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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
10/08/2004	00	First approved new technical basis document for the Los Alamos National Laboratory – Occupational Environmental Dose. Incorporates formal internal and NIOSH review comments. Initiated by Jack E. Buddenbaum.
03/26/2010	01	Revision adds new environmental external and uptake data prior to 1971. Added Attributions and Annotations section. Incorporated SEC-00061 and SEC-00051. Intakes to assign maximum doses for four primary radionuclides during the specified employment period for the class of Los Alamos National Laboratory employees added to the Special Exposure Cohort (1943–1975) are included. Section 4.1.3.3 clarified ‘partial’ dose reconstruction with respect to ambient external dose; additional instructions to dose reconstructors were added to section 4.3.1, ‘Ambient Radiation.’ These state that on-site ambient dose is to be based on the environmental film badge and TLD results available from 1965 onward. In support of this, rows with years prior to 1965 were deleted from Table 4-26. Single correction to a preposition in Section 4.2.1. Incorporates review comments from formal internal and NIOSH review. Incorporates changes required by the adoption of an 83.14 SEC determination. This alters the definition of the class of Los Alamos National Laboratory employees added to the SEC (1943-1975), and removes the area-specific and monitoring restrictions from the class definition making the SEC class now include all employees in all areas of the LANL during the period 1943-1975. Constitutes a total rewrite of the document. Training required: As determined by Objective Manager. Initiated by Donald N. Stewart.

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ACRONYMS AND ABBREVIATIONS

AMAD	activity median aerodynamic diameter
Bq	becquerel
Ci	curie
DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
g	gram
G/MAP	gaseous/mixed activation product
hr	hour
HYPO	Water Boiler Reactor in high-power configuration
ICRP	International Commission on Radiological Protection
km	kilometer
LAHDRA	Los Alamos Historical Document Retrieval and Assessment
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LOPO	Water Boiler Reactor in low-power configuration
m	meter
MDA	minimum detectable activity
MFP	mixed fission product
mrem	millirem
NCRP	National Council on Radiation Protection and Measurements
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
P/VAP	particulate and vapor activation products
pCi	picocurie
POC	probability of causation
s	second
SRDB Ref ID	Site Research Database Reference Identification (number)
Sv	sievert
TA	technical area
TBD	technical basis document
TLD	thermoluminescent dosimeter
U.S.C.	United States Code
yr	year
µCi	microcurie

μm	micrometer
μrem	microrem
§	section or sections

4.1 INTRODUCTION

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word “facility” is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an “atomic weapons employer facility” or a “Department of Energy [DOE] facility” as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as “any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)” [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled “Exposure in the Performance of Duty.” That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer “shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation[1]] guidelines established under subsection (c) …” [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation, 42 C.F.R. Pt. 82) define “performance of duty” for DOE employees with a covered cancer or restrict the “duty” to nuclear weapons work (NIOSH 2007a).

The statute also includes a definition of a DOE facility that excludes “buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program” [42 U.S.C. § 7384l(12)]. While this definition excludes Naval Nuclear Propulsion Facilities from being covered under the Act, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled “Exposure in the Performance of Duty”] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally-derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external occupational radiation exposures are considered valid for inclusion in a dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived (NIOSH 2007a):

- Background radiation, including radiation from naturally occurring radon present in conventional structures

[1] The U.S. Department of Labor (DOL) is ultimately responsible under the EEOICPA for determining the POC.

- Radiation from X-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons

4.1.1 Purpose

The purpose of this TBD is to describe potential occupational environmental dose to Los Alamos National Laboratory (LANL) workers. Occupational environmental exposure refers to exposures workers received while on the site but outside facilities from elevated ambient radiation, from facility effluent releases to the environment, and from resuspension of radionuclides in soils. Effluent releases can result in internal and external exposures by inhalation of airborne radionuclides and by submersion in an effluent. This TBD provides estimated annual intakes for inhalation exposure and estimated doses as a result of submersion and ambient exposure at LANL.

4.1.2 Scope

As discussed in Part 2 of the LANL Site Profile (ORAUT 2004), operations at Los Alamos have occurred in land divisions called technical areas (TAs). Table 2-1 of Part 2 lists each TA with information on the types of radionuclides that were present at some time during operations there. Activities that have occurred at LANL since operations began in 1943 have been highly variable on the site and over time. This TBD addresses occupational environmental exposure by considering available source term information that has been compiled for some of the TAs, as well as results of published environmental measurements for a larger number of TAs.

This analysis recognized that effluents from a particular LANL TA would have the greatest impact on workers in that TA, but that such effluents could affect workers in nearby TAs. A comprehensive site-wide atmospheric model for predicting onsite worker exposures from the highly variable releases of radionuclides to the air would be useful for evaluating these impacts, but LANL has not developed such a model. This TBD relies to a great extent on environmental measurements (i.e., air-monitoring data), and to a lesser extent on source term emission estimates, to estimate worker exposures. Environmental measurements do not distinguish the source of emissions and, therefore, reflect air concentrations from nearby as well as more distant sources. The emissions estimates are useful in filling in some gaps in measurement data, and they are critical to estimating exposures that occurred before the start of comprehensive and routine measurement data reports.

4.1.3 Special Exposure Cohort

Based on the findings and recommendations of NIOSH and the Advisory Board on Radiation and Worker Health, the Secretary of the U.S. Department of Health and Human Services (HHS) has determined that, for the period of March 15, 1943, through December 31, 1975, internal doses for certain employees may not be feasibly reconstructed. For this reason, two classes of employees of the LANL have been added to the Special Exposure Cohort. NIOSH has subsequently proposed a revision to the class for the period March 15, 1943, through December 31, 1975 which removes the area-specific and monitoring requirements from the class definition.

4.1.3.1 September 1, 1944 through July 18, 1963

NIOSH and the Advisory Board on Radiation and Worker Health have determined that it is not feasible to reconstruct internal doses for workers involved in the radioactive lanthanum (RaLa) program, due to a lack of bioassay monitoring or other workplace measurements that would allow the reconstruction of individual doses or some maximum dose. For this reason, the Secretary of HHS has added the following class of employees to the Special Exposure Cohort (NIOSH 2006).

> Employees of the Department of Energy, predecessor agencies, and their contractors or subcontractors who were monitored or should have been monitored for exposure to ionizing radiation associated with radioactive lanthanum (RaLa) operations at Technical Area 10 (Bayo Canyon Site), Technical Area 35 (Ten Site) and Buildings H, Sigma, and U (located within Technical Area 1) at the Los Alamos National Laboratory (LANL) for a number of work days aggregating at least 250 work days during the period from September 1, 1944, through July 18, 1963, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

4.1.3.2 March 15, 1943 through December 31, 1975

Internal dose reconstruction was found not to be feasible for an additional class of employees of LANL due to the absence of bioassay monitoring or other workplace measurements for the potential intake of certain radionuclides associated with radioactive material use in a number of Technical Areas. For this reason, the Secretary of HHS added a class of employees to the Special Exposure Cohort (NIOSH 2007b).

> Employees of the Department of Energy predecessor agencies and their contractors or subcontractors who were monitored or should have been monitored for radiological exposures while working in operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory (LANL) for a number of workdays aggregating at least 250 work days during the period from March 15, 1943, through December 31, 1975, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Subsequently, NIOSH has proposed a modified class to remove the area-specific and monitoring requirements from the class definition (ref the new 83.14 ER when approved by OCAS).

> All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Los Alamos National Laboratory in Los Alamos, New Mexico, from March 15, 1943 through December 31, 1975, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort.

4.1.3.3 Partial Dose Reconstructions

NIOSH has determined that it is possible to reconstruct or bound external doses and occupational medical X-ray dose and therefore individuals with non-presumptive cancers, or who do not meet the definitions of the classes of employees added to the SEC, can be considered for partial dose reconstructions, including doses from environmental radioactive material on-site ambient dose-rate fields in years for which data are available.

As documented by NIOSH (2007b), partial dose reconstructions can include internal dose from tritium (from 1950 onward), polonium (from 1944 to 1956), plutonium (from 1944 onward), and uranium (from 1943 onward) when based on records of bioassay monitoring. These radionuclides were likely to compose a part of the internal dose received by LANL employees from intake of radionuclides from the general environment. Although for later years data are available to characterize environmental internal doses in great detail, such data are not available, typically, for years before 1971. On-site ambient doses may be included in partial dose estimates for years in which they may be based on a consistent environmental dose measurement program, specifically, 1965 and later.

4.2 INTERNAL EXPOSURE FROM ONSITE ATMOSPHERIC RADIONUCLIDE CONCENTRATIONS

4.2.1 Onsite Releases to Air

In Part 2 of the LANL Site Profile (ORAUT 2004), Table 2-1 lists LANL TAs and potential sources of radioactive materials that are or were present at some time at each TA. Enriched and depleted uranium, as well as plutonium isotopes, are commonly listed sources. Due to the many different types of applied research that have been conducted at LANL, Table 2-1 also lists tritium, noble gases, and fission and activation products.

LANL has reported effluents for many of the TAs from 1971 to 1995 [1]. In recent years, the reporting of air emissions has been by stack or vent. It is not possible to ascertain at this point how comprehensive the current reporting of effluents is. Estimates of emissions from the Omega Reactors (TA-2), for example, have not been obtained. Furthermore, LANL has not assessed the exact locations of releases in relation to potential receptors in a TA.

An ambient air-monitoring program at LANL began as early as 1954 with a single station on the roof of the Administration Building in TA-3 (Johnson 1954). In 1959, a network of about 15 stations was put into operation. At present, about 60 stations conduct continuous air sampling. About 20 of the presently operational stations are on the site, with the remainder being offsite or perimeter stations. Figure 4-1 shows the location of active onsite and offsite monitoring stations. Historical results of the AIRNET monitoring network through 2000 are available on the LANL Web site (LANL 2003), and annual environmental surveillance reports summarize yearly results. However, results are not reported for many TAs, and data are missing for some radionuclides and some years. Locations of the air-monitoring stations in relation to a specific worker location in a TA are not well known.

Due to the lack of comprehensiveness of both effluent and air-monitoring data, the approach to estimation of worker intakes of radionuclides from air due to emissions from the TAs relied on a combination of the effluent and air-monitoring data in this TBD. Because air-monitoring data from a TA include concentrations from effluents from that TA as well as resuspension of previously deposited radionuclides and effluents from nearby TAs, this analysis preferred these data for estimation of air concentrations and ultimately worker intakes. The analysis used emissions data to fill some of the known gaps in monitoring data (see Section 4.2.1.3).

4.2.1.1 Emissions Data

Tables A-1 through A-22 in Attachment A list emissions data. The tables list source emissions data by year and TA. If effluents were reported by stack or building vent (1971 to present), the tables sum effluents from the stacks and vents in each TA. For earlier years (1943 to 1970), the effluent releases in this document rely on data from the Centers for Disease Control and Prevention Los Alamos Historical Document Retrieval and Assessment (LAHDRA) project (ENSR 2002), including unpublished data; however, these data were determined to be insufficient for reconstruction of environmental internal doses.

4.2.1.1.1 Episodic Releases

LANL reported accidental releases of tritium and plutonium in the 1970s. Before that time, LANL noted some accidental releases (for example, a fire at TA-21 in July 1957), but accurate release estimates were not available (ENSR 2002). There were two tritium releases from TA-3 and one from TA-33. There was a plutonium release from TA-21 in October 1970 (ENSR 2002). The emissions estimates (Tables A-1 through A-22 in Attachment A) include these and other episodic releases for which data were available along with routine stack releases for those years.

4.2.1.1.2 Bayo Canyon Releases

Experiments in TA-10, Bayo Canyon, involved detonation of explosives around radioactive materials. These detonations dispersed materials, principally ^{140}La, to the atmosphere and could have caused exposure to LANL employees. The dominant dose pathway would have been exposure to gamma radiation from ^{140}La that was deposited on the ground (i.e., groundshine). An analysis by Kraig (1997) of offsite exposures to ^{140}La as a result of these detonations indicated that the groundshine dose contribution was approximately 3 orders of magnitude higher than that from inhalation and immersion in the contaminated air.

4.2.1.2 Radionuclides of Significance

Before describing how air concentrations in the TAs from emissions and monitoring data were estimated in this analysis, it is important to focus the analysis on radionuclides that are potentially

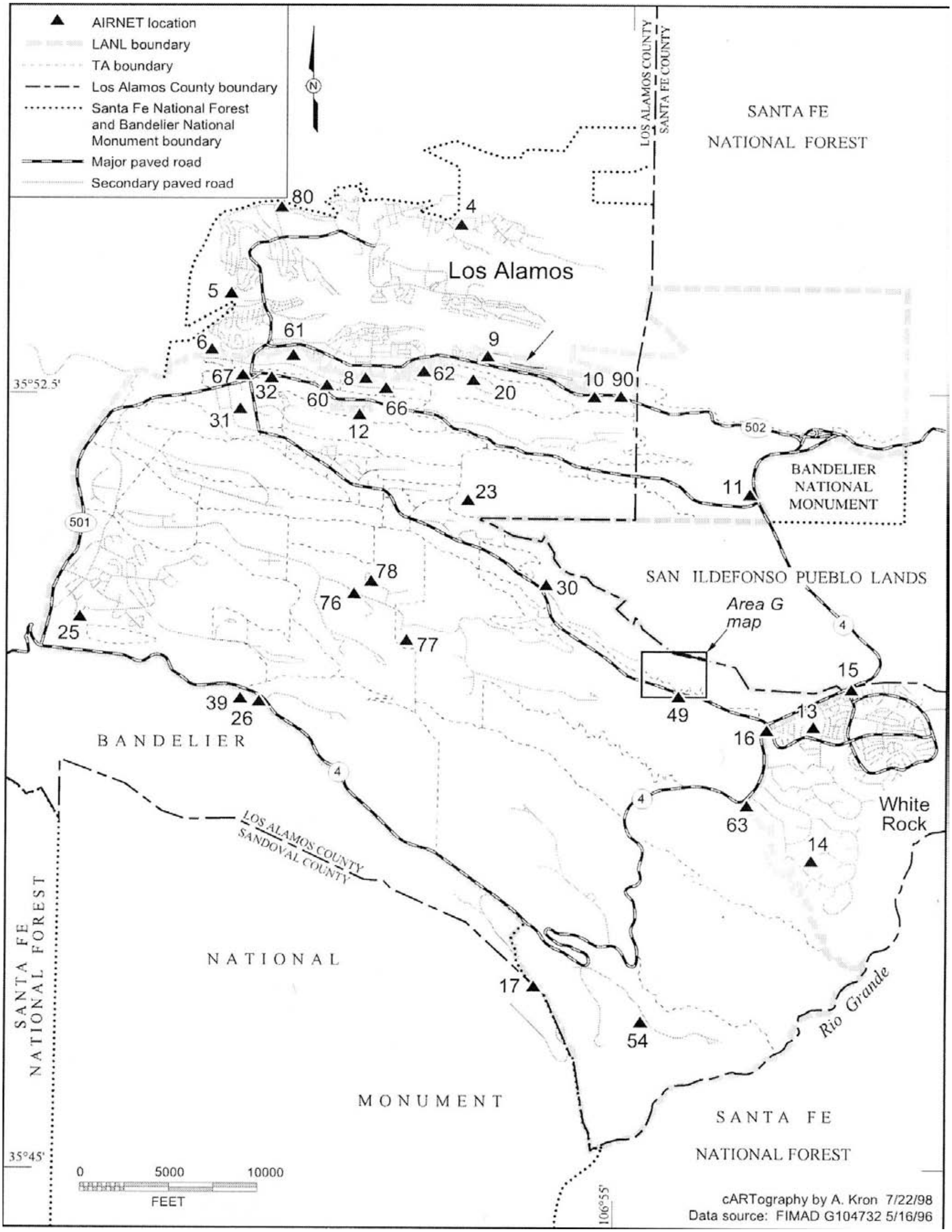

Figure 4-1. Offsite, perimeter, and onsite AIRNET locations (LANL 2002, p. 167).

significant to dose. The basis for selection of radionuclides for estimating air concentrations were screening calculations (see Table B-1 of Attachment B) to estimate which radionuclides that were listed as effluents were likely to contribute to at least 95% of the worker's total effective 50-year committed dose during each year [2]. Because the assumptions in screening overestimate potential exposures, it is believed these criteria correctly eliminate insignificant radionuclides from further concern.

The screening analysis evaluated the potential inhalation dose from the maximum annual reported emission of each radionuclide for the entire site (listed by TA in Tables A-1 through A-22). In this analysis, inhalation dose was calculated for each radionuclide by estimating maximum air concentrations using a screening-level dispersion model (NCRP 1996). An annual inhalation rate of 3,400 m^3/yr was assumed, which corresponds to continuous moderate activity (1.7 m^3/hr) over a 2,000-hour work year. The effective dose factors for each radionuclide are from the CD supplement to International Commission on Radiological Protection (ICRP) Publication 68 (ICRP 2001). An activity median aerodynamic diameter (AMAD) of 5 µm was assumed for all airborne particulates [3]. For elements, or groups of elements, for which isotopes were not specified [i.e., plutonium, uranium, mixed fission products (MFP), and particulate and vapor activation products (P/VAP)], a representative dose factor was selected that maximized the dose calculations for that group [4].

The National Council on Radiation Protection and Measurements (NCRP) screening model chosen for these calculations (NCRP 1996) is a simple dispersion model that accounts for potential increases in exposure due to building wake effects for close-in receptors (i.e., those less than 100 m from the source location). A calculated generic dispersion factor represents the ratio of air concentration (χ) to emission rate (Q) for any radionuclide:

$$\chi/Q = f/(\pi u h k) \text{ s/m}^3 \qquad (4\text{-}1)$$

where:

- χ = concentration at receptor (Ci/m^3)
- Q = stack or building vent release rate (Ci/s)
- f = wind frequency
- u = wind speed (m/s)
- h = height of effluent release (m)
- k = constant (m)

The values that were used for the independent factors f and k correspond to defaults in NCRP (1996), such that f is assumed equal to 0.25 (the maximum frequency for any compass point), and k is 1 m. The calculation assumed an average wind speed u of 2.8 m/s and an average effluent release height h of 8 m. The average wind speed at Los Alamos has been reported to be about 2.8 to 3 m/s (LANL 1994, 1999). The specification of an effluent release height of 8 m results in a dispersion factor that is more favorable to claimants because this assumes that releases are near ground level, rather than from elevated stacks, which increases estimated ground level concentrations. The calculated dispersion factor was 0.0036 s/m^3.

The maximum dose calculations for each isotope (or representative isotope), were summed for each year (Table B-1). The yearly contributions of each isotope to the collective annual dose were evaluated to identify which radionuclides collectively contributed 95% or more of the yearly dose. The results of this comparison are given in Table B-1. The other radionuclides that collectively contributed less than 5% of the yearly dose were considered relatively insignificant in relation to inhalation dose. The analysis indicated that the relatively significant radionuclides for which intakes should be evaluated were ^{3}H, ^{140}La, ^{232}Th, uranium, plutonium, and the groups of radionuclides specified as

MFPs and P/VAPs. The uranium isotopes include ^{234}U, ^{235}U, and ^{238}U, and the plutonium isotopes include ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am, according to the emissions estimates.

4.2.1.3 Estimation of Air Concentrations

Air-monitoring data, when available, formed the basis for estimates of air concentrations at each TA [5]. For some areas, especially TA-21 and TA-54, more than one monitoring station was active during many years (LANL 2003). In these cases, the analysis averaged concentrations over all stations in the TA. For years and locations when monitoring data were not available, the analysis based an estimate on the relationship between source emission rate and air concentration for years when data were available.

Some concentration data for years before 1971 were available for this analysis. For some TAs, air concentration data were not available for any year or for many of the years after 1970. Therefore, a method had to be devised to provide reasonable estimates of air concentrations for those years at those TAs. For other instances, LANL reportedly discontinued analysis in some years for selected radionuclides they deemed insignificant.

For TA-3 and TA-21, both ambient air-monitoring data and release estimates for plutonium were available for several years of interest. Based on the relationship between plutonium air concentrations and releases for these TAs, a ratioing method was developed to estimate concentrations in other TAs where effluent estimates were available but ambient air-monitoring data were absent [6]. This method involved calculating the average ratio of plutonium air concentration to the estimated emission rate over all years for which both quantities were available. For TA-3, this average ratio (from 14 years of data) was 2.2×10^{-12} pCi/m^3 per pCi/yr released. The maximum ratio for that period was 2.9×10^{-11} pCi/m^3 per pCi/yr released. A regression analysis gave a correlation coefficient *r* of 0.93, which indicates a strong correlation between source emission rate and measured air concentrations for TA-3. For TA-21, this average ratio (from 25 years of data) was also 2.2×10^{-12} pCi/m^3 per pCi/yr released. The maximum ratio for TA-21 was 1.4×10^{-11} pCi/m^3 per pCi/yr released. A regression analysis of the TA-21 data gave a correlation coefficient *r* of 0.65 for the TA-21 ratios, which indicates a moderate correlation [7].

While this ratioing method requires the assumption that dispersion at all TAs is similar to that in TA-21 and TA-3, that same assumption would be required of a simplistic model such as the one used for screening. Therefore, the ratioing method provides a reasonable estimate of average air concentrations at the LANL TAs for years in which monitoring results were not available [8]. Because the average ratio tends to reflect the strong influence of one or two high ratios during the represented periods, this method provides a reasonable estimation of concentrations that would result in a value more favorable to the claimant than a more in-depth modeling effort might produce. Furthermore, the use of maximum site-wide intakes for environmental dose lessens the likelihood of underprediction.

This ratio of plutonium air concentration to plutonium source emission rate, with units of years per cubic meter, was used to estimate air concentrations of all radionuclides at TAs for years for which ambient monitoring data were not available. The reason for not developing separate ratios for other radionuclides is that monitoring data tended to be more limited for most other radionuclides (with the exception of ^{3}H). The justification for applying the plutonium ratios to other radionuclides showed in the calculated ratios for other radionuclides when monitoring data were available. For ^{3}H, the average of 88 ratios of measured air concentration to source emission rate was 1.7×10^{-12} yr/m^3, with a maximum ratio of 3.8×10^{-11} yr/m^3. For uranium, the average of 13 ratios of measured air concentration to source emission rate was 2.3×10^{-12} yr/m^3, with a maximum ratio of 1.9×10^{-11} yr/m^3. The ratios for ^{3}H and uranium are very similar to those calculated for plutonium; therefore, the plutonium values can reasonably be applied for estimating air concentrations for all radionuclides of significance.

Tables C-1 to C-26 in Attachment C list estimated average air concentrations for selected TAs. Table C-27 lists estimated average air concentration by year because TA data was not produced. The selected TAs correspond to those for which either monitoring data were available or source emissions were listed in Tables A-1 through A-22. To summarize, when monitoring data were available, average air concentrations represent annual measured results from AIRNET monitoring stations (LANL 2003). In the absence of monitoring data, the tables list estimated air concentrations that correspond to the ratioing method that is described above, using the ratios developed for plutonium. Footnotes to the tables indicate when the ratioing method was applied.

In years before 1992, the monitoring data did not report concentrations of uranium in an isotope-specific manner. That is, the data reported concentrations as mass of uranium element per unit volume. In this case, the analysis made an assumption about the isotopic makeup of the uranium to convert to units of radioactivity. Assuming the mass concentration of uranium corresponds to the isotopic makeup of enriched uranium, which exhibits a higher specific activity than depleted or natural uranium due largely to the increase in the amount of ^{234}U present (DOE 2001), the activity concentration of uranium was maximized [9]. Assuming an isotopic ratio, in atom percent, of 0.02%:2.96%:97.02% for ^{234}U:^{235}U:^{238}U, the specific activity of enriched uranium (activity of uranium per mass) is 1.55×10^{-6} Ci/g. This specific activity was used to convert uranium mass concentration to activity concentration, and once this conversion is made, the approach is to assume all uranium activity is ^{234}U because the dose factor for ^{234}U is slightly higher than those for ^{235}U and ^{238}U. Thus, Tables C2-C5, C7-C17, C19-C25, and C-27, report all uranium activity as ^{234}U.

The air-monitoring data listed concentrations of plutonium isotopes separately for ^{238}Pu and ^{239}Pu. Rather than track the concentrations separately, there was a decision to add activities for both isotopes and report them as ^{239}Pu, which has a slightly higher dose coefficient. Thus, Tables C-1 through C-27 report all plutonium or alpha as ^{239}Pu.

Tables C-1 through C-27 sometimes list the MFP and P/VAP categories. MFPs include predominantly ^{90}Sr and ^{137}Cs. The P/VAP group includes $^{73,74}As$, $^{76,77r,82}Br$, ^{68}Ga, ^{68}Ge, $^{193,195m,197}Hg$, and ^{75}Se (LANL 2000). For simplicity, the entire intake from each category should be assumed to be composed solely of the radionuclide that results in the highest dose. Brackett (2010) ran comparisons for the radionuclides in the lists based on ICRP (1995) dose coefficients. For the MFP source term, the dose reconstructor should select ^{137}Cs for most organs and ^{90}Sr for the bone and red bone marrow. For the P/VAP category, either ^{68}Ge, Type M, or ^{75}Se, Type F, should be used based on which of the two results in the higher dose.

4.2.1.4 Estimation of Occupational Intakes

The following discussion addresses estimation of two different sets of occupational intakes: intakes from 1945 to 1970, for which air-monitoring data were not available in a consistent format (i.e., before formal annual environmental reports), and intakes from 1971 to the present, for which monitoring data became more consistently available.

4.2.1.4.1 Intakes, 1945 to 1970

As stated above, the period 1945 through 1970 is enveloped by the SEC period for the LANL, and it is not necessary to estimate environmental internal doses for the purpose of partial dose reconstruction during this period. Only partial dose reconstructions are possible in the pre-1976 time frame. Such partial dose reconstructions will include internal dose based only on internal dose monitoring data, in addition to external doses.

4.2.1.4.2 Intakes, 1971 to present

Using the average air concentrations from Tables C-1 to C-27 of Attachment C, this analysis estimated annual inhalation intakes in becquerels per year for each radionuclide and TA for years after 1970 by assuming a breathing rate of 2,400 m^3/yr based on an occupancy of 2,000 hr/yr. Tables 4-1 to 4-23 list the annual intakes for each TA by year, and Table 4-31 lists site-wide maximum intakes, which represent the yearly maximums of all averages across the LANL for each radionuclide.

Even from the post-1970 monitoring and emissions data, intake values for all radionuclides for every year were not available for many of the TAs. In cases where only a few years of data were missing for a given radionuclide, but the trend indicated that operations had probably not changed, this analysis made an estimate based on data in other years. The footnotes of Tables 4-1 through 4-23 indicate the basis for this type of estimate. If there was no clearly established trend, such estimates could not be made. Some of the gaps might exist because previous measurements indicated further yearly monitoring for a particular radionuclide was not warranted based on previous low-level measurements or estimates. Further, some TAs probably were not in operation at the time of the data gap.

Section 4.2.1.3 describes specific representative isotopes for the MFP and P/VAP groupings, which are listed in the footnotes of tables that contain these designations. To calculate doses for these groupings, dose reconstructors should use the dose factor for the specified representative radionuclide.

Information on solubility and particle sizes was not available for the radionuclides in Tables 4-1 to 4-23. Therefore, dose reconstructors should assume that all activity intakes are respirable and should make selections of solubility designations to maximize the dose to the organ of interest in the absence of relevant solubility data. An AMAD of 5 µm, consistent with ICRP 68 (ICRP 1995) default recommendations, should be assumed for environmental particulates because no site-specific information to the contrary has been identified.

4.2.2 Resuspension

Resuspension of radionuclides from contaminated soil has been a potential source of internal dose to workers at LANL since the beginning of operations. A work area in which radionuclide emissions took place is a potential area of exposure to resuspended radionuclides that were deposited on the soil. The radionuclide emissions in Tables A-1 through A-22 do not include contributions from resuspended soil. Resuspension is generally more important for recently contaminated soil than for soil with older contamination because erosion and downward migration of radionuclides from the upper soil layers diminish the source term over time. In Section 4.2.1, measured concentrations of radionuclides are the basis for the estimates of intake in the listed TAs; these estimates include resuspended radionuclides at those TAs.

In its early years of operation, LANL discharged liquid effluents from TA-1, TA-21, and TA-50 (formerly TA-35 and TA-45) to Acid, Pueblo, Los Alamos, and Mortandad Canyons. These canyon areas became contaminated with radionuclides. Due to the extent of soil contamination, these areas pose the greatest potential for significant historical intake from resuspension, particularly if recently contaminated soil was exposed to wind erosion or excavation activities. In addition, experiments with radioactive lanthanum in Bayo Canyon (TA-10) led to contamination of soil. The canyon areas are presently not part of work areas in any TA. LANL had decommissioned the TA-10 worksite by 1963, at which time it had cleaned up surface debris and excavated contaminated waste disposal facilities (LASL 1979). With the exception of TA-10, TA-21, and TA-50, TAs at LANL received minor contamination, if any (Kennedy and Purtymun 1971a). Nevertheless, if workers spent significant time in these canyons in areas where air-monitoring was not conducted, dose reconstructions should consider intakes and exposures from resuspension.

LANL has investigated resuspension in Acid, Pueblo, and Bayo Canyons (Ferenbaugh et al. 1982; LASL 1979). Table 4-25 lists estimated air concentrations of selected radionuclides in the canyons for conditions during the 1970s. For Mortandad and Los Alamos Canyons, information on soil contamination levels is available for estimation of resuspension (Purtymun, Stoker, and Peters 1980); this study indicated that plutonium isotopes, ^{137}Cs, and ^{90}Sr were found in soil during the 1970s at levels in excess of those that would be expected due to fallout. Estimates of air concentrations require the application of a resuspension factor to the measured levels. Assuming a resuspension factor of 1×10^{-9}/m (LASL 1979; Kennedy and Purtymun 1971b; Purtymun, Stoker, and Peters 1980), Table 4-25 lists estimated air concentrations for these areas.

4.3 EXTERNAL EXPOSURE

4.3.1 Ambient Radiation

More than 30 years of environmental monitoring reports (for example, LASL 1959, 1960) contain measured ambient gamma radiation levels. Figure 4-2 shows the network of thermoluminescent dosimeters (TLDs) currently in use at LANL for this purpose. Table 4-26 lists data for TA-3, TA-18, TA-53, and TA-54. TA-36 reported elevated exposures from experiments at TA-18 for several years. All of these areas recorded gamma doses above natural background (terrestrial and cosmic) radiation. Results are cumulative millirem per year based on 8,760 hours. A conversion factor is provided with Table 4-26 to convert these values to an annual dose based on 2,080 hours. The TLD results demonstrate the gamma-shine influence on other monitoring stations from the critical assembly experiments in TA-18. LANL environmental TLD data has a lognormal distribution. Site-wide maximum and geometric mean values are presented and are based on results from these four TAs. LANL annual reports present site background doses, and those are presented in Table 4-26. If no background is given, a 10-year average of reported site background is presented.

Individual TA data are available only for 1965 and after. However, periodic H-Division Progress Reports give sporadic monthly data from 1959. These reports indicate that initially 65 film badges were placed around the county and then, in September of 1959, approximately 25 stations were added. By 1965, 100 area badges were in use at LANL and in the Los Alamos area; attempts to locate these data have been unsuccessful. For partial dose reconstructions, data from 1965 and later have been determined to provide a sufficient basis for the estimation of on-site ambient doses. From 1965 through 1970, only site-wide maximum doses are available.

Eight H-Division Monthly Progress reports indicate an increase in environmental gamma dose at locations around the East Gate Laboratory in 1960 and 1961. This higher environmental dose was due to a 120-Ci ^{60}Co source in the laboratory. The highest recorded value was 6.6 R during the first three quarters of 1961 – the source was then removed (Courtwright, Dummer, and Taschner 1996). Reports from those years state that 100 area (film) badges were used in 1959 and 1960 and gave 1-year results of "less than 0.5 rem/yr" (LASL 1959, 1960). Reports indicate that elevated gamma levels occurred in the early years of TA-2 activities (ENSR 2002). No ‘typical’ external doses may be reliably inferred from these inconsistent reports, so on-site ambient doses are applied from the available data on the environmental dose measurements from 1965 onward.

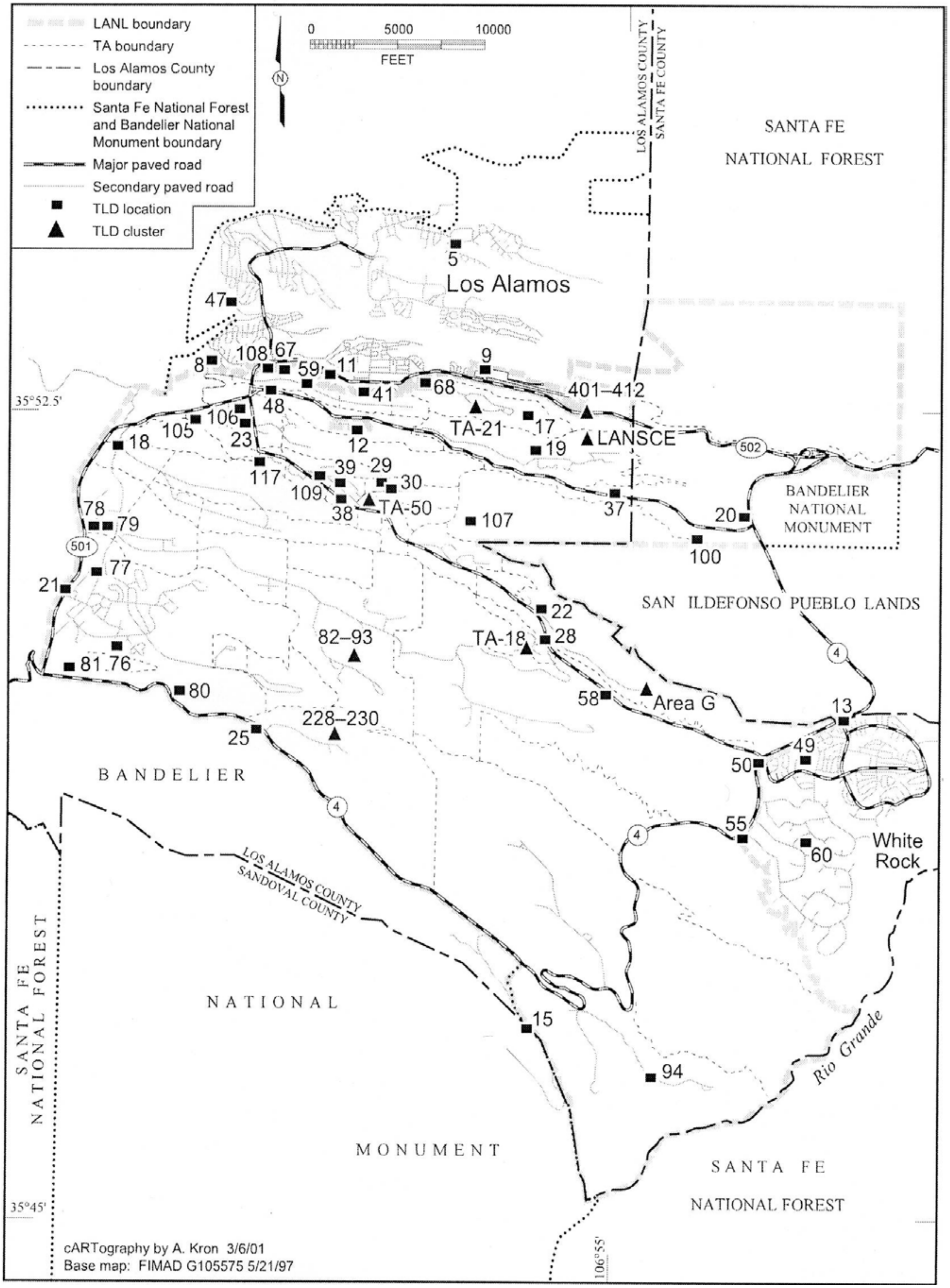

Figure 4-2. Offsite, perimeter, and onsite TLD locations (LANL 2002, p. 81).

A special survey found elevated ambient radiation in Acid Canyon, which LANL used from 1951 to 1964 for liquid waste discharge from TA-45. LANL remediated the contaminated parts of Acid Canyon in 1967. Radiation data from before that time were not available. Data that are available indicate that in 1978 two areas of the canyon still exhibited elevated gamma dose rates. The areas are characterized by steep cliffs and were not routine work locations. Nevertheless, if workers spent significant time in these areas, exposures are possible. The above-background dose rates LANL reported for 1978 were 1.1 μrem/hr on average with a maximum of 50 μrem/hr (Ferenbaugh et al. 1982). Before remediation in 1967, dose rates in the canyon could have been an order of magnitude higher.

The annual site-wide maximum ambient radiation dose rates are given in Table 4-31 along with the side-wide maximum intakes. These dose rates can be used if worker location during the period of employment is not accurately known.

Bayo Canyon Releases

Experiments from 1944 to 1962 in TA-10, Bayo Canyon, involved detonation of explosives around radioactive materials. These detonations dispersed materials, principally ^{140}La, to the atmosphere and could have caused exposure to LANL workers. LANL has studied the impacts of these experiments extensively (Courtwright, Dummer, and Taschner 1996). Although the focus was on impacts off the LANL site, that analysis examined a receptor at the town site (TA-0). These results are applicable to LANL workers in TA-0, TA-2, TA-21, TA-35, TA-41, TA-43, TA-48, TA-53, TA-60, and TA-61 to the extent that these TAs were occupied during the years of the tests.

Exposures are weighted by direction from TA-10. The prevailing wind direction is from Bayo Canyon to the west and north (that is, away from the Laboratory). On average, the wind carried ^{140}La to the east (TA-0) and to the southeast (TA-2, etc.) about 3% of the time, so no adjustment for wind frequency is necessary. The distance to the receptor at TA-0 is 2.9 km, which is less than distances to the other TAs. An adjustment for distance is not possible from the available information. Therefore, the LANL-calculated impacts for TA-0 apply to nearby TAs. More distant TAs would have impacts at least 1 order of magnitude smaller.

Table 4-27 lists calculated doses to the receptor at TA-0, TA-2, and vicinity for 1945 to 1960 (Kraig 1997). The dominant dose pathway would be exposure to gamma radiation from ^{140}La deposited on the ground. Other pathways such as inhalation and other radionuclides are much less important (Kraig 1997). In addition to dose, Table 4-27 lists the annual average depositions that were calculated from the available information.

4.3.2 Release of Noble Gases

TA-2 (nuclear reactor area) and TA-53 [Los Alamos Neutron Science Center (LANSCE) accelerator] have a history of noble gas releases. The following sections describe the estimation of external dose from these releases.

4.3.2.1 Omega Reactors TA-2

The Omega reactors in TA-2 were in operation from 1944 to 1992, and during that time they emitted predominantly noble gases. LANL did not routinely measure effluents from the Omega reactors [the Water Boiler Reactor in low- and high-power configurations (LOPO and HYPO), and Omega West] until 1967. After that time, LANL monitored ^{41}Ar emissions until the reactors ceased operation. In 1973, LANL reported ^{133}Xe and ^{135}Xe emissions, but it was at a combined rate less than that of ^{41}Ar. Because dose coefficients for xenon isotopes are 3 to 5 times less than that for ^{41}Ar, estimated doses for xenon isotopes are insignificant in relation to the ^{41}Ar doses.

Only ^{41}Ar is listed consistently in the source emissions for this TA. The annual average air concentrations of ^{41}Ar listed in Table C-28 of Attachment C for TA-2 were calculated using screening-level models from NCRP (1996). Because there was no mention of a stack in association with TA-2 in the early years, this analysis assumed that releases and receptors were at essentially the same height for all years.

To calculate average annual air concentrations using the emissions data in Table A-2, this analysis used the following model (NCRP 1996, p. 12):

$$\chi/Q = fB/u \text{ s/m}^3 \tag{4-2}$$

where:

- χ = concentration at receptor (Ci/m^3)
- Q = stack or building vent release rate (Ci/s)
- f = wind frequency
- B = Gaussian plume model diffusion factor modified for building wake effects (1/m^2)
- u = wind speed (m/s)

The value for the independent factor f corresponds to the default of 0.25 (the maximum frequency for any compass point) from NCRP (1996), and the site-specific value for u is 2.8 m/s (LANL 1994, 1999). The value for B of 2×10^{-4} is from Figure 2.3 in NCRP (1996) for a distance of 500 m. This is the average distance a receptor was assumed to be from the release point. This B value was the largest value for this receptor distance for any projected cross-sectional frontal area (A_G) of the building that influenced airflow. The resultant average χ/Q was 1.8×10^{-5} s/m^3.

The analysis calculated average annual doses from these concentrations by assuming an individual was exposed to this air concentration for 2,000 hr/yr. The analysis used dose coefficients for skin and whole body from the Federal Guidance Report No. 12 (Eckerman and Ryman 1993). The dose coefficient for skin is 3.74×10^{-6} mrem per µCi-s/m^3 (1.01×10^{-13} Sv per Bq-s/m^3) and for whole body is 2.41×10^{-6} mrem per µCi-s/m^3 (6.50×10^{-14} Sv per Bq-s/m^3). For pre-1967 years, exposures to noble gases in TA-2 could be estimated from area badge data (which has not been found at this time) or by assuming that the annual dose for 2,000-hr/yr exposure is the peak average annual dose in Table 4-26.

4.3.2.2 Los Alamos Neutron Science Center (TA-53)

The large, high-current accelerator at TA-53 began operation in 1976. Since then, this facility released megacurie quantities of activation products annually through the exhaust stack. In addition to ^{41}Ar, the accelerator stack released significant activities of ^{11}C, ^{13}N, and ^{15}O. While not noble gases, these three nuclides have extremely short half-lives and cause radiation exposure more like noble gases than long-lived particulates. Therefore, this discussion considers emissions for all these radionuclides.

After 1981, emissions were often reported as gaseous/mixed activation products (G/MAPs) without differentiating the radionuclides in that category. Submersion dose coefficients for the four radionuclides (^{11}C, ^{13}N, ^{15}O, and ^{41}Ar) are less than or equal to the skin dose factor for ^{15}O (1.04×10^{-13} Sv/Bq or 3.85×10^{-6} mrem/µCi) or the whole-body dose factor for ^{41}Ar (6.50×10^{-14} Sv/Bq or 2.41×10^{-6} mrem/µCi) according to Federal Guidance Report No. 11 (Eckerman, Wolbarst, and Richardson 1988). Therefore, this analysis simplified the calculations by assuming that the composite emissions activity for all four radionuclides was equal to that for ^{15}O alone for skin dose, and to that for ^{41}Ar alone for whole-body dose.

To estimate air concentrations from the LANSCE stack, the analysis considered three work locations: TA-53, TA-21, and TA-72. TA-53 was the location where the accelerator operated. The two nearby locations were the east end of TA-21 (DP East; 2,000 m south-southeast of TA-53) and the west end of TA-72 (on East Jemez Road; 700 m south-southeast of TA-53). An average wind rose for each of five meteorological stations at LANL, which are discussed in the 1999 Site-Wide Environmental Impact Statement for LANL (DOE 1999), indicates that the predominant wind directions from TA-53 are to the north and northeast (Figure 4-3).

For TA-53, this analysis used the same approach that was adopted for TA-2 to estimate average air concentrations. Again, this assumed no stack release and resulted in an average χ/Q of 1.8×10^{-5} s/m^3 (receptor 500 m from the emission point).

Bowen (1987) modeled dispersion from the LANSCE stack using Gaussian equations. However, the calculations were for a receptor at the site boundary (East Gate) rather than for onsite work locations. The East Gate is approximately 800 m east of TA-53. The dispersion factor from this modeling effort was adjusted for this work to apply to TA-21 and TA-72 to develop average annual concentrations. The adjustment was based on distances from TA-53, and differential wind frequencies were ignored. Wind frequencies toward both TA-21 and TA-72, as measured at the East Gate, are 3%, which is consistent with Figure 4-3. The wind frequency toward the public receptor is 13%. Therefore, the assumption that wind frequency is 13% (i.e., not adjusting the dispersion factor based on wind frequencies) is an approach more favorable to the claimant.

The calculated χ/Q for the East Gate receptor (800 m from TA-53) was 3.8×10^{-6} s/m^3 (Bowen 1987). Because TA-72 is approximately the same distance (700 m) from TA-53 as the East Gate, this χ/Q was used to estimate average annual air concentrations at this location. This value of χ/Q was adjusted to account for the increased distance of TA-21 from TA-53 (2,000 m) by multiplying the χ/Q for the East Gate by a factor of one-third. The factor of one-third was derived by comparing the Gaussian plume model diffusion factor P in NCRP (1996, Figure 2.2) for a 30-m stack and the two different distances (800 m and 2,000 m). The resultant estimate of χ/Q is approximately 1.3×10^{-6} s/m^3. This information is summarized below.

Receptor	Distance/direction from TA-53	Average *X*/*Q* (s/m^3)
East Gate	800m/East	3.8 E-06
TA-21	2,000m/SSE	1.3 E-06
TA-72	700m/SSE	3.8 E-06

Table C-29 of Attachment C lists the results of these calculations for TA-53, TA-21, and TA-72.

This analysis calculated estimates of external dose (skin and whole body) from LANSCE emissions for TA-53, TA-21, and TA-72. The estimated doses in Tables 4-29 and 4-30 are based on average annual air concentrations in TA-53, TA-21, and TA-72 from Table C-29. The concentrations at TA-53 assumed a ground-level release. Therefore, the air concentration estimates for TA-53 account for the fact that a percentage of the emissions from that location was diffuse, rather than from the 30-m stack.

4.4 UNCERTAINTY

As discussed in previous sections, estimates of annual intakes employed conservative assumptions when information was lacking. Due to the lack of information on particle size and solubility, this analysis compensated for the uncertainty of these elements by assuming that all effluents were in the respirable size range and by selecting solubility based on the highest dose rate.

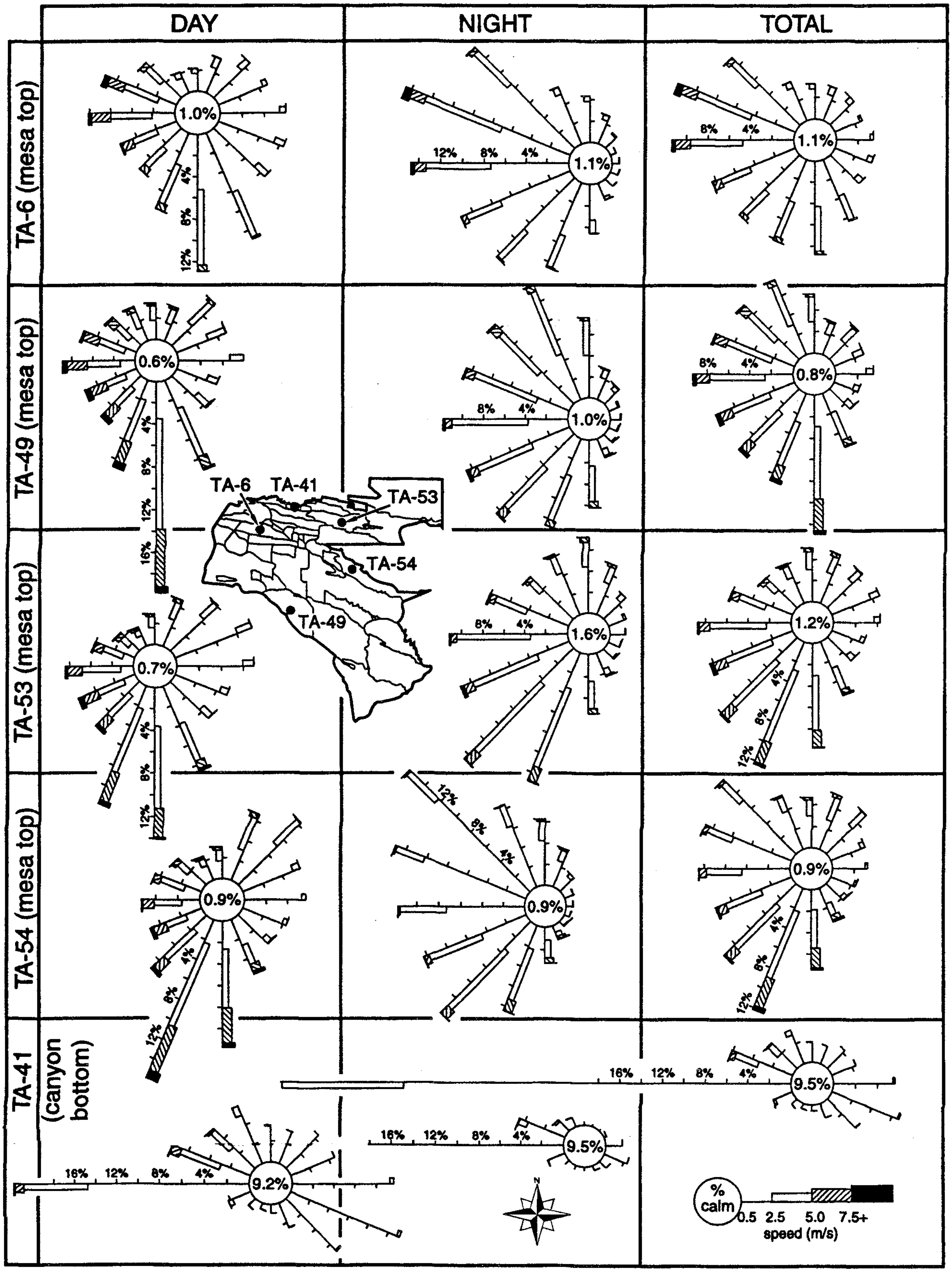

Figure 4-3. Average wind rose for five meteorological stations (DOE 1999).

Effluent data for 1971 and later have an estimated uncertainty of ±20%. Data from earlier years are much less accurate because of less reliable measurement technology and less stringent reporting requirements. As stated elsewhere, the pre-1971 period is included in the SEC period for the LANL and it is not necessary to estimate environmental internal doses for the purpose of partial dose reconstruction in the early years.

The accuracy of the area badge data is also about ±20%. However, subtraction of background from these measurements adds more uncertainty because of the variability and selection of background information.

Table 4-1. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-2 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971			3.1E-04[c]	3.5E-03[c]
1972			3.1E-04[c]	3.5E-03[c]
1973			3.1E-04[c]	3.5E-03[c]
1974			3.1E-04[c]	3.5E-03[c]
1975			3.1E-04[c]	3.5E-03[c]
1976			3.1E-04[c]	3.5E-03[c]
1977			3.1E-04[c]	3.5E-03[c]
1978			3.1E-04[c]	3.5E-03[c]
1979			3.1E-04[c]	3.5E-03[c]
1980			3.1E-04[c]	3.5E-03[c]
1981			3.1E-04[c]	3.5E-03[c]
1982			3.1E-04[c]	3.5E-03[c]
1983			3.1E-04[c]	3.5E-03[c]
1984			3.1E-04[c]	3.5E-03[c]
1985			3.1E-04[c]	3.5E-03[c]
1986			3.1E-04[c]	3.5E-03[c]
1987		3.6E+03	8.9E-05	4.7E-03
1988		1.0E+04	2.0E-03	6.3E-03
1989		3.0E+03	2.0E-04	8.9E-03
1990		1.5E+03	1.2E-04	3.2E-03
1991		6.9E+02	4.4E-05	6.6E-03
1992		5.7E+02	1.3E-04	3.3E-03
1993		3.3E+02	5.7E-04	2.4E-03
1994		5.6E+02	2.8E-04	1.5E-03
1995	4.6E-04	4.5E+02	5.5E-04	3.7E-03
1996		5.2E+02[c]	3.1E-04[c]	3.5E-03[c]
1997		5.2E+02[c]	3.1E-04[c]	3.5E-03[c]
1998		5.2E+02[c]	3.1E-04[c]	3.5E-03[c]
1999		5.2E+02[c]	3.1E-04[c]	3.5E-03[c]
2000	0.0E+00	2.4E+02	1.3E-04	1.6E-03
2001		2.4E+02[d]	1.3E-04[d]	1.6E-03[d]
2002		2.4E+02[d]	1.3E-04[d]	1.6E-03[d]
2003		2.4E+02[d]	1.3E-04[d]	1.6E-03[d]

a. Calculated from estimated air concentrations in Table C-2, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of values from 1991 to 1995.
d. Assumed to be the same as value in 2000.

Table 4-2. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{232}Th, ^{234}U, MFP, and P/VAP for TA-3 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	Th-232	U-234	MFP[c]	P/VAP[d]
1971		2.7E+04	2.5E-02		2.3E-02		
1972	2.8E-03	4.4E+03	1.2E-02		6.9E-03		
1973	6.2E-04	4.7E+03	1.2E-02	3.0E-03	1.4E-02	2.5E+00	
1974			2.9E-01		3.9E-02	6.7E-02	
1975		6.4E+03	8.2E-02		3.8E-02	3.6E-02	
1976			7.7E-03		7.1E-02	8.1E-02	
1977		1.2E+05	6.5E-03		6.6E-02	9.4E-02	
1978		2.9E+04	1.1E-02		3.6E-02	7.9E-02	
1979		8.8E+05	2.1E-01		5.1E-02	9.2E-02	
1980		1.3E+03	1.4E-01		3.0E-02	8.3E-02	
1981		2.6E+05	7.7E-03		4.6E-02	3.4E-02	
1982		5.7E+05	1.5E-02		6.3E-02	1.5E-02	
1983		6.7E+05	1.7E-02		3.5E-02	3.3E-03	
1984		5.2E+05	2.2E-02		4.2E-02	8.1E-03	
1985		6.2E+05	3.8E-02		6.7E-02	6.8E-03	
1986		3.6E+05	3.8E-02		1.2E-01	9.4E-03	
1987		2.5E+05	1.3E-02		1.7E-01	4.2E-03	
1988		2.4E+06	1.0E-02		9.8E-02	5.8E-03	
1989		8.5E+04	7.6E-03		7.1E-02	7.5E-03	
1990		1.5E+05	4.2E-03		3.8E-02	7.6E-03	
1991	1.3E-04	2.0E+03	1.1E-04		8.2E-03	2.8E-03	
1992	2.8E-04	3.6E+03	2.2E-04		3.2E-03	1.6E-03	
1993	1.7E-03	7.1E+02	4.9E-03		1.3E-03	1.2E-03	
1994	5.2E-04	2.7E+02	2.8E-04		3.3E-03	7.5E-03	
1995	1.3E-03	8.0E+02	2.6E-04		1.8E-03	1.8E-01	4.4E+02
1996	1.3E-04	1.7E+02	2.4E-04	3.2E-05	2.1E-03		
1997	2.2E-04	4.8E+02	2.4E-04	7.4E-05	1.5E-03		
1998	3.1E-04	3.6E+02	3.6E-05	8.2E-05	1.3E-03		3.1E+00
1999	2.0E-04	3.6E+02	2.4E-04	4.3E-05	1.7E-03		
2000	0.0E+00	3.2E+02	2.3E-04	2.5E-05	2.7E-03		
2001	0.0E+00	4.1E+02	5.3E-05	2.7E-05	2.4E-03		
2002	1.5E-04[e]	3.4E+02	1.6E-04	5.0E-05	1.9E-03		
2003	1.5E-04[e]	3.9E+02	1.6E-04	5.0E-05	1.9E-03		

a. Calculated from estimated air concentrations in Table C-3, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. It is favorable to the claimant to assume all is ^{90}Sr.
d. It is favorable to the claimant to assume all is ^{68}Ge, Type M.
e. Estimated from average of corresponding values for 1997 to 2001.

Table 4-3. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-5 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971				
1972				
1973		1.4E+04	1.7E-03	4.1E-02
1974		1.1E+04	2.2E-03	1.4E-02
1975		2.3E+04	1.9E-03	9.9E-03
1976		1.6E+04	4.4E-04	8.4E-03
1977		7.6E+03	1.9E-03	1.1E-02
1978		2.1E+03	2.6E-03	8.4E-03
1979		2.0E+03	7.5E-04	1.1E-02
1980		2.3E+03	8.9E-05	7.7E-03
1981		5.9E+02	5.4E-04	5.8E-03
1982		3.3E+03	1.3E-04	5.8E-03
1983		2.3E+03	2.8E-04	6.6E-03
1984		2.4E+03	1.2E-04	5.1E-03
1985		1.7E+03	0.0E+00	4.5E-03
1986		1.3E+03	8.9E-05	3.7E-03
1987		2.6E+03	1.8E-05	5.4E-03
1988		2.0E+03	1.8E-05	9.7E-03
1989		4.7E+02	3.6E-05	1.1E-02
1990		4.3E+02	1.6E-04	4.4E-03
1991		4.9E+02	6.2E-05	7.6E-03
1992	1.2E-04	5.9E+02	7.1E-05	3.0E-03
1993		3.5E+02	1.3E-04	3.1E-03
1994		2.0E+02	1.1E-04	3.1E-03
1995	3.0E-04	3.2E+02	3.9E-04	4.2E-03
1996	2.2E-04	1.5E+02	1.1E-04	5.0E-03
1997	2.1E-04	7.3E+02	4.4E-05	2.2E-03
1998	1.8E-04	4.4E+03	8.9E-05	2.1E-03
1999	3.2E-04	2.9E+02	1.8E-05	1.9E-03
2000	2.7E-05	3.6E+02	1.8E-04	4.8E-03
2001	0.0E+00	5.6E+02	0.0E+00	3.0E-03
2002	1.5E-04[c]	1.3E+03[c]	6.6E-05[c]	2.8E-03[c]
2003	1.5E-04[c]	1.3E+03[c]	6.6E-05[c]	2.8E-03[c]

a. Calculated from estimated air concentrations in Table C-4, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7 × 10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1997 to 2001.

Table 4-4. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-6 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		4.8E+03	3.6E-03	3.3E-02
1972		3.9E+03	1.3E-02	8.3E-03
1973				
1974		2.1E+03	2.3E-03	6.9E-03
1975	9.8E-04	2.9E+03	4.8E-03	3.7E-03
1976		3.3E+03	3.5E-04	8.1E-03
1977	2.7E-05	3.3E+03	1.5E-03	2.3E-02
1978	2.7E-05	6.7E+02	2.4E-03	9.9E-03
1979	0.0E+00	3.7E+02	2.9E-04	4.5E-03
1980	8.9E-06	5.1E+02	2.3E-04	3.9E-03
1981	4.0E-03	8.9E+02	5.1E-04	4.4E-03
1982	1.8E-05	1.5E+03	1.1E-04	4.3E-03
1983		1.5E+03	1.1E-04	4.7E-03
1984		5.9E+02	1.1E-04	2.8E-03
1985		1.1E+03	1.7E-04	5.3E-03
1986	2.8E-04	4.8E+02	1.1E-04	5.1E-03
1987	1.3E-04	1.5E+03	5.3E-05	5.5E-03
1988	5.7E-04	1.3E+03	6.2E-05	7.2E-03
1989	2.5E-04	3.1E+02	4.1E-04	9.0E-03
1990	1.4E-04	1.9E+02	1.9E-04	6.4E-03
1991	8.0E-05	2.1E+02	8.9E-05	7.4E-03
1992	4.0E-04	3.6E+02	1.5E-04	2.4E-03
1993	1.3E-04	4.4E+02	2.0E-04	2.0E-03
1994	3.6E-04	1.7E+02	7.1E-05	2.5E-03
1995	5.1E-04	4.8E+02	1.1E-03	1.8E-03
1996		0.0E+00		
1997–2003				

a. Calculated from estimated air concentrations in Table C-5 assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.

Table 4-5. Estimated annual average intakes of ^{3}H for TA-9 (Bq/yr).[a]

Year	H-3[b]
1971	
1972	2.1E+05
1973	1.1E+04
1974	3.8E+02
1975	
1976	3.8E+04
1977	7.6E+03
1978	7.6E+02
1979	1.5E+03
1980	1.5E+03
1981–2003	

a. Calculated from estimated air concentrations in Table C-6 assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.

Table 4-6. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-11 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		5.6E+03	4.2E-03	1.2E-02
1972	2.9E-03	3.2E+03	4.3E-03	8.3E-03
1973		1.7E+03	2.0E-03	1.4E-02
1974–2003				

a. Calculated from estimated air concentrations in Table C-8 assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7 × 10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.

Table 4-7. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-15 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		1.1E+04	3.7E-03	6.2E-02
1972	2.0E-03	3.7E+03	4.5E-03	8.3E-03
1973	1.8E-04	2.8E+03	1.4E-03	2.8E-02
1974–1977				
1978		2.1E+04		
1979–1991				
1992				4.5E-01
1993		1.4E+02		9.7E-01
1994		2.6E+02	3.6E-05	5.9E-03
1995	4.5E-04	2.3E+02	3.3E-04	1.3E-03
1996	2.0E-04	1.5E+02	1.2E-04	4.6E-03
1997	1.7E-04	2.5E+02	5.8E-05	2.6E-03
1998	1.9E-04	2.7E+02	7.1E-05	1.3E-03
1999	2.0E-04	2.3E+02	7.1E-05	1.7E-03
2000	3.6E-05	2.4E+02	4.4E-06	2.4E-03
2001	2.2E-04	3.1E+02	0.0E+00	5.8E-03
2002	1.8E-06	3.7E+02	0.0E+00	3.4E-03
2003	1.3E-04[c]	2.8E+02[c]	2.9E-05[c]	2.9E-03[c]

a. Calculated from estimated air concentrations in Table C-9, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7 × 10^{-2} Bq/pCi; blanks indicate no data are available for those years).
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1998 to 2002.

Table 4-8. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-16 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		6.0E+03	5.4E-03	2.8E-02
1972	3.6E-03	4.1E+03	5.1E-03	8.3E-03
1973	2.7E-04	2.1E+03	2.5E-03	1.4E-02
1974		1.6E+03	2.7E-03	9.6E-03
1975	3.6E-04	2.4E+03	1.7E-03	3.6E-03
1976		2.7E+03	4.2E-04	4.8E-03
1977	0.0E+00	4.0E+03	1.7E-03	3.8E-02
1978	0.0E+00	8.0E+02	3.2E-03	6.6E-03
1979	0.0E+00	2.9E+02	1.8E-03	3.6E-03
1980	0.0E+00	1.5E+03	9.8E-05	4.1E-03
1981	1.7E-04	2.5E+02	3.2E-04	3.2E-03
1982	2.7E-05	1.3E+03	8.9E-05	3.2E-03
1983		1.5E+03	4.9E-05	3.2E-03
1984		1.7E+03	0.0E+00	1.8E-03
1985		1.3E+03	3.5E-04	3.8E-03
1986	2.4E-04	6.3E+02	5.3E-05	1.8E-03
1987	8.9E-05	1.3E+03	6.7E-05	2.6E-03
1988	1.7E-04	5.7E+02	7.5E-05	4.7E-03
1989	2.1E-04	3.5E+02	5.3E-05	8.1E-03
1990	2.5E-04	1.5E+02	1.4E-04	4.6E-03
1991	1.1E-04	6.7E+01	8.9E-05	5.4E-03
1992	9.8E-05	2.1E+02	5.3E-04	2.5E-03
1993		1.2E+02	4.4E-05	1.7E-03
1994		1.2E+03	0.0E+00	2.3E-03
1995	4.1E-04	2.4E+04	2.9E-04	1.7E-03
1996	1.6E-04	3.2E+03	3.6E-05	2.4E-03
1997	2.0E-04	8.3E+03	7.1E-05	1.7E-03
1998	2.3E-04	3.3E+04	8.0E-05	2.6E-03
1999	2.8E-04	7.3E+03	1.1E-04	1.3E-03
2000	0.0E+00	8.1E+03	0.0E+00	1.3E-03
2001	1.8E-05	9.1E+03	0.0E+00	1.7E-03
2002	1.5E-04[c]	1.3E+04[c]	5.2E-05[c]	1.7E-03[c]
2003	1.5E-04[c]	1.3E+04[c]	5.2E-05[c]	1.7E-03[c]

a. Calculated from estimated air concentrations in Table C-10, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7 × 10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1997 to 2001.

Table 4-9. Estimated annual average intakes of ^{234}U for TA-18 (pCi/yr).[a]

Year	U-234
1971–1978	
1979	7.7E-04
1980–2003	

a. Calculated from estimated air concentrations in Table C-11, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7 × 10^{-2} Bq/pCi; blanks indicate no data are available for those years).

Table 4-10. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{234}U, and MFP for TA-21 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234	MFP[c]
1971	5.7E-04[d]	1.1E+04	2.6E-03	1.1E-02	
1972	5.7E-04[d]	2.0E+04[e]	7.5E-03	9.6E-03	
1973	5.7E-04[d]	2.0E+04	2.0E-03	1.4E-02	2.0E-04
1974	5.7E-04[d]	2.0E+04[e]	2.1E-03	6.9E-03	5.7E-04
1975	5.7E-04[d]	8.5E+03	1.6E-03	4.3E-03	2.8E-04
1976	5.7E-04[d]	5.3E+03	6.7E-04	5.8E-03	1.1E-04
1977	5.7E-04[d]	6.9E+03	1.9E-03	1.3E-02	6.4E-04
1978	6.6E-06	6.9E+03[e]	2.0E-03	1.3E-02	2.0E-04
1979	3.7E-06	5.1E+02	5.4E-04	1.1E-02	9.1E-05
1980	1.2E-05	1.5E+03	2.8E-03	9.9E-03	8.2E-04
1981	5.7E-06	7.5E+02	4.1E-04	5.0E-03	5.5E-04
1982	6.8E-06	2.1E+03	5.3E-04	1.3E-02	8.5E-05
1983	1.9E-05	2.7E+03	8.0E-05	4.3E-03	1.6E-04
1984	5.7E-04[d]	1.2E+03	1.3E-04	8.9E-03	6.1E-05
1985	5.7E-04[d]	2.1E+03	3.6E-05	5.8E-03	7.1E-05
1986	5.7E-04[d]	2.2E+03	1.2E-04	4.8E-03	6.3E-05
1987	5.7E-04[d]	6.9E+03	9.8E-05	4.8E-03	3.7E-05
1988	5.7E-04[d]	5.3E+03	7.1E-05	7.2E-03	3.0E-05
1989	5.7E-04[d]	2.2E+03	1.2E-04	1.1E-02	6.1E-06
1990	5.7E-04[d]	1.7E+03	2.0E-04	6.7E-03	2.5E-06
1991	0.0E+00	1.1E+03	1.7E-04	7.5E-03	5.9E-06
1992	2.4E-04	1.2E+03	2.2E-04	3.3E-03	4.7E-06
1993	3.2E-04	5.6E+02	4.4E-04	2.4E-03	2.0E-06
1994	5.7E-04	4.5E+02	5.9E-04	2.5E-03	9.8E-06
1995	5.5E-04	1.1E+03	1.1E-03	2.8E-03	
1996	3.7E-04	4.1E+02	1.5E-03	2.2E-02	
1997	3.8E-04	6.3E+02	1.5E-03	1.9E-03	
1998	5.0E-04	1.5E+03	2.3E-03	1.4E-03	
1999	2.6E-04	8.2E+02	3.1E-04	1.9E-03	
2000	8.3E-05	9.7E+02	3.3E-04	1.8E-03	
2001	0.0E+00	9.6E+02	3.3E-04	2.3E-03	
2002	2.4E-04[f]	9.8E+02[f]	9.5E-04[f]	1.9E-03[f]	
2003	2.4E-04[f]	9.8E+02[f]	9.5E-04[f]	1.9E-03[f]	

a. Calculated from estimated air concentrations in Table C-12, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. MFP = mixed fission products; favorable to the claimant to assume all is ^{90}Sr.
d. Assumed to be the highest value of all years for which data are available.
e. Assumed to be the highest value of the two adjacent years.
f. Estimated from average of corresponding values for 1997 to 2001.

Table 4-11. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-33 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		6.6E+04	7.4E-03	1.1E-02
1972		2.4E+04	4.9E-03	1.2E-02
1973		8.0E+03	1.5E-03	2.8E-02
1974		1.9E+04	2.5E-03	9.6E-03
1975		2.1E+04	2.0E-03	3.4E-03
1976		7.9E+03	4.7E-04	5.6E-03
1977		1.1E+03	1.6E-03	1.1E-02
1978		3.3E+03	2.5E-03	8.4E-03
1979		5.3E+03	6.1E-04	5.4E-03
1980		5.9E+03	3.1E-04	6.2E-03
1981		4.0E+03	3.5E-04	5.0E-03
1982		1.2E+04	2.1E-04	5.1E-03
1983		4.8E+03	0.0E+00	2.9E-03
1984		7.5E+03	6.2E-04	2.5E-03
1985		1.4E+04	0.0E+00	2.7E-03
1986		4.2E+03	5.3E-05	2.0E-03
1987		2.6E+03	7.1E-05	4.5E-03
1988		7.7E+03	3.6E-05	1.3E-02
1989		2.4E+03	0.0E+00	7.3E-03
1990		1.1E+03	6.5E-04	7.7E-03
1991		4.3E+02	6.2E-05	1.7E-03
1992		4.9E+02	8.0E-05	1.3E-03
1993		4.0E+02	1.6E-04	1.4E-03
1994		2.4E+02	4.4E-05	1.3E-03
1995	3.5E-04	4.7E+02	1.4E-03	1.5E-03
1996	3.5E-04[c]	1.9E+02	1.4E-03[c]	1.5E-03[c]
1997	2.8E-04	1.2E+02	1.2E-04	1.2E-03
1998	2.1E-04	1.7E+02	1.2E-04	1.4E-03
1999	2.2E-04	5.3E+02	1.1E-04	1.8E-03
2000	0.0E+00	4.5E+02	1.8E-05	9.9E-04
2001		4.4E+02	0.0E+00	1.3E-03
2002		3.4E+02[d]	7.5E-05[d]	1.3E-03[d]
2003		3.4E+02[d]	7.5E-05[d]	1.3E-03[d]

a. Calculated from estimated air concentrations in Table C-13, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Assumed to be the highest value of the two adjacent years.
d. Estimated from average of corresponding values for 1997 to 2001.

Table 4-12. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{234}U, MFP, and P/VAP for TA-35 (Bq /yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234	MFP[c]	P/VAP[d]
1971		9.2E+05	1.4E-03			
1972		7.3E+05	3.5E-03			
1973		3.6E+05	4.6E-04			
1974		4.1E+05	1.6E-03			
1975		7.0E+05	1.2E-03			
1976		4.9E+05	4.6E-04			
1977		2.3E+05	1.6E-04			
1978		2.0E+05	3.8E-04			
1979		3.8E+05	1.4E-03			
1980		7.3E+03	4.0E-05			
1981		9.2E+05[e]	5.2E-05			
1982		9.2E+05[e]	2.5E-04			
1983		1.8E+03	1.8E-04			
1984		6.0E+04	8.1E-05			
1985		1.5E+03	1.1E-04			
1986		1.4E+04	7.1E-05			
1987		4.5E+04	1.2E-04			
1988		3.5E+04	3.4E-05			
1989		5.3E+03	1.3E-04			
1990		1.2E+01	1.7E-04			
1991		1.3E-03	2.4E-04			
1992		2.9E+01	7.0E-05			
1993			5.3E-05			
1994			7.6E-05			
1995	6.9E-06		5.8E-05	1.4E-04	3.2E-04	3.2E-04
1996–2003						

a. Calculated from estimated air concentrations in Table C-14, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. It is favorable to the claimant to assume all is ^{90}Sr.
d. It is favorable to the claimant to assume all is ^{68}Ge, Type M.
e. Assume highest average value for ^{3}H in 1981 and 1982; there are no source terms or environmental data readily available.

Table 4-13. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-36 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		5.1E+03	2.4E-03	7.8E-02
1972		3.9E+03	5.1E-03	8.3E-03
1973		3.9E+03	2.0E-03	1.4E-02
1974–1992				
1993		1.5E+02		
1994		1.7E+02	1.0E-03	6.2E-03
1995	4.1E-04	4.9E+02	1.0E-03	8.0E-03
1996	1.3E-04	1.5E+02	7.1E-05	4.3E-03
1997	1.8E-04	1.8E+02	5.8E-05	3.4E-03
1998	1.9E-04	2.4E+02	2.2E-05	3.1E-03
1999	3.2E-04	2.3E+02	4.0E-05	3.1E-03
2000	4.4E-05	2.1E+02	1.3E-05	2.9E-03
2001	0.0E+00	3.3E+02	0.0E+00	1.4E-02
2002	1.8E-06	3.7E+02	0.0E+00	3.4E-03
2003	1.1E-04[c]	2.8E+02[c]	1.5E-05[c]	5.2E-03[c]

a. Calculated from estimated air concentrations in Table C-15, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1998 to 2002.

Table 4-14. Estimated annual average intakes of ^{3}H, ^{239}Pu, and ^{234}U for TA-39 (Bq/yr).[a]

Year	H-3[b]	Pu-239	U-234
1971			1.7E+01
1972			2.1E+01
1973–1976			
1977	5.2E+03	8.9E-06	1.1E-02
1978	2.0E+03	3.1E-03	1.1E-02
1979	2.1E+03	3.3E-04	3.6E-03
1980	3.7E+03	3.9E-04	6.5E-03
1981	1.6E+03	1.8E-04	4.3E-03
1982	2.0E+04	2.4E-04	7.4E-03
1983	4.1E+03	1.6E-04	1.4E-03
1984	1.9E+03	0.0E+00	3.2E-03
1985	5.5E+03	0.0E+00	4.6E-03
1986	3.3E+03	1.3E-04	2.7E-03
1987–2003			

a. Calculated from estimated air concentrations in Table C-16, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.

Table 4-15. Estimated annual average intakes of ^{3}H, ^{239}Pu, and ^{234}U for TA-41 (Bq/yr).[a]

Year	H-3[b]	Pu-239	U-234
1971	9.4E+04	3.7E-03	
1972	3.2E+04	2.1E-03	
1973	1.7E+04	3.0E-04	
1974–1978			
1979	4.2E+04		
1980	1.2E+05		
1981	3.7E+04		
1982	3.8E+04		
1983	2.9E+05		
1984	1.4E+06		
1985	3.7E+05		
1986	3.9E+05		
1987	1.4E+05		
1988	5.1E+05		
1989	3.4E+06		
1990	1.3E+06		
1991	1.1E+06		
1992	8.6E+04		
1993	1.4E+05	2.0E-06	
1994	5.0E+04	3.9E-06	
1995	2.3E+04	3.0E-06	1.8E-06
1996	3.2E+04		
1997	1.2E+04		
1998	1.1E+04		
1999	3.8E+03		
2000	1.8E+03		
2001	1.6E+05		
2002	3.7E+04[c]		
2003	3.7E+04[c]		

a. Calculated from estimated air concentrations in Table C-17, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1997 to 2001.

Table 4-16. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-43 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971		5.7E+03	9.8E-03	1.9E-02
1972		3.7E+03	8.9E-03	8.3E-03
1973		1.9E+03	4.6E-03	1.4E-02
1974			1.3E-03	
1975			3.2E-04	
1976			1.5E-03	
1977			9.1E-04	
1978			3.0E-04	
1979			1.5E-04	
1980			3.6E-05	
1981			7.2E-05	
1982			2.7E-04	
1983			6.5E-04	
1984			2.1E-04	
1985			3.5E-04	
1986			5.7E-04	
1987			9.9E-05	
1988			2.9E-04	
1989–1994				
1995	5.3E-05		1.0E-04	2.2E-04
1996–2003				

a. Calculated from estimated air concentrations in Table C-19, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.

Table 4-17. Estimated annual average intakes of ^{234}U for TA-46 (Bq/yr).[a]

Year	U-234
1971	7.8E-04
1972	2.3E-02
1973	4.2E-04
1974	8.0E-05
1975	1.0E-04
1976	6.1E-05
1977	7.8E-07
1978	4.9E-03
1979	4.4E-04
1980	2.9E-04
1981	2.7E-03
1982	4.0E-04
1983	7.0E-06
1984	1.0E-05
1985	5.5E-06
1986	7.8E-07
1987–2003	

a. Calculated from estimated air concentrations in Table C-20, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.

Table 4-18. Estimated annual average intakes of ^{241}Am, ^{239}Pu, ^{234}U, MFP, and P/VAP for TA-48 (Bq/yr).[a]

Year	Am-241	Pu-239	U-234	MFP[b]	P/VAP[c]
1971		3.7E-03			
1972		2.2E-02	1.6E-03		
1973		3.9E-03	3.8E-04	2.0E-01	
1974		4.7E-03	2.5E-04	1.8E-01	
1975		2.4E-03	6.7E-04	1.4E-01	
1976		9.8E-04	2.2E-02	2.4E-01	
1977		1.6E-03	1.1E-02	4.3E-01	
1978		3.7E-04	2.2E-03	2.3E-01	
1979		6.6E-05	2.1E-03	2.1E-01	
1980		3.1E-04	1.3E-04	3.4E-01	
1981		2.6E-04	4.5E-04	2.7E-01	
1982		1.9E-03	1.4E-03	2.1E-01	
1983		6.4E-04	1.0E-04	1.6E-01	
1984		5.0E-04	2.6E-04	3.1E-01	
1985		4.0E-04	3.7E-04	2.4E-01	
1986		5.6E-04	1.2E-04	4.9E-01	
1987		1.2E-04	3.1E-04	2.4E-01	
1988		1.4E-04	4.3E-05	2.2E-01	
1989		2.9E-04	5.3E-05	8.5E+01	
1990		2.9E-04	3.3E-05	2.0E-01	
1991		1.1E-04		2.1E-01	2.0E+01
1992		1.3E-03	8.1E-05	5.4E-01	7.4E+00
1993		6.2E-04	2.8E-04	2.6E-01	1.5E+01
1994		6.3E-04	7.8E-05	7.6E-02	1.6E+01
1995	3.3E-04	6.1E-04	1.0E-04	5.2E+00	5.2E+00
1996	9.8E-07	2.1E-06			2.0E-02
1997	7.0E-08	4.9E-07	2.7E-05		3.5E-01
1998	7.2E-08				2.1E-02
1999			1.2E-07		7.6E-01
2000					3.3E+00
2001					4.5E-01
2002					9.8E-01[d]
2003					9.8E-01[d]

a. Calculated from estimated air concentrations in Table C-21, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. It is favorable to the claimant to assume all is ^{90}Sr.
c. It is favorable to the claimant to assume all is ^{68}Ge, Type M.
d. Estimated from average of corresponding values for 1997 to 2001.

Table 4-19. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-49 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971	5.9E-04[c]	2.0E+04	7.4E-03	3.3E-02
1972	5.9E-04[c]	2.8E+03	6.7E-03	1.7E-02
1973	5.9E-04[c]	4.3E+03	1.7E-03	1.4E-02
1974	5.9E-04[c]	2.9E+03	2.8E-03	1.2E-02
1975	8.9E-05	2.8E+03	1.9E-03	3.7E-03
1976	5.9E-04[c]	2.9E+03	3.8E-04	7.4E-03
1977	0.0E+00	1.6E+03	1.4E-03	1.5E-02
1978	0.0E+00	6.7E+02	2.3E-03	8.4E-03
1979	0.0E+00	7.2E+02	4.1E-04	5.6E-03
1980	2.0E-04	2.8E+02	5.7E-04	5.2E-03
1981	8.0E-05	5.9E+02	5.2E-04	4.5E-03
1982	0.0E+00	9.2E+02	1.6E-04	6.6E-03
1983	5.9E-04[c]	1.5E+03	8.9E-06	8.9E-04
1984	5.9E-04[c]	1.7E+03	7.1E-05	2.2E-03
1985	5.9E-04[c]	4.8E+03	4.6E-04	3.5E-03
1986	5.9E-04[c]	3.3E+02	8.9E-05	2.8E-03
1987	1.1E-04	2.4E+03	5.3E-05	2.8E-03
1988	5.9E-04	1.3E+03	6.2E-05	4.1E-03
1989	5.9E-04[c]	3.5E+02	0.0E+00	6.1E-03
1990	1.5E-04	1.5E+02	7.1E-05	3.7E-03
1991	9.8E-05	1.2E+02	1.5E-04	3.2E-03
1992	4.4E-05	2.1E+02	1.1E-03	4.5E-03
1993	1.3E-04	3.2E+02	2.5E-04	3.0E-03
1994	4.1E-04	1.9E+02	2.3E-04	1.8E-03
1995	3.0E-04	2.9E+02	2.8E-04	1.7E-03
1996	4.3E-04	2.3E+02	4.6E-04	2.2E-03
1997	1.8E-04	4.7E+02	5.3E-05	7.6E-04
1998	2.8E-04	9.0E+02	1.1E-04	1.6E-03
1999	2.4E-04	4.5E+02	4.0E-05	1.6E-03
2000	1.3E-03	4.7E+02	1.8E-05	1.2E-03
2001	4.9E-04[d]	5.0E+02[d]	1.4E-04[d]	1.5E-03[d]
2002	4.9E-04[d]	5.0E+02[d]	1.4E-04[d]	1.5E-03[d]
2003	4.9E-04[d]	5.0E+02[d]	1.4E-04[d]	1.5E-03[d]

a. Calculated from estimated air concentrations in Table C-22, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Assumed to be the highest value of all years for which data are available.
d. Estimated from average of corresponding values for 1996 to 2000.

Table 4-20. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{232}Th, ^{234}U, and MFP for TA-50 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	Th-232	U-234	MFP[c]
1971		8.4E+04	3.1E-03			
1972			5.4E-03			
1973			4.9E-04			3.4E-03
1974			7.6E-04			1.9E-02
1975			8.0E-04			8.9E-03
1976			2.1E-04			5.8E-03
1977			1.4E-02			1.8E-02
1978			3.4E-03			8.4E-03
1979			5.7E-04			2.2E-03
1980			2.3E-04			1.7E-03
1981			3.5E-04			5.1E-03
1982			1.3E-03			3.1E-03
1983			1.1E-03			1.9E-03
1984			7.2E-04			1.9E-03
1985			3.9E-04			1.8E-03
1986			5.6E-04			4.2E-03
1987			8.8E-04			4.6E-03
1988			4.0E-04			2.9E-03
1989			9.0E-05			2.1E-03
1990			2.9E-05			8.3E-04
1991			2.7E-04			6.5E-04
1992			1.1E-04			7.5E-04
1993			5.5E-05			7.9E-04
1994			6.1E-05			1.4E-03
1995	1.2E-05		1.4E-04			
1996	2.1E-06		8.2E-06		3.7E-05	
1997	1.6E-06		1.1E-05		2.5E-07	
1998	1.3E-06		2.9E-06	1.5E-05	3.7E-05	
1999	2.5E-05		1.0E-05	7.2E-06	3.7E-06	
2000	2.7E-05		1.9E-06	1.0E-05		
2001	1.1E-08		8.4E-06			
2002	1.1E-05[d]		6.8E-06[d]			
2003	1.1E-05[d]		6.8E-06[d]			

a. Calculated from estimated air concentrations in Table C-23, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. H-3 intake multiplied by 1.5 to account for submersion dose.
c. It is favorable to the claimant to assume all is ^{90}Sr.
d. Estimated from average of corresponding values for 1997 to 2001.

Table 4-21. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{234}U, and P/VAP for TA-53 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234[c]	P/VAP[d]
1971		1.1E+04	5.9E-03	2.2E-02	
1972	3.9E-03	4.4E+03	5.7E-03	9.6E-03	
1973	1.8E-04	4.2E+03	2.2E-03	1.4E-02	
1974		1.3E+04	2.8E-03	1.5E-02	
1975	2.7E-04	9.5E+03	2.0E-03	7.3E-03	
1976		6.5E+03	4.4E-04	8.5E-03	
1977	1.1E-04	4.7E+03	1.6E-03	1.5E-02	
1978		1.7E+03	1.5E-03	5.5E-03	
1979		5.7E+02	4.4E-04	1.1E-02	
1980	8.0E-05	8.3E+02	6.4E-04	1.1E-02	
1981	1.2E-04	7.2E+02	5.6E-04	3.6E-03	
1982	8.9E-06	9.7E+02	2.0E-04	7.3E-03	3.6E+04
1981		1.5E+03	8.9E-05	3.4E-03	5.2E+05
1984		1.2E+03	5.3E-05	4.5E-03	4.9E+05
1985		1.6E+03	1.1E-04	3.7E-03	3.9E+01
1986	2.7E-04	1.3E+03	7.1E-05	4.2E-03	2.0E+01
1987	7.1E-05	2.0E+03	3.6E-05	4.2E-03	3.9E+01
1988	1.9E-04	3.2E+03	2.0E-04	7.9E-03	2.0E+01
1989	2.9E-04	4.5E+02	8.9E-05	9.9E-03	2.0E+01
1990	2.0E-04	5.2E+02	2.1E-04	9.7E-03	1.6E+01
1991	6.2E-05	1.5E+02	2.7E-04	5.4E-03	3.9E+01
1992	1.6E-04	6.5E+02	2.2E-04	6.9E-03	1.4E+02
1993	3.3E-04	3.2E+02	1.2E-04	1.7E-03	2.0E+03
1994	3.5E-04	2.5E+02	2.2E-04	1.9E-03	6.1E+01
1995	5.4E-04	3.6E+02	9.6E-04	1.6E-03	5.6E+01
1996		1.1E+02			2.7E+01
1997		5.0E+03			1.8E+02
1998		1.1E+03			6.4E+02
1999		6.7E+02			4.9E-01
2000		8.5E+02			1.8E+02
2001		1.9E+03			2.1E+02
2002		1.9E+03[e]			2.4E+02[e]
2003		1.9E+03[e]			2.4E+02[e]

a. Calculated from estimated air concentrations in Table C-24, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. It is favorable to the claimant to assume all is ^{90}Sr.
d. It is favorable to the claimant to assume all is ^{68}Ge, Type M.
e. Estimated from average of corresponding values for 1997 to 2001.

Table 4-22. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-54 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	U-234
1971–1975				
1976	8.6E-03[c]	4.4E+04	2.8E-03	1.5E-02
1977	4.6E-04	2.5E+04	3.2E-03	2.3E-02
1978	2.0E-04	7.6E+03	7.4E-03	1.4E-02
1979	4.4E-04	4.7E+03	2.0E-03	1.1E-02
1980	3.7E-04	7.1E+03	1.3E-03	1.2E-02
1981	1.4E-04	2.9E+03	9.7E-04	1.2E-02
1982	8.0E-05	3.1E+03	1.3E-03	1.2E-02
1983	8.6E-03[c]	2.4E+03	6.2E-05	4.1E-03
1984	8.6E-03[c]	8.4E+03	1.6E-03	9.2E-03
1985	8.6E-03[c]	1.0E+04	2.1E-03	8.8E-03
1986	1.6E-03	3.7E+03	2.0E-03	8.5E-03
1987	8.4E-04	4.3E+03	1.2E-03	7.4E-03
1988	3.4E-04	3.1E+03	1.6E-03	2.2E-02
1989	7.9E-04	3.8E+03	1.5E-03	1.3E-02
1990	2.8E-04	2.2E+03	4.3E-04	7.2E-03
1991	3.6E-04	1.1E+04	1.6E-03	8.4E-03
1992	1.7E-04	5.9E+03	4.4E-04	2.9E-03
1993	3.4E-04	5.2E+03	7.1E-04	3.1E-03
1994	5.6E-04	4.4E+03	6.3E-04	8.8E-03
1995	1.2E-03	5.8E+03	1.6E-03	5.2E-03
1996	5.6E-03	6.8E+03	7.5E-03	4.9E-03
1997	8.6E-03	1.1E+04	1.3E-02	5.5E-03
1998	1.4E-03	1.7E+04	2.0E-03	6.8E-03
1999	1.4E-03	1.3E+04	2.1E-03	1.1E-02
2000	1.1E-03	1.6E+04	9.0E-04	7.5E-03
2001	9.0E-04	3.1E+04	5.2E-04	5.2E-03
2002	4.6E-03	1.6E+04	9.2E-03	5.3E-03
2003	1.9E-03[d]	1.9E+04[d]	3.0E-03[d]	7.1E-03[d]

a. Calculated from estimated air concentrations in Table C-25, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Assumed to be the highest value of all years for which data are available.
d. Estimated from average of corresponding values for 1998 to 2002.

Table 4-23. Estimated annual average intakes of ^{241}Am, ^{3}H, ^{239}Pu, ^{232}Th, and ^{234}U for TA-55 (Bq/yr).[a]

Year	Am-241	H-3[b]	Pu-239	Th-232	U-234
1971–1977					
1978			7.8E-05		
1979			2.1E-05		
1980			5.7E-05		
1981			1.9E-05		
1982		5.5E+03	5.1E-04		
1983		1.3E+04	2.1E-04		
1984		4.5E+04	2.0E-04		
1985			2.1E-04		
1986		3.0E+05	4.6E-05		
1987		2.5E+04	4.8E-05		
1988		9.2E+04	3.0E-03		
1989		7.8E+04	4.3E-04		
1990		4.9E+04	9.1E-05		
1991		2.7E+04	3.9E-04		
1992		3.0E+04	2.2E-04		
1993		1.9E+04	3.3E-05		
1994		6.6E+03	2.3E-05		
1995	1.1E-06	4.6E+03	3.2E-06		
1996	6.1E-06	9.1E+03	1.7E-05		1.1E-05
1997	7.0E-05	3.5E+03	2.1E-05	8.6E-06	
1998	7.4E-07	3.5E+03	1.2E-05	5.9E-06	
1999	1.1E-05	5.3E+02	1.2E-05		1.4E-05
2000	6.4E-05	1.9E+03	4.9E-04		
2001	1.2E-06	9.7E+02	8.4E-06	2.9E-05	3.3E-05
2002	2.9E-05[c]	2.1E+03[c]	1.1E-04[c]		
2003	2.9E-05[c]	2.1E+03[c]	1.1E-04[c]		

a. Calculated from estimated air concentrations in Table C-27, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. Estimated from average of corresponding values for 1997 to 2001.

Table 4-24. Estimated annual average intakes of ^{239}Pu and MFPs from the general Los Alamos area (Bq/yr).[a]

Year	Pu-239	MFP
1958		5.5E+02
1959	3.55E-01	2.6E+02
1960	3.55E-01	1.2E+01
1961	3.55E+00	2.9E+02
1962	3.55E-01	4.0E+02
1963	3.55E-01	3.7E+02
1964	3.55E-01	6.1E+01
1965		1.4E+01
1966		1.3E+01
1967	8.88E-02	3.6E+00
1968		1.5E+01
1969		1.2E+01
1970		1.5E+01

a. Calculated from estimated air concentrations in Table C-26, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.

Table 4-25. Estimated air concentrations from resuspension (pCi/m^3).[a]

Nuclide	Bayo Canyon 1978	LA Canyon 1977	Mortandad Canyon 1977	Acid Canyon 1978	Pueblo Canyon 1978
Pu-239		3E-05	4E-04	7E-05	2.5E-05
Pu-238			5E-04		
Cs-137		1.3E-03	7E03		
Sr/Y-90	1E-05				
U-238	8E-04				

a. Data are for primary contaminants in each location; other cells are blank..

Table 4-26. Area badge data, annual TLD or film results (mrem).[a]

Year	Site-wide maximum	TA-3[b]	TA-18[b]	TA-53[b]	TA-54[b]	Background[c,d]	Geometric mean	Geometric standard deviation
2002	156	*115*	156	*129*	236	*150*	152	1.31
2001[e]	570	*570*	*224*	*170*	236	*150*	238	1.69
2000[e]	268	*268*	*195*	*212*	236	*150*	208	1.24
1999[e]	241	*143*	*216*	*241*	*233*	*150*	192	1.28
1998	426	*157*	153	*426*	*213*	*150*	201	1.56
1997[e]	462	*145*	*197*	*462*	*181*	*150*	205	1.60
1996	173	*127*	241	159	*173*	*150*	166	1.27
1995	378	*123*	378	142	*161*	*150*	174	1.56
1994	160	*130*	127	152	*160*	*150*	143	1.11
1993	148	*118*	128	142	*148*	*150*	137	1.11
1992	236	*122*	123	135	*236*	144	147	1.31
1991	178	*130*	136	178	*162*	*150*	150	1.14
1990	178	*137*	136	178	*162*	164	155	1.13
1989	149	*115*	149	94	*129*	152	126	1.22
1988	188	*150*	188	113	*131*	155	145	1.21
1987	166	*166*	153	115	*132*	152	142	1.16
1986	183	*183*	181	143	*160*	152	163	1.11
1985	187	*143*	187	145	160	150	156	1.12
1984	183	*139*	183	161	*159*	150	158	1.11
1983	188	*150*	188	163	*157*	150	161	1.10
1982	163	163	153	138	116	146	142	1.14
1981	175	156	175	123	91	139	134	1.29
1980	303	*211*	303	146	134	152	180	1.40
1979	252	*141*	*252*	150	150	153	165	1.27
1978	234	*144*	*182*	*234*	112	137	157	1.33
1977	273	*273*	*164*	*203*	NM	151	183	1.29
1976	261	*238*	*261*	*172*	NM	145	188	1.31
1975	380	*380*	*220*	*169*	NM	158	202	1.47
1974	137	NA	345	169	150	151	191	1.49
1973[f]	345	128	*345*	178	NA	184	195	1.54
1972[f]	160	150	*225*	NA	NA	176	181	1.23
1971	106	138	*276*	NA	NA	169	186	1.43
1970	132	NA	NA	NA	NA	NA	NA	NA
1969	302	NA	NA	NA	NA	NA	NA	NA
1968	302	NA	NA	NA	NA	NA	NA	NA
1967	302	NA	NA	NA	NA	NA	NA	NA
1966	354	NA	NA	NA	NA	NA	NA	NA
1965	423	NA	NA	NA	NA	NA	NA	NA
1967	302	NA	NA	NA	NA	450 [10]	NA	NA

Year	Site-wide maximum	TA-3[b]	TA-18[b]	TA-53[b]	TA-54[b]	Background[c,d]	Geometric mean	Geometric standard deviation
1966	354	NA	NA	NA	NA	450	NA	NA
1965	423	NA	NA	NA	NA	450	NA	NA

a. Dose is based on 8,760 hr/yr and can be adjusted to 2,080 hr/yr by multiplying by 0.237. NA= data not available.
b. Numbers in *italics* are averages of several area badges in the TA.
c. Backgrounds in *italics* are a 10- yr average, because actual background is not given.
d. Reported background is the average background for Los Alamos town site plus 2-sigma (or 20%).
e. Neutron dose included for 1997 and 1999 at TA-18 and 2000 and 2001 at TA-3 and TA-18.
f. In these years, TA-36 exposure was elevated due to experiments at adjacent TA-18: 1973 dose, 81 mrem (net); 1972 dose, 53 mrem (net). For the only other year of data, 1971, dose was not elevated.

Table 4-27. Estimated annual deposition of ^{140}La and doses from radioactive lanthanum experiments.[a]

Year	Dose[b] (mrem)	Deposition[c] (µCi/m^2)
1945	8	4.2E3
1946	8	4.2E3
1947	9	4.7E3
1948	3	1.6E3
1949	12	6.3E3
1950	8	4.2E3
1951	3	1.6E3
1952	1	5.3E2
1953	9	4.7E3
1954	15	7.9E3
1955	23	1.2E4
1956	21	1.1E4
1957	10	5.3E3
1958	6	3.2E3
1959	5	2.6E3
1960	3	1.6E3

a. Applicable to town site (TA-0), TA-2, and vicinity.
b. Source: Kraig (1997, Figure 5).
c. Calculated from Kraig (1997, Equations 2 and 3).

Table 4-28. Estimated average external doses from ^{41}Ar released from TA-2 (mrem/yr).[a]

Year	Skin[b]	Whole body[c]
1971	2.4E+00	1.6E+00
1972	9.8E-01	6.3E-01
1973	4.2E-01	2.7E-01
1974	4.8E-03	3.1E-03
1975	3.6E-01	2.3E-01
1976	5.2E-01	3.4E-01
1977	4.8E-01	3.1E-01
1978	3.7E-01	2.4E-01
1979	5.4E-01	3.5E-01
1980	7.9E-01	5.1E-01
1981	4.6E-01	3.0E-01
1982	5.3E-01	3.4E-01
1983	6.4E-01	4.1E-01
1984	5.1E-01	3.3E-01
1985	6.0E-01	3.9E-01
1986	4.2E-01	2.7E-01
1987	3.6E-01	2.3E-01
1988	4.1E-01	2.6E-01
1989	3.4E-01	2.2E-01
1990	2.5E-01	1.6E-01
1991	3.1E-01	2.0E-01
1992	2.2E-01	1.4E-01

a. Assumes receptor is at 500 m from the source 2,000 hr/yr, no plume depletion, no plume rise (stack height is zero).
b. Calculated using skin dose factor for ^{41}Ar from Eckerman and Ryman (1993).
c. Calculated using whole-body dose factor for ^{41}Ar from Eckerman and Ryman (1993).

Table 4-29. Estimated average external doses from G/MAPs released from TA-53 (mrem/yr).[a]

Year	Skin[b]	Whole body[c]
1943–1976	Not in operation	
1976	9.3E+00	5.8E+00
1977	7.5E+01	4.7E+01
1978	1.9E+02	1.2E+02
1979	1.9E+02	1.2E+02
1980	2.3E+02	1.4E+02
1981	5.6E+02	3.5E+02
1982	4.0E+02	2.5E+02
1983	7.3E+02	4.6E+02
1984	1.2E+03	7.3E+02
1985	2.0E+02	1.2E+02
1986	1.8E+02	1.1E+02
1987	2.4E+02	1.5E+02
1988	1.9E+02	1.2E+02
1989	2.5E+02	1.5E+02
1990	1.9E+02	1.2E+02
1991	9.0E+01	5.7E+01
1992	1.1E+02	7.1E+01
1993	5.1E+01	3.2E+01
1994	7.9E+01	4.9E+01
1995	6.9E+01	4.3E+01
1996	1.7E+01	1.1E+01
1997	3.2E+01	2.0E+01
1998	1.2E+01	7.7E+00
1999	4.7E-01	3.0E-01
2000	1.1E+00	6.8E-01
2001	9.3E+00	5.8E+00
2002	1.1E+01[d]	6.9E+00[d]
2003	1.1E+01[d]	6.9E+00[d]

a. Assumes receptor is at 500 m from the source 2,000 hr/yr, no plume depletion, no plume rise (stack height is zero).
b. Calculated using skin dose factor for ^{15}O from Eckerman and Ryman (1993).
c. Calculated using whole-body dose factor for ^{41}Ar from Eckerman and Ryman (1993).
d. Estimated assuming equal to average of corresponding values for 1997 to 2001.

Table 4-30. Estimated average external doses at TA-21 and TA-72 from G/MAPs released from TA-53 (mrem/yr).

	TA-21		TA-72	
Year	Skin[a]	Whole body[b]	Skin[a]	Whole body[b]
1976	6.55E-01	4.10E-01	1.97E+00	1.23E+00
1977	5.30E+00	3.31E+00	1.59E+01	9.93E+00
1978	1.30E+01	8.14E+00	3.91E+01	2.44E+01
1979	1.32E+01	8.28E+00	3.97E+01	2.48E+01
1980	1.62E+01	1.02E+01	4.87E+01	3.05E+01
1981	3.93E+01	2.46E+01	1.18E+02	7.37E+01
1982	2.79E+01	1.75E+01	8.38E+01	5.24E+01
1983	5.13E+01	3.21E+01	1.54E+02	9.62E+01
1984	8.17E+01	5.11E+01	2.45E+02	1.53E+02
1985	1.40E+01	8.76E+00	4.21E+01	2.63E+01
1986	1.25E+01	7.79E+00	3.74E+01	2.34E+01
1987	1.67E+01	1.04E+01	5.01E+01	3.13E+01
1988	1.35E+01	8.42E+00	4.04E+01	2.52E+01
1989	1.74E+01	1.08E+01	5.21E+01	3.25E+01
1990	1.37E+01	8.55E+00	4.11E+01	2.57E+01
1991	6.37E+00	3.98E+00	1.91E+01	1.19E+01
1992	8.01E+00	5.01E+00	2.40E+01	1.50E+01
1993	3.56E+00	2.23E+00	1.07E+01	6.68E+00
1994	5.56E+00	3.48E+00	1.67E+01	1.04E+01
1995	4.85E+00	3.03E+00	1.46E+01	9.10E+00
1996	1.22E+00	7.65E-01	3.67E+00	2.30E+00
1997	2.23E+00	1.39E+00	6.68E+00	4.17E+00
1998	8.68E-01	5.42E-01	2.60E+00	1.63E+00
1999	3.34E-02	2.09E-02	1.00E-01	6.26E-02
2000	7.68E-02	4.80E-02	2.30E-01	1.44E-01
2001	6.57E-01	4.10E-01	1.97E+00	1.23E+00
2002	7.72E-01[c]	4.83E-01[c]	2.32E+00c	1.45E+00[c]
2003	7.72E-01[c]	4.83E-01[c]	4.83E-01c	1.45E+00[c]

a. Calculated using skin dose factor for ^{15}O from Eckerman and Ryman (1993).
b. Calculated using whole-body dose factor for ^{41}Ar from Eckerman and Ryman (1993).
c. Estimated assuming equal to average of corresponding values for 1997 to 2001.

Table 4-31. Estimated annual site-wide maximum intakes and ambient dose rates for all radionuclides.

Year	Maximum intakes (Bq/yr)[a]							Maximum ambient dose rates (mrem/yr)
	Am-241	H-3	Pu-239	Th-232	U-234	MFP[b]	P/VAP[c]	
1971		9.2E+05	2.5E-02		1.7E+01			276
1972		7.3E+05	2.2E-02		2.1E+01			225
1973		3.6E+05	1.2E-02		4.1E-02			345
1974		4.1E+05	2.9E-01		3.9E-02			137
1975		7.0E+05	8.2E-02		3.8E-02			380
1976		4.9E+05	7.7E-03		7.1E-02	2.4E-01		238
1977	4.6E-04	2.3E+05	1.4E-02		6.6E-02	4.3E-01		273
1978	2.0E-04	2.0E+05	1.1E-02		3.6E-02	2.3E-01		234
1979	4.4E-04	8.8E+05	2.1E-01		5.1E-02	2.1E-01		252
1980	3.7E-04	1.2E+05	1.4E-01		3.0E-02	3.4E-01		303
1981	4.0E-03	9.2E+05	7.7E-03		4.6E-02	2.7E-01		175
1982	8.0E-05	9.2E+05	1.5E-02		6.3E-02	2.1E-01	3.6E+04	163
1983	1.9E-05	6.7E+05	1.7E-02		3.5E-02	1.6E-01	5.2E+05	188
1984		1.4E+06	2.2E-02		4.2E-02	3.1E-01	4.9E+05	183
1985		6.2E+05	3.8E-02		6.7E-02	2.4E-01	3.9E+01	187
1986	1.6E-03	3.9E+05	3.8E-02		1.2E-01	4.9E-01	2.0E+01	183
1987	8.4E-04	2.5E+05	1.3E-02		1.7E-01	2.4E-01	3.9E+01	166
1988	5.9E-04	2.4E+06	1.0E-02		9.8E-02	2.2E-01	2.0E+01	188
1989	7.9E-04	3.4E+06	7.6E-03		7.1E-02	8.5E+01	2.0E+01	149
1990	2.8E-04	1.3E+06	4.2E-03		3.8E-02	2.0E-01	1.6E+01	178
1991	3.6E-04	1.1E+06	1.6E-03		8.4E-03	2.1E-01	3.9E+01	178
1992	4.0E-04	8.6E+04	1.3E-03		4.5E-01	5.4E-01	1.4E+02	236
1993	1.7E-03	1.4E+05	4.9E-03		9.7E-01	2.6E-01	2.0E+03	148
1994	5.7E-04	5.0E+04	1.0E-03		8.8E-03	7.6E-02	6.1E+01	160
1995	1.3E-03	2.4E+04	1.6E-03		8.0E-03	5.2E+00	4.4E+02	161
1996	5.6E-03	3.2E+04	7.5E-03	3.2E-05	2.2E-02		2.7E+01	241
1997	8.6E-03	1.2E+04	1.3E-02	7.4E-05	5.5E-03		1.8E+02	462
1998	1.4E-03	3.3E+04	2.3E-03	8.2E-05	6.8E-03		6.4E+02	426
1999	1.4E-03	1.3E+04	2.1E-03	4.3E-05	1.1E-02		7.6E-01	241
2000	1.3E-03	1.6E+04	9.0E-04	2.5E-05	7.5E-03		1.8E+02	268
2001	9.0E-04	1.6E+05	5.2E-04	2.9E-05	1.4E-02		2.1E+02	570
2002	4.6E-03	3.7E+04	9.2E-03	5.0E-05	5.3E-03		2.4E+02	156
2003	1.9E-03	3.7E+04	3.0E-03	5.0E-05	7.1E-03		2.4E+02	

a. Values are the maximum annual average intake reported for all technical areas in Tables 4-1 through 4-23 for each radionuclide, and are based on an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no release or air concentration data were available.

b. It should be assumed that the intake is composed solely of ^{137}Cs, except for the organs bone surface and red bone marrow, in which case ^{90}Sr should be assumed (Brackett 2010).

c. The dose reconstructor should assume all is either ^{68}Ge, Type M, or ^{75}Se, Type F, depending on which is higher for the organ of interest (Brackett 2010).

4.5 ATTRIBUTIONS AND ANNOTATIONS

Where appropriate in the preceding text, bracketed callouts have been inserted to indicate information, conclusions, and recommendations to assist in the process of worker dose reconstruction. These callouts are listed in this section with information that identifies the source and justification for each item. Conventional references are provided in the next section that link data, quotations, and other information to documents available for review on the Oak Ridge Associated Universities (ORAU) Team servers.

[1] Buddenbaum, Jack E. ENSR. Health Physicist. August 2004.
Emissions and monitoring data was provided by Scott Miller and Joe Graf of LANL.

[2] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
The procedural document for development of TBDs (ORAUT-PROC-0031, ORAUT 2007) directs that the occupational environmental dose analysis be limited "to the 10 radionuclides that contribute to at least 95% of the dose." The determination of which radionuclides these are is the subject of Section 4.2.1.2 in this document. Due to the changing missions and operations at LANL over the years, the 10 radionuclides that fulfill this requirement have varied over the years. Therefore, a decision was made to select the radionuclides for each year that contributed the highest doses that summed to at least 95% of the total estimated dose for that year.

[3] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
In the absence of site-specific information, the AMAD of 5 µm is consistent with ICRP default recommendations (ICRP 1995) for worker exposure to airborne particulates

[4] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
When emissions estimates did not specify isotopic contributions, the isotope with the highest effective dose factor was selected as representative of the group. For example, for plutonium emissions, all of the effluent was assumed to be ^{239}Pu, which has the highest effective dose factor of all radionuclides in the group (^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am). This assumption tended to maximize the estimated potential impact of plutonium so that the importance of this group was not underestimated in the screening analysis.

[5] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
Air monitoring was the preferred source of data for estimation of air concentrations of air particulates at LANL. These data, which are available for many TAs over time, represent contributions from stack or vent effluents and area sources (such as contaminated soil) within the TA in which they are located, but they also represent contributions from nearby TAs.

[6] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
The ratioing method is, in effect, an empirically-derived χ/Q, that represents the relationship between the air concentration and the source term. Unlike model-derived χ/Q values, however, this empirical value includes the contributions of resuspended contaminated soil, and thus it is likely to be a higher value than might be predicted by a simplified dispersion model. It is specific for the conditions under which it was measured, the location of the air monitors relative to the source(s), and the source configurations themselves. While it cannot be manipulated to represent other source configurations, atmospheric conditions, or downwind distances, it is a reasonable estimate in the absence of more complex dispersion models that address resuspension.

[7] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
The linear regression analysis was carried out using a spreadsheet to evaluate whether the reported emissions for TA-3 and TA-21 correlated with the measured air concentrations at each TA, and how strong this correlation was. The results indicated that the air concentrations were linearly correlated, and that the relationship could be characterized as moderate to strong according to the calculated correlation coefficients. The fact that the average ratios were almost identical gave further confidence that this observed relationship is causal rather than coincidental.

[8] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
Although the ratioing method does not directly allow evaluation of the effect of different source configurations on nearby air concentrations, the following information is pertinent. The stacks from which most of the plutonium is released at TA-3 are approximately 16 m in height. The comparable stack at TA-21 is 10 m in height. This difference in stack heights did not significantly affect the calculated ratio. This could be because wake effects alter plume dispersion similarly in both areas, or possibly because resuspension dominates the measured air concentration in both areas (if plutonium concentrations in soil are similar in both locations). It is further pertinent to consider that for plutonium in particular, releases from TA-3 and TA-21 were significantly greater that from other areas (more than 2 orders of magnitude). Thus, although there could be some error in not accounting for differential source configurations, the TA-3 and TA-21 measurements are used directly to define the site-wide maximum intakes, and the ratioing method thus does not affect these intake estimates.

[9] McDowell-Boyer, Laura M. ORAU Team. Environmental Engineer. August 2006.
The isotopic ratio, in atom percent, of natural uranium is 0.0055%:0.72%:99.28% for ^{234}U:^{235}U:^{238}U, and that for depleted uranium is 0.0007%:0.20%:99.80% (DOE 2001). The specific activity of natural uranium is 6.75×10^{-7} Ci/g, and of depleted uranium is $4.76 \times 10\text{-}^{7}$ Ci/g, both of which are smaller than that for enriched uranium. Therefore, the assumption that all uranium is enriched uranium provides an upper bound on the calculated total activity of uranium based on reported total uranium values.

[10] Buddenbaum, Jack E. ENSR. Health Physicist. August 2004.
Emissions and monitoring data was provided by Scott Miller and Joe Graf of LANL.

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ATTACHMENT A
SOURCE EMISSIONS

Tables A-1 through A-22 contain emissions data that have been reported by year and radionuclide for many of the TAs at LANL. In recent years, effluents have been reported by stack and/or building vent; in these cases, the effluents were summed within a TA. For years up to and including 1970, the reported effluent releases rely on data from the Centers for Disease Control and Prevention LAHDRA project; in the year 1970 and after, the reported releases are from annual environmental surveillance reports. Blank values in these tables indicate no data.

Table A-1. Estimated source emissions from TA-1 (µCi/yr).

Year	Pu
1943	No source estimates for this year
1944	No source estimates for this year
1945	2.11E+05
1946	2.65E+05
1947	4.21E+05
1948–2001	No source estimates for these years
2002	
2003	

Table A-2. Estimated source emissions from TA-2 (µCi/yr).

Year	Ar-41
1943–1966	No source estimates for this year
1967	1.55E+10
1968	6.48E+09
1969	1.80E+09
1970	1.30E+09
1971	1.57E+09
1972	6.40E+08
1973	2.73E+08
1974	3.12E+06
1975	2.37E+08
1976	3.39E+08
1977	3.15E+08
1978	2.39E+08
1979	3.51E+08
1980	5.13E+08
1981	3.01E+08
1982	3.42E+08
1983	4.18E+08
1984	3.35E+08
1985	3.90E+08
1986	2.76E+08
1987	2.32E+08
1988	2.64E+08
1989	2.22E+08
1990	1.60E+08
1991	2.03E+08
1992	1.40E+08
1993–2003	Not in operation

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Table A-3. Estimated source emissions from TA-3 (µCi/yr).

Year	Am-241	H-3	I-131	Pu	Th-232	U	MFP	P/VAP
1943–1951	No source estimates for these years							
1952				1.00E+01				
1953				2.30E+02				
1954				1.30E+03				
1955				1.89E+03				
1956				1.49E+03				
1957				1.12E+03				
1958				3.21E+03				
1959				8.90E+02				
1960				2.97E+03				
1961				1.92E+03				
1962				1.80E+03				
1963			6.52E+05	8.60E+02				
1964			2.97E+05	6.50E+02				
1965			3.81E+05	1.59E+03				
1966				1.88E+03				
1967				4.19E+03				
1968				6.05E+03				
1969				1.16E+04				
1970				1.35E+04				
1971		8.90E+07	6.95E+03	1.43E+04		5.80E+02		
1972		4.80E+07[a]	7.40E+03[a]	7.90E+03[a]		3.60E+02[a]		
1973			4.23E+03	7.30E+03	1.56E+01	5.93E+02	1.28E+04	
1974			4.73E+03	1.47E+03		2.02E+02	3.42E+02	
1975		2.20E+07	1.36E+03	4.20E+02		1.94E+02	1.84E+02	
1976		0.00E+00	3.00E+02	3.95E+01		3.63E+02	4.15E+02	
1977		4.00E+08	8.80E+01	3.35E+01		3.38E+02	4.81E+02	
1978		9.98E+07	8.10E+01	5.83E+01		1.85E+02	4.03E+02	
1979		3.02E+09	1.58E+02	1.07E+03		2.61E+02	4.72E+02	
1980		4.55E+06	9.40E+01	7.41E+02		1.55E+02	4.24E+02	
1981		8.99E+08	4.40E+01	3.96E+01		2.36E+02	1.72E+02	
1982		1.94E+09	7.85E+02	7.44E+01		3.21E+02	7.63E+01	
1983		2.28E+09	8.30E+01	8.85E+01		1.81E+02	1.71E+01	
1984		1.78E+09	7.30E+01	1.15E+02		2.14E+02	4.15E+01	
1985		2.12E+09	1.46E+02	1.95E+02		3.44E+02	3.47E+01	
1986		1.23E+09	3.80E+01	1.94E+02		6.31E+02	4.79E+01	
1987		8.51E+08		6.49E+01		8.68E+02	2.16E+01	
1988		8.35E+09		5.19E+01		5.00E+02	2.97E+01	
1989		2.91E+08		3.91E+01		3.65E+02	3.82E+01	
1990		4.96E+08		2.16E+01		1.96E+02	3.89E+01	
1991		2.05E+08		3.08E+01		2.44E+02	1.41E+01	
1992		1.15E+08		2.73E+00		1.98E+02	8.42E+00	
1993		7.63E+07		1.74E+00		2.18E+02	6.05E+00	
1994		5.38E+07		6.00E+00		1.96E+02	3.84E+01	
1995	4.02E+00	2.25E+06		5.35E+01		1.53E+02	9.38E+02	9.38E+02
1996	1.22E+00			2.31E+01	1.64E-01	3.87E+01		
1997	3.70E-01			3.50E+00	3.80E-01	2.20E+01		
1998	1.60E+00			1.10E+01	4.20E-01	3.10E+01		6.70E+00
1999	2.60E+00			2.10E+01	2.20E-01	7.60E+00		
2000	1.80E-01			3.20E+00	1.30E-01	6.80E+00		
2001	2.60E-01			9.20E+00	1.40E-01	7.10E+00		

Year	Am-241	H-3	I-131	Pu	Th-232	U	MFP	P/VAP
2002								
2003								

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.

Table A-4. Estimated source emissions from TA-9 (µCi/yr).

Year	H-3
1943–1971	No source estimates for these years
1972	7.00E+08[a]
1973	3.60E+07[b]
1974	1.30E+06
1975	No source estimates for this year
1976	1.29E+08
1977	2.60E+07
1978	2.60E+06
1979	5.00E+06
1980	5.00E+06
1981–2001	No source estimates for these years
2002	
2003	

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.
b. Value taken from LASL (1973) due to inconsistencies in database for 1973.

Table A-5. Estimated source emissions from TA-10 (µCi/yr).

Year	U
1943	No source estimates for this year
1944	1.0 0E+04
1945	1.00E+04
1946	3.00E+04
1947	4.00E+04
1948	6.00E+04
1949	1.00E+05
1950	5.00E+05
1951	2.00E+05
1952	2.00E+05
1953	2.00E+05
1954	4.00E+03
1955	3.30E+04
1956	3.50E+04
1957	1.10E+04
1958	7.00E+03
1959	1.20E+04
1960	7.00E+03
1961	8.82E+05
1962	1.82E+05
1963	5.00E+04
1964–2001	No source estimates for these years
2002	
2003	

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Table A-6. Estimated source emissions from TA-15 (µCi/yr).

Year	H-3	Th-232	U
1943	No source estimates for this year		
1944			6.00E+04
1945			1.20E+05
1946			2.40E+05
1947			3.60E+05
1948			5.40E+05
1949			8.70E+05
1950			4.50E+06
1951			2.00E+06
1952			1.80E+06
1953			1.60E+06
1954			1.49E+06
1955			1.19E+06
1956			7.93E+05
1957			1.20E+06
1958			1.07E+06
1959			5.16E+05
1960			7.14E+05
1961			3.48E+05
1962			4.73E+05
1963			3.96E+05
1964			5.97E+05
1965			5.72E+05
1966			9.42E+05
1967	3.59E+09	2.00E+09	7.20E+05
1968	4.50E+09	2.00E+09	5.37E+05
1969	4.50E+09		4.28E+05
1970	2.87E+10		3.07E+05
1971	2.66E+09		4.95E+05
1972	1.81E+09		1.64E+05
1973	9.30E+08[a]		
1974–1977	No source estimates for these years		
1978	7.16E+07		
1979–1991	No source estimates for these years		
1992			2.29E+03
1993			4.94E+03
1994			7.87E+03
1995–2001	No source estimates for these years		
2002			
2003			

a. Value taken from LASL (1973) due to omission in database for 1973.

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Table A-7. Estimated source emissions from TA-16 (µCi/yr).

Year	H-3	U
1943–53	No source estimates for these years	
1954		3.80E+04
1955	No source estimates for this year	
1956	No source estimates for this year	
1957		1.40E+04
1958	No source estimates for this year	
1959		1.00E+03
1960		5.00E+04
1961	No source estimates for this year	
1962	No source estimates for this year	
1963		4.80E+04
1964		3.00E+03
1965		4.00E+03
1966	No source estimates for this year	
1967		5.00E+03
1968		3.90E+04
1969		3.00E+03
1970		1.10E+04
1971		2.00E+03
1972–1991	No source estimates for these years	
1992	6.28E+04	
1993	7.73E+05	
1994	2.46E+07	
1995	8.90E+07	
1996	9.90E+07	
1997	9.80E+07	
1998	2.40E+08	
1999	1.60E+08	
2000	2.60E+08	
2001	7.90E+09	
2002		
2003		

Table A-8. Estimated source emissions from TA-18 (µCi/yr).

Year	U
1943–1978	No source estimates for these years
1979	3.95E+00
1980–2001	No source estimates for these years
2002	
2003	

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Table A-9. Estimated source emissions from TA-21 (µCi/yr).

Year	Am-241	H-3	Pu	U	MFP
1943–1947	No source estimates for these years (see TA-1 data)				
1948			1.55E+05		
1949			1.55E+05		
1950			1.85E+05		
1951			2.70E+04		
1952			5.70E+04		
1953			3.50E+04		
1954			2.20E+04		
1955			8.80E+04		
1956			7.60E+04		
1957			7.40E+04		
1958			8.00E+04		
1959			1.86E+05		
1960			3.53E+04		
1961			6.24E+03		
1962			7.99E+03	6.29E+03	
1963			2.87E+04	3.05E+04	
1964			1.24E+04	2.31E+03	
1965			9.31E+03	9.13E+03	
1966			1.04E+04	1.00E+04	
1967			9.99E+03	6.91E+03	
1968			1.94E+03	1.30E+03	
1969			4.17E+03	3.56E+03	
1970			2.82E+03	1.03E+03	
1971		5.00E+06	1.79E+03	1.18E+03	
1972			2.17E+03	1.20E+03[a]	
1973		4.00E+06[b]	1.40E+03	9.08E+02	1.00E+00
1974			5.71E+00	6.00E+02	2.90E+00
1975		3.06E+08	1.11E+01	7.21E+02	1.44E+00
1976		9.50E+07	1.22E+01	8.70E+02	5.50E-01
1977		1.33E+08	9.99E+00	3.17E+02	3.26E+00
1978	3.40E-02		3.07E+01	3.05E+02	1.03E+00
1979	1.90E-02	9.49E+07	6.46E+00	6.55E+02	4.68E-01
1980	6.10E-02	1.06E+08	2.27E+00	6.33E+02	4.18E+00
1981	2.90E-02	1.08E+08	1.31E+01	1.02E+03	2.80E+00
1982	3.50E-02	1.69E+08	1.58E+01	1.04E+03	4.35E-01
1983	9.50E-02	1.80E+08	9.92E+00	7.06E+02	7.94E-01
1984		8.02E+08	1.73E+01	9.90E+02	3.14E-01
1985		3.67E+08	1.06E+01	3.82E+02	3.61E-01
1986		4.48E+08	3.57E+00	2.12E+02	3.24E-01
1987		5.96E+08	1.43E+00	2.07E+02	1.88E-01
1988		5.28E+08	7.13E-01	5.88E+01	1.54E-01
1989		4.55E+08	1.39E+00	2.89E+01	3.10E-02
1990		4.39E+08	9.01E-01	4.32E+01	1.30E-02
1991		3.24E+08	8.45E-01	9.20E+01	3.00E-02
1992		4.29E+08	8.70E-01	5.20E+01	2.40E-02
1993		4.26E+08	8.10E-01	5.17E+01	1.00E-02
1994		3.32E+08	2.40E+00	1.82E+02	5.00E-02
1995	7.72E-03	7.12E+08	6.41E-01	1.71E+00	

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Year	Am-241	H-3	Pu	U	MFP
1996		3.90E+08			
1997		2.10E+08			
1998		4.60E+08			
1999		4.90E+08			
2000		9.40E+08			
2001		4.90E+08			
2002					
2003					

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.
b. Value taken from LASL (1973) due to inconsistencies in database for 1973.

Table A-10. Estimated source emissions from TA-33 (µCi/yr).

Year	H-3	U
1943–1965	No source estimates for these years	
1966		1.00E+04
1967–1970	No source estimates for these years	
1971	4.10E+09	
1972	2.90E+09[a]	
1973	3.90E+09[b]	
1974	5.92E+09	
1975	3.48E+09	
1976	1.35E+09	
1977	3.70E+10	
1978	1.78E+10	
1979	1.05E+10	
1980	6.97E+09	
1981	6.09E+09	
1982	1.36E+10	
1983	4.41E+09	
1984	7.11E+09	
1985	4.87E+09	
1986	6.66E+09	
1987	1.00E+09	
1988	No source estimates for this year	
1989	1.77E+09	
1990	8.54E+08	
1991	2.54E+08	
1992	3.18E+08	
1993	3.50E+08	
1994	4.56E+08	
1995	1.09E+08	
1996	No source estimates for this year	
1997	4.30E+07	
1998	6.50E+07	
1999	9.40E+08	
2000	1.20E+09	

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Year	H-3	U
2001	4.60E+08	
2002		
2003		

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.
b. Value taken from LASL (1973) due to inconsistencies in database for 1973.

Table A-11. Estimated source emissions from TA-35 (µCi/yr).

Year	Am-241	H-3	Pu	U	MFP	P/VAP
1943–1966	No source estimates for these years					
1967			6.60E+00			
1968			5.90E+00			
1969			5.57E+00			
1970			4.21E+00			
1971		3.13E+09	7.37E+00			
1972		2.50E+09[a]	1.79E+01			
1973		1.23E+09	2.35E+00			
1974		1.40E+09	8.01E+00			
1975		2.39E+09	5.91E+00			
1976		1.66E+09	2.37E+00			
1977		7.86E+08	8.19E-01			
1978		6.76E+08	1.96E+00			
1979		1.30E+09	7.40E+00			
1980		2.50E+07	2.07E-01			
1981			2.66E-01			
1982			1.30E+00			
1983		6.00E+06	9.26E-01			
1984		2.06E+08	4.17E-01			
1985		5.28E+06	5.61E-01			
1986		4.76E+07	3.63E-01			
1987		1.55E+08	6.36E-01			
1988		1.18E+08	1.72E-01			
1989		1.82E+07	6.80E-01			
1990		4.00E+04	8.95E-01			
1991		4.30E+00	1.22E+00			
1992		1.00E+05	3.58E-01			
1993		MDA[b]	2.70E-01			
1994			3.90E-01			
1995	3.55E-02		2.97E-01	6.93E-01	1.63E+00	1.63E+00
1996–2001	No source estimates for these years					
2002						
2003						

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.
b. MDA = minimum detectable activity.

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Table A-12. Estimated source emissions from TA-36 (µCi/yr).

Year	U
1943–1957	No source estimates for these years
1958	4.30E+04
1959	8.00E+03
1960	1.40E+04
1961	No source estimates for this year
1962	1.00E+04
1963	1.40E+04
1964	4.00E+03
1965	2.00E+04
1966	2.80E+04
1967	4.80E+04
1968	2.70E+04
1969	1.90E+04
1970	6.00E+03
1971	1.00E+04
1972	4.00E+03
1973–2001	No source estimates for these years
2002	
2003	

Table A-13. Estimated source emissions from TA-39 (µCi/yr).

Year	U
1943–53	No source estimates for these years
1954	1.91E+05
1955	1.48E+05
1956	1.73E+05
1957	2.66E+05
1958	2.85E+05
1959	1.89E+05
1960	1.16E+05
1961	1.63E+05
1962	1.63E+05
1963	1.26E+05
1964	1.15E+05
1965	1.07E+05
1966	1.23E+05
1967	2.00E+05
1968	5.00E+04
1969	6.60E+04
1970	5.10E+04
1971	8.70E+04
1972	1.10E+05
1973–2001	No source estimates for these years
2002	
2003	

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Table A-14. Estimated source emissions from TA-41 (µCi/yr).

Year	H-3	Pu	U
1943–1966	No source estimates for these years		
1967		1.20E+02	
1968		3.30E+01	
1969		9.00E+00	
1970		7.80E+00	
1971	3.20E+08	1.90E+01	
1972	1.10E+08[a]	1.10E+01	
1973	5.90E+07	1.52E+00	
1974–1978	No source estimates for these years		
1979	1.43E+08		
1980	4.14E+08		
1981	1.26E+08		
1982	1.30E+08		
1983	9.74E+08		
1984	4.78E+09		
1985	1.27E+09		
1986	1.32E+09		
1987	4.70E+08		
1988	1.73E+09		
1989	1.16E+10		
1990	4.44E+09		
1991	3.84E+09		
1992	2.92E+08		
1993	4.83E+08	1.00E-02	
1994	1.72E+08	2.00E-02	
1995	7.85E+07	1.56E-02	9.02E-03
1996	1.10E+08		
1997	4.20E+07		
1998	3.60E+07		
1999	1.30E+07		
2000	6.30E+06		
2001	5.30E+08		
2002			
2003			

a. Value taken from LASL (1972) due to inconsistencies or omissions noted in database for 1972.

Table A-15. Estimated source emissions from TA-42 (µCi/yr).

Year	Pu source
1943–1968	No source estimates for these years
1969	8.10E+02
1970–2001	No source estimates for this year
2002	
2003	

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Table A-16. Estimated source emissions from TA-43 (µCi/yr).

Year	Am-241	Pu	U
1943–1972	No source estimates for these years		
1973		4.80E-01	
1974		6.91E+00	
1975		1.65E+00	
1976		7.72E+00	
1977		4.65E+00	
1978		1.55E+00	
1979		7.55E-01	
1980		1.84E-01	
1981		3.68E-01	
1982		1.39E+00	
1983		3.33E+00	
1984		1.05E+00	
1985		1.80E+00	
1986		2.91E+00	
1987		5.06E-01	
1988		1.46E+00	
1989–1994	No source estimates for these years		
1995	2.69E-01	5.27E-01	1.12E+00
1996–2001	No source estimates for these years		
2002			
2003			

Table A-17. Estimated source emissions from TA-46 (µCi/yr).

Year	U source
1950–70	Operations started in 1950; no source estimates for these years
1971	4.00E+00
1972	1.20E+02[a]
1973	2.17E+00
1974	4.10E-01
1975	5.20E-01
1976	3.10E-01
1977	4.00E-03
1978	2.53E+01
1979	2.27E+00
1980	1.48E+00
1981	1.38E+01
1982	2.03E+00
1983	3.60E-02
1984	5.10E-02
1985	2.80E-02
1986	4.00E-03
1987–2001	No source estimates for these years
2002	
2003	

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.

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Table A-18. Estimated source emissions from TA-48 (µCi/yr).

Year	Am-241	Pu	U	MFP	P/VAP	G/MAP
195X–1966	Started operations in mid 1950s; no source estimates for these years					
1967		1.10E+02				
1968		1.50E+02				
1969		1.30E+02				
1970		5.70E+01				
1971		1.89E+01				
1972		1.13E+02	8.00E+00[a]			
1973		1.98E+01	1.96E+00	1.02E+03		
1974		2.39E+01	1.26E+00	9.41E+02		
1975		1.23E+01	3.44E+00	7.22E+02		
1976		5.02E+00	1.12E+02	1.23E+03		
1977		8.38E+00	5.52E+01	2.19E+03		
1978		1.91E+00	1.12E+01	1.17E+03		
1979		3.36E-01	1.08E+01	1.07E+03		
1980		1.57E+00	6.66E-01	1.75E+03		
1981		1.32E+00	2.31E+00	1.37E+03		
1982		9.95E+00	7.33E+00	1.09E+03		
1983		3.30E+00	5.11E-01	8.16E+02		
1984		2.55E+00	1.34E+00	1.57E+03		
1985		2.07E+00	1.91E+00	1.21E+03		
1986		2.85E+00	6.11E-01	2.50E+03		
1987		6.15E-01	1.58E+00	1.25E+03		
1988		7.24E-01	2.20E-01	1.11E+03		
1989		1.49E+00	2.70E-01	4.35E+05		
1990		1.48E+00	1.70E-01	1.04E+03		
1991		5.86E-01		1.08E+03	1.00E+05	1.78E+05
1992		6.72E+00	4.17E-01	2.74E+03	3.79E+04	
1993		3.16E+00	1.42E+00	1.35E+03	7.59E+04	
1994		3.22E+00	4.00E-01	3.90E+02	8.13E+04	
1995	1.71E+00	3.10E+00	5.37E-01	2.64E+04	2.64E+04	
1996	5.00E-03	1.10E-02			1.00E+02	
1997	3.60E-04	2.50E-03	1.40E-01		1.80E+03	
1998	3.70E-04				1.10E+02	
1999			6.10E-04		3.90E+03	
2000					1.70E+04	
2001					2.30E+03	
2002						
2003						

a. Value taken from LASL (1972) due to inconsistencies or omissions in database for 1972.

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Table A-19. Estimated source emissions from TA-50 (µCi/yr).

Year	Am-241	Pu	Th-232	U	MFP
1943–1966	No source estimates for these years				
1967		1.01E+02			
1968		6.88E+01			
1969		4.20E+01			
1970		2.04E+01			
1971		1.60E+01			
1972		2.74E+01			
1973		2.49E+00			1.72E+01
1974		3.90E+00			8.83E+01
1975		4.11E+00			4.22E+01
1976		1.10E+00			2.75E+01
1977		6.96E+01			8.58E+01
1978		1.74E+01			3.99E+01
1979		2.90E+00			1.06E+01
1980		1.17E+00			8.25E+00
1981		1.79E+00			2.42E+01
1982		6.54E+00			1.45E+01
1983		5.55E+00			9.08E+00
1984		3.67E+00			8.90E+00
1985		2.02E+00			8.49E+00
1986		2.88E+00			2.01E+01
1987		4.51E+00			2.16E+01
1988		2.05E+00			1.38E+01
1989		4.59E-01			9.78E+00
1990		1.48E-01			3.92E+00
1991		1.38E+00			3.09E+00
1992		5.50E-01			3.57E+00
1993		2.80E-01			3.75E+00
1994		3.10E-01			6.79E+00
1995	6.26E-02	7.21E-01			
1996	1.10E-02	4.20E-02		1.90E-01	
1997	8.40E-03	5.41E-02		1.30E-03	
1998	6.50E-03	1.50E-02	7.70E-02	1.90E-01	
1999	1.30E-01	5.11E-02	3.70E-02	1.90E-02	
2000		9.80E-03	5.30E-02		
2001	5.80E-05	4.30E-02			
2002					
2003					

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Table A-20. Estimated source emissions from TA-53 (µCi/yr).

Year	H-3	I-131	P/VAP	G/MAP
1943–1973	No source estimates for these years			
1974				1.00E-02
1975				1.00E-02
1976	1.71E+08			5.89E+09
1977	2.90E+08			4.76E+10
1978				1.17E+11
1979				1.19E+11
1980				1.46E+11
1981	6.59E+06			3.53E+11
1982	2.72E+05		1.8E+08	2.51E+11
1983			2.6E+09	4.61E+11
1984	2.70E+07		2.5E+09	7.34E+11
1985	6.96E+06		2.0E+05	1.26E+11
1986	6.10E+06		1.0E+05	1.12E+11
1987	1.52E+07		2.0E+05	1.50E+11
1988	4.27E+06		1.0E+05	1.21E+11
1989	8.20E+06		1.0E+05	1.56E+11
1990	2.84E+06		8.0E+04	1.23E+11
1991	8.87E+05		2.0E+05	5.72E+10
1992	4.21E+07		7.3E+05	7.20E+10
1993	4.86E+07		1.0E+07	3.20E+10
1994	1.46E+07		3.1E+05	5.00E+10
1995	3.17E+06		2.9E+05	4.36E+10
1996	4.80E+06	3.50E+02	1.4E+05	1.10E+10
1997	1.70E+07		9.0E+05	2.00E+10
1998	3.80E+06		3.3E+06	7.80E+09
1999	2.30E+06		2.5E+03	3.00E+08
2000	2.90E+06		9.3E+05	6.90E+08
2001	6.37E+06		1.1E+06	5.90E+09
2002				
2003				

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Table A-21. Estimated source emissions from TA-54 (µCi/yr).

Year	Pu	U
1943–1976	No source estimates for these years	
1977	3.00E-03	
1978	2.60E-02	
1979	1.30E-02	
1980	3.00E-03	
1981	1.00E-02	
1982	2.00E-02	
1983	2.00E-03	
1984	2.30E-02	
1985	6.00E-03	
1986	1.65E-01	
1987	2.60E-02	
1988	1.40E-02	
1989	2.20E-02	
1990	8.40E-02	
1991	4.50E-02	
1992	1.00E-02	
1993	<MDA	
1994	1.00E-02	
1995	8.48E-04	
1996		
1997		2.80E-02
1998–2001	No source estimates for these years	
2002		
2003		

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Table A-22. Estimated source emissions from TA-55 (µCi/yr).

Year	Am-241	H-3	Pu	Th-232	U
1943–1977	No source estimates for these years				
1978			3.99E-01		
1979			1.08E-01		
1980			2.94E-01		
1981			9.70E-02		
1982		1.87E+07	2.59E+00		
1983		4.42E+07	1.07E+00		
1984		1.52E+08	1.04E+00		
1985			1.07E+00		
1986		1.01E+09	2.34E-01		
1987		8.54E+07	2.45E-01		
1988		3.14E+08	1.53E+01		
1989		2.66E+08	2.22E+00		
1990		1.67E+08	4.68E-01		
1991		9.12E+07	2.00E+00		
1992		1.02E+08	1.12E+00		
1993		6.46E+07	1.70E-01		
1994		2.26E+07	1.20E-01		
1995	5.45E-03	1.56E+07	1.63E-02		
1996	3.10E-02	3.10E+07	8.85E-02		5.50E-02
1997		1.20E+07	1.10E-01	4.40E-02	
1998	3.80E-03	1.20E+07	6.20E-02	3.00E-02	
1999	5.40E-02	1.80E+06	6.30E-02		7.10E-02
2000	3.30E-01	6.40E+06	2.50E+00		
2001	6.20E-03	3.30E+06	4.30E-02	1.50E-01	1.70E-01
2002					
2003					

ATTACHMENT B
SCREENING ESTIMATES

Table B-1 presents results of a screening analysis to identify radionuclides of potential significance to inhalation dose. The analysis, described in Section 4.2.1.2, evaluated the potential 50-year effective committed inhalation dose that would be associated with the maximum annual reported emission of each radionuclide from data in Tables A-1 through A-22. Inhalation doses were calculated by estimating maximum air concentrations using a screening-level dispersion model and assuming an annual inhalation rate of 3,400 m^3/yr and maximum effective dose factors from the CD1 compilation for ICRP 68 (ICRP 2001). An AMAD of 5 µm was assumed for all airborne particulates. For elements, or groups of elements, for which specific isotopes were not specified (i.e., plutonium, uranium, MFPs, and P/VAPs), a representative dose factor was selected that maximized the dose calculations for that group.

Table B-1. Results of screening analysis to identify potentially significant contributors to inhalation dose.

Year	Maximum total effective dose (Sv/yr)	Radionuclides contributing to ≥95% of dose
1944	2.98E-02	^{140}La, U
1945	5.05E-01	^{140}La, Pu
1946	5.89E-01	^{140}La, Pu
1947	7.18E-01	^{140}La, Pu
1948	3.87E-01	^{140}La, Pu, U
1949	7.66E-01	^{140}La, Pu, U
1950	9.51E-01	^{140}La, Pu, U
1951	2.08E-01	Pu, U
1952	3.39E-01	^{140}La, Pu, U
1953	1.95E-01	^{140}La, Pu, U
1954	4.92E-01	^{140}La, U
1955	1.04E+00	^{140}La, U
1956	8.88E-01	^{140}La, U
1957	5.26E-01	^{140}La, Pu, U
1958	3.53E-01	^{140}La, Pu, U
1959	3.15E-01	^{140}La, Pu, U
1960	2.06E-01	^{140}La, Pu, U
1961	6.12E-01	^{140}La, U
1962	3.43E-01	^{140}La, U
1963	5.20E-02	Pu, U
1964	6.40E-02	Pu, U
1965	6.02E-02	Pu, U
1966	9.68E-02	U
1967	8.33E+02	^{232}Th
1968	8.33E+02	^{232}Th
1969	4.83E-02	Pu, U
1970	4.36E-02	^{3}H, Pu, U
1971	5.60E-02	Pu, U
1972	2.04E-02	Pu, U
1973	4.31E-04	^{3}H, Pu, U
1974	2.27E-03	^{3}H, Pu
1975	1.16E-03	^{3}H, Pu, U
1976	5.33E-04	^{3}H, U
1977	9.63E-03	^{3}H
1978	4.66E-03	^{3}H
1979	7.73E-03	^{3}H, Pu

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Year	Maximum total effective dose (Sv/yr)	Radionuclides contributing to ≥95% of dose
1980	2.21E-03	^{3}H, Pu
1981	1.69E-03	^{3}H, U
1982	2.80E-02	^{3}H, P/VAP
1983	3.54E-01	P/VAP
1984	3.36E-01	P/VAP
1985	1.41E-03	^{3}H, Pu
1986	1.89E-03	^{3}H, Pu
1987	4.01E-04	^{3}H, P/VAP, Pu, U
1988	2.24E-03	^{3}H
1989	3.36E-03	^{3}H, MFP
1990	1.19E-03	^{3}H
1991	1.06E-03	^{3}H, P/VAP
1992	4.37E-04	^{3}H, P/VAP, U
1993	1.97E-03	^{3}H, P/VAP, U
1994	9.31E-04	^{3}H, U
1995	4.57E-04	^{3}H, MFP, P/VAP, Pu

ATTACHMENT C
AIR CONCENTRATIONS
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Tables C-1 through C-29 provide estimated average air concentrations for TAs at LANL for which air-monitoring and/or emissions data were available. Air-monitoring data, when available, formed the basis for estimates at each TA. For some TAs, more than one monitoring station was active during many years. In these cases, the concentrations were averaged over all stations in the TA. For years and locations when monitoring data were not available, an estimate was made based on the relationship between source emission rate and air concentration for years when data were available (see Section 4.2.1.3). Blank values in these tables indicate no data.

Table C-1. Estimated average air concentrations for ^{239}Pu for TA-1 (pCi/m^3).[a]

Year	Pu-239 average air concentration
1943–1944	Not available[b]
1945	4.6E-01
1946	5.8E-01
1947	9.3E-01
1948–1975	Not available[b]
1976–2003	TA was decontaminated in 1975

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

Table C-2. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-2 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1986	Not available[b]			
1987		2.7E+01	1.0E-06	5.3E-05
1988		7.8E+01	2.3E-05	7.1E-05
1989		2.3E+01	2.2E-06	1.0E-04
1990		1.1E+01	1.3E-06	3.7E-05
1991		5.2E+00	5.0E-07	7.5E-05
1992		4.3E+00	1.5E-06	3.7E-05
1993		2.5E+00	6.4E-06	2.7E-05
1994		4.2E+00	3.1E-06	1.7E-05
1995	5.2E-06	3.4E+00	6.2E-06	4.2E-05
1996	Not available[b]			
2000	0.00E+00	1.8E+00	1.5E-06	1.8E-05
2001–2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-2, averaged over results reported at locations within the TA (LANL 2003).
b. Source term estimates or measured air concentrations not available during these years.

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AIR CONCENTRATIONS
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Table C-3. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, ^{232}Th, ^{234}U, MFP, and P/VAP for TA-3 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	Th-232	U-234	MFP	P/VAP
1943–1951	Not available[b]							
1952				2.2E-05[c]				
1953				5.1E-04[c]				
1954				2.9E-03[c]				
1955				4.2E-03[c]				
1956				3.3E-03[c]				
1957				2.5E-03[c]				
1958				7.1E-03[c]				
1959				2.0E-03[c]				
1960				6.5E-03[c]				
1961				4.2E-03[c]				
1962				4.0E-03[c]				
1963			1.4E+00[c]	1.9E-03[c]				
1964			6.5E-01[c]	1.4E-03[c]				
1965			8.4E-01[c]	3.5E-03[c]				
1966				4.1E-03[c]				
1967				9.2E-03[c]				
1968				1.3E-02[c]				
1969				2.6E-02[c]				
1970				3.0E-02[c]				
1971		2.0E+02	1.0E-02	2.8E-04		2.6E-04		
1972	3.2E-05	3.3E+01	1.6E-02[c]	1.4E-04		7.8E-05		
1973	7.0E-06	3.5E+01	9.3E-03[c]	1.4E-04	3.4E-05[c]	1.6E-04	2.8E-02[c]	
1974			1.0E-02[c]	3.2E-03[c]		4.4E-04[c]	7.5E-04[c]	
1975		4.8E+01	3.0E-03[c]	9.2E-04[c]		4.3E-04[c]	4.0E-04[c]	
1976			6.6E-04[c]	8.7E-05[c]		8.0E-04[c]	9.1E-04[c]	
1977		8.8E+02[c]	1.9E-04[c]	7.4E-05[c]		7.4E-04[c]	1.1E-03[c]	
1978		2.2E+02[c]	1.8E-04[c]	1.3E-04[c]		4.1E-04[c]	8.9E-04[c]	
1979		6.6E+03[c]	3.5E-04[c]	2.4E-03[c]		5.7E-04[c]	1.0E-03[c]	
1980		1.0E+01[c]	2.1E-04[c]	1.6E-03[c]		3.4E-04[c]	9.3E-04[c]	
1981		2.0E+03[c]	9.7E-05[c]	8.7E-05[c]		5.2E-04[c]	3.8E-04[c]	
1982		4.3E+03[c]	1.7E-03[c]	1.6E-04[c]		7.1E-04[c]	1.7E-04[c]	
1983		5.0E+03[c]	1.8E-04[c]	1.9E-04[c]		4.0E-04[c]	3.8E-05[c]	
1984		3.9E+03[c]	1.6E-04[c]	2.5E-04[c]		4.7E-04[c]	9.1E-05[c]	
1985		4.7E+03[c]	3.2E-04[c]	4.3E-04[c]		7.6E-04[c]	7.6E-05[c]	
1986		2.7E+03[c]	8.4E-05[c]	4.3E-04[c]		1.4E-03[c]	1.1E-04[c]	
1987		1.9E+03[c]		1.4E-04[c]		1.9E-03[c]	4.8E-05[c]	
1988		1.8E+04[c]		1.1E-04[c]		1.1E-03[c]	6.5E-05[c]	
1989		6.4E+02[c]		8.6E-05[c]		8.0E-04[c]	8.4E-05[c]	
1990		1.1E+03[c]		4.8E-05[c]		4.3E-04[c]	8.6E-05[c]	
1991	1.5E-06	1.5E+01		1.2E-06		9.3E-05	3.1E-05[c]	
1992	3.2E-06	2.7E+01		2.5E-06		3.6E-05	1.9E-05[c]	
1993	1.9E-05	5.3E+00		5.6E-05		1.4E-05	1.3E-05[c]	
1994	5.8E-06	2.0E+00		3.2E-06		3.7E-05	8.4E-05[c]	
1995	1.4E-05	6.0E+00		2.9E-06		2.0E-05	2.1E-03[c]	2.1E-03[c]
1996	1.5E-06	1.3E+00		2.7E-06	3.6E-07[c]	2.3E-05		
1997	2.5E-06	3.6E+00		2.7E-06	8.4E-07[c]	1.7E-05		
1998	3.5E-06	2.7E+00		4.0E-07	9.2E-07[c]	1.5E-05		1.5E-05[c]

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Year	Am-241	H-3	I-131	Pu-239	Th-232	U-234	MFP	P/VAP
1999	2.2E-06	2.7E+00		2.7E-06	4.8E-07[c]	1.9E-05		
2000	0.0E+00	2.4E+00		2.6E-06	2.9E-07[c]	3.0E-05		
2001	0.0E+00	3.1E+00		6.0E-07	3.1E-07[c]	2.7E-05		
2002–2003	Not available[b]							

a. From AIRNET database of summarized measured concentrations for TA-3, averaged over results reported at locations in the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 of 2.2×10^{-12} yr/m^3.

Table C-4. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-5 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1972	Not available[b]			
1973		1.0E+02	1.9E-05	4.7E-04
1974		8.1E+01	2.4E-05	1.6E-04
1975		1.7E+02	2.2E-05	1.1E-04
1976		1.2E+02	4.9E-06	9.5E-05
1977		5.7E+01	2.2E-05	1.3E-04
1978		1.6E+01	2.9E-05	9.5E-05
1979		1.5E+01	8.4E-06	1.2E-04
1980		1.7E+01	1.0E-06	8.7E-05
1981		4.4E+00	6.1E-06	6.5E-05
1982		2.5E+01	1.5E-06	6.5E-05
1983		1.7E+01	3.1E-06	7.4E-05
1984		1.8E+01	1.3E-06	5.7E-05
1985		1.2E+01	0.0E+00	5.0E-05
1986		9.8E+00	1.0E-06	4.1E-05
1987		1.9E+01	2.0E-07	6.1E-05
1988		1.5E+01	2.0E-07	1.1E-04
1989		3.5E+00	4.0E-07	1.2E-04
1990		3.2E+00	1.8E-06	5.0E-05
1991		3.7E+00	7.0E-07	8.6E-05
1992	1.4E-06	4.4E+00	8.0E-07	3.4E-05
1993		2.6E+00	1.5E-06	3.5E-05
1994		1.5E+00	1.2E-06	3.5E-05
1995	3.4E-06	2.4E+00	4.4E-06	4.8E-05
1996	2.5E-06	1.1E+00	1.2E-06	5.6E-05
1997	2.4E-06	5.5E+00	5.0E-07	2.4E-05
1998	2.0E-06	3.3E+01	1.0E-06	2.4E-05
1999	3.6E-06	2.2E+00	2.0E-07	2.1E-05
2000	3.0E-07	2.7E+00	2.0E-06	5.4E-05
2001	0.0E+00	4.2E+00	0.0E+00	3.4E-05
2002–2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-3, averaged over results reported at locations in the TA (LANL 2003).
b. Source term estimates or measured air concentrations not available during these years.

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Table C-5. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-6 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1970	Not available[b]			
1971		3.6E+01	4.1E-05	3.7E-04
1972		2.9E+01	1.5E-04	9.3E-05
1973				
1974		1.6E+01	2.6E-05	7.8E-05
1975	1.1E-05	2.2E+01	5.5E-05	4.2E-05
1976		2.5E+01	3.9E-06	9.1E-05
1977	3.0E-07	2.5E+01	1.7E-05	2.6E-04
1978	3.0E-07	5.0E+00	2.7E-05	1.1E-04
1979	0.0E+00	2.8E+00	3.3E-06	5.1E-05
1980	1.0E-07	3.8E+00	2.6E-06	4.3E-05
1981	4.5E-05	6.7E+00	5.7E-06	5.0E-05
1982	2.0E-07	1.1E+01	1.2E-06	4.8E-05
1983		1.1E+01	1.2E-06	5.3E-05
1984		4.4E+00	1.2E-06	3.1E-05
1985		8.3E+00	1.9E-06	6.0E-05
1986	3.1E-06	3.6E+00	1.2E-06	5.8E-05
1987	1.5E-06	1.1E+01	6.0E-07	6.2E-05
1988	6.4E-06	9.4E+00	7.0E-07	8.1E-05
1989	2.8E-06	2.3E+00	4.6E-06	1.0E-04
1990	1.6E-06	1.4E+00	2.1E-06	7.2E-05
1991	9.0E-07	1.6E+00	1.0E-06	8.3E-05
1992	4.5E-06	2.7E+00	1.7E-06	2.7E-05
1993	1.5E-06	3.3E+00	2.2E-06	2.2E-05
1994	4.1E-06	1.3E+00	8.0E-07	2.8E-05
1995	5.7E-06	3.6E+00	1.2E-05	2.1E-05
1996		0.0E+00		
1997–2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-3, averaged over results reported at locations within the TA (LANL 2003).
b. Source term estimates or measured air concentrations not available during these years.

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Table C-6. Estimated average air concentrations for ^{3}H for TA-9 (pCi/m^3).[a]

Year	H-3
1943–1971	Not available[b]
1972	1.5E+03
1973	7.9E+01
1974	2.9E+00
1975	Not available[b]
1976	2.8E+02
1977	5.7E+01
1978	5.7E+00
1979	1.1E+01
1980	1.1E+01
1981–2003	Not available[b]

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

Table C-7. Estimated average air concentrations for ^{234}U for TA-10 (pCi/m3).[a]

Year	U-234
1943	Not available[b]
1944	2.2E-02
1945	2.2E-02
1946	6.6E-02
1947	8.8E-02
1948	1.3E-01
1949	2.2E-01
1950	1.1E+00
1951	4.4E-01
1952	4.4E-01
1953	4.4E-01
1954	8.8E-03
1955	7.3E-02
1956	7.7E-02
1957	2.4E-02
1958	1.5E-02
1959	2.6E-02
1960	1.5E-02
1961	1.9E+00
1962	4.0E-01
1963	1.1E-01
1964–2003	Not available[b]

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

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Table C-8. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-11 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1970	Not available[b]			
1971		4.2E+01	4.7E-05	1.4E-04
1972	3.3E-05	2.4E+01	4.8E-05	9.3E-05
1973		1.3E+01	2.3E-05	1.6E-04
1974–2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-3, averaged over results reported at locations within the TA (LANL 2003).
b. Source term estimates or measured air concentrations not available during these years.

Table C-9. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, ^{232}Th, and ^{234}U for TA-15 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	Th-232	U-234
1944					1.3E-01[b]
1945					2.6E-01[b]
1946					5.3E-01[b]
1947					7.9E-01[b]
1948					1.2E+00[b]
1949					1.9E+00[b]
1950					9.9E+00[b]
1951					4.4E+00[b]
1952					4.0E+00[b]
1953					3.5E+00[b]
1954					3.3E+00[b]
1955					2.6E+00[b]
1956					1.7E+00[b]
1957					2.6E+00[b]
1958					2.4E+00[b]
1959					1.1E+00[b]
1960					1.6E+00[b]
1961					7.7E-01[b]
1962					1.0E+00[b]
1963					8.7E-01[b]
1964					1.3E+00[b]
1965					1.3E+00[b]
1966					2.1E+00[b]
1967		7.9E+03[b]		4.4E+03[b]	1.6E+00[b]
1968		9.9E+03[b]		4.4E+03[b]	1.2E+00[b]
1969		9.9E+03[b]			9.4E-01[b]
1970		6.3E+04[b]			6.8E-01[b]
1971		8.2E+01	4.2E-05		7.0E-04
1972	2.2E-05	2.8E+01	5.1E-05		9.3E-05
1973	2.0E-06	2.1E+01	1.6E-05		3.1E-04
1974–1977	Not available[c]				
1978		1.6E+02[b]			
1979–1991	Not available[c]				
1992					5.0E-03b
1993		1.1E+00			1.1E-02b

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Year	Am-241	H-3	Pu-239	Th-232	U-234
1994		2.0E+00	4.0E-07		6.7E-05
1995	5.1E-06	1.8E+00	3.7E-06		1.4E-05
1996	2.3E-06	1.1E+00	1.4E-06		5.2E-05
1997	2.0E-06	1.9E+00	6.5E-07		2.9E-05
1998	2.2E-06	2.1E+00	8.0E-07		1.4E-05
1999	2.3E-06	1.7E+00	8.0E-07		1.9E-05
2000	4.0E-07	1.8E+00	5.0E-08		2.7E-05
2001	2.5E-07	2.3E+00	0.0E+00		6.6E-05
2002	2.0E-08	2.8E+00	0.0E+00		3.8E-05
2003	Not available[c]				

a. From AIRNET database of summarized measured concentrations for TA-15, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2 × 10^{-12} yr/m^3.
c. Source term estimates or measured air concentrations not available during these years.

Table C-10. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, and ^{234}U for TA-16 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	U-234
1943–1953	Not available[b]				
1954					8.4E-02[c]
1955					
1956					
1957					3.1E-02[c]
1958					
1959					2.2E-03[c]
1960					1.1E-01[c]
1961					
1962					
1963					1.1E-01[c]
1964					6.6E-03[c]
1965					8.8E-03[c]
1966					
1967					1.1E-02[c]
1968					8.6E-02[c]
1969					6.6E-03[c]
1970					2.4E-02[c]
1971		4.5E+01	1.0E-02	6.1E-05	3.2E-04
1972	4.0E-05	3.1E+01		5.7E-05	9.3E-05
1973	3.0E-06	1.6E+01		2.8E-05	1.6E-04
1974		1.2E+01		3.0E-05	1.1E-04
1975	4.0E-06	1.8E+01		1.9E-05	4.0E-05
1976		2.0E+01		4.7E-06	5.4E-05
1977	0.0E+00	3.0E+01		1.9E-05	4.3E-04
1978	0.0E+00	6.0E+00		3.6E-05	7.4E-05
1979	0.0E+00	2.2E+00		2.0E-05	4.0E-05
1980	0.0E+00	1.1E+01		1.1E-06	4.7E-05
1981	1.9E-06	1.9E+00		3.6E-06	3.6E-05
1982	3.0E-07	1.0E+01		1.0E-06	3.6E-05
1983		1.1E+01		5.5E-07	3.6E-05
1984		1.3E+01		0.0E+00	2.0E-05

Year	Am-241	H-3	I-131	Pu-239	U-234
1985		9.5E+00		3.9E-06	4.3E-05
1986	2.7E-06	4.7E+00		6.0E-07	2.1E-05
1987	1.0E-06	9.9E+00		7.5E-07	2.9E-05
1988	1.9E-06	4.3E+00		8.5E-07	5.3E-05
1989	2.4E-06	2.7E+00		6.0E-07	9.1E-05
1990	2.8E-06	1.1E+00		1.6E-06	5.2E-05
1991	1.2E-06	5.0E-01		1.0E-06	6.1E-05
1992	1.1E-06	1.6E+00		6.0E-06	2.8E-05
1993		9.0E-01		5.0E-07	1.9E-05
1994		9.1E+00		0.0E+00	2.6E-05
1995	4.6E-06	1.8E+02		3.3E-06	1.9E-05
1996	1.8E-06	2.4E+01		4.0E-07	2.7E-05
1997	2.2E-06	6.2E+01		8.0E-07	1.9E-05
1998	2.6E-06	2.5E+02		9.0E-07	2.9E-05
1999	3.2E-06	5.5E+01		1.2E-06	1.5E-05
2000	0.0E+00	6.1E+01		0.0E+00	1.4E-05
2001	2.0E-07	6.8E+01		0.0E+00	1.9E-05
2002–2003	Not available[b]				

a. From AIRNET database of summarized measured concentrations for TA-16, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.

Table C-11. Estimated average air concentrations for ^{234}U for TA-18 (pCi/m^3).[a]

Year	U-234
1943–1978	Not available[b]
1979	8.7E-06
1980–2003	Not available[b]

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

Table C-12. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, ^{234}U, and MFP for TA-21 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	U-234	MFP
1943–1947	Not available[b]					
1948				3.4E-01[c]		
1949				3.4E-01[c]		
1950				4.1E-01[c]		
1951				5.9E-02[c]		
1952				1.3E-01[c]		
1953				7.7E-02[c]		
1954				4.8E-02[c]		
1955				1.9E-01[c]		
1956				1.7E-01[c]		
1957				1.6E-01[c]		
1958				1.8E-01[c]		
1959				4.1E-01[c]		
1960				7.8E-02[c]		

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Year	Am-241	H-3	I-131	Pu-239	U-234	MFP
1961				1.4E-02[c]		
1962				1.8E-02[c]	1.4E-02[c]	
1963				6.3E-02[c]	6.7E-02[c]	
1964				2.7E-02[c]	5.1E-03[c]	
1965				2.0E-02[c]	2.0E-02[c]	
1966				2.3E-02[c]	2.2E-02[c]	
1967				2.2E-02[c]	1.5E-02[c]	
1968				4.3E-03[c]	2.9E-03[c]	
1969				9.2E-03[c]	7.8E-03[c]	
1970				6.2E-03[c]	2.3E-03[c]	
1971		8.5E+01		2.9E-05	1.2E-04	
1972		3.6E+01		8.4E-05	1.1E-04	
1973		1.5E+02		2.3E-05	1.6E-04	2.2E-06[c]
1974		6.8E+01		2.4E-05	7.8E-05	6.4E-06[c]
1975		6.4E+01		1.8E-05	4.8E-05	3.2E-06[c]
1976		4.0E+01		7.6E-06	6.5E-05	1.2E-06[c]
1977		5.2E+01		2.1E-05	1.5E-04	7.2E-06[c]
1978	7.5E-08[c]	2.3E+01		2.3E-05	1.5E-04	2.3E-06[c]
1979	4.2E-08[c]	3.8E+00		6.1E-06	1.3E-04	1.0E-06[c]
1980	1.3E-07[c]	1.1E+01		3.1E-05	1.1E-04	9.2E-06[c]
1981	6.4E-08[c]	5.6E+00		4.6E-06	5.6E-05	6.2E-06[c]
1982	7.7E-08[c]	1.6E+01		6.0E-06	1.5E-04	9.6E-07[c]
1983	2.1E-07[c]	2.0E+01		9.0E-07	4.8E-05	1.7E-06[c]
1984		8.8E+00		1.5E-06	1.0E-04	6.9E-07[c]
1985		1.6E+01		4.0E-07	6.6E-05	7.9E-07[c]
1986		1.6E+01		1.4E-06	5.4E-05	7.1E-07[c]
1987		5.2E+01		1.1E-06	5.4E-05	4.1E-07[c]
1988		4.0E+01		8.0E-07	8.1E-05	3.4E-07[c]
1989		1.7E+01		1.3E-06	1.3E-04	6.8E-08[c]
1990		1.3E+01		2.2E-06	7.6E-05	2.9E-08[c]
1991	0.0E+00	8.5E+00		1.9E-06	8.4E-05	6.6E-08[c]
1992	2.7E-06	9.4E+00	1.0E+00	2.5E-06	3.8E-05	5.3E-08[c]
1993	3.6E-06	4.2E+00		4.9E-06	2.8E-05	2.2E-08[c]
1994	6.4E-06	3.4E+00		6.6E-06	2.8E-05	1.1E-07[c]
1995	6.2E-06	8.0E+00		1.2E-05	3.2E-05	
1996	4.2E-06	3.1E+00		1.7E-05	2.5E-04	
1997	4.3E-06	4.8E+00		1.7E-05	2.1E-05	
1998	5.6E-06	1.1E+01		2.6E-05	1.6E-05	
1999	2.9E-06	6.1E+00		3.5E-06	2.2E-05	
2000	9.3E-07	7.3E+00		3.7E-06	2.0E-05	
2001	0.0E+00	7.2E+00		3.7E-06	2.6E-05	
2002–2003	Not available[b]					

a. From AIRNET database of summarized measured concentrations for TA-21, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-21 of 2.28×10^{-12} yr/m^3.

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Table C-13. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, and ^{234}U for TA-33 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	U-234
1943–1965	Not available[b]				
1966					2.2E-02[c]
1967–1870	Not available[b]				
1971		5.0E+02	1.0E-02	8.3E-05	1.2E-04
1972		1.8E+02		5.5E-05	1.4E-04
1973		6.0E+01		1.7E-05	3.1E-04
1974		1.4E+02		2.8E-05	1.1E-04
1975		1.6E+02		2.3E-05	3.9E-05
1976		5.9E+01		5.3E-06	6.4E-05
1977		8.0E+00		1.8E-05	1.2E-04
1978		2.5E+01		2.8E-05	9.5E-05
1979		4.0E+01		6.9E-06	6.0E-05
1980		4.4E+01		3.5E-06	7.0E-05
1981		3.0E+01		3.9E-06	5.6E-05
1982		8.8E+01		2.4E-06	5.7E-05
1983		3.6E+01		0.0E+00	3.3E-05
1984		5.6E+01		7.0E-06	2.8E-05
1985		1.1E+02		0.0E+00	3.0E-05
1986		3.1E+01		6.0E-07	2.2E-05
1987		2.0E+01		8.0E-07	5.1E-05
1988		5.8E+01		4.0E-07	1.5E-04
1989		1.8E+01		0.0E+00	8.2E-05
1990		7.9E+00		7.3E-06	8.7E-05
1991		3.2E+00		7.0E-07	1.9E-05
1992		3.7E+00		9.0E-07	1.5E-05
1993		3.0E+00		1.8E-06	1.6E-05
1994		1.8E+00		5.0E-07	1.5E-05
1995	3.9E-06	3.5E+00		1.5E-05	1.7E-05
1996		1.4E+00			
1997	3.1E-06	9.0E-01		1.4E-06	1.3E-05
1998	2.4E-06	1.3E+00		1.4E-06	1.5E-05
1999	2.5E-06	4.0E+00		1.2E-06	2.0E-05
2000	0.0E+00	3.4E+00		2.0E-07	1.1E-05
2001		3.3E+00		0.0E+00	1.4E-05
2002–2003					

a. From AIRNET database of summarized measured concentrations for TA-33, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.

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Table C-14. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, ^{234}U, MFP, and P/VAP for TA-35 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234	MFP	P/VAP
1943–1966	Not available[b]					
1967			1.5E-05			
1968			1.3E-05			
1969			1.2E-05			
1970			9.3E-06			
1971		6.9E+03	1.6E-05			
1972		5.5E+03	3.9E-05			
1973		2.7E+03	5.2E-06			
1974		3.1E+03	1.8E-05			
1975		5.3E+03	1.3E-05			
1976		3.7E+03	5.2E-06			
1977		1.7E+03	1.8E-06			
1978		1.5E+03	4.3E-06			
1979		2.9E+03	1.6E-05			
1980		5.5E+01	4.6E-07			
1981			5.9E-07			
1982			2.9E-06			
1983		1.3E+01	2.0E-06			
1984		4.5E+02	9.2E-07			
1985		1.2E+01	1.2E-06			
1986		1.0E+02	8.0E-07			
1987		3.4E+02	1.4E-06			
1988		2.6E+02	3.8E-07			
1989		4.0E+01	1.5E-06			
1990		8.8E-02	2.0E-06			
1991		9.5E-06	2.7E-06			
1992		2.2E-01	7.9E-07			
1993			5.9E-07			
1994			8.6E-07			
1995	7.8E-08		6.5E-07	1.5E-06	3.6E-06	3.6E-06
1996–2003	Not available[b]					

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2 × 10-12 yr/m^3.

b. Source term estimates or measured air concentrations not available during these years.

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Table C-15. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-36 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1957	Not available[b]			
1958				9.5E-02[c]
1959				1.8E-02[c]
1960				3.1E-02[c]
1961	Not available[b]			
1962				2.2E-02[c]
1963				3.1E-02[c]
1964				8.8E-03[c]
1965				4.4E-02[c]
1966				6.2E-02[c]
1967				1.1E-01[c]
1968				5.9E-02[c]
1969				4.2E-02[c]
1970				1.3E-02[c]
1971		3.8E+01	2.7E-05	9.5E-02
1972		2.9E+01	5.7E-05	1.8E-02
1973		2.9E+01	2.2E-05	3.1E-02
1974–1992	Not available[b]			
1993		1.1E+00		
1994		1.3E+00	1.2E-05	7.0E-05
1995	4.6E-06	3.7E+00	1.1E-05	9.0E-05
1996	1.5E-06	1.1E+00	8.0E-07	4.9E-05
1997	2.0E-06	1.4E+00	6.5E-07	3.8E-05
1998	2.1E-06	1.8E+00	2.5E-07	3.5E-05
1999	3.6E-06	1.7E+00	4.5E-07	3.5E-05
2000	5.0E-07	1.6E+00	1.5E-07	3.3E-05
2001	0.0E+00	2.5E+00	0.0E+00	1.5E-04
2002	2.0E-08	2.8E+00	0.0E+00	3.8E-05
2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-36, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2 × 10^{-12} yr/m^3.

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Table C-16. Estimated average air concentrations for ^{3}H, ^{239}Pu, and ^{234}U for TA-39 (pCi/m^{3}).[a]

Year	H-3	Pu-239	U-234
1943–1953	Not available[b]		
1954			4.2E-01[c]
1955			3.3E-01[c]
1956			3.8E-01[c]
1957			5.9E-01[c]
1958			6.3E-01[c]
1959			4.2E-01[c]
1960			2.6E-01[c]
1961			3.6E-01[c]
1962			3.6E-01[c]
1963			2.8E-01[c]
1964			2.5E-01[c]
1965			2.4E-01[c]
1966			2.7E-01[c]
1967			4.4E-01[c]
1968			1.1E-01[c]
1969			1.5E-01[c]
1970			1.1E-01[c]
1971			1.9E-01[c]
1972			2.4E-01[c]
1973–1976	Not available[b]		
1977	3.9E+01	1.0E-07	1.2E-04
1978	1.5E+01	3.5E-05	1.3E-04
1979	1.6E+01	3.7E-06	4.0E-05
1980	2.8E+01	4.4E-06	7.3E-05
1981	1.2E+01	2.0E-06	4.8E-05
1982	1.5E+02	2.7E-06	8.4E-05
1983	3.1E+01	1.8E-06	1.6E-05
1984	1.4E+01	0.0E+00	3.6E-05
1985	4.2E+01	0.0E+00	5.1E-05
1986	2.5E+01	1.5E-06	3.0E-05
1987–2003	Not available[b]		

a. From AIRNET database of summarized measured concentrations for TA-39, averaged over results reported at locations within the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2 × 10^{-12} yr/m^{3}.

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Table C-17. Estimated average air concentrations for ^{3}H, ^{239}Pu, and ^{234}U for TA-41 (pCi/m^3).[a]

Year	H-3	Pu-239	U-234
1943–1966	Not available[b]		
1967		2.64E-04	
1968		7.26E-05	
1969		1.98E-05	
1970		1.72E-05	
1971	7.0E+02	4.18E-05	
1972	2.4E+02	2.42E-05	
1973	1.3E+02	3.34E-06	
1974–1978	Not available[b]		
1979	3.1E+02		
1980	9.1E+02		
1981	2.8E+02		
1982	2.9E+02		
1983	2.1E+03		
1984	1.1E+04		
1985	2.8E+03		
1986	2.9E+03		
1987	1.0E+03		
1988	3.8E+03		
1989	2.6E+04		
1990	9.8E+03		
1991	8.4E+03		
1992	6.4E+02		
1993	1.1E+03	2.2E-08	
1994	3.8E+02	4.4E-08	
1995	1.7E+02	3.4E-08	2.0E-08
1996	2.4E+02		
1997	9.2E+01		
1998	7.9E+01		
1999	2.9E+01		
2000	1.4E+01		
2001	1.2E+03		
2002–2003	Not available[b]		

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

Table C-18. Estimated average air concentrations for ^{239}Pu for TA-42 (pCi/m^3).[a]

Year	Pu-239
1943–1968	Not available[b]
1969	1.8E-03
1970–2003	Not available[b]

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

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Table C-19. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-43 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1971	Not available[b]			
1971		4.3E+01	1.1E-04	2.2E-04
1972		2.8E+01	1.0E-04	9.3E-05
1973		1.4E+01	5.2E-05	1.6E-04
1974			1.5E-05[c]	
1975			3.6E-06[c]	
1976			1.7E-05[c]	
1977			1.0E-05[c]	
1978			3.4E-06[c]	
1979			1.7E-06[c]	
1980			4.0E-07[c]	
1981			8.1E-07[c]	
1982			3.1E-06	
1983			7.3E-06[c]	
1984			2.3E-06[c]	
1985			4.0E-06[c]	
1986			6.4E-06[c]	
1987			1.1E-06[c]	
1988			3.2E-06[c]	
1989–1994	Not available[b]			
1995	5.9E-07[c]		1.2E-06[c]	2.5E-06[c]
1996–2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-43, averaged over results reported at locations in the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.

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Table C-20. Estimated average air concentrations for ^{234}U for TA-46 (pCi/m^3).[a]

Year	U-234
1943–1970	Not available[b]
1971	8.8E-06
1972	2.6E-04
1973	4.8E-06
1974	9.0E-07
1975	1.1E-06
1976	6.8E-07
1977	8.8E-09
1978	5.6E-05
1979	5.0E-06
1980	3.3E-06
1981	3.0E-05
1982	4.5E-06
1983	7.9E-08
1984	1.1E-07
1985	6.2E-08
1986	8.8E-09
1987–2003	Not available[b]

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3, unless otherwise indicated.

b. Source term estimates or measured air concentrations not available during these years.

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Table C-21. Estimated average air concentrations for ^{241}Am, ^{239}Pu, ^{234}U, MFP, and P/VAP for TA-48 (pCi/m^3).[a]

Year	Am-241	Pu-239	U-234	MFP	P/VAP
1943–1966	Not available[b]				
1967		2.4E-04			
1968		3.3E-04			
1969		2.9E-04			
1970		1.3E-04			
1971		4.2E-05			
1972		2.5E-04	1.8E-05		
1973		4.4E-05	4.3E-06	2.2E-03	
1974		5.3E-05	2.8E-06	2.1E-03	
1975		2.7E-05	7.6E-06	1.6E-03	
1976		1.1E-05	2.5E-04	2.7E-03	
1977		1.8E-05	1.2E-04	4.8E-03	
1978		4.2E-06	2.5E-05	2.6E-03	
1979		7.4E-07	2.4E-05	2.4E-03	
1980		3.5E-06	1.5E-06	3.9E-03	
1981		2.9E-06	5.1E-06	3.0E-03	
1982		2.2E-05	1.6E-05	2.4E-03	
1983		7.3E-06	1.1E-06	1.8E-03	
1984		5.6E-06	2.9E-06	3.5E-03	
1985		4.6E-06	4.2E-06	2.7E-03	
1986		6.3E-06	1.3E-06	5.5E-03	
1987		1.4E-06	3.5E-06	2.8E-03	
1988		1.6E-06	4.8E-07	2.4E-03	
1989		3.3E-06	5.9E-07	9.6E-01	
1990		3.3E-06	3.7E-07	2.3E-03	
1991		1.3E-06		2.4E-03	2.2E-01
1992		1.5E-05	9.2E-07	6.0E-03	8.3E-02
1993		7.0E-06	3.1E-06	3.0E-03	1.7E-01
1994		7.1E-06	8.8E-07	8.6E-04	1.8E-01
1995	3.8E-06	6.8E-06	1.2E-06	5.8E-02	5.8E-02
1996	1.1E-08	2.4E-08			2.2E-04
1997	7.9E-10	5.5E-09	3.1E-07		4.0E-03
1998	8.1E-10				2.4E-04
1999			1.3E-09		8.6E-03
2000					3.7E-02
2001					5.1E-03
2002–2003	Not available[b]				

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.

b. Source term estimates or measured air concentrations not available during these years.

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Table C-22. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, and ^{234}U for TA-49 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	U-234
1943–1970	Not available[b]				
1971		1.5E+02	1.0E-02	8.4E-05	3.7E-04
1972		2.1E+01		7.6E-05	1.9E-04
1973		3.2E+01		1.9E-05	1.6E-04
1974		2.2E+01		3.2E-05	1.4E-04
1975	1.0E-06	2.1E+01		2.1E-05	4.2E-05
1976		2.2E+01		4.3E-06	8.4E-05
1977	0.0E+00	1.2E+01		1.6E-05	1.7E-04
1978	0.0E+00	5.0E+00		2.6E-05	9.5E-05
1979	0.0E+00	5.4E+00		4.6E-06	6.4E-05
1980	2.2E-06	2.1E+00		6.4E-06	5.9E-05
1981	9.0E-07	4.4E+00		5.9E-06	5.1E-05
1982	0.0E+00	6.9E+00		1.8E-06	7.4E-05
1983		1.1E+01		1.0E-07	1.0E-05
1984		1.3E+01		8.0E-07	2.5E-05
1985		3.6E+01		5.2E-06	3.9E-05
1986		2.5E+00		1.0E-06	3.2E-05
1987	1.2E-06	1.8E+01		6.0E-07	3.1E-05
1988	6.6E-06	9.6E+00		7.0E-07	4.6E-05
1989		2.6E+00		0.0E+00	6.9E-05
1990	1.7E-06	1.1E+00		8.0E-07	4.2E-05
1991	1.1E-06	9.0E-01		1.7E-06	3.6E-05
1992	5.0E-07	1.6E+00		1.3E-05	5.1E-05
1993	1.5E-06	2.4E+00		2.8E-06	3.4E-05
1994	4.6E-06	1.5E+00		2.6E-06	2.1E-05
1995	3.4E-06	2.2E+00		3.1E-06	1.9E-05
1996	4.8E-06	1.7E+00		5.2E-06	2.4E-05
1997	2.1E-06	3.5E+00		6.0E-07	8.6E-06
1998	3.2E-06	6.7E+00		1.3E-06	1.8E-05
1999	2.8E-06	3.4E+00		4.5E-07	1.8E-05
2000	1.5E-05	3.6E+00		2.0E-07	1.3E-05
2001–2003	Not available[b]				

a. From AIRNET database of summarized measured concentrations for TA-49, averaged over results reported at locations in the TA (LANL 2003).
b. Source term estimates or measured air concentrations not available during these years.

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Table C-23. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, ^{232}Th, ^{234}U, and MFP for TA-50 (pCi/m^3).[a]

Year	Am-241	H-3	I-131	Pu-239	Th-232	U-234	MFP
1943–1966	Not available[b]						
1967				2.2E-04[c]			
1968				1.5E-04[c]			
1969				9.2E-05[c]			
1970				4.5E-05[c]			
1971		6.3E+02	1.0E-02	3.5E-05[c]			
1972				6.0E-05[c]			
1973				5.5E-06[c]			3.8E-05[c]
1974				8.6E-06[c]			2.1E-04[c]
1975				9.0E-06[c]			1.0E-04[c]
1976				2.4E-06[c]			6.5E-05[c]
1977				1.5E-04[c]			2.0E-04[c]
1978				3.8E-05[c]			9.5E-05[c]
1979				6.4E-06[c]			2.5E-05[c]
1980				2.6E-06[c]			2.0E-05[c]
1981				3.9E-06[c]			5.8E-05
1982				1.4E-05[c]			3.5E-05[c]
1983				1.2E-05[c]			2.2E-05
1984				8.1E-06[c]			2.1E-05[c]
1985				4.4E-06[c]			2.0E-05[c]
1986				6.3E-06[c]			4.8E-05[c]
1987				9.9E-06[c]			5.1E-05[c]
1988				4.5E-06[c]			3.3E-05[c]
1989				1.0E-06[c]			2.3E-05[c]
1990				3.3E-07[c]			9.3E-06[c]
1991				3.0E-06[c]			7.4E-06[c]
1992				1.2E-06[c]			8.5E-06[c]
1993				6.2E-07[c]			8.9E-06[c]
1994				6.8E-07[c]			1.6E-05[c]
1995	1.4E-07[c]			1.6E-06[c]			
1996	2.4E-08[c]			9.2E-08[c]		4.2E-07[c]	
1997	1.8E-08[c]			1.2E-07[c]		2.9E-09[c]	
1998	1.4E-08[c]			3.3E-08[c]	1.7E-07[c]	4.2E-07[c]	
1999	2.9E-07[c]			1.1E-07[c]	8.1E-08[c]	4.2E-08[c]	
2000				2.2E-08[c]	1.2E-07[c]		
2001	1.3E-10[c]			9.5E-08[c]			
2002–2003	Not available[b]						

a. From AIRNET database of summarized measured concentrations for TA-50, averaged over results reported at locations in the TA (LANL 2003), unless otherwise noted.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.

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Table C-24. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{131}I, ^{239}Pu, ^{234}U, and P/VAP for TA-53 (pCi/m^{3}).[a]

Year	Am-241	H-3	I-131	Pu-239	U-234	P/VAP
1943–1970	Not available[b]					
1971		7.9E+01		6.6E-05	2.5E-04	
1972	4.4E-05	3.3E+01		6.4E-05	1.1E-04	
1973	2.0E-06	3.2E+01		2.5E-05	1.6E-04	
1974		9.8E+01		3.1E-05	1.7E-04	
1975	3.0E-06	7.1E+01		2.3E-05	8.2E-05	
1976		4.9E+01		5.0E-06	9.6E-05	
1977	1.2E-06	3.5E+01		1.8E-05	1.7E-04	
1978	0.0E+00	1.3E+01		1.7E-05	6.2E-05	
1979	0.0E+00	4.3E+00		4.9E-06	1.2E-04	
1980	9.0E-07	6.2E+00		7.2E-06	1.3E-04	
1981	1.3E-06	5.4E+00		6.3E-06	4.0E-05	
1982	1.0E-07	7.3E+00		2.2E-06	8.2E-05	4.0E+02[c]
1983		1.1E+01		1.0E-06	3.9E-05	5.8E+03[c]
1984		8.9E+00		6.0E-07	5.1E-05	5.5E+03[c]
1985		1.2E+01		1.2E-06	4.2E-05	4.4E-01[c]
1986	3.0E-06	9.6E+00		8.0E-07	4.8E-05	2.2E-01[c]
1987	8.0E-07	1.5E+01		4.0E-07	4.7E-05	4.4E-01[c]
1988	2.1E-06	2.4E+01		2.3E-06	8.9E-05	2.2E-01[c]
1989	3.3E-06	3.4E+00		1.0E-06	1.1E-04	2.2E-01[c]
1990	2.2E-06	3.9E+00		2.4E-06	1.1E-04	1.8E-01[c]
1991	7.0E-07	1.1E+00		3.0E-06	6.1E-05	4.4E-01[c]
1992	1.8E-06	4.9E+00		2.5E-06	7.8E-05	1.6E+00[c]
1993	3.7E-06	2.4E+00		1.4E-06	1.9E-05	2.2E+01[c]
1994	3.9E-06	1.9E+00		2.5E-06	2.1E-05	6.9E-01[c]
1995	6.1E-06	2.7E+00		1.1E-05	1.8E-05	6.3E-01[c]
1996		8.0E-01	7.7E-04[c]			3.1E-01[c]
1997		3.7E+01[c]				2.0E+00[c]
1998		8.4E+00[c]				7.3E+00[c]
1999		5.1E+00[c]				5.5E-03[c]
2000		6.4E+00[c]				2.0E+00[c]
2001		1.4E+01				2.4E+00[c]
2002–2003	Not available[b]					

a. From AIRNET database of summarized measured concentrations for TA-53, averaged over results reported at locations in the TA (LANL 2003), unless otherwise indicated.
b. Source term estimates or measured air concentrations not available during these years.
c. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^{3}.

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Table C-25. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, and ^{234}U for TA-54 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	U-234
1943–1975	Not available[b]			
1976		3.3E+02	3.1E-05	1.7E-04
1977	5.2E-06	1.9E+02	3.6E-05	2.6E-04
1978	2.2E-06	5.7E+01	8.3E-05	1.6E-04
1979	5.0E-06	3.5E+01	2.3E-05	1.2E-04
1980	4.2E-06	5.3E+01	1.4E-05	1.4E-04
1981	1.6E-06	2.2E+01	1.1E-05	1.3E-04
1982	9.0E-07	2.3E+01	1.4E-05	1.3E-04
1983		1.8E+01	7.0E-07	4.7E-05
1984		6.3E+01	1.8E-05	1.0E-04
1985		7.6E+01	2.4E-05	9.9E-05
1986	1.8E-05	2.8E+01	2.3E-05	9.5E-05
1987	9.5E-06	3.2E+01	1.4E-05	8.3E-05
1988	3.8E-06	2.3E+01	1.8E-05	2.5E-04
1989	8.9E-06	2.9E+01	1.7E-05	1.4E-04
1990	3.2E-06	1.6E+01	4.8E-06	8.1E-05
1991	4.1E-06	8.1E+01	1.8E-05	9.5E-05
1992	1.9E-06	4.4E+01	4.9E-06	3.2E-05
1993	3.8E-06	3.9E+01	8.0E-06	3.5E-05
1994	6.3E-06	3.3E+01	7.1E-06	9.9E-05
1995	1.4E-05	4.4E+01	1.8E-05	5.8E-05
1996	6.3E-05	5.1E+01	8.5E-05	5.6E-05
1997	9.7E-05	8.4E+01	1.5E-04	6.2E-05
1998	1.5E-05	1.3E+02	2.3E-05	7.6E-05
1999	1.6E-05	1.0E+02	2.4E-05	1.2E-04
2000	1.3E-05	1.2E+02	1.0E-05	8.5E-05
2001	1.0E-05	2.3E+02	5.9E-06	5.9E-05
2002	5.2E-05	1.2E+02	1.0E-04	6.0E-05
2003	Not available[b]			

a. From AIRNET database of summarized measured concentrations for TA-54, averaged over results reported at locations in the TA (LANL 2003).

b. Source term estimates or measured air concentrations not available during these years.

Table C-26. Estimated average air concentrations for Los Alamos general area, 1958 to 1970 (pCi/m^3).

Year	Pu-239[a]	MFP[b]
1958		6.2E+00
1959	4.0E-03	2.9E+00
1960	4.0E-03	1.3E-01
1961	4.0E-02[c]	3.3E+00
1962	4.0E-03	4.5E+00
1963	4.0E-03	4.2E+00
1964	4.0E-03	6.9E-01
1965		1.6E-01
1966		1.5E-01
1967	1.0E-03	4.0E-02
1968		1.7E-01
1969		1.3E-01
1970		1.7E-01

a. Based on monthly H-Division reports.
b. Monthly reports for 1962 use both 4E-14 µCi/cm^3 and 4 E-15 µCi/cm^3.
c. From annual reports for beta radioactivity in air.

Table C-27. Estimated average air concentrations for ^{241}Am, ^{3}H, ^{239}Pu, ^{232}Th, and ^{234}U for TA-55 (pCi/m^3).[a]

Year	Am-241	H-3	Pu-239	Th-232	U-234
1943–1977	Not available[b]				
1978			8.8E-07		
1979			2.4E-07		
1980			6.5E-07		
1981			2.1E-07		
1982		4.1E+01	5.7E-06		
1983		9.7E+01	2.4E-06		
1984		3.3E+02	2.3E-06		
1985			2.4E-06		
1986		2.2E+03	5.1E-07		
1987		1.9E+02	5.4E-07		
1988		6.9E+02	3.4E-05		
1989		5.9E+02	4.9E-06		
1990		3.7E+02	1.0E-06		
1991		2.0E+02	4.4E-06		
1992		2.2E+02	2.5E-06		
1993		1.4E+02	3.7E-07		
1994		5.0E+01	2.6E-07		
1995	1.2E-08	3.4E+01	3.6E-08		
1996	6.8E-08	6.8E+01	1.9E-07		1.2E-07
1997		2.6E+01	2.4E-07	9.7E-08	
1998	8.4E-09	2.6E+01	1.4E-07	6.6E-08	
1999	1.2E-07	4.0E+00	1.4E-07		1.6E-07
2000	7.3E-07	1.4E+01	5.5E-06		
2001	1.4E-08	7.3E+00	9.5E-08	3.3E-07	3.7E-07
2002–2003	Not available[b]				

a. Based on estimated average ratio of plutonium activity:source emission activity for TA-3 and TA-21 of 2.2×10^{-12} yr/m^3.
b. Source term estimates or measured air concentrations not available during these years.

ATTACHMENT C
AIR CONCENTRATIONS

Table C-28. Estimated average annual air concentrations of ^{41}Ar for TA-2 (μCi/m^3).[a]

Year	Ar-41
1944–1966	No emissions data available
1967	8.8E-03
1968	3.7E-03
1969	1.0E-03
1970	7.4E-04
1971	9.0E-04
1972	3.7E-04
1973	1.6E-04
1974	1.8E-06
1975	1.4E-04
1976	1.9E-04
1977	1.8E-04
1978	1.4E-04
1979	2.0E-04
1980	2.9E-04
1981	1.7E-04
1982	2.0E-04
1983	2.4E-04
1984	1.9E-04
1985	2.2E-04
1986	1.6E-04
1987	1.3E-04
1988	1.5E-04
1989	1.3E-04
1990	9.1E-05
1991	1.2E-04
1992	8.0E-05
1993–2003	Reactors not in operation

a. Receptor assumed to be at 500 m from ground-level release point.

ATTACHMENT C
AIR CONCENTRATIONS

Table C-29. Estimated average annual air concentrations of G/MAPs for TA-53, TA-21, and TA-72 (µCi/m^3).

Year	TA-53[a]	TA-21[b]	TA-72[c]
1943–1975	LANSCE not in operation		
1976	3.4E-03	2.37E-04	7.10E-04
1977	2.7E-02	1.91E-03	5.73E-03
1978	6.7E-02	4.70E-03	1.41E-02
1979	6.8E-02	4.78E-03	1.43E-02
1980	8.3E-02	5.86E-03	1.76E-02
1981	2.0E-01	1.42E-02	4.25E-02
1982	1.4E-01	1.01E-02	3.02E-02
1983	2.6E-01	1.85E-02	5.55E-02
1984	4.2E-01	2.95E-02	8.84E-02
1985	7.2E-02	5.06E-03	1.52E-02
1986	6.4E-02	4.50E-03	1.35E-02
1987	8.6E-02	6.02E-03	1.81E-02
1988	6.9E-02	4.86E-03	1.46E-02
1989	8.9E-02	6.27E-03	1.88E-02
1990	7.0E-02	4.94E-03	1.48E-02
1991	3.3E-02	2.30E-03	6.89E-03
1992	4.1E-02	2.89E-03	8.67E-03
1993	1.8E-02	1.29E-03	3.86E-03
1994	2.9E-02	2.01E-03	6.02E-03
1995	2.5E-02	1.75E-03	5.25E-03
1996	6.3E-03	4.42E-04	1.33E-03
1997	1.1E-02	8.03E-04	2.41E-03
1998	4.5E-03	3.13E-04	9.40E-04
1999	1.7E-04	1.20E-05	3.61E-05
2000	3.9E-04	2.77E-05	8.31E-05
2001	3.4E-03	2.37E-04	7.11E-04
2002			
2003			

a. Receptor assumed to be at 500 m from ground-level release point.
b. Receptor assumed to be at 2,000 m from 30-m stack release height.
c. Receptor assumed to be at 700 m from 30-m stack release height.