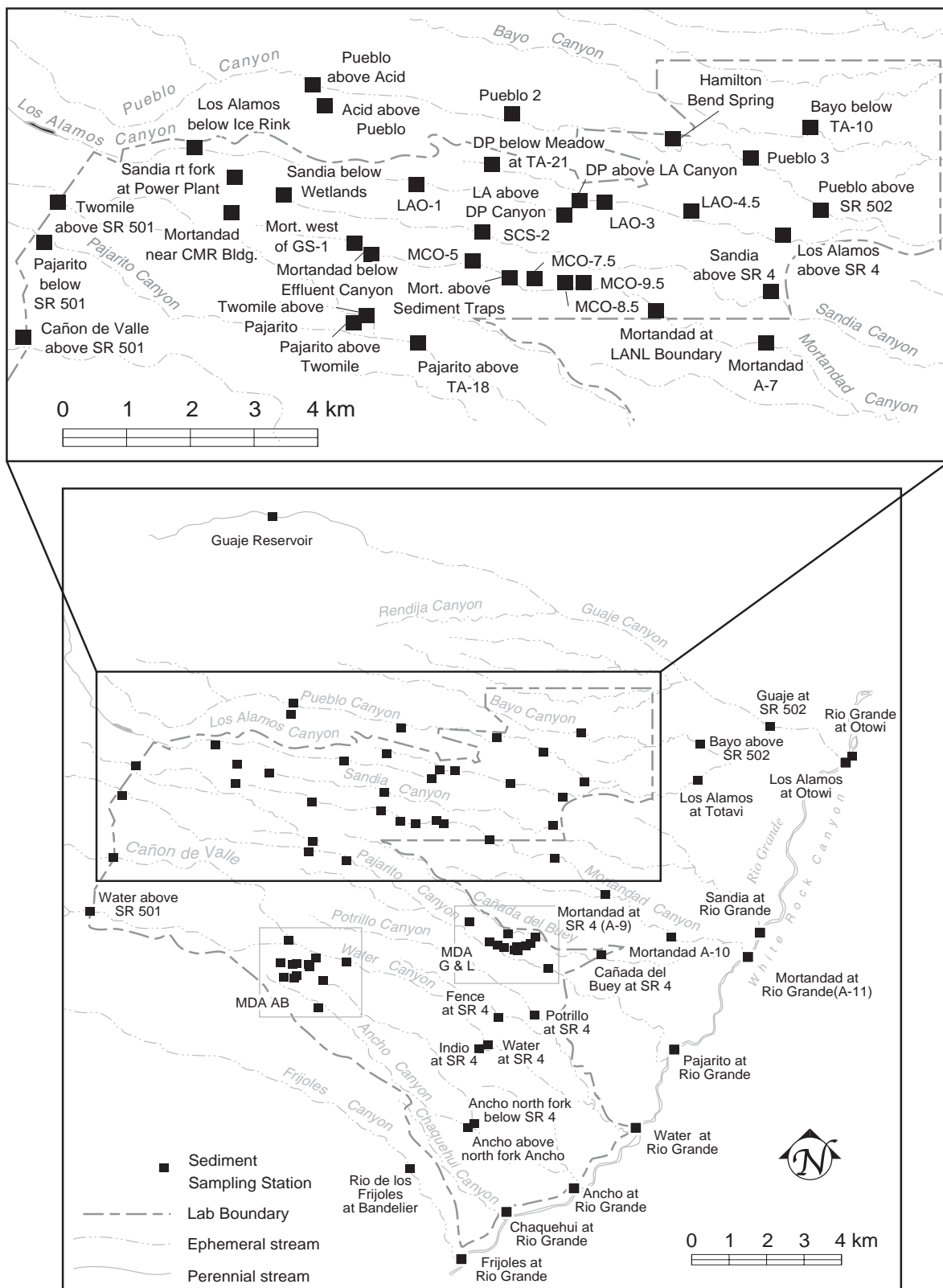


Figure 6-18. Storm runoff sampling (gauging) stations in the vicinity of Los Alamos National Laboratory.

## 6. Watershed Monitoring



**Figure 6-19.** Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-20 and 6-21.

## 6. Watershed Monitoring

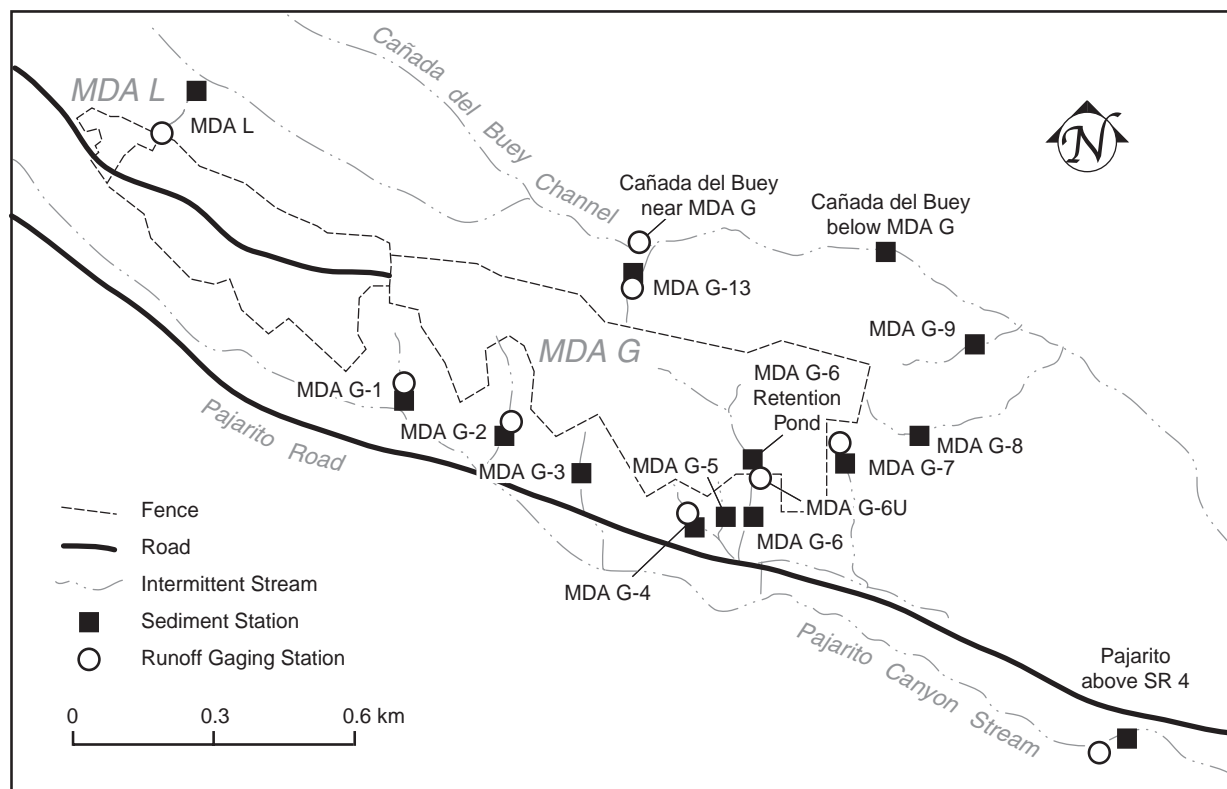


Figure 6-20. Sediment and storm runoff sampling stations at TA-54, Area L and Area G.

the Pueblo and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on pueblo land. The watersheds that pass through LANL onto the pueblo are Los Alamos, Sandia, and Mortandad canyons.

### 3. Sampling and Analysis Procedures

Our procedures for sampling and analysis depended on what types of samples were taken and where and how they were taken. We collect grab samples of base flow from free-flowing streams near the bank. When required, we filter and preserve grab samples in the field. The storm runoff (gauging) stations are equipped with automated samplers, which are activated during major flow events. We submit a time-weighted composite sample of the collected runoff water for chemical analysis. The analytical laboratory filters and preserves runoff samples, because filtering highly sediment-laden waters in the field is difficult.

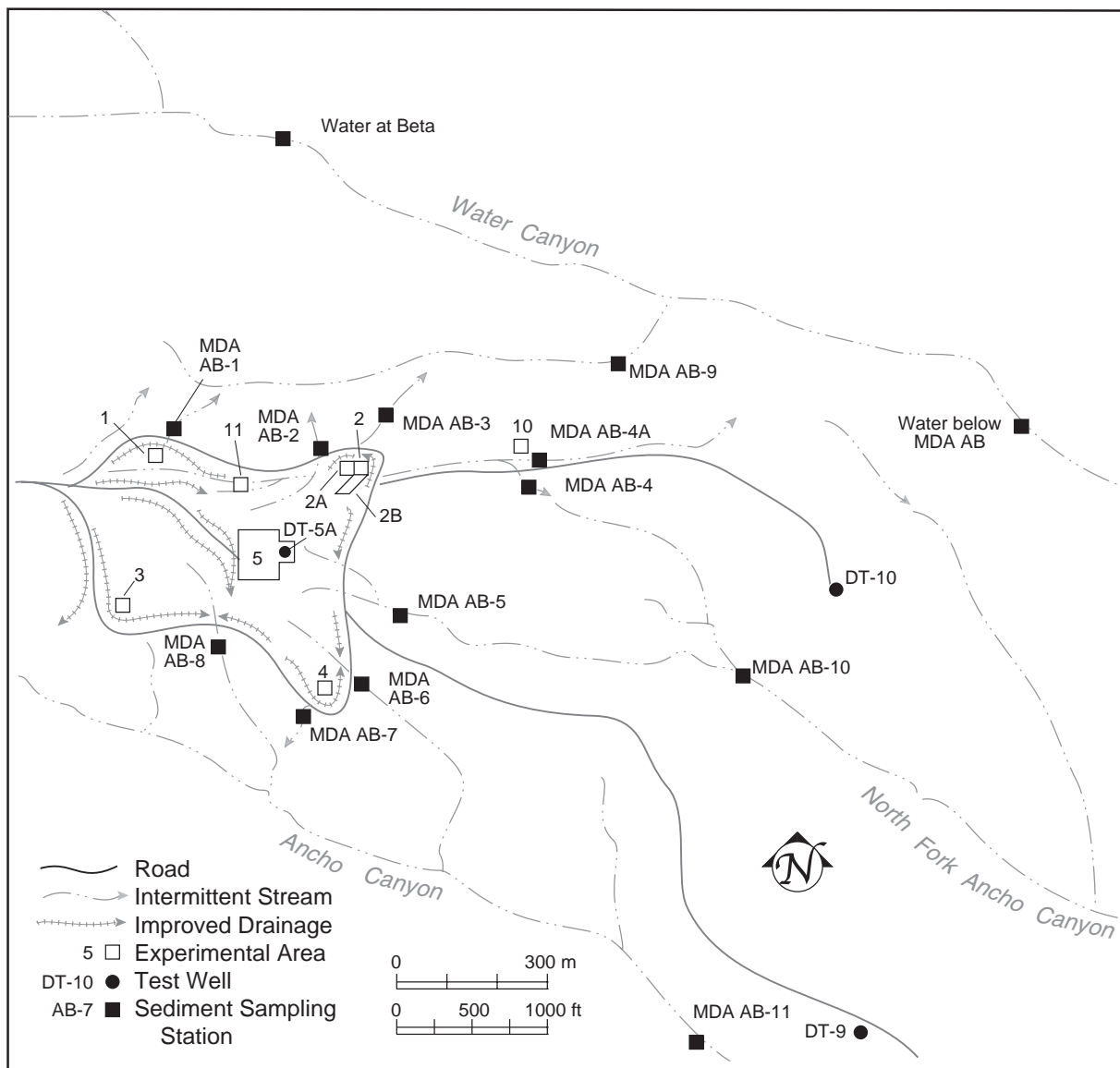
We collect sediment samples from the main channels of flowing streams. To get samples from the beds of intermittently flowing streams, we use a disposable scoop to collect samples across the main channel to a depth of 20 mm.

### F. 2002 Watershed Monitoring Results

Surface water and sediment samples are analyzed for gross alpha, gross beta, and selected radionuclides (americium-241; cesium-137; plutonium-238; plutonium-239,-240; strontium-90; uranium isotopes; and tritium). Tables S6-1 and S6-2 in the Data Supplement list the results of radiochemical analyses of surface water and sediment samples for 2002. The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity where available. Uranium was analyzed by isotopic methods; from these values, specific activities for each isotope were used to calculate the total uranium concentration.

To emphasize values that are detections, Table S6-3 lists radionuclides detected in surface water samples and compares the results to regulatory standards. Detections are defined as values that exceed both the analytical method detection limit (MDL) (where available) and three times the individual measurement uncertainty. The right-hand columns of Table S6-3 show how the results compare to the standards shown.

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**Figure 6-21.** Sediment sampling stations at Area AB, TA-49.

Qualifier codes are shown in some tables because some analytical results that meet the detection criteria are not detections: in some cases, the analyte was found in the laboratory blank or was below the MDL, but the analytical result was reported as the minimum detectable activity. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation. For an explanation of the qualifier codes, see Tables S5-5, S5-6, and S5-7 in the Data Supplement.

Tables S6-4 and S6-5 (reservoir sediments) list radiological detections for results that are higher than river or reservoir sediment background levels and

identify values that are near or above SALs. Table S6-4 shows all tritium detections regardless of screening levels.

Table S6-6 lists the results of general chemical analyses of surface water samples for 2002. Table S6-7 lists surface water perchlorate results. The results of trace metal analyses of surface water appear in Table S6-8 and those for sediments appear in Table S6-9.

In 2002, we analyzed samples for organic constituents at selected surface water and sediment stations. Samples were analyzed for volatile organic compounds (surface water only), semivolatile organic compounds, PCBs, and HE. Analytical methods are given in

## 6. Watershed Monitoring

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Table A-4 and analytes for each suite are listed in Tables A-5 through A-8, all in Appendix A. The stations and organic suites for which we sampled are listed in Table S6-10 for surface water and in Table S6-11 for sediments. For surface water samples, we rejected many of the possible organic detections the analytical laboratory reported because the compounds were either detected in method blanks (that is, they were introduced during laboratory analysis) or detected in field quality-control samples, including equipment and trip blanks. Trip blanks go along during sampling to determine whether organic constituents come from sample transportation and shipment. Only method blanks are available for comparison with organic results for sediments. Table S6-12 shows organic compounds detected above the analytical laboratory's reporting level in 2002 and results from field quality-control samples. Table S6-13 shows organic compounds detected in sediments.

### G. Site-Wide Monitoring Issues

#### 1. Radioactivity in Surface Water

In storm runoff samples, gross alpha activity results were elevated above the New Mexico state stream standard for livestock watering. The gross alpha values are likely caused by high sediment concentrations in the runoff, rather than by Laboratory operations. None of the individual radioactive isotopes were found above the 100-mrem DOE DCGs for public dose in storm runoff samples. However, some plutonium-239,-240 results greater than the DCG were found in Pueblo Canyon storm runoff samples collected on different dates in 2002 by the RRES-R and by the New Mexico Environment Department (NMED) (NMED 2003a). There is a minimal opportunity for exposure to the runoff, however, as flow is short-lived and not used as a drinking water source.

The DCGs are derived with continuous exposure to water for the period of 1 year assumed (DOE 2003). In order to compare sample results with the DCGs, we calculated the time-weighted average annual radioactivity in runoff, using Pueblo Canyon as a probable worst-case watershed. To maximize data coverage, we used all available results from LANL and NMED for five radionuclides. We did not include uranium in the calculation because uranium in Pueblo Canyon sediments is predominantly natural in origin and contains less than 1% of Laboratory-derived uranium (Gallaher and Efurd 2002).

Table S6-14 in the Data Supplement summarizes the calculated annual average concentrations of the individual radionuclides in upper and lower Pueblo Canyon and compares them against the 100-mrem DCGs. This calculation is new to this report series and so the results for both 2001 and 2002 are summarized to give a better overall picture. Annualized plutonium-239,-240 activities in Pueblo Canyon were approximately 5% of the public dose DCG, and the sum of the measured radioactive constituents was approximately 6% of the DCG. Even though individual storm runoff samples in Pueblo Canyon may be greater than the DCG, surface water quality averaged throughout the entire year reaches only a few percent of the DCG.

#### 2. Gross Alpha and Selenium Levels in Storm Runoff

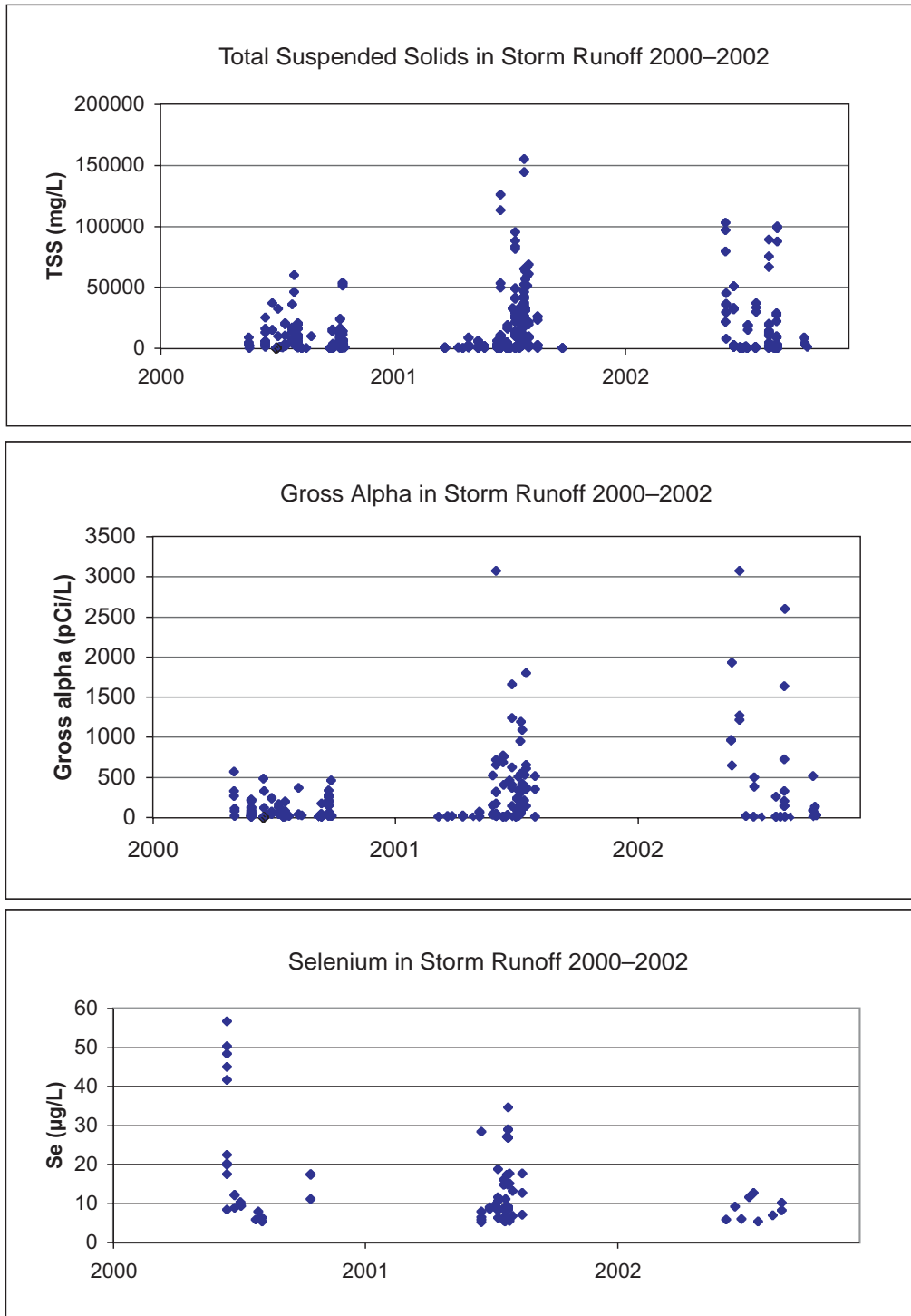
Monitoring results of storm runoff after the Cerro Grande fire have shown widespread gross alpha activities and total recoverable selenium concentrations greater than the New Mexico surface water stream standards of 15 pCi/L and 5 µg/L, respectively (NMWQCC 2002a). In response to these findings, the NMED designated several Los Alamos area drainages as water-quality impaired and added them to the federal Clean Water Act § 303(d) List (NMED 2003b). The affected drainages are Guaje Canyon (selenium, gross alpha), Rendija Canyon (selenium), Pueblo Canyon (selenium, gross alpha), Los Alamos Canyon (selenium, gross alpha), Mortandad Canyon (gross alpha), Pajarito Canyon (selenium, gross alpha), and Water Canyon (selenium, gross alpha).

Figure 6-22 shows the trends in gross alpha, selenium, and total suspended solid concentrations in storm runoff samples collected in the 3 years since the Cerro Grande fire. In 2002, gross alpha activities were approximately the same as in 2001, remaining several orders of magnitude greater than the stream standard. The largest gross alpha activities were registered in Guaje, Rendija, and Pueblo canyons during large runoff events. The gross alpha activities generally correspond to the total suspended solids concentrations. The data indicate that LANL did not produce the elevated alpha activities but that these levels come predominantly from enhanced natural sediment loads caused by increased erosion after the fire.

The selenium concentrations progressively declined over the 3-year period. The downward trend in selenium concentrations is possibly related to a



## 6. Watershed Monitoring



**Figure 6-22.** Time trends in total suspended solids, gross alpha (alpha) activity, and total recoverable selenium (detections only) in storm runoff on the Pajarito Plateau, 2000–2002. Data include results from background sites and stations below Laboratory operations.

## 6. Watershed Monitoring

general flushing of Cerro Grande ash from the landscape. If the trend continues in upcoming years, the concentrations found likely will meet the stream standard for selenium.

To examine further whether elevated concentrations are from Laboratory operations or natural sources, we assessed how levels of these constituents vary with location. In Figures 6-23 and 6-24, we compare gross alpha activities and selenium concentrations in background storm runoff samples collected upstream or north of LANL against those collected onsite or downstream of the Laboratory. Both constituents are normalized by comparing them to an independent measure (either total suspended solids or iron) to adjust for the suspended sediment load. The plots show no appreciable differences in gross alpha activities or selenium concentrations between background samples and on-site samples, and they indicate that the elevated concentrations are largely caused by factors other than Laboratory operations. While the Laboratory has released alpha emitters into some canyons, particularly Pueblo Canyon, the effect is small compared to the total gross alpha activities measured at on-site or background stations.

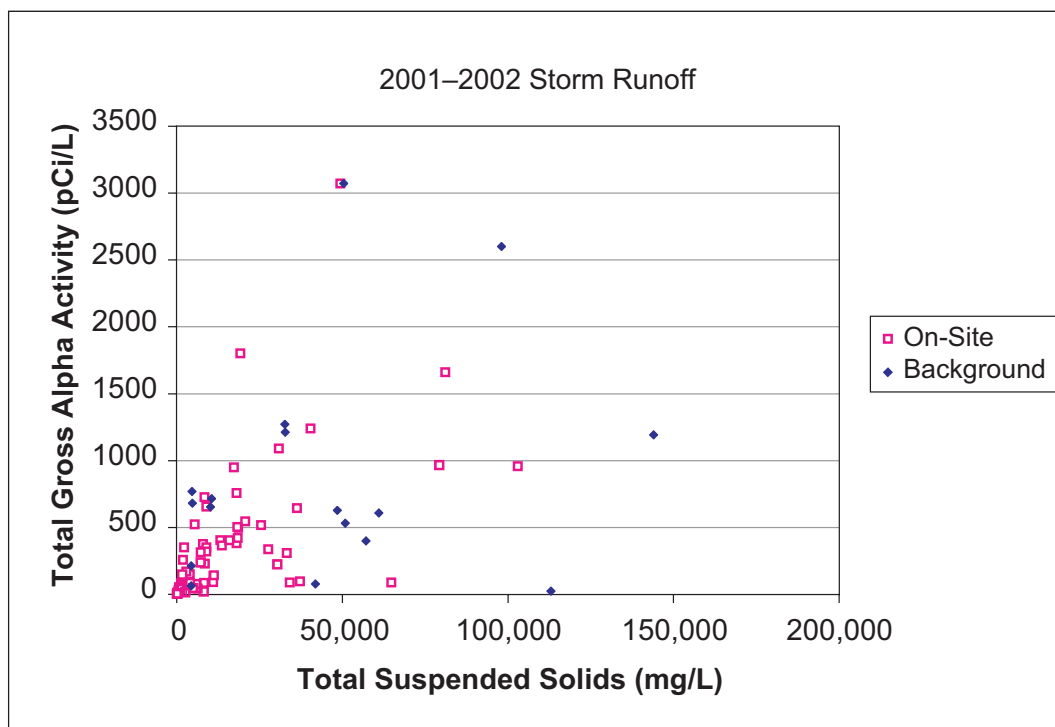
### 3. Perchlorate in Surface Water

Across the country, perchlorate is increasingly recognized as one of the most significant pollutants in waters because of its environmental persistence and toxicity. In 2002, we continued to monitor for perchlorate in all water samples. We used the conventional EPA method 314.0 to analyze 25 base-flow and 37 storm runoff samples for perchlorate (Table S6-7). At a minimum detection limit of 4  $\mu\text{g/L}$ , perchlorate was not detected in any of these samples. While the Laboratory released significant quantities of perchlorate in past effluent discharges, the 2002 surface water data indicate that perchlorate has not remained in the surface environment.

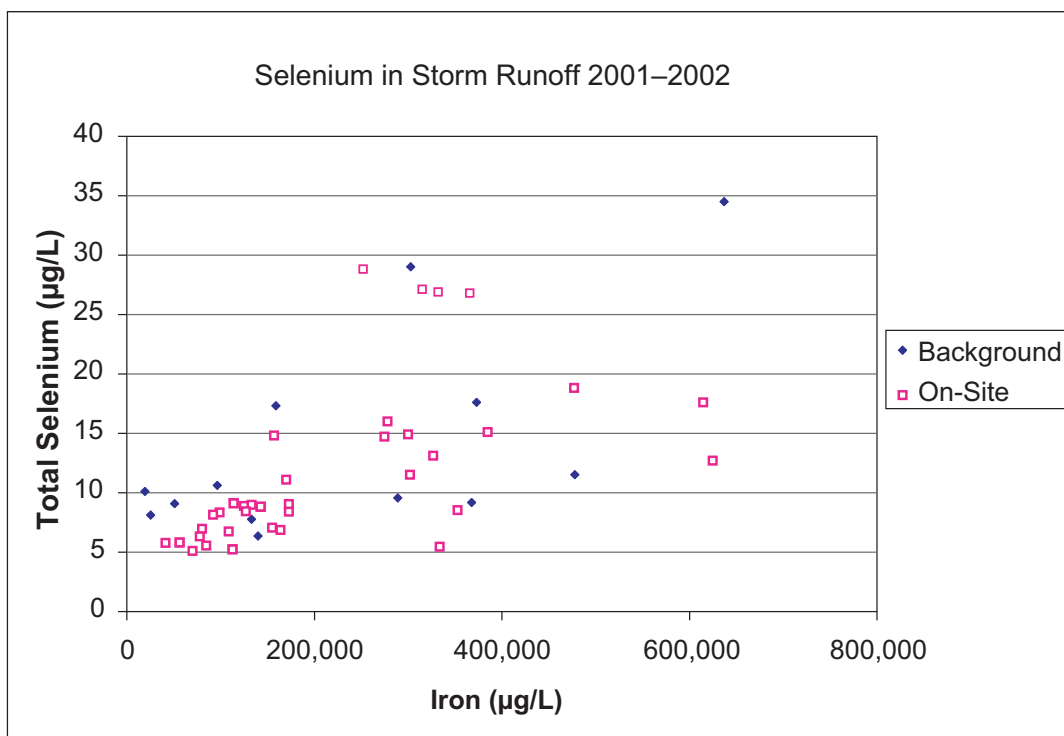
A new and more sensitive analytic method is being tested and may be reported on in next year's Environmental Surveillance Report.

### 4. Polychlorinated Biphenyls in Surface Water and Sediments

The state Human Health Standard for total PCBs is 0.0017  $\mu\text{g/L}$  and applies to waters designated as existing fisheries or having attainable fishery use. The



**Figure 6-23.** Comparison of gross alpha (alpha) activities in storm runoff at sites located upstream or north of (background) and near or downstream from (on-site) Laboratory operations.



**Figure 6-24.** Comparison of selenium concentrations in storm runoff at sites located upstream or north of (background) and near or downstream from (on-site) Laboratory operations.

standards have two subclasses, (1) cancer-causing and (2) persistent. The PCB standard is identified as both persistent and cancer causing. The state applies the Persistent Human Health Standards to all tributaries of waters with a designated, existing, or attainable fishery use and to all the drainages that flow to the Rio Grande from the Laboratory. The human health standard is intended to protect fish consumption use. The rationale for applying it to tributaries such as the LANL canyons where no fish exist is to prevent migration into fisheries. The state has also promulgated Wildlife Habitat Standards. The Wildlife Habitat Standard for PCBs is 0.014 µg/L, which applies when a discharge creates any water that could be used by wildlife, including short-term stream flow.

The standards specify that Clean Water Act (CWA), 40 CFR Part 36, analytical methods be used to determine water quality. The CWA analytical method for PCBs has a typical detection limit of 0.1 µg/L. This detection limit is above both the Human Health Standard and the Wildlife Standard. EPA Method 1668, often called the Congener Method, was developed for low-level PCB measurements. Though not approved by the NMWQCC and not included by EPA in 40 CFR 136,

the Congener Method can measure PCBs at levels comparable to the New Mexico surface water quality standards.

The Laboratory is cooperating with the NMED Surface Water Quality and Oversight Bureaus, Los Alamos County, San Ildefonso Pueblo, and the Department of Energy in a study that uses the Congener Method to develop an understanding of regional PCB concentrations. An early finding of this study showed that regional background soils, upstream of the Laboratory, along the Rio Chama and the Rio Grande, in 2001 had a mean concentration of 0.05 µg/kg (Gonzales and Fresquez 2003).

PCBs have been detected in sediments in all the major canyons that flow across Laboratory lands, with the exception of Ancho Canyon and Cañada del Buey (Figure 6-8). Numerous potential release sites (PRSs) across the Laboratory are contaminated with PCBs. The concentrations are generally less than 10 mg/kg. Minimal erosion from these sites can be detected in downstream sediments at µg/kg concentrations.

Two sediment samples had concentrations of PCBs that are just below the EPA Region 6 residential soil-screening level. We collected both samples in Sandia

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Canyon. The samples contained the PCB mixture Aroclor-1260 at 213  $\mu\text{g}/\text{kg}$  and 205  $\mu\text{g}/\text{kg}$ . The EPA residential soil-screening level for Aroclor-1260 is 220  $\mu\text{g}/\text{kg}$ . For comparison, the NMED Hazardous Waste Bureau has established a default soil cleanup level of 1  $\text{mg}/\text{kg}$  or 1,000  $\mu\text{g}/\text{kg}$  (NMED 2000).

Storm runoff samples collected in Sandia Canyon on July 4 and July 14, 2002, also contained PCB mixtures. Aroclor-1260 and Aroclor-1254 were measured at 0.11  $\mu\text{g}/\text{L}$  and 0.08  $\mu\text{g}/\text{L}$ , respectively.

The source of the PCBs measured in runoff is most likely PCB contamination present in the sediments in the wetland.

### 5. Mercury in Storm Runoff and Sediments

All water bodies contain some mercury from natural sources (including volcanoes and rock weathering) and from human activities (such as burning fossil fuels and industrial waste discharge) (USGS 1997). For example, near Los Alamos we detect mercury in about half of the sediment samples collected at background sites west and north of the Laboratory. During the previous few years, we detected mercury in all five samples collected from Guaje Reservoir, located on the flanks of the Jemez Mountains in the Santa Fe National Forest and far from LANL operations.

Mercury is of concern because of its toxicity, persistence, and ability to accumulate in the tissue of people and fish (ATSDR 2003). Mercury also threatens the health of fish-eating wildlife, such as raccoons. The New Mexico departments of health and environment issued a mercury health advisory regarding consumption of fish caught in Cochiti Reservoir.

The NMED has been concerned because a review of recent storm runoff data led to the conclusion that there has been an increase in mercury detections near Los Alamos that exceed the NMWQCC Wildlife Habitat Standard of 0.77  $\mu\text{g}/\text{L}$  (NMED 2003a). Our water analyses do not directly bear this out. In the last 2 years, we have performed more than 500 analyses of surface waters in the region; only 2 results of the 500 samples showed mercury levels greater than the wildlife standard.

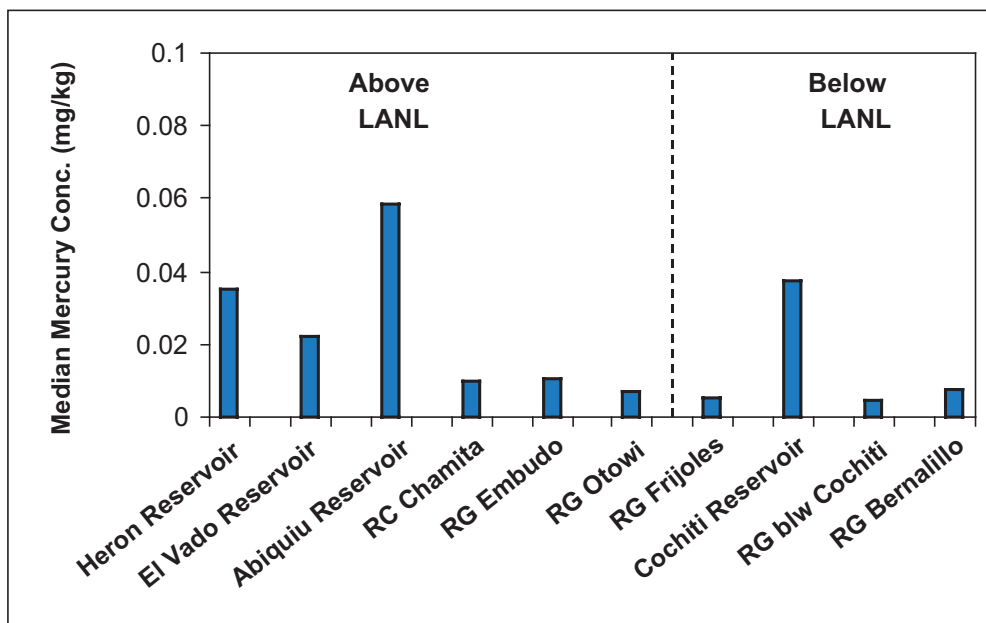
In 2002, we analyzed 88 storm runoff samples for mercury and detected it in 19 samples (20%); one of these detections was from a background station, Guaje Canyon above Rendija Canyon. None of the detections were greater than the acute aquatic life standard. Near Area G, more than half (6 of 11) of the runoff samples contained detectable levels of mercury.

Because local runoff events are short in duration, there is minimal exposure to wildlife from storm runoff. Our analyses show that virtually all of the mercury measured in the water samples is in the form of particulates. Since 2000, mercury was detected in only 1 of 250 surface water samples that were filtered to remove sediment. Particulate mercury may be carried into the Rio Grande by runoff and then biologically transformed to enter the water column and the food chain.

Available data suggest that mercury may be more abundant in the northernmost watersheds from Pajarito Canyon to Guaje Canyon and around Area G and Area AB (Figure 6-13). Since 2000, 6 of the 20 largest mercury sediment concentrations were from Pueblo Canyon and, in total, nearly one-half (9 of 20) of the largest concentrations were found in the Los Alamos Canyon watershed, followed by Mortandad Canyon (four results), Sandia Canyon (two results), and Pajarito Canyon (two results). The higher mercury concentrations in these areas may reflect mercury added by urban or Laboratory sources beyond the background sources.

Regardless of the sources of the mercury in Los Alamos area watersheds, a major question arises of how the contamination in these drainages will ultimately affect the Rio Grande. We compiled recent sediment-sampling results for the Rio Grande drainage system and looked for differences between stations located above and below the Laboratory. Since the Cerro Grande fire, the Laboratory and the US Geological Survey have measured mercury concentrations in more than 60 sediment samples from the Rio Grande drainage system. We collected approximately half of these samples downstream from the Laboratory. Figure 6-25 compares median mercury concentrations measured in samples collected along the Rio Chama and Rio Grande for 2000 to 2002. We expected the Rio Grande downstream from the Laboratory would be affected the most during this time period because it would emphasize post-Cerro Grande fire changes. The figure presents the results in an upstream-to-downstream order and includes data from both river- and reservoir-monitoring stations.

Figure 6-25 shows that median mercury concentrations in Rio Grande sediments collected below the Laboratory are comparable to those collected upstream of LANL. Overall, mercury levels are higher in reservoir sediments than channel sediments because of differences in grain size and chemical composition



**Figure 6-25.** Median mercury concentrations in sediments collected along the Rio Chama (RC) and Rio Grande (RG), 2000 through 2002. The stations are ordered in a north-to-south direction (left to right on graph). The RG Frijoles station includes all data from the Rio Grande collected between Otowi Bridge and Cochiti Reservoir.

between the sediments. Statistically, mercury concentrations in Cochiti Reservoir bottom sediments are indistinguishable from those in Heron, El Vado, and Abiquiu reservoirs (Kruskal Wallis Median Test and Mann Whitney U Test,  $\alpha = 0.05$ ). Similarly, Rio Grande bed sediments collected below the Laboratory contain mercury levels that are statistically indistinguishable from the mercury levels found in samples collected above the Laboratory. Supporting the finding of minimal LANL mercury impacts in the Rio Grande is a study by Fresquez et al. (1999) that found higher mercury levels in fish upstream of LANL than downstream.

In summary, storm runoff in the Los Alamos area occasionally contains detectable mercury, which is at levels below the acute aquatic life stream standard. The higher concentrations have been seen below Laboratory operations as well as in watercourses draining undeveloped National Forest lands that are not affected by Laboratory operations. Because mercury concentrations measured at on-site storm runoff stations are not largely different than those measured at background stations, it is difficult to gauge to what degree Laboratory operations have changed or increased mercury levels. Sediment-monitoring results suggest that higher concentrations of mercury may be present in the northernmost

drainages, particularly in Pueblo Canyon. The source(s) of the higher concentrations, however, remains uncertain because of appreciable mercury concentrations measured at stations not affected by Laboratory operations. Extensive sampling of sediments in the Rio Grande drainage system after the Cerro Grande fire shows that mercury levels are statistically the same below the Laboratory as they are above. While storm runoff from the Los Alamos area has entered the Rio Grande, we find no identifiable increase in mercury concentrations in Rio Grande channel or reservoir sediments downstream from the Laboratory.

### 6. Metals in Surface Waters

All 2002 base-flow samples met applicable standards and screening levels. Overall, the total metal concentrations in storm runoff were markedly less than measured in the previous years because of lesser-magnitude stream flows. In storm runoff, three metals were found at levels greater than New Mexico livestock watering standards: dissolved aluminum (greater than the standard in 7% of samples), dissolved lead (3%), and dissolved vanadium (3%). A high percentage of the results were below these standards, and the



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average water quality easily met the standards. The bulk, if not all, of these higher concentrations appear to be caused by naturally occurring metal concentrations.

After the 2000 Cerro Grande fire, elevated concentrations of many naturally occurring metals have been found in storm runoff. How much of the metals come from Laboratory sources rather than from natural sources is difficult to determine. In this report, we employ an exploratory approach to identify possible LANL effects in sediment-laden storm runoff samples. The technique accounts for metal contributions from the suspended sediment and allows us to distinguish LANL effects with some statistical confidence. In waters upstream or north of LANL (that is, background locations), we found significant correlations between many metals and other independent water quality measurements that serve as measures of the amount of sediment in the sample, such as total suspended solids or concentrations of aluminum or iron. Table S6-15 in the Data Supplement presents equations used to describe how the background levels of the metals and selected radionuclides in runoff vary with suspended sediment load or other measurements. We used estimated prediction limits from linear regression to identify analytical results that are above the range measured in the background waters. The background sites include stations immediately upstream from the Laboratory along State Road (SR) 501 and a station north of LANL operations (Guaje above Rendija station). We applied the approach to most of the metals for which we routinely analyze. Some metals (mercury, molybdenum, silver, and thallium) have not been detected frequently enough for this type of analysis.

Our analysis shows significant naturally occurring concentrations of arsenic, beryllium, cobalt, lead, nickel, and vanadium in storm runoff samples. In contrast, above-background concentrations of barium, chromium, copper, and zinc are indicated. We flagged values greater than the 95% upper prediction limit computed for background as possibly originating from LANL operations. To illustrate, Figure 6-26 highlights the above-background (outlier) values identified using regression analyses for barium and chromium. The metals are plotted against the suspended sediment proxy, aluminum in both of these examples, and the lines describing the 95% upper prediction limits for background concentrations are shown. The graphs show how the above-background values plot in distinct separation from the other values.

Figures 6-2 through 6-15 show the general locations where two or more samples within a canyon contained above-background metal concentrations. Table S6-16 in the Data Supplement lists above-background storm runoff analytical results for metals and selected radionuclides. The table indicates the largest departures from background levels for chromium to be in Sandia Canyon (elevated by up to 8 times) and for barium (2 times) to be in Water Canyon and Cañon de Valle. Laboratory HE processing is most likely responsible for these above-background barium values. (See the following watershed-specific discussions.) At some locations, multiple potential sources may account for the elevated metal levels, including urban runoff and residual ash from the Cerro Grande fire.

None of the above-background total metal concentrations are a health concern. Regulatory limits for these metals apply to dissolved concentrations, and the storm runoff samples readily meet these dissolved-concentration limits.

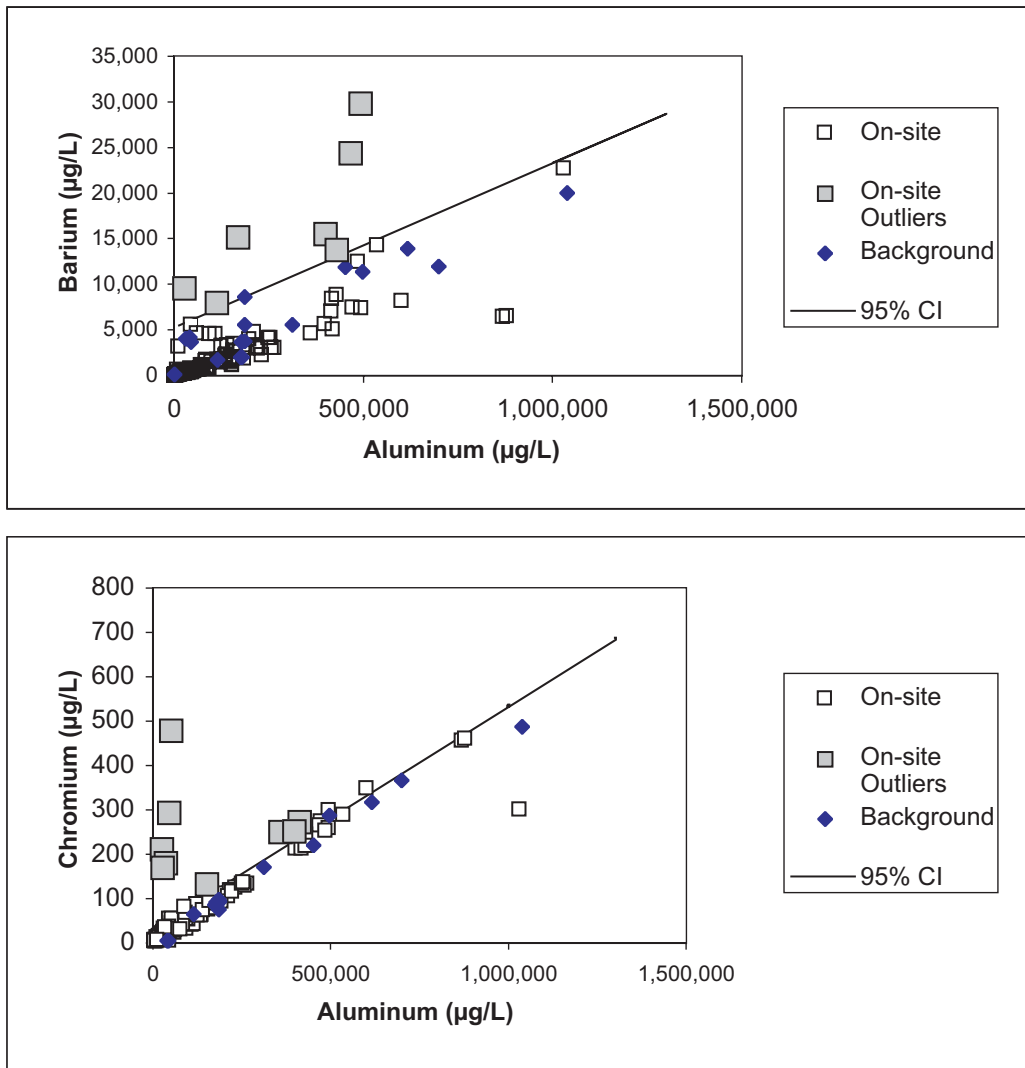
### 7. Post-Fire Changes in the Rio Grande

After the Cerro Grande fire, increased flows in watercourses have accelerated the downstream movement of stream sediments and contaminants into the Rio Grande. During the largest runoff events of each of the past 3 years, flows extended across the Pajarito Plateau to the Rio Grande. Several risk analyses of the early sampling results concluded that health risks associated with use of Rio Grande water did not significantly increase when compared with prefire conditions (RAC 2002, IFRAT 2002, Kraig et al. 2002).

Past studies have identified cesium-137 and plutonium-239,-240 to be among the contaminants most likely to reflect post-fire effects. Ash and storm runoff samples taken in 2000 after the fire and upstream of the Laboratory found cesium-137 levels to be more than 10 times higher than normal (Johansen et al. 2001; Katzman et al. 2001; Gallaher et al. 2002). Several studies (Bitner et al. 2001) have shown that fires concentrate fallout-derived cesium-137 from vegetation into the soil where it is available for redistribution by runoff. In addition, large runoff events in Pueblo Canyon in 2001 and 2002 have accelerated the transport of Laboratory-derived plutonium-239,-240 into lower Los Alamos Canyon and the Rio Grande (ESP 2002; NMED 2003c).

Our preliminary review of the sampling results indicates small but measurable increases in cesium-137 and

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**Figure 6-26.** Above-background barium and chromium concentrations in storm-runoff samples identified through regression analyses. The outlier values are larger than the upper 95% prediction limit (line) for background samples, 2001 through 2002.

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plutonium-239,-240 activities in Cochiti Reservoir bottom sediments, but no apparent changes in dissolved metal concentrations in the Rio Grande or reservoir. Cesium-137 levels in Cochiti Reservoir bottom sediments increased quickly after the fire by three-to-five times in September 2000; but since then, the cesium-137 levels have decreased to near prefire levels at most sampling locations (Figure 6-27). The median post-fire cesium-137 activity in Cochiti Reservoir sediments is approximately 10% of the health-based residential soil SAL of 5.3 pCi/g. The downward trend in cesium-137 activities since September 2000 indicates that the increase probably was associated with the initial flush of fallout-derived ash into the Rio Grande.

Plutonium-239,-240 activities in Cochiti Reservoir bottom sediments showed increases after the Cerro Grande fire in the upper and middle sections of the reservoir (Figure 6-28), yet remained far below the health-based residential SAL. At the upper station, activities continually increased throughout the 3-year period 2000-2002 to approximately 6 times above prefire levels. At the middle station, plutonium-239,-240 activities reached a historical high in 2002, increasing to approximately 18 times above prefire levels. A slight increase was found in the lower station near Cochiti Dam. The median postfire plutonium-239,-240 activity in Cochiti Reservoir sediment is approximately 0.1% of the SAL of 44 pCi/g.

Dissolved metal concentrations in 17 Rio Grande samples collected below the Laboratory since 2000 were lower than levels prescribed in EPA primary drinking water standards. Dissolved metal concentrations measured in post-fire samples were generally comparable to or lower than prefire values.

### H. Watershed Monitoring Issues

#### 1. Guaje Canyon (Includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities. We found mercury at levels greater than the New Mexico Wildlife Habitat Standard in a storm runoff sample from the background station, Guaje Canyon above Rendija Canyon. This result, along with the repeated detection of mercury in Guaje Reservoir sediments, shows the presence of the metal in the watershed north of LANL outside of any current or past operations.

#### 2. Los Alamos Canyon (Includes Bayo, Acid, Pueblo, and DP Canyons)

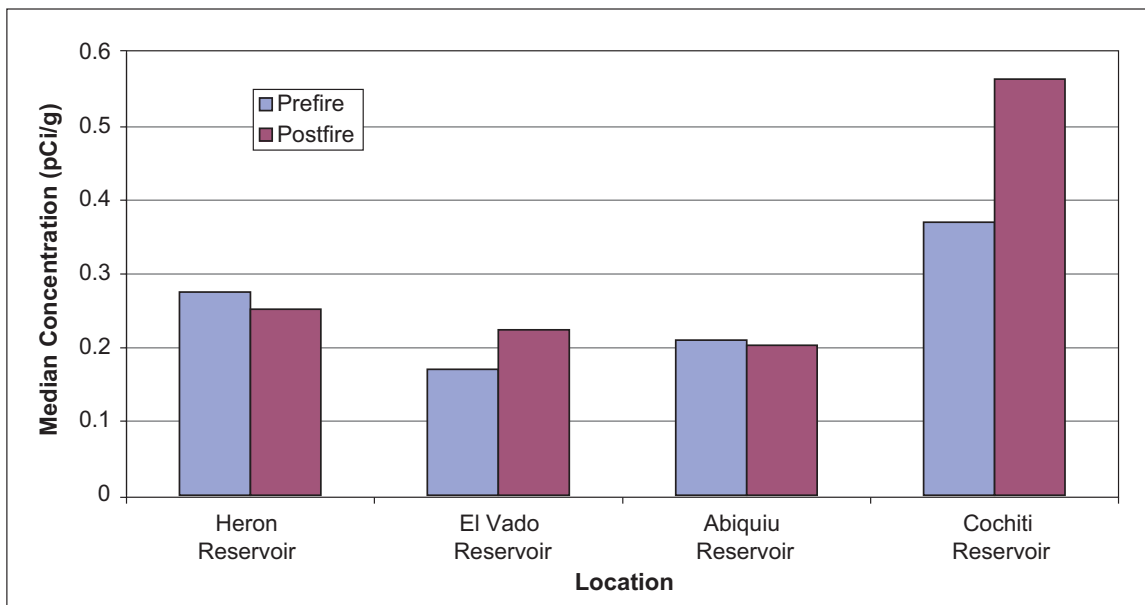
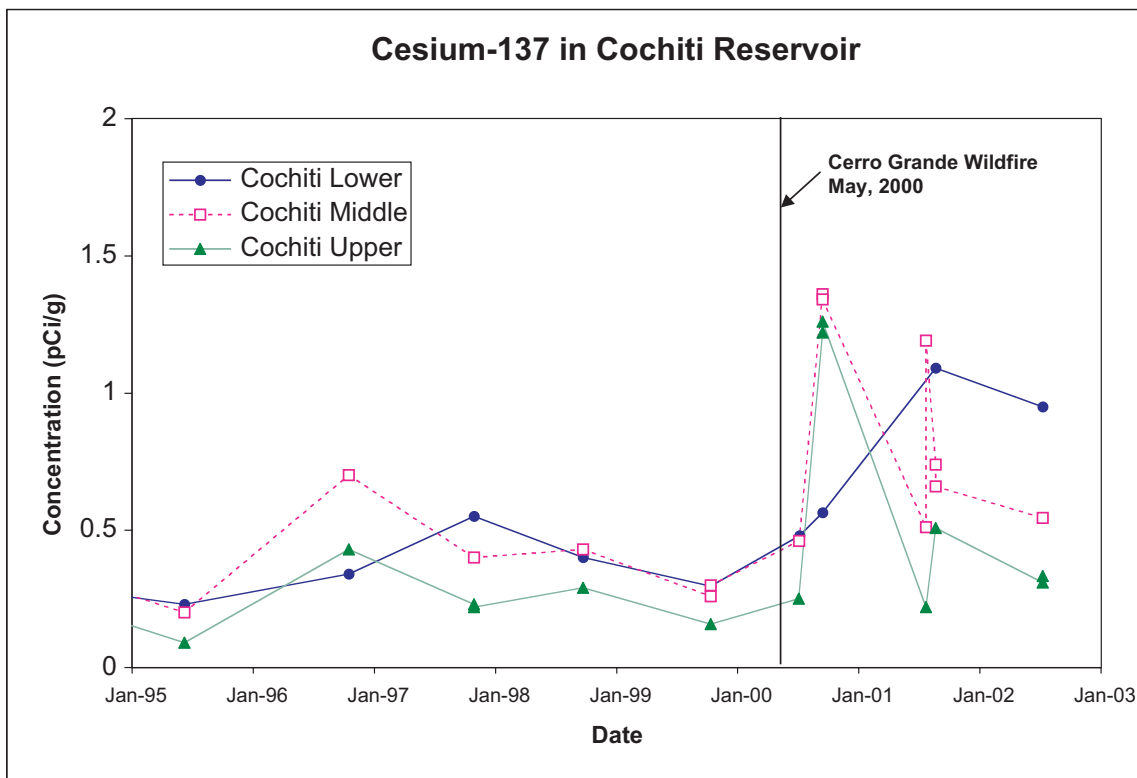
Los Alamos Canyon has a large drainage that heads in the Sierra de Los Valles. The Laboratory has used the land in the Los Alamos Canyon watershed continuously since the mid-1940s, with operations conducted at some time in all of the subdrainages. Each of the canyons draining the watershed also receives urban runoff from the Los Alamos town site.

In sediments of both Los Alamos and Pueblo canyons, above-background levels of plutonium and cesium-137 extend for tens of kilometers from the sources in Acid and DP canyons (Figures 6-3 through 6-5). The contamination extends off site across San Ildefonso lands and reaches the Rio Grande near the Otowi Bridge. Plutonium-239,-240 contamination from the Acid Canyon discharge has been traced in stream sediments more than 55 km from the effluent source into lower Cochiti Reservoir (Gallaher and Efurud 2002).

Plutonium-238 and plutonium-239,-240 activities have remained relatively constant since the fire, and 2002 analyses show comparable levels (Figure 6-29). After the Cerro Grande fire, cesium-137 in Pueblo Canyon sediments increased by as much as 10 times, following more than a decade of gradual decline; and we saw elevated levels again in 2002. The increase appears to partly reflect mobilization of fallout cesium-137 in ash from burned vegetation. In 2001, anomalously high americium-241 activity was measured in Pueblo Canyon sediments above Acid Canyon, but our 2002 analysis found a level consistent with earlier results. Overall, we found radioactivity levels in lower Los Alamos Canyon to be similar to prefire levels. Throughout the watershed, contamination levels remained below SALs.

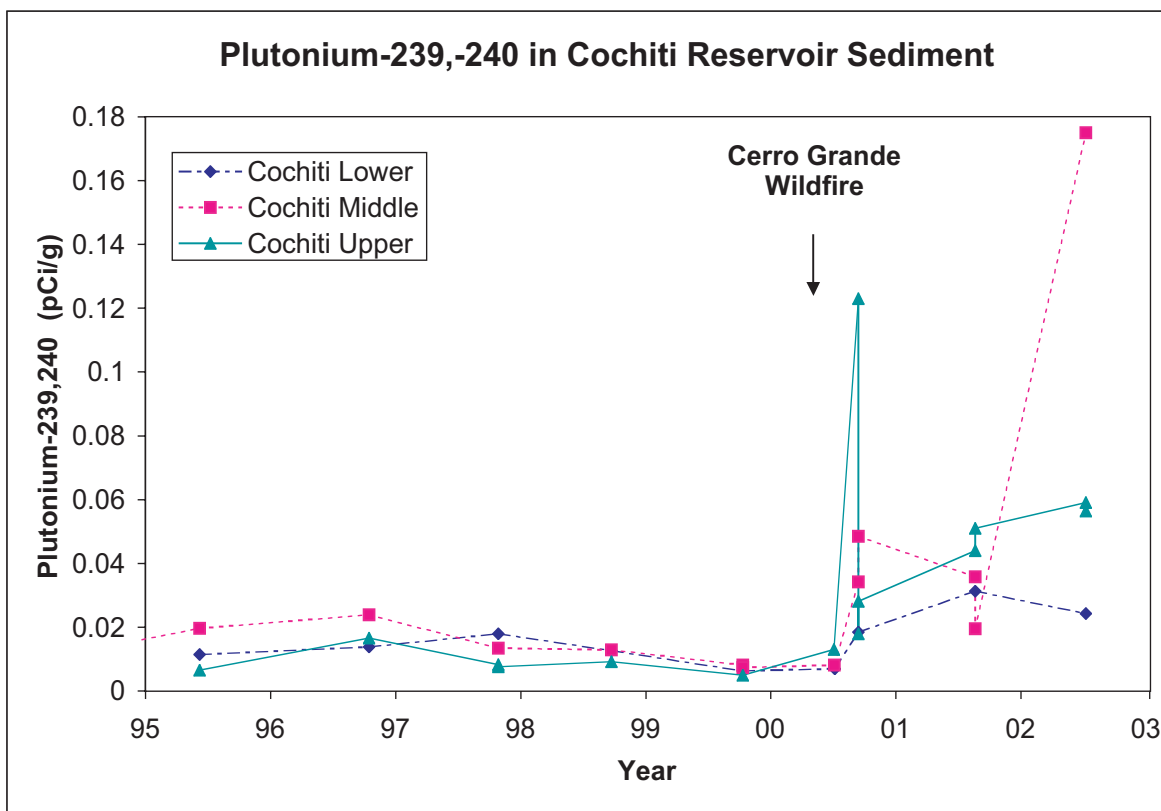
In the 2001 report, we showed that large-magnitude floods in Pueblo Canyon significantly accelerated the downstream movement of plutonium. Although there were fewer floods in Pueblo Canyon in 2002, a large runoff event on the evening of June 21 produced the highest flow for the year, with a peak runoff of 582 cfs, and eroded more sediment. The Laboratory did not analyze samples collected from this event for radioactivity. However, analysis of the runoff by NMED indicated that the runoff event transported more than 18 mCi of plutonium into lower Los Alamos Canyon (NMED 2003c). Despite the recent enhanced movement of radioactivity from Pueblo Canyon, the effect on radioactivity at downstream sites has been

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**Figure 6-27.** Cesium-137 trends (top) and median concentrations (bottom) in reservoir bottom sediments before and after the May 2000 Cerro Grande fire.

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**Figure 6-28.** Plutonium-239,-240 activity trends in Cochiti Reservoir sediments before and after the May 2000 Cerro Grande fire.

slight. This indicates that possibly (1) sediments carried by runoff were diluted by the large volume of sediments contained in the flood or (2) the large runoff events carried much of the extra sediment load directly into the Rio Grande where it mixed with a larger volume of sediments.

Upward trends in mercury concentrations in Pueblo Canyon sediments are suggested in a limited data set, possibly triggered by post-Cerro Grande conditions. Figure 6-30 shows that the most recent mercury concentrations in two of the sampling stations in the canyon have increased two-to-four times above prefire levels. No trends are evident in the adjacent Los Alamos Canyon sediments. Because the apparent upward trend in Pueblo Canyon is based on only a few samples, additional mercury data will be needed to confirm the pattern.

### 3. Sandia Canyon

Sandia Canyon heads on the plateau within the Laboratory's TA-3 area and has a total drainage area of

about 5.5 mi<sup>2</sup>. This relatively small drainage extends eastward across the central part of the Laboratory and crosses San Ildefonso Pueblo land before joining the Rio Grande.

Several storms in 2002 caused runoff to flow into the normally dry lower reaches of Sandia Canyon. Analysis of the runoff shows PCBs and above-background levels of chromium, copper, mercury, silver, and zinc. Analysis of the stream sediments shows elevated levels of the same constituents (except for copper) and PAHs. The highest concentrations in the sediments were found above the wetlands in the upper portion of the watershed, but elevated levels were also found in runoff samples collected in the lower reaches near the Laboratory boundary. PCBs (runoff and sediment) and PAHs (sediment) concentrations approached health-based screening levels. Sandia Canyon drains some of the most densely developed portions of the Laboratory. As such, there are multiple potential sources for these constituents.



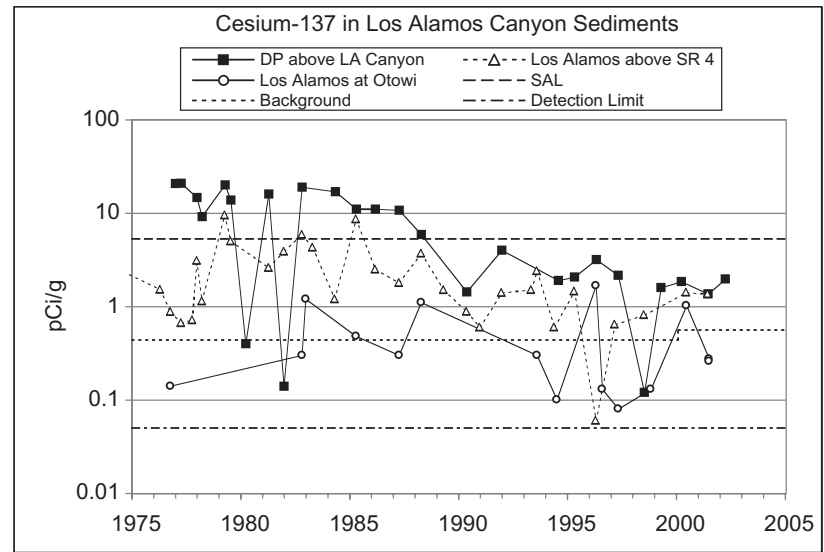
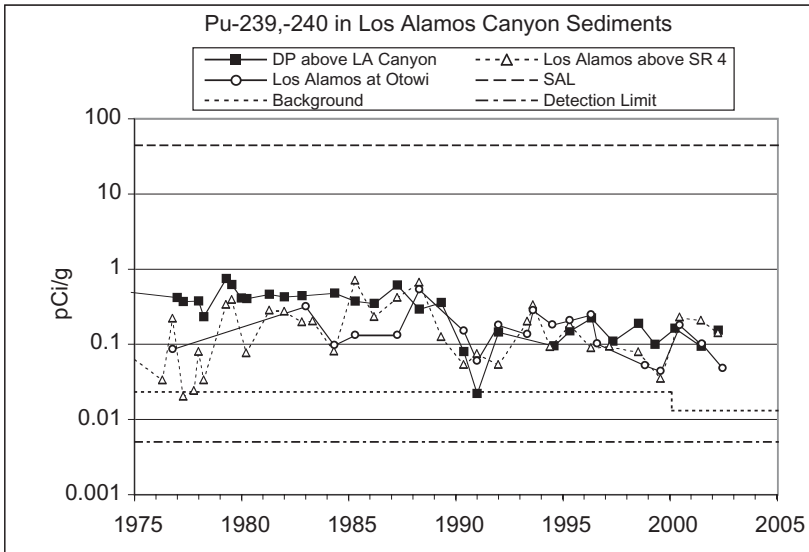
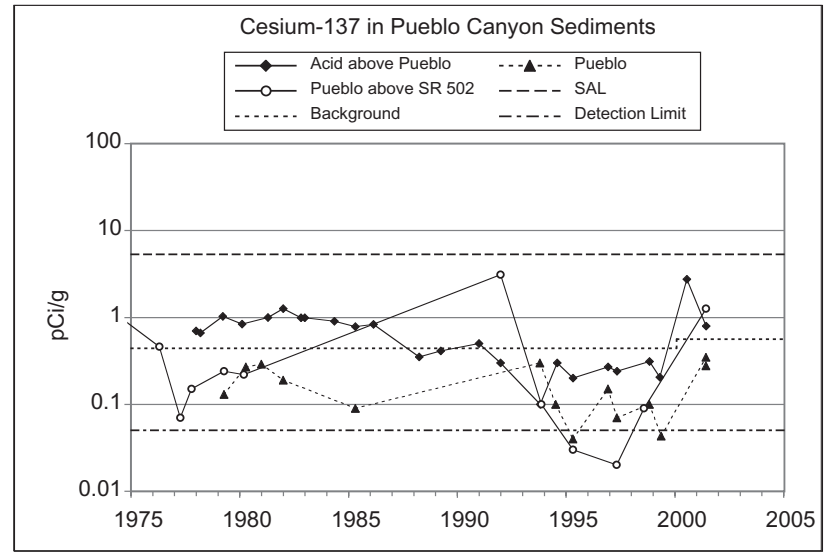
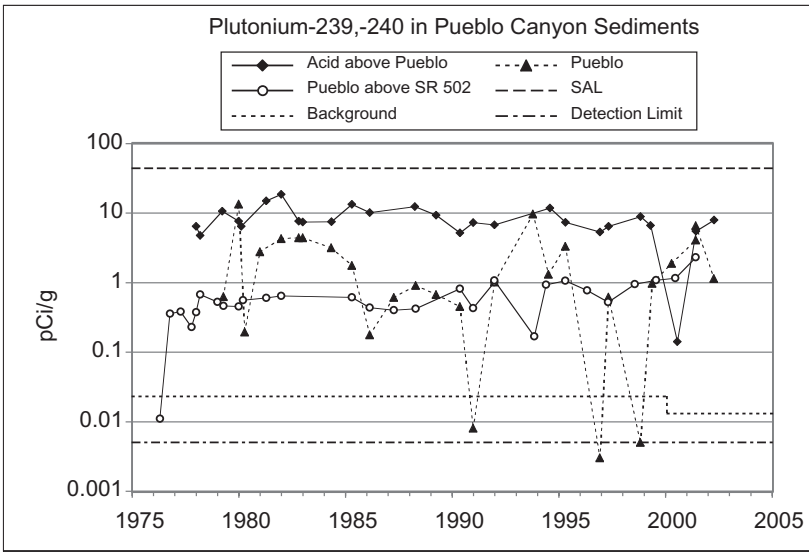
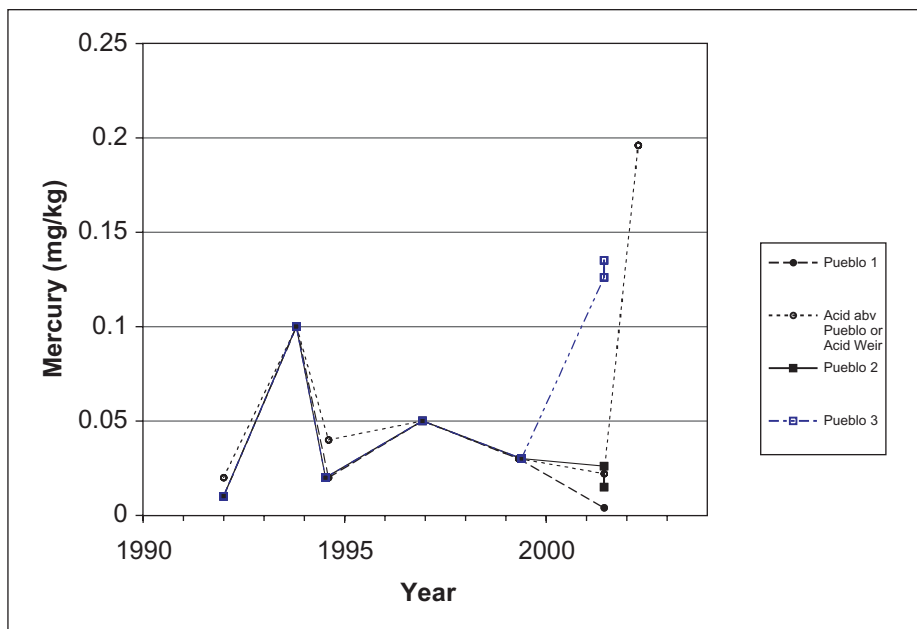


Figure 6-29. Long-term radioactivity trends in Los Alamos and Pueblo canyon sediments.

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**Figure 6-30.** Mercury concentration trends in Pueblo Canyon's channel sediments. Former sediment station Acid Weir was renamed Acid above Pueblo in 2002.

### 4. Mortandad Canyon (Includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon heads on the Pajarito Plateau near the main Laboratory complex at TA-3. The canyon crosses San Ildefonso Pueblo land before joining the Rio Grande.

Despite the history of extensive releases into the watershed, radioactivity in sediments is only slightly elevated above background levels at the Laboratory's eastern boundary, downstream of the effluent discharges. Americium-241, cesium-137, and plutonium-239,-240 activities in sediments at the boundary are orders of magnitude lower than at upstream stations closer to the RLWTF discharge (Figures 6-2 through 6-5). The absence of stream flow near the Laboratory boundary is the main reason for the drop-off in sediment radioactivity downstream. Using mass spectrometry analyses, Gallaher and others (Gallaher et al. 1997) concluded that Laboratory-derived plutonium at levels near fallout values might extend 3.2 km (2 mi) beyond the Laboratory boundary.

The PAH benzo(a)pyrene was detected in the middle reach of Mortandad Canyon slightly in excess of the EPA residential soil-screening level (Figure 6-9). As discussed previously, the PAHs are possibly associated with highway runoff or the Cerro Grande fire.

Several phthalate organic compounds were reported in sediment samples collected below Area L, Area G, and in Cañada del Buey near SR-4. These phthalate values are a few percent of the EPA residential soil-screening levels. The phthalate detections may be false positives. Phthalates are commonly detected in environmental samples, usually because of analytical laboratory contamination associated with plastic containers and equipment. Above-background cadmium values were also detected in sediments from these same stations, at levels up to 1.6 times background.

**a. Long-Term Trends.** Figure 6-31 shows activities of plutonium-238, plutonium-239,-240, and cesium-137 at five stations in Mortandad Canyon. All of the stations are located below the RLWTF discharge. The stations MCO-8.5 and -9.5 and the LANL boundary are located below the sediment traps. For the plots discussed in this section, we describe only detections of a particular radionuclide in sediments; samples without such detections are not included.

Radioactivity levels in sediments just below the RLWTF have not changed appreciably in the past decade, but recent monitoring results show that the levels near the Laboratory boundary are higher than previously recognized. The plots show that plutonium and cesium activities at MCO-8.5 and -9.5 increased

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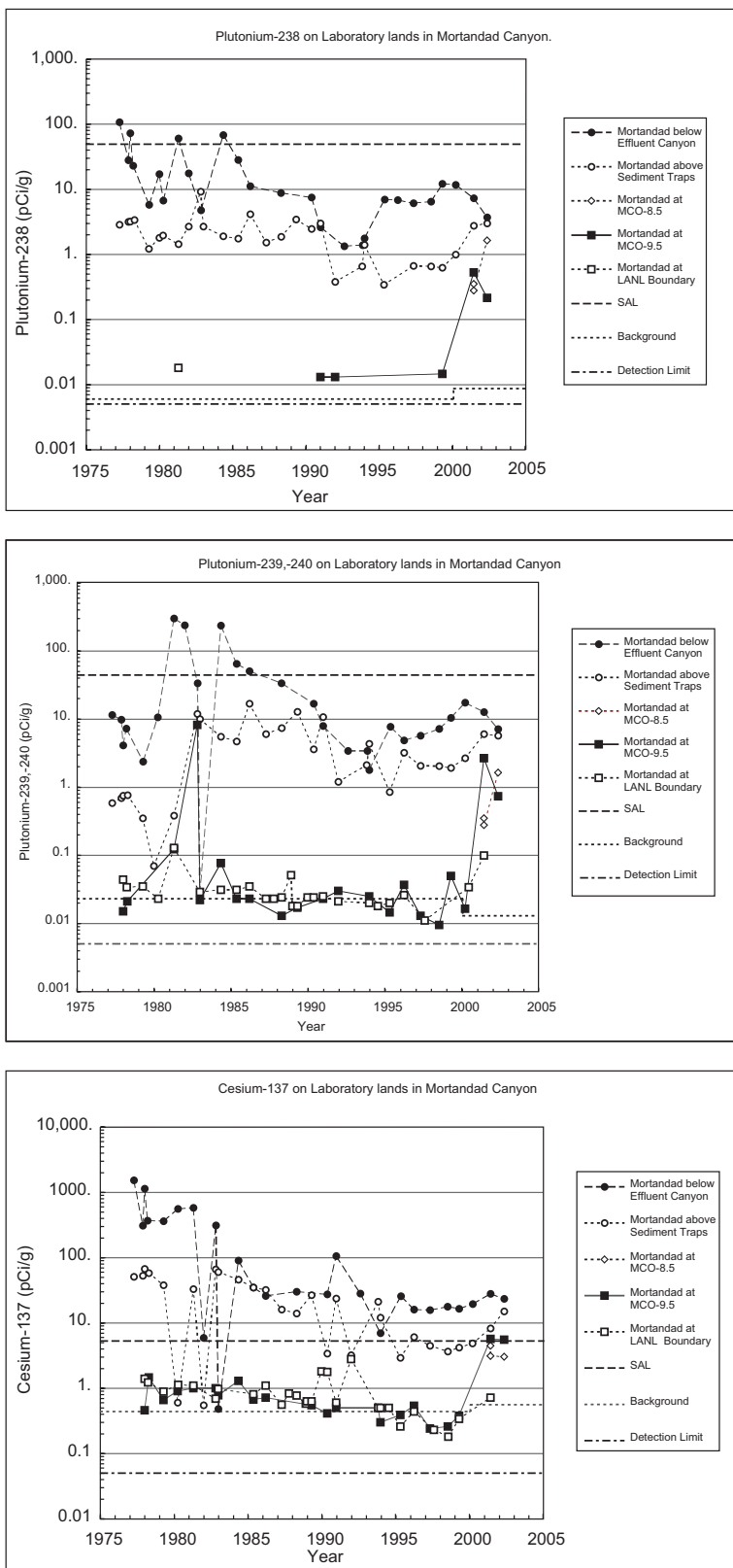


Figure 6-31. Long-term radioactivity trends in Mortandad Canyon sediments.

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significantly in 2001; relocating the sampling stations to the active channel caused this increase. Data from the relocated stations indicate contamination is 10 times higher at sites closer to the boundary than previous recorded, but (except for cesium-137) remain below SALs.

Cesium-137 activities below the RLWTF discharge point have been greater than the SAL. At the Laboratory boundary in 2002, cesium-137 activities were less than 10% of the SAL.

### 5. Pajarito Canyon (Includes Twomile and Threemile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the south-central part of the Laboratory before entering Los Alamos County lands in White Rock.

We found americium-241, plutonium-238, and plutonium-239,-240 at activities greater than background in a number of sediment samples collected in the vicinity and downstream of Area G. Both plutonium isotopes were about 10 times background at the G-6 retention pond. These results are generally consistent with past values. Mercury was detected often in sediment and storm runoff samples from the small tributary channels that drain the southern perimeter of Area G, though levels were below standards.

A sediment sample from Pajarito Canyon above SR-4 contained many metals and radionuclides elevated two-to-five times above background. The sample station was relocated in 2002. Previously the station was below SR-4 where flow is rapid and little sediment accumulates; the relocated station is in a depositional area upstream of the berm formed by SR-4. The higher analyte levels may be caused by the finer texture of sediment that accumulates above the highway. Some of the elevated constituents (for example, cesium-137, barium, and manganese) also were found at high concentrations in post-Cerro Grande fire runoff samples (Gallaher et al. 2002). Because the station is now located where sediment accumulates, both fire-related and Laboratory-derived constituents are probably present.

PCBs and PAHs were detected at levels below the EPA residential soil-screening level in Pajarito Canyon

sediments. Silver was measured at above-background concentrations in storm runoff at several stations within the canyon floor and in the southern channels near Area G (Figures 6-12 and 6-13). Trace levels of HE compounds were detected in two storm runoff samples collected in the western and eastern portions of Pajarito Canyon within the Laboratory. Each of these compounds was less than 10% of the EPA tap water-screening levels.

### 6. Water Canyon (Includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon heads on the flanks of the Sierra de Los Valles on US Forest Service land and extends across the Laboratory to the Rio Grande. Water Canyon and tributary Cañon de Valle pass through the southern portion of the Laboratory where explosives development and testing take place. Elevated concentrations of barium, cyclotetramethylenetetra nitramine (HMX), and RDX have been measured in sediment and surface water. Sampling of springs in the vicinity of the 260 outfall showed elevated concentrations of barium and boron from Laboratory operations. Barium is present above background levels in storm runoff, and RDX is present in storm runoff near the 2-ppb EPA Tap Water Health Advisory in Cañon de Valle and down Water Canyon.

Area AB at TA-49 was the site of underground nuclear-weapons testing from 1959 to 1961 (Purtymun and Stoker 1987, ESP 1988). These tests involved HEs and fissionable material insufficient to produce a nuclear reaction. Area AB drains into Ancho and Water canyons. Legacy surface contamination is responsible for the above-background concentrations of plutonium and americium present in the sediments downstream of this site. However, the site of highest surface contamination at Area AB drains north to Water Canyon, but no above-ground plutonium extends more than 110 yards beyond Area AB.

#### I. Quality Assurance

To process watershed samples, we used the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5. QA performance for the year is also described in Chapter 5.

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# 7. Soil Monitoring









## 7. Soil Monitoring

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### A. Introduction (*Philip Fresquez*)

Soil acts as an integrating medium that can account for contaminants released to the atmosphere. These contaminants are released either directly in gaseous effluents (e.g., air-stack emissions), indirectly from resuspension of on-site contamination (e.g., firing sites and waste disposal areas), or through liquid effluents released to a stream that is subsequently used for irrigation (DOE 1991).

A soil-sampling-and-analysis program provides the most direct means of determining the concentration, inventory, distribution, and long-term buildup of radionuclides and radioactivity around nuclear facilities. The knowledge gained from a soil radiological sampling program is critical for providing information about potential pathways, such as soil ingestion, food crops, resuspension into the air, and contamination of groundwater, that may result in a radiation dose to a person.

The overall soil-surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) consists of

- (1) an institutional component that monitors soil contaminants within and around LANL, according to Department of Energy Orders 5400.1, (now replaced by 450.1) (DOE 2003) and 5400.5 (DOE 1993); and
- (2) a facility component that monitors soil contaminants within and around the Laboratory's principal low-level waste disposal area (Area G), according to DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and the Laboratory's principal explosive test facility (Dual Axis Radiographic

Hydrodynamic Test [DARHT]), according to the Mitigation Action Plan (DOE 1996).

The objectives of these programs are to determine the following:

- (1) radionuclide and nonradionuclide (heavy metals and organic constituents) concentrations in soils collected from potentially impacted areas (institution-wide and facility-specific);
- (2) trends over time (that is, whether radionuclides and nonradionuclides are increasing or decreasing over time); and
- (3) committed effective dose equivalent (CEDE) to surrounding-area residents using the RESRAD computer model. See Chapter 3 for information on potential radiation doses to individuals from exposure to soils.

In May 2000, a catastrophic wildfire burned across the Los Alamos area. The fire burned more than 7,500 acres of LANL lands, and some areas are known to contain radionuclides and chemicals in soils and plants above regional concentrations (Fresquez et al. 1998, Gonzales et al. 2000). Some of these materials may have been suspended in smoke and ash and transported by wind—principally downwind of the fire. (The predominant wind direction during the fire was to the northeast of LANL.) Since the fire, the soils team has collected and compared many soil samples from areas impacted by the fire with samples collected before the fire (Fresquez et al. 2000, Fresquez et al. 2001a). This year, we continue this evaluation by including tables that compare data collected before the fire (before 1999) with data collected in one, two, and three sampling events after the fire (2000–2002).

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### B. Quality Assurance/Quality Control

The team conducts soil-surface sampling according to written, standardized quality assurance/quality control (QA/QC) procedures and protocols. These procedures and protocols are identified in the overall QA Project Plan (QAPP) for the Soils, Foodstuffs and Biota Monitoring Project (RRES-ECO 2002); and, more specifically in the operating procedures (OPs) entitled “Soil Sampling for the Soil Monitoring Program,” LANL-ESH-20-SF-OP-007, R0, 1997, and “Sampling and Sample Processing for the Waste-Site Monitoring Program,” LANL-ESH-20-SF-OP/HCP-011, 1999. Accordingly, collection of samples for chemical analyses follows a set procedure to ensure proper collecting, processing, submitting, chemical analyzing, validating and verifying analyses, and tabulating of analytical results.

Personnel collect soil samples for radionuclide and heavy-metal analysis from the 0- to 2-in. depth and soil samples for the analysis of organic compounds from the 0- to 6-in depth. We collect all samples from relatively level, open (unsheltered by trees or buildings), rock-free, and undisturbed areas and from the same (general) locations year after year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting. Paragon Analytics, Inc., of Fort Collins, Colorado, analyzed the soil samples for radionuclides and nonradionuclides. Organic constituents were not analyzed this year: we collect and analyze them about every third year. Paragon met all QA/QC requirements.

### C. Institutional Monitoring

#### 1. Monitoring Network

The team collected soil samples from 3 regional locations, 10 perimeter sites, and 12 sites within the LANL boundary (Figure 7-1). Areas sampled at LANL are not from contaminated areas known as potential release sites (PRSs). Instead, the majority of on-site soil-sampling stations are located on mesa tops close to and downwind from major facilities or operations at LANL. We selected these locations to assess soils that may have been contaminated from air-stack emissions and fugitive dust (the resuspension of dust from PRSs and active firing sites). The 10 perimeter stations are located within 4 km (2.5 mi) of the Laboratory. These stations reflect the soil conditions of the inhabited areas to the north of the Laboratory

(Los Alamos town site area—four stations) and east (White Rock area and San Ildefonso Pueblo lands—four stations). The other two stations, one located on US Forest Service land to the west and the other located on US Park Service land (Bandelier National Monument) to the southwest, provide additional coverage. Team members compare soil samples from all these areas with soils collected from regional locations in northern New Mexico that surround the Laboratory and where radionuclides, metals, and organic constituents are mostly from natural sources or worldwide fallout events. These areas are located near Embudo to the north, Cochiti to the south, and Jemez to the southwest. All are more than 32 km (20 mi) away from the Laboratory and are beyond the range of potential influence from normal Laboratory operations as required by the DOE (DOE 1991).

#### 2. Radiochemical Analytical Results

Table 7-1 presents a summary of selected radionuclide concentrations in surface soils collected from on-site, perimeter, and regional sites during the year 2002. The complete data set is in the Data Supplement (Table S7-1).

Most radionuclide concentrations (activity) in soils collected from individual on-site and perimeter stations were nondetectable; i.e., the analytical result was lower than three times the counting uncertainty = 99% confidence level (Corely et al. 1981) or within regional statistical reference levels (RSRLs). The RSRL is the upper-level regional concentration (mean plus two standard deviations = 95% confidence level) (Purtymun et al. 1980, Purtymun et al. 1987) from data collected from regional areas over the last 5 years (1998–2002). The radionuclides detected and that were above RSRLs were still very low (e.g., in the pCi/g range) and far below screening action levels (SALs). SALs were developed by the Environmental Restoration (ER) Project at the Laboratory to identify the contaminants of concern on the basis of a conservative 15-mrem/yr protective dose limit (ER 2002). Therefore, the concentrations and distributions of all observed radionuclides in soils from all sites (institutional site locations), including on-site soils, collected in 2002 are of no significant health concern. This finding is also supported by analyses of overstory vegetation and comparison of radionuclide concentrations to health indicators. (See Chapter 8.)

As a group (using detectable and nondetectable values), the average concentrations of tritium; total

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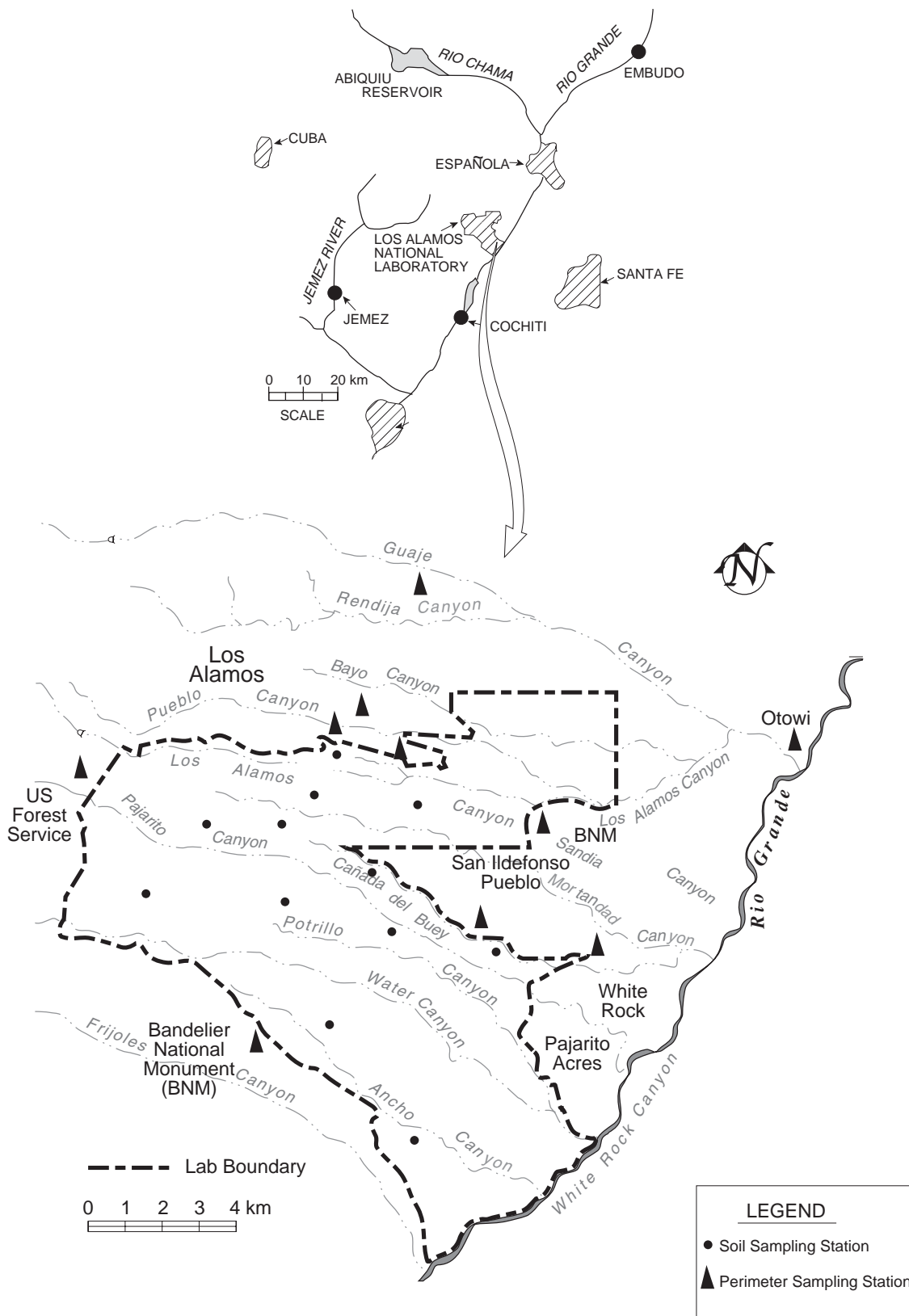


Figure 7-1. Off-site regional and perimeter and onsite Laboratory soil sampling locations.

**Table 7-1. Selected Mean (std dev) Radionuclide Concentrations in Surface (0- to 2-in. depth) Soils Collected from Regional, Perimeter, and On-Site Locations during 2002**

Location	<sup>3</sup> H (pCi/mL)	totU (µg/g dry)	<sup>238</sup> Pu (pCi/g dry)	<sup>239,240</sup> Pu (pCi/g dry)	<sup>241</sup> Am (pCi/g dry)
<b>Regional Stations</b>					
	0.23 (0.25)	2.37 (0.58)	-0.002 (0.002) <sup>a</sup>	0.004 (0.006)	0.002 (0.003)
RSRL <sup>b</sup>	0.75	3.2	0.0045	0.017	0.014
SAL <sup>c</sup>	6,400 <sup>d</sup>	100	49	44	39
<b>Perimeter Stations</b>					
	1.26 (0.90)	4.26 (1.99)*	0.003 (0.003)*	0.063 (0.120)*	0.011 (0.011)*
<b>On-Site Stations</b>					
	1.74 (1.00)*	3.63 (0.99)*	0.002 (0.002)*	0.056 (0.098)*	0.012 (0.016)*

<sup>a</sup> See Appendix B for an explanation of the presence of negative values.

<sup>b</sup> Regional Statistical Reference Level: this is the upper-limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

<sup>c</sup> Los Alamos National Laboratory screening action level based on a residual radioactive (RESRAD) computer code version 6.21 (ER 2002)

<sup>d</sup> Equivalent to the SAL of 890 pCi/g dry soil at 12% moisture (ER 2002)

\*Means from perimeter and on-site stations within the same column followed by an \* were statistically higher than regional using a Student's t-test at the 0.05 probability level.

uranium; plutonium-238; plutonium-239,-240; and americium-241 in soils collected from both perimeter and on-site areas were significantly higher ( $\alpha = 0.05$ ) than concentrations in soils from regional locations. Although statistically higher than regional soils, the concentrations of plutonium-238 and americium-241 in soils from perimeter and on-site areas are still within RSRLs. Also, the higher levels of uranium detected in soil samples collected from perimeter and on-site areas may be a result of either geologic or soil differences between the areas rather than any contamination effects. Soils in the Los Alamos area, for example, are derived from Bandelier (volcanic) tuff and have higher-than-average natural uranium concentrations, ranging from 3 to 11  $\mu\text{g}$  of uranium per gram of soil (Crowe et al. 1978).

As for tritium and plutonium-239,-240, these slightly elevated levels above regional levels may be caused in part by fallout. Radionuclides caused by fallout vary from one area to another, depending on wind patterns, elevation, and precipitation (Whicker and Schultz 1982); and fallout likely is more concentrated in the area of the Laboratory because it lies at a higher elevation and receives more precipitation than the regional areas. The tritium levels are probably attributable more to Laboratory operations than to fallout. The slightly higher amounts of tritium in soil samples collected from perimeter and especially from on-site areas, as compared to regional areas, have been observed in past surveys; albeit concentrations of tritium have been generally decreasing over time (Fresquez et al. 1996, Fresquez et al. 1998). Similarly, the levels of plutonium-239,-240 have been reported to be in higher concentrations in perimeter and on-site soils in past years (Fresquez et al. 1998).

### 3. Cerro Grande Fire Effects and Trends over Time (Radiochemical)

Table S7-2 in the Data Supplement shows the results of radionuclide concentrations in soils collected (in 1999) before and (in 2000 through 2002) after the Cerro Grande fire. Because only one regional site, Embudo, was predominantly downwind of the fire, it was the only regional station compared with prefire soil conditions. With the exception of the regional station, the team made statistical comparisons within LANL and perimeter sites and years (e.g., 1999 as compared to 2000–2002). All of the radionuclides in the regional soil site collected in 2002 were similar to radionuclide concentrations in soils collected in 1999 before the fire.

Similarly, most mean radionuclide concentrations, with the exception of tritium, in soils collected in 2000–2002 from LANL and perimeter areas after the Cerro Grande fire were statistically similar ( $\alpha = 0.05$ ) to soils collected before the fire in 1999. The increase in tritium concentrations in the year 2002, as compared to previous years, was probably related to Laboratory operations, however. These data are similar to past years (Fresquez et al. 2000).

Trends based on the last 5 years from 1998 through 2002 for the radionuclides (tritium, plutonium-239,-240) that exhibited statistical differences compared to regional concentrations (Table 7-1) and thought to be attributable to LANL operations are in Figures 7-2 and 7-3. The concentrations of tritium and plutonium-239,-240 over time show that the elements were generally not increasing over most of the evaluation time period, until 2002. At this time, we noted a small increase in the concentrations for both elements. Although tritium concentrations spiked in soils from perimeter and on-site areas during the year 2002, tritium, over the long-term, has been significantly decreasing over time (Fresquez et al. 1996, Fresquez et al. 1998).

### 4. Nonradiochemical Analytical Results

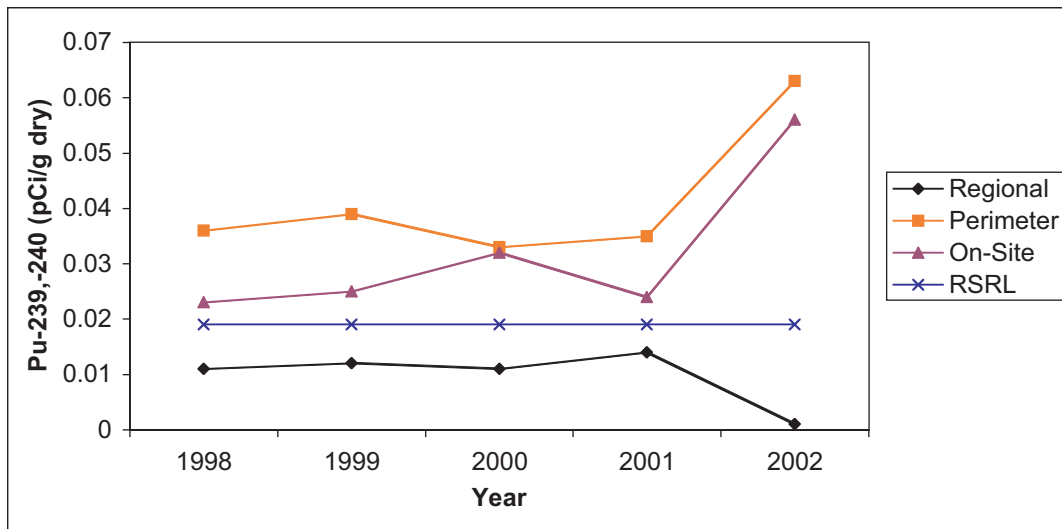
In the past years, the team analyzed soils within and around LANL for 22 light, heavy, and nonmetal trace elements (occur at  $< 1000 \mu\text{g/g}$  in soil) and 3 light and heavy abundant elements (occur at  $> 1000 \mu\text{g/g}$  in soil). Most of these elements, with the exception of two light metals (barium and beryllium) and two heavy metals (mercury and lead) were either below the limits of detection (LOD, the analytical reporting limit) or within RSRLs. Therefore, we analyzed only the four metal elements that were consistently detected above the LODs in past years.

Table 7-2 contains a summary of results for barium, beryllium, mercury, and lead in soils collected from perimeter, on-site, and regional areas. (See Table S7-3 in the Data Supplement for the complete data set.) In general, very few individual sites from either perimeter or on-site areas had barium, beryllium, mercury, or lead concentrations above RSRLs; and these concentrations were far below SALs. The Environmental Protection Agency (EPA 2000) derived SALs for nonradionuclides are based on potential health concerns.

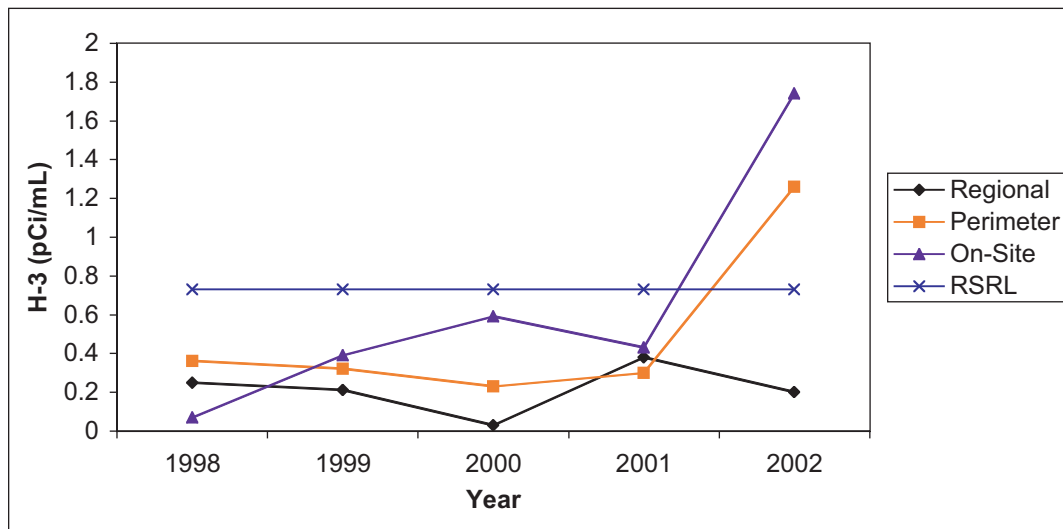
Comparing the means of these elements in soils collected from perimeter and on-site areas, compared



## 7. Soil Monitoring



**Figure 7-2.** Plutonium in soils collected from regional, perimeter, and on-site locations from 1998 to 2002.



**Figure 7-3.** Tritium in soils collected from regional, perimeter, and on-site locations from 1998 to 2002.

**Table 7-2. Mean (std dev) Total Trace Element Concentrations ( $\mu\text{g/g}$  dry) in Surface Soils (0- to 2-in. depth) Collected from Regional, Perimeter, and On-Site Locations during 2002<sup>a</sup>**

Location	Barium	Beryllium	Mercury	Lead
<b>Regional Stations</b>	116.3 (15.8)	0.39 (0.06)	0.014 (0.001)	8.4 (1.2)
<b>RSRL<sup>b</sup></b>	153.7	0.90	0.030	17.4
<b>SAL<sup>c</sup></b>	5,500	150	23	400
<b>Perimeter Stations</b>	85.9 (40.1)	0.47 (0.18)	0.015 (0.005)	12.8 (7.1)
<b>On-Site Stations</b>	107.9 (45.6)	0.58 (0.14)*	0.019 (0.003)*	13.6 (3.2)*

<sup>a</sup>Trace elements were digested using EPA method 3051 and analyzed using EPA methods 6020 (lead), 7471A (mercury) and 6010B (barium and beryllium).

<sup>b</sup>Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

<sup>c</sup>Los Alamos National Laboratory Screening Action Level (EPA 2000)

\*Means from perimeter and on-site stations within the same column followed by an \* were statistically higher than regional background using a Student's t-test at the 0.05 probability level.

with regional areas, shows that the concentrations of beryllium, mercury, and lead in soils collected from on-site areas were significantly higher ( $\alpha = 0.05$ ) than concentrations from regional soils. These results, with the exception of mercury, which was higher, are similar to concentrations reported in past years (Ferenbaugh et al. 1990, Fresquez 1999, Fresquez and Gonzales 2000, Fresquez et al. 2001b). Although beryllium, mercury, and lead concentrations in soils from on-site areas were statistically higher than regional soils, the differences between the two sites were very small and, again, the amounts were below RSRLs and far below SALs. Therefore, these concentrations in soils within on-site areas are of no significant human health concern.

### 5. Cerro Grande Fire Effects and Trends over Time (Nonradiochemical)

See Table S7-4 in the Data Supplement for the results of a comparison of barium, beryllium, mercury, and lead before (1999) and after (2000–2002) the Cerro Grande fire. All of the metals in the regional soil site (Embudo) that was directly downwind of the Cerro Grande fire were similar in concentrations to metals in soils collected before the fire. Similarly, all of the metals analyzed in soils collected from perimeter and on-site areas after the Cerro Grande fire were statistically ( $\alpha = 0.05$ ) similar to soils collected before

the fire in 1999. For more information about other trace elements in soils collected within and around LANL directly after the fire, see Fresquez et al. 2000.

Considering trends over time, the metals that showed a statistical difference to regional background concentrations were graphed over a 5-year period (1998–2002). The concentrations of beryllium, mercury, and lead in soils from on-site areas during this time period show stable-to-decreasing concentrations (Figures 7-4 through 7-6).

### D. Facility Monitoring (John Nyhan and Philip Fresquez)

#### 1. Monitoring Network

The two main facilities where soil monitoring takes place are the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) (Figure 7-7) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001a) (Figure 7-8). Area G, approximately 63 acres in size, is located in the Laboratory's Waste Disposal Site (TA-54) at the east end of the Laboratory. The team collects approximately 18 soil surface samples at designated places within and around the perimeter of Area G on an annual basis. DARHT, approximately 20 acres in size, is located at R-Site (TA-15) at the southwest end of the Laboratory. We collect approxi-

## 7. Soil Monitoring

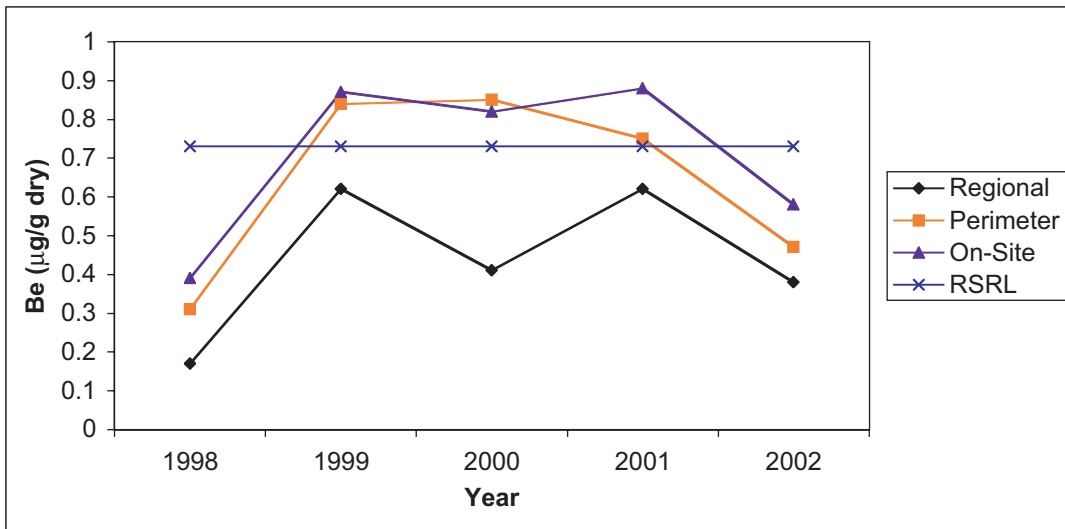


Figure 7-4. Beryllium in soils collected from regional, perimeter, and on-site locations from 1998 to 2002.

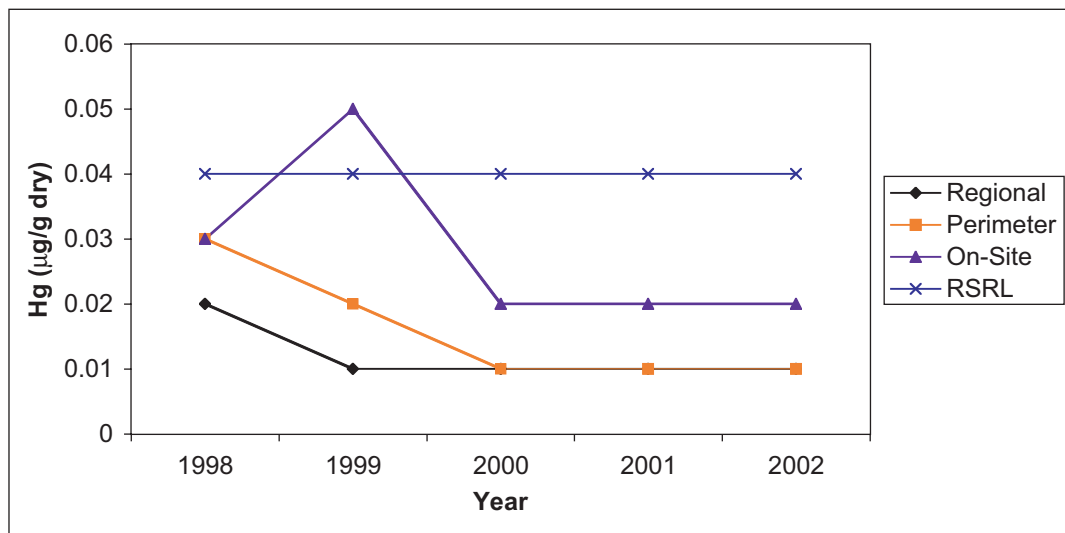


Figure 7-5. Mercury in soils collected from regional, perimeter, and on-site locations from 1998 to 2002.

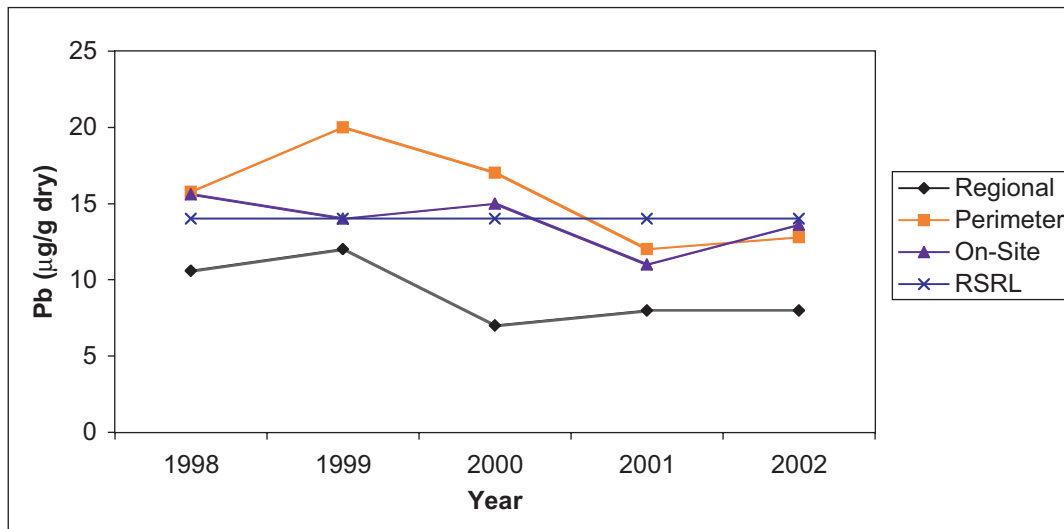


Figure 7-6. Lead in soils collected from regional, perimeter, and on-site locations from 1998 to 2002.

mately four soil and four sediment samples on an annual basis at designated locations within the DARHT grounds.

We compare results for radionuclides in soils collected at Area G to RSRLs, whereas we compare results for radionuclides and nonradionuclides in soils and sediments collected at DARHT to baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and trace elements in soils and sediments around the DARHT facility (1996–1999) before the operation phase (after 2000). The Mitigation Action Plan for the DARHT facility at LANL mandated the establishment of baseline (preoperational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). These concentrations of radionuclides and trace elements are calculated from the mean DARHT facility sample concentration plus two standard deviations. (**Note:** Prior evaluations of BSRLs with RSRLs show no statistical differences between the two, and the use of BSRLs at DARHT is for compliance reasons.)

## 2. Radiochemical Analytical Results and Trends over Time for TA-54, Area G

A summary of results of selected radionuclides in soils collected from within and around the perimeter of Area G during the 2002 year is in Table 7-3. The complete data set is in Nyhan et al. 2003a.

In general, the mean concentrations of tritium; plutonium-238; and plutonium-239,-240 in soils collected inside and on the outside perimeter of Area G were statistically higher than regional concentrations. For americium-241, only the mean concentrations of soil samples collected along the outside perimeter were higher than regional concentrations. More specifically, the team found that detectable concentrations of radionuclides of interest in most of the 18 samples collected within and around Area G and, with the exception of cesium-137, strontium-90, and uranium, were above RSRLs (Nyhan et al. 2003a). Of the soil samples collected, for example, 100% contained tritium; 94% contained plutonium-239,-240; 63% contained plutonium-238; and 44% contained americium-241 at levels greater than the RSRL concentrations of these radionuclides. Concentrations of plutonium-238 and plutonium-239,-240 in soils were largest in samples collected on the northern and eastern sides of Area G, whereas tritium concentrations were largest on the southwestern and southern sides of Area G. Both of these trends were consistent with results from previous years (Fresquez et al. 1999, Nyhan et al. 2000, Nyhan et al. 2001b).

Although concentrations of tritium; plutonium-238; plutonium-239,-240; and americium-241 in soils collected within and around Area G were higher than RSRLs, all but one sample were within LANL SALs. This one sample (29-03), collected outside of Area G and south of the tritium shafts, contained more than

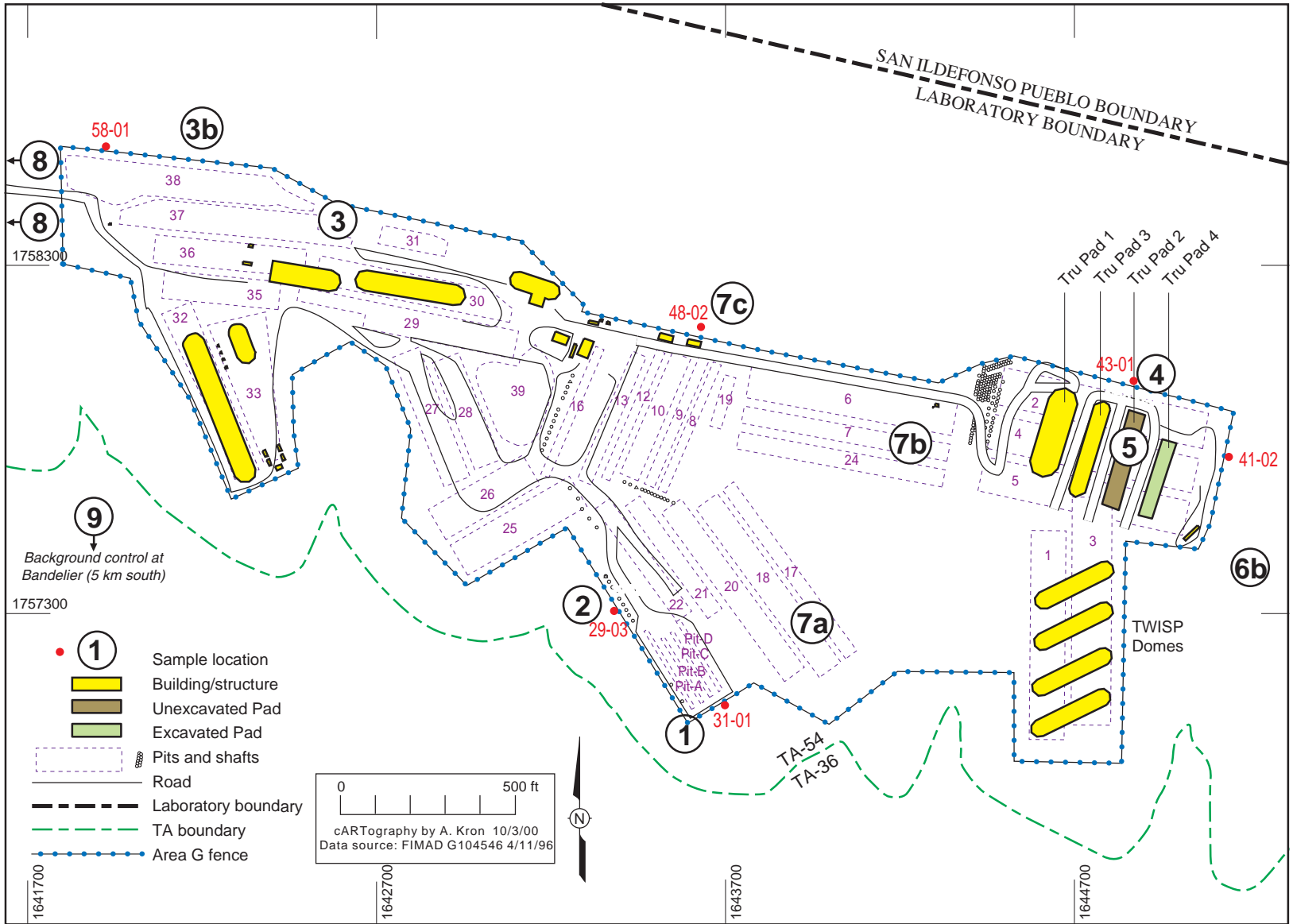


Figure 7-7. Site/sample locations of soils and vegetation at Area G. Site # 8 is located farther west and Site # 9 is located farther south than what is shown here.



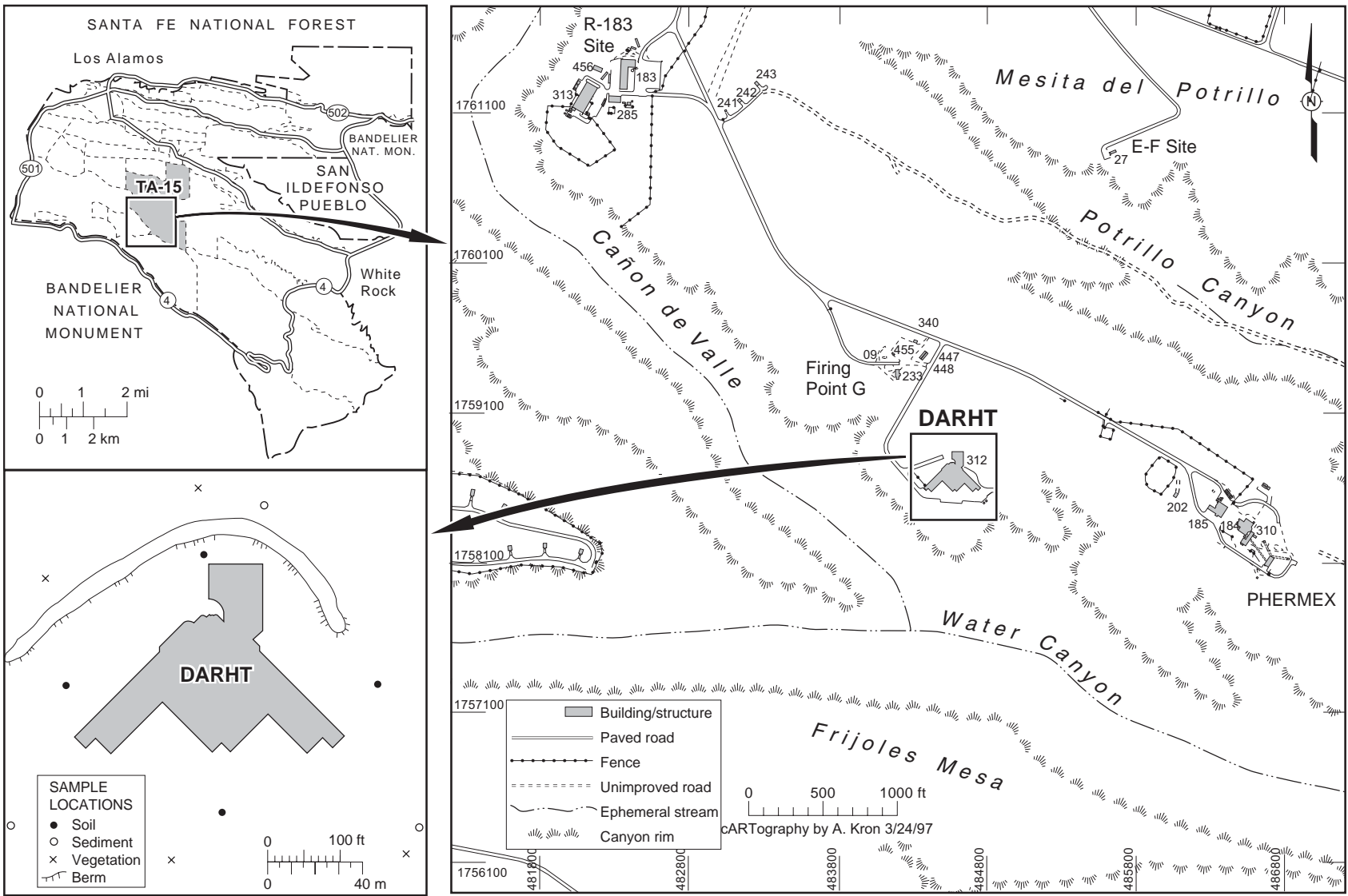


Figure 7-8. Sampling locations at the DARHT facility at TA-15.

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**Table 7-3. Selected Mean (std dev) Radionuclide Concentrations in Surface Soils (0- to 2-in. depth) Collected Inside and Outside (Perimeter) the Grounds of Area G in 2002**

Location	<sup>3</sup> H (pCi/mL)	<sup>241</sup> Am (pCi/g dry)	<sup>238</sup> Pu (pCi/g dry)	<sup>239,240</sup> Pu (pCi/g dry)
Regional <sup>a</sup>	0.23	0.0023	-0.0017	0.0043
RSRL <sup>b</sup>	0.75	0.014	0.0045	0.017
SAL <sup>c</sup>	6,400	39	49	44
Inside Fence	55 (84)*	0.011 (0.0092)	0.012 (0.0041)*	0.038 (0.027)*
Outside Fence (Perimeter)	1,900 (6,300)*	0.086 (0.12)*	0.25 (0.55)*	0.25 (0.28)*

<sup>a</sup>Data from Table 7-1.

<sup>b</sup>Regional Statistical Reference Level: this is the upper-limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

<sup>c</sup>Los Alamos National Laboratory Screening Action Level based on RESRAD version 6.21 (ER 2002)

\*Means from inside and outside (perimeter) Area G within the same column followed by an \* were statistically higher than regional using a Student's t-test at the 0.05 probability level.

three-fold larger concentrations of soil tritium (22,000 pCi/mL) than the SAL value of 6,400 pCi/mL. This information was forwarded to Area G management and is currently being investigated.

Concentrations of tritium and plutonium-239,-240 in selected samples collected within and around Area G during the last 5 years can be found in Figures 7-9 and 7-10, respectively. For tritium, both sample locations show significant increasing trends over time. The concentrations of plutonium-239,-240, on the other hand, albeit higher than the RSRL, show generally up and down trends. However, a slight increase of plutonium-239,-240 concentrations in soil samples collected from an area inside Area G appear for a 3-year period.

### 3. Radiochemical and Nonradiochemical Analytical Results and Trends over Time for TA-15, DARHT

The complete data set of results of radionuclides and nonradionuclides in soils collected from within the DARHT grounds during the year 2002 can be found in Nyhan et al. 2003b. Results show that most radionuclides and trace elements in soil and sediment samples were below BSRLs, and all samples were

substantially below SALs. Exceptions were concentrations of strontium-90, uranium, and cesium-137 found in the soil samples and strontium-90 and uranium in sediment samples. However, the concentrations are just above the BSRLs and are not significantly different. The soils had a slightly higher concentration of antimony than the BSRL value, and the sediments had a slightly higher concentration of selenium than the BSRL value. Again, these exceptions were not significantly different than the BSRL values.

### E. Special Monitoring Studies

#### 1. Concentration of Plutonium-239,-240 in Soil Surface Samples along a Transect Radiating Outward from LANL in the Predominant Wind Direction (Philip Fresquez and Bruce Gallaher)

We have reported plutonium-239,-240 concentrations in soils collected from both perimeter and on-site areas in past years to be in significantly higher ( $\alpha = 0.05$ ) concentrations than in soils from regional locations (Fresquez et al. 1998). Also, preliminary indications, based on long-term data, of cesium-137 and plutonium-239,-240 ratios, have shown possible LANL-derived plutonium in a north-to-northeasterly direction generally concurrent with the major wind

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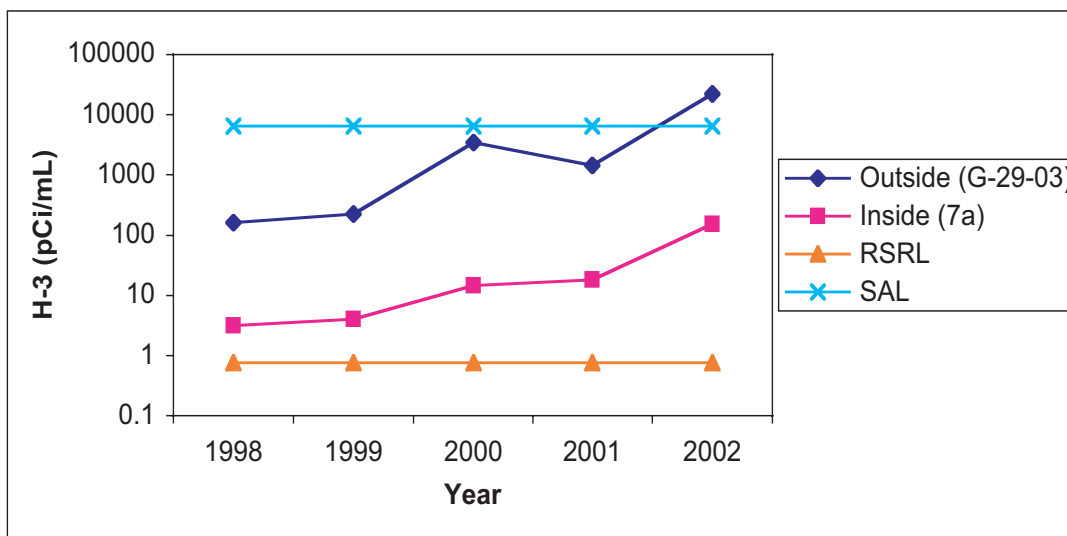


Figure 7-9. Tritium in soils collected from two selected locations at Area G at TA-54.

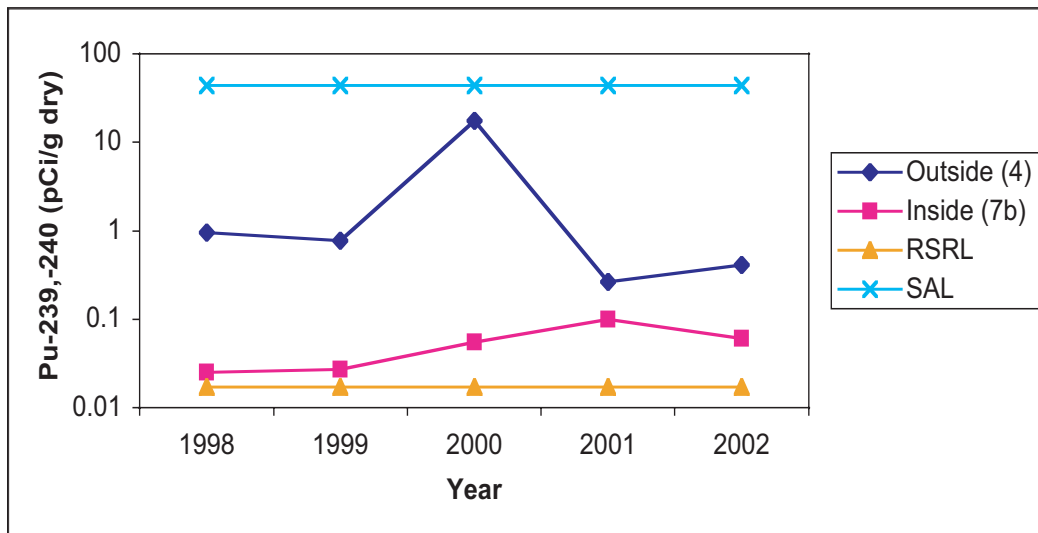


Figure 7-10. Plutonium-239,-240 in soils collected from two selected locations at Area G at TA-54.

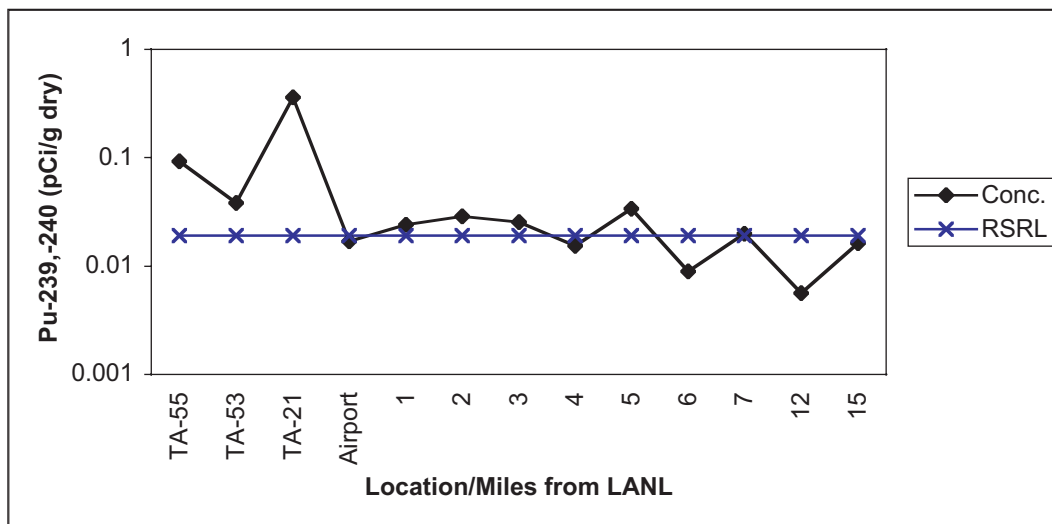
## 7. Soil Monitoring

direction in the area (Fresquez et al. 2002). The ratio of cesium-137 to plutonium-239,-240 concentrations from worldwide fallout (Hodge et al. 1996), for example, is constant at  $32 \pm 1$  (decay corrected to June 2002). LANL results from data summarized over a 26-year period show median cesium-137 (decay corrected)/plutonium-239,-240 ratios ranging from 2 to 27 in soils from on-site areas and from 5 to 37 in perimeter soils. Ratios from regional soils compared well with cesium-137/plutonium-239,-240 ratios from other background areas.

To more thoroughly understand the extent of LANL-added plutonium to perimeter areas, team members collected soil surface samples along a transect from LANL to regional areas in a northeasterly direction (predominant wind direction). Personnel collected composite soil samples beginning near the eastern end of the Los Alamos airport and then at every mile to a distance of 15 miles from LANL. We conducted all sampling and processing according to the protocols as defined in Section B of this chapter. Paragon Analytics, Inc. of Fort Collins, Colorado, analyzed samples for plutonium-239,-240 and cesium-137. The summary of results for plutonium-239,-240 are in Figure 7-11, and the complete results are in the Data Supplement in Table S7-5. Soil samples from other sites within LANL that are

associated with present (Los Alamos Plutonium Facility [TA-55]) and past (Disposal of Plutonium Site [TA-21]) plutonium-processing work are included for reference.

Results show no detectable activity for plutonium-238 in soils collected from any of the 15 transect sites, including LANL soils. We noted concentrations of plutonium-239,-240 that were both detectable and higher than the RSRL of 0.017 pCi/g dry in all of the on-site soil sample sites and up to 3 and 5 miles away from the LANL boundary. The concentrations of plutonium-239,-240 in soils collected from the Laboratory boundary generally decrease with distance primarily because plutonium-239,-240 concentrations vary with elevation and soil texture (Whicker and Schultz 1982). Although some ratios ( $\pm$  one sigma) up to 3 and 5 miles away do not overlap 32, these values, because of the high variability in the cesium-137 data, make these numbers too close to call at this point. Because the cesium-137/plutonium-239,-240 ratio up to one mile away deviates significantly from that for fallout, the slightly elevated plutonium-239,-240 level appears to be related to LANL sources. However, the concentrations are still very low ( $< 0.007$  pCi/g dry difference) and far below the SAL of 44 pCi/g dry. Again, this special monitoring study is preliminary and will be



**Figure 7-11.** Plutonium-239,-240 in soils collected along a transect radiating outward from LANL in the predominant wind direction.

repeated in 2003 to gain a more thorough understanding of plutonium-239,-240 concentrations in soils with distance from the Laboratory.

### **2. Concentration of Radionuclides in Soils and Lichen Collected from the Valles Caldera** (*Philip Fresquez*)

Results of split samples of soils and lichen from the Valles Caldera collected in association with the Pueblo of Jemez with distance from the Laboratory are in Tables S7-6 and S7-7, respectively. The Valles Caldera is located approximately 5 miles west of LANL. The question posed by the Pueblo of Jemez was, "Is there a concentration gradient of certain radionuclides from near LANL to distant areas of the tribal domain?" (AQA 2002).

The soils team conducted all sampling and processing according to the procedures and protocols defined in Section B of this chapter. Paragon Analytics, Inc. analyzed the soil and lichen samples for tritium; uranium; strontium-90; cesium-137; plutonium-238; plutonium-239,-240; curium-243,-244; and americium-241.

Most radionuclides in soils collected from the Valles Caldera were nondetectable, were within or very close to RSRLs (Table 7-1), and presented no discernable trend of higher-to-lower radionuclide concentrations in soils with distance from LANL (Table S7-6). However, the Valles Caldera, which is higher in elevation and receives higher amounts of precipitation than the regional locations, would be expected to contain higher

fallout levels. These data agree with the overall statistical evidence provided by the Pueblo of Jemez (AQA 2002). Similarly, most radionuclide concentrations in lichen appeared to have no discernable trends of higher-to-lower radionuclide concentrations with distance from LANL (Table S7-7). These results are also similar to those reported by AQA 2003.

### **3. Polychlorinated Biphenyls in Soils Collected from Regional Areas** (*Gil Gonzales and Philip Fresquez*)

As part of a regional polychlorinated biphenyl (PCB) study, the team collected soils along the Rio Chama and Rio Grande drainages to discern whether a background atmospheric source of PCBs exists that could impact surface water adjacent to LANL. We collected nine composite soil surface samples (0- to 6-in. depth) in southern Colorado and north-central New Mexico within the Rio Chama and Rio Grande drainages. Alta Laboratories analyzed soils for 209 PCBs. The complete data set is in Gonzales and Fresquez 2003 and at <http://lib-www.lanl.gov/cgi-bin/getfile?00783305.pdf>. Trace concentrations of total PCBs measured in soil (mean =  $4.7 \times 10^{-5}$   $\mu\text{g/g}$  wet) appear to be, at least in part, from background global atmospheric sources. The bimodal distribution of low-chlorinated PCB congeners and midchlorinated PCB congeners in the soil samples is interpreted to be typical of volatilized PCB congeners that are found in the atmosphere and dust from global fallout.



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## 8. Foodstuffs and Biota Monitoring









## 8. Foodstuffs and Biota Monitoring

contributing authors:

*Philip Fresquez, Gil Gonzales, John Nyhan, Lars Soholt, Timothy Haarmann, David Keller*

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### A. Foodstuff Monitoring (*Philip Fresquez*)

#### 1. Introduction

A wide variety of wild and domestic edible plant, fruit, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes a critical pathway by which radionuclides can be transferred to humans (Whicker and Schultz 1982). Therefore, over the years we have collected foodstuff samples (e.g., fruits, vegetables, grains, fish, milk, eggs, honey, herbal teas, mushrooms, piñon nuts, domestic animals, and large and small game animals) from the surrounding communities to determine the impacts of Laboratory operations on the human food chain. DOE Orders 5400.1 (replaced by 450.1) (DOE 2003), and 5400.5 (DOE 1993) mandate this monitoring program; and the requirements are in DOE 1991.

The objectives of the program are the following: (1) measure radioactive and nonradioactive (metals and/or organic) contaminant constituents in foodstuffs from on-site (LANL), perimeter, and regional (background) areas; (2) determine trends over time; and (3) estimate dose from the consumption of the foodstuffs. Chapter 3 discusses potential radiation doses to individuals from the ingestion of foodstuffs. This year, our report is on the collection and analysis of produce, fish, milk, and honey.

Since the Cerro Grande fire, personnel have collected and compared many foodstuff samples from areas impacted by the fire with samples collected before the fire. Again this year, the team continued this evaluation by including summarization tables that compare data collected before the fire (before or during 1999) with data collected for 3 years after the fire (2000–2002).

#### 2. Quality Assurance/Quality Control

The team conducts foodstuff sampling according to written, standardized Quality Assurance/Quality

Control (QA/QC) procedures and protocols identified in the overall “Quality Assurance Project Plan (QAPP) for the Soils, Foodstuffs, and Biota Monitoring Project” (RRES-ECO 2002). More specifically, LANL personnel work according to the following operating procedures (OPs):

- “Produce Sampling and Processing for the Foodstuffs Monitoring Program,” LANL-ESH-20-SF-OP-001, R0, 1997;
- “Milk and Tea Sampling and Processing for the Foodstuffs Monitoring Program,” LANL-ESH-20-SF-OP-005, R0, 1997;
- “Fish Sampling and Processing for the Foodstuffs Monitoring Program,” LANL-ESH-20-SF-OP-002, R0, 1997; and
- “Honey Sampling and Processing for the Foodstuffs Monitoring Program,” LANL-ESH-20-SF-OP-004, R0, 1997.

The collection of samples for chemical analyses follows a set procedure to ensure proper collecting, processing, submitting, chemical analyzing, handling, validating, and verifying of data and tabulating of analytical results. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting. Paragon Analytics, Inc. of Fort Collins, Colorado, analyzed the samples for tritium; cesium-137; strontium-90; uranium; plutonium-238; plutonium-239,-240; and americium-241. In some samples, they analyzed for barium, beryllium, mercury, lead, and selenium. Alta Analytical Laboratory of San Diego, California, analyzed the fish for 209 polychlorinated biphenyl (PCB) congeners. These companies met all LANL QA/QC requirements.

#### 3. Produce

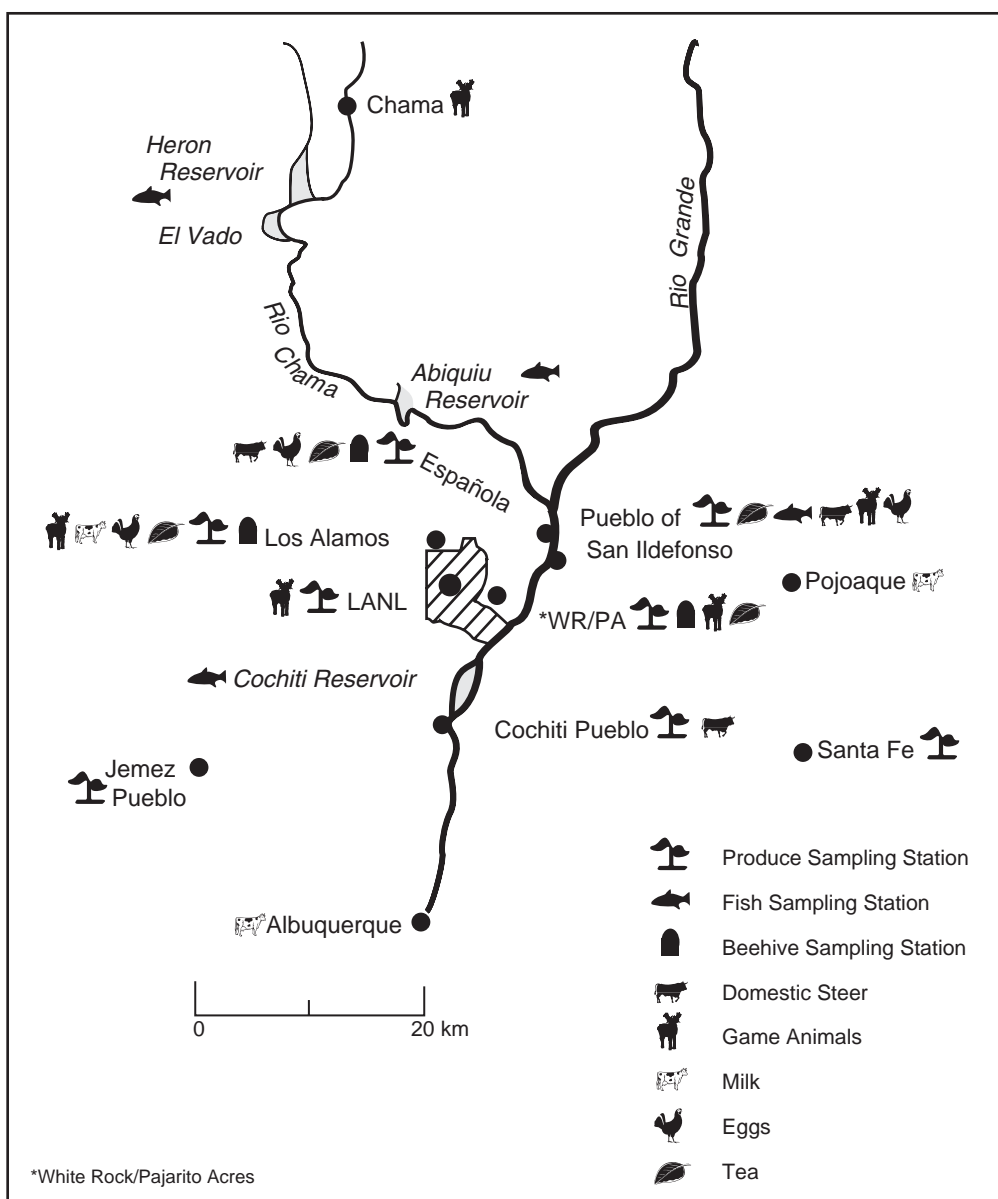
**a. Monitoring Network.** The team collects crop samples (fruits, vegetables, and grains) from perimeter

## 8. Foodstuffs and Biota Monitoring

areas (Los Alamos, White Rock/Pajarito Acres, San Ildefonso Pueblo/El Rancho, Cochiti Pueblo/Pena Blanca/Sile) and on-site areas (LANL) during the summer and fall of each year. Analysts compare these samples with samples collected from regional areas located throughout northern New Mexico (Figure 8-1).

**b. Radiochemical Analytical Results.** Table 8-1 shows a summary of concentrations of radionuclides in produce collected from on-site, perimeter,

and regional locations during the 2002 growing season. The complete data set is in the Data Supplement (Table S8-1). All radionuclide concentrations in fruits, vegetables, and grains collected from on-site, perimeter, and regional areas were very low ( $10^{-5}$  to  $10^{-3}$  pCi/g range), and most were nondetectable (where the result is lower than three counting uncertainties) and/or within regional statistical reference levels (RSRLs). The RSRL is the upper-level regional concentration (mean plus two standard deviations)



**Figure 8-1.** Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations. (Map denotes general locations only.).

**Table 8-1. Mean (std dev) Radionuclide Concentrations in Produce Collected from Regional, Perimeter, and On-Site Locations during the 2002 growing Season<sup>a</sup>**

Location	<sup>3</sup> H (pCi/mL)	<sup>137</sup> Cs (10 <sup>-3</sup> pCi/g dry)	<sup>90</sup> Sr (10 <sup>-3</sup> pCi/g dry)	totU (ng/g dry)	<sup>238</sup> Pu (10 <sup>-5</sup> pCi/g dry)	<sup>239</sup> Pu (10 <sup>-5</sup> pCi/g dry)	<sup>241</sup> Am (10 <sup>-5</sup> pCi/g dry)
<b>Regional Stations</b>							
RSRL <sup>c</sup>	-0.01 (0.12) <sup>b</sup> 0.45	-16.13 (15.82) 50	16.47 (8.09) 61	6.18 (6.07) 25	3.48 (6.95) 63	7.10 (5.95) 85	8.12 (21.20) 129
<b>Perimeter Stations</b>							
Los Alamos	0.18 (0.31) <sup>*</sup>	3.87 (17.09)	28.42 (22.64)	4.05 (3.76)	-0.98 (10.83)	3.86 (12.72)	16.82 (10.46)
White Rock/ Pajarito Acres	0.15 (0.1) <sup>*</sup>	-15.71 (11.42)	17.50 (12.14)	2.34 (2.03)	1.55 (3.6)	13.32 (9.22)	17.69 (9.58)
Cochiti Pueblo/Peña Blanca/Sile	0.13 (0.1) <sup>*</sup>	-7.10 (11.36)	12.73 (11.17)	4.44 (4.13)	-1.80 (8.93)	14.31 (13.78)	11.57 (8.57)
San Ildefonso Pueblo/ El Rancho	0.13 (0.06) <sup>*</sup>	-16.54 (25.25)	18.14 (11.38)	6.74 (10.05)	8.33 (15.19)	3.74 (8.44)	2.82 (8.98)
<b>On-Site Stations</b>							
LANL (Mesa)	0.52 (0.26) <sup>*</sup>	-2.90 (5.53)	16.63 (11.86)	0.98 (0.55)	-1.81 (4.52)	2.16 (2.96)	23.53 (28.37)

<sup>a</sup>No concentration guides exist for produce. When we used a Student's t-test at the 0.05 probability level, with the exception of tritium, no statistical differences occurred in any of the mean values from perimeter and on-site locations when compared with the mean values of the regional background.

<sup>b</sup>See Appendix B for an explanation of the presence of negative values.

<sup>c</sup>Regional Statistical Reference Level: this is the upper limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

\*Means followed by an \* were statistically higher than those in regional background.

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from samples collected over the last 5 years (1998–2002); this is a rolling 5-year value.

We found that as a group (and with using detectable and nondetectable values), most radionuclides, with the exception of tritium, in crops collected from perimeter and on-site areas were not significantly higher ( $\alpha = 0.05$ ) than in produce collected from regional locations. Tritium concentrations, albeit still below the RSRL of 0.45 pCi/mL, were statistically higher in produce from all perimeter and on-site areas, compared with produce collected from regional areas. The differences between the perimeter and regional reference sites, however, were very small; and the results compare well with past years (Fresquez et al. 1995, Fresquez et al. 2001a).

**c. Cerro Grande Fire Effects and Trends over Time (Radiochemical).** The mean radionuclide concentrations in produce collected before and during 1999 and after the fire (2000–2002) are in Table S8-2. Radionuclides, with the exception of tritium, in produce collected from perimeter and on-site areas in the years after the Cerro Grande fire, were statistically ( $\alpha = 0.05$ ) similar to produce collected before the fire. Tritium concentrations, albeit still lower than the RSRL, were significantly higher after the fire in produce collected from some perimeter areas. The difference in concentrations of tritium between sites,

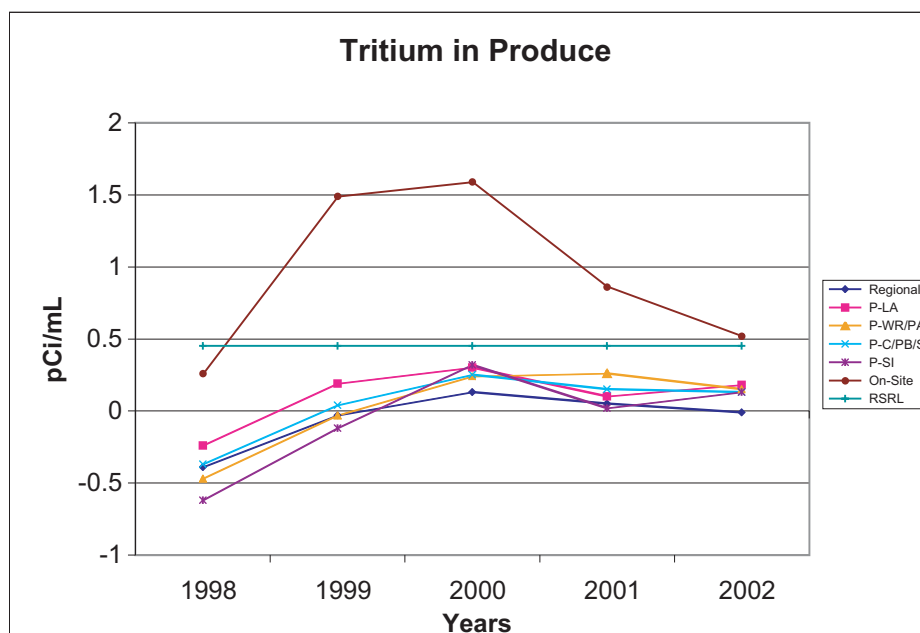
however, were very small; and the long-term trends show that tritium concentrations in produce from most of the perimeter stations are in a stable mode (Figure 8-2). Tritium concentrations in produce from on-site areas, after a small increase in 1999 and 2000, are in a decreasing mode.

### d. Nonradiochemical Analytical Results.

Table 8-2 shows a summary of selected metal elements in produce collected from on-site, perimeter, and regional locations. The complete data set is in Table S8-3. **Note:** The metal elements analyzed were either those that have been consistently detected above the limit of detection (LOD) in past years, have a history of use at LANL, and/or have been detected in significantly higher concentrations in soils.

Of the five metals analyzed in produce collected from perimeter and on-site areas, only three (barium, lead, and selenium) were detected above the LOD; beryllium and mercury were below the LOD. Of the three elements that were above the LOD, all were within RSRLs.

As a group, the levels of all the metal elements analyzed in produce from all perimeter and on-site areas were not significantly higher ( $\alpha = 0.05$ ) than in produce collected from regional areas. Of special note is that beryllium and lead, which were significantly higher in soils collected in perimeter and on-site areas



**Figure 8-2.** Tritium in produce collected from regional, perimeter, and on-site locations from 1998 to 2002.

## 8. Foodstuffs and Biota Monitoring

**Table 8-2. Selected Mean (std dev) Total Trace Element Concentrations ( $\mu\text{g/g}$  dry) in Produce Collected from Regional, Perimeter, and On-Site Locations during the 2002 Growing Season<sup>a</sup>**

Location	Ba		Be	Hg	Pb		Se	
<b>Regional Stations</b>								
	7.4	(4.7)	U <sup>b</sup>	U	1.44	(1.39)	0.69	(0.18)
RL <sup>c</sup>	<0.20		<0.20	<0.05	<0.15		<0.25	
RSRL <sup>d</sup>	28.9		0.20	0.05	9.7		0.90	
<b>Perimeter Stations</b>								
Los Alamos	24.3	(36.5)	U	U	2.94	(2.28)	0.59	(0.19)
White Rock/ Pajarito Acres	8.5	(8.7)	U	U	2.24	(1.65)	0.58	(0.15)
Cochiti Pueblo/Peña Blanca/Sile	23.2	(20.8)	U	U	1.85	(1.14)	0.58	(0.18)
San Ildefonso Pueblo/El Rancho	4.8	(4.4)	U	U	5.39	(8.41)	0.64	(0.12)
<b>On-Site Stations</b>								
LANL (Mesa)	9.0	(9.8)	U	U	2.72	(2.81)	0.49	(0.09)

<sup>a</sup>Analysis by EPA Method 3051 for total recoverable metals

<sup>b</sup>U = undetected; an analyte was analyzed but not detected above the reporting limit.

<sup>c</sup>Reporting limit

<sup>d</sup>Regional Statistical Reference Level: this is the upper limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

(Table 7-3), were not significantly higher in produce collected from perimeter or on-site areas compared with produce collected from regional areas. Trace-element uptake by plants from soils depends on many factors (Hausenbuiller 1974). Insoluble carbonate and phosphate complex formation may restrict heavy-metal uptake in plants growing in alkaline semiarid soils in the western portions of the US (Fresquez et al. 1991).

**e. Cerro Grande Fire Effects and Trends over Time (Nonradiochemical).** Table S8-4 in the Data Supplement shows trace elements in produce collected before and after the Cerro Grande fire. With the exception of selenium, none of the elements analyzed in produce collected after the Cerro Grande fire from almost all sites were significantly higher ( $\alpha = 0.05$ ) in concentrations than levels of trace elements in

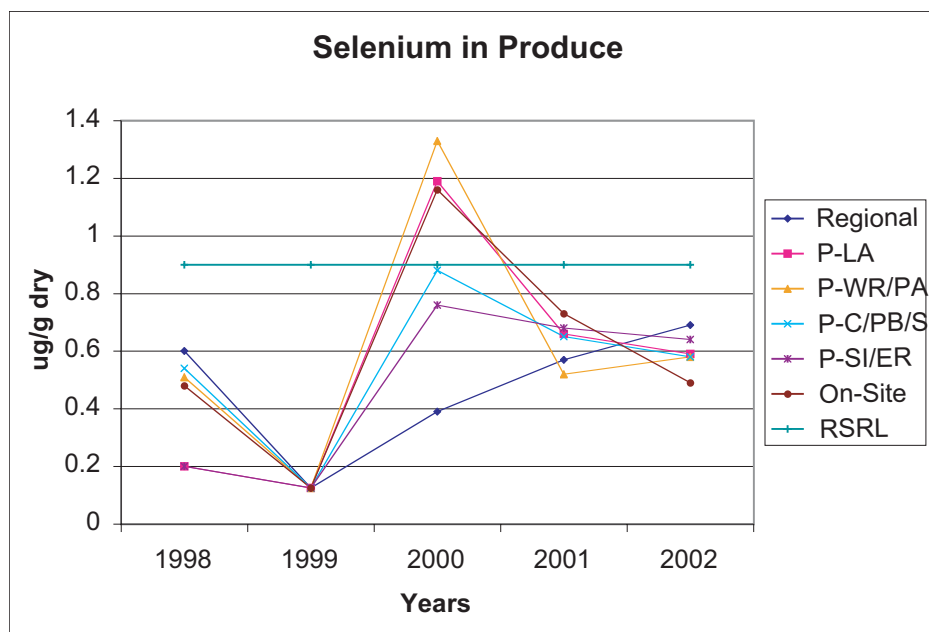
produce collected before the fire. It is hard to say that selenium concentrations in produce collected from these sites increased because of the Cerro Grande fire because

- (1) no other trace elements were elevated after the fire, and
- (2) selenium in soil samples collected from these same sites in 2000 (Fresquez et al. 2001b) and 2002 (Fresquez et al. 2002) (Table S7-4) were not significantly higher than selenium concentrations in soils collected in 1999 (Fresquez and Gonzales 2000).

Figure 8-3 displays the concentrations of selenium in produce collected at all sites from 1998 through 2002 and shows that selenium concentrations in produce from all sites since 2000 (after the fire) generally have decreased nearly to prefire levels.



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**Figure 8-3.** Selenium in produce collected from regional, perimeter, and on-site locations from 1998 to 2002.

### 4. Milk

**a. Monitoring Network.** No commercial dairies operate in the immediate vicinity of LANL. However, from time to time, milk producers request that the Laboratory analyze milk from goats located in the Los Alamos and/or White Rock/Pajarito Acres areas. These samples are compared with goat milk collected from regional areas.

**b. Radiochemical Analytical Results.** In 2002, all radionuclide concentrations in goat milk from the perimeter location (Pajarito Acres), located on the southeast side of LANL, were nondetectable or within upper-level regional concentrations. Tritium and strontium-90 levels, in particular, were similar to tritium and strontium-90 levels in milk from other states in the US (Black et al. 1995). The complete data set is in Table S8-5A.

**c. Cerro Grande Fire Effects and Trends over Time.** The radionuclides in goat milk collected before the Cerro Grande fire showed no significant differences to radionuclides in milk collected after the Cerro Grande fire (Table S8-5B).

### 5. Fish

**a. Monitoring Network.** We collect fish from Abiquiu and Cochiti reservoirs annually. Cochiti

Reservoir, a 10,500-acre impoundment that blocks the Rio Grande, is located approximately 5 miles downstream of LANL. Laboratory analysts compare fish collected from Cochiti Reservoir to fish collected from Abiquiu Reservoir. Abiquiu is located on the Rio Chama, which is upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands (Fresquez et al. 1994).

In 2002, the team also collected fish from a lake that is located on the eastern side of the Rio Grande on Pueblo of San Ildefonso lands and from the Rio Grande. Fish collected on the Rio Grande were from two general stretches: upstream and downstream of the Otowi Bridge. This bridge is located on State Road 502 and all tributaries that flow through LANL lands are located downstream of this structure. The Los Alamos team used gill nets to collect fish from the reservoirs and an electroshocking device to collect fish from the Rio Grande. The team analyzed all fish for radionuclides (muscle plus bone) and metals (fillet) and the fish (fillet) from the Rio Grande for PCBs.

Fish normally collected each year include two types: predators and bottom-feeders. On any given year, predator fish may include the following: northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*),

## 8. Foodstuffs and Biota Monitoring

white crappie (*Pomoxis annularis*), brown trout (*Salmo trutta*), white bass (*Morone chrysops*), and walleye (*Stizostedion vitreum*). Similarly, bottom-feeding fish may include the following: white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpionodes carpio*).

Bottom-feeding fish are better indicators of environmental contamination than the predator game fish because the bottom-feeding fish forage on the bottom where radionuclides readily bind to sediments (Whicker and Schultz 1982).

### b. Radiochemical Analytical Results.

**Reservoirs.** A summary of results of the predator and bottom-feeding fish collections from the reservoirs located upstream and downstream of LANL is found in Table 8-3. The complete data sets are in Table S8-6 and Table S8-7. Most radionuclide concentrations in predator and bottom-feeding fish collected from Cochiti Reservoir, downstream of LANL, were nondetectable or within upper-level regional concentrations. These results were similar to radionuclide contents in crappie, trout, and salmon collected from comparable background reservoirs and lakes in Colorado (Whicker et al. 1972; Nelson and Whicker 1969) and New Mexico (Fresquez et al. 1996, Fresquez et al. 1998a) and to radionuclide levels more recently in fish collected along the length of the Rio Grande from Colorado to Texas (Booher et al. 1998). Also, the results compare well with findings in fish collected in the Rio Grande below LANL in 1998 (Fresquez et al. 1999a).

Using detectable and nondetectable values, we found that most radionuclide concentrations, with the exception of americium-241, in predator and bottom-feeding fish collected downstream of LANL at Cochiti Reservoir were not significantly higher ( $\alpha = 0.05$ ) than radionuclide concentrations in fish collected upstream of LANL at Abiquiu Reservoir. However, for americium-241 the differences were very small (e.g., 0.00021 pCi/g dry), and the amount was still within the historic regional concentration (e.g.,  $< 6.6 \times 10^{-6}$  pCi/g dry).

**Rio Grande.** A summary of findings in the bottom-feeding fish collected from the Rio Grande downstream and upstream of LANL is in Table 8-4; the complete data set is in Table S8-8. Most radionuclides in bottom-feeding fish downstream of LANL on the Rio Grande were either nondetectable and/or within RSRLs. Mean concentrations, when we used detectable

and nondetectable values, of radionuclides in fish downstream of LANL, were similar to fish collected upstream of LANL. Uranium in fish collected from the Rio Grande is about two times higher than concentrations in fish from the reservoirs.

**San Ildefonso Pueblo Lake.** Radionuclide concentrations in small (< 10 in. long) and stocked catfish from San Ildefonso Pueblo Lake are in Table S8-9. All of the radionuclides, with the exception of total uranium, were well within the concentrations of radionuclides in fish from regional background fisheries (e.g., Abiquiu Reservoir and the Rio Grande upstream of LANL) and from past results from other similar fisheries (Fresquez et al. 1996, Fresquez et al. 1998a). On the other hand, total uranium in catfish from San Ildefonso Pueblo Lake was much higher than concentrations of uranium in fish collected from either Abiquiu Reservoir or from the Rio Grande—the Rio Grande fish, located upstream of LANL and collected just yards away from San Ildefonso Pueblo Lake, were about six times lower in concentration than that of fish collected from San Ildefonso Pueblo Lake. Because San Ildefonso Pueblo Lake is upstream from LANL and on the east side of the Rio Grande, the higher concentrations of uranium in these young and stocked fish probably reflect their source of origin rather than any effects from LANL operations.

**Cerro Grande Fire Effects and Trends over Time (Reservoirs).** Table S8-11 contains a comparison of radionuclide concentrations in fish collected at Abiquiu and Cochiti reservoirs before and after the Cerro Grande fire. The team collected fish on seven occasions after the fire. Most radionuclides in fish (muscle plus bone) from Cochiti Reservoir were nondetectable. Also, using detectable and nondetectable values, LANL analysts found no statistical differences ( $\alpha = 0.05$ ) in radionuclide concentrations in fish collected from Cochiti during any of the time periods after the Cerro Grande fire as compared to concentrations in fish collected before the fire. Accordingly, using a Mann-Kendall test at  $\alpha = 0.05$ , we found that most radionuclides in fish collected downstream at Cochiti after the fire showed no significant trends. Only americium-241 and strontium-90 in predator and bottom-feeding fish, respectively, showed significant short-term increases. Because no significant differences showed up in concentrations of these two radionuclides in fish collected before and after the fire (or in concentrations in fish collected from a regional reservoir upstream of LANL), the small increases from 2000 to 2002 were probably not related to the fire. The measured concentrations of cesium-137 are

**Table 8-3. Mean (std dev) Radionuclide Concentrations in Predator and Bottom-Feeding Fish (muscle plus bone) Collected from the Reservoirs Upstream and Downstream of Los Alamos National Laboratory during 2002**

Fish Type/ Location	<sup>90</sup> Sr (10 <sup>-2</sup> pCi/g dry)	<sup>137</sup> Cs (10 <sup>-2</sup> pCi/g dry)	totU (ng/g dry)	<sup>238</sup> Pu (10 <sup>-5</sup> pCi/g dry)	<sup>239</sup> Pu (10 <sup>-5</sup> pCi/g dry)	<sup>241</sup> Am (10 <sup>-5</sup> pCi/g dry)
<b>Predators</b>						
<b>Upstream (Abiquiu Reservoir):</b>						
	1.40 (0.51)	-0.29 (2.48) <sup>a</sup>	3.19 (1.34)	-4.84 (21.20)	16.70 (20.22)	14.52 (11.22)
<b>RSRL<sup>b</sup></b>	4.2	2.2	5.6	23.4	35.8	65.5
<b>Downstream (Cochiti Reservoir):</b>						
	2.37 (0.98)	-0.49 (4.44)	9.88 (12.65)	3.83 (21.89)	7.26 (12.50)	35.49 (15.09)*
<b>Bottom Feeders</b>						
<b>Upstream (Abiquiu Reservoir):</b>						
	2.80 (1.15)	0.10 (4.13)	12.22 (6.11)	5.89 (7.87)	13.87 (10.78)	8.74 (13.27)
<b>RSRL<sup>b</sup></b>	8.3	0.80	16.7	34.9	20.1	33.6
<b>Downstream (Cochiti Reservoir):</b>						
	2.98 (0.94)	-0.46 (2.85)	21.52 (16.67)	0.71 (7.54)	7.84 (5.88)	14.96 (5.39)

<sup>a</sup>See Appendix B for an explanation of the presence of negative values.

<sup>b</sup>Regional Statistical Reference Level: this is the upper-limit background concentration (mean + 2 std dev) based on data from 1998 to 2002.

\*Means within the same column and fish type followed by an \* were significantly different from Abiquiu (background) when we used a Student's t-test at the 0.05 probability level.

**Table 8-4. Mean (std dev) Radionuclide Concentrations in Bottom-Feeding Fish (muscle plus bone) Collected from the Rio Grande Upstream and Downstream of Los Alamos National Laboratory during 2002**

<b>Fish Type</b>	<b><sup>90</sup>Sr</b>		<b><sup>137</sup>Cs</b>		<b>totU</b>		<b><sup>238</sup>Pu</b>		<b><sup>239</sup>Pu</b>		<b><sup>241</sup>Am</b>	
<b>Location</b>	<b>(10<sup>-2</sup> pCi/g dry)</b>		<b>(10<sup>-2</sup> pCi/g dry)</b>		<b>(ng/g dry)</b>		<b>(10<sup>-5</sup> pCi/g dry)</b>		<b>(10<sup>-5</sup> pCi/g dry)</b>		<b>(10<sup>-5</sup> pCi/g dry)</b>	
<b>Upstream (Above the Otowi Bridge)</b>												
	2.44	(0.31)	-0.38	(1.21) <sup>a</sup>	35.89	(5.66)	-6.89	(21.54)	11.40	(7.48)	0.00	(9.90)
RSRL <sup>b</sup>	8.3		0.8		16.7		34.9		20.1		33.6	
<b>Downstream (Below the Otowi Bridge)</b>												
	3.17	(0.73)	1.90	(3.79)	29.12	(6.18)	-2.85	(24.81)	11.88	(19.87)	0.00	(16.45)

<sup>a</sup>See Appendix B for an explanation of the presence of negative values.

<sup>b</sup>Regional Statistical Reference Level: this is the upper-limit background concentration (mean + 2 std dev) based on (reservoir)bottom-feeding data from 1998 to 2002.

## 8. Foodstuffs and Biota Monitoring

in general agreement with the quality of runoff after the Cerro Grande fire, but are in marked contrast to the modeled (upper-bound) post-fire cesium-137 estimates made by an independent risk assessor employed by the State of New Mexico (RAC 2002). The modeled concentrations of cesium-137 in fish (RAC 2002) were three-to-four orders of magnitude higher than the actual values measured after the fire.

For a description of radionuclides in fish collected from Abiquiu and Cochiti reservoirs over a longer period of time (1976–2002), see Fresquez et al. 2002. That analysis showed no significant differences in any of the radionuclides, with the exception of uranium, in predator and bottom-feeding fish collected from Cochiti Reservoir over the past 2 1/2 decades compared with predator and bottom-feeding fish collected from Abiquiu. Total uranium was the only element that the LANL team found to be in significantly higher concentrations in both predator and bottom-feeding fish from Cochiti as compared with fish from an upstream reservoir. The higher uranium concentrations in fish collected from Cochiti, however, were related to natural sources (Fresquez et al. 1994 and Fresquez and Armstrong 1996). Although the long-term means were not significantly different from those of background fish, trend analyses show that tritium in predator fish and plutonium-239,-240 in bottom-feeding fish from Cochiti were significantly increasing over time, whereas strontium-90 and cesium-137 in fish from Cochiti were significantly decreasing over time. Plutonium-239,-240 in all fish, including those collected from reservoirs upstream of LANL, were increasing over time.

### c. Nonradiological (Metals) Analytical Results.

**Reservoirs.** A summary of selected total trace elements in the muscle (fillet) of predator and bottom-feeding fish collected from Abiquiu and Cochiti reservoirs during the year 2002 is in Table 8-5; the complete data sets are in Tables S8-12 and S8-13. In general, most of the trace elements in both predator and bottom-feeding fish collected upstream and downstream of LANL were below the LOD. Of the elements that were above the LOD (barium, mercury, and selenium), all collected from Cochiti Reservoir were within historical regional background concentrations and statistically similar to fish from Abiquiu.

Mercury concentrations, a major problem in New Mexico fisheries, were higher in all fish collected from Abiquiu than concentrations in fish from Cochiti. Both sets of data compared well with past

years (Fresquez et al. 1999b) and with data from the New Mexico Environment Department (NMED) (Yanicak 2001). Also, these data compare well with mercury concentrations in catfish collected from Conchas Lake, which averaged 0.25 µg/g wet weight, and Santa Rosa Lake, which ranged from 0.22 to 0.33 µg/g wet weight (Bousek 1996, Torres 1998).

A comparison of mercury concentrations in predator (N = 9) and bottom-feeding (N = 8) fish collected from both Abiquiu and Cochiti reservoirs (pooled data) shows that mercury concentrations in predator fish (mean = 0.16, std dev = 0.08) were similar to mercury in bottom-feeding fish (mean = 0.17, std dev = 0.10). Usually, mercury is found in higher concentrations in predator fish than in bottom-feeding fish. These higher concentrations occur because methyl mercury, which is fat- and water-soluble and easily taken up by living cells (Hammond and Foulkes 1986), readily biomagnifies (e.g., carnivorous fish > omnivorous fish > herbivorous fish) (Ochiai 1995). In both cases, the levels of mercury in predator and bottom-feeding fish muscle (fillets) collected at Abiquiu and Cochiti reservoirs were still below the US Food and Drug Administration's ingestion limit of 1 µg mercury/g wet weight (Torres 1998).

**Rio Grande.** A summary of selected total trace elements found in fish collected from the Rio Grande is in Table 8-6, and the complete data set is in Table S8-14. Most of the elements in predator and bottom-feeding fish collected upstream and downstream of LANL on the Rio Grande were below the LOD. Of the elements (barium, mercury, and selenium) that were above the LOD, all were within RSRLs. As a group, selenium concentrations in fish (predator and bottom-feeders pooled) collected from downstream areas were significantly higher at the 0.05 probability level than selenium levels in fish collected upstream of LANL influence. The differences were small, however.

**San Ildefonso Pueblo Lake.** A summary of findings in catfish collected from San Ildefonso Pueblo Lake is in Table 8-7, and the complete set of results is in Table S8-15. Most elements in fish from San Ildefonso Pueblo Lake were below the LOD. Of the elements (barium, mercury, and selenium) that were above the LOD, all were within the historical levels established from fish collected from the Rio Grande upstream of LANL. In fact, the data compare well with elements in fish collected from the Rio Grande, and mercury levels in these fish were considerably less than those in fish from the Rio Grande.

**Cerro Grande Fire Effects and Trends over Time (Reservoirs).** Except for mercury, trace elements

## 8. Foodstuffs and Biota Monitoring

**Table 8-5. Selected Mean (std dev) Total Trace-Element Concentrations ( $\mu\text{g/g}$  wet weight) in Predator and Bottom-Feeding Fish (muscle fillet) Collected from the Reservoirs Upstream and Downstream of Los Alamos National Laboratory in 2002**

Fish Type/Location	Ba	Hg	Pb	Se
<b>Predators</b>				
<b>Upstream (Abiquiu Reservoir):</b>				
	U <sup>a</sup>	0.17 (0.1)	U	0.93 (0.07)
<b>RL<sup>b</sup></b>	<0.1	<0.01	<0.15	<0.25
<b>RSRL<sup>c</sup></b>		0.41		0.74
<b>Downstream (Cochiti Reservoir):</b>				
	U	0.16 (0.08)	U	0.68 (0.13)
<b>Bottom Feeders</b>				
<b>Upstream (Abiquiu Reservoir):</b>				
	0.10 (0.08)	0.23 (0.09)	U	0.79 (0.25)
<b>RL<sup>b</sup></b>	<0.1	<0.01	<0.15	<0.25
<b>RSRL<sup>c</sup></b>	1.3	0.48		1.48
<b>Downstream (Cochiti Reservoir):</b>				
	0.25 (0.35)	0.08 (0.04)	0.12 (0.06)	0.66 (0.07)

<sup>a</sup>U = undetected: an analyte was analyzed but not detected above the reporting limit.  
<sup>b</sup>Reporting limit  
<sup>c</sup>Regional Statistical Reference Level is the upper limit background (mean + 2 std dev) from data from 1998 to 2002.

in fish collected from either Abiquiu or Cochiti within the past years were below the LOD. Consequently, only mercury data are described here with respect to comparisons over time before (1991–1999) and after (2000–2002) the Cerro Grande fire. See Table S8-16 for these results. Results show no significant differences ( $\alpha = 0.05$ ) in mercury concentrations in bottom-feeding fish collected at Cochiti Reservoir in any of the years after the Cerro Grande fire compared with mercury concentrations in fish collected at Cochiti before the fire. There appears to be no trend, either decreasing or increasing, based on the last 5 years of data (1998–2002) (Figure 8-4).

Fresquez and colleagues (Fresquez et al. 1999b) showed that mean mercury concentrations in fish collected from both reservoirs were significantly

decreasing over time. Analysts don't completely know why concentrations of mercury are decreasing in fish collected from Abiquiu and Cochiti, but the reduction of emissions in coal-burning power plants or the reduction of carbon sources within the reservoirs may be part of the reason. Since the early 1980s, for example, coal-burning power plants in the northwest corner of New Mexico have been required to install venturi scrubbers and bag houses to capture particulates and reduce air emissions (Martinez 1999). Also, because the conversion of mercury to methyl mercury is primarily a biological process, mercury concentrations in fish tissue rise significantly in impoundments that form behind new dams and then the concentrations gradually decline to an equilibrium level as the



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**Table 8-6. Selected Mean (std dev) Total Trace-Element Concentrations ( $\mu\text{g/g}$  wet weight) in Fish (muscle fillet) Collected from the Rio Grande Upstream and Downstream of Los Alamos National Laboratory in 2002**

Location	Ba	Hg	Pb	Se
<b>Upstream (Above the Otowi Bridge)</b>				
	0.09 (0.09)	0.10 (0.07)	U <sup>a</sup>	0.65 (0.11)
<b>RL<sup>b</sup></b>	<0.10	<0.01	<0.15	<0.25
<b>RSRL<sup>c</sup></b>	0.93	0.3 <sup>c</sup>		0.94
<b>Downstream (Below the Otowi Bridge)<sup>d</sup></b>				
	0.09 (0.08)	0.16 (0.08)	0.08 (0.03)	0.85 (0.16)*

<sup>a</sup>U = undetected: an analyte was analyzed but not detected above the reporting limit.

<sup>b</sup>Reporting limit

<sup>c</sup>Regional Statistical Reference Level is the upper limit background (mean + 2 std dev) from 1997 (Fresquez et al. 1999a) and present data.

\*Means within the same column followed by an \* were significantly different from upstream (background) when we used a Student's t-test at the 0.05 probability level.

**Table 8-7. Selected Mean (std dev) Total Trace-Element Concentrations ( $\mu\text{g/g}$  wet weight) in Bottom-Feeding Fish (muscle fillet) Collected from San Ildefonso Pueblo Lake in 2002**

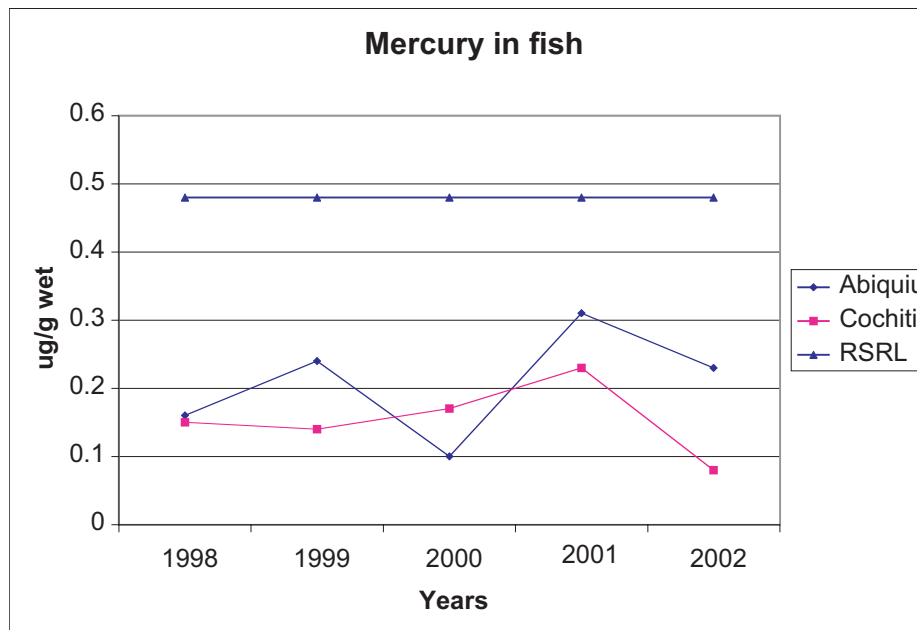
Location	Ba	Hg	Pb	Se
<b>San Ildefonso Lake</b>				
	0.08 (0.05)	0.03 (0.02)	U <sup>a</sup>	0.5 (0.08)
<b>RL<sup>b</sup></b>	<0.1	<0.01	<0.15	<0.25
<b>RSRL<sup>c</sup></b>	0.93	0.3		0.94

<sup>a</sup>U = undetected: an analyte was analyzed but not detected above the reporting limit.

<sup>b</sup>Reporting limit

<sup>c</sup>Regional Statistical Reference Level is the upper-limit background (mean + 2 std dev) from 1997 (Fresquez et al. 1999a) and 2002 Rio Grande data (Table S8-15) for Rio Grande fish.

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**Figure 8-4.** Mercury in fish collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1998 to 2002.

carbon provided by flooded vegetation is depleted (NMED 1999).

### **d. Nonradiological Analytical Results.** (*Gil Gonzales*)

**Rio Grande.** The summary results of PCBs in catfish and carp collected from the Rio Grande upstream and downstream of LANL is in Table 8-8 and in Table S8-17. The complete data set is in a report by Gonzales and Fresquez (2003) and at <http://lib-www.lanl.gov/cgi-bin/getfile?00783305.pdf>. Catfish from upstream ( $n = 5$ ) contained statistically higher concentrations ( $\alpha = 0.05$ ) of total PCBs (mean =  $0.028 \mu\text{g/g}$  wet) than catfish from downstream ( $n = 10$ ) (mean =  $0.015 \mu\text{g/g}$  wet). However, carp from upstream ( $n = 4$ ) contained lower concentrations of total PCBs (mean =  $0.0307 \mu\text{g/g}$  wet) than carp from downstream ( $n = 4$ ) ( $0.0798 \mu\text{g/g}$  wet); but, the difference was not statistically significant. The dominant PCB homologue in all fish samples was hexachlorobiphenyl. Total PCB concentrations in fish in 2002 were lower than in 1997; however, differences in analytical methods and other uncertainties exist. A review of historical quantitative PCB data for fish from the Rio Grande and Abiquiu and Cochiti reservoirs does not indicate a distinct contribution of PCBs from LANL to fish in the Rio Grande or Cochiti. Analysis of homologue patterns for fish does not provide evidence of a LANL contribution. Nevertheless, concentrations

of PCBs in fillets of fish sampled from the Rio Grande are indicative of potential adverse chronic health impacts from the consumption of these fish on a long-term basis, according to US Environmental Protection Agency (EPA) guidance.

## **6. Honey**

**a. Monitoring Network.** The Los Alamos team collects honey from two perimeter areas about every third year—Los Alamos and White Rock/Pajarito Acres. Analysts compare honey from these hives to honey collected from regional hives located in the Jemez area.

**b. Radiochemical Analytical Results.** The complete data set of radionuclides in honey from perimeter and regional locations is in Table S8-18. The mean concentration of all radionuclides in honey collected from the perimeter areas were within RSRLs.

**c. Cerro Grande Fire Effects and Trends over Time.** Radionuclide levels in honey from Los Alamos and White Rock collected in the years after the Cerro Grande fire were not significantly higher than in honey collected before the fire. All radionuclides, including tritium, were in concentrations similar to past years (Table S8-19) (Fresquez et al. 1997a, Fresquez et al.

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**Table 8-8. Mean (std dev) Total Polychlorinated Biphenyl Concentrations and TEQs<sup>a</sup> in Fillets of Catfish and Carp Collected from the Rio Grande in May 2002.<sup>b</sup>**

Fish Type	Downstream of LANL		Upstream of LANL	
	Concentration ( $\mu\text{g/g-ww}$ )	TEQs ( $\text{pg/g}$ )	Concentration ( $\mu\text{g/g-ww}$ )	TEQs ( $\text{pg/g}$ )
Catfish	1.5E-02 (1.1E-02)	0.29	2.8E-02 (0.79E-02)	1.6
Carp	8.0E-02 (1.1E-01)	2.7	3.5E-02 (3.9E-02)	3.9

<sup>a</sup>Toxicity equivalence quotients

<sup>b</sup>Values are based on full congener determinations.

1997b, Fresquez and Gonzales 2000). For a description of trends in bees and honey within the LANL environment over a longer period of time, see Fresquez et al. 1997a and Fresquez et al. 1997b.

### B. Biota Monitoring (*Gil Gonzales*)

#### 1. Introduction

In addition to mandating the monitoring of human foodstuffs for contaminants, DOE Orders 5400.1 (replaced by 450.1, DOE 2003) and 5400.5 mandate the monitoring of nonfoodstuff biota for the protection of ecosystems (DOE 1993). Although monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program (ESP), in 1994 when the DOE requested additional emphasis on nonfoodstuff biota. Laboratory personnel monitor nonfoodstuff biota, such as small mammals, amphibians and reptiles, birds, and vegetation, within and around LANL on a systematic or special study basis for radiological and nonradiological constituents.

Vegetation is one of the media that we periodically sample as part of the routine surveillance program. Vegetation is the foundation of ecosystems, as it provides the initial usable form of energy and nutrients that are transferred through food chains. Because of this function in the food chain, vegetation can serve as an important pathway of contaminants to biological systems. Such contaminants include those adhering to soil that is attached to plant surfaces and are ingested during the consumption of plants. Plants contain

radionuclides that settle on their surfaces from global fallout, i.e., foliar deposition, and, to a lesser extent, that are absorbed by plant roots (Whicker and Shultz 1982). Consequently, monitoring radionuclide concentrations in vegetation over time is important to understanding the nature of radionuclide transport through food chains and to understanding the dynamics of radioactivity in the environment at nuclear facilities.

A good baseline of radionuclides in plants at key locations can be used to characterize any releases from LANL activities, characterize pathways, and evaluate potential impacts to biota. With ecological risk assessment becoming an important issue at LANL and other DOE sites, information such as this will be helpful in establishing coefficients of contaminant transfer between trophic levels specific to each site so that accurate radiation dose estimates can be made (Whicker and Schultz 1982, Calabrese and Baldwin 1993, USEPA 1998).

The two main historical objectives of the biota program are to determine (1) on-site contaminant concentrations in biota and compare them with off-site regional concentrations and (2) trends over time. On-site concentrations are the result of potential Laboratory-added contamination plus, in many cases, natural sources. With the issuance of the interim standard on evaluating radiation doses to aquatic and terrestrial biota (DOE 2002), a new and third objective is providing data for use in evaluating compliance with specified limits on radiation dose to plants and animals. Chapter 3 includes the results of the applications of the standard that were made in 2002.

## 8. Foodstuffs and Biota Monitoring

### 2. Quality Assurance/Quality Control

Laboratory personnel conduct biota sampling according to written, standardized QA/QC procedures and protocols. These procedures and protocols are identified in the overall QAPP for the Soils, Foodstuffs and Biota Monitoring Project (RRES-ECO 2002); and, more specifically in the following OPs:

- “Produce Sampling and Processing for the Foodstuffs Monitoring Program,” LANL-ESH-20-SF-OP-001, R0, 1997;
- “Sampling and Sample Processing for the Waste-Site Monitoring Program,” LANL-ESH-20-SF-OP/HCP-011, R2;
- “Managing Bee Colonies,” LANL-ESH-20-BIO-OP-024, R0;
- “Rodent Trapping,” LANL-RRES-ECO-BIO-HCP/OP-035, R3; and
- “Mist Netting Birds,” LANL-RRES-ECO-BIO-HCP/OP-027, R2.

Paragon Analytics, Inc., analyzed the samples for tritium; plutonium-238; plutonium-239,-240; strontium-90; americium-241; cesium-137; and uranium. Also, for Dual Axis Radiographic Hydrodynamic Test facility (DARHT) samples, Paragon Analytics, Inc. analyzed the samples for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium. (**Note:** prior evaluations of metals at Area G have showed no elements of concern.) Paragon Analytics met all QA/QC requirements.

### 3. Institutional Monitoring

**a. Monitoring Network.** Vegetation sampling locations corresponded to soil sampling locations described in Chapter 7. Team members collect these samples from 3 regional background locations, 10 perimeter locations, and at 12 locations within the LANL boundary (Figure 7-1). In 2002, the team collected 25 samples of composite, unwashed overstory (shoot tip) conifer tree vegetation. We did not collect understory vegetation (e.g., grasses, forbs) in 2002.

Sampled overstory vegetation included *Pinus edulis* (piñon pine), *Pinus ponderosa* (ponderosa pine), and/or *Juniperus spp.* (juniper species). The samples themselves consisted of tree-shoot tips (needles and branch endings) approximately 2.5–5 cm

(1–2 in.) in length. Site differences did not allow sampling of the same overstory species at each sampling station; however, previous statistical analysis of species effect has shown no differences in radionuclide accumulation by species (Gonzales et al. 2000).

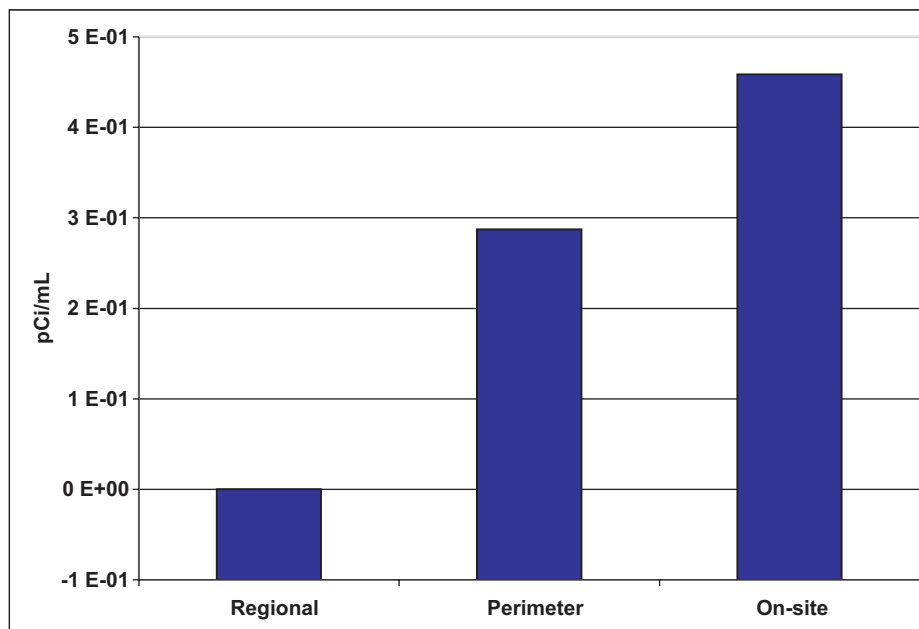
**b. Radiochemical Analytical Results.** The detailed data are in Table S8-20. Most radionuclide concentrations in overstory samples from on-site and perimeter stations were nondetectable or within RSRLs. Americium-241, cesium-137, and plutonium-238 were nondetectable in all samples including regional samples. Tritium and plutonium-239,-240 were nondetectable in the regional samples and detectable in some of the perimeter and on-site samples. Strontium-90, uranium-234, uranium-238, and total uranium were detectable in all of the samples at all of the sites; but levels were within RSRLs.

Statistical comparisons of all possible combinations of regional, perimeter, and on-site values for each radionuclide resulted in no statistical differences between sites, with one exception. The exception was statistically higher ( $\alpha = 0.05$ ) tritium in on-site overstory vegetation (mean = 2.4 pCi/g dry) than regional overstory (mean = 0 pCi/g dry); however, maximum concentrations of all radionuclides, including tritium, were lower than toxicity reference values. The results and comparisons between sites are consistent with results on overstory from the same locations in 1998 (Gonzales et al. 2000) and generally consistent with historical results on soils (Fresquez et al. 1998b). A decreasing concentration of tritium from on-site to perimeter to off-site regional locations is evident, as shown in Figure 8-5.

### 4. Facility Monitoring

**a. Monitoring Network.** The two main facilities where biota monitoring takes place are the Laboratory’s principal low-level radioactive waste disposal site (Area G) (Lopez 2002) (Figure 7-7) and the Laboratory’s principal explosive test facility (DARHT) (Nyhan et al. 2001a) (Figure 7-8). We compared results for radionuclide levels in biota collected at Area G with RSRLs and compared results for radionuclide and nonradionuclide levels in biota collected at DARHT with baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and trace elements in biota in the vicinity of the DARHT facility (1996–1999) before the operation phase (2000 and after). The Mitigation Action Plan for the DARHT facility at LANL man-

## 8. Foodstuffs and Biota Monitoring



**Figure 8-5.** Tritium mean concentrations in conifer-tree overstory samples collected within LANL (on-site), at the LANL perimeter, and at regional stations.

dated the establishment of baseline (preoperational) concentrations for potential environmental contaminants resulting from DARHT operations (DOE 1996). Laboratory personnel calculated these concentrations of radionuclides and trace elements from the mean DARHT facility sample concentration plus two standard deviations. (**Note:** Previous evaluations of BSRLs with RSRLs show no statistically significant differences between the two, and the use of BSRLs at DARHT is for compliance reasons.)

### b. Radionuclide Analytical Results for Area G (TA-54).

**Vegetation** (*John Nyhan*). In 2002, LANL personnel collected unwashed overstory vegetation samples at nine locations within and in the vicinity of Area G (Figure 7-7). Because of the on-going drought in the area, the team could not collect understory vegetation samples. The summary of selected sampling results is in Table 8-9; the complete data set is in Nyhan et al. 2003a. Results show that most of the mean radionuclide concentrations in the unwashed overstory vegetation samples collected at the Area G perimeter were above the RSRLs. The vegetation samples collected inside Area G had mean concentrations of tritium that exceeded RSRLs. Tritium concentrations in vegetation samples were largest on the southwestern and southern sides of Area G; and

plutonium-238 and plutonium-239,-240 concentrations were largest on the northeastern corner of Area G. These results are consistent with results from soils (Table 7-3) and with results from studies in previous years (Nyhan et al. 2000, Nyhan et al. 2001b). Significant changes over time were not detected in the concentrations of tritium at perimeter sampling locations that contained the largest concentrations of radionuclides in overstory vegetation.

**Bees** (*Timothy Haarmann*). Laboratory team members collected honeybee samples from two colonies located on the south end of Area G near the tritium shafts and one colony (regional reference site) established 10 km (6 mi) south of Jemez Springs, New Mexico. The data are in a report by Haarmann and Fresquez (2003). In general, all of the radionuclides, with the exception of tritium, in the honeybee colonies at Area G were within RSRLs. Tritium levels in the Area G bees were measured at 267 and 123 pCi/mL; the control colony contained tritium at 0.19 pCi/mL; and the RSRL for tritium is 3.8 pCi/mL. These results are similar to past results (Haarmann and Fresquez 1998, 1999, 2002).

**Small Mammals** (*Lars Soholt*). The team collected six composite small-mammal samples (five whole-body mice per composite) at Area G and one composite sample from a regional site. The transuranic nuclides and tritium concentrations were higher

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**Table 8-9. Selected Mean (std dev) Radionuclide Concentrations in Unwashed Overstory Vegetation Collected from Area G in 2002<sup>a</sup>**

Location	<sup>3</sup> H (pCi/mL) <sup>b</sup>	<sup>241</sup> Am (pCi/g ash)	<sup>238</sup> Pu (pCi/g ash)	<sup>239,-240</sup> Pu (pCi/g ash)
<b>On-Site</b>	8.8 (0.0)	0.040 (0.0)	0.0064 (0.0)	0.029 (0.0)
<b>Perimeter</b>	132 (281)	1.2 (2.0)	0.065 (0.099)	1.3 (2.2)
<b>Regional</b>	0.00 (0.16)	0.0025 (0.0019)	-0.00070 (0.0036)	0.0059 (0.0042)
<b>RSRL<sup>c</sup></b>	0.50	0.051	0.013	0.068

<sup>a</sup>Sample locations are shown in Figure 7-7.

<sup>b</sup>Concentration for <sup>3</sup>H is based on moisture in vegetation.

<sup>c</sup>Regional Statistical Reference Level: this is the upper (95%) level background concentration (mean + 2 std dev) from 1998 to 2002.

in small-mammal samples collected from on-site areas compared with the reference site and RSRLs. These data are similar to past years (Biggs et al. 1995 and 1997, Bennett et al. 1996 and 1998) and the RSRLs are in a report by Bennett et al. (2002).

### c. Radionuclide and Nonradionuclide Analytical Results for DARHT (TA-15).

**Vegetation** (*John Nyhan*). The summary of the results of selected radionuclides and trace elements in overstory vegetation at DARHT is in Table 8-10. The complete data set is in a report by Nyhan et al. (2003b). None of the radionuclide concentrations found in overstory vegetation samples were above BSRLs (Fresquez et al. 2001c), except for tritium and total uranium. Even these samples were not statistically different than the BSRL concentration because the difference was within one standard deviation of the BSRL concentration. Similarly, the mean trace-element concentrations in most of the samples were lower than BSRL concentrations, with the exception of arsenic, copper, and selenium. Again, the mean copper and selenium concentrations in the DARHT overstory samples were not significantly different than concentrations found in regional samples. Insufficient data exists to make a similar comparison for arsenic.

**Bees** (*Timothy Haarmann*). LANL personnel collected honeybee samples from five colonies approximately 100 m northwest of the DARHT facility. The data are in a report by Haarmann (2003). In general, results show that all radionuclides, with the exception of tritium, and all metals were within BSRLs. Honeybees collected from four of the five hives contained tritium concentrations higher than the BSRL. The BSRLs are in a report by Haarmann (2001).

**Small Mammals** (*Lars Soholt*). The team collected three composite samples (five whole-body mice per composite) on the DARHT facility grounds. Results for the plutonium isotopes, americium, and cesium in all small-mammal samples collected from DARHT were below minimum detectable concentrations. Only one radionuclide, tritium, in one sample (790 pCi/L) exceeded the BSRL of 626 pCi/L. Similarly, all metals were within BSRLs. BSRLs are in a report by Bennett et al. (2001).

**Birds** (*David Keller*). LANL team members collected eight bird composite samples (two-to-five birds per composite) that were all the same or similar species. All radionuclide concentrations were within BSRLs. Similarly, all but one of the bird samples analyzed for metals contained concentrations below the LOD. The sample that had the concentration above the LOD, however, was below the BSRL. BSRLs are in a report by Keller and Nyhan (2001).



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**Table 8-10. Selected Mean (std dev) Total Trace-Element Concentrations ( $\mu\text{g/g}$  dry) in Overstory Vegetation Collected at the DARHT Facility in 2002**

Sample Type	As	Cu	Se
On-Site	0.44 (0.074)	14 (5.5)	0.69 (0.074)
Regional <sup>a</sup>	0.10 <sup>b</sup>	3.3	0.20
BSRL <sup>c</sup>	0.28	4.6	0.35

<sup>a</sup>The regional overstory vegetation samples collected in 1996.

<sup>b</sup>Analysis was below the specific detection limit of the analytical method, so these values are reported as one-half the detection limit.

<sup>c</sup>BSRL is the Baseline Statistical Reference Level (Fresquez et al. 2001 b).

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## Standards for Environmental Contaminants

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1, "Environmental Safety and Health Reporting."

**Radiation Standards.** DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the DOE dose factors from DOE 1988a and DOE 1988b. The dose factors DOE adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard (RPS) for the public (NCRP 1987). Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. The PDLs and the DOE dose factors are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the

ICRP. The EDE includes doses from both internal and external exposure.

Radionuclide concentrations in air or water are compared to DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for air are the radionuclide concentrations in air that, if inhaled continuously for an entire year, would give a dose of 100 mrem. Similarly, the DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem per year. Derived air concentrations (DACs) were developed for protection of workers and are the air concentrations that, if inhaled throughout a "work year," would give the limiting allowed dose to the worker. Table A-2 shows the DCGs and DACs.

In addition to DOE standards, in 1985 and 1989, the EPA established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61, Subpart H. This regulation states that emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. DOE has adopted this dose limit (Table A-1). This dose is calculated at the location of a residence, school, business or office. In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 mrem to a member of the public. A complete listing a 40 CFR 61 Subpart H is available in ESH-17 2000.

**Nonradioactive Air Quality Standards.** Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

**National Pollutant Discharge Elimination System.** The types of monitoring required under National Pollutant Discharge Elimination System (NPDES), and the limits established for sanitary and industrial outfalls can be found at <http://eweb.lanl.gov/>.

**Drinking Water Standards.** For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico



## Appendix A

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Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Regulations go to <http://www.nmenv.state.nm.us/dwb/dwbtop.html>. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a

specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

**Surface Water Standards.** Concentrations of radionuclides in surface water samples may be compared to either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995). ([http://www.nmenv.state.nm.us/NMED\\_regs/swqb/20\\_6\\_4\\_nmac.pdf](http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.pdf)) The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

**Organic Analysis of Surface and Groundwaters: Methods and Analytes.** Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods as shown in Table A-4. This table shows the number of analytes included in each analytical suite. The specific compounds analyzed in each suite are listed in Tables A-5 through A-8.

**Table A-1. Department of Energy Public Dose Limits for External and Internal Exposures**

<b>Effective Dose Equivalent<sup>a</sup> at Point of Maximum Probable Exposure</b>	
<b>Exposure of Any Member of the Public<sup>b</sup></b>	
All Pathways	100 mrem/yr <sup>c</sup>
Air Pathway Only <sup>d</sup>	10 mrem/yr
Drinking Water	4 mrem/yr
<b>Occupational Exposure<sup>b</sup></b>	
Stochastic Effects	5 rem (annual EDE <sup>e</sup> )
<b>Nonstochastic Effects</b>	
Lens of eye	15 rem (annual EDE <sup>e</sup> )
Extremity	50 rem (annual EDE <sup>e</sup> )
Skin of the whole body	50 rem (annual EDE <sup>e</sup> )
Organ or tissue	50 rem (annual EDE <sup>e</sup> )
<b>Unborn Child</b>	
Entire gestation period	0.5 rem (annual EDE <sup>e</sup> )

<sup>a</sup>As used by DOE, effective dose equivalent (EDE) includes both the EDE from external radiation and the committed EDE to individual tissues from ingestion and inhalation during the calendar year.

<sup>b</sup>In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit (PDL) applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835, Occupational Radiation Protection.

<sup>c</sup>Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

<sup>d</sup>This level is from EPA's regulations issued under the Clean Air Act, (40 CFR 61, Subpart H) (EPA 1989a).

<sup>e</sup>Annual EDE is the EDE received in a year.

## Appendix A

**Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived Air Concentrations<sup>a</sup>**

Nuclide	$f_1^b$	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)	DCGs for Air Inhalation by the Public ( $\mu$ Ci/mL)	Class <sup>b</sup>	DACs for Occupational Exposure ( $\mu$ Ci/mL)
<sup>3</sup> H	—	2,000,000	80,000	$1 \times 10^{-7c}$	—	$2 \times 10^{-5c}$
<sup>7</sup> Be	$5 \times 10^{-3}$	1,000,000	40,000	$4 \times 10^{-8}$	Y	$8 \times 10^{-6}$
<sup>89</sup> Sr	$3 \times 10^{-1}$	20,000	800	$3 \times 10^{-10}$	Y	$6 \times 10^{-8}$
<sup>90</sup> Sr	$3 \times 10^{-1}$	1,000	40	$9 \times 10^{-12}$	Y	$2 \times 10^{-9}$
<sup>137</sup> Cs	$1 \times 10^0$	3,000	120	$4 \times 10^{-10}$	D	$7 \times 10^{-8}$
<sup>234</sup> U	$5 \times 10^{-2}$	500	20	$9 \times 10^{-14}$	Y	$2 \times 10^{-11}$
<sup>235</sup> U	$5 \times 10^{-2}$	600	24	$1 \times 10^{-13}$	Y	$2 \times 10^{-11}$
<sup>238</sup> U	$5 \times 10^{-2}$	600	24	$1 \times 10^{-13}$	Y	$2 \times 10^{-11}$
<sup>238</sup> Pu	$1 \times 10^{-3}$	40	1.6	$3 \times 10^{-14}$	W	$3 \times 10^{-12}$
<sup>239</sup> Pu	$1 \times 10^{-3}$	30	1.2	$2 \times 10^{-14}$	W	$2 \times 10^{-12}$
<sup>240</sup> Pu	$1 \times 10^{-3}$	30	1.2	$2 \times 10^{-14}$	W	$2 \times 10^{-12}$
<sup>241</sup> Am	$1 \times 10^{-3}$	30	1.2	$2 \times 10^{-14}$	W	$2 \times 10^{-12}$

<sup>a</sup>Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990); those for occupational exposure are based on radiation protection standards in 10 CFR 835. Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

<sup>b</sup>Gastrointestinal tract absorption factors ( $f_1$ ) and lung retention classes (Class) are taken from ICRP30 (ICRP 1988). Codes: Y = year, D = day, W = week.

<sup>c</sup>Tritium in the HTO form.

Table A-3. National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total Suspended Particulates	Annual	$\mu\text{g}/\text{m}^3$	60		
	30 days	$\mu\text{g}/\text{m}^3$	90		
	7 days	$\mu\text{g}/\text{m}^3$	110		
PM <sub>10</sub> <sup>a</sup>	24 hours	$\mu\text{g}/\text{m}^3$	150		
	Annual	$\mu\text{g}/\text{m}^3$		50	50
PM <sub>2.5</sub> <sup>b</sup>	24 hours	$\mu\text{g}/\text{m}^3$		150	150
	Annual	$\mu\text{g}/\text{m}^3$		15	15
Carbon monoxide	24 hours	$\mu\text{g}/\text{m}^3$		65	65
	8 hours	ppm	8.7	9	
Ozone	1 hour	ppm	13.1	35	
	1 hour	ppm		0.12	0.12
Nitrogen dioxide	8 hours	ppm		0.08	0.08
	Annual	ppm	0.05	0.053	0.053
Lead and lead compounds	24 hours	ppm	0.10		
	Calendar quarter	$\mu\text{g}/\text{m}^3$		1.5	1.5

<sup>a</sup>Particles  $\leq 10 \mu\text{m}$  in diameter.

<sup>b</sup>Particles  $\leq 2.5 \mu\text{m}$  in diameter.

**Table A-4. Organic Analytical Methods**

<b>Test</b>	<b>SW-846 Method</b>	<b>Number of Compounds</b>
Volatiles	624, 8260B	68
Semivolatiles	625, 8270C	69
PCB <sup>a</sup>	608, 8082, 8081	8
HE <sup>b</sup>	8330	14

<sup>a</sup>Polychlorinated biphenyls.

<sup>b</sup>High explosives.

**Table A-5. Volatile Organic Compounds**

<b>Analytes</b>	<b>Limit of Quantitation</b>
	<b>Water (µg/L)</b>
1,1,1,2-Tetrachloroethane	1
1,1,1-Trichloroethane	1
1,1,2,2-Tetrachloroethane	1
1,1,2-Trichloroethane	1
1,1-Dichloroethane	1
1,1-Dichloroethylene	1
1,1-Dichloropropene	1
1,2,3-Trichloropropane	1
1,2,4-Trimethylbenzene	1
1,2-Dibromo-3-chloropropane	1
1,2-Dibromoethane	1
1,2-Dichlorobenzene	1
1,2-Dichloroethane	1
1,2-Dichloropropane	1
1,3,5-Trimethylbenzene	1
1,3-Dichlorobenzene	1
1,3-Dichloropropane	1
1,4-Dichlorobenzene	1
2,2-Dichloropropane	1
2-Butanone	5
2-Chloroethylvinyl ether	5
2-Chlorotoluene	1
2-Hexanone	5
4-Chlorotoluene	1
4-Isopropyltoluene	1
4-Methyl-2-pentanone	5
Acetone	5
Acrolein	10
Acrylonitrile	10
Benzene	1

Table A-5. Volatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation
	Water (µg/L)
Bromobenzene	1
Bromochloromethane	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	1
Carbon disulfide	5
Carbon tetrachloride	1
Chlorobenzene	1
Chloroethane	1
Chloroform	1
Chloromethane	1
cis-1,3-Dichloropropylene	1
Dibromochloromethane	1
Dibromomethane	1
Dichlorodifluoromethane	1
Ethylbenzene	1
Hexachlorobutadiene	1
Iodomethane	5
Isopropylbenzene	1
m,p-Xylenes	2
Methylene chloride	5
Naphthalene	1
n-Butylbenzene	1
n-Propylbenzene	1
o-Xylene	1
sec-Butylbenzene	1
Styrene	1
tert-Butylbenzene	1
Tetrachloroethylene	1
Toluene	1
Toluene-d8	1
trans-1,2-Dichloroethylene	1
trans-1,3-Dichloropropylene	1
Trichloroethylene	1
Trichlorofluoromethane	1
Trichlorotrifluoroethane	5
Vinyl chloride	1
Xylenes (total)	3



**Table A-6. Semivolatile Organic Compounds**

<b>Analytes</b>	<b>Limit of Quantitation</b>	
	<b>Water (µg/L)</b>	<b>Sediments (mg/kg)</b>
1,2,4-Trichlorobenzene	10	0.33
1,2-Dichlorobenzene	10	0.33
1,2-Diphenylhydrazine	10	0.33
1,3-Dichlorobenzene	10	0.33
1,4-Dichlorobenzene	10	0.33
2,4,5-Trichlorophenol	10	0.33
2,4,6-Trichlorophenol	10	0.33
2,4-Dichlorophenol	10	0.33
2,4-Dimethylphenol	10	0.33
2,4-Dinitrophenol	20	0.67
2,4-Dinitrotoluene	10	0.33
2,6-Dinitrotoluene	10	0.33
2-Chloronaphthalene	1	0.03
2-Chlorophenol	10	0.33
2-Methyl-4,6-dinitrophenol	10	0.33
2-Methylnaphthalene	1	0.03
2-Nitrophenol	10	0.33
2-Picoline	10	0.33
3,3' -Dichlorobenzidine	10	0.33
4-Bromophenylphenylether	10	0.33
4-Chloro-3-methylphenol	10	0.33
4-Chloroaniline	10	0.33
4-Chlorophenylphenylether	10	0.33
4-Nitrophenol	10	0.33
Acenaphthene	1	0.03
Acenaphthylene	1	0.03
Aniline	10	0.33
Anthracene	1	0.03
Benzidine	50	1.67
Benzo(a)anthracene	1	0.03
Benzo(a)pyrene	1	0.03
Benzo(b)fluoranthene	1	0.03
Benzo(ghi)perylene	1	0.03
Benzo(k)fluoranthene	1	0.03
Benzoic acid	20	0.67
Benzyl alcohol	10	0.33
bis(2-Chloroethoxy)methane	10	0.33
bis(2-Chloroethyl) ether	10	0.33
bis(2-Chloroisopropyl)ether	10	0.33
bis(2-Ethylhexyl)phthalate	10	0.03
Butylbenzylphthalate	10	0.33
Chrysene	1	0.03
Dibenzo(a,h)anthracene	1	0.03
Dibenzofuran	10	0.33

**Table A-6. Semivolatile Organic Compounds (Cont.)**

<b>Analytes</b>	<b>Limit of Quantitation</b>	
	<b>Water (µg/L)</b>	<b>Sediments (mg/kg)</b>
Diethylphthalate	10	0.33
Dimethylphthalate	10	0.33
Di-n-butylphthalate	10	0.33
Di-n-octylphthalate	10	0.33
Fluoranthene	1	0.03
Fluorene	1	0.03
Hexachlorobenzene	10	0.33
Hexachlorobutadiene	10	0.33
Hexachlorocyclopentadiene	10	0.33
Hexachloroethane	10	0.33
Indeno(1,2,3-cd)pyrene	1	0.03
Isophorone	10	0.33
m-Nitroaniline	10	0.33
Naphthalene	1	0.03
Nitrobenzene	10	0.33
N-Methyl-N-nitrosomethylamine	10	0.33
N-Nitrosodiphenylamine	10	0.07
N-Nitrosodipropylamine	10	0.33
o-Nitroaniline	10	0.33
p-(Dimethylamino)azobenzene	10	0.33
Pentachlorophenol	10	0.33
Phenanthrene	1	0.03
Phenol	10	0.33
Pyrene	1	0.03
Pyridine	10	0.33

**Table A-7. Polychlorinated Biphenyls**

<b>Analytes</b>	<b>Limit of Quantitation</b>	
	<b>Water (µg/L)</b>	<b>Sediments (mg/kg)</b>
Aroclor 1016	0.5	0.003
Aroclor 1221	0.5	0.003
Aroclor 1232	0.5	0.003
Aroclor 1242	0.5	0.003
Aroclor 1248	0.5	0.003
Aroclor 1254	0.5	0.003
Aroclor 1260	0.5	0.003
Aroclor 1262	0.5	0.003

**Table A-8. High-Explosives Compounds**

<b>Analytes</b>	<b>Limit of Quantitation</b>	
	<b>Water (µg/L)</b>	<b>Sediments (mg/kg)</b>
1,3,5-Trinitrobenzene	0.105	0.08
2,4,6-Trinitrotoluene	0.105	0.08
2,4-Dinitrotoluene	0.105	0.08
2,6-Dinitrotoluene	0.105	0.08
2-Amino-4,6-dinitrotoluene	0.105	0.08
4-Amino-2,6-dinitrotoluene	0.105	0.08
HMX	0.105	0.08
Nitrobenzene	0.105	0.08
RDX	0.105	0.08
Tetryl	0.105	0.08
m-Dinitrobenzene	0.105	0.08
m-Nitrotoluene	0.105	0.08
o-Nitrotoluene	0.105	0.08
p-Nitrotoluene	0.105	0.08

## References

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- NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).
- NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).
- NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).



## Units of Measurement

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table B-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is  $2.0 \times 10^3$ , the decimal point should be moved three numbers (insert zeros if no numbers are given) to the **right** of its present location. The number would then read 2,000. If the value given is  $2.0 \times 10^{-5}$ , the decimal point should be moved five numbers to the **left** of its present location. The result would be 0.00002.

Table B-2 presents conversion factors for converting SI units into US Customary Units. Table B-3 presents abbreviations for common measurements.

### Data Handling of Radiochemical Samples

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are

sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the following equation:

$$s = \sqrt{\frac{\sum_{i=1}^N (\bar{c} - c_i)^2}{(N - 1)}}$$

where

$c_i$  = sample  $i$ ,

$\bar{c}$  = mean of samples from a given station or group, and

$N$  = number of samples a station or group comprises.

This value is reported as one standard deviation ( $1s$ ) for the station and group means.

### Tables

**Table B-1. Prefixes Used with SI (Metric) Units**

Prefix	Factor	Symbol
mega	1 000 000 or $10^6$	M
kilo	1 000 or $10^3$	k
centi	0.01 or $10^{-2}$	c
milli	0.001 or $10^{-3}$	m
micro	0.000001 or $10^{-6}$	$\mu$
nano	0.000000001 or $10^{-9}$	n
pico	0.000000000001 or $10^{-12}$	p
femto	0.000000000000001 or $10^{-15}$	f
atto	0.000000000000000001 or $10^{-18}$	a

## Appendix B

**Table B-2. Approximate Conversion Factors for Selected SI (Metric) Units**

Multiply SI (Metric) Unit	by	to Obtain US Customary Unit
Celsius (°C)	$9/5 + 32$	Fahrenheit (°F)
centimeters (cm)	0.39	inches (in.)
cubic meters (m <sup>3</sup> )	35.3	cubic feet (ft <sup>3</sup> )
hectares (ha)	2.47	acres
grams (g)	0.035	ounces (oz)
kilograms (kg)	2.2	pounds (lb)
kilometers (km)	0.62	miles (mi)
liters (L)	0.26	gallons (gal.)
meters (m)	3.28	feet (ft)
micrograms per gram (µg/g)	1	parts per million (ppm)
milligrams per liter (mg/L)	1	parts per million (ppm)
square kilometers (km <sup>2</sup> )	0.386	square miles (mi <sup>2</sup> )

**Table B-3. Common Measurement Abbreviations and Measurement Symbols**

aCi	attocurie
Bq	becquerel
Btu/yr	British thermal unit per year
Ci	curie
cm <sup>3</sup> /s	cubic centimeters per second
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
ft <sup>3</sup> /min	cubic feet per minute
ft <sup>3</sup> /s	cubic feet per second
kg	kilogram
kg/h	kilogram per hour
lb/h	pound per hour
lin ft	linear feet
m <sup>3</sup> /s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
µg/m <sup>3</sup>	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
mCi	millicurie
mg	milligram
mR	milliroentgen

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**Table B-3. Common Measurement Abbreviations and Measurement Symbols (Cont.)**


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m/s	meters per second
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m <sup>3</sup>	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m <sup>3</sup>	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m <sup>3</sup>	picogram per cubic meter
PM <sub>10</sub>	small particulate matter (less than 10 µm diameter)
PM <sub>2.5</sub>	small particulate matter (less than 2.5 µm diameter)
R	roentgen
s, SD, or σ	standard deviation
s.u.	standard unit
sq ft (ft <sup>2</sup> )	square feet
TU	tritium unit
>	greater than
<	less than
≥	greater than or equal to
≤	less than or equal to
±	plus or minus
~	approximately

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**Reference**

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Batelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).







### Description of Technical Areas and Their Associated Programs

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-2. The main programs conducted at each of the areas are listed in this Appendix.

**TA-0:** The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos town site and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos town site.

**TA-2, Omega Site:** Omega West Reactor, an 8-MW nuclear research reactor, is located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor will be transferred to the institution for placement into the decontamination and decommissioning (D&D) program beginning in 2006.

**TA-3, Core Area:** The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space.

**TA-5, Beta Site:** This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

**TA-6, Twomile Mesa Site:** The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

**TA-8, GT Site (or Anchor Site West):** This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

**TA-9, Anchor Site East:** At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

**TA-11, K Site:** Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

**TA-14, Q Site:** This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

**TA-15, R Site:** This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays), a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the site where DARHT (the dual-axis radiographic hydrotest facility) is being constructed. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.

**TA-16, S Site:** Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

**TA-18, Pajarito Laboratory Site:** This is a nuclear facility that studies both static and dynamic behavior of multiplying assemblies of nuclear materials. The Category I quantities of special nuclear materials (SNM) are used to support a wide variety of programs such as Stockpile Management, Stockpile Stewardship, Emergency Response, Nonproliferation, Safeguards, etc. Experiments near critical are operated by remote control using low-power reactors called criti-

## Appendix C

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cal assemblies. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a critical amount of fissionable material so that the effects of various shapes, sizes, and configurations can be studied. These machines are also used as a large-quantity source of fission neutrons for experimental purposes. In addition, this facility provides the capability to perform hands-on training and experiments with SNM in various configurations below critical.

**TA-21, DP Site:** This site has two primary research areas: DP West and DP East. DP West has been in the D&D program since 1992, and six buildings have been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, were relocated during 1997, and the remainder of the site was scheduled for D&D in future years. DP East is a tritium research site.

**TA-22, TD Site:** This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

**TA-28, Magazine Area A:** This is an explosives storage area.

**TA-33, HP Site:** An old, high-pressure, tritium-handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

**TA-35, Ten Site:** This site is divided into five facility management units. Work here includes nuclear safeguards research and development that are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating.

**TA-36, Kappa Site:** Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

**TA-37, Magazine Area C:** This is an explosives storage area.

**TA-39, Ancho Canyon Site:** The behavior of nonnuclear weapons is studied here, primarily by

photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

**TA-40, DF Site:** This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

**TA-41, W Site:** Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

**TA-43, Health Research Laboratory:** This site is adjacent to the Los Alamos Medical Center in the town site. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

**TA-46, WA Site:** This TA contains two facility management units. Activities include applied photochemistry research including the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Facility is located at the east end of this site. Environmental management operations are also located here.

**TA-48, Radiochemistry Site:** Laboratory scientists and technicians perform research and development (R&D) activities at this site on a wide range of chemical processes including nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

**TA-49, Frijoles Mesa Site:** This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

**TA-50, Waste Management Site:** This site is divided into two facility management units, which include managing the industrial liquid and radioactive liquid

waste received from Laboratory technical areas and activities that are part of the waste treatment technology effort.

**TA-51, Environmental Research Site:** Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are performed at this site.

**TA-52, Reactor Development Site:** A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.

**TA-53, Los Alamos Neutron Science Center:** The Los Alamos Neutron Science Center, including the linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility is located at this TA. Also located at TA-53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator, and R&D activities in accelerator technology and high-power microwaves.

**TA-54, Waste Disposal Site:** This site is divided into two facility management units for the radioactive solid and hazardous chemical waste management and disposal operations and activities that are part of the waste treatment technology effort.

**TA-55, Plutonium Facility Site:** Processing of plutonium and research on plutonium metallurgy are done at this site.

**TA-57, Fenton Hill Site:** This site is located about 28 miles west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains and was the location of the Laboratory's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. The high elevation and remoteness of the site make Fenton Hill a choice location for astrophysics experiments. A gamma ray observatory is located at the site.

**TA-58:** This site is reserved for multiuse experimental sciences requiring close functional ties to programs currently located at TA-3.

**TA-59, Occupational Health Site:** Occupational health and safety and environmental management activities are conducted at this site. Emergency management offices are also located here.

**TA-60, Sigma Mesa:** This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.

**TA-61, East Jemez Road:** This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.

**TA-62:** This site is reserved for multiuse experimental science, public and corporate interface, and environmental research and buffer zones.

**TA-63:** This is a major growth area at the Laboratory with expanding environmental and waste management functions and facilities. This area contains physical support facilities operated by Johnson Controls Northern New Mexico.

**TA-64:** This is the site of the Central Guard Facility and headquarters for the Laboratory Hazardous Materials Response Team.

**TA-66:** This site is used for industrial partnership activities.

**TA-67:** This is a dynamic testing area that contains significant archeological sites.

**TA-68:** This is a dynamic testing area that contains archeological and environmental study areas.

**TA-69:** This undeveloped TA serves as an environmental buffer for the dynamic testing area.

**TA-70:** This undeveloped TA serves as an environmental buffer for the high-explosives test area.

**TA-71:** This undeveloped TA serves as an environmental buffer for the high-explosives test area.

**TA-72:** This is the site of the Protective Forces Training Facility.

**TA-73:** This area is the Los Alamos Airport.

**TA-74, Otowi Tract:** This large area, bordering the Pueblo of San Ildefonso on the east, is isolated from most of the Laboratory and contains significant concentrations of archeological sites and an endangered species breeding area. This site also contains Laboratory water wells and future well fields.





## Related Web Sites

For more information on environmental topics at Los Alamos National Laboratory, access the following Web sites:

*<http://www.airquality.lanl.gov/pdf/ESR/LA-14085-ENV.pdf> provides access to *Environmental Surveillance at Los Alamos during 2002*.*

*<http://www.airquality.lanl.gov/ESRIndex.htm> provides access to supplemental data tables for 2002.*

*<http://www.lanl.gov> reaches the Los Alamos National Laboratory Web site.*

*<http://www.energy.gov> reaches the national Department of Energy Web site.*

*<http://labs.ucop.edu> provides information on the three laboratories managed by the University of California.*

*<http://www.esh.lanl.gov/~AirQuality> accesses LANL's Meteorology and Air Quality Group.*

*<http://www.esh.lanl.gov/~esh18/> accesses LANL's Water Quality and Hydrology Group.*

*<http://swrc.lanl.gov/> accesses LANL's Solid Waste Regulatory Compliance Group.*

*<http://www.esh.lanl.gov/%7Eesh20/> accesses LANL's Ecology Group.*

*<http://erproject.lanl.gov> provides information on LANL's Environmental Restoration Project.*







<i>activation products</i>	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
<i>albedo dosimeters</i>	Albedo dosimeters are used to measure neutrons around TA-18. They use a neutron-sensitive polyethylene phantom to capture neutron backscatter to simulate the human body.
<i>alpha particle</i>	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
<i>ambient air</i>	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
<i>aquifer</i>	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
<i>artesian well</i>	A well in which the water rises above the top of the water-bearing bed.
<i>background radiation</i>	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
<i>beta particle</i>	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
<i>biota</i>	The types of animal and plant life found in an area.
<i>blank sample</i>	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
<i>blind sample</i>	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.
<b>BOD</b>	Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.
<b>CAA</b>	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state

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	and local governments to develop and execute air pollution prevention and control programs.
<b>CERCLA</b>	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
<b>CFR</b>	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the <i>Federal Register</i> .
<b>COC</b>	Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.
<b>contamination</b>	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
<b>controlled area</b>	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
<b>Ci</b>	Curie. Unit of radioactivity. One Ci equals $3.70 \times 10^{10}$ nuclear transformations per second.
<b>cosmic radiation</b>	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
<b>CWA</b>	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
<b>DOE</b>	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.
<b>dose</b>	A term denoting the quantity of radiation energy absorbed.
<b>EDE</b>	Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to $100 \times 0.12 = 12$ mrem. CEDE: committed effective dose equivalent TEDE: total effective dose equivalent
<b>maximum individual dose</b>	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the

	Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
<i>population dose</i>	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)
<i>whole body dose</i>	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
<i>EA</i>	Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
<i>effluent</i>	A liquid waste discharged to the environment.
<i>EIS</i>	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
<i>emission</i>	A gaseous waste discharged to the environment.
<i>environmental compliance</i>	The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.
<i>environmental monitoring</i>	The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.
<i>environmental surveillance</i>	The sampling of contaminants in air, water, sediments, soils, food-stuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
<i>EPA</i>	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
<i>exposure</i>	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
<i>external radiation</i>	Radiation originating from a source outside the body.
<i>gallery</i>	An underground collection basin for spring discharges.

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<i>gamma radiation</i>	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
<i>gross alpha</i>	The total amount of measured alpha activity without identification of specific radionuclides.
<i>gross beta</i>	The total amount of measured beta activity without identification of specific radionuclides.
<i>groundwater</i>	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
<i>half-life, radioactive</i>	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ( $1/2 \times 1/2$ ), after three half-lives, one-eighth ( $1/2 \times 1/2 \times 1/2$ ), and so on.
<i>hazardous waste</i>	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.
<i>hazardous waste constituent</i>	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
<i>HSWA</i>	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
<i>hydrology</i>	The science dealing with the properties, distribution, and circulation of natural water systems.
<i>internal radiation</i>	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
<i>ionizing radiation</i>	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
<i>isotopes</i>	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have

similar chemical behaviors but can have different nuclear behaviors.

- long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

<i>LLW</i>	Low-level waste. The level of radioactive contamination in LLW is not strictly defined. Rather, LLW is defined by what it is not. It does not include nuclear fuel rods, wastes from processing nuclear fuels, transuranic (TRU) waste, or uranium mill tailings.
<i>MCL</i>	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.
<i>MEI</i>	Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.
<i>mixed waste</i>	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
<i>mrem</i>	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
<i>NEPA</i>	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.
<i>NESHAP</i>	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
<i>nonhazardous waste</i>	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
<i>NPDES</i>	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges



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	into surface waterways.
<i>nuclide</i>	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
<i>outfall</i>	The location where wastewater is released from a point source into a receiving body of water.
<i>PCB</i>	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCB are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCB are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCB, with limited exceptions, in 1976.
<i>PDL</i>	Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).
<i>perched groundwater</i>	A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.
<i>person-rem</i>	A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive.
<i>pH</i>	A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
<i>pollution</i>	Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).
<i>point source</i>	An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.
<i>ppb</i>	Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as $\mu\text{g/L}$ or $\text{ng/mL}$ . Also used to express the weight/weight ratio as $\text{ng/g}$ or $\mu\text{g/kg}$ .
<i>ppm</i>	Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as $\text{mg/L}$ . Also used to express the weight/weight ratio as $\mu\text{g/g}$ or $\text{mg/kg}$ .
<i>QA</i>	Quality assurance. Any action in environmental monitoring to ensure

	the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.
<i>QC</i>	Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.
<i>rad</i>	Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body. $1 \text{ rad} = 1,000 \text{ millirad (mrad)}$
<i>radionuclide</i>	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
<i>RESRAD</i>	A computer modeling code designed to model radionuclide transport in the environment.
<i>RCRA</i>	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
<i>release</i>	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.
<i>rem</i>	Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation. $\text{rem} = \text{rad} \times \text{quality factor}$ $1 \text{ rem} = 1,000 \text{ millirem (mrem)}$
<i>SAL</i>	Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.
<i>SARA</i>	Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.
<i>saturated zone</i>	Rock or soil where the pores are completely filled with water, and no air is present.
<i>SWMU</i>	Solid waste management unit. Any discernible site at which solid

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	<p>wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).</p>
<i>terrestrial radiation</i>	<p>Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.</p>
<i>TLD</i>	<p>Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.</p>
<i>TRU</i>	<p>Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.</p>
<i>TSCA</i>	<p>Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this act for controlling substances found to be detrimental to human health or to the environment.</p>
<i>tuff</i>	<p>Rock formed from compacted volcanic ash fragments.</p>
<i>uncontrolled area</i>	<p>An area beyond the boundaries of a controlled area (see controlled area in this glossary).</p>
<i>unsaturated zone</i>	<p>See vadose zone in this glossary.</p>
<i>UST</i>	<p>Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.</p>
<i>vadose zone</i>	<p>The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.</p>
<i>water table</i>	<p>The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.</p>

<i>water year</i>	October through September.
<i>watershed</i>	The region draining into a river, a river system, or a body of water.
<i>wetland</i>	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
<i>wind rose</i>	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
<i>worldwide fallout</i>	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.





ACD	air curtain destructor
AIRNET	Air Monitoring Network
AOC	area of concern
ARPA	Archeological Resources Protection Act
AST	above-ground storage tank
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
BTEX	total aromatic hydrocarbon
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COE	Army Corps of Engineers
CWA	Clean Water Act
CY	calendar year
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
D&D	decontamination and decommissioning
DOE	Department of Energy
DRO	diesel-range atomic comound
DU	depleted uranium
DX	Dynamic Experimentation Group (LANL)
EA	Environmental Assessment
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Engineering Sciences and Applications Group (LANL)
ES&H	environment, safety, & health
ESP	Environmental Surveillance Program (LANL)
FGR	flue gas recirculation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FY	fiscal year
GMAP	gaseous mixed air activation products
HAP	hazardous air pollutants
HAZWOPER	hazardous waste operations (training class)
HE	high-explosive
HENV	JCNNM Health and Environmental laboratory
HEWTF	High-Explosive Wastewater Treatment Facility
HMX	cyclotetramethylenetetra nitramine



## Acronyms and Abbreviations

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HPAL	Health Physics Analysis Laboratory (LANL)
HPTL	High Pressure Tritium Laboratory
HSR-4	Health Physics Measurements Group (LANL) (Health, Safety, and Radiation Protection Division)
HSWA	Hazardous and Solid Waste Amendments
HWA	Hazardous Waste Act (New Mexico)
HT	elemental tritium
HTO	tritium oxide
IC	ion chromatography
ICPES	inductively coupled plasma emission spectrometry
ICPMS	inductively coupled plasma mass spectrometry
ICRP	International Commission on Radiological Protection
IRMP	Integrated Resources Management Plan
ISM	Integrated Safety Management (LANL)
JCNNM	Johnson Controls Northern New Mexico
LAAO	Los Alamos Area Office (DOE)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LANL	Los Alamos National Laboratory (or the Laboratory)
LEDA	Low-Energy Demonstration Accelerator
LLMW	low-level mixed waste
LLW	low-level radioactive waste
LOD	limits of detection
LSC	liquid scintillation counting
MAP	Mitigation Action Plan
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
MEI	maximally exposed individual
MRL	minimum risk level
MSGP	Multi-Sector General Permit
NAGPRA	Native American Grave Protection and Repatriation Act
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NFA	no further action
NHPA	National Historic Preservation Act
NIS	LANL Nonproliferation and International Security Division
NMAC	New Mexico Administrative Code
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMED-DOB	New Mexico DOE Oversight Bureau
NMEIB	New Mexico Environmental Improvement Board

## Acronyms and Abbreviations

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NMOCD	New Mexico Administrative Code
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NNSA	US National Nuclear Security Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	US Nuclear Regulatory Commission
OB/OD	open burning/open detonation
ODS	ozone depleting substance
PAH	polycyclic aromatic hydrocarbon
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyls
PDL	public dose limit
PE	performance evaluation
PHERMEX	Pulsed high-energy radiographic machine emitting x-rays
ppb	parts per billion
ppm	parts per million
PRS	potential release site
PS-13	Environment, Safety, and Health Training Group (LANL)
P/VAP	particulate/vapor activation products
QA	quality assurance
QAP	Quality Assurance Program
QC	quality control
R&D	research and development
RAC	Risk Assessment Corporation
RadNESHAP	NESHAP for Radionuclides
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RESRAD	residual radioactive material computer code
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
ROD	record of decision
RPD	relative percent difference
RRES	Risk Reduction and Environmental Stewardship Division (LANL)
RRES-ECO	Ecology Group (LANL)
RRES-EP	Environmental Protection Program (LANL)
RRES-MAQ	Meteorology and Air Quality Group (LANL)
RRES-PP	Pollution Prevention Group (LANL)
RRES-R	Remediation Group (LANL)
RRES-SWRC	Solid Waste Regulatory Compliance Group (LANL)
RRES-WQH	Water Quality and Hydrology Group (LANL)
RSRL	regional statistical reference level
SA	supplement assessment
SAL	screening action level
SDWA	Safe Drinking Water Act
SEA	Special Environmental Analysis

## Acronyms and Abbreviations

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SHPO	State Historic Preservation Officer (New Mexico)
SI	International System of Units
SODAR	sonic detection and ranging
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
STL	Severn-Trent Laboratories
STP	site treatment plan
s.u.	standard units
SVOC	semivolatile organic compound
SWA	Solid Waste Act
SWEIS	site-wide environmental impact statement
SWIPO	Site-Wide Projects Office
SWPP	Storm Water Prevention Plan
SWMR	solid waste management regulations
SWMU	solid waste management unit
SWS	Sanitary Wastewater Systems Facility (LANL)
TA	Technical Area
TCE	trichloroethylene
TDS	total dissolved solids
T&E	threatened and endangered
TEDE	total effective dose equivalent
TEOM	tapered-element oscillating microbalance
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TPH	total petroleum hydrocarbon
TRC	total residual chlorine
TRI	toxic chemical release inventory
TRU	transuranic waste
TRPH	total recoverable petroleum hydrocarbon
TSCA	Toxic Substances Control Act
TSP	total suspended particulate matter
TSS	total suspended solids
TTHM	total trihalomethane
UC	University of California
USFS	United States Forest Service
USGS	United States Geological Survey
UST	underground storage tank
VAP	vaporous activation products
VCA	voluntary corrective action
VOC	volatile organic compound
WASTENET	Waste Management Areas Network (for air monitoring)
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Plant
WM	Waste Management (LANL)
WSC	Waste Stream Characterization
WWW	World Wide Web

## Acronyms and Abbreviations

### Elemental and Chemical Nomenclature

Actinium	Ac	Molybdenum	Mo
Aluminum	Al	Neodymium	Nd
Americium	Am	Neon	Ne
Argon	Ar	Neptunium	Np
Antimony	Sb	Nickel	Ni
Arsenic	As	Niobium	Nb
Astatine	At	Nitrate (as Nitrogen)	NO <sub>3</sub> -N
Barium	Ba	Nitrite (as Nitrogen)	NO <sub>2</sub> -N
Berkelium	Bk	Nitrogen	N
Beryllium	Be	Nitrogen dioxide	NO <sub>2</sub>
Bicarbonate	HCO <sub>3</sub>	Nobelium	No
Bismuth	Bi	Osmium	Os
Boron	B	Oxygen	O
Bromine	Br	Palladium	Pd
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Phosphate (as Phosphorus)	PO <sub>4</sub> -P
Californium	Cf	Platinum	Pt
Carbon	C	Plutonium	Pu
Cerium	Ce	Polonium	Po
Cesium	Cs	Potassium	K
Chlorine	Cl	Praseodymium	Pr
Chromium	Cr	Promethium	Pm
Cobalt	Co	Protactinium	Pa
Copper	Cu	Radium	Ra
Curium	Cm	Radon	Rn
Cyanide	CN	Rhenium	Re
Carbonate	CO <sub>3</sub>	Rhodium	Rh
Dysprosium	Dy	Rubidium	Rb
Einsteinium	Es	Ruthenium	Ru
Erbium	Er	Samarium	Sm
Europium	Eu	Scandium	Sc
Fermium	Fm	Selenium	Se
Fluorine	F	Silicon	Si
Francium	Fr	Silver	Ag
Gadolinium	Gd	Sodium	Na
Gallium	Ga	Strontium	Sr
Germanium	Ge	Sulfate	SO <sub>4</sub>
Gold	Au	Sulfite	SO <sub>3</sub>
Hafnium	Hf	Sulfur	S
Helium	He	Tantalum	Ta
Holmium	Ho	Technetium	Tc
Hydrogen	H	Tellurium	Te
Hydrogen oxide	H <sub>2</sub> O	Terbium	Tb
Indium	In	Thallium	Tl
Iodine	I	Thorium	Th
Iridium	Ir	Thulium	Tm
Iron	Fe	Tin	Sn
Krypton	Kr	Titanium	Ti
Lanthanum	La	Tritiated water	HTO
Lawrencium	Lr (Lw)	Tritium	<sup>3</sup> H
Lead	Pb	Tungsten	W
Lithium	Li	Uranium	U
Lithium fluoride	LiF	Vanadium	V
Lutetium	Lu	Xenon	Xe
Magnesium	Mg	Ytterbium	Yb
Manganese	Mn	Yttrium	Y
Mendelevium	Md	Zinc	Zn
Mercury	Hg	Zirconium	Zr

## Acronyms and Abbreviations

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## **Standard UC-902 (Environmental Sciences) and UC-707 (Health and Safety) Distribution**

### **US Department of Energy**

National Nuclear Security Administration  
Office of Environmental Policy and Guidance  
NNSA Service Center Albuquerque  
Los Alamos Site Office  
Environmental Measurements Laboratory  
Idaho Operations Office  
Nevada Operations Office  
Oak Ridge Operations Office  
Savannah River Operations Office

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Battelle, Pacific Northwest Laboratories  
Bechtel Nevada  
Brookhaven National Laboratory  
EG&G Mound Applied Technologies  
Lawrence Livermore National Laboratory  
Oak Ridge National Laboratory  
Pantex Plant  
Sandia National Laboratories, New Mexico  
Sandia National Laboratories, California

### **State of New Mexico**

Office of the Governor  
NM Health Department  
NM Environment Department  
NM Environment Improvement Board  
NM Oil Conservation Division  
NM Energy, Minerals, & Natural Resources  
Department  
NM State Engineer's Office  
Scientific Laboratory Division

### **Other External Distribution**

#### **University of California**

President's Council, Office of the President  
Environment, Health, and Safety Office

#### **Environmental Protection Agency**

#### **NM Congressional Delegation**

#### **Elected Officials**

#### **County of Los Alamos**

#### **NM Office of Indian Affairs**

#### **Indian Pueblo Governors, Northern NM**

Pueblo of Cochiti  
Pueblo of Jemez  
Pueblo of Nambé  
Pueblo of Picuris  
Pueblo of Pojoaque  
Pueblo of San Ildefonso  
Pueblo of San Juan  
Pueblo of Santa Clara

### **Indian Pueblo Governors, Northern NM (Cont.)**

Pueblo of Santo Domingo  
Pueblo of Taos  
Pueblo of Tesuque

### **Eight Northern Indian Pueblo Council**

Pueblo Office of Environmental Protection

### **Bureau of Indian Affairs**

### **National Park Service**

### **Bandelier National Monument**

### **US Fish and Wildlife Service**

### **US Forest Service**

### **US Geological Survey**

### **Concerned Citizens for Nuclear Safety**

### **Los Alamos Study Group**

### **Responsive Environmental Action League**

### **Johnson Controls, Inc.**

### **Libraries**

Mesa Public Library, Los Alamos, NM  
Mesa Public Library, White Rock Branch  
UNM-LA, Los Alamos, NM  
Santa Fe Public Library, Santa Fe, NM  
New Mexico State Library, Santa Fe, NM

### **Media**

The Monitor, Los Alamos, NM  
The New Mexican, Santa Fe, NM  
The Reporter, Santa Fe, NM  
The Taos News, Taos, NM  
Albuquerque Journal, Albuquerque, NM  
Albuquerque Journal North, Santa Fe, NM  
Albuquerque Tribune, Albuquerque, NM  
KRSN Radio, Los Alamos, NM  
KOAT-TV, Albuquerque, NM  
KOB-TV, Albuquerque, NM  
KGGM-TV, Albuquerque, NM

### **Internal Distribution**

#### **Director's Office**

Director  
Laboratory Counsel  
Public Affairs Officer

#### **Health, Safety, and Radiation Protection Division**

Group HSR-1, Health Physics Operations

Group HSR-2, Occupational Medicine

Group HSR-3, Facility Risk Assessment

Group HSR-12, Health Physics Measurements

Risk Reduction & Environmental Stewardship

Division Office

Group RRES-MAQ, Meteorology and Air Quality

Group RRES-WQH, Water Quality and Hydrology

Group RRES-SWRC, Solid Waste Regulatory

Compliance

Group RRES-ECO, Ecology Group

Other Laboratory Groups



*The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:*

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*Water Quality and Hydrology Group, RRES-WQH (David B. Rogers and Robert Beers, Coordinators)*

*Solid Waste Regulatory Compliance Group, RRES-SWRC (Karen Lyncoln, Coordinator)*

*Ecology Group, RRES-ECP (Phillip Fresquez, Coordinator)*

*Environmental Restoration Project, RRES-RS (Virginia Smith, Coordinator)*

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