7. Soil Monitoring

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A. Introduction

A soil-sampling-and-analysis program provides the most direct means of determining the inventory, concentration, distribution, and long-term accumulation of radionuclides and other contaminants around nuclear facilities (DOE 1991). A soil characterization program provides information about potential pathways (such as soil ingestion, food crops, resuspension into the air, and contamination of groundwater) that may deliver radioactive materials or chemicals to humans.

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 in accordance with Department of Energy (DOE) Orders 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) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
- principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996).

The objectives of LANL's soil-surveillance program are to determine the following:

(1) radionuclide and nonradionuclide (heavy metals and organic constituents) concentrations in soils collected from potentially impacted areas (lab-wide and facility-specific);

(2) trends over time (i.e., whether radionuclides and nonradionuclides are increasing or decreasing over time); and

(3) the committed effective dose equivalent potentially received by surrounding-area residents (see Chapter 3 for the potential radiation doses that individuals may receive from exposure to soils).

B. Soil Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides, the Environmental Stewardship Division's soil-sampling team first compares the analytical results of soil samples collected from the Laboratory's on-site and perimeter areas to regional (RSRLs) or baseline (BSRLs) statistical reference levels. Where the levels exceed RSRLs (or BSRLs), we then compare the concentrations to the screening levels; and, finally, if needed, to the standards. Table 7-1 summarizes the levels and/or standard used to evaluate the soil monitoring program.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from soil data collected from regional background locations away from the influence of the Laboratory over the past five years. (Note: For a list of regional locations see Fresquez 2004a.) RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of the Environmental Surveillance Report.

- On-site baseline levels: The Mitigation Action Plan for LANL's DARHT facility (the Laboratory's principal explosive test facility) mandated the establishment of baseline (preoperational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). BSRLs are the concentrations of radionuclides and nonradionuclides in soils and sediments around the DARHT facility during the years 1996 to 1999, before the operation phase (as of the year 2000). The BSRL concentrations of radionuclides and trace elements are calculated from the mean DARHT-facility sample concentration plus two standard deviations (Fresquez et al. 2001a). (Note: Prior evaluations of BSRLs with RSRLs show no statistical differences between the two. The soil-sampling team uses BSRLs at DARHT to meet Mitigation Action Plan requirements.)
- Screening levels: LANL's Environmental Restoration Project developed screening (action) levels for radionuclides to identify contaminants of concern on the basis of a conservative (e.g., residential) 15-mrem protective dose limit (ER 2002). We compared nonradionuclides to the human health medium-specific screening levels that the US Environmental Protection Agency (EPA) has set at a 10^{-6} risk (EPA 2004). If a constituent exceeds an SL, then the reason for that increase is more thoroughly investigated
- Standard: If screening levels are exceeded, then a dose to a person would be calculated using the RESRAD computer model (Yu et al. 1995). The calculated dose would be based on a residential scenario with soil ingestion, inhalation of suspended dust, and ingestion of homegrown fruits and vegetables as the primary exposure pathways for one or more radionuclides taken from Table S7-1. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis that we used can be found in Fresquez et al. (1996). This calculated dose would be compared to the 100-mrem/yr DOE standard.

Table 7-1. Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level	Background Level
Radionuclides	On-site, Perimeter and Area G	100 mrem	15 mrem	RSRL
	DARHT	100 mrem	15 mrem	BSRL
Nonradionuclides	On-site and Perimeter		10^{-6} risk (resident)	RSRL
	Area G		10^{-6} risk (industrial)	RSRL
	DARHT		10^{-6} risk (industrial)	BSRL

C. Institutional Monitoring

1. Monitoring Network

For a complete description of the soil-sampling monitoring network see Fresquez (2004a). In the past, the soil-sampling team collected samples from 12 on-site, 10 perimeter, and three regional locations on an annual basis (Figure 7-1). Because a review of past analytical data has shown that levels of radionuclides (Fresquez et al. 1998) and nonradionuclides (Fresquez et al. 2000, Fresquez et al. 2001b) in soils collected within and around LANL have been very low and, for the most part, have not increased over time, soils will now be sampled once every three years.

Although the soil-sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we collect two perimeter soil samples on their lands that are downwind of Area G , the Laboratory's principal low-level radioactive waste disposal site. Area G, approximately 63 acres in size, is located in the Laboratory's Waste Disposal Site (TA-54) at the Laboratory's eastern boundary.

One sample, identified as "San Ildefonso," was collected across Mortandad canyon from Area G, and the other sample, identified as "Tsankawi/PM-1," was collected about 2.5 miles from Area G. These samples were analyzed by Paragon Analytics, Inc., for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; and uranium-238. Also, the soils were analyzed for barium, beryllium, mercury, lead, and selenium.

2. Radionuclide Analytical Results

When we compared the radionuclide concentrations from both sites with regional background concentrations, we found that most radionuclides (with the exception of plutonium-239,240 in the San Ildefonso sample, and uranium isotopes in the Tsankawi/PM-1 sample) were either nondetectable or below RSRLs (Table S7-1). A nondetectable value is one in which the result is lower than three times the total propagated uncertainty and is not significantly different from zero (Keith 1991; Corely et al. 1981).

The 0.038 pCi/g dry amount of plutonium-239,240 we detected in the San Ildefonso soil sample was just above the RSRL value of 0.032 pCi/g but far below the SL of 44 pCi/g dry. Comparing the concentrations of plutonium-239,240 to soil samples that have been collected since 1996 from this same location show that, for the most part, levels have been within regional background concentrations (Figure 7-2). Similarly, the levels of uranium isotopes in the soil sample collected from the Tsankawi/PM-1 site show only a slightly higher level than the RSRL. And a comparison of the isotopic ratio of uranium-234 to uranium-238 in the Tsankawi/PM-1 sample shows that the uranium is of natural origin and probably not a Laboratory contribution because there are no firing sites close by.

3. Nonradionuclide Analytical Results

The results of the trace metal analysis—barium, beryllium, mercury, lead, and selenium—in soils collected from San Ildefonso Pueblo lands can be found in Table S7-2. All concentrations of metals in soils from San Ildefonso Pueblo lands were below RSRLs.

D. Facility Monitoring

1. Monitoring Network

Facility-specific soil monitoring is done at Area G (Lopez 2002) and at DARHT (Nyhan et al. 2001a). The soil-sampling team collects approximately 15 soil-surface samples at designated places within and around the perimeter of Area G on an annual basis (Figure 7-3). These samples were analyzed by Paragon Analytics, Inc., for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; and uranium-238.

DARHT, approximately 20 acres in size, is located at R-Site (TA-15) at the Laboratory's southwestern end. We collect approximately four soil and four sediment samples annually at designated locations within the DARHT grounds. Paragon Analytics, Inc., analyzed all samples for concentrations of tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; and uranium isotopes, and for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium.

We compare Area G's results for radionuclides in soils to RSRLs, whereas we compare DARHT results for radionuclides and nonradionuclides in soils and sediments to BSRLs.

2. Radionuclide Analytical Results for TA-54, Area G

Many soil samples collected at Area G contained concentrations of tritium, plutonium-239,240, plutonium-238 , and americium-241 above RSRLs. (Note: All data can be found in Fresquez and Lopez 2005.) In contrast, the levels of cesium-137, strontium-90, and uranium isotopes in all of the soil samples at Area G were either nondetectable or within RSRLs. The highest levels of tritium in soils were detected outside the perimeter of Area G's southern portion near the tritium waste disposal shafts. Highest concentrations of the plutonium isotopes were detected in the northern and northeastern portions of Area G and are probably associated with the TRU waste storage areas. These data are similar to past years (Nyhan et al. 2003a, Fresquez et al. 2004a) and all are below LANL screening levels.

The highest reported concentrations of tritium in samples collected within and around Area G during the last seven years show increasing trends between 1998 and 2002, and then a decline between 2002 and 2004 (Figure 7-4). It is not completely known why the concentrations of tritium in soils at these two locations at Area G dropped so dramatically, but the low soil water contents at the surface during these drought years may be but one factor, as tritium is associated with the water cycle. As for the plutonium-239,240 concentrations in the two "worst case" soil areas at Area G, one sample, located on the outside of the perimeter fence line on the northeast corner, is generally decreasing, whereas the other sample, located inside the fence line on the north side, is statistically ($\alpha = 0.05$) increasing over time (Figure 7-5).

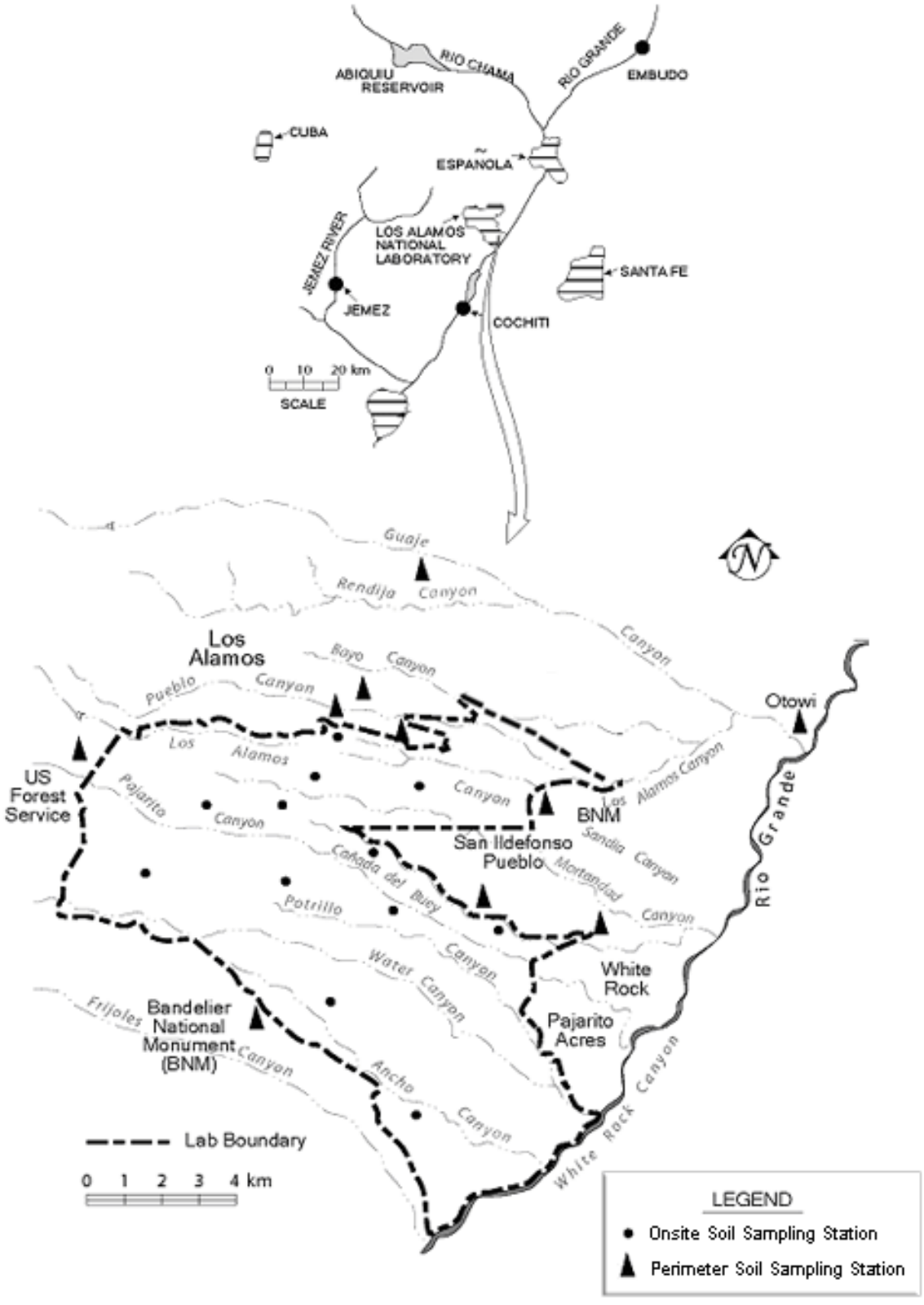

Figure 7-1. Off-site regional and perimeter and on-site Laboratory soil sampling locations.

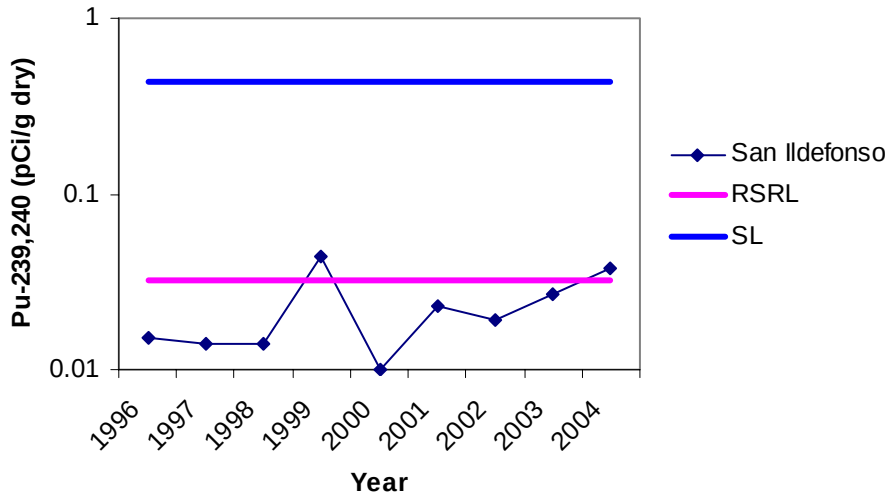

Figure 7-2. plutonium-239,240 concentrations in soil samples collected from San Ildefonso Pueblo lands over time approximately one-half mile northeast of Area G as compared to the regional statistical reference level (RSRL) and to the screening level (SL).

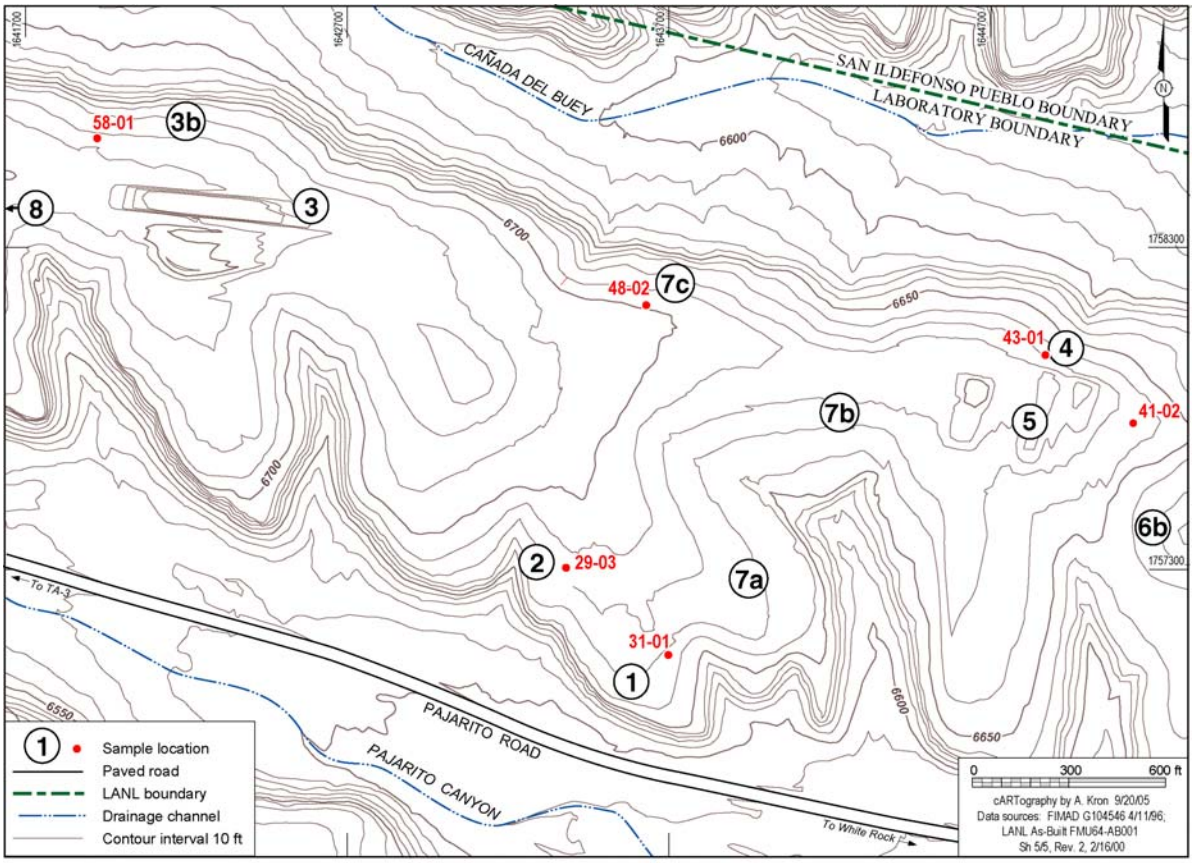

Figure 7-3. Site/sample locations of soils and vegetation at Area G. Site #8 is located farther west than shown. (This figure has been edited for operational security purposes.)

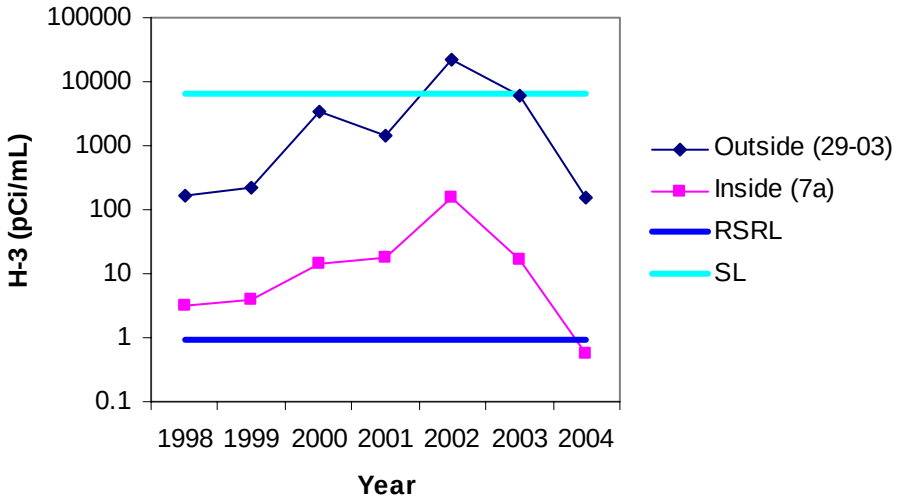

Figure 7-4. Tritium in surface soils collected from two selected (worst case) locations within and around Area G at TA-54 from 1998 to 2004 as compared to the regional statistical reference level (RSRL) and screening level (SL).

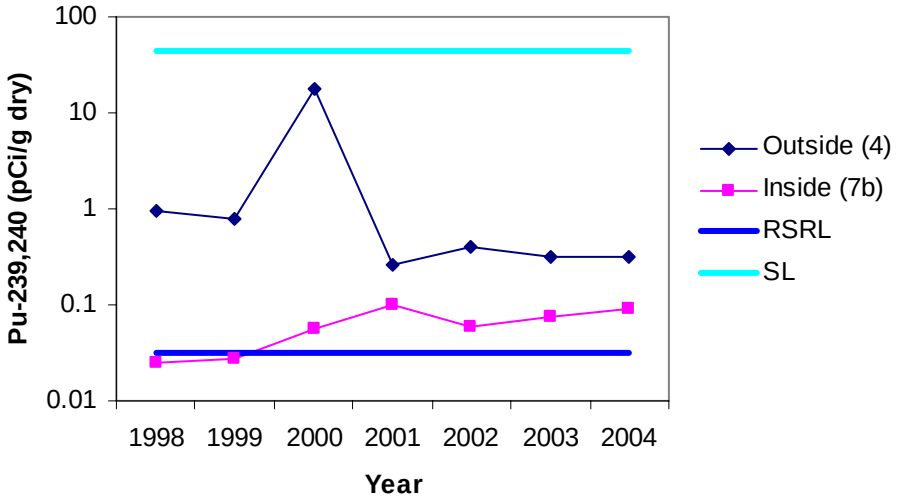

Figure 7-5. Plutonium-239,240 in surface soils collected from two selected (worst case) locations at Area G at TA-54 from 1998 to 2004 as compared to the regional statistical reference level (RSRL) and screening level (SL).

3. Radionuclide and Nonradionuclide Analytical Results for TA-15, DARHT

Most soil, and especially sediment, samples contained radionuclide concentrations that were either nondetectable or below BSRL values. (Note: All data can be found in Fresquez 2004b.) Also, most radionuclide concentrations in DARHT soils and sediments were generally similar to radionuclide concentrations found in regional background concentrations (Fresquez 2004a).

Radionuclides that were above the BSRLs included concentrations of cesium-137 and uranium-238 in three out of the four soil samples, and plutonium-239,240 and americium-241 in one out of the four soil samples. These data, at least for cesium-137 and uranium-238, had exhibited similar results in past years (Nyhan et al. 2003b; Fresquez et al. 2004b). All radionuclides, however, were far below screening levels. Some of the soil samples had isotopic uranium ratios consistent with depleted uranium. Depleted uranium,

a metal used as a substitute for the enriched uranium in weapon components tested at LANL, was also detected in vegetation (Fresquez 2004b), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) collected from around the DARHT grounds.

Most trace metal elements in soil and sediment samples collected at the DARHT facility were below BSRLs. The metals that were detected above the BSRLs included beryllium in one of four soil samples nearest the firing point, and selenium and thallium in some samples. All samples, however, were still far below the EPA screening levels. In the last two years, we have found elevated concentrations of antimony in many of the soil/sediment sampling locations. In 2004, however, the antimony concentrations in all of the soil/sediment samples were at baseline levels.

E. Quality Assurance/Quality Control

The soil-sampling team conducts soil-surface sampling according to written, standard quality-assurance/quality-control (QA/QC) procedures and protocols. These QA/QC procedures and protocols are identified in the overall "QA Project Plan (QAPP) for the Soils, Foodstuffs, and Biota Monitoring Project" (RRES-MAQ-QAPP, 2004); and, in the following operating procedures:

- "Soil Sampling," RRES-MAQ-707, R5, 2004;
- "Facility Soil and Vegetation Sampling," RRES-MAQ-711, R5, 2004;
- "Processing and Submitting Samples," RRES-MAQ-706, R5, 2004; and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota," RRES-MAQ-712, R0, 2004.

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results is conducted in a correct and consistent manner from year to year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting.

Members of the soil-sampling team collect soil samples for the analysis of radionuclide and trace elements (e.g., metals) from the 0- to 2-in. depth to capture the majority of contaminants from current air emissions and from fugitive dust. All samples are collected from relatively level, open (unsheltered by trees or buildings), rock-free, and undisturbed areas, and from the same (general) locations year after year. Paragon Analytics, Inc., of Fort Collins, Colorado, a company that met all QA/QC requirements, analyzed the soil samples for radionuclides and nonradionuclides.

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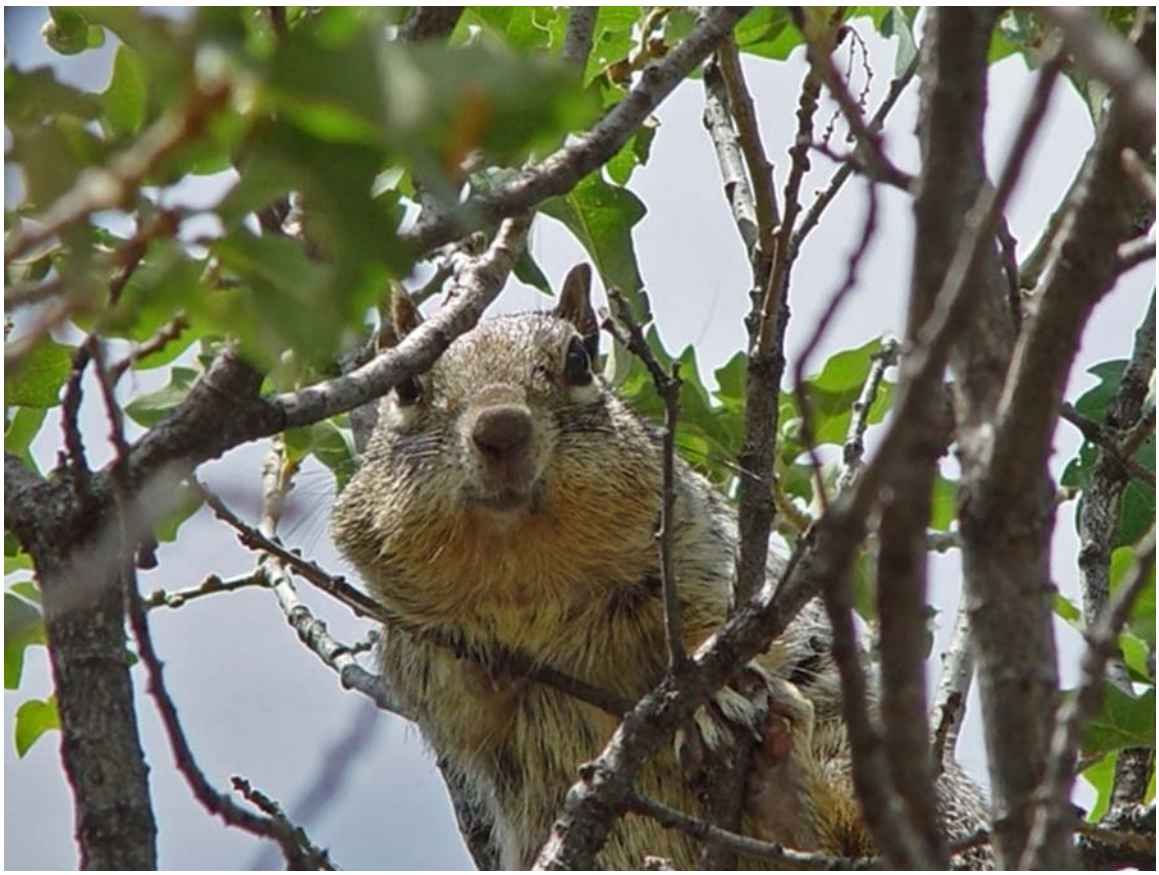
7. Soil Monitoring

8. Foodstuffs and Biota Monitoring



8. Foodstuffs and Biota Monitoring

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A. Foodstuffs Monitoring

1. Introduction

A wide variety of wild and domestic edible vegetable, fruit, grain, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes an important pathway by which radionuclides (Whicker and Schultz 1982) and nonradionuclides (metals and organics) (Gough et al. 1979) can be transferred to humans. Therefore, we 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 area and communities to determine the impacts of Laboratory operations on the human food chain. Department of Energy (DOE) Orders 450.1 (DOE 2003), and 5400.5 (DOE 1993) mandate this monitoring program; and the guidance for assessing these impacts are in DOE (1991).

The objectives of the program are:

(1) measure radioactive and nonradioactive contaminants in foodstuffs from on-site (the Los Alamos National Laboratory [LANL]) and perimeter areas, and then compare them to 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, we focus on the collection and analysis of radionuclides and metals in domestic produce from neighboring communities. Also, wild edible plants collected from Pueblo de San Ildefonso lands within Mortandad Canyon were analyzed and assessed.

2. Foodstuffs Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides to foodstuffs, we first compare analytical results of foodstuffs samples collected from perimeter areas to regional statistical reference levels (RSRLs). Where the levels exceed RSRLs, we then compare the concentrations to screening levels (SLs) if available; and, if needed, to standards, if available. Table 8-1 summarizes the levels and/or the standards used to evaluate the foodstuffs monitoring program.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from foodstuffs data collected from regional locations away from the influence of the Laboratory (> 9 miles away) (DOE 1991) over the past five years. (Note: For a list of regional locations see the section A3a, "Monitoring Network".) RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of the Environmental Surveillance Report.
- SL: The Meteorology and Air Quality Group Dose assessment team at the Laboratory developed screening levels for radionuclides to identify the contaminants of concern on the basis of a conservative 1 mrem protective dose limit (RRES-MAQ-DOSE, R0, 2003). Nonradionuclides, like mercury in fish, are compared to the Environmental Protection Agency water quality criterion (EPA 2001). If a constituent exceeds the SL, then the reason for that increase will be more thoroughly investigated.

- Standard: Based on the concentrations of radionuclides in foodstuffs, we calculate a dose to a person (see Chapter 3). This dose is compared with the 100-mrem/yr DOE all pathway dose standard. Nonradionuclides, like mercury and polychlorinated biphenyls in fish, are compared to Food and Drug Administration levels (FDA 2000).

Table 8-1. Standards and Other Reference Levels Applied to Foodstuffs

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	All foodstuffs	100 mrem	1.0 mrem	RSRLs
Nonradionuclides					
Trace elements	On-site and perimeter	All foodstuffs			RSRLs
Mercury	Perimeter	Fish	1 µg/g in edible portion (wet)	0.3 µg/g in edible portion	RSRLs
Polychlorinated Biphenyls	Perimeter	Fish	2 µg/g in edible portion		RSRLs
	On-site and Perimeter	Animals	3 µg/g in edible portion		RSRLs

3. Domestic Edible Plants

a. Monitoring Network. Approximately 44 crop samples (fruits, vegetables, and grains) were collected from regional and perimeter areas in the summer and fall of 2004 and analyzed for radionuclides and other trace elements (Figure 8-1). Regional background areas sampled included Jemez Springs, Española, Santa Clara, Dixon, Ojo Sarco, and Velarde. Perimeter locations sampled included the Los Alamos town site, White Rock/Pajarito Acres, the Pueblo de San Ildefonso, and the Pueblo of Cochiti (including the neighboring community of Sile). Produce samples collected from the perimeter areas were compared with crop samples collected from regional areas. Radionuclides and metals in produce from background areas are due to worldwide fallout and to natural sources. The analyses included the following radionuclides: tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, and uranium isotopes. The metals that were analyzed include barium, beryllium, mercury, lead, and selenium.

4. Radionuclide Analytical Results

Radionuclide concentrations in produce collected from regional and perimeter locations during the 2004 growing season can be found in Table S8-1 of the detailed data tables in the attached disk. Most radionuclide concentrations in fruits, vegetables, and grains collected from perimeter areas were nondetectable and are consistent with past years. A nondetectable value is one in which the result is lower than three times the total propagated uncertainty and is not significantly ($\alpha = 0.01$) different from zero (Keith 1991, Corely et al. 1981).

Of the very few radionuclides that were detected in perimeter crops, almost all were below RSRLs. RSRLs are generated from a wide variety of crop data collected from regional areas away from the influence of the Laboratory over the last five years. One of the radionuclides that was detected above the RSRL (>183×10^{-3} pCi/g dry) was strontium-90 in one lettuce plant from the Los Alamos town site (195×10^{-3} pCi/g dry). This result, albeit just above the RSRL, is not unusual as radionuclides differ in concentration from plant species to plant species (Seel et al. 1995), and strontium-90, an analog of calcium, has been shown to be higher in lettuce and lettuce-type plants (average = 173×10^{-3} pCi/g dry) than other nonleafy crop plants (average = 29×10^{-3} pCi/g dry) (Fresquez et al. 2002). Also, this amount was far below the SL of 1 pCi/g dry for strontium-90 (e.g., < 1 mrem). Other radionuclides in perimeter crops that were detected above RSRLs included U-234 and U-238 in carrot samples collected from the Los Alamos townsite. However, the ratio of U-234 to U-238 indicate that this is natural uranium and not a Laboratory contribution. Therefore, all radionuclides in crop plants from all communities surrounding the Laboratory were indistinguishable from natural or fallout levels.

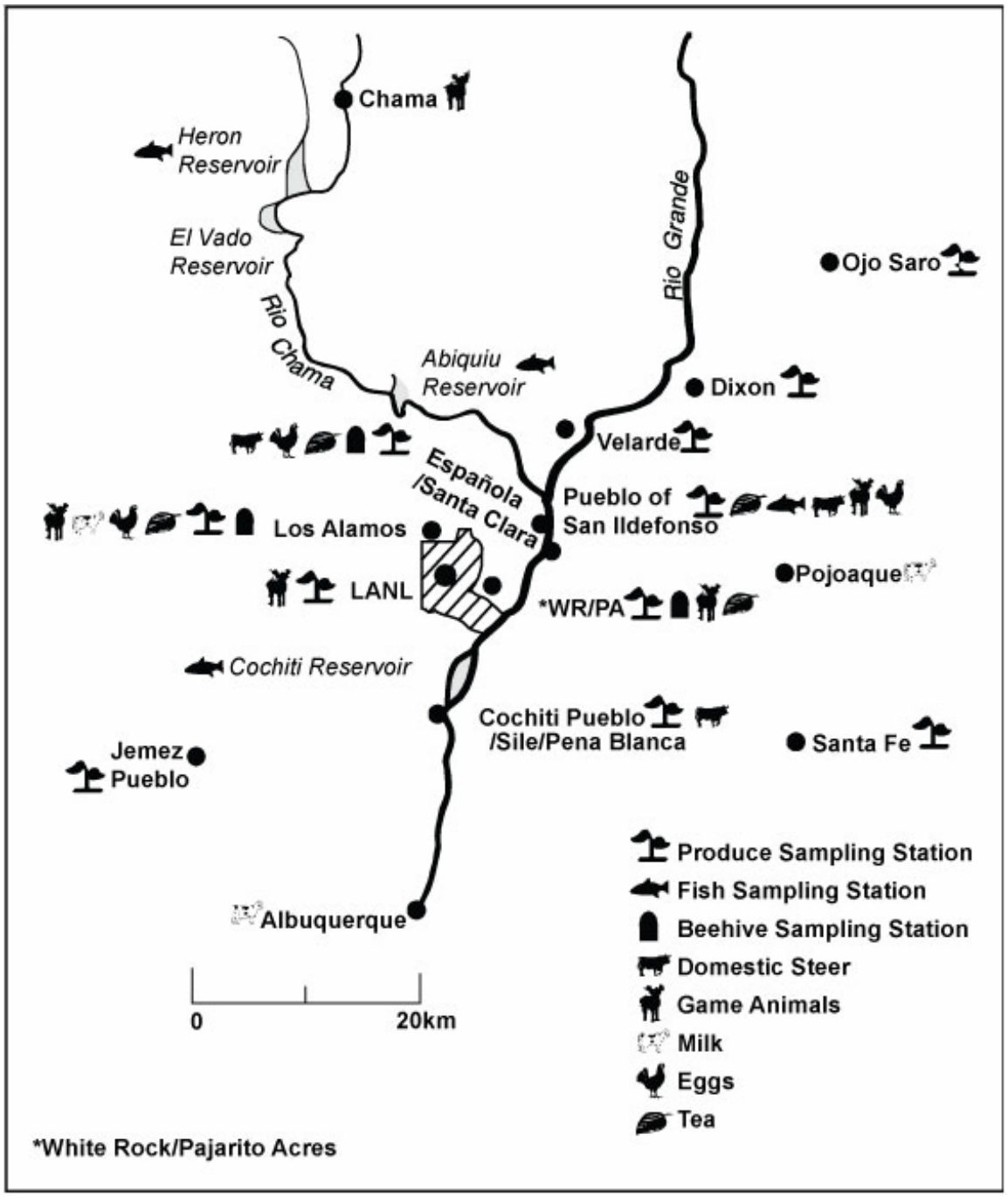

Figure 8-1. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations.

5. Nonradionuclide Analytical Results

All trace element concentrations in vegetable and fruit samples collected from Los Alamos, White Rock/Pajarito Acres, Cochiti/Sile, and San Ildefonso Pueblo were below or very similar to the RSRLs (Table S8-2). Results are similar to past years and no increasing trends are noted.

6. Wild Edible Plants

a. Monitoring Network. Common purslane (Portulaca sp.), is one of the most important wild foods in New Mexico with usage dating back a thousand years (TSFNM 2004), and wild spinach (Spinacia sp), a common leafy green, were collected within Mortandad Canyon on Pueblo de San Ildefonso lands. Composite samples (two of purslane and one of spinach) of these wild plant foods were collected approximately 5 to 50 m (16 to 160 ft) from the LANL boundary fence line. Also, acorns from oak trees (Quercus sp.) were collected about 200 m (650 ft) from the LANL boundary fence line. The analysis included the following radionuclides: tritium, plutonium-238, plutonium-239, 240, strontium-90, americium-241, cesium-137, and uranium isotopes. The metals that were analyzed include barium, beryllium, mercury, lead, and selenium.

b. Radionuclide Analytical Results. The analyses detected a few radionuclides that were in higher concentrations than the RSRLs (Table S8-3). Purslane contained higher concentrations of strontium-90 and plutonium-239,-240, and wild spinach contained higher levels of strontium-90 compared with regional background concentrations (Figure 8-2). All concentrations, however, were below SLs. This year is the first time these plants have been sampled in Mortandad Canyon on Pueblo lands and analyzed for radionuclides; therefore, these data cannot be compared with past results. This study will be repeated and soil samples will also be collected so that the relationship between plants and soil can be made.

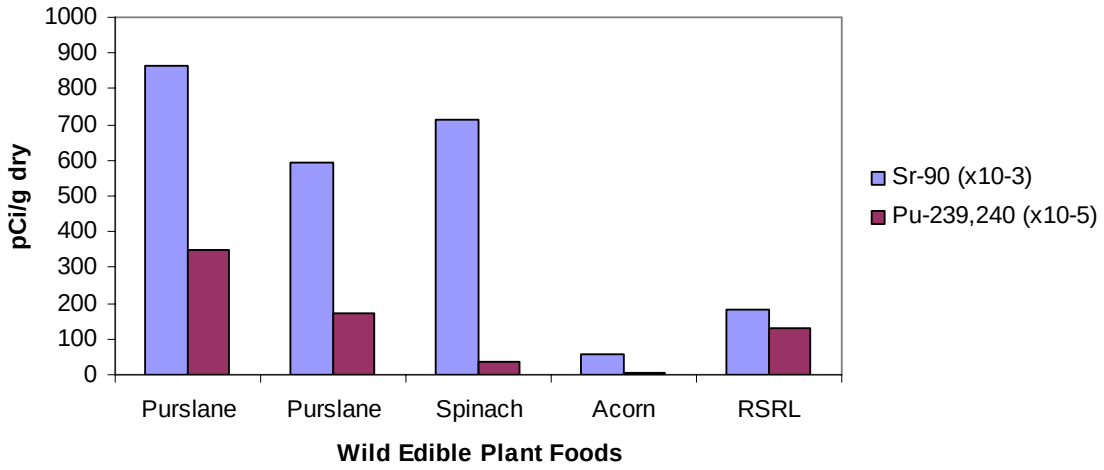

Figure 8-2. Sr-90 and Pu-239,240 concentrations in wild edible plant foods collected within Mortandad Canyon on San Ildefonso Pueblo lands as compared to regional statistical reference levels (RSRLs).

c. Nonradionuclide Analytical Results. All trace element concentrations, with the exception of barium, in wild edible plants were either undetected or below RSRLs (Table S8-4). Barium in both purslane samples was about three times higher than regional background concentrations reported for common produce plants (Figure 8-3). There are no SLs or standards for barium in food plants, but barium is bioaccumulated by many edible plant species (EHC 1990). The highest amount of barium detected in purslane plants (320 µg/g dry) collected within Mortandad Canyon on San Ildefonso Pueblo lands, for example, is below that found in mulberry (470 µg/g), walnut (550 µg/g), grape (630 µg/g), and Brazil nut (2,400 µg/g) plants (Robinson et al. 1950). The other wild food plant, spinach (22 µg/g of barium), that was collected in the same area as the purslane plants was very similar in barium concentrations to other leafy plants like lettuce (22 to 36 µg/g). Therefore, the bioaccumulation of barium by purslane plants is suspected. In any case, since this was the first time these plants have been sampled in Mortandad Canyon on Pueblo lands and analyzed for metals, we will repeat this study next year. We also will collect soil samples so that a correlation to plant samples can be made.

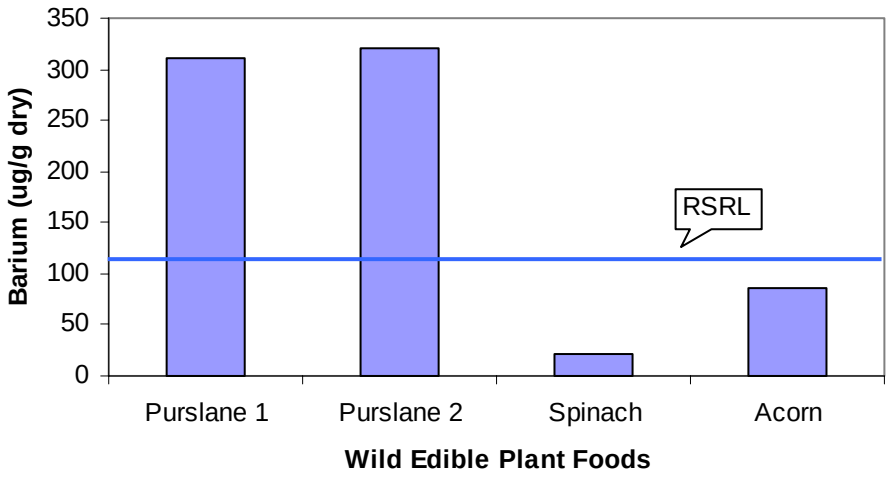

Figure 8-3. Barium concentrations in wild edible plant foods collected from within Mortandad Canyon on San Ildefonso Pueblo lands as compared to the regional statistical reference level (RSRL).

B. Nonfoodstuffs Biota Monitoring

1. Introduction

DOE Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate the monitoring of nonfoodstuffs biota for the protection of ecosystems. Although monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, site-wide vegetation monitoring started in 1994. Laboratory personnel monitor small mammals, amphibians and reptiles, birds, and vegetation, within and around LANL on a systematic basis or for special studies for radiological and nonradiological constituents.

The three objectives of the nonfoodstuffs biota program are to determine

(1) on-site and perimeter contaminant concentrations in biota and compare them with regional background concentrations,

(2) trends over time, and

(3) dose to plants and animals.

Chapter 3 includes the results of the biota dose in 2004 at LANL.

2. Nonfoodstuffs Biota Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides in nonfoodstuffs biota, we first compare the analytical results of biota samples collected from on-site and perimeter areas with regional (RSRLs) or with baseline (BSRLs) statistical reference levels. If the levels exceed RSRLs (or BSRLs), then we compare the concentrations with SLs, if available, and then to standards, if available. Table 8-2 summarizes the standards used to evaluate the biota-monitoring program. A discussion of these comparison levels is as follows:

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from nonfoodstuffs biota data collected from regional locations away from the influence of the Laboratory (> 9 miles away) (DOE 1991) over the past five years. RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of the Environmental Surveillance Report.
- Baseline levels: BSRLs are the concentrations of radionuclides and nonradionuclides in biota around the DARHT facility (1996–1999) before the operation phase (as of the year 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 Mitigation Action Plan reasons.)

- SL: Screening levels for radionuclides in nonfoodstuffs biota were set at 10% of the standard by the Meteorology and Air Quality Group dose assessment team at the Laboratory to identify the contaminants of concern. Nonradionuclides are compared with Toxicity Reference Values (LANL 2004) reported by the Environmental Restoration Program (Ryti et al. 1999). If a constituent exceeds the SL, the reason for that increase will be more thoroughly investigated.
- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1 rad/d DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/d for terrestrial animals (DOE 2002).

Table 8-2. Standards and Other Reference Levels Applied to Nonfoodstuffs Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants and aquatic biota	1 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1 rad/d	0.1 rad/d	BSRLs
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Nonradionuclides	On-site and perimeter	Biota		TRVs[a]	RSRLs
	DARHT	Biota		TRVs	BSRLs

[a]TRVs = Toxicity Reference Values (LANL 2004)

3. Institutional Monitoring

No institutional monitoring of vegetation was performed in 2004—samples are usually collected every third year. For a discussion of results reported in past years, see Gonzales et al. (2000) for results from sampling conducted in 1998 and Fresquez and Gonzales (2004) for results from sampling conducted in 2002 and 2003. In general, all radionuclide concentrations in vegetation from perimeter and on-site areas are low, and most were either nondetectable or within RSRLs. Only a few radionuclides, particularly plutonium-239,-240 and uranium, in both overstory and understory vegetation from on-site areas, were detected. An on-site area where plutonium-239,-240 was noted to be in higher concentrations in/on native vegetation as compared with the RSRL was at Technical Area (TA)-21 (DP-Site). The values, however, were still very low, and the difference between on site concentrations and regional background concentrations was small. Also, the uranium isotopic ratio in vegetation from some on-site areas indicated depleted uranium deposition. Depleted uranium, a metal used as a substitute for the enriched uranium in weapons components tested at LANL, is probably a result of airborne deposition from firing sites (Hansen 1974).

4. Facility Monitoring

a. Monitoring Network. Facility-specific biota monitoring is conducted at the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001a). 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 BSRLs. A complete description of the Area G and the DARHT sites and sampling methodology can be found in Fresquez and Lopez (2004) and Fresquez (2004), respectively. Samples at Area G and DARHT were analyzed for tritium, cesium-137, strontium-90, americium-241, and plutonium and uranium isotopes. In addition, DARHT samples were analyzed for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium.

b. Radionuclide Analytical Results for Area G (TA-54)

i. Vegetation. Unwashed overstory (trees) and understory (grass and forb) vegetation samples were collected at nine locations within and around the perimeter of Area G (Figure 7-3). Most radionuclides were either nondetectable or less than the RSRLs for vegetation. (Note: All data can be found in Fresquez and Lopez 2004.) The exceptions were tritium in overstory and some understory vegetation, particularly in the south portion of Area G. Of the eight overstory samples collected within and around the perimeter of Area G, for example, all of the samples contained detectable concentrations of tritium greater than the RSRL of 2.3 pCi/mL. The tritium concentrations in overstory samples ranged from 2.3 to 83,000 pCi/mL, and the largest amount was detected in vegetation collected adjacent to the tritium shafts. Concentrations of tritium in deep-rooted overstory vegetation at this site appear to be fluctuating greatly from year to year (Figure 8-4). Also, a few plant samples had some foliar contamination from americium-241 and plutonium isotopes in/on them—the highest concentrations occurring in the northern sections of Area G. All radionuclide concentrations were below the SL (0.1 rad/day) and DOE dose limit of 1 rad/day for the protection of terrestrial plants (DOE 2002).

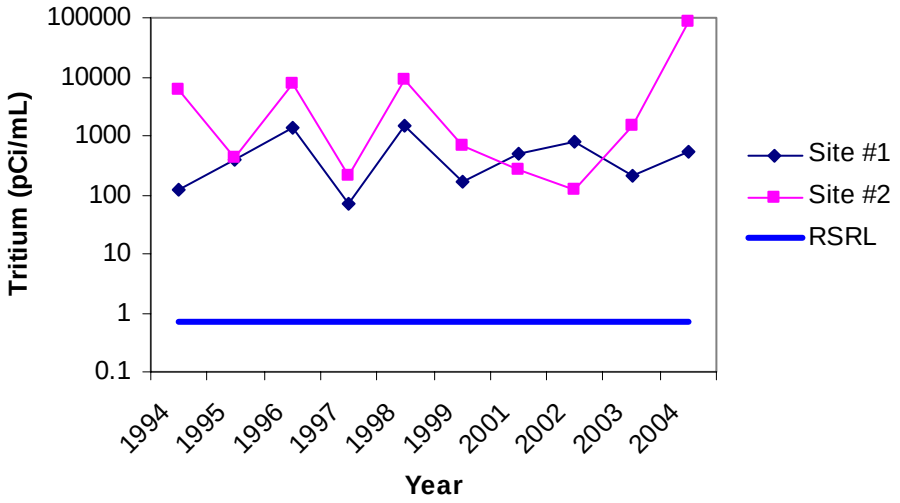

Figure 8-4. Tritium in overstory vegetation collected from two selected (worst case) locations outside of Area G at TA-54 from 1994 to 2004 as compared to the regional statistical reference level (RSRL) (see Figure 7-3 for location information).

ii. Small Mammals. Field mice (*Peromyscus spp.*) and rock squirrels (*Sciurus spp.*) were collected at Area G from 2001 through 2003 for the following purpose: (1) identify radionuclides occurring in small mammal (whole body) tissues as a result of living and foraging on the waste management area and (2) determine if doses to small mammals are of concern. (Note: These are the most recent data available; all data can be found in Fresquez et al. 2005.) In addition, we collected mice from the proposed expansion area to the west of Area G to gain baseline information. Most radionuclides, with the exception of cesium-137 and strontium-90, in whole-body burdens of mice were detectable and higher than the RSRL. This pattern reflects elevated radionuclide levels found in the vegetation that provides the principal food source for the rodents (Fresquez and Lopez 2004). These body burdens are similar to past results (Bennett et al. 1996a, 1998, 2002). The highest tritium concentrations in mice collected at Area G were associated with the tritium disposal pits located on the south end, whereas concentrations of the actinides varied widely. One sample, collected in 2003 over the inactive disposal pits (site #7a), showed unusually high levels of cesium, strontium, and transuranics not seen in past years (Fresquez et al. 2004a). We will collect animals from this area in subsequent years to determine if this anomaly persists. Although uranium concentrations in mice from Area G were higher than RSRLs, the U isotopic ratios of most samples indicated that the uranium was naturally occurring.

Most radionuclides, with the exception of tritium, in rock squirrels collected from within Area G at site #7a were either nondetectable or within RSRLs. These results are in contrast to the results obtained for the mice samples at site #7a; radionuclides in mice samples were much higher than in rock squirrels. The difference in radionuclide concentrations between mice and rock squirrels may be due to the differences in their foraging habits and living area.

Although levels of some radionuclides were elevated above background levels in tissues of mice at Area G, average doses received were quite low, around 0.005 rad/day. This amount is below the SL (0.01 rad/day) and DOE dose limit of 0.1 rad/day for the protection of terrestrial animals (DOE 2002).

c. Radionuclide and Nonradionuclide Analytical Results for DARHT (TA-15)

i. Vegetation. Unwashed overstory and understory vegetation were collected at four locations around the DARHT facility. Sample results were compared with BSRL data established for a four-year-long preoperational period (Fresquez et al. 2001). All radionuclides, with the exception of U-238 in overstory vegetation, were either nondetectable or within BSRL values. (Note: All data can be found in Fresquez 2004.) All of the overstory vegetation samples collected around the DARHT facility contained U-238 concentrations just above the BSRL and correlate with the U-238 concentrations in soils. The uranium on all of the overstory (and some understory) plants had U-234 and U-238 ratios consistent with that of depleted uranium. Depleted uranium, a metal used as a substitute for the enriched uranium in weapon components tested at LANL, was also detected in soils (Fresquez 2004), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) at DARHT. Trace elements, with the exception of copper and selenium in overstory and selenium in understory vegetation, were below the BSRL values. Copper and selenium concentrations in overstory and selenium in understory vegetation are similar to past years, although they do not correlate very well with the soil's data. Nyhan et al. (2003) discusses the consequences of elevated copper and particularly selenium in plants.

ii. Small Mammals. Samples of (whole body) field mice (Peromyscus spp.) were collected from within the grounds of the DARHT facility at LANL, Technical Area 15, from 2001 through 2003. (Note: These are the most recent data available, and all data can be found in Fresquez 2005.) Results, which represent three years since the start of operations in 2000, were compared with BSRL data established over a four-year-long preoperational period (Bennett et al. 2000).

Most radionuclides in whole-body tissue of mice collected from 2001 through 2003 were either at nondetectable levels or below BSRLs for mice. The few radionuclides that were above BSRLs included uranium isotopes, and the ratios of U-234 to U-238 in nearly 60% of the samples were consistent with depleted uranium. Depleted uranium was also detected in soil, vegetation, bee, and small mammal samples from around the DARHT grounds. Although the amounts of uranium in some mice samples were just above BSRLs, all concentrations resulted in doses below the SL (0.01 rad/day) and DOE limit of 0.1 rad/day for the protection of terrestrial animals (DOE 2002).

iii. Bees. During 2003, honey bees were collected from four colonies located at the DARHT at LANL, analyzed for various radionuclides and trace elements, and compared to BSRL for bees (Haarmann 2001). (Note: These are the most recent data available, and all data can be found in Hathcock and Haarmann 2004.) All of the radionuclides and nonradionuclides, with the exception of copper, were within BSRLs. The ratio of U-234 and U-238 in bees indicates a depleted uranium source. The indication of depleted uranium was consistent with the soil, vegetation, and small mammal data..

C. Special Monitoring Study: Polychlorinated Biphenyls (PCBs) in the Rio Grande Using Semi-permeable Membrane Devices ("Fat Bags")

Polychlorinated biphenyls are extensively distributed worldwide and ubiquitous in the environment. Concern has existed for years that LANL has released PCBs into the environment that may have reached the Rio Grande. From 1997 to 2002, studies were conducted on PCBs in fish taken from the Rio Grande and from Cochiti and Abiquiu reservoirs (Gonzales and Fresquez 2003). The studies assessed potential effects to both nonhumans and humans that consume the fish and to determine whether LANL has contributed to the PCB burdens. Generally, the studies identified more risk to humans than to nonhumans. Some cases have shown concentrations of PCBs in fish above LANL to be higher than below LANL, and in other cases the reverse has been true. Conclusions about contributions from LANL have been less than definitive because the fish are mobile, possibly spending time upstream and downstream from LANL. This study complements the fish studies by sampling PCB congeners in the Rio Grande using stationary

semipermeable membrane devices. We sampled dissolved PCBs from the Rio Grande at two locations above LANL and three locations below LANL in 2002 and 2003. Total PCB concentrations upstream of LANL ranged from 3.12 to 4.02 ng/g (ppb) compared to 3.13 to 3.98 ng/g (ppb) at the location downstream of LANL. Semi-permeable membrane devices concentrated PCBs from water by a factor of about 10^4. Using somewhat of a "fingerprinting" method, homologue patterns of the sampled PCBs were compared with patterns of brand-name formulations to establish whether the "parent" aroclor(s) (PCB mixtures) of the Rio Grande samples are of the same aroclors found at LANL. Results showed only a small amount of similarity between the type of aroclors indicated in the Rio Grande below LANL and aroclors known to exist at LANL. Also it was concluded that, for the particular time period studied, LANL was not likely contributing PCBs to the Rio Grande as indicated by the statistically similar total PCB concentrations between the two stations above LANL and the station immediately below LANL. This same conclusion has been made in reports on the previous fish studies. For more information on this study, see Gonzales and Montoya (2005).

D. Quality Assurance/Quality Control

The team conducts foodstuffs and nonfoodstuffs sampling according to Quality Assurance/Quality Control (QA/QC) procedures and protocols identified in the overall "Quality Assurance Project Plan" for the Soil, Foodstuffs and Biota Monitoring Project" (RRES-CMT-QAPP, R1); and the following procedures:

- "Facility Soil and Vegetation Sampling," RRES-MAQ-711, R5, 2004,
- "Rodent Trapping," RRES-ECO-BIO-HCP/OP-035, R3,
- "Managing and Sampling Honey Bee Hives" RRES-ECO-301, R0, 2004,
- "Processing and Submitting Samples," RRES-MAQ-706, R5, 2004; and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota," RRES-MAQ-712, R0, 2004.

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results, is conducted in a correct and consistent manner from year to year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting. 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 samples and met all LANL QA/QC requirements. Results for radionuclides, with the exception of tritium, are reported on a per gram ash basis. Tritium is reported on a per mL basis. To convert radionuclide units to a dry or wet weight basis for dose assessments, multiply the media results in a per gram ash weight basis by the appropriate ash/dry and dry/wet weight ratio provided in Fresquez et al. (2004b).

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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 450.1, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "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 EPA dose factors from EPA 1988. The dose factors EPA 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 for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit 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 public dose limits and the DOE occupational dose limits 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 with 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/.

Appendix A

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 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 with 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*). 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. The specific compounds analyzed in each suite are listed in the supplemental tables for Chapters 5 and 6.

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Table A-1. Department of Energy Dose Limits for External and Internal Exposures

	Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
Air Pathway Only[d]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[e]
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

[a] Refer to Glossary for definition.
[b] 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 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.
[c] 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.
[d] This level is from EPA's regulations issued under the Clean Air Act, (40 CFR 61, Subpart H) (EPA 1989a).
[e] Refer to Glossary for definition.

Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived Air Concentrations[a]

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 (μCi/mL)	Class[b]	DACs for Occupational Exposure (μCi/mL)
^{3}H	—	2,000,000	80,000	1×10^{-7}[c]	—	2×10^{-5}[c]
^{7}Be	5×10^{-3}	1,000,000	40,000	4×10^{-8}	Y	8×10^{-6}
^{89}Sr	3×10^{-1}	20,000	800	3×10^{-10}	Y	6×10^{-8}
^{90}Sr	3×10^{-1}	1,000	40	9×10^{-12}	Y	2×10^{-9}
^{137}Cs	1×10^{0}	3,000	120	4×10^{-10}	D	7×10^{-8}
^{234}U	5×10^{-2}	500	20	9×10^{-14}	Y	2×10^{-11}
^{235}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}Pu	1×10^{-3}	40	1.6	3×10^{-14}	W	3×10^{-12}
^{239}Pu	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{240}Pu	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{241}Am	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}

[a] 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.
[b] Gastrointestinal tract absorption factors (f_1) and lung retention classes (Class) are taken from ICRP-30 (ICRP 1988). Codes: Y = year, D = day, W = week.
[c] 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	Federal Standards 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	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM_{10}[a]	Annual	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
$PM_{2.5}$[b]	Annual	$\mu g/m^3$		15	15
	24 hours	$\mu g/m^3$		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	$\mu g/m^3$		1.5	1.5

[a]Particles ≤10 μm in diameter.
[b]Particles ≤2.5 μm in diameter.

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DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

DOE 2003b: US Department of Energy, "Environment, Safety, and Health Reporting," US Department of Energy Order 231.1A (August 19, 2003).

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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).

Appendix A

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 2.0×10^{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 2.0×10^{-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 standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1*s*) for the station and group means.

Appendix B

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}	μ
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

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^3)	35.3	cubic feet (ft^3)
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^2)	0.386	square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
Bq	becquerel
Btu/yr	British thermal unit per year
Ci	curie
cm^3/s	cubic centimeters per second
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
ft^3/min	cubic feet per minute
ft^3/s	cubic feet per second
kg	kilogram
kg/h	kilogram per hour
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second
μCi/L	microcurie per liter
μCi/mL	microcurie per milliliter
μg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
μm	micrometer
μmho/cm	micro mho per centimeter
mCi	millicurie
mg	milligram
mR	milliroentgen
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^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 μm diameter)
$PM_{2.5}$	small particulate matter (less than 2.5 μm diameter)
R	roentgen
s, SD, or σ	standard deviation
s.u.	standard unit
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than

Table B-3. Common Measurement Abbreviations and Measurement Symbols (Cont.)

<	less than
≥	greater than or equal to
≤	less than or equal to
±	plus or minus
~	approximately

Reference

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle 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, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.

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 located. 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 critical 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 special nuclear materials in various configurations below critical. The special nuclear materials at this site are in the process of being relocated to the Nevada Test Site.

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: 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: 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 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 research and development 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; includes Area G.

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 KSL Services.

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 de 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.lanl.gov/orgs/rres/maq/AirReports.htm	provides access to Environmental Surveillance reports and supplemental data tables.
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.lanl.gov/orgs/rres/maq/index.htm	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.

Appendix D

activation products	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.
albedo dosimeters	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.
alpha particle	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.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
aquifer	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.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	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.
beta particle	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.
biota	The types of animal and plant life found in an area.
blank sample	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.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.
BOD	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.

CAA — Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.

CERCLA — 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.

CFR — Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the *Federal Register*.

COC — Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

contamination — (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.

controlled area — Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Ci — Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.

cosmic radiation — High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

CWA — 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.

DOE — US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.

dose — A term denoting the quantity of radiation energy absorbed.

absorbed dose — The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that

material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

dose equivalent The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

EDE 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.

CDE Committed dose equivalent. Committed dose equivalent ($H_{T,50}$) means the dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

CEDE Committed effective dose equivalent Committed effective dose equivalent ($H_{E,50}$) means the sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor (w_T)--that is, $H_{E,50} = \sum w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert).

TEDE Total effective dose equivalent Total effective dose equivalent (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

maximum individual dose 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.

population dose 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.)

whole body dose 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).

EA	Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
effluent	A liquid waste discharged to the environment.
EIS	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.
emission	A gaseous waste discharged to the environment.
environmental compliance	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.
environmental monitoring	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.
environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	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.

gross alpha The total amount of measured alpha activity without identification of specific radionuclides.

gross beta The total amount of measured beta activity without identification of specific radionuclides.

groundwater Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.

half-life, radioactive 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 × 1/2), after three half-lives, one-eighth (1/2 × 1/2 × 1/2), and so on.

hazardous waste 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.

hazardous waste constituent The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly 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.

hydrology The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation 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.

ionizing radiation 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.

isotopes 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).

MCL 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.

MEI 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.

mixed waste 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).

mrem Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.

NEPA 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.

NESHAP National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.

nonhazardous waste 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.

NPDES National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.

nuclide 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.

outfall The location where wastewater is released from a point source into a receiving body of water.

PCB 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.

PDL 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).

perched groundwater 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.

person-rem 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.

pH 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.

pollution Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).

point source An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.

ppb Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or µg/kg.

ppm Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as µg/g or mg/kg.

QA 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.

QC 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.

rad 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 rad = 1,000 millirad (mrad)

radionuclide 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.

RESRAD A computer modeling code designed to model radionuclide transport in the environment.

RCRA Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

release Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem 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.

rem = rad × quality factor
1 rem = 1,000 millirem (mrem)

SAL Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.

SARA 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.

saturated zone Rock or soil where the pores are completely filled with water, and no air is present.

SWMU Solid waste management unit. Any discernible site at which solid 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).

terrestrial radiation 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.

TLD 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.

TRU 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.

TSCA 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.

tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	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.
vadose zone	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.
water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
water year	October through September.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
AST	above-ground storage tank
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
CFR	Code of Federal Regulations
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
DOB	DOE Oversight Bureau
DOE	Department of Energy
DRO	diesel-range organic compound
DU	depleted uranium
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENV	Environmental Stewardship Division
ENV-ECO	Ecology Group (LANL)
ENV-MAQ	Meteorology and Air Quality Group (LANL)
ENV-SWRC	Solid Waste Regulatory Compliance Group (LANL)
ENV-WQH	Water Quality and Hydrology Group (LANL)
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
FY	fiscal year
GEL	General Engineering Laboratory
GMAP	gaseous mixed air activation products
HE	high-explosive
HMX	cyclotetramethylenetetranitramine

HSR-4	Health Physics Measurements Group (LANL) (Health, Safety, and Radiation Protection Division)
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
ISM	Integrated Safety Management (LANL)
LANL	Los Alamos National Laboratory (or the Laboratory)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
NCR	nonconformance report
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PERC	perchloroethylene
PM	particulate matter
ppb	parts per billion
PSTB	Petroleum Storage Tank Bureau (NMED)
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)

RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SA	supplement analysis
SAL	screening action level
SL	screening level
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SWEIS	Site-Wide Environmental Impact Statement
SWPP	Storm Water Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act
UC	University of California

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_3-N
Barium	Ba	Nitrite (as Nitrogen)	NO_2-N
Berkelium	Bk	Nitrogen	N
Beryllium	Be	Nitrogen dioxide	NO2
Bicarbonate	HCO_3	Nobelium	No
Bismuth	Bi	Osmium	Os
Boron	B	Oxygen	O
Bromine	Br	Palladium	Pd
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Phosphate (as Phosphorus)	PO_4-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_3	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_4
Gold	Au	Sulfite	SO_3
Hafnium	Hf	Sulfur	S
Helium	He	Tantalum	Ta
Holmium	Ho	Technetium	Tc
Hydrogen	H	Tellurium	Te
Hydrogen oxide	H_2O	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	^3H
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

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