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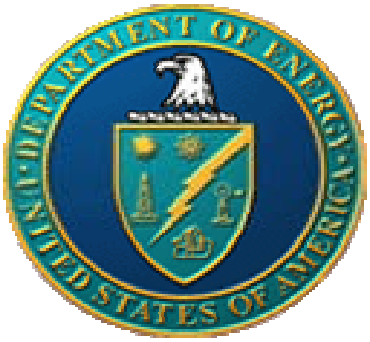
Summary
Annual Site Environmental Report
Radiological Doses and Releases
1998–2001

December 2004



U.S. Department of Energy
Office of Air, Water and Radiation Protection
Policy and Guidance

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Annex A: Summary of Radioniclide Air Emissions from Department or Energy Facilities for 1998-2001 was prepared by Gustavo Vásquez, EH-41 with technical support provided by Lissa Staven and Sandra Snyder of Battelle, Pacific Northwest National Laboratory.

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Contents

Executive Summary

Background and Purpose

U.S. Department of Energy (DOE) sites conducting significant environmental protection programs prepare Annual Site Environmental Reports (ASERs). The purposes of ASERs are to present environmental data so as to characterize site environmental management performance, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts (DOE 1990a). ASERs document the potential radiological and nonradiological impacts of DOE operations on the public and environment near each site. This summary report provides an overview of radiological releases, monitoring, and dose estimates described in ASERs for 36 DOE sites[1] for the years 1998 through 2001.

Conclusions

Based on the ASERs reviewed, the 36 sites successfully met all environmental regulations, permit limits, and DOE Order requirements regarding radioactive emissions to air and water, public radiation doses, and radiation protection of biota.

Estimated Radiation Doses to the Public

Information from ASERs on estimated radiation doses to the public is discussed in section 2 of this report. The major conclusions from that section are summarized below.

- Estimated doses to the maximally exposed individual (MEI) and the population surrounding DOE sites (Table 2-1) are based on releases to the air and water, along with other sources of potential exposure such as contaminants released historically that persist in the environment and ongoing operation of facilities that emit direct radiation. (An accelerator is an example of a facility for which direct radiation represents a significant fraction of the dose. The radiation produced by the accelerator beam is of sufficient energy that some of the radiation passes through the facility's shielding and creates a potential exposure outside the accelerator building.) These dose estimates, which likely overestimate any actual exposure, most often were less than one percent of applicable standards.

- Ninety-three percent of estimated doses reported to the MEI over the four-year summary period are less than 10 mrem, or 10% of the DOE 100 mrem/yr all pathways limit. The MEI is a hypothetical individual who remains at the point of greatest potential exposure throughout the year. Assumptions used in defining the MEI vary among DOE sites and have varying degrees of conservatism.

- In more than 99% of the estimated doses to MEI, the air pathway contribution is less than 1 mrem, or 10% of the Environmental Protection Agency's 10 mrem/yr air pathway limit.

[1] Throughout this summary report, the terms "DOE site" and "DOE facility" describe those operations at a site or facility that are under DOE jurisdiction and subject to DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993). In a few situations, the site itself, or part of the site, does not belong to DOE, and operations or activities involving radioactive material are conducted there that are not subject to DOE authority under DOE O 5400.5. In such cases, the discussion and information presented herein refers to DOE operations or activities, unless otherwise indicated.

- For at least one year of the four-year summary period, twelve DOE sites reported estimated doses to the MEI of greater than 1 mrem/yr (Table 2-2). These dose estimates are attributable to one or more of the following:

  ○ conservative assumptions (including worst-case, improbable scenarios),

  ○ residual radioactivity from historic releases at DOE sites, and

  ○ direct radiation from ongoing operations.

- Population dose estimates are similarly low. Population dose is the sum of estimated doses to all persons within, usually, a 50-mile radius of the DOE site and is used to assess performance and for trending. Because there is no regulatory limit on collective doses to place them in perspective, they typically are compared to the collective dose estimate from background radiation.

- Dose estimates have remained consistent despite a reduction of more than 50 percent in annual releases of radioactive contaminants to the air and water from DOE sites. This is, in part, attributable to the prominence of both historic releases and direct radiation in dose estimates, both of which are unaffected by current releases of radionuclides to the air or water.

- Although the emission data and public dose estimates compiled from the DOE facilities vary from year-to-year, the variations generally reflect changes in operations or programs, changes in assumptions used in modeling, changes in the environmental or emission monitoring programs, or variability in sample analysis. No significant upward trends, potentially reflecting poor operational controls, are evident. Rather, these conclusions reflect the results of efforts throughout the DOE complex to maintain public doses as low as reasonably achievable

<u>Releases of Radioactive Materials to Air and Water</u>

Information from ASERs on releases of radioactive materials to air and water is discussed in section 3 of this report. The major conclusions from that section are summarized below.

- Annual releases of radionuclides from DOE facilities to the air and water ranged from 120,000 curies to 160,000 curies for the period 1998−2001 (Table 1-3). This reflects a reduction of more than 50 percent from the 1990−1994 period in annual releases from DOE sites.

- Tritium and noble gases account for most of the radioactivity released from DOE facilities to the air. Short-lived fission and activation products (i.e., those with a half-life [$t_{½}$] less than 3 hours) is the next most common category of radionuclides released. Less than one percent of releases are comprised of longer-lived fission and activation products or actinides.

- On an activity basis (curies), liquid releases are predominantly tritium.

- While operating facilities at some sites have had unplanned releases in addition to their routine discharges, none of these non-routine releases resulted in radiation doses exceeding DOE or other regulatory limits.

Groundwater Radiological Monitoring and Surveillance

Information from ASERs on groundwater radiological monitoring and surveillance is discussed in section 4 of this report. The major conclusions from that section are summarized below.

- All sites monitored groundwater on-site for radionuclides, and about half the sites also reported information on off-site radionuclide monitoring.

- Only eight sites (BET, BNL, ETEC, LANL, LEHR, NRF, NTS, and PANX) indicated the number of off-site wells that were used for radionuclide monitoring.

- The most common radionuclides detected in groundwater were tritium and uranium (at 22 and 18 sites, respectively).

- At those DOE sites where contaminants have migrated beyond DOE's property boundaries, the levels detected are significantly below applicable standards. Groundwater contamination is being remediated in accordance with agreements between DOE and external agencies (the U.S. Environmental Protection Agency and state agencies).

Biota Dose Evaluation

Information from ASERs on radiation protection of biota is discussed in section 5 of this report. The major conclusions from that section are summarized below.

- In all cases, for both aquatic and terrestrial systems, the results of dose evaluations demonstrated compliance with applicable DOE requirements for protection of biota.

- The availability and application of DOE's Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE-STD-1153-2002; DOE 2002b), contributed to an increase in the inclusion of biota dose evaluations in ASERs. Of the ASERs reviewed for this summary report, biota dose evaluation was discussed in approximately 14% in 1998, approximately 28% in 1999, approximately 43% in 2000, and 50% in 2001. Overall, biota dose evaluation was discussed in one-third of the ASERs reviewed for the four-year period.

- The most commonly applied method by the sites in conducting biota dose evaluation was the graded approach contained in the DOE Technical Standard (in 34 of 47 ASERs).

1.0 Introduction

U.S. Department of Energy (DOE) sites conducting significant environmental protection programs prepare Annual Site Environmental Reports (ASERs). The purposes of ASERs are to present environmental data so as to characterize site environmental management performance, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts (DOE 1990a). ASERs document the potential radiological and nonradiological impacts of DOE operations on the public and environment near each site.

This summary report provides an overview of radiological releases, monitoring, and dose estimates described in the ASERs published by the 36 DOE sites[1] that reported on radiological monitoring programs during the years 1998 through 2001 (Table 1-1). This report summarizes data from these sites on radiological releases to air and water, potential doses to people living near the sites, groundwater monitoring for radionuclides, and biota dose evaluation.

The ASER for Yucca Mountain, Nevada, is not summarized in this report, except that a site description appears in Appendix C. The Yucca Mountain ASER includes radiological monitoring and related data gathered as part of activities to characterize the site as the location for a geologic repository for spent nuclear fuel and high-level radioactive waste. DOE activities at Yucca Mountain do not, however, yet involve radioactive materials. Such activities are dependent upon DOE's receipt of a license from the Nuclear Regulatory Commission.

DOE's Office of Air, Water and Radiation Protection Policy and Guidance regularly reviews ASERs to assess trends and compliance with Order DOE 5400.5 (DOE O 5400.5), *Radiation Protection of the Public and the Environment* (DOE 1993), and periodically prepares ASER summary reports documenting the reviews. With the issuance of this report, the office has summarized radiological releases and doses reported in ASERs for 1990−1994 and 1998−2001. Prior to 1990, summaries were prepared by a predecessor office.

Table 1-1. DOE Sites Reporting on Radiological Release, Monitoring, and Dose in ASERs During 1998–2001

Site/ Location	Program Office (a)	Years w/Rad Data	Principal Activity
Ames Laboratory (Ames) Ames, IA	SC	1998–2001	Energy Research
Argonne National Laboratory-East (ANLE) Argonne, IL	SC	1998–2001	Energy Research
Ashtabula Environmental Management Project (AEMP) Ashtabula, OH	EM	1998–2001	Environmental Remediation
Battelle Columbus Laboratories (BCL) (b) Columbus, OH	EM	1998–2001	Environmental Remediation
Bettis Atomic Power Laboratory (BET) West Mifflin, PA	NNSA	1998–2001	Naval Nuclear Propulsion Research and Support
Brookhaven National Laboratory (BNL) Upton, NY	SC	1998–2001	Energy Research
Energy Technology Engineering Center (ETEC) Conga Park, CA	EM	1998–2001	Environmental Remediation

[1] Throughout this summary report, the terms "DOE site" and "DOE facility" describe those operations at a site or facility that are under DOE jurisdiction and subject to DOE O 5400.5. In a few situations, the site itself, or part of the site, does not belong to DOE, and operations or activities involving radioactive material are conducted there that are not subject to DOE authority under DOE O 5400.5. In such cases, the discussion and information presented herein refers to DOE operations or activities, unless otherwise indicated.

Site/ Location	Program Office (a)	Years w/Rad Data	Principal Activity
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL) Berkeley, CA	SC	1998–2001	Energy Research
Fernald Environmental Management Project (FEMP) Fernald, OH	EM	1998–2001	Environmental Remediation
Grand Junction Office (GJO) Grand Junction, CO	EM	1998–2001	Remediation Research
Hanford Site (HANF) Richland, WA	EM	1998–2001	Environmental Remediation
Idaho National Engineering and Environmental Laboratory (INEEL) Idaho Falls, ID	EM	1998–2001	Research
Knolls Atomic Power Laboratory-Kesselring (KAPL-2) West Milton, NY	NNSA	1998–2001	Naval Propulsion Training and Prototype
Knolls Atomic Power Laboratory-Knolls (KAPL-1) Schenectady, NY	NNSA	1998–2001	Naval Nuclear Propulsion Research and Support
Knolls Atomic Power Laboratory-Windsor (KAPL-3) Windsor, CT	NNSA	1998–1999 (c)	Radiological Remediation Complete
Laboratory for Energy-Related Health Research (LEHR) Davis, CA	NNSA	1998–2001	Environmental Remediation
Lawrence Livermore National Laboratory (LLNL) and LLNL Site 300 (LLNL-300) Livermore, CA	NNSA	1998–2001	Research and Stockpile Stewardship
Los Alamos National Laboratory (LANL) Los Alamos, NM	NNSA	1998–2001	Research and Stockpile Stewardship
Miamisburg Environmental Management Project (MEMP) Miamisburg, OH	EM	1998–2001	Environmental Remediation
Monticello Mill Tailings Site (MMTS) Monticello, UT	EM	1998–2000 (d)	Environmental Remediation (closed)
Naval Reactors Facility (NRF) Idaho Falls, ID	NNSA	1998–2001	Naval Nuclear Propulsion Research and Support
Nevada Test Site (NTS) Mercury, NV	NNSA	1998–2001	Weapons Testing (moratorium)
Oak Ridge Reservation (ORR) Oak Ridge, TN	SC (e)	1998–2001	Stockpile Stewardship, Science, Environmental Remediation
Paducah Gaseous Diffusion Plant (PGDP) Paducah, KY	EM	1998–2001	Environmental Remediation
Pantex Plant (PANX) Amarillo, TX	NNSA	1998–2001	Stockpile Stewardship
Portsmouth Gaseous Diffusion Plant (POR) Portsmouth, OH	EM	1998–2001	Environmental Remediation
Princeton Plasma Physics Laboratory (PPPL) Princeton, NJ	SC	1998–2001	Fusion Research
Sandia National Laboratories, Albuquerque (SNLA) Albuquerque, NM	NNSA	1998–2001	Stockpile Stewardship
Sandia National Laboratories, Tonopah (SNLT) Tonopah, NV	NNSA	1998–2001	Weapons Deployment Test Range
Savannah River Site (SRS) Aiken, SC	EM	1998–2001	Environmental Remediation, Stockpile Stewardship
Stanford Linear Accelerator Center (SLAC) Stanford, CA	SC	1998–2001	Energy Research

Site/ Location	Program Office (a)	Years w/Rad Data	Principal Activity
Thomas Jefferson National Accelerator Facility (JLAB) Newport News, VA	SC	1998–2001	Research
Waste Isolation Pilot Plant (WIPP) Carlsbad, NM	EM	1998–2001	Waste Disposal
Weldon Spring Site Remedial Action Project (WSSRAP) St. Charles County, MO	EM	1998–2001	Environmental Remediation
West Valley Demonstration Project (WVDP) (f) West Valley, NY	EM	1998–2001	Environmental Remediation

a. National Nuclear Security Administration (NNSA), Office of Civilian Radioactive Waste Management (RW), Office of Environmental Management (EM), Office of Science (SC)
b. This report summarizes data for the West Jefferson Site only. The King Avenue Site reported data on release concentrations in 1998; radiological monitoring at the King Avenue Site was discontinued after the completion of remediation activities in 1998.
c. All on-site structures were removed from KAPL-3 by the end of 1999. Radiological remediation was completed in 2000. No radiological monitoring was conducted in 2000 or 2001.
d. Surface remediation was completed at MMTS in 1999, and no radiological monitoring of atmospheric emissions or direct radiation was conducted after that year. Radiological monitoring of liquid effluents continued in 2000, the last year for which an ASER was published.
e. SC was the landlord for ORR in 2001 and the program office managing ORNL. Two operational areas of ORR are managed by other program offices: NNSA manages the Y-12 National Security Complex, and EM manages ETTP.
f. WVDP is a project with a defined scope, as established by the West Valley Demonstration Project Act (Pub. L. 96-368), which is occurring on land owned by the State of New York. Not all releases from the WVDP site premises are from the conduct of DOE operations. As such, not all releases from the WVDP site premises are within the jurisdiction of DOE O 5400.5 nor are all such releases summarized in this report.

1.1 DOE's Environmental Monitoring and Surveillance Programs

DOE conducts environmental monitoring and surveillance programs at its facilities where radioactive materials are produced, used, or disposed, or where the public may be exposed to radiation from DOE operations (DOE 1990a). These programs aid in determining whether facility operations are functioning as designed to properly control releases of radioactive and nonradioactive materials. They also provide a means to assess compliance with applicable environmental radiation protection standards, including Order DOE 5400.5 (DOE O 5400.5). In addition, programs to reduce levels of radioactive releases to as low as reasonably achievable (ALARA) are documented.

Managers at each DOE facility report in ASERs on their environmental programs and the estimated environmental impacts of operations. These reports include estimates of the radiation dose to both individual members of the public and the general population that could have resulted from operations at the site during the year. The reports also describe nonradioactive effluents released to the environment, as well as releases from some disposal and cleanup operations involving radioactive and chemically hazardous materials. This summary report only addresses the radiological aspects of the ASERs.

Monitoring of releases from DOE facilities takes place at both the point of release (effluent monitoring) and in the environment (environmental surveillance) and is used to ensure compliance with effluent control requirements and other applicable environmental standards. For most facilities, releases of radioactive material are not measurable in the environment beyond the DOE site boundary. Therefore, doses to the public must be estimated rather than obtained through direct measurement. These estimates are based on monitoring data taken from liquid effluent release points or airborne discharge locations. Mathematical models are used to predict the dispersion of the radionuclides throughout the environment, and dose

estimates are based on the calculated concentrations in the environment. For facilities such as accelerators, whose primary contribution to public dose is direct external radiation, measurements from on-site and off-site thermoluminescent dosimeters (TLDs) are used as the basis for dose calculations.

The dose estimates are then compared with applicable DOE and Environmental Protection Agency (EPA) standards to assess a site's performance (DOE 1993, EPA 1977). The dose calculations rely on conservative assumptions, which vary from site to site and, in some cases, from year to year for a given site. The expectation is that any actual or likely doses would be lower than estimates presented in the ASERs.

1.2 Requirements and Guidance for the Preparation of ASERs

ASERs are prepared pursuant to DOE Orders and guidance issued by the Office of Environment, Safety and Health. The applicable DOE Orders during 1998–2001 were DOE O 231.1, *Environment, Safety and Health Reporting* (DOE 1996), DOE O 5400.1, *General Environmental Protection Program* (DOE 1990a)[2], and DOE O 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993).

DOE O 231.1 establishes basic requirements for ASERs, including reporting "data on effluent releases, environmental monitoring, and estimates of radiological doses to the public associated with releases of radioactive material for DOE sites" (DOE 2000a). DOE O 5400.1 described a suggested content and format for ASERs. Annual guidance issued by the Office of Environment, Safety and Health supplements the requirements in DOE Orders (DOE 2000c, DOE 2001a, DOE 2002a). Specific requirements and guidance are discussed further in relevant sections of this report.

1.3 Organization of this Report

Section 2.0 discusses estimated doses for both the MEI and the general population. Section 3.0 summarizes estimated releases of radioactive materials to the air and water at operating DOE sites. Section 4.0 discusses groundwater monitoring activities, and section 5.0 contains information on biota dose assessments.

Appendix A is a glossary of terms used in this report. Appendix B provides a list of contacts from whom information regarding the ASERs used to prepare this report may be obtained. The ASERs provide more detail on all aspects of site operations, including site geography, quantity and identity of the radionuclides and chemicals released, radioactive and chemically hazardous material handling and cleanup, and facility descriptions. Appendix C provides a brief description of the operations at each of the DOE sites addressed in this report along with an overview of the site's environmental monitoring program.

Annex A is a summary of reports filed by DOE sites as part of their compliance with EPA regulations regarding atmospheric releases of radionuclides (40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities). Annex A includes data on atmospheric releases and related dose estimates for six sites that are not otherwise addressed in this ASER summary report: Kansas City Plant, Missouri; Lovelace Respiratory Research Institute, New Mexico; Environmental Measurements Laboratory, New York; Fermi National Accelerator Laboratory,

[2] DOE O 231.1 was cancelled by DOE O 231.1A on August 19, 2003; DOE O 5400.1 was cancelled by DOE O 450.1 on January 15, 2003.

Illinois; National Renewable Energy Laboratory, Colorado; and Rocky Flats Environmental Technology Site, Colorado.

1.4 Comparison with the 1990−1994 ASER Summary Report

This summary report for ASERs published from 1998 through 2001 does not include information from 14 DOE sites that were addressed in the 1990–1994 report (Table 1-2). Seven of these sites are part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), which Congress transferred from DOE to the U.S. Army Corps of Engineers in 1997. Three sites no longer prepare ASERs because they are no longer owned or operated by DOE. Two sites prepare ASERs but do not conduct radiological monitoring because of the small amount of radioactive material used on-site. For two other sites (RFETS and Fermi), program management decided to stop preparing ASERs, and, in these cases, the respective DOE program and site offices are responsible for confirming, and ensuring adequate documentation of, compliance with DOE O 5400.5.

The discussion of dose estimates (section 2) and releases of radioactive contaminants to the air and water (section 3) parallels the 1990−1994 report. This report contains additional information on atmospheric releases in Annex A, which summarizes reports filed by DOE sites with EPA. This report also includes two new sections. Groundwater monitoring is discussed in section 4 and biota dose evaluation is discussed in section 5. Both topics have become more prominent parts of DOE's environmental protection programs in recent years and are more thoroughly discussed in the ASERs for 1998−2001 than they were for 1990−1994.

Annual dose estimates to the maximally exposed individual (MEI) and the population surrounding DOE sites have remained about the same throughout the period covered by both reports. Figure 1-1 and Figure 1-2 display average and median MEI and population dose estimates, respectively, by year for 1990–1994 and 1998–2001. Most estimated doses to the MEI are less than 1.0 mrem, and most population dose estimates are less than 1.0 person-rem. As a result, the median MEI dose estimate is less than 0.5 mrem and the median population dose estimate is less than 0.5 person-rem (except for 1994, where it is about 0.6 person-rem). A small number of sites report dose estimates that are large enough to bring the annual averages noticeably higher than the median for the year. The range of average dose estimates is 1.0−2.5 mrem for the MEI and 2.0−5.0 person-rem for the population.

Dose estimates remained consistent through 1990–1994 and 1998–2001 despite a reduction of more than 50 percent in annual releases of radioactive contaminants to the air and water from DOE sites (Table 1-3). One reason is that the primary contributors to dose at some sites are releases that occurred prior to 1998. For example, the primary contributor to the estimated dose to the MEI at BET and BNL is the release of radionuclides in the 1950s and 1960s that persist in the environment. At some other sites (e.g., JLAB, LANL, SLAC) the primary contributor to the MEI dose estimate is direct radiation exposure from operating facilities. An accelerator is the most common type facility emitting direct radiation. It is produced by the accelerator beam and is highly penetrating so that some of the radiation passes through the facility's shielding and creates a potential exposure outside the accelerator building. Neither historic releases nor ongoing direct radiation are included in the estimates of annual releases to the air and water.

Table 1-2. DOE Sites Included in the 1990−1994 ASER Summary Report But Not in this Summary Report for 1998−2001

Site/ Location	Reason for Discontinuing ASER Publication
Bates Linear Accelerator (Bates) Middleton, MA	Operated by the Massachusetts Institute of Technology as a national user facility.
Colonie Interim Storage Site (CISS) Colonie, NY	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
Fermi National Accelerator Laboratory (Fermi) Batavia, IL	Discontinued publication of ASERs after 1996 as part of DOE's "necessary and sufficient" requirements review process. Program management assumed responsibility for confirming Fermi site compliance with DOE O 5400.5 radiation protection requirements.
Hazelwood Interim Storage Site (HISS) Hazelwood, MO	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
Inhalation Toxicology Research Institute (ITRI) Albuquerque, NM	Became part of the private, non-profit Lovelace Respiratory Research Institute.
Maywood Interim Storage Site (MISS) Bergen County, NY	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
Middlesex Sampling Plant (MSP) Middlesex, NJ	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
National Renewable Energy Laboratory Golden, CO	No radioactive emissions monitoring required during 1998–2001.
New Brunswick Site (NBS) New Brunswick, NJ	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
Niagara Falls Storage Site (NFSS) Lewiston Township, NY	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.
Pinellas Plant (PIN) St. Petersburg, FL	Closed by DOE in 1993; transferred to local government for privatization.
Rocky Flats Environmental Technology Site (RFETS) [formerly Rocky Flats Plant (RFP)] Golden, CO	EM management decision to stop preparing ASERs after 1994. Program management assumed responsibility for confirming RFETS compliance with DOE O 5400.5 radiation protection requirements.
Sandia National Laboratories, Livermore Livermore, CA	No radioactive emissions monitoring required during 1998–2001.
Wayne Interim Storage Site (WISS) Wayne Township, NJ	Transferred to the U.S. Army Corps of Engineers in 1997 as part of FUSRAP.

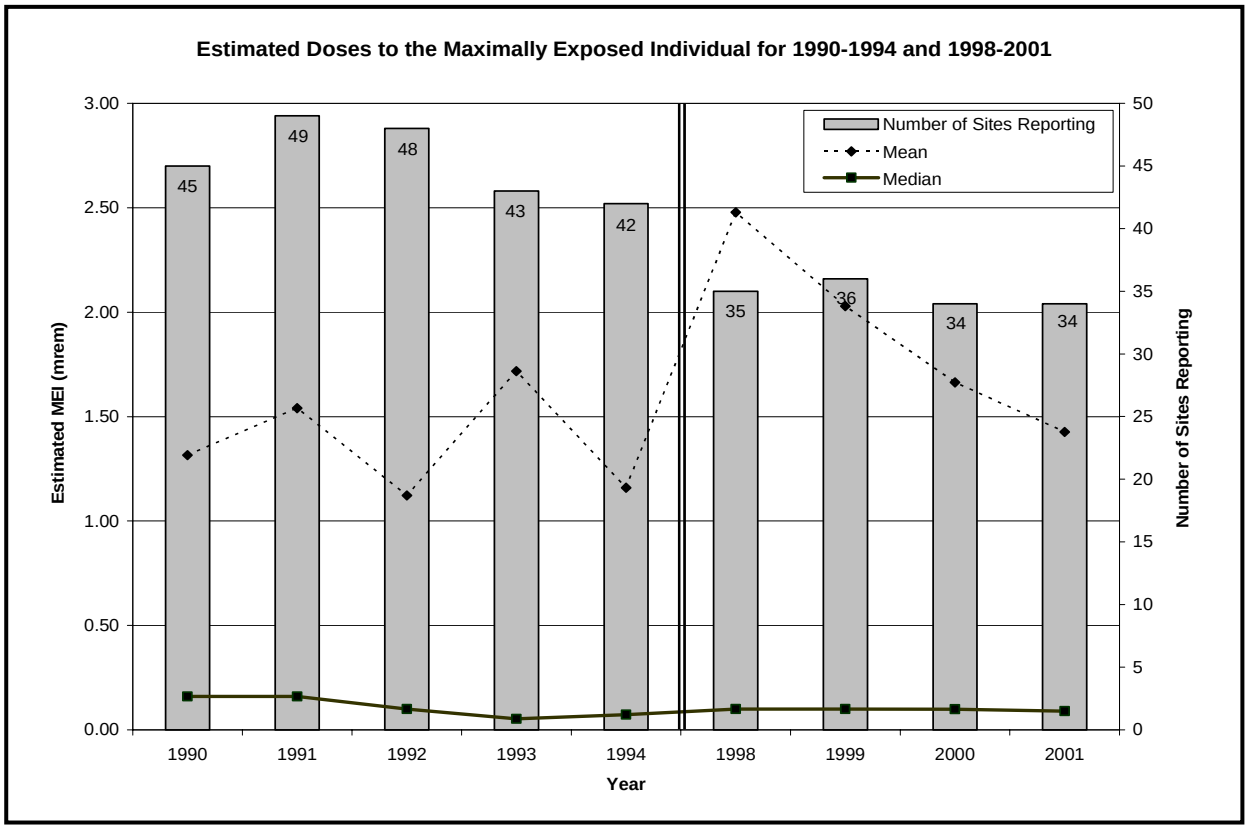

Figure 1-1. Estimated doses to the MEI for 1990 to 1994 and 1998 to 2001.

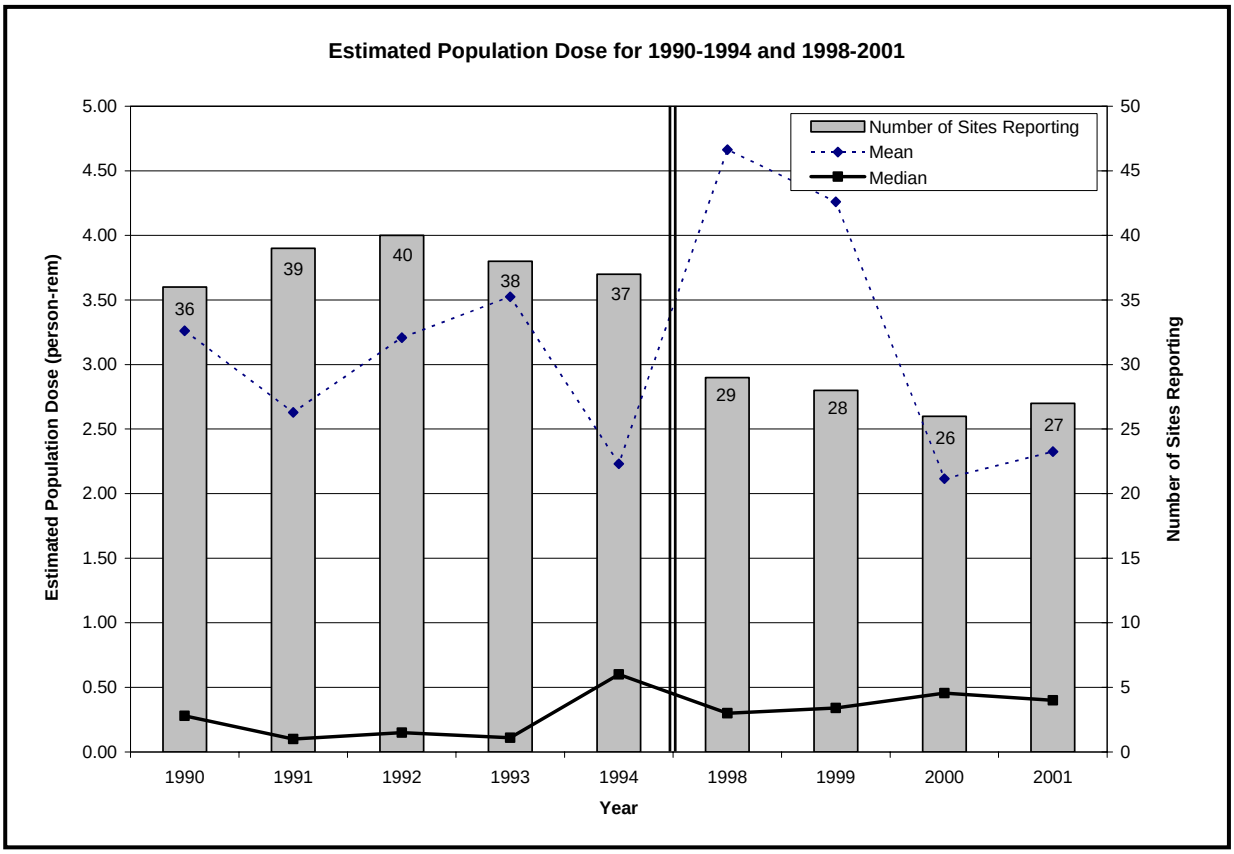

Figure 1-2. Estimated population dose for 1990 to 1994 and 1998 to 2001.

Table 1-3. Total Radionuclides Released from DOE Sites to the Air and Water (curies)

Year	Atmospheric Releases	Liquid Effluent	Total
1990	650,000	24,000	670,000
1991	390,000	16,000	410,000
1992	330,000	18,000	350,000
1993	280,000	16,000	300,000
1994	280,000	57,000	340,000
1998	130,000	11,000	140,000
1999	110,000	6,500	120,000
2000	120,000	5,500	130,000
2001	160,000	4,300	160,000

2.0 Estimated Radiation Doses to the Public

This section summarizes estimated public doses reported in ASERs from 1998−2001.

2.1 Background

ASERs provide two sets of calculations for the doses received from DOE operations: the estimated dose to the MEI and the estimated collective dose to the population living within 80 km (50 mi) of the DOE site (the population dose).

Dose estimates are based on site-specific conditions and may incorporate data from environmental sampling of atmospheric and liquid effluents or groundwater contamination (summarized in sections 3 and 4 of this report), monitoring of direct radiation, and modeling of potential releases. For each DOE site, dose estimates presented in ASERs are calculated rather than measured, and the calculations rely upon conservative assumptions. Therefore, any actual dose is likely to be lower than the estimate contained in the ASER.

In its suggested content and format for ASERs, DOE O 5400.1 stated:

> The Environmental Report should contain an assessment of the potential radiation exposure to the public which could have resulted from site operations during the calendar year. The assessment should be as accurate and realistic as possible. The modeling and calculation methodology used in the dose assessment should be included or referenced. A comparison of results with applicable standards and relevant parameters (e.g., natural and manmade sources of exposure) also should be included (DOE 1990a).

Dose estimates are calculated using appropriate Federal guidance and dose conversion factors approved by DOE and EPA for internal organs impacted by inhalation and ingestion of radioactive materials (DOE 1988b, EPA 1988) and for external doses (DOE 1988a, EPA 1993). These factors are based on recommendations of the International Commission on Radiological Protection (ICRP 1978).

Limits on the dose to individuals and requirements for dose evaluations are contained in DOE O 5400.5 (DOE 1993). The DOE dose limit for an individual in the vicinity of a DOE facility is 100 mrem/yr (1 mSv/yr) effective dose equivalent for all pathways and all sources of exposure (DOE 1990a, DOE 1993), and each DOE site must strive to maintain doses as low as reasonably achievable (ALARA). Because the 100-mrem/yr limit applies to "all sources," each DOE facility must maintain doses at a fraction of the limit to be sure that its contribution to dose to a member of the public does not cause that person to exceed the limit from all sources. In general, DOE assumes that if the DOE all pathway dose to the MEI is less than one-third to one-fourth the 100 mrem/yr limit, sites are complying with the "all sources" limit. Otherwise, sites would need to consider doses from other sources in their evaluation to be sure the MEI is not exposed to doses exceeding the 100 mrem limit. In addition, EPA regulations (40 CFR Part 61, Subpart H) limit the dose to an individual from a single site from airborne radionuclide emissions to 10 mrem/yr (0.1 mSv/yr).

A population dose estimate provides an indication of the overall radiological impact of site operations. The population dose reported in the ASER is one factor used to evaluate the effectiveness of the site's ALARA program (see DOE O 5400.5, II.2.a(2) and II.6.b). Population dose estimates are useful in comparing operations over time and among facilities, and the estimates are an integral part of radiation protection program planning. There are no regulatory limits for population dose.

2.2 Maximally Exposed Individuals

The dose to the MEI is to be reported annually for each DOE site with a radiological monitoring program. DOE ASER guidance states that the MEI

> should be a conservative, but realistic, estimate based on a scenario that approximates an actual situation. The estimate should be reasonable but not likely to underestimate the MEI dose. Calculation of the dose to a person spending 100% of his time at the fence line is useful for comparison purposes, but it overestimates the dose to the most exposed individual and biases comparative analyses (DOE 2002a).

The guidance further states that the MEI estimate should include "multiple exposure pathways and releases from multiple sources (e.g., point and diffuse) if they contribute to the dose to the same individuals," and ASERs "should clearly describe the location of critical receptors and the scenarios used to calculate the estimated doses" (DOE 2002a).

Table 2-1 lists the estimated maximum potential doses to individuals from each DOE site by pathway and year. The table also indicates what percentage of the DOE 100-mrem/yr limit this dose represents. The total MEI all-source estimates range from less than 1 mrem/yr (0.01 mSv/yr) to 37 mrem/yr (0.37 mSv/yr), or from less than one to 37 percent of the DOE 100 mrem/yr limit. The table also reports the percentage of EPA's 10-mrem/yr limit on dose to an individual via the air pathway. The values range from less than 1 mrem/yr (0.01 mSv/yr) to 2.6 mrem/yr (0.26 mSv/yr), or up to 26 percent of the EPA limit. (Compliance with the EPA limit on atmospheric releases is discussed further in Annex A of this report.)

Most dose estimates are at the lower end of these ranges – about 70 percent of the 1998–2001 ASERs report estimated doses to the MEI below one percent of the applicable standard. Doses at the higher end of the range (above 1 mrem/yr) are described in Table 2-2. These estimates are based on conservative assumptions (in some instances improbable, worst-case scenarios), and sites expect any actual dose to fall well below the estimated dose. For example, Bettis expects that any actual dose to an individual off-site would fall below 0.3 mrem/yr, or about 10 percent of the maximum estimated potential dose of 2.6 mrem/yr.

Each site determines the appropriate exposure pathway(s) to use in dose calculations based on the nature of site operations and local conditions. ORR includes consumption of fish and other wildlife, drinking water, other water uses (swimming, wading, boating), and other sources of direct radiation exposure. The dominant exposure pathway at accelerator facilities (e.g, JLAB, PPPL, SLAC) is direct radiation. SRS reports a sportsman dose to account for potential exposures to people participating in on-site controlled hunts separately from the MEI.

Each site also determines who the hypothetical MEI is (e.g., where they would reside or travel to receive the largest dose). For some sites, this person resides at the closest off-site residence. Other DOE sites (e.g., BNL, JLAB, LLNL, MEMP, PPPL) assume that a person remains at the point of highest potential exposure at the site boundary for 24 hours per day throughout the year (a fenceline dose estimate). Still other sites, such as Paducah, take a "worst-case" approach and assume the same individual is exposed to the most extreme conditions from each pathway. At Paducah, this person would eat the most contaminated deer found on site (the dominant contributor to the dose estimate), ingest contaminated soil, drive twice a day by the area with the greatest potential for direct radiation exposure, and live at the point of the nearest off-site neighbor with the greatest potential for exposure from airborne emissions.

Based on the data reported, all sites control exposure to well below applicable dose limits. However, caution is required in interpreting dose estimates for a single site and comparing estimates among sites. The degree of conservatism in assumptions and the methodologies underlying dose estimates both vary from site to site, and in some cases, even from year to year for a given site.

For example, AEMP calculates dose to the MEI based only on monitoring of point sources, excluding any contribution from diffuse sources that might be captured in the site's perimeter monitoring. ETEC reports an MEI based on both point and non-point source emissions. ETEC reported an MEI of 1.3×10^{-6} mrem in 1998 from point sources and an MEI of 2.5×10^{-3} mrem from area sources (i.e., potential resuspension of radionuclides from contaminated soils). ETEC also reported MEI this way in 1999, with values of 2.2×10^{-7} mrem from point sources and 6.6×10^{-7} mrem from area sources. In 2000 and 2001, ETEC did not report an estimate from area sources because environmental conditions (wet conditions, the presence of grasses) were assumed to prevent resuspension. Grand Junction factored point and non-point sources into its MEI and population dose estimates for all four years, and with the exception of 1999, included the contribution from radon in its MEI estimate. (Radon is regulated separately and is not normally included in estimates for comparison to the dose limit.)

At some sites, the components factored into the MEI changed during the four-year period based on site-specific monitoring or other local conditions. At NTS, for example, in 1998 the MEI of 0.092 mrem was based on potential air emissions as calculated through the CAP88 model for compliance with EPA regulations. Exposure estimates from environmental monitoring data were reported separately and were a lower value (0.017 mrem) than the CAP88-generated estimate. The MEI for 1999 was reported as the combination of the CAP88 value for atmospheric releases (0.12 mrem), an estimated dose from drinking milk produced by cows feeding from pastures on which radioactive fallout from nuclear testing was deposited (0.01 mrem), and an estimated dose from eating meat from three species of wildlife (mourning dove, black-tailed jack rabbit, and mule deer) that may have consumed water or vegetation from contaminated areas at NTS (0.5 mrem). In 1999, NTS discontinued sampling of milk, meat, and food crops, and the exposure estimate for milk consumption was based on average ^{90}Sr concentrations from samples collected from 1995 through 1998. The 2000 MEI was the total of estimates generated by CAP88 (0.17 mrem) and from eating meat from doves (0.16 mrem). The 2001 MEI was the total of estimates generated by CAP88 (0.17 mrem) and from eating chukar partridges (0.07 mrem).

For the air pathway, most sites use the CAP88 model to calculate committed effective dose equivalent. INEEL reports an MEI value calculated by a more site-specific model (MDIFF; used in Table 2-1 of this report) and also a slightly lower value calculated through CAP88. Hanford uses GENII for estimating doses for its ASERs and CAP88 to demonstrate compliance with Subpart H. BCL uses both CAP88 and EPA's COMPLY computer model. PPPL also uses the COMPLY model, which bases estimates on the annual quantity of radioactive materials used on a site (presumed release scenarios) and generally results in more conservative doses than those calculated with the CAP88 model. (Further discussion of the use of atmospheric models in dose calculation is provided in Annex A.)

2.3 Population Dose Estimates

DOE requires that sites with radiological monitoring programs estimate population (or collective) dose at least annually. The population dose reflects the potential collective dose to all persons living within 80 km (50 mi) of the site. Table 2-1 presents the population dose estimates for each DOE site for the period 1998 through 2001. The table is intended to facilitate a review of the

data from each site and should not be viewed as a system for ranking sites or comparing estimates among sites.

DOE does not prescribe a particular way to calculate population dose. Population dose can be calculated, for example, by dividing the area around a site into segments. The average dose to an individual living in a segment multiplied by the total number of people living in that segment yields the segment's population dose. The sum of the population doses for all segments equals the total population dose. Note that the average dose used in this calculation is not the MEI, and in fact, it is always far less than the MEI.

Atmospheric releases typically are the dominant contributor to population dose. Exceptions include some accelerator facilities (e.g., LBNL, SLAC) where potential exposure to direct radiation may be the predominant factor.

WSSRAP employed the most tailored approach for calculating population dose among the ASERs reviewed for this report. It examined all potential exposure pathways and estimated the collective dose only to those population groups with the potential for exposure. As the site explained in its 1998 ASER:

> Since all air monitoring stations (other than the background station) are within a 13 km (8.1 mi) radius of the site, and all results measured within this radius are well below NESHAPs and DOE limits, incorporating a dose calculation for a population within 80 km (49.6 mi) of the site is unnecessary. Rather, the collective population dose equivalent was calculated for specific target populations where complete exposure pathways were found to exist.

Moreover, WSSRAP redefined the potential exposure pathways and target populations each year as remediation was completed. For example, in 2001 the inhalation pathway was not considered applicable and the potentially exposed population included only recreational users of a nearby lake.

2.4 Comparison of Dose Estimates in ASERs and Subpart H Reports

This report includes a summary (Annex A) of reports filed by DOE sites for calendar years 1998−2001 as part of their compliance with EPA regulations regarding atmospheric releases of radionuclides (40 CFR Part 61, Subpart H). Table 2-3 lists the MEI and population dose estimates contained in these Subpart H reports and the ***air pathway*** contribution to MEI dose (which usually is less than the total MEI dose) and the population dose estimates from ASERs.

The dose estimates in these two reports are different during one or more years for some DOE sites. In general, this is because requirements, assumptions, and the choice of model for estimating doses in ASERs and Subpart H reports often differs. Both reported values indicate compliance with applicable standards.

For example, in 2001, LBNL calculated a dose to the MEI only from the air pathway (5.6×10^{-2} mrem), which was used in its Subpart H report. This dose estimate assumes the MEI is located where the hypothetical individual would receive the highest exposure from airborne releases alone. The LBNL ASER for 2001 explains the basis for the value reported in the LBNL Subpart H report and also contains a higher total estimated dose to an MEI (4.0×10^{-1} mrem) based on exposure to both airborne particles (3.0×10^{-2} mrem) and direct radiation (3.3×10^{-1} mrem). This MEI would be located in a different place throughout the year – the location that presents the greatest potential exposure from all pathways.

Similarly, Hanford's population dose reported in its ASERs includes contributions from both air and water pathways, whereas the population dose reported in its Subpart H reports includes only the contribution from the air pathway. For 2001, these are the same value (4.0×10^{-1} person-rem) because the contribution from the water pathway (3.7×10^{-3} person-rem) did not affect the overall dose estimate. For estimated doses to the MEI, to comply with state regulations, Hanford assumes the MEI is an on-site, non-DOE worker for purposes of its Subpart H reports. As a result, the estimate in its Subpart H reports is higher than the estimated dose to the MEI reported in its ASERs, which assumes the individual is located off-site.

SRS also includes air and water pathways in the population dose estimate reported in its ASER. In addition, SRS uses CAP88 to demonstrate compliance with Subpart H and the more site-specific MAXDOSE SR model to calculate the dose to the MEI for its ASER.

For another example, the ASERs for naval reactor facilities (KAPL-1, KAPL-2, and KAPL-3) identify the air contribution to MEI as a value less than 1.0×10^{-1} mrem. The Subpart H reports for these facilities contain more precise values, the highest of which is the estimate from KAPL-2 for 1998 of 3.6×10^{-2} mrem.

2.5 Conclusions

Based on the information provided in the ASERs reviewed, the 36 sites successfully met all environmental regulations, permit limits, and DOE Order requirements for radioactive emissions to air and water, and public radiation doses. As reported in the ASERs, 93% of estimated doses to the MEI are less than 10% of the DOE 100 mrem/yr all pathways limit. In more than 99% of the estimated doses to the MEI reported in the ASERs, the air pathway contribution is less than 10% of the EPA 10 mrem/yr air pathway limit. Most dose estimates are less than 1% of these applicable limits. Population dose estimates are similarly low. Although there is no applicable limit for comparison, Table 2-1 provides estimates of population dose from background radiation for perspective. These values, considered in light of the similarly low rates of atmospheric and liquid emissions, reflect the results of efforts throughout the DOE complex to maintain public doses as low as reasonably achievable.

Because of the different exposure scenarios and modeling approaches used by DOE sites, comparing MEI or population dose estimates can be misleading. It might be inaccurate to conclude, for example, that the risk to the public is greater at site A just because it presents a higher population dose estimate than site B. Site A may have used more conservative assumptions, or the estimates might rely on different routes of exposure or differences in any of several other factors. In addition, the size of the population has a significant impact on population dose estimates (e.g., lower emissions in a densely populated area can result in a larger population dose estimate than higher emissions in an area with a small population size). Similarly, the MEI at one site might be based on an unlikely but plausible exposure scenario, whereas a different DOE site might calculate MEI based on an implausible "worst-case" scenario.

Moreover, no direct relationship exists between estimates of population dose and MEI. As is explained in sections 2.2 and 2.3, these estimates are appropriately derived from different assumptions and methodologies because they are prepared for different purposes. In general, MEI is calculated for a hypothetical individual remaining near but just beyond the site boundary at a location that would present the greatest exposure potential from all pathways. Population dose typically is based on the projected dispersion of atmospheric releases to the population within 80 km (50 mi) of the center of the DOE site.

For those sites reporting MEI, population dose, and population size, the potential dose to the MEI is about 1,200 times greater than the average individual dose indicated by the population dose estimate. For the subset of those sites that based MEI on atmospheric releases alone, the MEI is about 120 times greater than the average individual dose indicated by the population dose estimate. This difference in MEI and average individual dose reflects the distribution of the population dose over the potentially affected population (an average that includes high and low doses); for the atmospheric pathway, greater dispersion resulting in greatly reduced downwind air concentrations for the population compared to the MEI; and the more conservative assumptions that are typical in the MEI calculation.

Seventy-three of the ASERs reviewed reported population dose estimates for both DOE operations and naturally occurring radiation. Based on these 73 ASERs, the average population dose associated with DOE operations is 2.3 person-rem, and the average population dose associated with natural sources is 7.3×10^{5} person-rem.

Table 2-1. 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
ENVIRONMENTAL MANAGEMENT (EM)									
Ashtabula Environmental Management Project (AEMP)									
1998	1.4×10^{-3}	<1	—	—	1.4×10^{-3} (a)	<1	—	—	—
1999	1.5×10^{-3}	<1	—	—	1.5×10^{-3}	<1	—	—	—
2000	5.8×10^{-2}	<1	—	—	5.8×10^{-2}	<1	—	—	—
2001	2.0×10^{-2}	<1	—	—	2.0×10^{-2}	<1	—	—	—
Battelle Columbus Laboratories (BCL) (b)									
1998	—	—	—	—	0.0×10^{0}	0	8.1×10^{-4}	—	2.1×10^{6}
1999	—	—	—	—	0.0×10^{0}	0	7.0×10^{-4}	—	2.1×10^{6}
2000	—	—	—	—	0.0×10^{0}	0	7.6×10^{-4}	—	2.3×10^{6}
2001	—	—	—	—	0.0×10^{0}	0	7.7×10^{-4}	—	2.3×10^{6}
Energy Technology Engineering Center (ETEC) (c)									
1998	2.5×10^{-3}	<1	—	—	2.5×10^{-3}	<1	9.4×10^{-2}	3.0×10^{6}	9.8×10^{6}
1999	8.8×10^{-7}	<1	—	—	8.8×10^{-7}	<1	4.8×10^{-5}	2.0×10^{6}	9.8×10^{6}
2000	7.7×10^{-7}	<1	—	—	7.7×10^{-7}	<1	2.2×10^{-4}	3.0×10^{6}	1.0×10^{7}
2001	3.1×10^{-6}	<1	—	—	3.1×10^{-6}	<1	7.5×10^{-4}	3.0×10^{6}	1.0×10^{7}
Fernald Environmental Management Project (FEMP)									
1998	5.0×10^{-2}	<1	—	8.2×10^{0}	8.2×10^{0}	8	—	—	—
1999	9.0×10^{-2}	<1	—	8.3×10^{0}	8.4×10^{0}	8	—	—	—
2000	2.8×10^{-1}	3	—	1.1×10^{1}	1.1×10^{1}	11	—	—	—
2001	2.0×10^{-1}	2	—	1.2×10^{1}	1.2×10^{1}	12	—	—	—
Grand Junction Office (GJO) (d)									
1998	3.3×10^{-3}	<1	—	6.9×10^{-3}	1.0×10^{-2}	<1	4.8×10^{-3}	—	1.2×10^{5}
1999	1.4×10^{-3}	<1	—	1.2×10^{-1}	1.2×10^{-1}	<1	9.5×10^{-3}	—	1.2×10^{5}
2000	1.1×10^{-2}	<1	—	8.7×10^{-2}	9.8×10^{-2}	<1	6.6×10^{-3}	—	1.5×10^{5}
2001	4.7×10^{-2}	<1	—	3.3×10^{-2}	8.0×10^{-2}	<1	6.4×10^{-3}	—	1.5×10^{5}
Hanford Site (HANF)									
1998	1.5×10^{-2}	<1	7.7×10^{-3}	—	2.2×10^{-2}	<1	1.9×10^{-1}	1.1×10^{5}	3.8×10^{5}
1999	5.8×10^{-3}	<1	2.1×10^{-3}	—	7.9×10^{-3}	<1	2.5×10^{-1}	1.1×10^{5}	3.8×10^{5}
2000	2.2×10^{-3}	<1	1.2×10^{-2}	—	1.4×10^{-2}	<1	3.0×10^{-1}	1.1×10^{5}	3.8×10^{5}
2001	7.7×10^{-3}	<1	1.7×10^{-3}	—	9.4×10^{-3}	<1	4.0×10^{-1}	1.1×10^{5}	4.9×10^{5}

a. AEMP reports a MEI value of 2.4×10^{-3} on p. xi; the value of 1.4×10^{-3} used here appears on p. 18 and is consistent with constituent values reported in the ASER.
b. MEI reported as “no measurable dose.”
c. MEI estimates for 1998−1999 include releases from point and area sources; 2000−2001 estimates based on point sources only.
d. Radon exposure is the "other" pathway contribution to MEI; variability coincides with annual estimates of non-point radon emission release rates.
— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
Idaho National Environmental and Engineering Laboratory (INEEL)									
1998	8.0×10^{-3}	<1	—	—	8.0×10^{-3}	<1	7.5×10^{-2}	4.4×10^{4}	1.2×10^{5}
1999	8.0×10^{-3}	<1	—	—	8.0×10^{-3}	<1	3.7×10^{-2}	4.4×10^{4}	1.2×10^{5}
2000	5.7×10^{-2}	<1	—	—	5.7×10^{-2}	<1	5.3×10^{-1}	4.4×10^{4}	2.3×10^{5}
2001	7.4×10^{-2}	<1	—	—	7.4×10^{-2}	<1	5.9×10^{-1}	4.4×10^{4}	2.3×10^{5}
Miamisburg Environmental Management Project (MEMP)									
1998	4.2×10^{-2}	<1	1.3×10^{-2}	6.0×10^{-2}	1.1×10^{-1}	<1	2.6×10^{0}	1.0×10^{6}	3.0×10^{6}
1999	1.1×10^{-1}	1	7.0×10^{-3}	1.1×10^{0} (e)	1.2×10^{0}	1	2.2×10^{0}	1.0×10^{6}	3.0×10^{6}
2000	1.6×10^{-1}	2	8.0×10^{-3}	7.7×10^{-3}	1.8×10^{-1}	<1	1.3×10^{0}	1.0×10^{6}	3.1×10^{6}
2001	1.1×10^{-1}	1	5.0×10^{-3}	1.1×10^{-1}	2.3×10^{-1}	<1	2.8×10^{0}	1.0×10^{6}	3.1×10^{6}
Monticello Mill Tailings Site (MMTS) (f)									
1998	—	—	—	3.7×10^{1}	3.7×10^{1}	37	7.6×10^{1}	—	—
1999	—	—	—	2.2×10^{1}	2.2×10^{1}	22	4.8×10^{1}	—	—
Paducah Gaseous Diffusion Plant (PGDP)									
1998	2.9×10^{-3}	<1	0.0×10^{0}	2.3×10^{0}	2.3×10^{0}	2	2.7×10^{-3}	2.0×10^{5}	5.0×10^{5}
1999	1.7×10^{-3}	<1	2.9×10^{-4}	6.9×10^{-1}	6.9×10^{-1}	<1	—	—	—
2000	8.8×10^{-3}	<1	5.5×10^{-4}	1.9×10^{0}	1.9×10^{0}	2	—	—	—
2001	3.7×10^{-3}	<1	0.0×10^{0}	3.7×10^{0}	3.7×10^{0}	4	—	—	—
Portsmouth Gaseous Diffusion Plant (POR) (g)									
1998	2.5×10^{-4}	<1	—	5.0×10^{-1}	5.0×10^{-1}	<1	2.3×10^{-1}	—	9.2×10^{5}
1999	2.8×10^{-1}	3	5.3×10^{-2}	5.9×10^{-1}	9.2×10^{-1}	<1	1.0×10^{0}	—	6.0×10^{5}
2000	4.7×10^{-2}	<1	4.2×10^{-2}	2.8×10^{0}	2.9×10^{0}	3	1.7×10^{-1}	—	6.0×10^{5}
2001	6.0×10^{-2}	<1	3.9×10^{-2}	1.9×10^{0}	2.0×10^{0}	2	2.0×10^{-1}	—	6.0×10^{5}
Savannah River Site (SRS)									
1998	7.0×10^{-2}	<1	1.2×10^{-1}	—	1.9×10^{-1}	<1	5.3×10^{0}	1.9×10^{5}	6.2×10^{5}
1999	6.0×10^{-2}	<1	2.2×10^{-1}	—	2.8×10^{-1}	<1	6.6×10^{0}	—	6.2×10^{5}
2000	4.0×10^{-2}	<1	1.4×10^{-1}	—	1.8×10^{-1}	<1	6.2×10^{0}	—	6.2×10^{5}
2001	5.0×10^{-2}	<1	1.3×10^{-1}	—	1.8×10^{-1}	<1	7.2×10^{0}	—	7.1×10^{5}

e. Includes levels of ^{238}Pu in one set of vegetation samples.

f. Radiological monitoring of atmospheric, direct radiation, and radon discontinued after completion of surface remediation in 1999. ASER publication ceased after 2000. 1998 and 1999 MEI estimates include radon contribution of 7 mrem/yr and 3 mrem/yr, respectively. ASER identifies 1990 census data as the source for population size but does not report the value used for the population dose calculation.

g. Values reflect contribution from DOE and USEC operations, except the "other" pathway, which reflects potential exposure to direct radiation only from DOE operations. See ASERs for split within individual estimates.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
Waste Isolation Pilot Plant (WIPP) (h)									
1998	—	—	—	—	—	—	—	—	1.0×10^{5}
1999	2.2×10^{-6}	<1	0.0×10^{0}	0.0×10^{0}	2.2×10^{-6}	<1	—	—	1.0×10^{5}
2000	5.2×10^{-6}	<1	0.0×10^{0}	0.0×10^{0}	5.2×10^{-6}	<1	—	—	1.0×10^{5}
2001	5.0×10^{-6}	<1	0.0×10^{0}	0.0×10^{0}	5.0×10^{-6}	<1	—	—	1.0×10^{5}
Weldon Spring Site Remedial Action Project (WSSRAP) (i)									
1998	2.6×10^{0}	26	—	5.0×10^{0}	7.6×10^{0}	8	1.4×10^{0}	—	1.7×10^{5}
1999	—	—	—	2.6×10^{0}	2.6×10^{0}	3	1.8×10^{-1}	—	1.1×10^{5}
2000	—	—	3.5×10^{-1}	—	3.5×10^{-1}	<1	1.0×10^{-1}	—	1.1×10^{5}
2001	—	—	2.4×10^{-1}	—	2.4×10^{-1}	<1	1.0×10^{-1}	—	1.1×10^{5}
West Valley Demonstration Project (WVDP) (j)									
1998	3.4×10^{-2}	<1	3.1×10^{-2}	—	6.5×10^{-2}	<1	3.3×10^{-1}	3.8×10^{5}	1.3×10^{6}
1999	1.1×10^{-2}	<1	5.6×10^{-2}	—	6.8×10^{-2}	<1	2.4×10^{-1}	3.8×10^{5}	1.3×10^{6}
2000	8.1×10^{-3}	<1	5.3×10^{-2}	—	6.1×10^{-2}	<1	2.2×10^{-1}	3.8×10^{5}	1.3×10^{6}
2001	4.6×10^{-3}	<1	3.5×10^{-2}	—	4.0×10^{-2}	<1	1.9×10^{-1}	4.0×10^{5}	1.3×10^{6}
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)									
Bettis Atomic Power Laboratory (BET)									
1998	2.0×10^{-1}	2	0.0×10^{0}	2.3×10^{0}	2.5×10^{0}	3	1.4×10^{0}	9.0×10^{5}	3.0×10^{6}
1999	2.8×10^{-1}	3	0.0×10^{0}	2.3×10^{0}	2.6×10^{0}	3	1.5×10^{0}	9.0×10^{5}	3.0×10^{6}
2000	1.3×10^{-1}	1	0.0×10^{0}	2.3×10^{0}	2.4×10^{0}	2	1.0×10^{0}	9.0×10^{5}	3.0×10^{6}
2001	1.4×10^{-1}	1	0.0×10^{0}	2.3×10^{0}	2.4×10^{0}	2	1.2×10^{0}	9.0×10^{5}	3.0×10^{6}
Knolls Atomic Power Laboratory - Kesselring (KAPL-2) (k)									
1998	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	3.0×10^{-1}	8.5×10^{4}	1.2×10^{6}
1999	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	3.0×10^{-1}	8.9×10^{4}	1.2×10^{6}
2000	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	3.0×10^{-1}	8.9×10^{4}	1.2×10^{6}
2001	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	8.6×10^{4}	1.2×10^{6}

h. Background values only for 1998. WIPP received its first shipment of transuranic waste on March 26, 1999.

i. Potentially exposed population defined annually through pathway analysis; limited to 13 km of the site, rather than 80 km.

j. Liquid effluent pathway includes contributions from DOE operations and the North Plateau groundwater plume, which resulted from releases that occurred prior to DOE assuming operational control at WVDP. The dose contribution from the liquid effluent pathway for DOE operations alone is 0.008 mrem for 1998, 0.028 mrem for 1999, 0.030 mrem for 2000, and 0.014 mrem for 2001.

k. Population dose from natural radiation sources is calculated annually from TLD readings.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
Knolls Atomic Power Laboratory - Knolls (KAPL-1) (k)									
1998	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	8.8×10^{4}	1.3×10^{6}
1999	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	9.5×10^{4}	1.3×10^{6}
2000	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	9.5×10^{4}	1.3×10^{6}
2001	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	9.3×10^{4}	1.3×10^{6}
Knolls Atomic Power Laboratory - Windsor (KAPL-3) (k,l)									
1998	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	2.5×10^{5}	3.4×10^{6}
1999	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.0×10^{-1}	2.7×10^{5}	3.4×10^{6}
Laboratory for Energy-Related Health Research (LEHR)									
1998	8.6×10^{-2}	<1	—	—	8.6×10^{-2}	<1	1.2×10^{-3}	—	1.8×10^{6}
1999	1.4×10^{-3}	<1	—	—	1.4×10^{-3}	<1	4.0×10^{-5}	—	1.8×10^{6}
2000	7.5×10^{-4}	<1	—	—	7.5×10^{-4}	<1	2.6×10^{-5}	—	1.9×10^{6}
2001	1.0×10^{-3}	<1	—	—	1.0×10^{-3}	<1	2.2×10^{-4}	—	1.1×10^{5} (m)
Lawrence Livermore National Laboratory (LLNL)									
1998	4.9×10^{-2}	<1	—	—	4.9×10^{-2}	<1	6.8×10^{-1}	1.8×10^{6}	6.3×10^{6}
1999	1.0×10^{-1}	1	—	—	1.0×10^{-1}	<1	1.7×10^{0}	1.8×10^{6}	6.3×10^{6}
2000	3.7×10^{-2}	<1	—	—	3.7×10^{-2}	<1	4.7×10^{-1}	1.8×10^{6}	6.9×10^{6}
2001	1.7×10^{-2}	<1	—	—	1.7×10^{-2}	<1	1.6×10^{-1}	1.8×10^{6}	6.9×10^{6}
Lawrence Livermore National Laboratory - Site 300									
1998	2.4×10^{-2}	<1	—	—	2.4×10^{-2}	<1	1.1×10^{1}	—	5.4×10^{6}
1999	3.5×10^{-2}	<1	—	—	3.5×10^{-2}	<1	1.1×10^{1}	—	5.4×10^{6}
2000	1.9×10^{-2}	<1	—	—	1.9×10^{-2}	<1	2.5×10^{0}	—	6.0×10^{6}
2001	5.4×10^{-2}	<1	—	—	5.4×10^{-2}	<1	9.4×10^{0}	—	6.0×10^{6}
Los Alamos National Laboratory (LANL) (n)									
1998	—	—	—	1.9×10^{1}	1.9×10^{1}	19	8.0×10^{-1}	9.0×10^{4}	2.3×10^{5}
1999	—	—	—	1.6×10^{1}	1.6×10^{1}	16	3.0×10^{-1}	1.1×10^{5}	2.6×10^{5}
2000	—	—	—	1.3×10^{1}	1.3×10^{1}	13	1.0×10^{0}	1.1×10^{5}	2.6×10^{5}
2001	—	—	—	4.2×10^{0}	4.2×10^{0}	4	1.6×10^{0}	1.1×10^{5}	2.7×10^{5}

k. Population dose from natural radiation sources is calculated annually from TLD readings.
l. All on-site structures removed by the end of 1999; radiological monitoring discontinued.
m. Population dose based on 10-km radius of LEHR to "to avoid including the large number of receptors in the Sacramento area whose exposure to radionuclides resulting from the Site would be negligible, but whose population numbers would have a large effect on the collective population dose results."
n. Location of MEI changed in 2000 based on a review of all on-site sources of penetrating radiation, and MEI estimates re-calculated for 1998 and 1999 to account for the new location (see 2000 LANL ASER, Table 3-3). In 2001, the MEI calculations reverted to the location used prior to 2000.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
Naval Reactors Facility (NRF) (o)									
1998	4.5×10^{-4}	<1	0.0×10^{0}	—	4.5×10^{-4}	<1	0.0×10^{0}	5.4×10^{4}	1.5×10^{5}
1999	3.5×10^{-4}	<1	0.0×10^{0}	—	3.5×10^{-4}	<1	0.0×10^{0}	5.4×10^{4}	1.5×10^{5}
2000	3.2×10^{-4}	<1	0.0×10^{0}	—	3.2×10^{-4}	<1	0.0×10^{0}	5.4×10^{4}	1.5×10^{5}
2001	1.8×10^{-4}	<1	0.0×10^{0}	—	1.8×10^{-4}	<1	0.0×10^{0}	4.5×10^{4}	1.5×10^{5}
Nevada Test Site (NTS) (p)									
1998	9.2×10^{-2}	<1	—	—	9.2×10^{-2}	<1	2.7×10^{-1}	3.1×10^{3}	3.2×10^{4}
1999	1.2×10^{-1}	1	—	5.1×10^{-1}	6.3×10^{-1}	<1	3.8×10^{-1}	5.2×10^{3}	3.7×10^{4}
2000	1.7×10^{-1}	2	—	1.6×10^{-1}	3.3×10^{-1}	<1	4.4×10^{-1}	5.8×10^{3}	3.8×10^{4}
2001	1.7×10^{-1}	2	—	7.0×10^{-2}	2.4×10^{-1}	<1	4.4×10^{-1}	1.4×10^{4}	3.8×10^{4}
Pantex Plant (PANX)									
1998	5.0×10^{-3}	<1	—	—	5.0×10^{-3}	<1	1.1×10^{-2}	2.5×10^{4}	2.7×10^{5}
1999	2.0×10^{-3}	<1	—	—	2.0×10^{-3}	<1	3.7×10^{-3}	2.4×10^{4}	2.7×10^{5}
2000	1.6×10^{-4}	<1	—	—	1.6×10^{-4}	<1	1.6×10^{-3}	2.2×10^{4}	2.7×10^{5}
2001	1.3×10^{-5}	<1	—	—	1.3×10^{-5}	<1	1.4×10^{-4}	2.7×10^{4}	2.9×10^{5}
Sandia National Laboratories, Albuquerque (SNLA)									
1998	8.0×10^{-4}	<1	—	—	8.0×10^{-4}	<1	3.0×10^{-2}	—	7.0×10^{5}
1999	8.5×10^{-4}	<1	—	—	8.5×10^{-4}	<1	2.2×10^{-2}	—	7.0×10^{5}
2000	3.5×10^{-3}	<1	—	—	3.5×10^{-3}	<1	8.0×10^{-2}	—	7.0×10^{5}
2001	3.0×10^{-3}	<1	—	—	3.0×10^{-3}	<1	6.8×10^{-2}	—	7.0×10^{5}
Sandia National Laboratories, Tonopah (SNLT) (q)									
1998	2.4×10^{-2}	<1	—	—	2.4×10^{-2}	<1	—	—	—
1999	2.4×10^{-2}	<1	—	—	2.4×10^{-2}	<1	—	—	—
2000	2.4×10^{-2}	<1	—	—	2.4×10^{-2}	<1	—	—	—
2001	2.4×10^{-2}	<1	—	—	2.4×10^{-2}	<1	—	—	—

o. Population dose reported a no measurable dose to the general public.

p. MEI values per description in ASER, which contains additional dose estimates based on environmental sampling (see section 2.1). Variability in population dose attributed to natural radiation sources is due to expected fluctuations in environmental monitoring data.

q. MEI estimate calculated from one year of continuous air monitoring performed in 1996−1997. ASERs report that this estimate will continue to be used as long as there is no change in the status of the source of diffuse radiological emissions. Ongoing activities do not release radioactive emissions to the atmosphere.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
SCIENCE (SC)									
Ames Laboratory (AMES)									
1998	0.0×10^{0}	<1	—	—	0.0×10^{0}	<1	—	—	—
1999	1.3×10^{-16}	<1	—	—	0.0×10^{0}	<1	—	—	—
2000	1.1×10^{-8}	<1	—	—	1.1×10^{-8}	<1	—	—	—
2001	2.2×10^{-4}	<1	—	—	2.2×10^{-4}	<1	—	—	—
Argonne National Laboratory-East (ANLE)									
1998	2.7×10^{-2}	<1	2.6×10^{-2}	1.0×10^{-2}	6.3×10^{-2}	<1	1.7×10^{0}	2.5×10^{6}	8.4×10^{6}
1999	1.5×10^{-2}	<1	4.6×10^{-2}	1.0×10^{-2}	7.1×10^{-2}	<1	9.7×10^{-1}	2.5×10^{6}	8.4×10^{6}
2000	4.7×10^{-2}	<1	1.9×10^{-2}	1.0×10^{-2}	7.6×10^{-2}	<1	3.2×10^{0}	2.5×10^{6}	8.4×10^{6}
2001	3.7×10^{-2}	<1	1.6×10^{-2}	1.0×10^{-2}	6.3×10^{-2}	<1	2.4×10^{0}	2.7×10^{6}	8.9×10^{6}
Brookhaven National Laboratory (BNL) (r)									
1998	2.1×10^{-1}	2	—	7.4×10^{0}	7.6×10^{0}	8	7.7×10^{0}	2.9×10^{5}	5.1×10^{6}
1999	1.3×10^{-1}	1	0.0×10^{0}	4.5×10^{0}	4.6×10^{0}	5	4.8×10^{0}	—	5.1×10^{6}
2000	1.8×10^{-1}	2	0.0×10^{0}	3.1×10^{0}	3.3×10^{0}	3	6.7×10^{0}	—	5.1×10^{6}
2001	1.4×10^{-1}	1	0.0×10^{0}	2.4×10^{0}	2.5×10^{0}	3	5.7×10^{-1}	—	5.1×10^{6}
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL) (s)									
1998	3.0×10^{-1}	3	—	4.0×10^{-1}	7.0×10^{-1}	<1	3.0×10^{0}	1.3×10^{6}	5.0×10^{6}
1999	8.1×10^{-2}	<1	—	2.0×10^{-1}	2.8×10^{-1}	<1	9.2×10^{-1}	1.3×10^{6}	5.0×10^{6}
2000	8.9×10^{-2}	<1	—	2.0×10^{-1}	2.9×10^{-1}	<1	8.0×10^{-1}	1.3×10^{6}	5.0×10^{6}
2001	3.0×10^{-2}	<1	—	3.3×10^{-1}	4.0×10^{-1}	<1	9.0×10^{-1}	1.3×10^{6}	5.0×10^{6}
Oak Ridge Reservation (ORR) (t)									
1998	7.3×10^{-1}	7	2.7×10^{0}	5.7×10^{0}	8.4×10^{0}	8	1.2×10^{1}	2.6×10^{5}	8.8×10^{5}
1999	7.0×10^{-1}	7	4.0×10^{0}	6.7×10^{0}	1.1×10^{1}	11	1.9×10^{1}	2.6×10^{5}	8.8×10^{5}
2000	4.0×10^{-1}	4	1.3×10^{0}	8.4×10^{0}	9.7×10^{0}	10	1.3×10^{1}	2.6×10^{5}	8.8×10^{5}
2001	8.0×10^{-1}	8	4.0×10^{0}	4.0×10^{-1}	5.2×10^{0}	5	8.4×10^{0}	3.1×10^{5}	1.0×10^{6}

r. ASERs identify customer records of the Long Island Power Authority as the primary source of population data but do not report the population size used for the population dose calculation. According to BNL officials, the population dose estimate is based on a population size of 5.1×10^{6}.

s. 1998 and 1999 population doses corrected per errata reported in 2000 ASER.

t. MEI estimates include worst-case scenario for consumption of deer, geese, and wild turkey. Population dose estimate is based on air emissions only; 1998 and 1999 ASERs also report an all pathways, "highest imaginable" population dose estimate of 60 person-rem and 30 person-rem, respectively.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-1 (continued). 1998−2001 MEI and Population Dose Estimates

Year	Maximally Exposed Individual (MEI)						Population dose		
	Air pathway contribution (mrem/yr)	% of 10 mrem/yr air pathway limit	Liquid effluent pathway contribution (mrem/yr)	Other pathway contribution (mrem/yr)	Total dose to MEI (all pathways) (mrem/yr)	% of DOE 100-mrem/yr limit	Population dose (person-rem/yr)	Natural radiation population dose (person-rem/yr)	Population within 50 mi (80 km)
Princeton Plasma Physics Laboratory (PPPL)									
1998	6.7×10^{-1}	7	2.8×10^{-3}	—	6.8×10^{-1}	<1	—	—	—
1999	2.6×10^{-1}	3	2.1×10^{-3}	—	2.6×10^{-1}	<1	2.7×10^{0}	—	—
2000	2.1×10^{-1}	2	2.3×10^{-3}	2.3×10^{-6}	2.1×10^{-1}	<1	1.6×10^{0}	—	—
2001	6.2×10^{-1}	6	3.0×10^{-3}	5.8×10^{-6}	6.2×10^{-1}	<1	5.3×10^{0}	—	—
Stanford Linear Accelerator Center (SLAC)									
1998	4.0×10^{-4}	<1	—	4.6×10^{0}	4.6×10^{0}	5	9.9×10^{0}	1.5×10^{6}	4.9×10^{6}
1999	3.0×10^{-2}	<1	—	4.4×10^{0}	4.5×10^{0}	5	1.7×10^{1}	1.5×10^{6}	4.9×10^{6}
2000	3.0×10^{-2}	<1	—	5.6×10^{0}	5.7×10^{0}	6	1.5×10^{1}	1.5×10^{6}	4.9×10^{6}
2001	8.0×10^{-2}	<1	—	5.2×10^{0}	5.3×10^{0}	5	2.1×10^{1}	1.5×10^{6}	4.9×10^{6}
Thomas Jefferson National Accelerator Facility (JLAB)									
1998	2.1×10^{-4}	<1	—	1.0×10^{0}	1.0×10^{0}	1	7.3×10^{-4}	—	—
1999	8.0×10^{-2}	<1	—	5.3×10^{0}	5.3×10^{0}	5	—	—	—
2000	4.8×10^{-2}	<1	—	3.8×10^{0}	3.8×10^{0}	4	—	—	—
2001	1.1×10^{-2}	<1	—	7.0×10^{0}	7.0×10^{0}	7	2.5×10^{-2}	—	2.1×10^{5}

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

Table 2-2. Sites Reporting an MEI Dose Greater Than 1 mrem/yr for At Least One Year from 1998−2001

Site Name	MEI Range (1998−2001, low to high)	Dominant Contributor to Estimated MEI
Bettis Atomic Power Laboratory	2.4 to 2.6 mrem/yr	2.3 mrem/yr to person assumed to walk for 1 hour per day along a stream bank in areas with elevated radioactivity attributed to effluent releases in the 1950s and 1960s.
Brookhaven National Laboratory	2.5 to 7.6 mrem/yr	2.4 to 7.4 mrem/yr to person consuming 64 lbs of deer meat and 15 lbs of fish with average levels of ^{137}Cs contamination. ^{137}Cs primarily attributed to BNL releases during the 1950s and 1960s.
Fernald	8.2 to 11.7mrem/yr	8.2 to 11.5 mrem/yr to person assumed to remain at fenceline at point of exposure to direct radiation from radon in K-65 silos.
Los Alamos National Laboratory	4.2 to 19 mrem/yr	4.2 to 19 mrem/yr to person assumed to regularly drive by the on-site location with highest potential for direct radiation exposure.
Miamisburg Environmental Management Project	0.1 to 1.2 mrem/yr	1.1 mrem/yr attributed to inclusion of levels of ^{238}Pu in one set of vegetation samples in 1999 (the single year in which the estimate exceeded 1 mrem).
Monticello Mill Tailings Site	22 to 37 mrem/yr	19 to 30 mrem/yr from gamma radiation to person living just off-site. ASER attributes reduction in estimate from 30 mrem in 1998 to 19 mrem in 1999 to completion of remedial actions. Location of MEI also changed.
Oak Ridge Reservation	5.2 to 11 mrem/yr	0.4 to 8.4 mrem/yr to person assumed to eat the hypothetical worst possible deer, geese, and turkey (i.e., the heaviest and the highest measured concentrations of ^{137}Cs and ^{90}Sr) from the year's hunt. 0.4 mrem is estimated for 2001 when the deer hunt was not held. Other major contributors to dose estimates include direct radiation and fish consumption.
Paducah Gaseous Diffusion Plant	0.69 to 3.7 mrem/yr	0.53 to 3.4 mrem/yr to person assumed to eat the two deer with the highest dose potential from the eight deer sampled during the year.
Portsmouth Gaseous Diffusion Plant	0.5 to 2.9 mrem/yr	0.5 to 2.8 mrem/yr to person assumed to regularly drive by location with highest potential for direct radiation exposure.
Stanford Linear Accelerator Center	4.5 to 5.7 mrem/yr	4.4 to 5.6 mrem/yr from accelerator-produced direct radiation to person assumed to remain 24 hours/day, 365 days/year at a public location closest to locations of the highest-reading dosimeters on the SLAC boundary.
Thomas Jefferson National Accelerator Laboratory	1.0 to 7.0 mrem/yr	1.0 to 7.0 mrem/yr from accelerator-produced direct radiation to person assumed to remain at location of boundary monitor.
Weldon Spring Site Remedial Action Project	0.2 to 7.6 mrem/yr	2.6 to 5 mrem/yr from direct radiation exposure to worker remaining at boundary of Weldon Spring Chemical Plant. Estimates for 1998–1999 only; remediation completed.

Table 2-3. Comparison of Dose Estimates from ASERs and Subpart H Reports for 1998−2001

YEAR	ASER MEI Air Pathway Contribution (mrem)	Subpart H MEI Air Pathway (mrem) (a)	ASER Population Dose (person-rem)	Subpart H Population Dose (person-rem)	ASER Population within 50 mi (80 km)	Subpart H Population within 50 mi (80 km)
Environmental Management (EM)						
Ashtabula Environmental Management Project (AEMP)						
1998	1.4×10^{-3}	—	—	—	—	—
1999	1.5×10^{-3}	—	—	—	—	—
2000	5.8×10^{-2}	—	—	—	—	—
2001	2.0×10^{-2}	—	—	—	—	—
Battelle Columbus Laboratories (BCL)						
1998	—	—	8.1×10^{-4}	—	2.1×10^{6}	—
1999	—	—	7.0×10^{-4}	—	2.1×10^{6}	—
2000	—	—	7.6×10^{-4}	—	2.3×10^{6}	—
2001	—	—	7.7×10^{-4}	—	2.3×10^{6}	—
Energy Technology Engineering Center (ETEC)						
1998	2.5×10^{-3}	2.5×10^{-3}	9.4×10^{-2}	8.5×10^{-2}	9.8×10^{6}	1.0×10^{7}
1999	8.8×10^{-7}	8.8×10^{-7}	4.8×10^{-5}	9.5×10^{-5}	9.9×10^{6}	1.0×10^{7}
2000	7.7×10^{-7}	7.7×10^{-7}	2.2×10^{-4}	2.2×10^{-6}	1.0×10^{7}	1.0×10^{7}
2001	3.1×10^{-6}	3.1×10^{-6}	7.5×10^{-4}	7.5×10^{-4}	1.0×10^{7}	1.0×10^{7}
Fernald Environmental Management Project (FEMP)						
1998	5.0×10^{-2}	2.6×10^{-1}	—	—	—	—
1999	9.0×10^{-2}	2.9×10^{-1}	—	1.3×10^{0}	—	2.7×10^{6}
2000	2.8×10^{-1}	2.5×10^{0}	—	3.9×10^{0}	—	2.7×10^{6}
2001	2.0×10^{-1}	8.0×10^{-1}	—	3.5×10^{0}	—	2.7×10^{6}
Grand Junction Office (GJO)						
1998	3.3×10^{-3}	3.3×10^{-3}	4.8×10^{-3}	1.5×10^{-3}	1.2×10^{5}	1.2×10^{5}
1999	1.4×10^{-3}	1.4×10^{-3}	9.5×10^{-3}	6.3×10^{-4}	1.2×10^{5}	1.2×10^{5}
2000	1.1×10^{-2}	1.1×10^{-2}	6.6×10^{-3}	6.1×10^{-4}	1.5×10^{5}	1.2×10^{5}
2001	4.7×10^{-2}	4.7×10^{-2}	6.4×10^{-3}	2.6×10^{-3}	1.5×10^{5}	1.2×10^{5}
Hanford Site (HANF)						
1998	1.5×10^{-2}	1.3×10^{-2}	1.9×10^{-1}	8.4×10^{-2}	3.8×10^{5}	3.8×10^{5}
1999	5.8×10^{-3}	2.9×10^{-2}	2.5×10^{-1}	1.9×10^{-1}	3.8×10^{5}	3.8×10^{5}
2000	2.2×10^{-3}	4.6×10^{-2}	3.0×10^{-1}	1.8×10^{-1}	3.8×10^{5}	3.8×10^{5}
2001	7.7×10^{-3}	1.2×10^{-1}	4.0×10^{-1}	4.0×10^{-1}	4.9×10^{5}	4.9×10^{5}
Idaho National Environmental and Engineering Laboratory (INEEL) (b)						
1998	8.0×10^{-3}	1.0×10^{-2}	7.5×10^{-2}	7.5×10^{-2}	1.2×10^{5}	1.2×10^{5}
1999	8.0×10^{-3}	1.6×10^{-3}	3.7×10^{-2}	3.7×10^{-2}	1.2×10^{5}	1.2×10^{5}
2000	5.7×10^{-2}	1.2×10^{-2}	5.3×10^{-1}	—	2.3×10^{5}	1.2×10^{5}
2001	7.4×10^{-2}	1.8×10^{-4}	5.9×10^{-1}	5.9×10^{-1}	2.3×10^{5}	2.3×10^{5}
Miamisburg Environmental Management Project (MEMP)						
1998	4.2×10^{-2}	6.6×10^{-2}	2.6×10^{0}	2.3×10^{0}	3.0×10^{6}	3.0×10^{6}
1999	1.1×10^{-1}	5.1×10^{-2}	2.2×10^{0}	2.1×10^{0}	3.0×10^{6}	3.0×10^{6}
2000	1.6×10^{-1}	1.9×10^{-1}	1.3×10^{0}	1.1×10^{0}	3.1×10^{6}	3.0×10^{6}
2001	1.1×10^{-1}	1.1×10^{-1}	2.8×10^{0}	2.7×10^{0}	3.1×10^{6}	3.1×10^{6}

a. Estimates based on point or diffuse sources, or both; see Annex A and site-specific Subpart H reports for details.
b. Estimates include contribution to dose from Naval Reactors Facility.

Table 2-3 (continued). Comparison of Dose Estimates from ASERs and Subpart H Reports for 1998−2001

YEAR	ASER MEI Air Pathway Contribution (mrem)	Subpart H MEI Air Pathway (mrem) (a)	ASER Population Dose (person-rem)	Subpart H Population Dose (person-rem)	ASER Population within 50 mi (80 km)	Subpart H Population within 50 mi (80 km)
Monticello Mill Tailings Site (MMTS)						
1998	—	—	7.6×10^{1}	—	—	—
1999	—	—	4.8×10^{1}	—	—	—
Paducah Gaseous Diffusion Plant (PGDP)						
1998	2.9×10^{-3}	2.9×10^{-3}	2.7×10^{-3}	2.7×10^{-3}	5.0×10^{5}	5.4×10^{5}
1999	1.7×10^{-3}	1.7×10^{-3}	—	6.5×10^{-2}	—	5.4×10^{5}
2000	8.8×10^{-3}	3.0×10^{-3}	—	1.3×10^{-2}	—	5.4×10^{5}
2001	3.7×10^{-3}	3.7×10^{-3}	—	1.1×10^{0}	—	5.0×10^{5}
Portsmouth Gaseous Diffusion Plant (POR)						
1998	2.5×10^{-4}	5.3×10^{-5}	2.3×10^{-1}	2.3×10^{-1}	9.2×10^{5}	6.0×10^{5}
1999	2.8×10^{-1}	4.8×10^{-4}	1.0×10^{0}	—	6.0×10^{5}	6.0×10^{5}
2000	4.7×10^{-2}	—	1.7×10^{-1}	—	6.0×10^{5}	—
2001	6.0×10^{-2}	1.4×10^{-2}	2.0×10^{-1}	1.8×10^{-1}	6.0×10^{5}	6.7×10^{5}
Savannah River Site (SRS)						
1998	7.0×10^{-2}	8.0×10^{-2}	5.3×10^{0}	8.1×10^{0}	6.2×10^{5}	6.2×10^{5}
1999	6.0×10^{-2}	5.1×10^{-2}	6.6×10^{0}	5.1×10^{0}	6.2×10^{5}	6.2×10^{5}
2000	4.0×10^{-2}	5.0×10^{-2}	6.2×10^{0}	4.9×10^{0}	6.2×10^{5}	6.2×10^{5}
2001	5.0×10^{-2}	5.7×10^{-2}	7.2×10^{0}	5.6×10^{0}	7.1×10^{5}	7.1×10^{5}
Waste Isolation Pilot Plant (WIPP) (c)						
1998	—	—	—	—	1.0×10^{5}	7.9×10^{4}
1999	2.2×10^{-6}	2.2×10^{-6}	—	4.9×10^{-6}	1.0×10^{5}	7.9×10^{4}
2000	5.2×10^{-6}	5.2×10^{-6}	—	1.1×10^{-5}	1.0×10^{5}	7.9×10^{4}
2001	5.0×10^{-6}	5.0×10^{-6}	—	1.1×10^{-5}	1.0×10^{5}	7.9×10^{4}
Weldon Spring Site Remedial Action Project (WSSRAP)						
1998	2.6×10^{0}	2.0×10^{-2}	1.4×10^{0}	1.4×10^{0}	1.7×10^{5}	2.9×10^{5}
1999	—	4.0×10^{-1}	1.8×10^{-1}	1.8×10^{-1}	1.1×10^{5}	2.9×10^{5}
2000	—	—	1.0×10^{-1}	1.0×10^{-1}	1.1×10^{5}	2.1×10^{5}
2001	—	—	1.0×10^{-1}	—	1.1×10^{5}	—
West Valley Demonstration Project (WVDP)						
1998	3.4×10^{-2}	3.4×10^{-2}	3.3×10^{-1}	2.6×10^{-1}	1.3×10^{6}	1.3×10^{6}
1999	1.1×10^{-2}	1.1×10^{-2}	2.4×10^{-1}	1.1×10^{-1}	1.3×10^{6}	1.3×10^{6}
2000	8.1×10^{-3}	8.1×10^{-3}	2.2×10^{-1}	6.9×10^{-2}	1.3×10^{6}	1.4×10^{6}
2001	4.6×10^{-3}	4.6×10^{-3}	1.9×10^{-1}	5.9×10^{-2}	1.3×10^{6}	1.4×10^{6}

a. Estimates based on point or diffuse sources, or both; see Annex A and site-specific Subpart H reports for details.
c. Population size used for Subpart H report does not include some small communities and rural areas.

Table 2-3 (continued). Comparison of Dose Estimates from ASERs and Subpart H Reports for 1998−2001

YEAR	ASER MEI Air Pathway Contribution (mrem)	Subpart H MEI Air Pathway (mrem) (a)	ASER Population Dose (person-rem)	Subpart H Population Dose (person-rem)	ASER Population within 50 mi (80 km)	Subpart H Population within 50 mi (80 km)
National Nuclear Security Administration (NNSA)						
Bettis Atomic Power Laboratory (BET)						
1998	2.0×10^{-1}	2.0×10^{-1}	1.4×10^{0}	1.4×10^{0}	3.0×10^{6}	3.0×10^{6}
1999	2.8×10^{-1}	2.8×10^{-1}	1.5×10^{0}	1.4×10^{0}	3.0×10^{6}	3.0×10^{6}
2000	1.3×10^{-1}	1.3×10^{-1}	1.0×10^{0}	1.0×10^{0}	3.0×10^{6}	3.0×10^{6}
2001	1.4×10^{-1}	1.4×10^{-1}	1.2×10^{0}	1.2×10^{0}	3.0×10^{6}	3.0×10^{6}
Knolls Atomic Power Laboratory - Kesselring (KAPL-2)						
1998	1.0×10^{-1}	3.6×10^{-2}	3.0×10^{-1}	3.0×10^{-1}	1.2×10^{6}	1.2×10^{6}
1999	1.0×10^{-1}	3.1×10^{-2}	3.0×10^{-1}	2.4×10^{-1}	1.2×10^{6}	1.2×10^{6}
2000	1.0×10^{-1}	2.0×10^{-2}	3.0×10^{-1}	1.7×10^{-1}	1.2×10^{6}	1.2×10^{6}
2001	1.0×10^{-1}	5.7×10^{-3}	1.0×10^{-1}	3.5×10^{-2}	1.2×10^{6}	1.2×10^{6}
Knolls Atomic Power Laboratory - Knolls (KAPL-1)						
1998	1.0×10^{-1}	1.6×10^{-3}	1.0×10^{-1}	3.5×10^{-3}	1.3×10^{6}	1.3×10^{6}
1999	1.0×10^{-1}	7.8×10^{-4}	1.0×10^{-1}	1.9×10^{-3}	1.3×10^{6}	1.3×10^{6}
2000	1.0×10^{-1}	6.9×10^{-4}	1.0×10^{-1}	1.7×10^{-3}	1.3×10^{6}	1.3×10^{6}
2001	1.0×10^{-1}	3.8×10^{-4}	1.0×10^{-1}	1.2×10^{-3}	1.3×10^{6}	1.3×10^{6}
Knolls Atomic Power Laboratory - Windsor (KAPL-3)						
1998	1.0×10^{-1}	8.5×10^{-6}	1.0×10^{-1}	4.9×10^{-5}	3.4×10^{6}	3.4×10^{6}
1999	1.0×10^{-1}	1.3×10^{-6}	1.0×10^{-1}	7.5×10^{-6}	3.4×10^{6}	3.4×10^{6}
Laboratory for Energy-Related Health Research (LEHR)						
1998	8.6×10^{-2}	4.2×10^{-3}	1.2×10^{-3}	1.8×10^{-4}	1.8×10^{6}	1.0×10^{5}
1999	1.4×10^{-3}	1.4×10^{-3}	4.0×10^{-5}	4.0×10^{-5}	1.8×10^{6}	1.0×10^{5}
2000	7.5×10^{-4}	7.5×10^{-4}	2.6×10^{-5}	2.6×10^{-5}	1.9×10^{6}	1.0×10^{5}
2001	1.0×10^{-3}	1.0×10^{-3}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{5}	1.0×10^{5}
Lawrence Livermore National Laboratory (LLNL)						
1998	4.9×10^{-2}	5.5×10^{-2}	6.8×10^{-1}	8.4×10^{-1}	6.3×10^{6}	6.3×10^{6}
1999	1.0×10^{-1}	1.2×10^{-1}	1.7×10^{0}	2.2×10^{0}	6.3×10^{6}	6.3×10^{6}
2000	3.7×10^{-2}	3.8×10^{-2}	4.7×10^{-1}	5.2×10^{-1}	6.9×10^{6}	6.3×10^{6}
2001	1.7×10^{-2}	1.7×10^{-2}	1.6×10^{-1}	1.6×10^{-1}	6.9×10^{6}	6.9×10^{6}
Lawrence Livermore National Laboratory - Site 300						
1998	2.4×10^{-2}	2.4×10^{-2}	1.1×10^{1}	1.1×10^{1}	5.4×10^{6}	5.4×10^{6}
1999	3.5×10^{-2}	3.5×10^{-2}	1.1×10^{1}	1.1×10^{1}	5.4×10^{6}	5.4×10^{6}
2000	1.9×10^{-2}	1.9×10^{-2}	2.5×10^{0}	2.5×10^{0}	6.0×10^{6}	5.4×10^{6}
2001	5.4×10^{-2}	5.4×10^{-2}	9.4×10^{0}	9.4×10^{0}	6.0×10^{6}	6.0×10^{6}
Los Alamos National Laboratory (LANL)						
1998	—	1.7×10^{0}	8.0×10^{-1}	8.0×10^{-1}	2.3×10^{5}	2.6×10^{5}
1999	—	3.2×10^{-1}	3.0×10^{-1}	3.2×10^{-1}	2.6×10^{5}	2.6×10^{5}
2000	—	6.4×10^{-1}	1.0×10^{0}	1.0×10^{0}	2.6×10^{5}	2.5×10^{5}
2001	—	1.8×10^{0}	1.6×10^{0}	1.6×10^{0}	2.7×10^{5}	2.7×10^{5}

a. Estimates based on point or diffuse sources, or both; see Annex A and site-specific Subpart H reports for details.

Table 2-3 (continued). Comparison of Dose Estimates from ASERs and Subpart H Reports for 1998−2001

YEAR	ASER MEI Air Pathway Contribution (mrem)	Subpart H MEI Air Pathway (mrem) (a)	ASER Population Dose (person-rem)	Subpart H Population Dose (person-rem)	ASER Population within 50 mi (80 km)	Subpart H Population within 50 mi (80 km)
Naval Reactors Facility (NRF) (d)						
Nevada Test Site (NTS)						
1998	9.2×10^{-2}	9.2×10^{-2}	2.7×10^{-1}	2.7×10^{-1}	3.2×10^{4}	3.2×10^{4}
1999	1.2×10^{-1}	1.2×10^{-1}	3.8×10^{-1}	3.8×10^{-1}	3.7×10^{4}	3.7×10^{4}
2000	1.7×10^{-1}	1.7×10^{-1}	4.4×10^{-1}	4.4×10^{-1}	3.8×10^{4}	3.8×10^{4}
2001	1.7×10^{-1}	1.7×10^{-1}	4.4×10^{-1}	4.4×10^{-1}	3.8×10^{4}	3.8×10^{4}
Pantex Plant (PANX)						
1998	5.0×10^{-3}	5.0×10^{-3}	1.1×10^{-2}	1.1×10^{-2}	2.7×10^{5}	2.7×10^{5}
1999	2.0×10^{-3}	2.0×10^{-3}	3.7×10^{-3}	3.7×10^{-3}	2.7×10^{5}	2.7×10^{5}
2000	1.6×10^{-4}	1.6×10^{-4}	1.6×10^{-3}	1.6×10^{-3}	2.7×10^{5}	2.7×10^{5}
2001	1.3×10^{-5}	6.6×10^{-4}	1.4×10^{-4}	2.1×10^{-3}	2.9×10^{5}	2.9×10^{5}
Sandia National Laboratories, Albuquerque (SNLA)						
1998	8.0×10^{-4}	8.0×10^{-4}	3.0×10^{-2}	4.1×10^{-2}	7.0×10^{5}	7.0×10^{5}
1999	8.5×10^{-4}	8.5×10^{-4}	2.2×10^{-2}	2.2×10^{-2}	7.0×10^{5}	7.0×10^{5}
2000	3.5×10^{-3}	3.5×10^{-3}	8.0×10^{-2}	8.0×10^{-2}	7.0×10^{5}	7.0×10^{5}
2001	3.0×10^{-3}	3.0×10^{-3}	6.8×10^{-2}	6.8×10^{-2}	7.0×10^{5}	7.0×10^{5}
Sandia National Laboratories, Tonopah (SNLT)						
1998	2.4×10^{-2}	2.4×10^{-2}	—	—	—	—
1999	2.4×10^{-2}	2.4×10^{-2}	—	—	—	6.7×10^{3}
2000	2.4×10^{-2}	2.4×10^{-2}	—	—	—	6.9×10^{3}
2001	2.4×10^{-2}	2.4×10^{-2}	—	—	—	—
Science (SC)						
Ames Laboratory (AMES)						
1998	0.0×10^{0}	—	—	—	—	—
1999	1.3×10^{-16}	—	—	—	—	—
2000	1.1×10^{-8}	—	—	—	—	—
2001	2.2×10^{-4}	—	—	—	—	—
Argonne National Laboratory - East (ANLE)						
1998	2.7×10^{-2}	1.6×10^{-2}	1.7×10^{0}	1.7×10^{0}	8.4×10^{6}	8.4×10^{6}
1999	1.5×10^{-2}	4.3×10^{-3}	9.7×10^{-1}	9.7×10^{-1}	8.4×10^{6}	8.4×10^{6}
2000	4.7×10^{-2}	4.6×10^{-2}	3.2×10^{0}	3.2×10^{0}	8.4×10^{6}	8.4×10^{6}
2001	3.7×10^{-2}	3.6×10^{-2}	2.4×10^{0}	2.4×10^{0}	8.9×10^{6}	8.9×10^{6}
Brookhaven National Laboratory (BNL)						
1998	2.1×10^{-1}	2.1×10^{-1}	7.7×10^{0}	7.7×10^{0}	5.1×10^{6}	5.1×10^{6}
1999	1.3×10^{-1}	1.3×10^{-1}	4.8×10^{0}	4.8×10^{0}	5.1×10^{6}	5.1×10^{6}
2000	1.8×10^{-1}	1.8×10^{-1}	6.7×10^{0}	6.7×10^{0}	5.1×10^{6}	5.1×10^{6}
2001	1.4×10^{-1}	1.4×10^{-1}	5.7×10^{-1}	5.7×10^{-1}	5.1×10^{6}	5.1×10^{6}

a. Estimates based on point or diffuse sources, or both; see Annex A and site-specific Subpart H reports for details.
d. Included with dose estimates for the Idaho National Engineering and Environmental Laboratory.

Table 2-3 (continued). Comparison of Dose Estimates from ASERs and Subpart H Reports for 1998−2001

YEAR	ASER MEI Air Pathway Contribution (mrem)	Subpart H MEI Air Pathway (mrem) (a)	ASER Population Dose (person-rem)	Subpart H Population Dose (person-rem)	ASER Population within 50 mi (80 km)	Subpart H Population within 50 mi (80 km)
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)						
1998	2.8×10^{-1}	2.5×10^{-1}	3.0×10^{0}	2.5×10^{0}	5.0×10^{6}	5.0×10^{6}
1999	8.1×10^{-2}	8.1×10^{-2}	9.2×10^{-1}	7.4×10^{-1}	5.0×10^{6}	5.0×10^{6}
2000	8.9×10^{-2}	8.9×10^{-2}	8.0×10^{-1}	5.6×10^{-1}	5.0×10^{6}	5.0×10^{6}
2001	3.0×10^{-2}	5.6×10^{-2}	9.0×10^{-1}	4.8×10^{-1}	5.0×10^{6}	5.0×10^{6}
Oak Ridge Reservation (ORR)						
1998	7.3×10^{-1}	7.3×10^{-1}	1.2×10^{1}	1.2×10^{1}	8.8×10^{5}	8.8×10^{5}
1999	7.0×10^{-1}	7.0×10^{-1}	1.9×10^{1}	1.9×10^{1}	8.8×10^{5}	1.9×10^{5}
2000	4.0×10^{-1}	4.0×10^{-1}	1.3×10^{1}	1.3×10^{1}	8.8×10^{5}	9.5×10^{5}
2001	8.0×10^{-1}	8.0×10^{-1}	8.4×10^{0}	8.3×10^{0}	1.0×10^{6}	1.0×10^{6}
Princeton Plasma Physics Laboratory (PPPL)						
1998	6.7×10^{-1}	1.0×10^{-1}	—	—	—	—
1999	2.6×10^{-1}	1.0×10^{-1}	2.7×10^{0}	2.7×10^{0}	—	—
2000	2.1×10^{-1}	9.8×10^{-2}	1.6×10^{0}	1.6×10^{0}	—	1.6×10^{7}
2001	6.2×10^{-1}	3.0×10^{-1}	5.3×10^{0}	5.3×10^{0}	—	1.6×10^{7}
Stanford Linear Accelerator Center (SLAC)						
1998	4.0×10^{-4}	4.3×10^{-4}	9.9×10^{0}	3.3×10^{-3}	4.9×10^{6}	4.9×10^{6}
1999	3.0×10^{-2}	1.4×10^{-5}	1.7×10^{1}	7.7×10^{-7}	4.9×10^{6}	4.9×10^{6}
2000	3.0×10^{-2}	3.2×10^{-2}	1.5×10^{1}	1.9×10^{-1}	4.9×10^{6}	4.9×10^{6}
2001	8.0×10^{-2}	8.0×10^{-2}	2.1×10^{1}	2.3×10^{-1}	4.9×10^{6}	4.9×10^{6}
Thomas Jefferson National Accelerator Facility (JLAB)						
1998	2.1×10^{-4}	—	7.3×10^{-4}	—	—	—
1999	8.0×10^{-2}	8.2×10^{-2}	—	—	—	—
2000	4.8×10^{-2}	4.8×10^{-2}	—	2.5×10^{-1}	—	—
2001	1.1×10^{-2}	1.1×10^{-2}	2.5×10^{-2}	2.2×10^{-2}	2.1×10^{5}	—

a. Estimates based on point or diffuse sources, or both; see Annex A and site-specific Subpart H reports for details.

3.0 Releases of Radioactive Materials to Air and Water

3.1 Background

Each DOE site with radiological activities monitors releases to air and water as appropriate to site-specific circumstances and as necessary to demonstrate compliance with applicable Federal, state, and local regulations, including DOE's ALARA policy. DOE O 5400.1 suggested that ASERs use this monitoring program to identify the radionuclides of concern and the total number of curies in airborne and liquid effluents (DOE 1990a). The Order adds that, "For purposes of reporting radiological effluent data, gross radioactivity measurements are unacceptable, unless specified by applicable federal, state, or local regulation."[4] Pursuant to the Order, ASERs also identify unplanned releases that occurred during the year.

Releases from DOE sites are reported in terms of the number of curies of each radionuclide discharged or as a concentration (i.e., curies per unit air or water). Most often a total quantity for the year is reported for an operating facility, where, for example, the total volume of air flowing through an exhaust stack is known and can be combined with monitoring results to estimate total releases. Concentration data most often is reported for diffuse sources, such as contaminants in soil that are dispersed by local wind conditions, where an estimate of air flow or total releases would be more uncertain than for point sources.

Each site calculates an estimated dose to the MEI and population from these releases and other data (e.g., direct radiation monitoring at accelerator facilities). For 1998 through 2001, these dose estimates fell well below applicable limits. (See section 2 of this report.)

In comparing release information to dose estimates, it is important to consider dose conversion factors (see definition in Appendix B) and other aspects of dose calculation. DOE site might release several radionuclides, each with distinct properties (such as half-life, mode of decay, chemical characteristics, radiological toxicity, and physical form). In addition, dispersion mechanisms (how the material is released to and moves through the environment) and exposure pathways vary. Each of these properties influences the dose attributable to a particular release, as well as cumulative releases over the course of a year. For example, the highest reported releases to both air and water were from SRS in 1998 – a total of 1.1×10^5 curies, which was mostly tritium. This translated to an estimated dose to the MEI of 0.19 mrem and to the population of 5.3 person-rem. Similarly, some DOE sites release thousands of curies of ^{85}Kr to the atmosphere in a year. This might account for a significant percentage of the total curies of radioactive material discharged to the environment, yet contribute a very small percentage to the estimated dose. This small contribution to dose occurs because ^{85}Kr is a noble gas that does not concentrate in the body and emits mostly beta particles.

3.2 Routine Releases

Routine releases of radionuclides to the air and water reflect the nature of operations at a given DOE site. Examples of the isotopes that might be included in these releases are listed in Table 3-1. Tables 3-2 and 3-4 list the quantities (in total curies) of specific radionuclides or classes of radionuclides released to the air and water, respectively, from DOE sites by year for 1998 through 2001. These tables also indicate when releases are reported in ASERs as concentrations, rather than total quantity for the year. Such reporting in concentration most often

[4] Several DOE sites report gross alpha and beta measurements in ASERs. Gross alpha and beta measurements are screening values that help identify the potential for unexpected releases and the need for additional monitoring of particular radionuclides.

indicates monitoring of a diffuse source and is indicative of environmental remediation activities. Tables 3-3 and 3-5 provide the total releases to air and water, respectively, in each category by year.

3.3 Non-Routine Releases

Non-routine releases (unplanned radiological releases) can occur as a result of leaks, spills, equipment malfunctions, or accidents involving radiological materials. During 1998 through 2001, non-routine releases at DOE sites involved small amounts of radiological materials and short duration events. Consequently, non-routine releases accounted for only a small fraction of the radioactivity released from DOE sites during this time frame. For such non-routine releases, either there was no measurable contribution to public dose or the contribution was too small to affect the annual estimate.

Non-routine releases reported in ASERs are described below. Non-routine atmospheric releases also are discussed in Annex A, which summarizes reports filed with EPA to demonstrate compliance with atmospheric release regulations (Subpart H). Some events included in Annex A were not discussed in the applicable ASER. These events include tritium releases at NTS for 1998−2001 that resulted from a 1995 incident. In addition, for 1998, Annex A identifies three unplanned releases at Hanford and one at ORR that were not discussed in the ASERs (and the Hanford ASER for 1998 describes a release from an overpressurized drum that is not included in Annex A). For 1999 and 2000, Annex A includes seven unplanned releases at Paducah and three at ORR that are not mentioned in ASERs.

1998

Hanford – Three non-routine releases. The first was an atmospheric release of radioactivity in trace amounts due to an overpressurized 208-L (55-gal) drum at the AN Tank Farm, 200-East Area. The second release involved trace amounts of radioactively contaminated water that splashed out of a pit during cleaning operations at the SX Tank Farm, 200-West Area. In the third event, radioactively contaminated water was released from a broken fire line in the 327 Building, 300 Area.

LANL – Two non-routine releases. On January 27,1998, 60 Ci of tritium was released to the air due to a faulty gasket seal, and during the week of October 6, 1998, approximately 30 Ci of tritium was released to the air from the same facility due to improper tritium handling operations. (The Subpart H report indicates that 23 Ci of tritium was released during the October 1998 event.)

LBNL – One non-routine release. On July 24, 1998, 35 Ci of tritium was released into the atmosphere from the National Tritium Labeling Facility during a waste treatability study.

1999

Hanford – One non-routine release. On May 20,1999, inspection of a shipping cask that had been transported from 100-K Area to Chem-Nuclear Systems in Barnwell, South Carolina, indicated areas where the contamination limit of 22,000 disintegrations per minute/100cm² was exceeded. An investigation found that the shipping cask malfunctioned and contamination leached from the outer surface of the cask following immersion of the cask in the 105-K East Basin prior to shipping. Use of this type of cask was discontinued.

LANL – Two non-routine releases. During the week of June 4, 1999, 5 microcuries of silicon-32 was released the air from the radiochemistry facility, TA-48. During the week of June 25,1999,

approximately 50 microcuries of technetium-99 was released into a room at the Chemistry and Metallurgy Research facility. Both releases had a dose impact of less than 1 microrem (0.001mrem).

NTS – One non-routine release. On November 10, 1999, low-level tritium contamination was found in a source storage vault in Building A-1 at the North Las Vegas Facility.

SNL-A – Two non-routine releases. On June 28, 1999, and again on September 3, 1999, leakage from the Gamma Irradiation Facility (GIF) was discovered. The leak was estimated as high as 1 gal/hr above the estimated 0.5 gal/hr normally lost through evaporation. Tritium was the only radionuclide detected in the water, and it was detected at levels a factor of 10 below EPA drinking water standards. By September 15, 1999, the leakage had dropped to 0.5 gal/hr. A GIF Risk Management Plan was submitted to DOE on October 8, 1999.

2000

Hanford – One potential non-routine release. During a routine functional test of the 291-Z-1 stack air monitoring system at the Plutonium Finishing Plant, a worker dropped a wrench onto the continuous air monitor. This caused the alarm to go off, indicating a potential release of 3.6×10^{-5} Ci of $^{239, 240}$Pu. Analysis indicated that no release actually occurred.

2001

Hanford – One non-routine release. 7.68 liters (2 gal) of radioactively contaminated liquid (160 pCi/L alpha and 290 pCi/L beta) leached from the Effluent Retention Disposal Facility into the soil after a release valve failed in a pipeline.

LANL – Two non-routine releases. Fifty gallons of partially treated radioactive liquid waste water was accidentally released from Holding Tank 21-113 and TA-21. In addition, 7,565 Ci (280 TBq) of tritium was released over the course of an hour to the air from the Weapons Engineering Tritium Facility. The release was isolated and stopped. The total dose from the event was less than 1 mrem (1.0×10^{-2} mSv).

WVDP − One potential non-routine release. It was discovered by survey that the waste tank farm ventilation system had a small amount of unexpected condensate of ^{137}Cs deposited from the stack. The area was isolated, and the contamination removed. No releases occurred as a result of this event. No dose was calculated.

3.4 Conclusions

Atmospheric releases are predominantly tritium, noble gases, and short-lived fission and activation products (Table 3-3). Tritium accounts for just over half these releases. Noble gases, primarily ^{85}Kr and ^{41}Ar, account for about 43 percent of the releases. The remaining releases are almost entirely short-lived fission and activation products. Actinides (e.g., Pu) and other radionuclides account for less than one percent of total releases. Liquid releases are predominantly (greater than 99 percent) tritium (Table 3-5).

While operating facilities at some sites have had unplanned releases in addition to their routine discharges, none of these non-routine releases resulted in radiation doses exceeding DOE or other regulatory limits.

Table 3-1. Examples of Radioisotopes Released from DOE Sites

Category	Atmospheric Releases	Liquid Releases
Noble gases ($t_{½}$ < 40 days)	^{41}Ar, ^{85}Kr, ^{222}Rn, ^{133}Xe, ^{135}Xe, ^{137}Xe, ^{138}Xe	Not Applicable
Fission and activation products ($t_{½}$ < 3 hours)	^{11}C, ^{13}N, ^{15}O, ^{88}Rb	Not Applicable
Fission and activation products ($t_{½}$ > 3 hours)	^{14}C, ^{60}Co, ^{51}Cr, ^{24}Na, ^{129}Sb, ^{99}Tc	^{110m}Ag, ^{137m}Ba, ^{140}Ba, ^{7}Be, ^{83}Br, ^{141}Ce, ^{143}Ce, ^{144}Ce, ^{58}Co, ^{60}Co, ^{51}Cr, ^{64}Cu, ^{55}Fe, ^{59}Fe, ^{140}La, ^{141}La, ^{54}Mn, ^{56}Mn, ^{99}Mo, ^{22}Na, ^{24}Na, ^{95}Ni, ^{32}P, ^{143}Pr, ^{86}Rb, ^{103m}Rh, ^{105}Rh, ^{105m}Rh, ^{103}Ru, ^{105}Ru, ^{106}Ru, ^{99m}Tc, ^{127}Te, ^{127m}Te, ^{129}Te, ^{129m}Te, ^{131}Te, ^{131m}Te, ^{132}Te, ^{187}W, ^{93}Y, ^{65}Zn, ^{69}Zn, ^{69m}Zn, ^{95}Zr,
Iodine	^{129}I, ^{131}I, ^{133}I, ^{135}I	^{130}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I, ^{135}I
Strontium	^{89}Sr, ^{90}Sr	^{89}Sr, ^{90}Sr- ^{90}Y, ^{91}Sr- ^{91m}Y- ^{91}Y, ^{92}Sr- ^{92}Y
Cesium	^{134}Cs, ^{136}Cs, ^{137}Cs, ^{138}Cs	^{134}Cs, ^{136}Cs, ^{137}Cs
Uranium	^{234}U, ^{235}U, ^{236}U, ^{238}U	^{234}U, ^{235}U, ^{236}U, ^{238}U
Plutonium	^{239}Pu, ^{240}Pu	^{239}Pu
Other actinides	^{241}Am, ^{237}Np, ^{234}Th	^{241}Am, ^{239}Np, ^{234m}Pa, ^{234}Th,
Other	Po, Ra	

Table 3-2. Atmospheric Monitoring Results (curies)

Year	Fission and Activation Products								Actinides			Other Radio-nuclides	Annual Site Totals
	Tritium	Noble Gases: Krypton-85	Noble Gases: Other (T1/2 <40 days)	Iodine	Strontium	Cesium	Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)	Uranium	Plutonium	Other		
ENVIRONMENTAL MANAGEMENT (EM)													
Ashtabula Environmental Management Project (AEMP)													
1998	—	—	—	—	—	—	—	—	conc	—	—	—	—
1999	—	—	—	—	—	—	—	—	conc	—	—	—	—
2000	—	—	—	—	—	—	—	—	conc	—	—	—	—
2001	—	—	—	—	—	—	—	—	conc	—	—	—	—
Battelle Columbus Laboratories (BCL)													
1998	—	—	—	—	1.2×10^{-6}	2.3×10^{-6}	—	6.7×10^{-6}	4.4×10^{-8}	2.6×10^{-9}	1.5×10^{-6}	—	1.1×10^{-5}
1999	—	—	—	—	2.1×10^{-8}	2.0×10^{-6}	—	6.3×10^{-6}	3.2×10^{-8}	2.2×10^{-9}	1.3×10^{-6}	—	9.7×10^{-6}
2000	—	—	—	—	2.1×10^{-8}	2.1×10^{-6}	—	5.6×10^{-6}	3.2×10^{-8}	1.1×10^{-9}	1.3×10^{-6}	—	9.1×10^{-6}
2001	—	—	—	—	2.8×10^{-8}	2.1×10^{-6}	—	6.5×10^{-6}	3.1×10^{-8}	1.6×10^{-9}	1.3×10^{-6}	—	1.0×10^{-5}
Energy Technology Engineering Center (ETEC) (a)													
1998	1.9×10^{-5}	—	—	—	0.0×10^{0}	8.7×10^{-7}	—	3.5×10^{-7}	0.0×10^{0}	4.0×10^{-9}	0.0×10^{0}	—	2.0×10^{-5}
1999	—	—	—	—	0.0×10^{0}	1.5×10^{-7}	—	6.8×10^{-8}	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	—	2.2×10^{-7}
2000	2.7×10^{-5}	—	—	—	0.0×10^{0}	2.6×10^{-7}	—	0.0×10^{0}	1.1×10^{-8}	1.3×10^{-6}	0.0×10^{0}	—	2.9×10^{-5}
2001	0.0×10^{0}	—	—	—	1.4×10^{-7}	2.5×10^{-6}	—	6.9×10^{-7}	9.6×10^{-9}	0.0×10^{0}	0.0×10^{0}	—	3.3×10^{-6}
Fernald Environmental Management Project (FEMP)													
1998	—	—	conc	—	—	—	—	—	conc	—	conc	conc	—
1999	—	—	conc	—	—	—	—	—	conc	—	conc	conc	—
2000	—	—	conc	—	—	—	—	—	conc	—	conc	conc	—
2001	—	—	conc	—	—	—	—	—	conc	—	conc	conc	—
Grand Junction Office (GJO) (b)													
1998	—	—	—	—	—	—	—	—	1.6×10^{-6}	—	—	2.7×10^{-6}	4.3×10^{-6}
1999	—	—	—	—	—	—	—	—	6.4×10^{-7}	—	—	9.6×10^{-7}	1.6×10^{-6}
2000	—	—	—	—	—	—	—	—	4.9×10^{-7}	—	—	2.1×10^{-6}	2.6×10^{-6}
2001	—	—	—	—	—	—	—	—	9.5×10^{-7}	—	—	6.4×10^{-6}	7.4×10^{-6}
Hanford Site (HANF)													
1998	2.8×10^{2}	—	—	3.1×10^{-4}	3.8×10^{-4}	2.2×10^{-4}	—	4.8×10^{-7}	—	2.9×10^{-4}	3.3×10^{-5}	—	2.8×10^{2}
1999	1.9×10^{2}	—	—	1.9×10^{-4}	4.2×10^{-4}	8.6×10^{-5}	—	2.5×10^{-7}	—	3.9×10^{-4}	4.8×10^{-5}	—	1.9×10^{2}
2000	1.2×10^{2}	—	—	1.2×10^{-3}	3.3×10^{-4}	1.8×10^{-4}	—	1.9×10^{-6}	—	9.1×10^{-4}	9.4×10^{-5}	—	1.2×10^{2}
2001	3.3×10^{2}	—	—	8.4×10^{-4}	3.0×10^{-4}	2.1×10^{-4}	—	3.0×10^{-8}	1.8×10^{-10}	4.2×10^{-4}	4.6×10^{-5}	—	3.3×10^{2}
Idaho National Engineering and Environmental Laboratory (INEEL)													
1998	1.0×10^{2}	4.7×10^{3}	1.2×10^{3}	2.0×10^{-2}	3.1×10^{-4}	5.1×10^{-3}	1.1×10^{0}	8.2×10^{-1}	5.0×10^{-3}	5.5×10^{-6}	—	2.7×10^{-3}	6.0×10^{3}
1999	7.5×10^{1}	1.9×10^{3}	1.2×10^{3}	1.0×10^{-2}	1.3×10^{-4}	2.0×10^{-2}	4.2×10^{-1}	6.3×10^{-1}	5.0×10^{-2}	2.4×10^{-6}	—	3.3×10^{-4}	3.2×10^{3}
2000	6.8×10^{2}	2.5×10^{3}	1.5×10^{3}	4.1×10^{-1}	0.1×10^{-1}	1.7×10^{-1}	2.3×10^{0}	1.5×10^{0}	—	1.1×10^{-3}	—	5.0×10^{-3}	4.7×10^{3}
2001	2.0×10^{3}	1.4×10^{4}	1.0×10^{3}	6.0×10^{-2}	3.4×10^{-3}	2.8×10^{-3}	0.0×10^{0}	8.7×10^{1}	—	5.6×10^{-5}	—	—	1.7×10^{4}

a. Excludes naturally occurring radionuclides (^{7}Be, ^{40}K, ^{210}Po) reported in ETEC ASERs for information only and not factored into dose estimates.
b. "Other radionuclides" are natural decay products of uranium.
— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)
“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-2 (continued). Atmospheric Monitoring Results (curies)

Year	Fission and Activation Products								Actinides				
		Noble Gases					Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)				Other Radio-nuclides	Annual Site Totals
	Tritium	Krypton-85	Other (T1/2 <40 days)	Iodine	Strontium	Cesium			Uranium	Plutonium	Other		
Miamisburg Environmental Management Project (MEMP)													
1998	7.4×10^{2}	—	1.9×10^{0}	—	—	—	—	—	1.5×10^{-8}	1.5×10^{-4}	—	—	7.4×10^{2}
1999	8.0×10^{2}	—	1.0×10^{0}	—	—	—	—	—	1.5×10^{-8}	1.1×10^{-5}	—	—	8.0×10^{2}
2000	3.8×10^{2}	—	3.2×10^{0}	—	—	—	—	—	2.9×10^{-8}	9.4×10^{-6}	—	—	3.8×10^{2}
2001	8.3×10^{2}	—	4.6×10^{0}	—	—	—	—	—	2.9×10^{-8}	5.7×10^{-6}	—	—	8.4×10^{2}
Monticello Mill Tailings Site (MMTS) (c)													
1998	—	—	—	—	—	—	—	—	conc	—	conc	conc	—
1999	—	—	—	—	—	—	—	—	conc	—	conc	conc	—
Paducah Gaseous Diffusion Plant (PGDP) (d)													
1998	—	—	—	—	—	—	—	1.0×10^{-2}	—	—	—	—	1.0×10^{-2}
1999	—	—	—	—	—	—	—	1.0×10^{-2}	—	—	—	—	1.0×10^{-2}
2000	—	—	—	—	—	—	—	6.3×10^{-3}	—	—	—	5.0×10^{-3}	1.0×10^{-2}
2001	—	—	—	—	—	—	—	2.0×10^{-2}	—	—	—	4.2×10^{-5}	2.0×10^{-2}
Portsmouth Gaseous Diffusion Plant (POR)													
1998	—	—	—	—	—	—	—	—	—	—	—	1.6×10^{-4}	1.6×10^{-4}
1999	—	—	—	—	—	—	—	—	—	—	—	6.4×10^{-5}	6.4×10^{-5}
2000	—	—	—	—	—	—	—	conc	conc	conc	conc	6.3×10^{-4}	6.3×10^{-4}
2001	—	—	—	—	—	—	—	5.8×10^{-4}	3.4×10^{-5}	1.7×10^{-5}	—	6.3×10^{-4}	1.3×10^{-3}
Savannah River Site (SRS) (e)													
1998	8.3×10^{4}	1.7×10^{4}	5.0×10^{-2}	1.3×10^{-2}	2.9×10^{-2}	5.4×10^{-3}	0.0×10^{0}	1.3×10^{-3}	2.8×10^{-4}	2.3×10^{-3}	2.1×10^{-4}	7.0×10^{-2}	1.0×10^{5}
1999	5.2×10^{4}	3.7×10^{4}	1.4×10^{-2}	7.4×10^{-3}	1.0×10^{-3}	1.5×10^{-2}	3.7×10^{-9}	9.1×10^{-4}	2.4×10^{-4}	2.2×10^{-3}	9.7×10^{-5}	2.6×10^{-2}	8.9×10^{4}
2000	3.2×10^{4}	5.3×10^{4}	3.3×10^{-5}	2.2×10^{-3}	3.9×10^{-3}	8.3×10^{-3}	1.1×10^{-9}	1.8×10^{-3}	9.4×10^{-4}	2.4×10^{-3}	3.6×10^{-4}	1.3×10^{-1}	8.5×10^{4}
2001	4.7×10^{4}	6.5×10^{4}	7.6×10^{-2}	2.8×10^{-2}	3.7×10^{-3}	3.5×10^{-3}	4.5×10^{-6}	1.6×10^{-3}	7.5×10^{-4}	2.3×10^{-3}	4.3×10^{-4}	1.7×10^{-1}	1.1×10^{5}
Waste Isolation Pilot Plant (WIPP)													
1998	—	—	—	—	conc	conc	—	conc	conc	conc	conc	conc	—
1999	—	—	—	—	conc	conc	—	conc	conc	conc	conc	conc	—
2000	—	—	—	—	0.0×10^{0}	conc	—	conc	conc	0.0×10^{0}	conc	conc	—
2001	—	—	—	—	0.0×10^{0}	conc	—	conc	conc	0.0×10^{0}	conc	conc	—
Weldon Spring Site Remedial Action Project (WSSRAP) (f)													
1998	—	—	1.7×10^{-1}	—	—	—	—	—	1.3×10^{-5}	—	4.2×10^{-5}	7.5×10^{-7}	1.7×10^{-1}
1999	—	—	—	—	—	—	—	—	1.1×10^{-5}	—	5.9×10^{-5}	—	7.0×10^{-5}
2000	—	—	—	—	—	—	—	—	4.2×10^{-7}	—	2.4×10^{-6}	—	2.8×10^{-6}

c. Radiological air monitoring discontinued after completion of surface remediation in 1999. ASER publication ceased after 2000.
d. Two on-site locations added as release sources for 2000−2001.
e. 1998 values for ^{90}Sr and ^{239}Pu include unidentified beta and alpha, respectively. These beta and alpha values were reported separately for 1999−2001.
f. Radiological atmospheric monitoring discontinued after final disposition of contaminated materials in 2000.
— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)
"conc" indicates that releases were reported in concentration and not as total curies for the year.

Table 3-2 (continued). Atmospheric Monitoring Results (curies)

Year	Fission and Activation Products								Actinides				
		Noble Gases											
	Tritium	Krypton-85	Other (T1/2 <40 days)	Iodine	Strontium	Cesium	Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	Other Radio-nuclides	Annual Site Totals
West Valley Demonstration Project (WVDP)													
1998	3.5×10^{-2}	—	—	5.0×10^{-3}	7.1×10^{-6}	2.5×10^{-5}	—	4.1×10^{-7}	2.9×10^{-7}	2.3×10^{-7}	3.1×10^{-7}	—	4.0×10^{-2}
1999	7.1×10^{-3}	—	—	1.9×10^{-3}	1.8×10^{-5}	1.0×10^{-4}	—	5.3×10^{-7}	2.5×10^{-7}	2.7×10^{-7}	5.1×10^{-7}	—	9.1×10^{-3}
2000	5.1×10^{-3}	—	2.7×10^{3}	1.3×10^{-3}	7.1×10^{-6}	1.7×10^{-5}	—	4.2×10^{-7}	2.0×10^{-7}	3.0×10^{-7}	4.3×10^{-7}	—	2.7×10^{3}
2001	2.7×10^{-2}	—	2.3×10^{3}	5.3×10^{-4}	3.3×10^{-4}	7.9×10^{-4}	—	4.9×10^{-7}	3.0×10^{-7}	1.1×10^{-6}	2.1×10^{-6}	—	2.3×10^{3}
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)													
Bettis Atomic Power Laboratory (BET)													
1998	—	—	—	—	—	—	—	2.6×10^{-6}	1.8×10^{-8}	1.3×10^{-8}	—	5.6×10^{-7}	3.1×10^{-6}
1999	—	—	—	—	—	—	—	1.7×10^{-6}	4.0×10^{-8}	1.3×10^{-8}	—	3.3×10^{-7}	2.1×10^{-6}
2000	—	—	—	—	—	—	—	1.3×10^{-6}	8.2×10^{-9}	2.5×10^{-9}	—	2.5×10^{-7}	1.5×10^{-6}
2001	—	—	—	—	—	—	—	9.9×10^{-7}	9.9×10^{-9}	4.2×10^{-9}	—	1.4×10^{-7}	1.2×10^{-6}
Knolls Atomic Power Laboratory - Kesselring (KAPL-2)													
1998	1.0×10^{-1}	1.0×10^{-3}	1.2×10^{0}	—	—	—	—	8.0×10^{-1}	—	—	—	—	2.1×10^{0}
1999	1.4×10^{-1}	1.0×10^{-3}	1.2×10^{0}	—	—	—	—	6.0×10^{-1}	—	—	—	—	1.9×10^{0}
2000	1.3×10^{-1}	1.0×10^{-3}	9.0×10^{-1}	—	—	—	—	4.0×10^{-1}	—	—	—	—	1.4×10^{0}
2001	1.0×10^{-1}	1.0×10^{-3}	6.0×10^{-1}	—	—	—	—	1.2×10^{-1}	—	—	—	—	8.2×10^{-1}
Knolls Atomic Power Laboratory - Knolls (KAPL-1)													
1998	—	8.7×10^{-1}	—	—	—	—	—	1.0×10^{-4}	1.0×10^{-5}	1.0×10^{-6}	—	—	8.7×10^{-1}
1999	—	1.6×10^{0}	—	—	—	—	—	1.0×10^{-4}	1.0×10^{-5}	1.0×10^{-6}	—	—	1.6×10^{0}
2000	—	5.7×10^{-1}	—	—	—	—	—	1.0×10^{-4}	1.0×10^{-5}	1.0×10^{-6}	—	—	5.7×10^{-1}
2001	—	1.9×10^{-1}	—	—	—	—	—	1.0×10^{-4}	1.0×10^{-5}	1.0×10^{-6}	—	—	1.9×10^{-1}
Knolls Atomic Power Laboratory - Windsor (KAPL-3) (g)													
1998	—	—	—	—	—	—	—	1.0×10^{-5}	—	—	—	—	1.0×10^{-5}
1999	—	—	—	—	—	—	—	1.0×10^{-5}	—	—	—	—	1.0×10^{-5}
Laboratory for Energy-Related Health Research (LEHR)													
1998	—	—	—	—	—	—	—	—	—	—	—	—	—
1999	—	—	—	—	—	—	—	—	—	—	—	—	—
2000	—	—	—	—	—	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—	—	—	—	conc	—
Lawrence Livermore National Laboratory (LLNL)													
1998	1.1×10^{2}	—	—	—	—	—	—	—	—	—	—	—	1.1×10^{2}
1999	2.8×10^{2}	—	—	—	—	—	—	—	—	—	—	—	2.8×10^{2}
2000	4.0×10^{1}	—	—	—	—	—	—	—	—	—	—	—	4.0×10^{1}
2001	2.0×10^{1}	—	—	—	—	—	—	—	—	—	—	—	2.0×10^{1}

g. All on-site structures removed by the end of 1999; radiological monitoring discontinued.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-2 (continued). Atmospheric Monitoring Results (curies)

Year	Fission and Activation Products								Actinides			Other Radio-nuclides	Annual Site Totals
	Tritium	Noble Gases: Krypton-85	Noble Gases: Other (T1/2 <40 days)	Iodine	Strontium	Cesium	Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)	Uranium	Plutonium	Other		
Los Alamos National Laboratory (LANL) (h)													
1998	8.2×10^{2}	—	1.5×10^{2}	—	—	—	7.8×10^{3}	9.0×10^{-2}	3.1×10^{-5}	1.1×10^{-5}	—	2.1×10^{-6}	8.8×10^{3}
1999	1.6×10^{3}	—	1.3×10^{1}	—	—	—	2.8×10^{2}	4.6×10^{-3}	7.7×10^{-6}	2.1×10^{-5}	—	3.0×10^{-6}	1.9×10^{3}
2000	2.4×10^{3}	—	2.3×10^{1}	—	—	—	6.8×10^{2}	9.3×10^{-1}	6.8×10^{-6}	5.8×10^{-6}	—	6.9×10^{-7}	3.1×10^{3}
2001	9.4×10^{3}	—	1.6×10^{1}	—	—	—	6.0×10^{3}	9.3×10^{-1}	7.3×10^{-6}	9.3×10^{-6}	—	5.6×10^{-7}	1.5×10^{4}
Naval Reactors Facility (NRF)													
1998	5.0×10^{-2}	3.0×10^{-1}	—	1.0×10^{-5}	—	9.2×10^{-5}	—	8.1×10^{-1}	—	—	—	—	1.2×10^{0}
1999	3.0×10^{-2}	5.0×10^{-2}	—	5.0×10^{-6}	—	1.5×10^{-4}	—	6.4×10^{-1}	—	—	—	—	7.2×10^{-1}
2000	5.0×10^{-2}	6.8×10^{-1}	—	9.0×10^{-6}	—	3.4×10^{-5}	—	6.4×10^{-1}	—	—	—	—	1.4×10^{0}
2001	9.0×10^{-2}	6.7×10^{-1}	—	1.3×10^{-6}	—	1.7×10^{-5}	—	2.8×10^{-1}	—	—	—	—	1.0×10^{0}
Nevada Test Site (NTS)													
1998	3.0×10^{2}	—	—	—	—	—	—	—	—	2.4×10^{-1}	—	—	3.0×10^{2}
1999	3.6×10^{2}	—	—	—	—	—	—	—	—	2.4×10^{-1}	—	—	3.6×10^{2}
2000	4.3×10^{2}	—	—	—	—	—	—	—	—	3.2×10^{-1}	5.0×10^{-2}	—	4.3×10^{2}
2001	5.6×10^{2}	—	—	—	—	—	—	—	—	3.2×10^{-1}	5.0×10^{-2}	—	5.6×10^{2}
Pantex Plant (PANX)													
1998	5.0×10^{-2}	—	—	—	—	—	—	—	1.8×10^{-4}	—	1.6×10^{-8}	—	5.0×10^{-2}
1999	1.6×10^{0}	—	—	—	—	—	—	—	7.0×10^{-5}	—	7.1×10^{-7}	1.5×10^{-6}	1.6×10^{0}
2000	2.7×10^{0}	—	—	—	—	—	—	—	6.7×10^{-7}	—	2.8×10^{-7}	3.3×10^{-6}	2.7×10^{0}
2001	3.3×10^{-1}	—	—	—	—	—	—	—	4.6×10^{-10}	conc	2.8×10^{-10}	—	3.3×10^{-1}
Sandia National Laboratories, Albuquerque (SNLA)													
1998	8.0×10^{0}	—	4.8×10^{0}	—	—	—	1.3×10^{-3}	3.5×10^{-5}	1.3×10^{-7}	1.0×10^{-13}	—	—	1.3×10^{1}
1999	3.6×10^{0}	—	5.3×10^{0}	—	—	—	4.5×10^{-4}	3.8×10^{-5}	2.5×10^{-6}	1.0×10^{-13}	—	—	8.9×10^{0}
2000	1.0×10^{1}	—	1.9×10^{1}	—	—	—	5.0×10^{-4}	8.0×10^{-4}	2.6×10^{-5}	1.0×10^{-13}	—	—	2.9×10^{1}
2001	4.5×10^{0}	—	1.6×10^{1}	—	3.8×10^{-7}	1.2×10^{-7}	7.6×10^{-4}	3.9×10^{-7}	1.1×10^{-6}	1.0×10^{-13}	9.7×10^{-6}	—	2.1×10^{1}
Sandia National Laboratories, Tonopah (SNLT)													
1998	—	—	—	—	—	—	—	—	—	conc	—	—	—
1999	—	—	—	—	—	—	—	—	—	conc	—	—	—
2000	—	—	—	—	—	—	—	—	—	conc	—	—	—
2001	—	—	—	—	—	—	—	—	—	conc	—	—	—
SCIENCE (SC)													
Ames Laboratory (AMES) (i)													
Argonne National Laboratory-East (ANLE)													
1998	2.0×10^{2}	2.8×10^{0}	2.5×10^{2}	—	—	—	5.7×10^{2}	—	1.0×10^{-6}	2.8×10^{-8}	—	—	1.0×10^{3}
1999	1.4×10^{2}	1.4×10^{0}	1.9×10^{2}	—	—	—	1.2×10^{2}	—	6.4×10^{-5}	2.4×10^{-7}	—	—	4.5×10^{2}
2000	1.3×10^{2}	4.6×10^{0}	1.6×10^{2}	—	—	—	1.6×10^{3}	—	8.4×10^{-7}	3.2×10^{-6}	—	—	1.9×10^{3}
2001	7.9×10^{1}	1.3×10^{1}	1.2×10^{2}	—	—	—	1.3×10^{3}	—	1.8×10^{-7}	1.8×10^{-6}	—	—	1.5×10^{3}

h. Variability in short-lived fission and activation products due principally to LANSCE operations.

i. No monitoring required by NESHAPS because of small inventory and lack of prospect for atmospheric release.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-2 (continued). Atmospheric Monitoring Results (curies)

Year	Fission and Activation Products								Actinides			Other Radio-nuclides	Annual Site Totals
	Tritium	Noble Gases: Krypton-85	Noble Gases: Other (T1/2 <40 days)	Iodine	Strontium	Cesium	Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)	Uranium	Plutonium	Other		
Brookhaven National Laboratory (BNL)													
1998	3.9×10^{1}	—	2.4×10^{3}	—	—	3.4×10^{-6}	5.8×10^{1}	7.7×10^{-4}	—	—	—	—	2.5×10^{3}
1999	2.0×10^{1}	—	1.6×10^{3}	—	—	5.3×10^{-5}	1.2×10^{1}	1.1×10^{-3}	—	—	—	—	1.6×10^{3}
2000	4.8×10^{0}	—	2.2×10^{3}	1.2×10^{-12}	—	8.8×10^{-6}	1.1×10^{3}	1.8×10^{-4}	—	—	—	—	3.3×10^{3}
2001	3.6×10^{0}	—	— (j)	9.2×10^{-3}	—	—	9.8×10^{3}	1.0×10^{-2}	—	—	—	—	9.8×10^{3}
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)													
1998	1.2×10^{2}	—	—	3.8×10^{-4}	—	—	1.1×10^{0}	1.1×10^{-3}	—	—	—	1.3×10^{-5}	1.2×10^{2}
1999	3.1×10^{1}	—	—	3.2×10^{-4}	—	—	3.4×10^{0}	1.0×10^{-3}	—	—	—	8.5×10^{-6}	3.4×10^{1}
2000	2.4×10^{1}	—	—	2.1×10^{-3}	—	—	9.1×10^{-1}	1.2×10^{-3}	—	—	—	5.6×10^{-4}	2.5×10^{1}
2001	2.0×10^{1}	—	—	6.7×10^{-4}	—	—	2.7×10^{0}	9.0×10^{-3}	—	—	—	4.3×10^{-4}	2.3×10^{1}
Oak Ridge Reservation (ORR) (k)													
1998	1.2×10^{2}	2.8×10^{2}	9.7×10^{3}	3.1×10^{0}	1.5×10^{-4}	6.5×10^{-6}	2.9×10^{-2}	2.0×10^{-2}	2.7×10^{-3}	8.9×10^{-4}	—	—	1.0×10^{4}
1999	5.3×10^{3}	4.9×10^{2}	4.7×10^{2}	1.9×10^{0}	1.8×10^{-4}	2.4×10^{3}	3.8×10^{2}	1.9×10^{1}	3.0×10^{-2}	3.3×10^{-4}	—	—	9.1×10^{3}
2000	1.6×10^{2}	2.9×10^{2}	4.4×10^{2}	2.5×10^{0}	9.1×10^{-5}	2.4×10^{3}	3.8×10^{2}	2.5×10^{1}	2.0×10^{-2}	6.9×10^{-6}	—	—	3.7×10^{3}
2001	3.9×10^{2}	4.9×10^{2}	1.4×10^{3}	4.5×10^{0}	8.6×10^{-5}	1.4×10^{3}	1.4×10^{3}	2.4×10^{1}	2.9×10^{-3}	9.1×10^{-6}	—	—	5.1×10^{3}
Princeton Plasma Physics Laboratory (PPPL) (l)													
1998	7.8×10^{1}	—	—	—	—	—	—	—	—	—	—	—	7.8×10^{1}
1999	8.3×10^{1}	—	—	—	—	—	—	—	—	—	—	—	8.3×10^{1}
2000	7.7×10^{1}	—	4.7×10^{-5}	—	—	—	—	—	—	—	—	—	7.7×10^{1}
2001	2.6×10^{2}	—	1.2×10^{-4}	—	—	—	—	—	—	—	—	—	2.6×10^{2}
Stanford Linear Accelerator Center (SLAC)													
1998	—	—	6.0×10^{-2}	—	—	—	2.6×10^{-1}	—	—	—	—	—	3.2×10^{-1}
1999	—	—	3.8×10^{0}	—	—	—	2.3×10^{1}	—	—	—	—	—	2.7×10^{1}
2000	—	—	3.8×10^{0}	—	—	—	2.3×10^{1}	—	—	—	—	—	2.7×10^{1}
2001	—	—	4.7×10^{0}	—	—	—	2.8×10^{1}	—	—	—	—	—	3.3×10^{1}
Thomas Jefferson National Accelerator Facility (JLAB) (m)													
1998	—	—	—	—	—	—	—	—	—	—	—	—	—
1999	—	—	—	—	—	—	—	—	—	—	—	—	—
2000	—	—	—	—	—	—	—	—	—	—	—	—	—
2001	2.0×10^{-2}	—	2.10×10^{-3}	—	—	—	1.4×10^{1}	3.7×10^{-3}	—	—	—	—	1.4×10^{1}

j. Brookhaven Medical Research Reactor (BMRR) last operated in December 2000. Prior year releases of ^{41}Ar attributed to activation during reactor cooling.

k. Includes emissions from ORNL, ETTP, and Y-12. Most variations are due principally to differences in waste feed to the TSCA incinerator. Radiocesium includes ^{138}Cs (T½=34 min) released from the High Flux Isotope Reactor at ORNL. Y-12 emissions are U.

l. Increase in tritium emissions during 2001 attributed to dismantlement activities at the Tokamak Fusion Test Reactor.

m. In 2001, JLAB reported "very low levels of radioactive gaseous and particulate emissions" from facility ventilation exhausts.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or states that the value was not measurable.)

“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-3. Total Atmospheric Releases by Year (curies)

Year	Fission and Activation Products								Actinides			Other Radio-nuclides	Annual Site Totals
	Tritium	Noble Gases		Radio-iodine	Radio-strontium	Radio-Cesium (a)	Other Short-Lived (T1/2 <3 hr)	Other (T1/2 >3 hr)	Uranium	Plutonium	Other		
		Krypton-85	Other (T1/2 <40 days)										
1998	8.6×10^{4}	2.2×10^{4}	1.4×10^{4}	3.1×10^{0}	2.9×10^{-2}	1.1×10^{-2}	8.4×10^{3}	2.6×10^{0}	8.2×10^{-3}	2.4×10^{-1}	2.9×10^{-4}	3.0×10^{-3}	1.3×10^{5}
1999	6.0×10^{4}	3.9×10^{4}	3.5×10^{3}	1.9×10^{0}	1.7×10^{-3}	2.4×10^{3}	8.2×10^{2}	2.1×10^{0}	7.3×10^{-2}	2.4×10^{-1}	2.1×10^{-4}	3.4×10^{-2}	1.1×10^{5}
2000	4.9×10^{4}	5.6×10^{4}	7.0×10^{3}	2.9×10^{0}	1.0×10^{-1}	2.4×10^{3}	3.9×10^{3}	2.9×10^{1}	1.6×10^{-2}	3.2×10^{-1}	4.9×10^{-2}	4.7×10^{-2}	1.2×10^{5}
2001	6.1×10^{4}	6.9×10^{4}	4.9×10^{3}	4.6×10^{0}	7.8×10^{-3}	1.4×10^{3}	1.9×10^{4}	1.1×10^{2}	3.7×10^{-3}	3.2×10^{-1}	4.9×10^{-2}	3.6×10^{-2}	1.6×10^{5}
Total	2.6×10^{5}	1.9×10^{5}	2.9×10^{4}	1.3×10^{1}	1.4×10^{-1}	6.2×10^{3}	3.2×10^{4}	1.6×10^{2}	1.0×10^{-1}	1.1×10^{0}	9.9×10^{-2}	1.2×10^{-1}	5.1×10^{5}

a. 1999−2001 values include releases of ^{138}Cs ($T_{½}$ =34 min) released from the High Flux Isotope Reactor at ORNL.

Table 3-4. Liquid Effluent Monitoring Results (curies)

Year	Fission and Activation Products					Actinides			Annual Site Totals
	Tritium	Iodine	Strontium	Cesium	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	
ENVIRONMENTAL MANAGEMENT (EM)									
Ashtabula Environmental Management Project (AEMP)									
1998	—	—	—	—	1.8×10^{-4}	1.2×10^{-4}	—	—	3.0×10^{-4}
1999	—	—	—	—	5.3×10^{-3}	5.0×10^{-3}	—	—	1.0×10^{-2}
2000	—	—	—	—	4.7×10^{-3}	4.6×10^{-3}	—	—	9.3×10^{-3}
2001	—	—	—	—	conc	conc	—	—	—
Battelle Columbus Laboratories (BCL)									
1998	—	—	conc	conc	conc	conc	conc	conc	—
1999	—	—	conc	conc	conc	conc	conc	conc	—
2000	—	—	conc	conc	conc	conc	conc	conc	—
2001	—	—	conc	conc	conc	conc	conc	conc	—
Energy Technology Engineering Center (ETEC) (a)									
1998	conc	—	conc	—	—	—	—	—	—
1999	conc	—	conc	—	—	—	—	—	—
2000	conc	—	conc	—	—	—	—	—	—
2001	conc	—	conc	—	—	—	—	—	—
Fernald Environmental Management Project (FEMP)									
1998	—	—	—	—	—	conc	—	—	—
1999	—	—	—	—	—	conc	—	—	—
2000	—	—	—	—	—	conc	—	—	—
2001	—	—	—	—	—	conc	—	—	—
Grand Junction Office (GJO) (b)									
1998	conc	—	—	—	—	—	—	—	—
1999	conc	—	—	—	—	—	—	—	—
2000	conc	—	—	—	—	—	—	—	—
Hanford Site (HANF) (c)									
1998	3.2×10^{1}	—	2.9×10^{-1}	—	2.9×10^{-5}	—	2.6×10^{-5}	4.3×10^{-5}	3.2×10^{1}
1999	9.0×10^{0}	—	7.0×10^{-2}	—	—	—	1.5×10^{-5}	1.6×10^{-5}	9.1×10^{0}
2000	2.1×10^{1}	—	2.8×10^{-1}	—	—	—	4.8×10^{-5}	7.9×10^{-6}	2.1×10^{1}
2001	1.9×10^{-1}	—	2.1×10^{-1}	—	—	—	3.9×10^{-5}	1.0×10^{-5}	4.0×10^{-1}
Idaho National Environmental and Engineering Laboratory (INEEL)									
1998	7.5×10^{1}	—	1.4×10^{-3}	—	2.7×10^{0}	—	—	—	7.8×10^{1}
1999	8.7×10^{1}	—	$1.\times10^{-2}$	—	3.8×10^{1}	—	—	—	1.3×10^{2}
2000	1.0×10^{2}	—	2.1×10^{-1}	9.0×10^{-2}	2.3×10^{0}	—	—	—	1.0×10^{2}
2001	conc	—	conc	conc	—	—	—	—	—
Miamisburg Environmental Management Project (MEMP)									
1998	2.5×10^{0}	—	—	—	—	3.7×10^{-4}	4.8×10^{-4}	—	2.5×10^{0}
1999	2.4×10^{0}	—	—	—	—	3.8×10^{-4}	2.3×10^{-4}	—	2.4×10^{0}
2000	1.7×10^{0}	—	—	—	—	3.4×10^{-4}	1.6×10^{-4}	—	1.7×10^{0}
2001	2.2×10^{0}	—	—	—	—	3.4×10^{-4}	1.2×10^{-4}	—	2.2×10^{0}
Monticello Mill Tailings Site (MMTS) (d)									
1998	—	—	—	—	—	conc	—	conc	—
1999	—	—	—	—	—	conc	—	conc	—
2000	—	—	—	—	—	conc	—	conc	—
Paducah Gaseous Diffusion Plant (PGDP)									
1998	—	—	—	—	conc	conc	—	—	—
1999	—	—	—	—	conc	conc	—	—	—
2000	—	—	—	—	conc	conc	—	—	—
2001	—	—	—	—	conc	conc	—	—	—

a. ASERs report no liquid releases containing radioactivity.
b. Discontinued liquid effluent monitoring in March 2000 based on historical data.
c. Tritium value includes releases to the Columbia River (factored into dose estimates) and tritium in waste sent to the State Approved Land Disposal Site (not factored into current dose estimates because of travel time to any release point).
d. ASER publication ceased after 2000.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or that the value was not measurable.)
"conc" indicates that releases were reported in concentration and not as total curies for the year.

Table 3-4 (continued). Liquid Effluent Monitoring Results (curies)

Year	Fission and Activation Products					Actinides			Annual Site Totals
	Tritium	Iodine	Strontium	Cesium	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	
Portsmouth Gaseous Diffusion Plant (POR)									
1998	—	—	—	—	conc	conc	—	—	—
1999	—	—	—	—	conc	conc	—	—	—
2000	—	—	—	—	conc	conc	conc	conc	—
2001	—	—	—	—	2.8×10^{0}	1.3×10^{0}	conc	conc	4.1×10^{0}
Savannah River Site (SRS) (e)									
1998	1.1×10^{4}	8.0×10^{-2}	3.0×10^{-1}	1.9×10^{-1}	—	1.0×10^{-1}	4.0×10^{-2}	2.0×10^{-5}	1.1×10^{4}
1999	6.3×10^{3}	8.0×10^{-2}	1.3×10^{-1}	1.0×10^{-1}	4.9×10^{-4}	1.3×10^{-1}	2.1×10^{-4}	1.5×10^{-5}	6.3×10^{3}
2000	6.0×10^{3}	8.0×10^{-2}	5.0×10^{-2}	9.0×10^{-2}	1.6×10^{-3}	3.7×10^{-4}	3.9×10^{-5}	1.9×10^{-5}	6.0×10^{3}
2001	4.3×10^{3}	8.0×10^{-2}	2.0×10^{-2}	8.0×10^{-2}	5.0×10^{-2}	2.2×10^{-4}	5.2×10^{-5}	1.4×10^{-5}	4.3×10^{3}
Waste Isolation Pilot Plant (WIPP) (f)									
1998	—	—	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	conc	conc	conc	—
1999	—	—	0.0×10^{0}	—	—	conc	conc	conc	—
2000	—	—	0.0×10^{0}	conc	conc	conc	conc	conc	—
2001	—	—	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	conc	conc	conc	—
Weldon Spring Site Remedial Action Project (WSSRAP)									
1998	—	—	—	—	—	0.0×10^{0}	—	4.3×10^{-4}	2.4×10^{-3}
1999	—	—	—	—	—	3.9×10^{-3}	—	1.5×10^{-4}	4.1×10^{-3}
2000	—	—	—	—	—	3.5×10^{-3}	—	2.7×10^{-4}	3.8×10^{-3}
2001	—	—	—	—	—	2.3×10^{-3}	—	2.3×10^{-4}	2.5×10^{-3}
West Valley Demonstration Project (WVDP)									
1998	2.0×10^{-1}	1.3×10^{-4}	3.7×10^{-3}	9.4×10^{-4}	5.9×10^{-3}	7.0×10^{-4}	7.5×10^{-6}	1.9×10^{-6}	2.2×10^{-1}
1999	1.1×10^{-1}	1.3×10^{-4}	3.4×10^{-3}	4.2×10^{-3}	3.0×10^{-3}	6.1×10^{-4}	8.0×10^{-6}	4.7×10^{-6}	1.2×10^{-1}
2000	1.4×10^{-1}	1.5×10^{-4}	5.8×10^{-3}	5.9×10^{-3}	4.6×10^{-3}	1.1×10^{-3}	8.8×10^{-6}	1.8×10^{-5}	1.6×10^{-1}
2001	1.2×10^{-1}	1.6×10^{-4}	1.4×10^{-1}	2.7×10^{-3}	3.0×10^{-3}	7.5×10^{-4}	9.3×10^{-6}	2.4×10^{-5}	2.6×10^{-1}
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)									
Bettis Atomic Power Laboratory (BET) (g)									
1998	—	—	conc	conc	—	conc	—	—	—
1999	—	—	conc	conc	—	conc	—	—	—
2000	—	—	conc	conc	—	conc	—	—	—
2001	—	—	conc	conc	—	conc	—	—	—
Knolls Atomic Power Laboratory - Kesserling (KAPL-2)									
1998	2.0×10^{-2}	—	—	—	—	—	—	—	2.0×10^{-2}
1999	2.0×10^{-2}	—	—	—	—	—	—	—	2.0×10^{-2}
2000	2.0×10^{-2}	—	—	—	—	—	—	—	2.0×10^{-2}
2001	2.0×10^{-2}	—	—	—	—	—	—	—	2.0×10^{-2}
Knolls Atomic Power Laboratory - Knolls (KAPL-1)									
1998	—	—	—	—	1.0×10^{-3}	1.0×10^{-6}	1.0×10^{-6}	—	1.0×10^{-3}
1999	—	—	—	—	1.0×10^{-3}	1.0×10^{-6}	1.0×10^{-6}	—	1.0×10^{-3}
2000	—	—	—	—	1.0×10^{-3}	1.0×10^{-6}	1.0×10^{-6}	—	1.0×10^{-3}
2001	—	—	—	—	1.0×10^{-3}	1.0×10^{-6}	1.0×10^{-6}	—	1.0×10^{-3}
Knolls Atomic Power Laboratory - Windsor (KAPL-3) (h)									
1998	—	—	—	—	—	—	—	—	—
1999	—	—	—	—	—	—	—	—	—
Laboratory for Energy-Related Health Research (LEHR) (i)									

e. 1998 values for ^{90}Sr and Pu include unidentified beta and alpha, respectively. These beta and alpha values were reported separately for 1999−2001.

f. Results from monitoring Sewage Lagoon. 0.0×10^{0} values are non-detect; concentrations are at background levels.

g. ASERs report no radioactive release to streams from 1998 through 2001.

h. ASERs report that liquid radioactive waste was solidified and shipped off-site. All on-site structures removed by the end of 1999; radiological monitoring discontinued.

i. No active radiological liquid effluent releases. 2001 ASER reports 3 samples (1 ^{14}C, 2 gross beta) above detection limits. Responsibility for surface water monitoring transferred to UC-Davis in 1997. NNSA continues monitoring of storm water in DOE areas of the site; detailed results are reported in an annual report separate from the ASER.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or that the value was not measurable.)
"conc" indicates that releases were reported in concentration and not as total curies for the year.

Table 3-4 (continued). Liquid Effluent Monitoring Results (curies)

Year	Fission and Activation Products					Actinides			Annual Site Totals
	Tritium	Iodine	Strontium	Cesium	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	
Lawrence Livermore National Laboratory (LLNL)									
1998	2.7×10^{-1}	—	—	1.3×10^{-5}	—	—	2.1×10^{-6}	—	2.7×10^{-1}
1999	1.9×10^{-1}	—	—	3.3×10^{-5}	—	—	1.8×10^{-6}	—	1.9×10^{-1}
2000	1.4×10^{-1}	—	—	2.5×10^{-5}	—	—	2.6×10^{-6}	—	1.4×10^{-1}
2001	1.3×10^{-1}	—	—	2.8×10^{-5}	—	—	3.0×10^{-6}	—	1.3×10^{-1}
Los Alamos National Laboratory (LANL)									
1998	—	—	—	—	—	—	—	—	—
1999	—	—	—	—	—	—	—	—	—
2000	—	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—	—
Naval Reactors Facility (NRF) (j)									
Nevada Test Site (NTS) (k)									
1998	1.1×10^{2}	—	2.4×10^{-5}	1.5×10^{-3}	—	—	4.2×10^{-5}	—	1.1×10^{2}
1999	2.5×10^{1}	—	3.2×10^{-5}	4.1×10^{-3}	—	—	5.4×10^{-5}	—	2.5×10^{1}
2000	—	—	—	—	—	—	—	—	—
2001	1.4×10^{1}	—	—	—	—	—	—	—	1.4×10^{1}
Pantex Plant (PANX) (l)									
Sandia National Laboratories, Albuquerque (SNLA) (m)									
Sandia National Laboratories, Tonopah (SNLT) (n)									
SCIENCE (SC)									
Ames Laboratory (AMES) (o)									
Argonne National Laboratory-East (ANLE)									
1998	1.3×10^{0}	—	3.5×10^{-3}	—	—	—	6.0×10^{-6}	4.0×10^{-5}	1.3×10^{0}
1999	4.4×10^{0}	—	3.7×10^{-3}	—	—	—	1.0×10^{-4}	1.0×10^{-4}	4.4×10^{0}
2000	1.2×10^{-1}	—	7.0×10^{-4}	—	—	—	1.0×10^{-4}	1.0×10^{-4}	1.2×10^{-1}
2001	1.0×10^{-1}	—	6.0×10^{-4}	—	—	—	1.0×10^{-4}	1.0×10^{-4}	1.0×10^{-1}
Brookhaven National Laboratory (BNL)									
1998	2.0×10^{-1}	—	0.0×10^{0}	3.0×10^{-4}	8.0×10^{-6}	—	—	—	2.0×10^{-1}
1999	1.1×10^{-1}	—	8.0×10^{-5}	2.6×10^{-4}	3.1×10^{-5}	—	—	—	1.1×10^{-1}
2000	1.1×10^{-1}	—	1.1×10^{-4}	1.2×10^{-4}	0.0×10^{0}	—	—	—	1.1×10^{-1}
2001	7.0×10^{-2}	—	3.0×10^{-5}	3.0×10^{-5}	0.0×10^{0}	—	—	—	7.0×10^{-2}
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)									
1998	4.6×10^{-1}	—	—	—	1.0×10^{-2}	—	—	—	4.7×10^{-1}
1999	5.0×10^{-2}	—	—	—	1.0×10^{-2}	—	—	—	6.0×10^{-2}
2000	7.0×10^{-2}	—	—	—	8.0×10^{-3}	—	—	—	8.0×10^{-2}
2001	5.0×10^{-2}	—	—	—	1.0×10^{-2}	—	—	—	6.0×10^{-2}
Oak Ridge Reservation (ORR) (p)									
1998	9.4×10^{2}	—	1.4×10^{0}	2.4×10^{-1}	1.6×10^{-1}	2.0×10^{-1}	2.1×10^{-4}	1.6×10^{-5}	9.4×10^{2}
1999	1.1×10^{3}	—	1.4×10^{0}	4.2×10^{-1}	2.6×10^{-1}	1.7×10^{-1}	3.3×10^{-5}	7.6×10^{-5}	1.1×10^{3}
2000	9.1×10^{2}	—	1.2×10^{0}	2.0×10^{-1}	7.0×10^{-2}	1.6×10^{-1}	3.1×10^{-5}	1.9×10^{-4}	9.1×10^{2}
2001	7.7×10^{2}	—	1.2×10^{0}	6.4×10^{-1}	1.8×10^{-1}	1.1×10^{-1}	2.6×10^{-5}	1.5×10^{-4}	7.7×10^{2}
Princeton Plasma Physics Laboratory (PPPL)									
1998	7.0×10^{-2}	—	—	—	—	—	—	—	7.0×10^{-2}
1999	8.0×10^{-2}	—	—	—	—	—	—	—	8.0×10^{-2}
2000	8.0×10^{-2}	—	—	—	—	—	—	—	8.0×10^{-2}
2001	1.0×10^{-1}	—	—	—	—	—	—	—	1.0×10^{-1}

j. ASERs report no radioactivity from ongoing operations to liquid effluent.
k. For 2000−2001, ASERs indicate that all discharges of radioactive liquids remained on-site.
l. ASERs report no release of liquid effluent containing radionuclides above background concentrations.
m. ASERs report that all radioactive liquid releases were from research reactors and were not detected above applicable standards.
n. No liquid radiological monitoring because of generally dry conditions and limited radioactive sources on site.
o. ASERS report no releases above limits to sewer from 1998 through 2001.
p. Includes releases from ORNL, ETTP, and Y-12. Most tritium releases are from ORNL; Most U releases are from Y-12.

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or that the value was not measurable.)
“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-4 (continued). Liquid Effluent Monitoring Results (curies)

Year	Fission and Activation Products					Actinides			Annual Site Totals
	Tritium	Radio-iodine	Radio-strontium	Radio-cesium	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	
Stanford Linear Accelerator Center (SLAC)									
1998	7.0×10^{-2}	—	—	—	—	—	—	—	7.0×10^{-2}
1999	7.1×10^{-3}	—	—	—	—	—	—	—	7.1×10^{-3}
2000	2.4×10^{-3}	—	—	—	—	—	—	—	2.4×10^{-3}
2001	2.1×10^{-3}	—	—	—	—	—	—	—	2.1×10^{-3}
Thomas Jefferson National Accelerator Facility (JLAB)									
1998	conc	—	—	—	conc	—	—	—	—
1999	conc	—	—	—	conc	—	—	—	—
2000	conc	—	—	—	conc	—	—	—	—
2001	8.8×10^{-1}	—	—	—	3.5×10^{-5}	—	—	—	8.8×10^{-1}

— = Data not reported in ASER. (Note: "0" indicates that the ASER reports a value of zero or that the value was not measurable.)
“conc” indicates that releases were reported in concentration and not as total curies for the year.

Table 3-5. Total Liquid Effluent Releases by Year (curies)

Year	Fission and Activation Products					Actinides			Annual Site Totals
	Tritium	Radio-iodine	Radio-strontium	Radio-cesium	Other (T1/2 >3 hr)	Uranium	Plutonium	Other	
1998	1.1×10^{4}	8.9×10^{-2}	6.0×10^{-1}	2.0×10^{-1}	2.8×10^{0}	1.3×10^{-1}	4.0×10^{-2}	5.5×10^{-4}	1.2×10^{4}
1999	6.4×10^{3}	8.9×10^{-2}	2.3×10^{-1}	1.1×10^{-1}	3.8×10^{1}	3.0×10^{-2}	6.5×10^{-4}	3.6×10^{-4}	6.5×10^{3}
2000	5.5×10^{3}	8.6×10^{-2}	5.5×10^{-1}	1.8×10^{-1}	2.4×10^{0}	9.8×10^{-3}	3.9×10^{-4}	6.0×10^{-4}	5.5×10^{3}
2001	4.3×10^{3}	8.8×10^{-2}	3.7×10^{-1}	8.8×10^{-2}	3.1×10^{0}	1.3×10^{0}	3.5×10^{-4}	5.3×10^{-4}	4.3×10^{3}
Total	2.7×10^{4}	3.5×10^{-1}	1.7×10^{0}	5.8×10^{-1}	4.7×10^{1}	1.5×10^{0}	4.1×10^{-2}	2.0×10^{-3}	2.7×10^{4}

4.0 Groundwater Radiological Monitoring and Surveillance

4.1 Background

DOE is responsible for conducting effluent monitoring and environmental surveillance programs to determine whether the public and the environment are adequately protected during DOE operations and whether the impact of those operations are in compliance with Federal, state, and local radiation standards and requirements. Groundwater monitoring is an integral component of these effluent monitoring and environmental surveillance programs. Since the late 1980's, DOE O 5400.1 has required the development and implementation of environmental protection, monitoring, and surveillance programs at DOE sites (DOE1990a). Furthermore, DOE O 5400.5 sets radiological standards for DOE sites and contractors that manage radioactive materials (DOE 1993). DOE sites must demonstrate compliance, through groundwater effluent monitoring and surveillance programs, with DOE O 5400.5 requirements for protecting the public and the environment.

Groundwater monitoring at DOE sites is conducted to determine the distribution of chemical and radiological constituents in groundwater and their potential impact on the public and the environment in close proximity to DOE sites. A fully integrated site-wide monitoring program should provide sufficient information on releases to the subsurface (groundwater, vadose zone, and aquifers) to allow estimates of radiological dose to demonstrate compliance with the DOE O 5400.5 dose limits. If individuals or populations living near a DOE site have the potential for radiological exposure, then the groundwater dose should be included in the estimated dose to the MEI.

DOE's Guide EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991), describes the elements of an acceptable effluent monitoring and environmental surveillance program for DOE sites involving radioactive materials. The primary purpose of this guide is to specify the necessary elements for effluent monitoring and environmental surveillance of radioactive materials at DOE sites to comply with both applicable Federal regulations and other DOE requirements.

DOE O 5400.1 was replaced in 2003 by DOE O 450.1, *Environmental Protection Program* (DOE 2003), which requires the development and implementation of an Environmental Management System (EMS) that includes a site-wide environmental monitoring and surveillance program. DOE G 450.1-6, *Ground Water Surveillance Monitoring Implementation Guide for Use with DOE O 450.1, Environmental Protection Program* (DOE 2004), provides a description of the elements of an integrated, site-wide groundwater surveillance monitoring program. This guidance, developed to assist in establishing a site-wide EMS, is a companion to EH-0173T. This guidance recommends the identification of surveillance monitoring networks designed to meet specific information needs related to groundwater protection, for compliance with external regulations and for long-term environmental stewardship. Per this Guide, groundwater monitoring networks for RCRA and other waste management facilities (e.g. radioactive waste management facilities subject to DOE O 435.1, *Radioactive Waste Management*), subsurface restoration activities, and environmental surveillance are to be integrated in the site-wide groundwater protection program. Although the ASERs evaluated for this report pre-date this requirement, beginning in 2000, annual ASER guidance (DOE 2000c) recommended the inclusion of related information in the ASERs in anticipation of DOE O 435.1 and to, in part, respond to a report by DOE's Office of the Inspector General (DOE 2000b).

A summary description of the site's groundwater monitoring network is provided in the ASER. This summary identifies the various monitoring objectives (e.g., RCRA hazardous waste management unit detection monitoring, environmental surveillance monitoring, or DOE O 435.1

monitoring) and describes the network established to meet these objectives. A series of tables could be used to summarize the number of active wells by area of the site and by purpose. They address the number of wells installed or abandoned during the current year, and any unique or innovative techniques employed in the site's groundwater monitoring network. The reporting approach is discussed further in annual guidance on the preparation of ASERs (DOE 2000c, DOE 2001a, DOE 2002a).

4.2 Results of 1998–2001 Groundwater Radionuclide Monitoring and Reporting in ASERs

The ASERs for 36 DOE sites were reviewed to assess information on groundwater monitoring for radionuclides, including the number of on- and off-site wells, number of samples taken per year, number of analyses performed, number of non-detect samples, drinking water dose, and radionuclides detected (Table 4.2). Each of the 36 sites conducted on-site radionuclide monitoring and indicated the number of wells sampled. About half the sites reported information on off-site radionuclide monitoring, but only eight sites (BET, BNL, ETEC, LANL, LEHR, NRF, NTS and PANX) indicated the number of off-site wells that were used for radionuclide monitoring.

The most common radionuclides detected were tritium (22 sites), uranium (18 sites), ^{90}Sr (14 sites), radium (12 sites), plutonium (9 sites), cesium (8 sites), and ^{99}Tc (6 sites). Frequency of detection of these radionuclides and ranges of concentrations vary widely across the DOE sites reviewed. Naturally occurring radionuclides may be present in groundwater above detection limits. The percent of samples with detectable levels of radionuclides also is affected by the purpose and location of the wells. Samples from wells intended to define trends within known plumes are more likely to contain detectable levels of contaminants then samples from wells located outside the known plume boundaries. Wells from the outside the boundaries might be sampled to collect background information, to provide early notice of additional areas of contamination, and for other purposes.

Most of the 36 DOE sites do not report a contribution to estimated radiation doses to the general public from radionuclides in groundwater. This is due to site-wide restrictions on access to groundwater. At those DOE sites where contaminants have migrated beyond DOE’s property boundaries, the levels detected are significantly below applicable standards. Groundwater contamination is being remediated in accordance with agreements between DOE and external agencies (the U.S. Environmental Protection Agency and state agencies).

Table 4-1. 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site?	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionu-clides Detected	# of Off-Site Ground-water Monitoring Wells	Radionu-clides Monitored Off-Site	Radionu-clides Detected Off-Site
ENVIRONMENTAL MANAGEMENT (EM)																			
Ashtabula Environmental Management Project (AEMP)																			
1998	Yes	Yes	27	13	—	—	No			D					D	—	—	U, Tc	U, Tc
1999	Yes	Yes	29	13	—	—	No			D					D	—	—	U, Tc	U, Tc
2000	Yes	Yes	22	14	—	—	No			D					D	—	—	U, Tc	U, Tc
2001	Yes	Yes	30	30	—	—	No			D					D	—	—	U, Tc	U, Tc
Battelle Columbus Laboratories (BCL)																			
1998	Yes	No	21	42	—	—	No		D			D	D		D	Co,Sb,Eu,Am	—	—	—
1999	Yes	No	21	42	—	—	No		D			D	D		D	Co,Sb,Eu,Am	—	—	—
2000	Yes	No	21	42	—	—	No		D			D	D		D	Co,Sb,Eu,Am	—	—	—
2001	Yes	No	21	42	—	—	No		D			D	D		D	Co,Sb,Eu,Am	—	—	—
Energy Technology Engineering Center (ETEC)																			
1998	Yes	Yes	45	—	284	54	No	D				D			D	Th	7	H-3	ND
1999	Yes	Yes	45	43	192	53	No	D				D			D	Th	7	H-3	ND
2000	Yes	Yes	47	43	173	54	No	D				D			D	Th	7	H-3	ND
2001	Yes	Yes	47	46	207	50	No	D				D			D	Th	7	H-3	H-3
Fernald Environmental Management Project (FEMP)																			
1998	Yes	Yes	—	—	—	—	—			D					D	—	—	U, Tc	U, Tc
1999	Yes	Yes	—	—	—	—	—			D					D	—	—	U, Tc	U, Tc
2000	Yes	Yes	—	—	—	—	—			D					D	—	—	U, Tc	U, Tc
2001	Yes	Yes	—	—	—	—	—			D					D	—	—	U, Tc	U, Tc
Grand Junction Office (GJO)																			
1998	Yes	No	12	—	—	—	No							D	D	—	—	—	—
1999	Yes	No	12	—	—	—	No							D	D	—	—	—	—
2000	Yes	No	6	—	—	—	No							D	D	—	—	—	—
2001	Yes	No	6	—	—	—	No							D	D	—	—	—	—
Hanford Site (HANF)																			
1998	Yes	Yes	671	>1,453	—	—	Yes	D	D	D	D	D	D	ND	D	Co, Am	—	H-3	—
1999	Yes	Yes	645	>1,333	—	—	Yes	D	D	D	D	D	D	ND	D	Co	—	H-3	—
2000	Yes	Yes	694	>1,513	—	—	Yes	D	D	D	D	D	D	D	D	Co	—	H-3	—
2001	Yes	Yes	735	2,095	18,051	41	Yes	D	D	D	D	D	D	D	D	Co, Am	—	H-3	—
Idaho National Environmental and Engineering Laboratory (INEEL)																			
1998	Yes	Yes	—	—	—	—	No	D	D								—	H-3, Sr	H-3, Sr
1999	Yes	Yes	—	—	—	—	No	D	D								—	H-3, Sr	H-3, Sr
2000	Yes	Yes	—	—	—	—	No	D	D								—	H-3, Sr	H-3, Sr
2001	Yes	Yes		2,597			No	D	D								—	H-3, Sr	H-3, Sr

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

Table 4-1 (continued). 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site?	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionuclides Detected	# of Off-Site Ground-water Monitoring Wells	Radionu-clides Monitored Off-Site	Radionu-clides Detected Off-Site
Miamisburg Environmental Management Project (MEMP)																			
1998	Yes	Yes	117	66	—	—	Yes	D					D	D	D	Th	—	H-3,Pu, U,Th,Ra	H-3,Pu, U,Th,Ra
1999	Yes	Yes	117	75	—	—	Yes	D					D	D	D	Th	—	H-3,Pu, U,Th,Ra	H-3,Pu, U,Th,Ra
2000	Yes	Yes	117	70	—	—	Yes	D					D	D	D	Th	—	H-3,Pu, U,Th,Ra	H-3,Pu, U,Th,Ra
2001	Yes	Yes	122	100	—	—	Yes	D					D	D	D	Th	—	H-3,Pu, U,Th,Ra	H-3,Pu, U,Th,Ra
Monticello Mill Tailings Site (MMTS)																			
1998	Yes	Yes	23	—	—	—	—							D	D		—	—	—
1999	Yes	Yes	>64	—	—	—	—							D	D		—	—	—
2000			>78											D	D		—	—	—
2001	Radiological monitoring discontinued after completion of surface remediation in 1999. 2000 groundwater reporting same as 1999. ASER publication ceased after 2000.																		
Paducah Gaseous Diffusion Plant (PGDP)																			
1998	Yes	Yes		—	—	—	—			D							—	Tc	Tc
1999	Yes	Yes	>150	—	—	—	—			D							—	Tc	Tc
2000	Yes	Yes		—	—	—	—			D							—	Tc	Tc
2001	Yes	Yes	>150	—	—	—	—			D							—	Tc	Tc
Portsmouth Gaseous Diffusion Plant (POR)																			
1998	Yes	Yes	>400	—	—	—	No			D			D		D	Am, Np	—	Tc, Np, Am, Pu, U	U
1999	Yes	Yes	>400	—	—	—	No			D			D		D	Am, Np	—	Tc, Np, Am, Pu, U	U
2000	Yes	Yes	>400	—	—	—	No			D			D		D	Am, Np	—	Tc, Np, Am, Pu, U	U
2001	Yes	Yes	>400	—	—	—	Yes			D			D		D	Am, Np	—	Tc, Np, Am, Pu, U	U
Savannah River Site (SRS)																			
1998	Yes	Yes	1,133	34,801	34,801	50	Yes	D									—	H-3	H-3
1999	Yes	Yes	1,224	26,958	26,958	50	Yes	D									—	H-3	H-3
2000	Yes	Yes	1,180	24,806	24,806	50	Yes	D									—	H-3	H-3
2001	Yes	Yes					Yes	D									—	H-3	H-3
Waste Isolation Pilot Plant (WIPP)																			
1998	Yes	No	7	14	14	—	No	ND	ND	ND	ND	ND	D	ND	D	—			
1999	Yes	No	7	14	14	—	No	ND	ND	ND	ND	ND	D	ND	D	—			
2000	Yes	No	7	14	14	—	No	D	D			D		D	D	D			
2001																			

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

Table 4-1 (continued). 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site?	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionu-clides Detected	# of Off-Site Ground-water Monitoring Wells	Radionu-clides Monitored Off-Site	Radionu-clides Detected Off-Site
Weldon Spring Site Remedial Action Project (WSSRAP)																			
1998	Yes	Yes	104	588	—	—	No							D	D	Th	—	Ra, U, Th	Ra, U, Th
1999	Yes	Yes	79	613	—	—	No							D	D	Th	—	Ra, U, Th	Ra, U, Th
2000	Yes	Yes	70	441	—	—	No							D	D	Th	—	Ra, U, Th	Ra, U, Th
2001	Yes	Yes	>80	>412	—	—	No							D	D	Th	—	Ra, U, Th	Ra, U, Th
West Valley Demonstration Project (WVDP)																			
	Yes	Yes	91	293	293	—	Yes	D	D		D	D					—	H-3, Sr	H-3, Sr
1999	Yes	Yes	91	293	293	—	Yes	D	D		D	D					—	H-3, Sr	H-3, Sr
2000	Yes	Yes	84	286	286	—	Yes	D	D		D	D					—	H-3, Sr	H-3, Sr
2001	Yes	Yes	84	286	286	—	Yes	D	D		D	D					—	H-3, Sr	H-3, Sr
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)																			
Bettis Atomic Power Laboratory (BET)																			
1998	Yes	Yes	25	38	190	72	No		ND			ND			D	—	4	Sr	Sr
1999	Yes	Yes	27	42	210	69	No		D			ND			D	—	4	Sr	Sr
2000	Yes	Yes	31	41	205	71	No		ND			ND			D	—	4	Sr	ND
2001	Yes	Yes	28	35	175	78	No		D			ND			D	—	4	Sr	Sr
Knolls Atomic Power Laboratory - Kesserling (KAPL-2)																			
1998	Yes	No	35	—	—	—	No	D	—	—	—	ND	—	—	ND	ND	—	—	—
1999	Yes	No	32	—	—	—	No	D	—	—	—	ND	—	—	ND	ND	—	—	—
2000	Yes	No	39	—	—	—	No	ND	—	—	—	ND	—	—	ND	ND	—	—	—
2001	Yes	No	37	—	—	—	No	ND	—	—	—	ND	—	—	ND	ND	—	—	—
Knolls Atomic Power Laboratory - Knolls (KAPL-1)																			
1998	Yes	No	36	—	—	—	No	D	D	—	—	ND	ND	—	ND		—	—	—
1999	Yes	No	36	—	—	—	No	D	D	—	—	ND	ND	—	ND		—	—	—
2000	Yes	No	36	—	—	—	No	D	D	—	—	ND	ND	—	ND		—	—	—
2001	Yes	No	36	—	—	—	No	D	D	—	—	ND	ND	—	ND		—	—	—
Knolls Atomic Power Laboratory - Windsor (KAPL-3)																			
1998	No groundwater monitoring for radionuclides. No radioactive waste disposal on-site.																		
1999																			
2000	All on-site structures removed by the end of 1999; radiological monitoring discontinued.																		
Laboratory for Energy-Related Health Research (LEHR)																			
1998	Yes	Yes	20	>160	>160	—	No	D					D	D		Am, Bi, C, Pb, Tl	20	H-3	—
1999	Yes	Yes	20	>164	>164	—	No	D						D		Bi, C, Pb	21	H-3, Pb, C, Bi, Ra	Pb, C, Bi, Ra
2000	Yes	Yes	20	>176	>176	—	No	D					D	D		Bi, C, Pb	24	H-3, Pb, C, Bi, Ra	Pb, C, Bi, Ra
2001	Yes	Yes	30	200	1,400	—	No	D								C	24	H-3, C	H-3, C

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

Table 4-1 (continued). 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site?	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionu-clides Detected	# of Off-Site Ground-water Monitoring Wells	Radionu-clides Monitored Off-Site	Radionu-clides Detected Off-Site
Lawrence Livermore National Laboratory (LLNL)																			
1998	Yes	Yes	20	—	—	—		D					ND	D	D		—	—	—
1999	Yes	Yes	18	—	—	—	Yes	D					ND	D	D		—	—	—
2000	Yes	Yes	21	—	—	—		D					ND	D	D		—	—	—
2001	Yes	Yes	21	—	—	—		D					ND	D	D		—	—	—
Lawrence Livermore National Laboratory - Site 300																			
1998	Yes	Yes	—	—	—	—		D					ND	D	D		—	—	—
1999	Yes	Yes	—	—	—	—	Yes	D					ND	D	D		—	—	—
2000	Yes	Yes	—	—	—	—		D					ND	D	D		—	—	—
2001	Yes	Yes	—	—	—	—		D					ND	D	D		—	—	—
Los Alamos National Laboratory (LANL)																			
1998	Yes	Yes	22	—	—	—	No	D	D			D	D		D	Am	7	—	—
1999	Yes	Yes	21	—	—	—	Yes	D				D	D		D	Am	7	—	—
2000	Yes	Yes	20	—	—	—	No	D	D			D	D		D	Am	7	—	—
2001	Yes	Yes	20	—	—	—	No	D	D			D	D		D	Am	7	—	—
Naval Reactors Facility (NRF)																			
1998	Yes	Yes	17	100	—	—	No	ND	ND			ND					13	H-3, Sr	H-3
1999	Yes	Yes	17	100	—	—	No	ND	ND			ND					13	H-3, Sr	H-3
2000	Yes	Yes	17	100	—	—	No	ND	ND			ND					13	H-3, Sr	H-3
2001	Yes	Yes	17	100	—	—	No	ND	ND			ND					13	H-3, Sr	H-3
Nevada Test Site (NTS)																			
1998	Yes	Yes	27	>52	>52	—	Yes	D	D				D	D	D		38	H-3,Pu, Sr, Ra	N
1999	Yes	Yes	27		>52	—	Yes	D	D				D	D	D		38	H-3,Pu, Sr, Ra	N
2000	Yes	Yes	23			—	Yes	D	D				D	D	D		38	H-3,Pu, Sr, Ra	N
2001	Yes	Yes	23			—	Yes	D	D				D	D	D		38	H-3,Pu, Sr, Ra	N
Pantex Plant (PANX)																			
1998	Yes	Yes	83	1,455	—	—	No	D	D				D	D	D		7		
1999	Yes	Yes	95	753	—	—	No	D	D				D	D	D		4		
2000	Yes	Yes	119	451	—	—	No	D					D	D	D		12		
2001	Yes	Yes	125	591	—	—	No	D					D	D	D		21		
Sandia National Laboratories, Albuquerque (SNLA)																			
1998	Yes	No	13														—	—	—
1999	Yes	No	11														—	—	—
2000	Yes	No	14														—	—	—
2001	Yes	No	13														—	—	—

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

Table 4-1 (continued). 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site?	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionu-clides Detected	# of Off-Site Ground-water Monitoring Wells	Radio-nuclides Monitored Off-Site	Radio-nuclides Detected Off-Site
Sandia National Laboratories, Tonopah (SNLT)																			
1998	Yes	No	—	—	—	—	No	ND					ND				—	—	—
1999	Yes	No	—	—	—	—	No	ND					ND				—	—	—
2000	Yes	No	—	—	—	—	No	ND					ND				—	—	—
2001	Yes	No	—	—	—	—	No	ND					ND				—	—	—
SCIENCE (SC)																			
Ames Laboratory (AMES)																			
1998	Yes																		
1999	Yes																		
2000	No																		
2001	No																		
Argonne National Laboratory (ANL)																			
1998	Yes		34	—	—	—		D	D										
1999	Yes		15	63				D	D										
2000	Yes	No	13	60	—	—	No	D	D										
2001	Yes	Yes	51	63	—	—	No	D	D										
Brookhaven National Laboratory (BNL)																			
1998	Yes	Yes	470	1,750			No	D	D							Na	116	H-3	H-3
1999	Yes	Yes	589	2,122			No	D	D							Na	116	H-3	H-3
2000	Yes	Yes	683	2,530			No	D	D							Na		H-3	H-3
2001	Yes	Yes	714	2,739			No	D	D							Na		H-3	H-3
Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)																			
1998	Yes	No	174	—	—	—	No	D									—	—	—
1999	Yes	No	182	—	—	—	No	D									—	—	—
2000	Yes	No	190	—	—	—	No	D									—	—	—
2001	Yes	No	198	—	—	—	No	D									—	—	—
Oak Ridge Reservation (ORR) [ORNL]																			
1998	Yes	Yes	>20	—	—	—	—	D	D	D		D				Co	—	—	—
1999	Yes	Yes	>24	—	—	—	—	D	D	D		D				Co			
2000	Yes	Yes	>24	—	—	—	—	D	D	D		D				Co			
2001	Yes	Yes	>24	—	—	—	—	D	D	D		D			D	Co	—	—	—
Princeton Plasma Physics Laboratory (PPPL)																			
1998	Yes	No	11				No	D									—	—	—
1999	Yes	Yes	11	—	—	—	Yes	D									—	—	—
2000	Yes	Yes					Yes	D									—	—	—
2001								D									—	—	—

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

Table 4-1 (continued). 1998−2001 Radionuclide Monitoring of Groundwater at DOE Sites

General Groundwater Monitoring Information								On-Site Groundwater Radionuclide Monitoring									Off-Site Groundwater Radionuclide Monitoring		
Year	Is Radio-nuclide Monitoring Conducted On-site? Y/N	Is Radio-nuclide Monitoring Conducted Off-site?	# of active wells monitored for radionu-clides	# of samples taken/ year	# of analyses performed	% of analyses that are non-detects	Is Ground-water or drinking water dose indicated?	Tritium	Sr-90	Tc-99	Iodine	Cs	Pu	Ra	U	Other Radionu-clides Detected	# of Off-Site Ground-water Monitoring Wells	Radionu-clides Monitored Off-Site	Radionu-clides Detected Off-Site
Stanford Linear Accelerator Center (SLAC)																			
1998	Yes	No	59	—	—	—	No	D									—	—	—
1999	Yes	No	60	—	—	—	No	D									—	—	—
2000	Yes	No	62	—	—	—	No	D									—	—	—
2001	Yes	No	79	—	—	—	No	D									—	—	—
Thomas Jefferson National Accelerator Facility (JLAB)																			
1998	Yes	Yes	15	—	—	—	Yes	D	D			D		D		Be,Na,Mn	—	—	—
1999	Yes	Yes	15	—	—	—	Yes	D								Be,Na,Mn	—	—	—
2000	Yes	Yes	15	—	—	—	Yes	D								Be,Na,Mn	—	—	—
2001	Yes	Yes	15	—	—	—	Yes	D								Be,Na,Mn	—	—	—

D = radionuclide was detected
ND = radionuclide was monitored for but not detected
Blank = radionuclide not monitored for
— = data not reported in ASER

5.0 Biota Dose Evaluation

5.1 Background

DOE facility operations, site remediation, and stewardship activities may result in releases of radionuclides to ambient air and water, accumulation of radionuclides in soil and sediment, and the potential for plants, animals, and members of the public to be exposed to radiation. Regarding environmental protection, it has been assumed in the past by scientific organizations (ICRP 1977) that if radiological controls and established dose limits for humans were found to be protective, then non-human species (i.e., biota: plants and animals) also would be sufficiently protected. This assumption is considered largely appropriate in cases where humans and other biota inhabit the same environment and contaminated area, and are subject to similar pathways of radiological exposure (Barnthouse 1995). This assumption is less appropriate in cases where human access is restricted (e.g., in high-contamination areas), but populations of plants and animals remain exposed (e.g., to contaminated water, sediment, and soil) (Jones et al. 2003). Prior to 1998 there were no nationally or internationally standardized approaches for evaluating potential radiological impacts to biota. In response to this need, DOE developed and published a Technical Standard that provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota (DOE 2002b). This methodology, and the results of biota dose assessments reported in the 1998–2001 ASERs, are discussed in this chapter.

5.2 Demonstrating Protection of Biota and Reporting Compliance with DOE Dose Limits and Requirements

DOE has been proactive in the area of requirements, guidance, and methods for demonstrating radiation protection of the environment (biota and ecosystems). Since 1990, DOE O 5400.5 has required that populations of aquatic organisms be protected using a dose limit of 1 rad/day (DOE 1993). While there are no formal DOE dose limits for terrestrial biota (e.g., as proposed in 10 CFR Part 834 but not currently in the DOE Orders), DOE has strongly recommended that ASERs demonstrate that site activities are also meeting DOE and internationally recommended dose limits for terrestrial biota.

Presently, DOE O 450.1 requires that as part of integrating EMSs into site Integrated Safety Management Systems (ISMSs), DOE elements must, as applicable, consider protection of biota (DOE 2003). Both aquatic and terrestrial evaluations are to be conducted as an integral part of a site's environmental monitoring and surveillance program, and the results of these evaluations are to be reported in the ASER.

ASERs document DOE activities, as appropriate to each site, that:

1) the absorbed dose to aquatic animals will not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radioactive material;

2) the absorbed dose to terrestrial plants will not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radioactive material; and

3) the absorbed dose to terrestrial animals will not exceed 0.1 rad/day (1 mGy/day) from exposure to radiation or radioactive material.

The screening and analysis methods contained in the DOE Technical Standard and summarized below provide a means of demonstrating that the above dose rate guidelines for aquatic and terrestrial biota are being achieved.

5.3 A Graded Approach for Demonstrating Protection

The DOE voluntary consensus Technical Standard, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE-STD-1153-2002; DOE 2002b), provides practical screening and analysis methods for demonstrating protection of biota and compliance with DOE Order requirements. Although the ASERs summarized in this report pre-date the final Technical Standard, tools and guidance included in the standard have been available to DOE sites since 1999 (DOE 2000d). The graded approach consists of a three-step process which guides the user from an initial, prudently conservative set of screening values to, if needed, a more rigorous analysis using site-specific information. This three-phased scheme helps to ensure that the evaluation effort is commensurate with the likelihood and severity of potential environmental impacts. In the general screening phase, measured radionuclide concentrations in environmental media are compared with the Biota Concentration Guides (BCGs). Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media that would not cause the biota dose limits to be exceeded. The multi-tiered analysis process provided in the Technical Standard also is appropriate for conducting detailed ecological risk assessments of radiological impact. The Technical Standard was developed by DOE through the Department's Biota Dose Assessment Committee (BDAC).

Several companion software tools for use with the DOE Technical Standard are provided for DOE and public use. In 2002, the RAD-BCG Calculator was released to provide a set of electronic spreadsheets for conducting the screening and analysis methods in the graded approach. In 2003, DOE released the RESRAD-BIOTA code and a supporting User's Guide. The code duplicates the graded approach methodology and includes additional advanced analysis features. The DOE Technical Standard and the RESRAD-BIOTA code are the preferred tools for estimating and evaluating doses to biota.

5.4 Reporting Guidance for ASERs

DOE first recommended that ASERs discuss radiation protection of biota for calendar year 1999 (DOE 2000c). This reporting guidance has continued for each subsequent year. The guidance recommends that ASERs address six elements, as appropriate to site-specific circumstances:

- Reference the applicable DOE biota dose limits and requirements;
- Identify the method used to assess compliance with these limits and briefly describe the process used;
- Describe the site areas evaluated and supporting data used in the evaluation (e.g., source of exposure data, biota and media type evaluated);
- Summarize the results (e.g., concentrations of radionuclides in environmental media compared to screening values, calculated doses compared to biota dose limits);
- Summarize integration of biota dose evaluation within site environmental surveillance and monitoring programs; and
- Summarize any outreach activities regarding radiation protection of biota.

5.5 Results of 1998–2001 Biota Dose Evaluation Reporting in ASERs

The availability of the DOE Technical Standard is effecting change within DOE regarding awareness of biota protection and demonstration of compliance with DOE biota protection

requirements. Addressing protection of biota in ASERs was first emphasized in ASER guidance for CY1999. Prior to 1999, compliance with DOE O 5400.5 dose limits for biota was addressed in very few ASERs. An interim version of the DOE Technical Standard on biota dose evaluation was made available for DOE field and program use in July 2000; the final version was published in July 2002.

The availability and application of this standardized evaluation methodology contributed to an increase in the inclusion of biota dose evaluations in ASERs. Of the ASERs reviewed for this summary report, biota dose evaluation was discussed in approximately 14% in 1998, approximately 28% in 1999, approximately 43% in 2000, and 50% in 2001 (Table 5-1). This reflects an increase from just five sites reporting in 1998 to 17 sites reporting in 2001. Overall, biota dose evaluation was discussed in one-third of the ASERs reviewed for the four-year period.

The most commonly applied method by the sites in conducting biota dose evaluation was the graded approach contained in the DOE Technical Standard (in 34 of 47 ASERs). Other methods included application of the CRITR model (in 5 ASERs), and some qualitative site-specific approaches (in 8 ASERs). Dose evaluations applicable to aquatic systems were presented in 34 of the 39 ASERS. Dose evaluations applicable to terrestrial systems were discussed in 32 of the 39 ASERs. Most sites using the graded approach were able to demonstrate protection of biota using the general screening phase of the methodology, which is designed to be practical and cost-effective. In all cases, for both aquatic and terrestrial systems, the results of the dose evaluations demonstrated compliance with applicable DOE requirements for protection of biota.

Table 5-1. 1998−2001 ASERs Containing Biota Dose Evaluation/Demonstration of Compliance with DOE Biota Dose Requirements

	1998	1999	2000	2001
ENVIRONMENTAL MANAGEMENT				
Ashtabula Environmental Management Project	—	—	—	—
Battelle Columbus Laboratories	—	—	—	—
Energy Technology Engineering Center	—	—	—	Yes
Fernald Environmental Management Project	(a)	(a)	(a)	(a)
Grand Junction Office	—	—	—	—
Hanford Site	Yes	Yes	Yes	Yes
Idaho National Environmental and Engineering Laboratory	—	—	—	—
Miamisburg Environmental Management Project	—	Yes	Yes	Yes
Monticello Mill Tailings Site	—	—	—	(b)
Paducah Gaseous Diffusion Plant	—	—	—	—
Portsmouth Gaseous Diffusion Plant	—	Yes	Yes	Yes
Savannah River Site	Yes	Yes	Yes	Yes
Waste Isolation Pilot Plant	—	Yes	Yes	Yes
Weldon Spring Site Remedial Action Project	—	—	—	—
West Valley Demonstration Project	—	—	—	Yes
NATIONAL NUCLEAR SECURITY ADMINISTRATION				
Bettis Atomic Power Laboratory	—	—	—	—
Knolls Atomic Power Laboratory - Kesserling	—	—	—	—
Knolls Atomic Power Laboratory - Knolls	—	—	—	—
Knolls Atomic Power Laboratory - Windsor	—	—	—	—
Laboratory for Energy-Related Health Research	—	—	—	—
Lawrence Livermore National Laboratory	—	—	Yes	Yes
Lawrence Livermore National Laboratory - Site 300	—	—	Yes	Yes
Los Alamos National Laboratory	—	—	Yes	Yes
Naval Reactors Facility	—	—	—	—
Nevada Test Site	—	Yes	Yes	Yes
Pantex Plant	—	—	—	—
Sandia National Laboratories, Albuquerque	—	—	—	—
Sandia National Laboratories, Tonopah	—	—	—	—
SCIENCE				
Ames Laboratory	—	—	—	—
Argonne National Laboratory-East	Yes	Yes	Yes	Yes
Brookhaven National Laboratory	—	—	Yes	Yes (c)
Ernest Orlando Lawrence Berkeley National Laboratory	—	—	Yes	Yes
Oak Ridge Reservation	Yes	Yes	Yes	Yes
Princeton Plasma Physics Laboratory	—	Yes	Yes	Yes
Stanford Linear Accelerator Center	—	—	—	—
Thomas Jefferson National Accelerator Facility	Yes (d)	Yes (d)	Yes (d)	Yes (d)
ASERs w/ Biota Dose Evaluation Information – Totals	5	10	15	17

a. While not addressed in its ASERs for 1998–2001, Fernald conducted retrospective analyses of biota dose for 1998–2001 and reported these results in its 2002 and 2003 ASERs.
b. ASER publication ceased after calendar year 2000.
c. Demonstration of compliance with biota dose limits is discussed in the BNL 2001 ASER, but quantitative analysis of results is not provided.
d. As reported by JLAB, compliance was determined through indirect qualitative consideration of site release data.
Yes = Biota Dose Evaluation was reported in ASER. All sites reporting successfully demonstrated compliance with DOE biota dose requirements.
— = Biota Dose Evaluation was not reported in ASER.

6.0 References

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Appendix A. Glossary, Acronyms & Abbreviations, and Numbers & Units

A.1 Glossary

Note: Italicized words are separately defined in this glossary.

absorbed dose
The energy imparted to matter by *ionizing radiation* per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of *rad* or *gray* (1 rad = 0.01 gray).

actinides
Elements in the periodic table with atomic number 89 (actinium) or greater, including thorium, uranium, and *plutonium*. All actinides are *radioactive*.

activation products
As *neutrons* interact with matter, either present as impurities in the cooling water of a nuclear reactor or in structural materials around a nuclear reactor or high-energy facility (e.g., an accelerator), stable atoms can be converted into *radionuclides*. These radionuclides are termed activation products and are distinguished from *fission products*, which are produced by the splitting of atoms during a nuclear reaction.

ALARA
Acronym for "as low as reasonably achievable." The phrase describes an approach to *radiation* protection to control or manage *exposures* (both individual and collective to the work force and the general public) and releases of *radioactive material* to the environment as low as social, technical, economic, practical, and public policy considerations permit. As used in DOE O 5400.5, *Radiation Protection of the Public and the Environment*, ALARA is not a *dose* limit, but rather it is a process that has as its objective the attainment of dose levels as far below the applicable limits of the Order as practicable.

alpha particle
A positively charged particle composed of two protons and two *neutrons* that is emitted during *radioactive decay* of certain *radioactive* atoms. Several *radionuclides* associated with DOE operations, such as *isotopes* of uranium, thorium, and *plutonium*, undergo radioactive decay by emitting alpha particles. Although high in energy, alpha particles can be stopped by several centimeters of air or a sheet of paper because of their mass.

aquifer
A natural underground layer, often of sand or gravel, that is capable of supplying significant quantities of water to wells or springs.

background radiation
Ionizing radiation in an area from sources other than those associated with an operating nuclear facility. In this report, background radiation primarily refers to the natural *radiation* of the earth and its atmosphere, consisting of *cosmic radiation* and *radioactive material* in the earth, air, and water, and naturally occurring radioactive elements found in the human body and elsewhere. Global fallout from nuclear testing also contributes to background radiation.

becquerel (Bq)

The name for a unit describing the quantity of radioactive material in the International System of Units (SI) that produces one nuclear disintegration per second. 1 Bq = 2.7×10^{-11} *curies* (Ci).

beta particle

A charged particle with the mass of an electron emitted from an atom's nucleus during the radioactive decay of certain *radionuclides*. If negatively charged, the beta particle is identical to an electron; if positively charged it is called a positron. Most beta particles are stopped by clothing or a thin sheet of metal or plastic because of their mass.

biota

The plant and animal life of a region.

collective dose equivalent and collective effective dose equivalent

See *population dose*.

committed dose equivalent

The predicted total *dose equivalent* to a tissue or organ over a 50-year period after a known intake of a *radionuclide* into the body. It does not include contributions from *external dose*. Committed dose equivalent is expressed in units of *rem* or *sievert*.

committed effective dose equivalent

The sum of the *committed dose equivalents* to various tissues in the body, each multiplied by the appropriate *weighting factor*. Committed effective dose equivalent is expressed in units of *rem* or *sievert*.

cosmic radiation

High-energy particulate and electromagnetic *radiations* that originate outside the earth's atmosphere in outer space. Cosmic radiation is part of *background radiation*.

curie (Ci)

A unit describing the quantity of radioactive material. One curie is the quantity of radioactive material needed to produce 3.7×10^{10} (37 billion) nuclear transformations per second. For environmental monitoring, a curie is usually too large to work with conveniently, and fractional units are often used (see *millicurie*).

decay, radioactive

The spontaneous transformation of one *radionuclide* into a different *nuclide*, which may or may not be *radioactive*, or into a different energy state of the same radionuclide through the emission of *alpha particles*, *beta particles*, *neutrons*, and/or *gamma* rays.

deep dose equivalent

The *dose equivalent* in tissue at a depth of 1 cm deriving from external (penetrating) *radiation*.

derived concentration guide (DCG)

The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (1 mSv). DCGs do not consider decay products when the parent radionuclide is the cause of the exposure. DCG values are presented in DOE O 5400.5 (DOE 1993).

dose

A general term denoting the quantity of *radiation* or energy absorbed. Dose is qualified when discussing specific *exposure* scenarios or conditions (e.g., dose to an organ within the body, the whole body, or a population group). (See other dose terms including *absorbed dose*, *organ dose*, *population dose*, and *whole-body dose*.)

dose conversion factor (DCF)

Typically in units of mrem/μCi (Sv/Bq), a factor that defines the absorbed dose (i.e., the committed radiation dose equivalent to an organ or the committed effective radiation dose equivalent) for a unit intake of a radionuclide through inhalation or ingestion. This factor, multiplied by the total intake through inhalation or ingestion in μCi (Bq) produces the estimated committed radiation dose equivalent to an organ or the committed effective radiation dose equivalent. These factors are listed in DOE (DOE 1988a, DOE 1988b) and EPA (EPA 1988) publications, and are based on recommendations of the ICRP (ICRP 1977, ICRP 1978).

dose equivalent

The product of *absorbed dose* in *rad* (or *gray*) in tissue and a *quality factor*. Dose equivalent is expressed in units of *rem* or *sievert*. Dose equivalent is designed to express, on a common scale, the injury produced as the result of *radiation exposure*, across all types of radiation.

dose rate

Radiation dose delivered per unit time (e.g., *rem*/h or *sievert*/h). Absorbed dose rate can be expressed as *rad*/h (*gray*/h), or rad/yr (gray/y).

effective dose equivalent

The summation of the products of the *dose equivalent* received by specific tissues of the body and a tissue-specific *weighting factor*. This sum is a risk-equivalent value and can be used to estimate the health-effects risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the *committed effective dose equivalent* from internal deposition of *radionuclides* and from penetrating *radiation* from sources external to the body. Effective dose equivalent is expressed in units of *rem* or *sievert*.

effluent

A substance emitted from a facility into water, air, or ground.

effluent monitoring

The collection and analysis of samples or measurements of liquid and gaseous effluents, or direct discharges to the ground, for purposes of characterizing and quantifying contaminants, assessing *radiation exposures* of members of the public, and demonstrating compliance with applicable standards.

environmental surveillance

The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs and the measurement of *external radiation* for purposes of characterizing and quantifying contaminants, assessing *radiation exposures* of members of the public, and demonstrating compliance with applicable standards.

exposure
A measure of the ionization produced in air by *x-rays* or *gamma radiation*. The unit of exposure is the *roentgen*. In more general terms, exposure is often used to denote contact with *radioactive materials* or proximity to *radiation* sources, as in defining radiation exposure pathways or conducting a radiation exposure analysis.

external radiation
Radiation originating from a source outside the body.

external dose
Dose received from *radiation* sources outside the body.

fast neutron
A *neutron* released during fission with an average kinetic energy of 2 MeV (megaelectronvolts).

fence line dose
The *dose* calculated at the point of highest potential *exposure* of individuals at any point of uncontrolled public access (i.e., outside the area where DOE restricts or controls public access for purposes of limiting radiation exposure).

fission products
Fission products are produced through the fission ("splitting") of larger atoms, such as uranium and *plutonium*, in a nuclear reaction. The fissioning of larger atoms results in smaller fission products and a release of energy in the form of radiation. Most fission products have short radioactive *half-lives*.

gamma radiation
Electromagnetic *radiation* emitted from the nucleus during nuclear transitions or particle annihilation. Gamma rays are photons that have no mass and no charge, and are identical to *x-rays* except for their point of origin. Gamma rays are emitted from the nucleus during nuclear reactions, and x-rays are emitted following transformations of electrons from a higher energy state to a lower energy state in an atom's electron shell. Gamma radiation frequently accompanies the emission of alpha or beta particles from the nucleus. Other types of electromagnetic radiation include microwaves, radiowaves, and visible light. Gamma rays are very penetrating since they have no mass and are best stopped by very dense (high atomic number) materials, such as lead.

gray (Gy)
The unit of *absorbed dose* in the International System of Units (SI). 1 Gy = 1 joule/kg = 100 *rad*.

half-life ($t_{1/2}$)
The time required for the activity of a *radionuclide* to decrease to half its original value through inherent *radioactive decay*. Each radionuclide has a unique half-life. These half-lives can range from a fraction of a second to billions of years.

internal radiation
Radiation from a source within the body. Internal radiation results from the deposition of *radionuclides* in body tissues through ingestion, inhalation, absorption through skin, or implantation. Potassium-40 (^{40}K), a naturally occurring radionuclide, is an example of a source of internal radiation in living organisms.

iodine, radioactive

Radioactive isotopes of iodine are of interest in *radiation dose* assessment because iodine tends to concentrate in the thyroid (a relatively small but important organ) of humans and animals. Radioactive iodine is produced by fission and is associated with *effluents* from nuclear reactors or nuclear fuel reprocessing, and their associated radioactive wastes.

ionizing radiation

Any *radiation* capable of displacing electrons from atoms or molecules as it passes through matter, thereby producing ions, directly or indirectly. (See *alpha particle*, *beta particle*, *cosmic radiation*, *gamma radiation*, and *x-rays*.)

isotopes

Nuclides having the same number of protons in their nuclei (hence, the same atomic number), but a different number of *neutrons* (therefore, a different mass number). For example, there are three major isotopes of uranium (U): $^{234, 235, 238}$U. Each has 92 protons in its nucleus, and 142, 143, and 146 neutrons, respectively. The chemical properties of all isotopes of a particular element are similar. (See *radioisotope*.)

krypton-85 (^{85}Kr)

A noble gas. It is a *radioactive isotope* of krypton and a *fission product* associated with nuclear reactor operations.

maximally exposed individual (MEI)

Hypothetical individual whose location and lifestyle is chosen to maximize the potential *radiation dose* through all relevant *exposure* pathways for *effluents* or *radiation* from a given facility or operation with the intent to represent the dose that is at the upper end of doses from plausible exposures. A representative member of the “critical group” also may be used as the MEI.

millicurie (mCi)

1/1000 of a *curie*.

millirem (mrem)

1/1000 of a *rem*.

naturally occurring radioactivity

The property of *radioactivity* exhibited by more than 50 *radionuclides* that exist naturally in the environment and in living organisms. Natural sources of radioactivity include *radioactive materials* in the earth (referred to as *terrestrial radiation*) and cosmogenic radionuclides formed by interactions of cosmic nucleons with target atoms in the atmosphere or in the earth.

neutron

An uncharged particle with a mass slightly larger than a proton (i.e., about 1,836 times the mass of an electron) found within the nucleus of an atom. When neutrons are high energy (about 2 megaelectronvolts, MeV), they are highly penetrating. The can be slowed, or moderated, through collisions with low atomic weight materials such as water.

noble gases

The six elemental gases are helium, neon, argon, krypton, xenon, and radon. They are chemically unreactive, but *radioactive isotopes* of each of the noble gases can be

produced through fission or activation and are generally associated with atmospheric *effluents* from nuclear reactor operation or nuclear fuel reprocessing.

nuclide

A general term referring to all known *isotopes*, both stable (279) and *unstable* (about 5,000), of the chemical elements. (For nuclides that are *radioactive*, see *radionuclide*.)

organ dose

A *dose equivalent* that involves *exposure* to a particular organ or set of organs. (See *weighting factor*.)

outfall

The place where a storm sewer or *effluent* line discharges to the environment. A point source.

person-rem

The unit of *population dose equivalent*. It is equal to the sum of calculated individual doses for a given population or the product of the population size and the average *dose* received by that population. Person-*sievert* is the comparable term in the International System of Units (SI).

plutonium (Pu)

A *radioactive*, metallic chemical element. Its most important *isotope*, ^{239}Pu, is produced by irradiating ^{238}U with *fast neutrons* in a nuclear reactor. This isotope is used in nuclear weapons and as a nuclear reactor fuel. Plutonium is one of the most restrictively controlled *radioactive materials* and may be found as a trace component of *effluents* from nuclear fuel reprocessing or in radioactive waste.

population dose

The sum of the *dose equivalents* or *effective dose equivalents* of all individuals in an exposed population typically within an 80-km (50-mile) radius measured from a point located centrally with respect to major facilities or DOE program activities, or the average dose equivalent or effective dose equivalent multiplied by the population size. Population dose is expressed in units of *person-rem* or person-*sievert*. For example, if 1,000 people received an average radiation dose equivalent of 1 *rem*, the population dose would be 1,000 *person-rem*. Population dose also is referred to as collective dose.

quality factor

Quality factor is the principal modifying factor used to calculate the *dose equivalent* from the *absorbed dose*. The physical measure of the relative effectiveness of equal absorbed doses from different particles in producing injuries is the linear energy transfer (LET). The higher the LET of the *radiation*, the greater the injury for a given absorbed dose. The quality factor expresses the relative effectiveness of a radiation based on its LET. When the absorbed dose is modified for purposes of radiation protection, it is multiplied by the quality factor (and any other appropriate modifying factors) to obtain the dose equivalent. The quality factors used are provided in DOE O 5400.5, *Radiation Protection of the Public and the Environment*. The quality factor for *x-rays*, *gamma radiation*, and *beta particles* is one, indicating a relatively low LET. The quality factor for *neutrons* with energy less than 10 kiloelectronvolts (keV) is 3, and for neutrons with energy greater than 10 keV is 10, indicating relatively higher LET. The quality factor for *alpha particles* is 20, indicating the highest relative LET.

rad

The special unit of *absorbed dose* of *ionizing radiation*. A *dose* of one rad equals the absorption of 100 ergs of ionizing energy per gram of absorbing material.

radiation

Particles or electromagnetic energy from atomic or nuclear processes.

radioactive decay

See decay, radioactive.

radioactive material

A material that exhibits *radioactivity*.

radioactivity

The property or characteristic of *radioactive material* to spontaneously "disintegrate" with the emission of energy in the form of *radiation*. The unit of radioactivity is the *curie* or *becquerel* (1 Ci = 3.7×10^{10} Bq).

radioisotope

A radioactive *isotope* of a specified element. Carbon-14 (^{14}C) is a radioisotope of carbon.

radionuclide

A *radioactive nuclide*. There are several hundred known radionuclides, some of which are man-made and some of which exist naturally.

rem

The unit that expresses human biological *dose equivalent* as a result of *exposure* to *ionizing radiation*. By applying the proper *quality factor*, the *absorbed dose* (in *rad*) can be converted into the dose equivalent in rem if the type of *radiation* (*alpha*, *beta*, *gamma*, *neutrons*, etc.) is known. (See *sievert*.)

roentgen (R)

A unit of *radiation exposure* expressed in terms of the amount of ionization produced by *x-rays* in a volume of air.

short-lived fission and activation products

For this report, those *radionuclides* produced through fission or activation processes that have radioactive *half-lives* of less than 3 hours (principally carbon-11 (^{11}C), nitrogen-13 (^{13}N), oxygen-15 (^{15}O), manganese-56, and barium-135(^{135}Ba)). Because they are short-lived, releases of such *radionuclides* generally pose less risk of *exposure* for humans than do the releases of longer-lived radionuclides, if for no other reason, because they undergo *radioactive decay* in transport before they reach members of the public.

sievert (Sv)

The unit for *dose equivalent* in the International System of Units (SI). 1 Sv = 100 *rem*.

terrestrial radiation

Radiation emitted by naturally occurring *radionuclides*, such as potassium-40 (^{40}K); the natural decay chains of uranium-238 (^{238}U), uranium-235 (^{235}U), or thorium-232 (^{232}Th); or cosmic-ray-induced *radionuclides* in the soil or air.

uncontrolled area

Any area to which access by the general public is not restricted or controlled for purposes of limiting *radiation exposure*.

unstable (element)
An element that is capable of *radioactive decay*.

weighting factor
An organ- or tissue-specific value representing the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. For example, 3% of the risk resulting from a *whole-body dose* is attributable to thyroid *exposure*. Weighting factors are listed in DOE O 5400.5, *Radiation Protection of the Public and the Environment*.

whole-body dose
A *dose* uniformly distributed over the entire body, rather than concentrated in a particular area of the body or certain organs.

x-rays
Penetrating electromagnetic (photon) *radiations* that are emitted following transformations of electrons from a higher energy state to a lower energy state in an atom's electron shell. They may be produced by bombarding a metallic target with fast electrons or by certain nuclear or atomic interaction. (*Gamma* rays are photons emitted from the nuclear.)

A.2 Acronyms and Abbreviations

AEMP	Ashtabula Environmental Management Project
ALARA	as low as reasonably achievable
ANLE	Argonne National Laboratory-East
ASER	Annual Site Environmental Report
ANSI	American National Standards Institute
BCG	Biota Concentration Guide
BCL	Battelle Columbus Laboratories
BET	Bettis Atomic Power Laboratory
BNL	Brookhaven National Laboratory
CAP88	Clean Air Package 1988
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CY	calendar year
DCF	Dose Conversion Factor
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
EDE	Effective Dose Equivalent
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park
FEMP	Fernald Environmental Management Project
FUSRAP	Formerly Utilized Sites Remedial Action Project
GJO	Grand Junction Office
HANF	Hanford Site
HISS	Hazelwood Interim Storage Site
ICRP	International Commission on Radiological Protection
INEEL	Idaho National Engineering and Environmental Laboratory
ITRI	Inhalation Toxicology Research Institute
JLAB	Thomas Jefferson National Accelerator Laboratory
KAPL-1	Knolls Atomic Power Laboratory-Knolls
KAPL-2	Knolls Atomic Power Laboratory-Kesselring
KAPL-3	Knolls Atomic Power Laboratory-Windsor
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LBNL	Ernest Orlando Lawrence Berkeley National Laboratory
LEHR	Laboratory for Energy-Related Health Research
LLNL	Lawrence Livermore National Laboratory
LLNL-300	Lawrence Livermore National Laboratory-Site 300
MEI	Maximally Exposed Individual
MEMP	Miamisburg Environmental Management Project
MMTS	Monticello Mill Tailings Site

NCRP	National Council on Radiation Protection and Measurements
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NG	noble gases
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
NRF	Naval Reactors Facility
NTS	Nevada Test Site
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PANX	Pantex Plant
PGDP	Paducah Gaseous Diffusion Plant
PIN	Pinellas Plant
POR	Portsmouth Gaseous Diffusion Plant
PPPL	Princeton Plasma Physics Laboratory
QA	Quality Assurance
RFETS	Rocky Flats Environmental Technology Site
RW	Office of Civilian Radioactive Waste Management
SC	Office of Science
SFMP	Surplus Facilities Management Program
SSFL	Santa Susana Field Laboratory
SLAC	Stanford Linear Accelerator Center
SLFAP	short-lived fission and activation products
SNL	Sandia National Laboratories
SNLA	Sandia National Laboratories - Albuquerque
SNLL	Sandia National Laboratories - Livermore
SNLT	Sandia National Laboratories - Tonopah
SRS	Savannah River Site
TLD	thermoluminescent dosimeter
UMTRAP	Uranium Mill Tailings Remedial Action Program
USEC	U.S. Enrichment Corporation
WSSRAP	Weldon Spring Site Remedial Action Project
WVDP	West Valley Demonstration Project
WIPP	Waste Isolation Pilot Plant
Y-12	Y-12 National Security Complex
YMP	Yucca Mountain Project

A.3 Numbers, Symbols, and Units

The following information is provided as a quick reference to assist the reader in interpreting the presentation of quantitative data, units of measurement, and abbreviations and symbols used throughout this report. In addition, definitions of many terms mentioned below and used elsewhere in this report are contained in the glossary.

Use of Scientific Notation

Numbers are presented in scientific notation. For example, the number 1,000,000 is written as 1×10^6, and 1/10,000 or 0.0001 is written as 1×10^{-4}. Translating from scientific notation requires moving the decimal point either left or right. If the exponent after the 10 is positive, the decimal point is moved to the right. Thus, to convert 4.5×10^5, move the decimal point in 4.5 to the right five places to get 450,000. Move the decimal point to the left if the exponent is negative, so that 3.2×10^{-3} becomes 0.0032.

Significant Figures

Most values presented in this report have been rounded to no more than two significant figures. For example, the number 213.3 appearing in an ASER would be rounded in this report to 210. In some cases, where two or more values are summed to obtain a total, the rounded total may not exactly equal the sum of its component values.

Units of Measurement

Values for radioactivity and radiation dose are presented in this report in English units, with the metric equivalent following in parenthesis. (An exception is made in tables, where only the English unit is presented to conserve space.) Other values are presented in the appropriate metric unit, followed by the English unit in parenthesis.

Units and Conversions

	Unit	Multiply by	to Obtain
Radioactivity	curie (Ci)	3.7×10^{10}	becquerel (Bq)
Radiation Dose	rem	100	sievert (Sv)
	rad	100	gray (Gy)
Length	centimeter (cm)	0.394	inch (in)
	meter (m)	3.28	feet (ft)
		1.09	yard (yd)
	kilometer (km)	0.621	mile (mi)
Area	square meter (m^2)	10.76	square foot (ft^2)
	hectare (ha)	2.47	acres (ac)
	square kilometer (km^2)	0.386	square mile (mi^2)
Volume (dry)	cubic meter (m^3)	1.308	cubic yard (yd^3)
Volume (liquid)	liter (L)	0.2642	gallon (gal)
Mass	gram (g)	0.035	ounce (oz)
	kilogram (kg)	2.205	pound (lb)
Concentration	grams per liter (g/L)	1,000	parts per million (ppm)
Temperature	degrees Centigrade (°C)	(°C × 9⁄5) + 32	degrees Fahrenheit (°F)
Time	Minute (min)		
	hour (hr)		
	year (yr)		

Prefixes for Units

Throughout this report, radioactivity and radiation dose often are expressed in units that represent fractions or multiples of the base units provided in the table above. These are indicated by adding prefixes to the base unit. For example, one-thousandth of a curie (1×10^{-3} Ci) is referred to as a millicurie (mCi). Common prefixes are listed in the table below.

Prefix	Value Multiplied by	
pico (p)	0.000000000001	or 1×10^{-12}
nano (n)	0.000000001	or 1×10^{-9}
micro (μ)	0.000001	or 1×10^{-6}
milli (m)	0.001	or 1×10^{-3}
kilo (k)	1,000	or 1×10^{3}
mega (M)	1,000,000	or 1×10^{6}
giga (G)	1,000,000,000	or 1×10^{9}
tera (T)	1,000,000,000,000	or 1×10^{12}

Radionuclide Nomenclature

Radionuclides are identified by their elemental name and isotopic number, e.g, ^{137}Cs or cesium-137. The table below lists the symbols for chemical elements for the radionuclides mentioned in this report.

Radionuclides mentioned in this report

Radionuclide	Symbol	Radionuclide	Symbol	Radionuclide	Symbol
Americium	Am	Iron	Fe	Rubidium	Rb
Antimony	Sb	Krypton	Kr	Ruthenium	Ru
Argon	Ar	Lanthanum	La	Silicon	Si
Barium	Ba	Manganese	Mn	Silver	Ag
Beryllium	Be	Molybdenum	Mo	Sodium	Na
Bromine	Br	Neptunium	Np	Strontium	Sr
Carbon	C	Nickel	Ni	Technetium	Tc
Cerium	Ce	Phosphorous	P	Thorium	Th
Cesium	Cs	Plutonium	Pu	Tungsten	W
Chromium	Cr	Polonium	Po	Uranium	U
Cobalt	Co	Praseodymium	Pr	Xenon	Xe
Copper	Cu	Protactinium	Pa	Yttrium	Y
Europium	Eu	Radium	Ra	Zinc	Zn
Hydrogen	H	Radon	Rn	Zirconium	Zr
Iodine	I	Rhodium	Rh		

a. Tritium is an isotope of the element hydrogen, hence the use of ^{3}H to represent tritium.

Appendix B. ASER Site Contact List

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Appendix C. Site Descriptions and Monitoring Programs

C.1 Introduction to Site Descriptions

This appendix contains descriptions of the DOE sites covered by this report. The sites are grouped alphabetically by their lead DOE Program Office. (To find the Program Office responsible for a site, see the Site Index, Table C-1.) As with data elsewhere in the report, the site descriptions reflect conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated into the site descriptions. These are summary descriptions intended to provide a context for interpreting data presented in chapters 2-5.

Table C-1. Site Index

Site	Program Office
Ames Laboratory	Science
Argonne National Laboratory-East	Science
Ashtabula Environmental Management Project	Environmental Management
Battelle Columbus Laboratories	Environmental Management
Bettis Atomic Power Laboratory	National Nuclear Security Administration
Brookhaven National Laboratory	Science
Energy Technology Engineering Center	Environmental Management
Ernest Orlando Lawrence Berkeley National Laboratory	Science
Fernald Environmental Management Project	Environmental Management
Grand Junction Office	Environmental Management
Hanford Site	Environmental Management
Idaho National Engineering and Environmental Laboratory	Environmental Management
Knolls Atomic Power Laboratory - Kesselring	National Nuclear Security Administration
Knolls Atomic Power Laboratory - Knolls	National Nuclear Security Administration
Knolls Atomic Power Laboratory - Windsor	National Nuclear Security Administration
Laboratory for Energy-Related Health Research	National Nuclear Security Administration
Lawrence Livermore National Laboratory	National Nuclear Security Administration
Los Alamos National Laboratory	National Nuclear Security Administration
Miamisburg Environmental Management Project	Environmental Management
Monticello Mill Tailings Site	Environmental Management
National Renewable Energy Laboratory	Energy Efficiency and Renewable Energy
Naval Reactors Facility	National Nuclear Security Administration
Nevada Test Site	National Nuclear Security Administration
Oak Ridge Reservation	Science
Paducah Gaseous Diffusion Plant	Environmental Management
Pantex Plant	National Nuclear Security Administration
Portsmouth Gaseous Diffusion Plant	Environmental Management
Princeton Plasma Physics Laboratory	Science
Sandia National Laboratories, Albuquerque	National Nuclear Security Administration
Sandia National Laboratories, Livermore	National Nuclear Security Administration
Sandia National Laboratories, Tonopah	National Nuclear Security Administration
Savannah River Site	Environmental Management
Stanford Linear Accelerator Center	Science
Thomas Jefferson National Accelerator Facility	Science
Waste Isolation Pilot Plant	Environmental Management
Weldon Spring Site Remedial Action Project (WSSRAP)	Environmental Management
West Valley Demonstration Project (WVDP)	Environmental Management
Yucca Mountain Site Characterization Project (YMP)	Civilian Radioactive Waste Management

The site descriptions are based on information presented in the ASERs. Differences among the descriptions reflect differences in practices among DOE's sites and differences in the level of detail presented in each site's annual environmental reports. For example, some sites report annual average high and low temperatures, some report temperature ranges by season, and some by representative month. Also, some sites have an extensive environmental monitoring

program that is described in detail within their ASERs, while other sites have much simpler programs to reflect the scale of their radioactive operations. Additional details on site operations and environmental monitoring programs are available in the ASER's and other site-specific documents.

For each site, the text below is divided into two sections. The first is labeled **Site Description**. This section briefly describes basic features of a site such as location, size, and mission. The description addresses details about the local geography (e.g., waterways that are important in understanding possible transport of contaminants from a site) and meteorology (weather conditions that affect the movement of any contaminants released to the air). Also described are regional land uses and population and the size of the workforce (all factors important to understanding the potential for people to be exposed to releases from a site).

The second section is labeled **Site Monitoring**. Each DOE site implements two types of monitoring program: effluent monitoring and environmental surveillance. Recommendations and requirements for effluent monitoring and environmental surveillance are provided in DOE's "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991) which establishes the radiological elements of an environmental monitoring program.

Effluent monitoring involves the collection and analysis of gaseous emission and liquid effluent samples at or near the point of release to characterize and quantify contaminants. Data are used to assess exposure of and risk to the public and to demonstrate compliance with applicable regulations.

Environmental surveillance involves the collection and analysis of water, ambient air, soil, foodstuffs, biota, and other media from DOE sites and environs and the measurement of external radiation. Data are used to evaluate impacts on the environment, confirm adherence to DOE environmental protection policies, support environmental decisions, and demonstrate compliance with applicable standards.

An important ancillary program is meteorological monitoring, collecting data to characterize the site atmospheric and climatological conditions.

Environmental data also may be used to establish background levels and site conditions against which the contaminant concentrations can be compared, to establish trends and determine long-term accumulation of site-related contaminants, and to help assess the effectiveness of process or facility treatments and controls designed to reduce effluents and emissions.

The routine sampling of environmental media that is conducted as part of effluent monitoring and environmental surveillance is designed to evaluate the exposure pathways through which radionuclides and other hazardous materials could reach humans. Site-specific individuals may be exposed directly or indirectly. External penetrating radiation exposes directly from radionuclides in the air or deposited on the ground. A person can take airborne contaminants directly into the body by inhalation or indirectly by consuming crops or animal products that have taken up deposited contaminants. Similarly, a person can ingest waterborne contaminants directly from drinking water or indirectly through crops and animal products. Some radionuclides, such as tritium, also can be absorbed through the skin. The potential radiation dose to humans from these exposure pathways is calculated and presented in the ASER.

The media typically included in a site environmental monitor program are:

Ambient Air. Samplers (e.g., low-volume air samplers, charcoal filters, and particulate monitors, typically are located based on wind dispersal patterns and regulatory requirements.

Direct Radiation. Direct penetrating radiation (gamma radiation) cannot be collected by filters or chemically trapped in any media but can be measured using environmental thermoluminescent dosimeters (TLDs). Dosimeters are usually placed along the site perimeter and at more distant locations where site operations may contribute to the external radiation dose.

Surface Water. NPDES permits require regular monitoring of out-falls. Drinking water samples are collected routinely at the site boundary and more distant communities. Surface water from on-site or nearby water bodies also is commonly sampled at both upstream and downstream locations. Methods used include periodic grab samples and continuous-flow monitoring.

Groundwater. Groundwater is monitored to evaluate impacts from current DOE operations and to monitor changes in contaminants that are already present from past DOE operations.

Soil and Sediment. Soil samples are used to establish background levels of radionuclides (both natural and those resulting from fallout from nuclear weapons testing) and to detect any long-term buildup of radionuclides from a site.

Animals. Animals are sampled to assess any risk to animals or to any person consuming the animals. Deer and fish are the animals most commonly sampled but the species may vary by site. Samples of tissue (muscle, liver, and thyroid) are collected from animals found on or near the site.

Agricultural Products. Agricultural products, and sometimes, native vegetation are monitored for potential migration and deposition of effluents from a site. Food products are normally chosen for their abundance in the region surrounding the site.

C.2 Civilian Radioactive Waste Management

The DOE Office of Civilian Radioactive Waste Management (OCRWM) has oversight responsibility for the Yucca Mountain Project.

Yucca Mountain Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Yucca Mountain is on lands administered by the Federal Government in the northern Mojave Desert. It is in Nye County, south-central Nevada, about 160 km (100 miles) northwest of Las Vegas. DOE is studying it as a potential geologic repository for commercial and defense spent nuclear fuel and high-level radioactive waste. The major focus of activities in from 1998 to 2001 was the documentation of more than two decades of scientific investigations, field tests, and laboratory analyses conducted to determine Yucca Mountain's suitability as a geologic repository.

Land on the Yucca Mountain site is controlled by three Federal agencies: DOE, the U.S. Air Force, and the U.S. Department of the Interior's Bureau of Land Management (BLM). Public access to DOE and Air Force lands is restricted. Some recreational activities occur on the BLM portion of the site. BLM has withdrawn public lands at Yucca Mountain from mining and mineral leasing.

Because of a lack of surface water and a very deep groundwater table, there is little agriculture in the region surrounding Yucca Mountain. The nearest farms are in the Amargosa Valley, 24–32 km (15–20 miles) south. The closest mining operation is a gold mine about 19 km (12 miles) to the west. Areas south and southwest of the site are popular throughout the year for recreational activities such as camping, hiking, hunting, and nature study.

Nye County and surrounding areas are rural and sparsely populated, and most residents are concentrated in a few small communities. Fewer than 22,000 people live within 84 km (52 miles) of Yucca Mountain. The nearest community is Amargosa Valley, with an estimated population of 1,400.

The climate is warm and arid to semiarid. Average maximum and minimum daily temperatures range from 22 to 34°C (72 to 93°F) in the summer and about 1 to 10.5°C (34 to 51°F) in the winter. Average annual precipitation ranges from about 10 to 25 cm (4 to 10 in.). Winds generally blow to the south or southeast during the day and to the north or northwest at night.

Yucca Mountain is an irregularly shaped, north-trending, volcanic upland about 6 to 10 km (4 to 6 miles) wide and 40 km (25 miles) long. The crest of the mountain has an elevation of 1,400 to 1,510 m (4,600 to 4,950 ft) above sea level.

The groundwater system is closed; that is, water leaves the system only by evapotranspiration. The primary source of recharge in this area is infiltration of precipitation. There are no springs, wetlands, or other natural sources of surface water at Yucca Mountain. The usually dry washes in the area can contain flowing water after very heavy, sustained rain or snow. On rare occasions, water in the washes flows to the Amargosa River more than 40 km (25 miles) to the south. Although referred to as a river, the Amargosa is dry along most of its length.

Bechtel-SAIC is the management and operating contractor for DOE.

Site Monitoring. The Yucca Mountain Project (YMP) did not manage radioactive waste, nor were there any other processes that required monitoring for the release of radioactive materials to the environment from 1998 through 2001. YMP collected local meteorology data, monitored for ambient air particulate matter, and monitored groundwater flows and levels in the Yucca Mountain region for purposes of site characterization.

C.3 Energy Efficiency and Renewable Energy

The DOE Office of Energy Efficiency and Renewable Energy has responsibility for the National Renewable Energy Laboratory.

National Renewable Energy Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The major research facilities of the National Renewable Energy Laboratory (NREL) are at four separate locations in Golden, Colorado, near Denver. These facilities include the South Table Mountain Site, the National Wind Technology Park, the Denver West Office Park, and the Joyce Street Facility. NREL began operations in 1977 as the Solar Energy Research Institute.

NREL supports research and development (R&D) programs in basic energy research, photovoltaics, wind energy, advanced vehicle technologies, biofuels, biomass electric, fuels

utilization, solar industrial technologies, building technologies, solar thermal electric, municipal solid waste, hydrogen, geothermal power, and superconductivity.

The climate is semiarid, typified by sparse precipitation, low relative humidity, abundant sunshine, and large daily and seasonal temperature variation. Average annual rainfall is less than 50 cm (20 in.).

Site Monitoring. The majority of radiation sources at the NREL are from three X-ray diffraction machines and two sealed-source level gauges. The latter are used on pilot-scale processes to measure the level of material in the process tanks. In addition, one on-site laboratory uses small quantities of radioisotopes for biological or chemical labeling.

No radioactive air emission monitoring is conducted because of the extremely low use of radioactive material at NREL facilities.

C.4 Environmental Management

From 1998−2001, the DOE Office of Environmental Management had responsibility for the following facilities covered by this report:

- Ashtabula Environmental Management Project
- Battelle Columbus Laboratories
- Energy Technology Engineering Center
- Fernald Environmental Management Project
- Grand Junction Office
- Hanford Site
- Idaho National Engineering and Environmental Laboratory
- Miamisburg Environmental Management Project
- Monticello Mill Tailings Site
- Paducah Gaseous Diffusion Plant
- Portsmouth Gaseous Diffusion Plant
- Savannah River Site
- Waste Isolation Pilot Plant
- Weldon Spring Site Remedial Action Project
- West Valley Demonstration Project

The following sections describe these sites and their monitoring programs.

C.4.1 Ashtabula Environmental Management Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Astabula Environmental Management Project (AEMP) is slightly northeast of Ashtabula, Ohio, 1.6 km (1 mile) south of Lake Erie and approximately 24 km (15 miles) west of the Ohio-Pennsylvania border. The 13-hectare (32-acre) site is surrounded by a security fence. Site buildings and pads are on about 3 ha (7 acres) of flat upland surface.

The plant's mission was to process uranium into extrusions and closed die forgings for DOE. The Nuclear Regulatory Commission approved a decommissioning plan in September 1997 and issued an amendment to the license for decommissioning activities.

The region is sparsely populated and heavily industrialized.

RMI Environmental Services (formally Earthline Technologies) is the prime contractor in managing the decontamination and decommissioning.

Site Monitoring. Air monitoring for gross alpha and beta is conducted via stack monitors and on- and off-site air monitoring stations. Surface water is monitored for ^{99}Tc and total uranium. In addition, sediment from Fields Brook is monitored, and soil samples collected on- and off-site are tested for uranium.

C.4.2 Battelle Columbus Laboratories

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Battelle Columbus Laboratories (BCL) are on the 479-hectare (1,183-acre) West Jefferson site. This rural site near West Jefferson, Ohio, is approximately 8 km (5 miles) west of Columbus. The Engineering Area occupies 202 ha (500 acres) in the southeastern portion of the site. DOE is decommissioning its activities at the site.

The land to the east, within the Bib Darby Creek floodplain, is heavily vegetated with deciduous trees, shrubbery, and high grasses. Battelle leases a portion of its West Jefferson land to farmers, typically for raising field crops such as corn or soybeans.

Climatic conditions in the region can be described as continental-temperate. Daily temperatures range from 22.9°C (73.3°F) in June, July, and August to –2.2°C (28°F) in December, January, and February. The annual average monthly rainfall is approximately 8.9 cm (3.5 in.).

The geological strata underlying the West Jefferson area consists of glacial till and outwash with formations of clay, sands, and gravel. A shallow aquifer is in the dense clay till, and a deep, or principal, aquifer is in the limestone bedrock underlying the till. The manmade Battelle Lake covers an area of about 10.1 ha (25 acres). Big Darby Creek accounts for the West Jefferson facility's principal surface-water flow.

In the past, Battelle Columbus Operations (BCO) conducted activities licensed by the Nuclear Regulatory Commission that involved small quantities of special nuclear and byproduct materials. As a consequence of the decreased DOE level of research and development, a quantity of both special nuclear and byproduct materials was packaged and disposed of in accordance with applicable regulations.

Decontamination and decommissioning (D&D) activities related to Laboratory facilities are part of the Battelle Columbus Laboratories Decommissioning Project (BCLDP), which DOE and Battelle Memorial Institute began in 1990 to remove radioactive contamination from Laboratory facilities. The King Avenue site in downtown Columbus experienced contamination due to uranium, thorium, and associated daughter products. The more rural West Jefferson site, which had a large hot cell facility and a decommissioned research reactor, had contamination from tranuranics, mixed fission products, and activation products. At present, the West Jefferson site is in a surveillance and maintenance mode of operation.

The prime contractor is Battelle Memorial Institute.

Site Monitoring. The basic objective of the BCO environmental monitoring program is to evaluate the control of effluent releases. The program ensures control of radioactive waste concentrations so that effluent releases are maintained as low as reasonably achievable and well below applicable standards.

C.4.3 Energy Technology Engineering Center

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Energy Technology Engineering Center (ETEC) occupies 36 ha (90 acres) within the 1,080-hectare (2,700-acre) Santa Susana Field Laboratory (SSFL) in the Simi Hills, approximately 48 km (30 miles) northwest of downtown Los Angeles, California.

ETEC is a former DOE research facility, currently undergoing closure. Closure activities include decontamination and decommissioning of facilities and remediation of soil and groundwater contamination.

There is no significant agricultural land use within 30 km (19 miles) of the site.

The region is semiarid, and the climate is controlled by the semipermanent Pacific high-pressure cell which produces light to moderate precipitation.

SSFL is owned by Boeing North American.

Site Monitoring. From 1998 through 2001, the Center conducted extensive media sampling in the surrounding area; this included off-site radiation, groundwater, and runoff water from the site. The evidence from soil, vegetation, water, and air samples from on- and off-site locations in addition to independent sampling by government and private organizations demonstrated that no radioactive contamination could result in excess exposure or risk.

C.4.4 Fernald Environmental Management Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Fernald Environmental Management Project (FEMP) is a site closure project on a 425-hectare (1,050-acre) tract of land outside the farming community of Fernald, Ohio. Downtown Cincinnati is approximately 29 km (18 miles) southeast of the site. The former uranium production area occupies approximately 55 ha (136 acres) in the center of the site. The waste pit area and K-65 silos are adjacent to the western edge of the former production area.

Based on the 2000 Census, there is an estimated population of 20,000 people within 8 km (5 miles) of the site and an estimated 2.8 million within 80 km (50 miles).

The average annual precipitation is 104 cm (41 in.). The prevailing winds are from the west through south-southwest approximately 40% of the time.

The Great Miami River cuts a terraced valley to the east of the site, while Paddy's Run, an intermittent stream, flows from north to south along the site's western boundary. In general, the site lies on a terrace that slopes gently between vegetated bedrock outcroppings to the north, southeast, and southwest.

Fluor Fernald is the closure management company.

Site Monitoring. FEMP operated a network of high-volume air particulate monitoring stations to measure the collective contributions from fugitive and point-source particulate emissions from the site. The sampling and analysis program for the fenceline and background locations consisted of biweekly total uranium, isotopic thorium, and total particulate analyses in addition to

a quarterly composite sample. The quarterly sample was analyzed for the expected major contributors to the radiological air inhalation dose at the site's boundary (uranium, thorium, and radium). In addition, FEMP conducted continuous monitoring of environmental radon concentrations based on an hourly average. Four stacks or vents at Building 71 and the Waste Pits Remedial Action Project were monitored for radionuclide emissions. The Building 71 stack filters were analyzed for isotopes of uranium and thorium and for total particulates. Direct radiation levels at and around FEMP were measured continuously with thermoluminescent dosimeters (TLDs).

In general, low levels of contaminants enter surface water at FEMP by two primary mechanisms: treated effluent, which was monitored as it was discharged to the Great Miami River, and uncontrolled runoff entering site drainages from areas with low levels of soil contamination. FEMP sampled and analyzed surface water from 16 locations, including 2 background locations, for various radiological constituents.

In 2001, 120 wells were monitored for water quality and 140 wells were monitored quarterly for groundwater elevations. In addition, FEMP monitored private wells and property boundary wells. Three private wells along Willey Road were monitored to assist in the evaluation of the total uranium plume migration. Property boundary monitoring consisted of 33 wells down-gradient of the site, along the eastern and southern portions of the site boundary. During 2000, the frequency of monitoring six Type 4 property boundary wells decreased to once every 5 years due to the lack of contamination in the aquifer at the depth these wells monitor.

Sediment samples were collected at 16 locations along Paddy's Run, the Storm Sewer Outfall Ditch, and the Great Miami River. All samples were analyzed for total uranium, and samples from Paddy's Run and the Storm Sewer Outfall Ditch also were analyzed for radium and thorium.

C.4.5 Grand Junction Office

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Grand Junction Office (GJO) is immediately south and west of Grand Junction, Colorado, about 1 kilometer (0.6 mile) from heavily populated areas. The GJO mission is to provide project management and engineering and scientific support to the Federal Government's environmental restoration programs.

GJO encompasses 23 ha (56 acres) at an elevation of approximately 1,390 m (4,560 ft) above sea level. In February 1999, DOE leased the southern portion of the site to the Grand Junction Economic Partnership Small Business Incubator Project. This project houses about 20 small businesses that range in operation from machining equipment to distribution of foodstuffs. The offices are used primarily for service-type businesses. In December 2001, DOE transferred ownership of a tract of land on the northwest portion of the property to the U.S. Army Reserve.

The population in the area surrounding GJO is approximately 116,000. Approximately 270 people worked at the facility in 2001, a decrease of 70 employees from 1998.

Moderate, semiarid climatic conditions prevail in the Grand Junction area. Daily temperatures range from an average maximum (June, July, and August) temperature of 32°C (89°F) to an average minimum (December, January, and February) temperature of –7°C (20°F). Average annual precipitation is about 22 cm (8.7 in.).

GJO lies adjacent to the Gunnison River in the 1,000-year floodplain and is separated from the river by an earthen flood-control dike. The Gunnison River, which converges with the Colorado River about 0.8 kilometer (0.5 mile) downstream of the facility, is used for seasonal recreation activities such as boating, fishing, and swimming. GJO occupies an elongated, north-south trending tract bounded on the west by the Gunnison River and on the north, south, and east by agricultural, open-range, and railroad lands.

Groundwater in the alluvial aquifer beneath the site, which is contaminated by leached products of on-site uranium mill tailings, is not used for any purpose. All domestic surface-water sources for the Grand Junction area are upstream of the GJO facility or are from the Colorado River Drainage system.

The GJO prime contractor is MACTEC-ERS.

Site Monitoring. The meteorological station, in the northern portion of the facility, began monitoring in 1993.

Radioactive air emissions were generated during the preparation (grinding, blending, and digestion) of environmental samples. An air handling control device measured such emissions from the Sample Plant, before release. Non-point-source radioactive air emissions were generated from soil transfer activities associated with the remediation of contamination caused by previous uranium mill operations and from Calibration Test Pit emissions (the source of radon emissions). Non-point-source radionuclides released from these operations included several isotopes of actinium, bismuth, lead, polonium, protactinium, radium, thorium, and uranium. Estimates of atmospheric radon were from selected radon flux measurements. The total mass of fugitive dust emissions was converted to individual radionuclide source strength using an activity-per-unit-mass value for each radionuclide. Analytical results for specific isotope activities in the soil material (total uranium, ^{226}Ra, and ^{230}Th) were used to calculate activities of other decay series radionuclides present in the soil.

No monitoring of GJO sewer effluent for radioactive constituents occurred after March 2000 because the facility received approval from the City of Grand Junction to discontinue such monitoring based on historical data.

Following remediation (during the early 1990s), monitoring locations on the Gunnison River upstream, adjacent to the site, and downstream reported between 5 and 10 picocuries per liter (pCi/L) total uranium. After an evaluation performed under the Long-Term Surveillance and Maintenance (LTSM) Program, monitoring was discontinued at the Upper Gunnison upstream location and the Middle Gunnison location adjacent to the site. As a result of the LTSM evaluation, ^{226}Ra and ^{228}Ra were removed from the analyte list at the Middle Gunnison location because they were consistently below the 5-pCi/L standard. Uranium was designated the principal radiological constituent of concern because, as a conservative species, it is more representative of current migration of site-related contaminants in the groundwater. GJO will continue to monitor Gunnison River surface-water concentrations of uranium for changes that might result from passive remediation of groundwater at the facility. Surface-water samples were analyzed for gross alpha and gross beta activity.

Water in the North Pond, South Pond, and Wetland Area is recharged by the aquifer underlying the facility and shows the same radiological characteristics as the aquifer. The ponds and Wetland Area were analyzed for total uranium, gross alpha, and gross beta activity.

In 2001, GJO groundwater monitoring involved one sampling event. At the request of the State of Colorado, monitoring will be performed at the same time every year (in the winter, when

historical data indicate that the highest concentrations occur due to low-flow conditions) to minimize seasonal fluctuations. In addition, the LTSM Program evaluated the groundwater monitoring strategy to determine the feasibility of decreasing the number of monitoring locations and analytes. Based on the evaluation, 42 of 48 wells were abandoned in 2000, leaving 6 wells for ongoing monitoring. These included five on-site wells and one down-gradient well. Radiological monitoring focused on gross alpha activity (excluding radon and uranium) and ^{234}U and ^{238}U.

C.4.6 Hanford Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Hanford Site is north of the City of Richland, Washington (population 36,900), on 1,517 km^2 (586 $miles^2$), only about 6% of which has been developed. The larger area has restricted public access and provides a buffer for the smaller areas that were used for production of nuclear materials, waste storage, and waste disposal.

Hanford's primary mission includes cleaning up and shrinking the size of the site to 194 km^2 (75 $miles^2$) by 2012. The cleanup mission includes three strategies: restoring the Columbia River corridor; moving the Central Plateau from primarily inactive waste storage to active waste characterization, treatment, storage, and disposal operations; and preparing for long-term stewardship and non-DOE Federal missions and other public and private sector uses.

Hanford is located principally in Benton and Franklin Counties, which have a combined population of about 184,000. About 10,400 people were employed at Hanford in 1999.

Hanford is in the semiarid Pasco Basin of the Columbia Plateau. The Columbia River flows eastward through the northern part of the Hanford Site and then turns south, forming part of the eastern site boundary.

The principal contractors in 2001 included Bechtel Hanford, Inc., the environmental restoration contractor; Fluor Hanford, Inc., the prime contractor for the nuclear legacy cleanup; Hanford Environmental Health Foundation, the contractor for health risk management; MACTEC-ERS, the prime contractor to the DOE Grand Junction Office, which is conducting vadose zone, geophysical characterization, and monitoring at former waste disposal facilities; Pacific Northwest National Laboratory, operated by Battelle Memorial Institute; Bechtel National, Inc., which is to design, build, and commission a waste treatment plant to vitrify Hanford's tank waste; and the CH2M Hill Hanford Group, Inc., the prime contractor to DOE's Office of River Protection.

Site Monitoring. Airborne radionuclide samples were collected at 45 continuously operating monitors, 24 on the site, 11 near the site perimeter, 8 in nearby communities, and 2 in distant communities. Airborne particles were sampled at each of these locations by continuously drawing air through a high-efficiency glass-fiber filter. The filters were analyzed for gross beta activity, and most were analyzed for gross alpha activity. Biweekly samples were combined into quarterly composite samples. The quarterly samples were analyzed for specific gamma-emitting radionuclides, ^{90}Sr, and plutonium isotopes. Selected composite samples were analyzed for uranium isotopes. Samples were collected at four locations for ^{129}I analysis by drawing air through a chemically treated low-background, petroleum-based charcoal absorbent cartridge. Samples were collected monthly and combined to form quarterly composite samples for each location. Atmospheric water vapor was collected for tritium analysis at 21 locations by

continuously drawing air through cartridges containing silica gel, which were exchanged every 4 weeks.

The Hanford Site operated a network of TLD monitoring stations. Samples of Columbia River water were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects and near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Hanford town site, and 300 Area. Samples were collected upstream from site facilities to Priest Rapids Dam and Vernita Bridge to provide background data.

In 2001, water samples were collected from an irrigation canal across the Columbia River, and downstream from the Hanford Site at Riverview and from an irrigation water supply on the Benton County shoreline near the southern boundary of the site.

Radionuclide concentrations in on-site drinking water were monitored for four DOE-owned water supply facilities. Samples from three locations were grab samples of untreated water. The 400 Area samples were grab samples of treated water. Samples of raw water from the 400 Area drinking water well were analyzed monthly. All drinking water samples were analyzed for gross alpha, gross beta, tritium, and ^{90}Sr.

The Hanford Site operated a large network of groundwater monitoring wells. Monitoring frequency was based on regulatory requirements, variability of historic data, proximity to waste sources, and characteristics of the groundwater flow system at the sampling locations. Most on-site groundwater samples were analyzed for tritium; selected samples were analyzed for other radionuclides. In 2001, vadose zone monitoring occurred on four major areas on the site. Several vadose zone monitoring instruments were installed at one borehole at the Waste Management Area B-BX-BY tank farms to provide continuous soil column monitoring.

Columbia River surface sediment was collected at depths of 0 to 15 cm (0 to 6 in.) from six permanently submerged river locations and six periodically inundated riverbank springs. In addition, sediment samples were collected behind Ice Harbor Dam on the Snake River. Samples were collected upstream of Hanford Site facilities at Priest Rapids Dam (the nearest upstream impoundment) to provide background data. Samples were also collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges and from the publicly accessible Richland shoreline. All sediment samples were analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{234}U, and ^{235}U. Selected sediment samples were also analyzed for ^{238}Pu and $^{239,\,240}$Pu. In 2001, grab samples were collected quarterly from the Fast Flux Test Facility pond and from West Lake. Samples were analyzed for gross alpha and beta concentrations, gamma-emitting radionuclides, and tritium. West Lake samples were also analyzed for ^{99}Tc, ^{234}U, ^{235}U, and ^{238}U.

Soil and vegetation samples were collected. Soil samples were analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, and $^{239,\,240}$Pu. Selected samples were analyzed for ^{241}Am. In addition, native vegetation samples were collected at 13 locations on and around the site and analyzed for ^{90}Sr, ^{137}Cs, ^{238}U, and ^{238}Pu.

Composite samples of raw whole milk were collected from three dairy farms in the East Wahluke area and from three dairy farms in the Sagemoor area. These areas were near the site perimeter in the prevailing downwind direction. Milk samples were also collected from a Sunnyside area dairy to indicate background radionuclide concentrations at a generally upwind location. Samples of milk were analyzed for tritium, ^{90}Sr, ^{129}I, and gamma emitters such as ^{137}Cs. Samples of leafy vegetables (e.g., cabbage and beets) and vegetables (e.g., tomatoes and potatoes) were obtained during the summer from gardens and farms in selected sampling

areas. The Riverview area was sampled because of its exposure to potentially contaminated irrigation water. All vegetable samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. Concord grapes were collected during the fall harvest. All grape samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. Locally produced red and white wines were analyzed for gamma-emitting radionuclides and tritium. An electrolytic enrichment method was used for tritium analysis by water distilled from the wine. Alfalfa samples were collected during harvest. All samples were analyzed for gamma-emitting radionuclides and ^{90}Sr.

C.4.7 Idaho National Engineering and Environmental Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Idaho National Engineering and Environmental Laboratory (INEEL) occupies approximately 2,300 km^2 (890 miles^2) of the upper Snake River Plain in southeastern Idaho. INEEL consists of several primary facilities on an expanse of otherwise undeveloped land (about 94% of the property).

The INEEL mission is to develop, demonstrate, deploy, and transfer advanced engineering technology and systems to private industry to improve U.S. competitiveness and security, the efficient production and use of energy, and the quality of life and the environment. In addition, INEEL is assessing and remediating past site contamination and putting wastes in more stable forms for disposal.

In 2001, INEEL employed about 8,100 people, a decrease of 100 workers since 1998. The area population, based on 1990 census figures, living within 80 km (50 miles) of the INEEL operational center was about 121,500. There are no permanent residents within 16 km (10 miles) of that center. Atomic City (population 25) is the closest community. The largest community is Idaho Falls (population about 50,000), 37 km (23 miles) east of the INEEL boundary.

The altitude, intermountain setting, and latitude at INEEL combine to produce a semiarid climate. Rainfall averages less than 22.8 cm (9.1 in.) per year. Temperatures range from a daily average of 15.7°C (60.3°F) in the summer to –5.2°C (22.6°F) in the winter. Prevailing wind patterns are from the southwest.

The site encompasses an important and relatively undisturbed expanse of the sagebrush-steppe ecosystem. The average elevation on INEEL is approximately 1,500 m (4,900 ft) above sea level. The site is bordered on the north and west by mountain ranges and on the south by three volcanic buttes. Lands immediately beyond the INEEL boundaries are desert, foothills, and agricultural fields. Most of the nearby farming is concentrated to the northeast.

INEEL is managed and operated by Bechtel BWXT Idaho, LLC. The Argonne National Laboratory-West reactor at INEEL is operated by the University of Chicago.

Site Monitoring. Radioactivity associated with airborne particulates was monitored continuously by 18 air samplers at 16 locations around INEEL. Three of the samplers were on the site, 7 were off the site near the boundary, and 6 were at distant locations. Placement of these samplers was based on wind dispersal patterns and regulatory requirements to monitor nearby population centers. Filters were screened weekly for gross alpha and gross beta activity. Weekly filter screening results for each location collected during the quarter were composited and analyzed for gamma-emitting radionuclides. Composites also were analyzed by location for

^{90}Sr or ^{238}Pu, $^{239, 240}$Pu, and ^{241}Am. Charcoal filters at each air sampling location were screened weekly for ^{131}I by gamma spectrometry.

TLDs measured ionizing radiation exposures at 14 locations on the site perimeter and at more distant locations. Dosimeters were changed twice a year.

INEEL collected drinking water samples semiannually from boundary and distant communities, and surface-water samples from the Snake River at Idaho Falls and Blass. Each water sample was submitted to the Idaho State University Environmental Assessment Laboratory for gross analyses for alpha- and beta-emitting radionuclides. Samples also were analyzed for tritium using liquid scintillation.

The U.S. Geologic Survey (USGS) INEEL Project Office performed groundwater monitoring analyses and studies of the Snake River Plain Aquifer under and adjacent to INEEL. This was done through an extensive network of wells on INEEL and at locations throughout the Eastern Snake River Plain. The USGS groundwater surveillance program monitored 177 observation and production wells on a schedule that ranged from monthly to annually.

Storm water from the coal piles at the Idaho Nuclear Technology and Engineering Center (INTEC) did not discharge to the Big Lost River system in 2001; thus, only visual monitoring occurred at 18 locations and analytical monitoring at two Radioactive Waste Management Complex (RWMC) locations.

Soil samples were used to establish background levels of radionuclides and to detect any long-term buildup from INEEL in off-site soils. Soil was sampled at RWMC, Butte City, Birch Creek, Monteview, Rexburg, Mud Lake, FAA Tower, Aberdeen, Blackfoot, Atomic City, Cwerey, Arco, St. Anthony, and Howe.

Samples of tissue (muscle, liver, and thyroid) were collected from sheep grazing on INEEL. Control samples were collected from sheep in the Blackfoot area. The muscle and liver from the sampled sheep were processed and analyzed by gamma spectrometry. Thyroids from each sheep were analyzed specifically for ^{131}I. In addition, tissues were collected from game animals killed accidentally on INEEL roads. Bird samples were collected from waste disposal ponds and analyzed for gamma-emitting radionuclides with a subset analyzed for ^{90}Sr, $^{239, 240}$Pu, and ^{241}Am.

INEEL monitored foods for potential migration and deposition of effluents from the site. The foods were chosen for their abundance in the upper Snake River Valley and their availability for testing. Lettuce samples were obtained from private gardens in communities. Potato samples were collected from nearby storage warehouses. Wheat samples were collected from grain elevators in the region. Each of these food types was analyzed for ^{90}Sr and gamma-emitting radionuclides. Milk samples were collected from single-family farms and commercial dairies and analyzed for tritium, ^{131}I, and ^{137}Cs.

In 2001, INEEL began reporting concentration rather than totals. Gross alpha/beta concentrations dominated monitoring.

C.4.8 Miamisburg Environmental Management Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Miamisburg Environmental Management Project (MEMP) is on 75 ha (184 acres) in Miamisburg, Ohio, approximately 16 km (10 miles) southwest of Dayton.

Current missions include the nuclear energy program, environmental restoration, and transition of the site to the community for reuse as a commercial facility (32 private businesses are operating at the site).

The Great Miami River flows southwest through the City of Miamisburg and dominates the geography of the surrounding region. The river valley is highly industrialized. The rest of the region is a mix of farmland, residential areas, small communities, and light industry. Many residences, five schools, the Miamisburg downtown area, and six of the City's parks are within 1.6 km (1 mile) of the site. The primary agricultural activity is raising field crops such as corn and soybeans. About 10% of the agricultural land is devoted to pasturing livestock.

Approximately 340,150 people live within 16 km (10 miles) of the site. An estimated 3.1 million people live within an 80-km (50-mile) radius.

The climate is moderate. The average annual precipitation rate is 83 cm (33 in.). The average temperature is about 15°C (60°F). The prevailing winds are from the south-southwest.

Site elevations vary from 216 to 268 m (700 to 900 ft) above sea level. No building in which radioactive material is processed is below an elevation of 242 m (790 ft). A 100-year storm event in the Great Miami River Basin would result in flooding to 213 m (700 ft).

The site is operated by BWXT of Ohio, Inc.

Site Monitoring. MEMP monitored 12 point sources for radionuclides, including tritium and isotopes of plutonium and uranium. In operational areas with release potential, room air and exhaust stacks were monitored continuously for tritium using strategically placed ionization chambers. Fixed continuous air samplers and continuous air monitors were used throughout the operational areas to detect airborne plutonium and uranium. In 2001, 20 ambient air sampling stations were in operation, 6 on and 14 off the site. Particulate air samples were analyzed for ^{238}Pu and $^{239, 240}$Pu. Samples from selected locations were analyzed for ^{228}Th, ^{230}Th, ^{232}Th, and other radionuclides as needed. Air samples for tritium were collected on a continuous basis. Plutonium and thorium analyses were performed on monthly composite samples for each on-site location and for off-site stations closest to the site.

Water samples were collected daily from four outfalls and analyzed for tritium and isotopes of plutonium, uranium, and thorium.

The Great Miami River and other regional surface waters were routinely sampled for tritium and isotopes of plutonium, uranium, and thorium. River sampling locations provided samples that were representative of river water at the point of entry and after considerable mixing with MEMP effluents. Samples were collected and analyzed monthly for tritium, $^{233, 234}$U, ^{238}U, ^{238}Pu, and $^{239, 240}$Pu. Great Miami River samples were analyzed quarterly for ^{228}Th, ^{230}Th, and ^{232}Th. A local stream just northeast of the site was sampled monthly for tritium.

MEMP sampled river and stream sediments quarterly and pond sediments on an annual basis. The river sediments were analyzed for ^{228}Th, ^{230}Th, ^{232}Th, ^{238}Pu, and $^{239, 240}$Pu. Samples collected from ponds were analyzed for ^{238}Pu and $^{239, 240}$Pu.

MEMP actively monitored groundwater at about 100 locations on-and off-site. Background samples were collected from community water supplies that were not affected by MEMP operations. For drinking water, the environmental reference location was in Tipp City, approximately 40 km (25 miles) north of MEMP. Private wells immediately down-gradient of MEMP and regional groundwater supplies were monitored closely for tritium. Monthly samples

were collected from seven community water supplies and six private wells. The Miamisburg community water supply was analyzed for ^{228}Th, ^{230}Th, ^{232}Th, $^{233, 234}$U, ^{238}U, ^{238}Pu, and $^{239, 240}$Pu. Plutonium and uranium samples were collected monthly, while thorium samples were collected at least quarterly. Monitoring wells along the western boundary of the site were analyzed for ^{226}Ra, ^{228}Ra, ^{228}Th, ^{230}Th, ^{232}Th, $^{233, 234}$U, ^{235}U, ^{238}U, ^{238}Pu, and $^{239, 240}$Pu. On-site production wells provided drinking and process water to the site. Samples from the production wells were analyzed for tritium, ^{228}Th, ^{230}Th, ^{232}Th, $^{233, 234}$U, ^{238}U, ^{238}Pu, and $^{239, 240}$Pu. Tritium samples were collected and analyzed weekly, plutonium and uranium samples were collected monthly, and thorium was analyzed at least quarterly.

Locally grown produce samples and vegetation were collected during the growing season. In 2001, samples of root crops and non-leafy vegetables were collected from a number of regional communities. Plutonium concentrations were determined through alpha spectroscopy. Tritium concentrations were determined through liquid scintillation spectrometry.

C.4.9 Monticello Mill Tailings Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Monticello Mill Tailings Site (MMTS) is near the City of Monticello in San Juan County, Utah. GJO manages remediation of the three operable units at MMTS: the mill site, a 44-hectare (108-acre) tract along Montezuma Creek south of the City of Monticello; 29 peripheral properties to the north and south of the mill site; and the surface (Montezuma Creek) and groundwater beneath and extending beyond the mill site.

Surface and groundwater and soils were contaminated during the 1950s and 1960s as a result of uranium and vanadium processing and milling activities. In 2001, most soil remediation was complete. The wastewater treatment plant, which treated contaminated surface water from the former mill site, stopped operating in 1999. All contaminated materials removed from the mill site and associated properties were encapsulated in a repository 1.6 kilometers (1 mile) south of the site, which officially closed in October 1999. About 1,946,000 cubic meters (2,545,000 cubic yards [3,666,000 dry tons]) of tailings were disposed of in the repository, with an estimated total activity of 2,780 Ci of ^{226}Ra.

In 2000, DOE transferred ownership of the former mill site and peripheral properties to the City of Monticello, along with some responsibility for ongoing remediation.

Site Monitoring. Before 1999, DOE conducted atmospheric radon, air particulate, direct gamma, and meteorological monitoring at the MMTS. After the completion of surface cleanup, there was no longer a need to monitor some environmental media, so radiological and air monitoring ended in 1999.

Surface-water and groundwater monitoring continued but on a quarterly schedule (January, April, July, and October). For surface water, the October sampling event was extensive because flows in Montezuma Creek, the primary surface-water body at MMTS, were typically the lowest and analyte concentrations were the highest. The Site had monitoring stations at the site and up- and down-gradient to Montezuma Creek. Analytes measured included gross alpha, gross beta, ^{226}Ra, and ^{228}Ra. For groundwater, analytes measured down-gradient of the Alluvial and Alluvial PeRT Wall Formations included gross alpha, gross beta, ^{226}Ra, and ^{230}Th. Analytes measured down-gradient of the Alluvial, Alluvial PeRT Wall, Dakota Sandstone, and Burro Canyon Formations, and cross-gradient of the Mancos Formation included gross alpha, gross beta, ^{226}Ra, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U.

C.4.10 Paducah Gaseous Diffusion Plant

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Paducah Gaseous Diffusion Plant (PGDP) in McCracken County, Kentucky, has been producing enriched uranium since 1952. In July 1993, DOE leased the production area of the site to the U.S. Enrichment Corporation (USEC), a private company. DOE retained responsibility for the environmental restoration, legacy waste management, facilities management, uranium hexafluoride (UF6) cylinder management, and decontamination and decommissioning of DOE Material Storage Areas.

PGDP is in a generally rural and agricultural area. The industrial portion of the site, which is inside a fenced security area, comprises about 303 ha (748 acres). The additional DOE-owned land at the site comprises 1,083 ha (2,675 acres), 279 ha (689 acres) of which is a buffer zone.

The population within an 80-km (50-mile) radius is about 500,000, of which 66,000 residents are within a 16-km (10-mile) radius. The center of the site is about 16 km (10 miles) west of Paducah, Kentucky, and 5 km (3 miles) south of the Ohio River.

PGDP is in the humid continental zone where summers are warm (July averages 26°C [79°F]), and winters are moderately cold (January averages 1.7°C [35°F]). Yearly precipitation averages about 125 cm (49 in.). The prevailing wind is from the south-southwest.

PGDP is operated by Bechtel/Jacobs, LLC.

Site Monitoring. Ambient air data was collected at 11 sites around PGDP to measure radionuclides emitted from site sources, including fugitive dust emissions. On-site meteorological data were used as input to calculate radiation dose to the public, as were meteorological data from Barkley Regional Airport.

Direct radiation monitoring at PGDP consisted of quarterly placement, collection, and analysis of TLDs at 49 monitoring locations around the site.

All PGDP surface-water runoff was released via outfalls either to the west to Bayou Creek or to the east to Little Bayou Creek. Radiological sampling was conducted at upstream Bayou Creek, downstream Little Bayou Creek, the convergence of both creeks, at the Ohio River confluence with the Mississippi River, which was the closest public drinking water supply source downstream of the Plant, and for background at Massac Creek. Radiological parameters for surface-water samples included several isotopes of cesium, plutonium, thorium, and uranium, as well as dissolved or suspended alpha and beta, ^{40}K, ^{60}Co, ^{99}Tc, ^{241}Am, and ^{237}Np.

PGDP monitored groundwater as part of three basic programs – monitoring of the northwest plume, the sanitary landfill, and residential wells. Scheduled sampling continued at more than 150 wells, including 21 residential wells. Three residential wells were sampled monthly, and 18 were sampled semiannually. Wells sampled monthly were analyzed for gross alpha and beta activity and ^{99}Tc.

Ditch sediments from 20 locations were sampled on a semiannual basis. Radiological parameters for sediment samples included alpha and beta activity, ^{40}K, ^{60}Co, ^{99}Tc, ^{230}Th, ^{137}Cs, ^{237}Np, and several isotopes of uranium and plutonium.

PGDP has an ongoing deer harvest program. Background samples from the Ballard Wildlife Management Areas were used for reference. Liver, muscle, and bone samples were analyzed for ^{90}Sr, ^{137}Cs, ^{237}Np, ^{239}Pu, and several isotopes of technetium and uranium. In addition, thyroid samples were analyzed for ^{99}Tc.

C.4.11 Portsmouth Gaseous Diffusion Plant

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Portsmouth Gaseous Diffusion Plant (POR) is on a 15-km^2 (5.8-square-mile) site in a rural area of Pike County, Ohio. Production facilities are leased to USEC for the separation of uranium isotopes, but most activities associated with the uranium enrichment process ended in 2001.

The site is 3.2 km (2 miles) east of the Scioto River in a small valley running parallel to and approximately 37 m (120 ft) above the Scioto River floodplain. The river valley is farmed extensively, particularly with grain crops.

The nearest residential center is Piketon (population about 1,900), which is about 8 km (5 miles) north of the site. The county's largest community, Waverly, about 16 km (10 miles) north of the site, has a population of about 4,400 residents. The total population within 80 km (50 miles) of the site is approximately 600,000. Several residences are adjacent to the southern half of the eastern boundary and along Wakefield Mound Road, directly west of the site. A nursing home, with a capacity of 36 residents, is located along Wakefield Road.

DOE is responsible for environmental remediation, waste management, and the Uranium Program at POR, as well as nonleased DOE property.

POR is operated by Bechtel/Jacobs, LLC.

Site Monitoring. POR collected samples from 14 ambient air monitoring stations and analyzed them for radionuclides that could be present in ambient air due to Plant activities (^{99}Tc, $^{233, 234}$U, ^{235}U, ^{236}U, and ^{238}U, ^{241}Am, ^{237}Np, ^{238}Pu, and $^{239, 240}$Pu). The ambient air monitoring stations measured radionuclides released from DOE and USEC point sources, fugitive air emissions, and background concentrations of radionuclides.

TLDs measured beta, gamma, and neutron radiation at 19 locations that included most ambient air monitoring locations. Five major POR facilities – the Waste Storage Facility, Process Building, SNM Storage Building, Bulk Storage Building, and Depleted Uranium Hexafluoride Cylinder Storage Yards – were monitored for direct radiation exposure levels. The Perimeter Road, which passes close to the edge of the cylinder yards, was used to assess potential exposure to the public in passing traffic.

POR had six discharge points, or outfalls, that discharged water from the site. Three outfalls discharged directly to surface water and three discharged to the Sewage Treatment Plant before leaving the site to the Scioto River. POR monitored outfalls for radiological discharges by collecting and analyzing water samples for ^{99}Tc, total uranium, uranium isotopes ($^{233, 234}$U), ^{238}Pu, and $^{239, 240}$Pu.

POR collected monthly water samples from five locations around the Depleted Uranium Hexafluoride Cylinder Storage Yards. Samples were analyzed for total uranium, uranium isotopes ($^{233, 234}$U, ^{235}U, ^{236}U, and ^{238}U), and transuranic radionuclides (^{237}Am, ^{238}Pu, and $^{239, 240}$Pu). USEC collected water samples at 14 locations upstream and downstream from the site.

These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek. As background measurements, samples were collected from local streams approximately 16 km (10 miles) north, south, east, and west of the site. Samples were collected weekly from the Scioto River and monthly from the other streams with the exception of the downstream locations on Little Beaver Creek, which were sampled weekly. Each sample was analyzed for alpha, beta, total uranium, and ^{99}Tc.

Sediment was collected in the spring and fall from the locations upstream and downstream where surface-water samples were collected and at the outfalls on the east and west sides of the site. Samples were analyzed for alpha and beta activity, total uranium, and ^{99}Tc. Soil samples were routinely collected in the on-site process area on unused land and in off-site locations as far as 16 km (10 miles) from the site; these samples were analyzed for alpha and beta activity, total uranium, and ^{99}Tc. In 2001, soil samples from five locations near ambient air monitoring stations were analyzed for selected transuranic radionuclides and isotopic uranium. One location was in the process area, three were on the site but not in the process area, and one was about 5 km (3 miles) from the site near Zahns Corner.

Biological monitoring at the site was used to assess the uptake of radionuclides and other constituents into local biota. Deer kidney and liver samples were collected and analyzed for ^{99}Tc, total uranium along with $^{233, 234}$U, ^{238}U, ^{237}Np, ^{238}Pu, $^{239, 240}$Pu, and ^{241}Am. Deer were collected from a background location approximately 15 miles west-northwest of the site in Bainbridge, Ohio. Fish were collected from the Scioto River, Little Beaver Creek, and Big Beaver Creek. The samples were analyzed for alpha and beta activity, ^{99}Tc, total uranium, transuranic radionuclides, and uranium isotopes.

POR routinely collected vegetation and crop samples. Each sample was analyzed for ^{99}Tc and total uranium.

C.4.12 Savannah River Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Savannah River Site (SRS) encompasses approximately 803 km^2 (310 miles^2) in Aiken, Allendale, and Barnwell Counties in South Carolina, adjacent to the Savannah River. SRS is approximately 19.3 km (12 miles) south of Aiken, South Carolina, and 24.1 km (15 miles) southeast of Augusta, Georgia.

The site's mission is to aid stewardship of the Nation's nuclear weapons stockpile (principally by recycling tritium); store, treat, and dispose of excess nuclear materials (including proposed plans to disposition more than 30 tons of surplus plutonium); treat and dispose of legacy wastes; and clean up environmental contamination.

Approximately 3,035 ha (7,500 acres) of the SRS is swampland. Approximately 40% of the site is forested with pine, gum, birch, oak, and hickory. Industrial, manufacturing, medical, and farming operations are conducted near the site. Farming is diversified and includes crops such as cotton, soybeans, corn, peaches, grapes, and small grains.

The average population density in the counties surrounding SRS is 85 people per square mile, with the largest concentration in the Augusta metropolitan area. Based on 1990 Census data, the population within an 80-km (50-mile) radius of SRS is about 620,100.

SRS has a relatively mild climate. The average annual rainfall is about 122 cm (48 in.). There is no prevailing wind direction; however, there is a relatively high frequency of winds from the

northeast during the late summer and early-to-mid fall and of winds from the south through northwest from late fall through spring. Daily temperatures range from an average low of 0°C (32ºF) during the winter to a high around 35°C (95ºF) during summer.

Five major SRS streams feed into the Savannah River, which borders the site. The river forms the boundary between South Carolina and Georgia. The two main on-site bodies of water, PAR Pond and L-Lake, are manmade. The Savannah River is used for drinking water by downriver residents.

SRS is operated by the Westinghouse Savannah River Company (WSRC).

Site Monitoring. SRS maintains an environmental monitoring network extending as far as 40 km (25 miles) and conducts limited monitoring near Savannah, Georgia, some 161 km (100 miles) from the site. Additionally, surveillance activities were performed by the South Carolina Department of Health and Environmental Control and the Georgia Department of Natural Resources.

SRS collected about 4,000 effluent samples a year from about 70 points of discharge to perform radiological effluent monitoring. Tritium accounts for most radioactive releases to the Savannah River. Krypton-85 and tritium in elemental and oxide forms accounted for nearly all airborne radioactivity released from the site.

There were 17 monitoring stations in and around SRS to monitor the air. With the exception of tritium, specific radionuclides were not detectable at the site perimeter.

Ambient gamma exposure rates in and around SRS were monitored on a quarterly basis by an extensive network of TLDs. In addition, surveillance program modifications were implemented during 1998 as a result of a 1997 critical contamination/critical pathway analysis; the number of air surveillance locations was reduced from 23 to 17.

In 1999, the SRS seepage basin sampling program was altered to reflect changes in discharge practices. Four seepage basins were eliminated from the program and two basins were added. Idle seepage basins were monitored and samples analyzed monthly for radionuclides.

In 1999, several changes, based on a 1998 critical contaminant pathway analysis, were implemented in the stream sampling program and five locations were eliminated from the program. Six on-site streams were monitored at 22 locations. Biweekly samples were analyzed for gross alpha, gross beta, tritium, and gamma radiation.

The Savannah River is subject to continuous surveillance at five locations via weekly sampling.

Groundwater beneath 5 to 10% of the site has been contaminated by industrial solvents, tritium, metals, or other constituents used or generated by SRS operations. Monitoring involved more than 1,100 wells in about 100 locations; approximately 25,000 radiological analyses and more than 125,000 nonradiological analyses were conducted on groundwater samples annually. This number of analyses represents a dramatic decrease since 1997 because of increased efficiency and reduced duplication.

Samples were collected from on-site locations and at water treatment plants for municipalities that use Savannah River water.

Soil samples were collected from four uncultivated and undistributed on-site locations and two off-site locations. Sediment samples were collected at approximately 20 locations.

There were nine surveillance points for freshwater aquatic food products, all on the site; saltwater species were harvested downstream, and shellfish were collected near the mouth of the Savannah River. Harvested mammals and turkeys were monitored for radionuclides. No agricultural products are grown on the site.

C.4.13 Waste Isolation Pilot Plant

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Waste Isolation Pilot Plant (WIPP) is in the remote Chihuahuan Desert of southeastern New Mexico, 42 km (26 miles) east of Carlsbad. WIPP is an underground repository for the disposal of TRU radioactive and mixed waste generated by defense-related activities. The repository is 655 meters (2,150 feet; approximately 0.5 mile) below the surface, excavated from a thick sequence of salt beds. The WIPP site encompasses approximately 41.4 km^2 (16 $miles^2$) of land. The site boundary extends a minimum of 1.6 km (1 mile) beyond any of the underground developments.

Most of the lands in the immediate WIPP vicinity are managed by BLM. Regional land uses include livestock grazing; potash mining; oil and gas exploration and production; and recreational activities such as hunting, camping, hiking, and bird watching.

Approximately 26 residents live within 16 km (10 miles) of the WIPP site. The nearest community is the village of Loving (estimated population 1,300), 29 km (18 miles) west-southwest of WIPP. Carlsbad is the densest populated area, with approximately 26,000 residents.

The Pecos River runs approximately 22 km (14 miles) southwest of the WIPP site.

In 1999, WIPP received its first waste shipment (from Los Alamos National Laboratory). Over the next 35 years, WIPP is expected to receive about 37,000 shipments of waste from locations across the United States.

Westinghouse TRU Solutions, LLC, is the management and operating contractor.

Site Monitoring. The WIPP Environmental Monitoring Program monitored air, surface water, groundwater, soils, and biota.

WIPP monitored airborne effluents at three stations. Each station used one or more fixed air samplers to collect particulates from the effluent air stream and a veraspore filter. Radionuclides of interest included ^{238}Pu, $^{239,\,240}Pu$, and ^{241}Am. Additional underground sampling used fixed air samplers and continuous air monitors. Gross alpha and beta measurements in airborne particulates were used as a screening technique to provide timely information on levels of radioactivity in the environment around the WIPP site. Airborne particulate samples were collected from seven locations around the site.

Surface-water samples were collected at 14 locations around the site. Samples were collected once in 2001 from 10 locations. Gamma and alpha spectrometry was used to determine the radionuclides of interest.

Groundwater samples were collected from seven wells around the WIPP site. Samples were collected twice in 2001 and analyzed for gross alpha and gamma. Results from three wells exhibited a pattern of activity above the minimum detectable concentration for ^{238}Pu and ^{241}Am. To help explain these apparently above-background concentrations, WIPP analyzed

groundwater for ^{226}Ra and ^{228}Ra during the fall 2000 sampling. Radium was detected in 100% of the samples.

Soil samples were collected from near the low-volume air samplers at six locations around WIPP. Measurements of radionuclides in depth profiles provided information about their vertical movements in the soil systems.

Sediment samples were collected from 12 locations around the site, mostly from the same water bodies used for surface-water samples.

Rangeland vegetation samples were collected from the six locations used for soil samples. The site also collected muscle tissues from two road-killed deer and one quail, both species commonly consumed by humans. Because fish is consumed in large amounts, fish samples were collected from different locations on the Pecos River. The vegetation and animal samples were sent to the laboratory for analysis.

C.4.14 Weldon Spring Site Remedial Action Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Weldon Spring Site is approximately 48 km (30 miles) west of St. Louis, Missouri. The site consists of two main areas, the 91-hectare (226-acre) Weldon Spring Chemical Plant and raffinate pits and the 3.6-hectare (9-acre) Weldon Spring Quarry, a former limestone quarry southwest of the chemical plant.

The major goals of the Weldon Spring Site Remedial Action Project (WSSRAP) are to eliminate potential hazards to the public and the environment posed by the waste materials on the Weldon Spring Site and, to the extent possible, make surplus real property available for other uses.

The two closest communities are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 miles) to the northeast. Their combined population in 2000 was 5,349.

The climate is continental with warm to hot summers and moderately cold winters. The average daily maximum and minimum temperatures are 18.6°C (65.4°F) and 8.2°C (46.7°F).

The chemical plant and raffinate pits are on the Missouri-Mississippi River surface drainage divide. The topography is gently undulating in the upland areas. No natural drainage channels traverse the site. In the surrounding area, manmade lakes are used for public fishing and boating. Surface water is not used for irrigation or as a public drinking water supply.

MK-Ferguson Company was the WSSRAP contractor.

Site Monitoring. Effluent and environmental monitoring at WSSRAP includes taking water samples at discharge points and from streams, lakes, ponds, groundwater, and springs. Samples are analyzed for uranium and its primary decay products (radium and thorium). Radiological air monitoring (particulates and gamma radiation) was discontinued at the end of 2000 because radioactive waste handling activities were essentially complete and no critical receptor air monitoring data had ever demonstrated a dose to the public of greater than 10% of EPA's 10 mrem standard.

C.4.15 West Valley Demonstration Project

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The West Valley Demonstration Project (WVDP) is in a rural setting approximately 50 km (30 miles) south of Buffalo, New York. Project facilities occupy approximately 80 ha (164 acres) of an area within the 1,350-hectare (3,300-acre) reservation of the Western New York Nuclear Service Center.

The project's mission is to solidify the high-level radioactive waste generated by nuclear fuel reprocessing activities at the site and decontaminate and decommission the project facilities.

WVDP is on the west shoulder of a steep-sided glacially scoured bedrock valley. It has an average elevation of 400 m (1,300 ft) on New York State's western plateau.

Land near the site is used primarily for agriculture and the climate is moderate, with an average annual temperature of 8.9°C (48°F). Rainfall is relatively high, averaging 104 cm (41 in.) per year.

West Valley Nuclear Services operates the site.

Site Monitoring. The Environmental Monitoring Program consisted of on-site effluent monitoring and on- and off-site environmental surveillance that measured samples for radiological and nonradiological constituents. Monitoring and surveillance included the collection of soil, sediment, water, air, and other samples at specific times.

The major near-term pathways for potential movement of contaminants away from the site are airborne transport and surface-water drainage. For this reason, the environmental monitoring program emphasizes the collection of air and surface-water samples from on-site locations such as plant ventilation stacks, water effluent points, and surface-water drainage locations.

Permitted effluent air emissions were monitored continuously for gross alpha and beta activity. Iodine-129 and tritium were measured in effluent ventilation air at some locations. There were six permanent samplers at effluent locations. Off-site sampling locations included those considered most representative of background conditions and those most likely to be downwind of airborne releases. Off-site air was sampled continuously at 10 locations. Four site perimeter locations and one on-site location were monitored for fallout and sampled every month.

Direct penetrating radiation was measured using on- and off-site TLDs. Measurement points on the site were near selected waste management units and around the inner security fence. Forty-three measurement points were used in 2001.

In general, surface-water samples were collected regularly and analyzed for gross alpha and gross beta activity, tritium, and pH at a minimum. Off-site surface waters were sampled upstream of the site for background radioactivity and downstream to measure possible project contributions.

Routine monitoring of groundwater included sampling for contamination and radiological indicator parameters and for specific analytes of interest and radionuclides at selected monitoring locations.

Animal and fish samples from potentially affected areas were gathered and analyzed for radionuclide content to reveal any long-term trends.

C.5 National Nuclear Security Administration

From 1998−2001, the National Nuclear Security Administration (NNSA) had oversight of the following sites included in this report:

- Bettis Atomic Power Laboratory
- Knolls Atomic Power Laboratory
- Laboratory for Energy-Related Health Research
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Naval Reactors Facility
- Nevada Test Site
- Pantex Plant
- Sandia National Laboratories. Albuquerque
- Sandia National Laboratories, Livermore
- Sandia National Laboratories, Tonopah

The following sections describe these sites and their monitoring programs.

C.5.1 Bettis Atomic Power Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Bettis Atomic Power Laboratory is on an approximately 80-hectare (200-acre) tract of land in the borough of West Mifflin, approximately 13 km (8 miles) southeast of Pittsburgh, Pennsylvania. The surrounding area is industrial, residential, and recreational.

The laboratory's mission is the design, development, testing, and operational follow of naval nuclear propulsion plants. Radiation sources at the site include small specimens of irradiated and unirradiated fuel materials.

Land use in the region around the site is largely industrial and residential. The population within an 80-km (50-mile) radius is approximately 3,000,000.

The site has a humid, continental climate modified only slightly by the Atlantic Seaboard and the Great Lakes. The average monthly temperatures in 2001 ranged from –1.6°C to 23°C (29°F to 73°F). The annual precipitation amounted to approximately 58.4 cm (23 in.).

The site is approximately 1,829 m (6,000 ft) northwest of the Monongahela River. The maximum elevation at the site is approximately 366 m (1,200 ft) above sea level, and the minimum elevation is about 300 m (975 ft) above sea level. Developed portions of the site are about 145 m (480 ft) above the surface of the Monongahela River.

In 1999, Bechtel Bettis, Inc., assumed operations of the facility for DOE.

Site Monitoring. Activities included: (1) liquid and air effluent monitoring; (2) collection and analysis of water samples from surface water, groundwater, and local municipal sources; (3) routine collection and analysis of sediment and biota samples from surface water; (4) continuous sampling of environmental air at off-site locations; and (5) continuous monitoring of radiation levels at the site perimeter and off-site locations.

C.5.2 Knolls Atomic Power Laboratory

The principal mission at Knolls Atomic Power Laboratory (KAPL) is research and development in the design and operation of naval nuclear propulsion plants. KAPL consists of three sites: the Knolls Site (KAPL-1), the Kesselring Site (KAPL-2), and the Windsor Site (KAPL-3).

C.5.2.1 Knolls Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The 70-hectare (170-acre) Knolls Site is in the Town of Niskayuna, New York, approximately 3.2 km (2 miles) east of Schenectady on the south bank of the Mohawk River. KAPL-1 facilities include administrative offices, machine shops, a sewage pumping station, wastewater treatment facilities, a boiler house, oil storage facilities, and chemistry, physics, and metallurgical laboratories.

The surrounding area consists of open land, light industry, small farms, a closed municipal landfill, and suburban residential areas.

The climate in the region is primarily continental, subjected to some modification from the maritime climate that prevails in the southeastern portion of New York State. Maximum temperatures during the winter are often below freezing and nighttime low temperatures frequently drop to –12°C (10°F) or lower. Snowfall is variable, averaging about 165 cm (65 in.) a year. The annual precipitation for the region is about 91 cm (36 in.) a year.

KAPL-1 is in the Mohawk River Valley at an elevation of about 100 m (330 ft) above sea level. Three small streams (East Boundary, Midline, and West Boundary) that receive drainage from the site drain to the river. The flow in these streams becomes extremely low during the dry summer season.

Groundwater at the site is limited due to both low porosity and permeability of the soil, which prohibits development of a potable water supply. There are no underlying principal or primary bedrock or overburden aquifers. Potable and some cooling water for site operations comes from the Schenectady and Niskayuna Municipal Water System; most water for noncontact cooling comes from the Mohawk River. There are no production wells on the site.

KAPL, Inc., a Lockheed Martin Company, operates the site.

Site Monitoring. Activities included: (1) liquid and air effluent monitoring; (2) routine collection and analysis of sediment and biota samples from the Mohawk River; (3) collection and analysis of water samples from surface water, groundwater, and local municipal sources; (4) continuous sampling of environmental air upwind and downwind from the site; and (5) continuous monitoring of radiation levels at the site perimeter and off-site locations.

C.5.2.2 Kesselring Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. KAPL-2 is near West Milton, New York, approximately 27 km (17 miles) north of Schenectady and 14.5 km (9 miles) southwest of Saratoga Springs on a 1,600-hectare (3,900-acre) site. The site contains two operating pressurized-water naval nuclear propulsion plants (S8G and MARF) and support facilities. The site is used for training personnel in the

operation of these plants. Two other nuclear propulsion plants (S3G and D1G) have been permanently shut down and defueled, and are being dismantled.

The surrounding area is a rural, sparsely populated region of wooded lands through which flow Glowegee Creek and several small streams that empty into Kayaderosseras Creek.

Climate conditions in the KAPL-2 area are the same as those described above for the Knolls Site.

Percolating water from rainfall and snowfall recharge the shallow unconfined aquifers beneath KAPL-2 and, in turn, the shallow groundwater recharges streams. Site drinking water comes from a well field in the Kayaderosseras Creek floodplain. Water for site operations comes from on-site production wells that are hydrologically separate from current and past operations areas.

In January 1998, the DOE Office of Naval Reactors determined to dismantle the S3G and D1G reactor plants. Shortly thereafter, dismantlement began, starting with the S3G plant. DOE plans to complete this project as soon as practicable subject to available funding.

KAPL, Inc., a Lockheed Martin Company, operates the site.

Site Monitoring. Activities included: (1) liquid and air effluent monitoring; (2) periodic collection and analysis of samples from Glowegee Creek water, sediment, and fish; (3) monitoring of Glowegee Creek water temperature upstream and downstream of site discharge locations; (4) a survey of aquatic life in the Glowegee Creek; (5) continuous sampling of environmental air upwind and downwind from the site; and (6) continuous monitoring of radiation levels at perimeter and off-site locations.

C.5.2.3 Windsor Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. KAPL-3 (also called the S1C Site) is on 4 ha (10 acres) of land near Windsor, Connecticut. It is approximately 8 km (5 miles) north of Hartford. The S1C naval nuclear propulsion prototype plant at KAPL-3 tested propulsion plant equipment as part of naval R&D efforts and trained naval personnel until its permanent shutdown in 1993. All structures on the site were removed by the end of 1999. In 2000, radiological remediation was completed to allow radiological release for unrestricted future use, with State and EPA agreement.

The area surrounding the site is a mixture of open land, industrial areas, tobacco and shrub farms, and suburban residential areas.

The climate in the region is typical for a northern temperate zone. The prevailing west-to-east movement of air carries most weather systems into the area. The location of the site in relation to the continent and the ocean is significant in that rapid weather changes can occur. Seasonally, weather characteristics vary from cold and dry air in winter to warm maritime air in summer. Typical minimum and maximum temperatures are –8°C (18°F) and 28°C (83°F), respectively; the average temperature is about 10°C (50°F). Annual snowfall is 127 to 138 cm (50 to 55 in) per year, and precipitation averages about 112 cm (44 in) per year.

The S1C Site is in the Connecticut River Valley, a broad basin of gently rolling terrain. The Farmington River, which is within 0.8 km (0.5 mile) of the site to the north, joins the Connecticut River about 8 km (5 miles) east of the site. Most areas within 3.2 km (2 miles) of the site are

between 46 and 76 m (150 and 250 ft) above sea level. A few hills reach 122 m (400 ft). The site elevation is about 55 m (180 ft).

There are three high-priority aquifers within 16 km (10 miles) of the site. In addition, the State of Connecticut has designated the Farmington River Valley a high-priority aquifer. The aquifer directly under the site is classified GB by the State.

The municipal water supply from the Metropolitan District Commission supplied water to the S1C Site. Water and other utilities have been disconnected.

KAPL, Inc., a Lockheed Martin Company, operates the site.

Site Monitoring. A State of Connecticut General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities and an Inland Wetlands and Water Course Permit issued by the Town of Windsor remained in effect during 2001 to support completion of site restoration (final chemical remediation, grading, seeding, and closure of on-site wells). Both permits are governed by a State Site Stormwater Pollution Prevention Plan and Stormwater Pollution Control Plan. A notice of termination request for the State permit was filed with the Department of Environmental Protection in November 2001. The Town of Windsor permit was to remain open pending EPA review of the Site Chemical Sampling and Analysis Report.

In 2001, the environmental monitoring of the S1C Site included the routine collection and radioanalysis of water and sediment samples from the Combustion Engineering Site Brook and the Farmington River, fish from the Farmington River, and radiation surveys of the Combustion Engineering Site Brook.

C.5.3 Laboratory for Energy-Related Health Research

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Laboratory for Energy-Related Health Research (LEHR) is a 6.1-ha (15-acre) parcel owned by the Regents of the University of California (UC), west of Sacramento. It is 2.4 km (1.5 miles) south of the main UC Davis campus, which has a population of 27,000 students and 17,000 staff members. The site is on a relatively flat plain bordered on the south by Putah Creek, lying outside the 100-year floodplain, in a rural agricultural area.

Research at LEHR through the mid-1980s focused on the health effects from chronic exposures to radionuclides, primarily ^{90}Sr and ^{226}Ra, simulating radiation effects on humans by using beagles. In the early 1970s, the ^{60}Co irradiator facility was constructed on the site to study the effects on beagles of chronic exposure to gamma radiation. Research at LEHR ended in 1989, and only decontamination and decommissioning activities have taken place since then. In addition to the DOE area remediation, UC Davis is evaluating potential environmental impacts from the inactive campus landfill units and numerous inactive campus low-level radioactive disposal sites (trenches and holes).

Site Monitoring. There were no radioactive effluent discharges from DOE-operated LEHR facilities from 1998 through 2001.

There are no point sources of radionuclide emissions to air at the site. The only potential sources are areas undergoing remediation and generating potentially contaminated dust from construction activities. From 1998 through 2001, monitoring for radioactive materials in air occurred at a number of locations at or near the site. Air samples were screened for alpha, beta,

and gamma (primarily ^{226}Ra, ^{90}Sr, ^{137}Cs, and ^{241}Pu) activity. The majority of results for samples collected at these locations were close to or below the minimum detectable activity for laboratory analysis methods.

From 1998 through 2001, UC Davis performed surface-water sampling quarterly in Putah Creek upstream and downstream of the site. This sampling included analyses for the same parameters as groundwater samples. UC Davis and DOE/NNSA performed storm water sampling at three lift points; the samples were analyzed for tritium, ^{14}C, ^{90}Sr, ^{226}Ra, and a number of hazardous materials.

During the same period, as part of the LEHR routine groundwater monitoring program, UC Davis performed groundwater monitoring quarterly at 23 wells (five wells are generally dry and were included only if the water table reached the appropriate level). Groundwater samples were analyzed for tritium, ^{14}C, ^{90}Sr, gross alpha and beta activity, and gamma emitters ^{137}Cs, ^{226}Ra, ^{232}Th, ^{241}Am, ^{241}Pu, etc.

C.5.4 Lawrence Livermore National Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Lawrence Livermore National Laboratory (LLNL) consists of two-sites: the Livermore Site in Livermore, California, and the Experimental Test Site (called Site 300) near Tracy, California. Nuclear weapons research and development are the primary LLNL functions, though it has additional programs in magnetic fusion research, laser isotope separation, non-nuclear energy research and development, and biomedical studies. Site 300 is used for materials testing and high explosives diagnostic work.

The Livermore Site occupies an area of 3.9 km^2 (1.3 miles^2), including the land that serves as a buffer zone, about 1.6 km (1 mile) from the Livermore city limits. Immediately south is the Sandia National Laboratories, Livermore facility. Surrounding the Livermore Site is a combination of residential areas, business parks, light industry, agricultural land, and open space.

The City of Livermore had an estimated 2001 population of about 75,200. There were 6.9 million residents within an 80-km (50-mile) radius of the Livermore Site.

The Livermore Site is in the southeastern portion of the Livermore Valley. The valley floor is at its highest elevation of 220 m (720 ft) above sea level along the eastern margin and gradually dips to 92 m (300 ft) at the southwest corner. The major streams passing through the Livermore Valley are Arroyo del Valle and Arroyo Mocho, which drain the southern highlands and flow intermittently.

Site 300 is 20 km (12 miles) east of the Livermore Site in the Altamont Hills of the Diablo Range; it occupies an area of 30.3 km^2 (11.7 miles^2). Surrounding land uses include light industry, recreation, and agriculture, primarily as grazing land for cattle and sheep.

The nearest residential area is the City of Tracy, population 61,200, located 10 km (6 miles) to the northeast. There are 6 million residents within 80 km (50 miles) of Site 300.

The topography of Site 300 is much more irregular that of the Livermore Site; a series of steep hills and ridges is oriented along a generally northwest-southeast trend and is separated by intervening ravines. The elevation ranges from about 540 m (1,765 ft) above sea level at the northwestern corner of the site to about 150 m (490 ft) in the southeastern portion.

Mild rainy winters and warm dry summers characterize the climate. The mean annual temperature for the Livermore Site in 2001 was 14.7°C (58.5°F). Both rainfall and wind exhibit strong seasonal patterns. About 50% of the wind comes from the southwest to westerly direction, with this pattern prevailing primarily during the summer. The highest and lowest annual rainfalls over a 10-year period were 54 and 21 cm (21 and 7.2 in.), and the average annual rainfall was 36 cm (14 in.). The meteorological conditions at Site 300, while generally similar to those at the Livermore Site, are modified by higher elevation and more pronounced topographic relief.

LLNL is operated by the University of California.

Site Monitoring. The LLNL monitoring networks were established for surveillance of air particulates and tritium near the Livermore Site and Site 300, as well as in the surrounding Livermore Valley and in the City of Tracy. The Livermore Site radiological air sampling network consisted of seven samplers measuring gross alpha and beta and gamma emitters at the site perimeter with one in the southeast quadrant in an area of known plutonium contamination (the location of the site-wide maximally exposed individual for National Emissions Standards for Hazardous Air Pollutants reporting purposes). The Livermore Site also maintained 12 continuously operating airborne tritium samplers on the site.

The Site 300 air particulate monitoring network included eight sampling units around the site near firing tables and one in downtown Tracy. There was one tritium sampler on Site 300.

LLNL deployed TLDs in the field at the Livermore Site and Site 300 at the beginning of each calendar quarter and retrieved them from the monitoring locations at the end of the quarter. In 2001, external doses from gamma radiation were monitored at 14 Livermore Site perimeter locations and at 22 Livermore Valley locations used for background comparisons. Similarly, gamma doses were monitored at nine perimeter monitoring locations at Site 300. In addition to the perimeter locations historically measured at Site 300, LLNL deployed TLDs to four on-site locations in 2000. Two off-site locations near Site 300 and two locations in Tracy also were monitored.

The LLNL sanitary sewer discharge permit required continuous monitoring of the effluent. Samplers collected flow-proportional composite samples and instantaneous grab samples that were analyzed for a number of parameters including radioactivity.

The routine LLNL storm water runoff monitoring network consisted of 10 sampling locations. Seven locations characterized storm water entering or leaving the site. LLNL began analyzing for plutonium in storm water in 1998. Additional locations were sampled beginning in 1999 and continuing through 2001 as part of a tritium source investigation. The Site 300 storm water sampling network contained seven locations from which samples were collected by grab sampling from storm runoff flowing into the stream channels. Storm water sampling and analyses were performed for gross alpha, gross beta, plutonium, and tritium.

Surface and drinking water near LLNL and the Livermore Valley were sampled semiannually. Sampling locations were surface-water bodies, drinking water outlets, and the on-site swimming pool. Samples were analyzed for gross alpha, gross beta, and tritium.

LLNL conducted surveillance monitoring of groundwater in the Livermore Valley and in the Altamont Hills through networks of wells and springs that included private off-site wells. LLNL has monitored tritium in water hydrologically down-gradient of the Livermore Site since 1988. Groundwater samples were obtained during 2001 from 21 of 23 wells in the Livermore Valley and measured for tritium activity. The LLNL perimeter network used three background (up-

gradient) wells near the eastern boundary and seven down-gradient wells near the western boundary. These wells were usually analyzed semiannually for radioactive constituents. Tritium activities were not measured in western perimeter wells in 2001. Additional groundwater sampling locations were established around the Plutonium Facility (Building 332) and the Tritium Facility (Building 331) in 1999. The Site 300 groundwater monitoring network included 12 off-site locations. One off-site well was 6 km (3.7 miles) west of Site 300 in the upper reaches of the Livermore Valley watershed. Eight off-site wells were near the southern boundary of Site 300 in or adjacent to the Corral Hollow Creek floodplain. On-site wells continued to monitor closed landfills, a former open-air high explosives burn pit, two connected surface-water impoundments, and two connected sewer ponds.

Since 1971, the soil and sediment surveillance monitoring program has included work in three areas: surface soil in the Livermore Valley and at Site 300, sediment at the Livermore Site, and vadose zone soils at the Livermore Site. Surface soil samples were collected at 19 locations in the Livermore Valley, including 6 locations at the LWRP, an area of known plutonium contamination, and at 14 locations at or near Site 300. Site 300 locations were established around firing tables and other areas of potential soil contamination. Sediment samples have been collected from selected arroyos and other drainage areas at and around the Livermore Site since 1988; these locations generally coincide with selected storm water sampling locations. Sediment sampling locations for Site 300 have not been established. Annual soil samples were analyzed for plutonium and gamma-emitting radionuclides. Sample collections from Site 300 for plutonium ended in 1997. Sediments were analyzed for plutonium, gamma-emitting radionuclides, and tritium.

In 2001, LLNL collected quarterly vegetation samples, usually annual grasses or small herbaceous plants from 18 fixed locations in the Livermore Valley, San Joaquin County, and Site 300 (four locations). Before 2001, one location in Livermore Valley and three locations on Site 300 were discontinued as unnecessary given the changes to LLNL operations; other sampling locations were the same as those used before 2000. Wine representing vineyards in the Livermore Valley, other regions of California, and different regions of Italy, France, and Germany were collected through commercial purchases and analyzed for tritium.

C.5.5 Los Alamos National Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Los Alamos National Laboratory (LANL) is about 100 km (63 miles) north-northeast of Albuquerque and 40 km (25 miles) northwest of Santa Fe in north-central New Mexico. The primary LANL mission is nuclear weapons research and stewardship, but the site has other research programs (e.g., laser fusion, nuclear materials).

About 6% of the total LANL land area is developed for buildings, roads, and support facilities, with the remaining land providing buffer areas for security and safety.

The 111-km^2 (43 $mile^2$) site is in a region of numerous mesas and canyons at the western boundary of the Rio Grande Rift, a major North American tectonic feature.

LANL is operated by the University of California.

Site Monitoring. The LANL radiological air-sampling network (AIRNET) measures environmental levels of airborne radionuclides that could be released from laboratory operations. LANL emissions include plutonium, americium, uranium, tritium, and activation

products. In 2001, the Laboratory operated more than 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. Four stations determined the regional background and fallout levels of atmospheric radioactivity. In 2001, there were more than 20 perimeter stations within 4 km (2.5 miles) of the LANL boundary.

The current network of annual sampling stations for surface-water and sediment surveillance includes a set of regional (or background) stations and a group of stations on or near LANL. The regional stations establish background quantities of radionuclides and radioactivity derived from natural minerals and from fallout affecting northern New Mexico and southern Colorado.

Soils, foodstuffs and biota were collected on and around LANL to help determine the impacts of laboratory operations on human health and the human food chain. The first monitoring program, soils, included sampling surface materials from 12 on-site and 10 perimeter areas around LANL.

C.5.6 Naval Reactors Facility

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Naval Reactors Facility (NRF) is a U.S. Naval Nuclear Propulsion Program facility on INEEL in southeastern Idaho, 10.7 km (6.7 miles) from the nearest INEEL boundary and is operated by Bechtel Bettis, Inc., Bettis Atomic Power Laboratory-Idaho. The developed portion, inside the security fence, covers approximately 34 of the total 1,800 ha (4,400 acres) under the cognizance of NRF. (See the INEEL description above for details.)

Three former naval reactor prototypes and the Expanded Core Facility are located within the NRF security fence. NRF examines developmental nuclear fuel material samples, naval spent nuclear fuel, and irradiated reactor plant components/materials; and it supports Naval Nuclear Propulsion plants.

Site Monitoring. Monitoring activities at NRF included: (1) liquid and air effluent monitoring, (2) routine collection and analysis of soil and biota samples, (3) collection and analysis of samples from groundwater and drinking water, and (4) continuous sampling of environmental air upwind and downwind from NRF.

The NRF radiation monitoring program also included measurement of ionizing radiation levels at 17 locations along the site security fence and 8 other locations inside NRF boundaries. The program used standard Navy calcium-fluoride TLDs, calibrated to a known source value. In addition, NRF placed 15 TLDs (in three groups of five) throughout the INEEL site between 5 and 10 miles from the NRF. All TLDs were collected and processed quarterly. In addition to the TLD network, NRF conducted radiation surveys around the fenced perimeter.

C.5.7 Nevada Test Site

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The southeast corner of the Nevada Test Site (NTS) is about 88 km (55 miles) northwest of Las Vegas, Nevada. NTS encompasses about 3,562 km^2 (1,375 $miles^2$). It is surrounded on the east, north, and west by the Nellis Air Force Range, which provides a buffer zone varying from 24 to 104 km (15 to 65 miles) between NTS and public lands. Mercury, at the southern end of NTS, is the main base camp for worker housing and administrative operations.

The mission of NTS falls into five main areas: national security, environmental management, stewardship of NTS, technology diversification, and energy efficiency and renewable energy. Nuclear testing at NTS ended in 1992. In 1999 NTS activities involving hazardous or radioactive materials consisted of subcritical nuclear tests, non-nuclear testing including controlled spills of hazardous material at the Hazardous Materials Spill Center, low-level radioactive and mixed waste disposal, and defense waste storage facilities for transuranic (TRU) and hazardous wastes.

NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. The climate is characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds. Higher elevations have sustained cooler temperatures and lower elevations have sustained warmer temperatures. In 2000, the average maximum temperature at Yucca Flats was 23°C (73°F) and the average minimum was 3°C (38°F). Average annual precipitation ranges between 8 and 25 cm (3 and 10 in.), depending on the elevation. Winds are primarily southerly during summer months and northerly during winter months. Wind velocities tend to be greater in the spring than in the fall.

Excluding Clark County (Las Vegas), the population density within a 150-km (90-mile) radius of NTS is about 0.4 person/km^2. The off-site area within 80 km (50 miles) of the NTS Control Point near the center of the site is predominantly rural. The largest nearby community is Pahrump (population 23,000) about 80 km south of the Control Point. The Amargosa Farm area, which has a population of about 1,200, is approximately 50 km (30 miles) southwest of the Control Point.

There are north- to northeast-trending mountain ranges separated by gentle sloping linear valleys and broad flat basins at the NTS. Elevation ranges from about 914 to 1,219 m (3,000 to 4,000 ft) in the valleys to the south and east to 1,676 to 2,225 m (5,500 to 7,300 ft) in the high country toward the northern and western boundaries. Surface drainage for Yucca and Frenchman Flats are closed systems that drain into the dry lake beds (playas) in each valley. The remaining area on the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms.

NTS is operated by Bechtel Nevada.

Site Monitoring. In 2000, air particulate samplers operated at 33 NTS locations. This was an increase over 1999, when only 25 stations operated. The filters were analyzed for gross alpha and gross beta activity. The filters from 4 weeks of sampling were composited, analyzed by gamma spectroscopy, and then analyzed for plutonium isotopes. Beginning in March 2000, the monthly composited filter samples were analyzed for ^{241}Am. In 1999, high-volume air samplers were installed at six off-site locations. The operation of these samplers ended in October 2000 to focus on source-term monitoring on the NTS. The Community Environmental Monitoring Program (CEMP), however, continues to collect off-site data as oversight verification of the results of source-term monitoring. High-volume filters were analyzed by gamma spectroscopy, composited over an approximate 1-month period, and analyzed for plutonium and, beginning in March 2000, ^{241}Am. Tritiated water vapor was monitored at 10 on- and 2 off-site locations and analyzed by liquid scintillation counting.

At the end of 2000, there were 86 active TLD locations. TLDs were deployed in two holders about 1 m (3.3 ft) above the ground and exchanged quarterly. Locations were chosen at the site boundary, where historical monitoring had occurred, or where operations or ground contamination had occurred.

Oversight environmental surveillance was conducted for stakeholders by the Desert Research Institute (DRI) of the University of Nevada. The program consists of a network of off-site monitoring stations operated by residents. In 2000, DRI managed 20 CEMP stations. Four more stations administered by the U.S. Environmental Protection Agency (EPA) were expected to come under the control of CEMP in late 2001. The CEMP stations included monitoring devices for direct measurement of gamma emitters and high-energy particles, such as TLDs and pressurized ion chambers, and low-volume particulate air samplers. All data collected by electronic sensors at the CEMP stations were stored in a datalogger. Current data readings were displayed on the site and updated every 6 seconds.

Surface waters on the NTS consisted of natural springs, containment ponds, and sewage lagoons. In 1999, sampling of on-site surface waters (reservoirs and natural springs) ended. In 2000, water samples were collected only from the containment ponds and sewage lagoons. Grab samples were collected quarterly from the two containment ponds. The on-site springs were not sampled because they are fed by locally derived groundwater that is not connected hydrologically to any aquifer that might have been affected by underground nuclear tests.

In 1996, DOE confirmed the locations of 828 underground tests at the NTS that were in areas of possible groundwater contamination. Approximately one-third of these tests were at or below the water table level. Detonations at or near the regional water table have contaminated local groundwater with more than 60 radionuclides. The USGS and Bechtel Nevada continued the groundwater monitoring program. Storm water surveys were conducted on the NTS through 2000.

In 1998, because of budget cuts and the standby status of nuclear testing, samples of game animals and garden vegetables were not collected. Also, the noble gas and tritium sampling network was discontinued in off-site locations.

Biota sampling was implemented in 1999. Five sites were selected for sampling over the following 5 years. The sites, considered the most contaminated and representative of the five types of contaminated sites on the NTS, were E Tunnel Ponds, Palanquin, Sedan T2, and Plutonium Valley. Each site was to be sampled once every 5 years and more frequently if contamination was higher than action levels. Vegetation samples were taken of primarily woody vegetation because of their more extensive root systems and use as major browse for wildlife. Extensive efforts were made to trap rabbits, doves, or chukars.

C.5.8 Pantex Plant

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Pantex Plant is in the Texas panhandle, 27 km (17 miles) northeast of Amarillo. The mission of the Plant is in the following areas: assembling nuclear weapons for the Nation’s stockpile; disassembling nuclear weapons being retired from the stockpile; evaluating, repairing, and retrofitting nuclear weapons in the stockpile; providing interim storage for plutonium pits from dismantled nuclear weapons; developing, fabricating, and testing chemical explosives and explosive components for nuclear weapons; and supporting DOE initiatives.

The site consists of about 4,100 ha (16,000 acres) of DOE-owned land, including 3,683 ha (9,100 acres) in the main plant area and 426 ha (1,077 acres) at Pantex Lake, which is about 4 km (2.5 miles) northeast of the main plant. In addition, DOE leases 2,247 ha (5,800 acres) of land south of the main plant from Texas Tech University for a safety and security buffer zone.

The land around the Pantex Plant is used mainly for winter wheat and grain sorghum farming and for ranching. Although dryland farming is dominant, some fields are irrigated from the Ogallala aquifer or the local playas. Several industrial facilities are in the general area.

Most of the area's population resides west-southwest of Pantex in Amarillo, which has a population of about 158,000 people. About 270,000 people live within 80 km (50 miles) of the plant. Approximately 3,200 people are employed at the plant.

The area's climate is semiarid, with large variations in daily temperature extremes. The average annual temperature for 2000 was 14.5°C (57.4°F). The total rainfall was 44.3 cm (17.65 in.), below the average annual rainfall of about 49.7 cm (19.56 in.). The prevailing wind direction is from the south to southwest.

Pantex is approximately 1,067 meters (3,500 feet) above sea level. The topography is relatively flat, characterized by rolling grassy plains and numerous playas (dry basins that can become lakes after heavy rainfall).

In 2001, BWXT-Pantex, LLC, was awarded the management and operating contract, replacing the Mason & Hanger Corporation, which had operated the plant since 1956. BWXT combines elements of BWX Technologies, Honeywell, and Bechtel.

Site Monitoring. The Pantex Plant's environmental radiological monitoring program involved measuring radioactivity in samples and calculating potential radiological doses to the off-site public. The program considered tritium, ^{232}Th, ^{234}U, ^{238}U, ^{238}Pu, and ^{239}Pu in air, groundwater, drinking water, surface water, soil, flora, and fauna. It did not consider radon, which originates from natural background sources, in release estimates or dose calculations.

Sensors at the meteorological tower automatically record average wind speed and direction and several other parameters every 15 minutes.

Since 1998, 27 stations have been used to monitor radionuclides in air; there are five on-site monitoring stations near operating areas at which airborne releases could occur. Seventeen radiological monitoring stations along the Plant perimeter provided coverage in the principal compass directions and in directions where residents lived and worked. There were five off-site air monitoring stations around the Plant.

Each monitoring station had a low-volume and a high-volume air sampler. Low-volume samplers contained filters to screen for gross alpha and gross beta activity, and silica gel to monitor for tritiated water vapor. High-volume samplers contained filters that screened ^{232}Th, ^{233,234}U, ^{238}U, ^{238}Pu, and ^{239,240}Pu. The samplers ran continuously, with weekly collection of filters. To obtain baseline information, analyses for ^{232}Th, ^{238}U, and ^{238}Pu began in 1998 at locations upwind and downwind from areas where operations involving these radionuclides were to occur and at the Bushland control location.

The monitors at the on-site and off-site monitoring stations sampled for oxidized tritium (tritiated water vapor) in ambient air. Fenceline monitors sampled for both the total amount of tritium and the amount of oxidized tritium in ambient air.

Since 1998, Pantex and the Texas Department of Health's Bureau of Radiation Control have cosampled TLDs at nine locations (one on the site, seven along the perimeter fence, and one off the site). In 2001, the Plant monitored independently at four other on-site and four off-site locations. The Plant generally placed TLDs at the locations where it operated its air monitors, and analyzed and replaced the TLDs at the end of each calendar quarter.

No rivers or streams flow through the Pantex Plant; the only surface water occurs in ditches and six playas. Effluents from Plant operations were treated and, along with some noncontact industrial discharges, directed into a network of ditches that drain to three playas. Surface-water monitoring generally depended on precipitation or discharge events; because samples could be collected only when flow occurred. Sampling occurred routinely at the Wastewater Treatment Facility, where flows were continuous. From 1998 to 2000 off-site surface water was sampled from a playa at the Bushland control location, where water was present only during part of the year. In addition to the six playas, the Plant had 22 permitted industrial outfalls and 24 storm water outfalls. Depending on permit requirements and flow at each outfall, sampling might or might not have occurred at these locations each year. In 2000, sampling occurred routinely at all industrial outfalls where discharges occurred (6 of the 22); at nine storm water outfalls determined to be representative of all 24 such outfalls, and at six playas, which included Pantex Lake and Bushland playa. Radiological sampling included gross alpha, gross beta, $^{233, 234}$U, ^{238}U, and tritium.

The Pantex Plant had an extensive on-and off-site network of 119 groundwater monitoring wells in 2001, up from 83 wells in 1998. The wells were sampled quarterly, semiannually, or annually depending on the analyte. In addition to the groundwater monitoring network, 34 landowners' domestic water wells were included in a systematic sampling plan. Nine of these domestic wells were sampled monthly; the remainder were sampled quarterly, semiannually, or annually. Radionuclides measured included gross alpha, gross beta, ^{226}Ra, ^{228}Ra, tritium, $^{233, 234}$U, ^{238}U, and $^{239, 240}$Pu. In 2000, routine drinking water samples were collected from 29 on-site locations; up from 19 locations in 1998. Four locations were monitored for radiological constituents. Gross alpha, gross beta, tritium, ^{90}Sr, ^{226}Ra, ^{228}Ra, ^{234}U, ^{238}U, and $^{239, 240}$Pu were detected in 2000.

From 1998 through 2000, the Plant collected on- and off-site soil samples. In 2000, soil was sampled routinely at 23 on-site locations (reduced from 42 in 1998), representing the Burning Ground, firing sites, Zone 4 West, and playas. Soil also was sampled at 25 off-site locations (up from 22 off-site locations in 1998). All soil samples were analyzed for ^{235}U, ^{238}U, and $^{239, 240}$Pu. In addition, soil samples from the three Zone 4 West locations and the Bushland upland location were analyzed for ^{238}Pu; samples from the firing sites and the Bushland location were analyzed for ^{232}Th; and samples from the playa and the Bushland location were analyzed for tritium.

Vegetation was sampled on- and off-site and analyzed for tritium, ^{234}U, ^{238}U, and $^{239, 240}$Pu. Radionuclide surveillance of prairie dogs was conducted semiannually at four on-site locations (Burning Ground, Playa 2, Playa 3, and Zone 8) and one control location. Control samples were collected at the Buffalo Lake National Wildlife Refuge near Umbarger, Texas. Whole-body composites were prepared for detection of tritium, $^{233, 234}$U, ^{238}U, and $^{239, 240}$Pu.

C.5.9 Sandia National Laboratories, Albuquerque

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Sandia National Laboratories, Albuquerque (SNLA) is surrounded by the Kirkland Air Force Base (KAFB) and is approximately 10.5 km (6.5 miles) east of downtown Albuquerque, New Mexico.

SNLA designs arming, fusing, and firing systems for nuclear explosives; safety and development studies for reactors; and special nuclear material transport and storage systems. Additional activities include development of waste disposal techniques and research on solar energy use, thermonuclear fusion, fossil fuels, and geothermal energy.

Within an 80-km (50-mile) radius of Sandia there are about 695,400 residents. The nonurban region is used mostly for forestry, and land on nearby Indian pueblos is used primarily for grazing.

Daily temperatures range from 32.7°C (90.8°F) to 16.6°C (61.8°F) in summer and 9.6°C (49.2°F) to –4.6°C (23.7°F) in winter.

SNLA is operated by the Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation.

Site Monitoring. The SNLA NESHAPs program monitored radionuclide air emissions at 18 facilities (16 point and 2 diffuse emission sources). In addition, SNLA collected meteorological and ambient air quality data from eight meteorological towers on KAFB.

SNLA monitored liquid effluent at 13 on-site locations. Groundwater monitoring occurred on an annual, biannual, or quarterly basis, depending on the area with samples taken from 67 groundwater wells on SNLA and KAFB.

C.5.10 Sandia National Laboratories, Livermore

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Sandia National Laboratories, Livermore (SNLL) is east of the City of Livermore, California (population approximately 79,000), in eastern Alameda County, 65 km (40 miles) east of San Francisco. The site is on 170 ha (413 acres) of land.

The mission of SNLL includes national security, energy and environmental research, and integrated manufacturing technologies.

The laboratory central site is surrounded on all sides by undeveloped land, which serves as a buffer zone. To the north is Lawrence Livermore National Laboratory, and farther north is an expanding business park and commercial development. The property to the south and east of the site comprises agricultural and low-density residential areas. Although principally residential, the area to the west encompasses a wide range of uses, which include a business park, grazing lands, vineyards, and other small agricultural and industrial developments.

Sandia Corporation, a wholly owned subsidiary of the Lockheed Martin Corporation, has been the operating contractor of Sandia National Laboratories since 1993.

Site Monitoring. SNLL had no routine emissions of radioactive materials to the air and, therefore, did not perform ambient air monitoring. LLNL performed air monitoring for radionuclides in the vicinity. However, SNLL did have dosimeters at four locations around the Laboratory, and seven off-site dosimeters. Each quarter, LLNL collected and processed data from the dosimeters.

Sanitary sewer effluent from SNLL was monitored continuously and analyzed weekly or monthly. SNLL monitored one sewer outfall. Tritium was among the parameters monitored.

Storm water runoff was sampled and usually inspected during the wet months. The entire site was inspected quarterly during dry weather for non-storm water discharges. In 2001, samples were collected from 8 of the 10 sampling locations, and monitored for tritium, among other parameters.

SNLL operated a network of aquifer protection wells. Groundwater monitoring occurred in areas of known contamination, areas of past contamination (that had been cleaned up), and areas thought to be able to provide early warning of contamination. In 1998, the 29-location groundwater monitoring network was sampled quarterly for tritium, radium, and uranium.

C.5.11 Sandia National Laboratories, Tonopah

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Sandia National Laboratories has responsibility for the Tonopah Test Range (TTR). The test range covers 1620 km^2 (624 $miles^2$) in the high desert region of west central Nevada, approximately 225 km (140 miles) northwest of Las Vegas.

Principal DOE activities at TTR include stockpile reliability testing, research and development (R&D) testing support of structural development; arming, fusing and firing systems testing; and testing nuclear weapon delivery systems.

The population within an 80-km (50-mile) radius of TTR is approximately 7,000.

The climate at TTR is mild and dry, but is subject to large diurnal seasonal changes in temperature. Average rainfall is between 10 and 30 cm (4 and 12 in.).

The topography is characterized by a broad flat valley bordered by two north- and south-trending mountain ranges.

Site Monitoring. Sandia Corporation conducted terrestrial surveillance at TTR to detect the possible migration of contaminants to off-site locations and to determine the potential impact of its operations on human health or the environment. Routine terrestrial surveillance occurred at on-site, perimeter, and off-site locations that remain essentially the same from year to year.

Ambient air quality monitoring is not currently required at TTR. Such monitoring last occurred in 1996 to determine the level of radiological constituents in the air.

The Sandia Corporation uses three active wells at TTR. EPA samples one of these wells for nitrate and nitrites every 3 years. In addition, EPA provides a radiological analysis survey for the Long-Term Hydrologic Monitoring Program. Sampling sites are based on State-specified programs.

The U.S. Air Force holds the NPDES permit for TTR wastewater discharges. The Air Force takes quarterly samples from the headwater end of the lagoon.

TTR soil samples were analyzed for 20 Inductively Coupled Plasma (ISP-20) stable metals plus mercury every other year. In 2001, nonradiological analyses were not performed.

C.6 Science

From 1998−2001, the DOE Office of Science had oversight of the following facilities:

- Ames Laboratory
- Argonne National Laboratory–East
- Brookhaven National Laboratory
- Ernest Orlando Lawrence Berkeley National Laboratory

- Oak Ridge Reservation
- Princeton Plasma Physics Laboratory
- Stanford Linear Accelerator Center
- Thomas Jefferson National Accelerator Facility

The following sections describe these sites and their monitoring programs.

C.6.1 Ames Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Ames Laboratory is on the campus of Iowa State University in Ames, Iowa. The City of Ames surrounds the main campus.

The laboratory's mission is to conduct fundamental research in the physical, chemical, materials, and mathematical sciences and engineering which underlie energy generating conversion, transmission and storage technologies, environmental improvement, and other technical areas essential to national needs. DOE owns 11 buildings with a total of about 30,400 m^2 (327,000 ft^2), and Ames Laboratory leased about 2,400 m^2 (26,000 ft^2) of space from the University in 2001.

The 2001 population of Ames was 51,000, which included the student population of about 25,000. The City of Ames is in Story County, which has a population of about 80,000.

The climate is temperate continental. Mean monthly temperatures vary from a low of –7.5°C (18.5°F) in January to a high of 23.8°C (74.8°F) in July. Average rainfall varies from 1.8 cm (0.7 in.) in January to 13.7 cm (5.4 in.) in June.

Iowa State University is the DOE contractor for Ames Laboratory.

Site Monitoring. The majority of the Laboratory's radioactive waste was generated through renovation activities that occurred in DOE buildings contaminated by past activities. Historically, radioactive materials handled at Ames included laboratory bench experiment quantities of normal and depleted uranium, ^{235}U, and thorium.

According to regulatory guidance and based on the isotope inventory in curies per year used at the Laboratory, air emissions were not monitored.

Liquid aqueous waste (laundry machine water) generated at the Waste Handling Facility was analyzed for radioactivity before release to the sanitary sewer. This wastewater was analyzed for gross alpha and gross beta activity.

In 2001 Ames did not sample storm or sanitary sewer water. The City of Ames sampled twice each year and Iowa State University sampled quarterly.

On the main campus, the groundwater monitoring network consisted of five wells. Four wells were down-gradient of the Laboratory's main campus facilities, and one was up-gradient, for background data. Two of the down-gradient wells belonged to the University. The University's wells were farther down-gradient than the DOE-owned wells, and they were screened into a deeper aquifer. The University was not required to monitor the groundwater on the main campus, nor did the Laboratory routinely monitor groundwater. In 2001, only Chemical Disposal Site (CDS) wells were monitored. The CDS was a small chemical burial site on University

property that was used from 1957 to 1966 for disposal of hazardous waste and waste from thorium and uranium production. The property was the subject of Remedial Investigations in the mid-1990s.

C.6.2 Argonne National Laboratory-East

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Argonne National Laboratory-East (ANLE) occupies 607 ha (1,500 acres) some 43 km (27 miles) southwest of Chicago, Illinois. ANLE conducts a broad research program in basic energy and related sciences (physical, chemical, material, nuclear, biomedical, and environmental) and serves as an engineering center for the study of nuclear and non-nuclear energy sources.

The terrain is gently rolling, partially wooded, former prairie and farmland. The grounds contain a number of small ponds and streams. The area immediately surrounding the site is the Waterfall Glen Forest Preserve, a 907-hectare (2,240-acre) site previously owned by the laboratory.

The total population within an 80-km (50-mile) radius is 8,889,321. Average annual temperature in 2001 was 10.5°C (50.9°F), and average annual precipitation was 90.68 cm (35.7 in.).

ANLE is operated by the University of Chicago.

Site Monitoring. ANLE regularly monitors airborne emissions of radioactive materials. ANLE monitored particulates in air for total alpha activity, total beta activity, ^{90}Sr, isotopic thorium, isotopic uranium, and ^{239}Pu at the site perimeter and at off-site locations.

TLDs measured dose rates from penetrating radiation (gamma rays) at 17 perimeter and on-site locations and five off-site locations.

The only detectable radionuclides in surface water due to ANLE discharges were in Sawmill Creek, below the wastewater discharge point. At various times during 2001, measurable levels of ^{3}H, ^{90}Sr, ^{239}Pu, and ^{241}Am were detected.

ANLE monitored radiological constituents in groundwater in several areas of the site. The former domestic water supply was monitored by collecting quarterly samples from the three inactive supply wells.

Ten monitoring wells were screened in the glacial drift and one in the dolomite adjacent to the Chicago Pile-Five reactor. Analysis included tritium and ^{90}Sr. Twenty-six monitoring wells in the 800 Area sanitary landfill were sampled on a quarterly basis and analyzed for tritium.

ANLE collected sediment samples from Sawmill Creek above, at, and below the point of wastewater treatment plant effluent discharge. Analyses were performed for ^{239}Pu and ^{241}Am.

C.6.3 Brookhaven National Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Brookhaven National Laboratory (BNL) is on a 2,130-hectare (5,265-acre) tract in Brookhaven Township on Long Island, New York, about 97 km (60 miles) east of New York City.

BNL conducts research in physics, biomedical, and environmental sciences, as well in energy technologies. BNL also builds and operates major facilities available to university, industrial, and government scientists. The newest BNL accelerator facility, the Relativistic Heavy Ion Collider, began operation in 2000. Historical operations and past waste management practices resulted in soil and groundwater contamination.

Approximately 1,457 ha (3,600 acres) at BNL are mostly wooded and represent native pine barrens ecology.

Nearly one-third of the 1.43 million people who reside in Suffolk County live in Brookhaven Township. There has been an increase in residential housing in Brookhaven Township in recent years. More than 75% of BNL's approximately 3,000 employees live within a 27-km (15-mile) radius of the Laboratory. Approximately 150 people reside in apartments and cottages on the site, and many of the scientists who visit stay in short-term on-site housing.

The monthly mean temperature in 2001 was 11°C (52.3°F), ranging from a monthly mean low temperature of –1.4°C (29.4°F) in January to a monthly mean high temperature of 23.5°C (74.3°F) in August. Total precipitation for 2001 was about 117 cm (46 in.) and most of the precipitation occurred from March through September. Prevailing winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall.

BNL lies on the western rim of the shallow Peconic River watershed. The site is gently rolling, with elevations varying between 13 and 37 meters (44 and 120 feet) above sea level.

BNL has been operated since 1998 by Brookhaven Science Associates, a not-for-profit partnership between Battelle Memorial Institute and the Research Foundation of the State University of New York.

Site Monitoring. BNL performed continuous radioactive emissions monitoring at several facilities, including the Brookhaven Linac Isotope Producer (BLIP) and the Target Processing Laboratory. Two facilities previously monitored on a continuous basis have been shut down. Following the discovery of an underground plume of tritiated groundwater emanating from a leak in the spent fuel storage pool, the High Flux Beam Reactor (HFBR) was kept in standby mode from January 1997 until November 1999, when DOE announced its permanent shutdown. In August 2000, DOE announced the permanent shutdown of the Brookhaven Medical Research Reactor (BMRR). Since the BMRR was no longer operating, the frequency of monitoring for radiological airborne emissions (principally ^{41}Ar) was reduced from continuous to semiannual.

The air samplers in the exhaust duct of the BLIB and the Target Processing Laboratory used glass-fiber filter paper designed to capture airborne particulate matter generated by these facilities. The filter paper was collected and analyzed weekly for gross alpha and beta activity.

An array of monitoring stations around BNL captured airborne particulate matter, and water vapor for tritium analysis. Filter paper was collected and analyzed weekly for gross alpha and beta activity. Charcoal cartridges were collected 1 week a month to be analyzed for radioiodine. Before April 1999, silica-gel samples were collected weekly for tritium analysis, but results from multiple years below the minimum detection limit were the basis for reducing the sampling frequency.

BNL also measured direct penetrating radiation exposures. TLDs were deployed on and off the site at residential locations. On-site locations were selected based on the potential for exposure to gaseous plumes, atmospheric particulates, and radiation-generating facilities. Forty-one on-site and 17 off-site TLDs were posted in 2001; in 1998, BNL deployed 24 on-site and 21 off-site TLDs. Six of the 42 on-site TLDs were near facilities that had greater probability to contribute to external dose.

Treated wastewater from the BNL Sewage Treatment Plant (STP) is discharged to the headwaters of the Peconic River. Real-time monitoring of the sanitary waste stream for radioactivity took place at two locations. The first was approximately 1.8 km (1.1 miles) from the STP; the second was just before the point where the influent entered the primary clarifier. In addition, effluent leaving the primary clarifier was monitored a third time for radioactivity. In 2001, the frequency of sample collection decreased from every 24 hours to every 48 hours, based on limited detection of contaminants in STP discharge and the reduced potential for discharge resulting from the shutdown of the HFBR and BMRR.

Surface-water monitoring occurred at several locations upstream and downstream of the point of discharge. Three stations upstream and seven stations downstream of the STP outfall were monitored. In addition, a sampling station along the Carmans River was monitored as a control location. Radionuclide measurements were performed on surface-water samples. Routine samples at two stations were collected three times a week, as flow permitted. Samples from one station were collected quarterly in 2001. All other sites were sampled quarterly by collecting instantaneous grab samples, as flow allowed.

Discharges to recharge basins were sampled for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. BNL sampled basin sediments on a 2-year cycle. However, reported levels of lead in 2000 above Suffolk County cleanup action levels at the outfall for the Central Steam Facility resulted in samples being taken in 2001.

Since 1998, the BNL Groundwater Protection Management Program has been tracking progress toward eliminating new contamination of the aquifer system. From 1998 through 2001, BNL installed several hundred permanent and temporary monitoring wells as a result of a comprehensive evaluation of known or potential contaminant source areas. The groundwater monitoring network grew to approximately 714 on- and off-site surveillance wells. In addition to water quality assessments, water levels were routinely measured to assess variations in directions and velocities of groundwater flow.

In 2001, 120 groundwater wells were monitored with regard to the active facilities. During this period, 594 wells were monitored for the restoration program. The potable and cooling water supply well network consisted of six wells. Groundwater quality was routinely monitored at all active supply wells because of the proximity of BNL's potable wells to known or suspected groundwater contamination plumes and source areas. Potable well water was sampled and analyzed for gross alpha, gross beta, tritium, ^{90}Sr, and gamma-emitting radionuclides.

BNL conducted routine monitoring of flora and fauna. Because soils contaminated with ^{137}Cs were used in past BNL landscaping projects, traces of contamination were found in deer. BNL began testing deer bone for ^{90}Sr content in 2000 and continued the analyses in 2001. BNL sampled small mammals (primarily squirrels) to determine their suitability as a surrogate for deer sampling. Meat was tested for gamma-emitting radionuclides and bone was tested for ^{90}Sr.

In 2000, BNL initiated the sampling of goose fecal material and lawn grasses to determine if there was potential for the Canada goose population to pick up ^{137}Cs contamination from landscape soils.

BNL maintained an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Annual sampling over the past several years depleted the number of larger fish. BNL suspended most on-site sampling in 2001 and will continue with the suspension for as long as 3 years to allow fish populations to recover and mature. Off-site fish sampling continued in 2001. All samples were analyzed for whole-body content of each analyte reported. In addition, fish were collected off the site and annual sampling of clams, sediment, and seawater was conducted.

A variety of vegetables were sampled for radiological analysis from farms near BNL as well as from an on-site garden. Soil sampling was conducted to correspond with vegetation sampling near air stations, goose fecal matter collection points, the on-site garden, and local farms. Soil samples were analyzed for gamma-emitting radionuclides.

C.6.4 Lawrence Berkeley National Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. Lawrence Berkeley National Laboratory (LBNL) is about 5 km (3 miles) east of San Francisco Bay on 478 ha (1,183 acres) of land owned by the University of California. The Laboratory's 8-hectare (200-acre) main site is under long-term lease to DOE. The main site is in the hills above the UC Berkeley campus, with elevations ranging from 150 to 330 m (500 to 1,100 ft) above sea level.

LBNL has about 190,000 m^2 (2 million ft^2) of research and support facilities, about 15% of which is off the main site.

The LBNL mission is to perform a wide-ranging program of general research in the physical and biological sciences. The Laboratory's facilities include several accelerators, various radiochemical laboratories, and a tritium-labeling laboratory.

The western portion of the site is in Berkeley (population 103,000), with the eastern portion in Oakland (population 399,000). About 3,000 scientists and support personnel work at LBNL. In addition, the Laboratory typically hosts 2,000 guests each year.

Adjacent land use consists of residential, institutional, and recreational areas. The area to the south and east of the Laboratory, which is University land, is maintained largely in a natural state but includes UC Berkeley recreational facilities and Botanical Garden. Northeast of the Laboratory are University buildings. LBNL is bordered on the north by single-family homes and on the west by the UC Berkeley campus as well as by multiunit dwellings and private homes. The area west of LBNL is highly urbanized.

The climate is temperate, influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west, and on the east by the East Bay hills. These physical barriers contribute significantly to the site's relatively warm wet winters and cool dry summers. The most prevalent wind pattern occurs during fair weather, with daytime westerly winds blowing off the Bay, followed by lighter nighttime southeasterly winds originating in the East Bay hills.

LBNL is operated by the University of California.

Site Monitoring. The LBNL air monitoring program consisted of two separate elements: exhaust emissions monitoring and ambient air surveillance. Collected stack exhaust samples were analyzed for five radiological parameters – gross alpha, gross beta, ^{14}C, ^{125}I, and tritium. The ambient air network contained four sites collecting particulate samples for gross alpha and

gross beta analysis, and an increasing number of sites collecting silica gel samples for tritium analysis. There were six tritium sites in the network until 2000, when one site was added. In 2001, eight additional sites brought the total number to fifteen. The network was expanded in response to a request from EPA to temporarily collect supplemental ambient tritium data.

Three real-time environmental monitoring stations around the site's perimeter contained gamma and neutron pulse counters that continuously detected and recorded direct gamma and neutron radiation. In addition, six TLDs near the site boundary and one at a remote location monitored gamma radiation.

Surface waters were sampled for gross alpha and beta activity and tritium. When creek flow occurred, a quarterly grab sample was collected. Sampling occurred once each year at two regional lakes. Storm water and sanitary sewer outfalls also were analyzed.

The LBNL sanitary sewer system, which is based on gravity flow, discharges through one of two monitoring stations, Hearst or Strawberry. The Hearst and Strawberry sewer outfalls were sampled continuously by automatic equipment that collected samples at half-hour intervals. The composite samples were collected biweekly for analysis of gross alpha, beta, ^{125}I, and tritium by a State-certified laboratory.

LBNL monitored groundwater for tritium. In 2001, 8 new monitoring wells were installed, bringing the total number of wells in the system to 198. Twenty monitoring wells were close to the site boundary, and one well was down-gradient from the Laboratory.

LBNL routinely performed annual soil and sediment sampling. Soil samples were taken from locations chosen to coincide with ambient air sampling stations. Samples were analyzed for gross alpha, gross beta, gamma emitters, and tritium. Sediment samples were collected from main and tributary beds of the North Fork of Strawberry Creek and Chicken Creek. Sediment samplers were analyzed for gross alpha, gross beta, gamma emitters, and tritium.

Routine sampling of vegetation and foodstuffs was not required under applicable environmental regulations. However, before the Laboratory considered the removal or release of trees to the public, the trees were sampled and analyzed for tritium. Also, in 2001, vegetation around the LBNL perimeter was sampled in response to a request by the Environmental Sampling Project Task Force.

C.6.5 Oak Ridge Reservation

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Oak Ridge Reservation (ORR) encompasses about 13,855 ha (34,235 acres) of mostly contiguous land. All but 246.4 ha (608 acres) west of the East Tennessee Technology Center (ETTC) are in the City of Oak Ridge, Tennessee. Approximately 8,100 ha (20,000 acres) comprise the Oak Ridge National Environmental Research Park. The residential section of Oak Ridge forms the northern boundary of the reservation. The Tennessee Valley Authority's Melton Hill and Watts Bar reservoirs on the Clinch and Tennessee Rivers, respectively, form the southern and western boundaries. The Oak Ridge Institute for Science and Education (ORISE), which is managed by Oak Ridge Associated Universities, uses 94.3 ha (233 acres) on the southeastern border of the ORR.

With the exception of the City of Oak Ridge, the land within 8 km (5 miles) of ORR is semirural, used primarily for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

The population of the 10-county region surrounding ORR is about 855,400, approximately 27,000 of whom reside in Oak Ridge. Knoxville, the major metropolitan area nearest Oak Ridge, is about 40 km (25 miles) to the east and has a population of about 173,200. ORR employs more than 13,000 people at three major operating sites: Y-12 National Security Complex (Y-12), Oak Ridge National Laboratory (ORNL), and ETTC.

- The Y-12 Complex is a manufacturing facility. Its mission focuses on remanufacture, surveillance, and assessment of weapon components, particularly those comprised of highly enriched uranium. Y-12 is managed by NNSA and operated by BWXT.

- ORNL conducts R&D in support of all four major DOE missions: science and technology, energy resources, environmental quality, and national security. In addition, ORNL is responsible for approximately 7,260 ha (18,000 acres) of undeveloped and developed land. Construction of the accelerator-based Spallation Neutron Source began in 1999 and is scheduled for completion in 2006. The accelerator is on 32 ha (80 acres) of Chestnut Ridge near ORNL. ORNL is managed by DOE's Office of Science and operated by the University of Tennessee/Battelle Memorial Institute.

- ETTC was the home of the Oak Ridge Gaseous Diffusion Plant. The gaseous diffusion cascades were permanently shut down in late 1997 and the plant is being decontaminated. The ETTC mission is to reindustrialize and reuse site assets through leasing of vacated facilities and incorporation of industrial organizations as partners in the ongoing restoration, decontamination and decommissioning, waste treatment and disposal, and diffusion technology development activities. ETTC is managed by DOE's Office of Environmental Management and operated by the Bechtel Jacobs Company, LLC.

The Y-12 Plant, ORNL, and ETTC are in a moderately populated area adjacent to the Clinch River.

The climate can be broadly classified as humid continental. The Cumberland Mountains to the northwest help modify the effects of cold air masses that frequently penetrate far south. The temperature during January averages about 2.2ºC (36ºF) and during July the temperatures average about 24.9ºC (78.6ºF). The mean annual temperature is 14.2°C (57.6°F). The 30-year average precipitation is 140 cm (55 in.), including about 24.4 cm (9.6 in.) of snowfall. Winds are significantly affected by the ridge-and-valley terrain, resulting in a dominance of winds from the east-northeast or southwest.

ORR lies in a valley between the Cumberland and Blue Ridge mountain ranges. It is in the Tennessee portion of the Valley and Ridge Province. The Knox aquifer is on the ORR.

Site Monitoring. Air monitoring is performed through exhaust stack monitoring and ambient air on-site monitoring stations. In addition, external gamma measurements are recorded weekly at ambient stations on- and off-site.

Surface water is monitored at each plant site. Sampling frequency and parameters vary among sites. Sampling is in addition to requirements mandated by the NPDES.

The Integrated Water Quality Program (IWQP) tracked and prioritized groundwater monitoring, which includes spring seeps, and surface water across the ORR.

A revised sediment sampling program was implemented in 1997. Downstream samples were analyzed annually and settable solids are collected on a semiannual basis.

Locally grown hay, foodstuffs, fish, and milk are analyzed. Harvested deer and turkey as well as resident geese are monitored each season.

C.6.6 Princeton Plasma Physics Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Princeton Plasma Physics Laboratory (PPPL) is in central New Jersey approximately 4.8 km (3 miles) east of Princeton University. The closest urban areas are New Brunswick, 23 km (14 miles) to the northeast, and Trenton, 19 km (12 miles) to the southwest. Major metropolitan areas, including New York City, Philadelphia, and Newark, are within 80 km (50 miles).

PPPL, which has operated since 1951, is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop scientific understanding and key innovations leading to an attractive fusion energy source. Related missions include conducting research along the broad frontier of plasma science and providing the highest quality of scientific education and experimentation.

PPPL is on the C- and D-Sites of the James Forrestal Research Campus of Princeton University. The site is surrounded by undisturbed areas with upland forest, wetlands, a minor stream flowing along the eastern boundary, and open grassy areas and cultivated fields on the west. The D-Site is completely surrounded with a chain-link fence for controlled access. In the late 1970s, D-Site became the home of the Tokamak Fusion Test Reactor, which is being dismantled, and of the National Spherical Torus Experiment. Public access for educational purposes is allowed on C-Site.

Central New Jersey has a mid-latitude, rainy climate with mild winters, hot summers, and no dry season. Temperatures range from below zero to above 38°C (100°F). Average annual precipitation is about 116 cm (46 in.).

PPPL is operated by Princeton University.

Site Monitoring. PPPL used the differential atmospheric tritium sampler (DATS) to measure elemental and oxide tritium at the D-Site stack and in the Radioactive Waste Handling Facility. DATS was used at 11 environmental sampling stations, 4 at D-Site boundary trailers, and 6 at remote air monitoring stations. The baseline monitoring station was moved from Hopewell, New Jersey (Mercer County), to Roebling, New Jersey (Burlington County). All of these sampling stations ran continuously.

Drainage from D-Site sumps was collected in the Liquid Effluent Collection tanks. Prior to release from these tanks to the sanitary sewer system, a sample was collected and analyzed for tritium concentrations and gross beta activity.

Surface-water samples at nine locations (two on and seven off the site) were analyzed for tritium. In August 1995, PPPL began to monitor tritium levels in on-site groundwater more intensely. This increase in monitoring was prompted by a slight increase in tritium in well TW-1 (north of D-Site). In 2000, 10 D-Site wells were sampled for tritium. Potable water was supplied by the public utility, Elizabethton Water Company. Beginning in 1984, baseline data were collected for water coming onto the site. Radiological analyses included spectroscopy and tritium-concentration determinations.

No foodstuffs, soil, or vegetation samples were gathered for analysis in 2000. In 1996, the Laboratory reviewed the requirements for soil and biota sampling and decided to discontinue the sampling program. Tritium was not detected in almost all samples and the data did not add to the understanding of tritium transport in the environment.

C.6.7 Stanford Linear Accelerator

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Stanford Linear Accelerator (SLAC) is on the San Francisco Peninsula, about halfway between San Francisco and San Jose, California. SLAC occupies 170 ha (420 acres) of land owned by Stanford University.

The area around SLAC is a mix of offices, schools (including the Stanford campus), single- and multifamily housing, and grazing lands. The SLAC site is in a belt of low, rolling foothills lying between the alluvial plain bordering San Francisco Bay on the east and the Santa Cruz Mountains on the west. The site varies in elevation from 53 to 114 m (174 to 374 ft) above sea level.

The SLAC mission centers around experimental and theoretical research in elementary particle physics using accelerated electron beams and a broad program of research in atomic and solid-state physics, chemistry, and biology. There is also an active program in the development of accelerators, detectors, and new sources and instrumentation for radiation research. The main instrument for research is the 3.2-km (2-mile) linear accelerator.

The estimated total population of the five closest communities is 38,400, with more than 4.9 million people living within 80 km (50 miles). The SLAC staff numbers about 1,350 people and, at any given time, SLAC hosts about 1,000 visiting scientists.

The climate is Mediterranean. Winters are cool and moist, and summers are mostly warm and dry. Daily mean temperatures are seldom below 0°C (32°F) or above 30°C (86°F). Rainfall averages about 56 cm (22 in.) per year.

SLAC is operated by Stanford University.

Site Monitoring. Airborne radionuclides were produced in the air volume surrounding several elements and operations of the accelerator. Continuous monitoring of such radionuclides was not required because EPA defined all SLAC emission points as minor sources of air pollution. NESHAP emissions were derived using calculations based on conservative assumptions.

SLAC maintains about 30 TLDs at the site boundary.

Three types of water – industrial wastewater, storm water, and groundwater – were monitored for radioactivity at SLAC. Since 1998, wastewater containing small quantities of radioactivity within regulatory limits has been discharged periodically from the site to the sanitary sewers. The only possible sources of liquid radioactive effluents were from low-conductivity water (LCW) cooling systems. All discharge batches potentially containing radioactivity were sampled and analyzed. Storm water was analyzed for a number of constituents including radioactivity.

The SLAC groundwater monitoring network consisted of 70 wells that were analyzed for a number of analytes including tritium.

Soil sampling for gamma-emitting radionuclides is performed when activities in the accelerator area, such as construction inside the accelerator enclosure, suggest that it would be prudent. To characterize background radioactivity more thoroughly, in 2001 SLAC adopted a policy of performing gamma analyses on soil samples from most on-site excavation projects. In 1999, soil was sampled from the area north of Linac Sector 13, which was formerly used to store radioactive accelerator components.

SLAC does not monitor vegetation or animals because calculations show that pathways to biota, liquid emissions, airborne emissions, and direct radiation exposure would not result in exposure levels that exceeded dose limits for plants or animals.

C.6.8 Thomas Jefferson National Accelerator Laboratory

This site description reflects conditions as they existed from 1998 through 2001. Organizational, operational, or other changes occurring after 2001 are not incorporated below.

Site Description. The Thomas Jefferson National Accelerator Laboratory (JLAB) is in Newport News, Virginia. The original JLAB mission evolved from the nuclear science community's recognition of the need for a state-of-the art electron accelerator with a continuous high-current electron beam.

The accelerator complex includes three underground halls that house the physics program experiments. The total DOE-owned parcel comprises 66 ha (162 acres). Adjacent to the DOE property is a dormitory used by guests and visiting scientists.

JLAB is in the northern section of Newport News at an average elevation of 10.4 m (34 ft) above sea level, which is above the 100-year floodplain.

JLAB is managed by the Southeastern Universities Research Association.

Site Monitoring. JLAB operated approximately 50 electronic radiation detectors and a series of associated passive integrating detectors deployed around the accelerator site with the primary purpose of measuring on-site radiation. The majority of the detectors were connected to a central computer system that could automatically record radiation levels for subsequent examination. Six electronic radiation measurement devices were installed along the accelerator and site boundary.

JLAB had a groundwater monitoring network of 15 wells. The wells were used for sampling and analysis during regular accelerator operations and experimental physics activities. The samples were analyzed for gross beta, tritium, ^{7}Be, ^{22}Na, and ^{54}Mn. The Laboratory also monitored Outfall 001.

Annex A. Summary of Radionuclide Air Emissions from Department of Energy Facilities for 1998–2001

U.S. Department of Energy
Office of Air, Water and Radiation Protection Policy and Guidance

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Introduction

Facilities owned or operated by the U.S. Department of Energy (DOE) handle and process radioactive materials in conjunction with their research, nuclear materials production, remediation, and waste disposal activities. During normal operations, some of these facilities have the potential to release small quantities of radionuclides to the environment.

Radionuclide emissions to the atmosphere from DOE facilities are regulated by the U.S. Environmental Protection Agency (EPA) under the authority of Section 12 of the Clean Air Act.[5] Three applicable subparts of the National Emission Standards for Hazardous Air Pollutants (NESHAPs; 40 CFR Part 61) set standards to limit public exposure to these releases.

- National Emissions Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities (40 CFR Part 61, Subpart H; hereafter Subpart H)

- National Emission Standards for Radon Emissions From Department of Energy Facilities (40 CFR Part 61, Subpart Q)

- National Emission Standards for Radon Emissions From the Disposal of Uranium Mill Tailings (40 CFR Part 61, Subpart T)

Subpart H requires that DOE facilities submit annual reports by June 30 each year to their respective EPA regional offices and to EPA headquarters describing site activities during the previous calendar year, including estimates of atmospheric radionuclide emissions and the resulting dose to the maximally exposed individual (MEI). (See 40 CFR 61.94.) In all cases, emissions from DOE facilities are well below regulatory limits.

DOE prepared this summary of the reports for calendar years 1998 through 2001 to provide EPA and other interested parties an overview of the information reported in the individual site reports. This summary is not required by the regulations and is provided with the intent of consolidating and clarifying information and data reported by the individual DOE sites.

An overview of DOE compliance with the Subpart H dose standard is provided in Section 1.0. In addition to the required compliance information, supplemental information on air emissions is discussed in Section 2.

Table 1 lists the DOE sites covered by this report, including the associated acronyms used in the figures, tables, and text. The sites are grouped according to the DOE operations office that manages their activities. Air emission reports for the four-year period were received from 34 sites in 1998 and 2001, 35 in 2000, and up to 37 DOE research or production sites in 1999**.** This annex includes data on atmospheric releases and related dose estimates for six sites that are not addressed in the ASER summary report for 1998−2001: Kansas City Plant, Missouri; Lovelace Respiratory Research Institute, New Mexico; Environmental Measurements Laboratory, New York; Fermi National Accelerator Laboratory, Illinois; National Renewable Energy Laboratory, Colorado; and Rocky Flats Environmental Technology Site, Colorado.

[5] Airborne radionuclide emissions also are regulated by DOE under the authority provided by the Atomic Energy Act of 1954, as amended, and the Department of Energy Organization Act of 1977, as amended. DOE Order 5400.5, Radiation Protection of the Public and the Environment, is the primary DOE directive relevant in this regard.

In the Subpart H annual reports, airborne emissions were assessed from routine emissions from point sources. However, other potential sources such as unplanned releases, emissions from diffuse and unmonitored sources, and radon also were evaluated as applicable for each site. Emissions from non-point (diffuse) sources were generally several orders of magnitude lower than emissions resulting from routine point source operations, except at sites where production and research operations have been suspended.

DOE Directives require the calculation of population dose to support DOE oversight of its activities and the application of its ALARA policy. Therefore, population dose estimates for each site are provided in this report for informational purposes and to support trending and assessment of ALARA policy effectiveness. There is no regulatory standard for population dose, and its estimation is not required by EPA.

1.0 Compliance with the Subpart H Dose Standard

This section covers information related to radiological impacts on the public resulting from operations at DOE facilities. Regulatory requirements for reporting by DOE facilities are discussed, as are the models used to prepare the dose estimates. The quantities of radionuclides released into the atmosphere from DOE facilities and the estimated doses to the MEI are summarized.

1.1 Regulatory Requirements

On December 15, 1989, EPA promulgated radionuclide emission standards, which became effective during calendar year 1990. Radionuclide emissions (other than radon) from DOE operations are regulated under 40 CFR Part 61, Subpart H. Radon emissions from DOE storage and disposal facilities are regulated under 40 CFR Part 61, Subpart Q and from uranium mill tailings disposal sites under 40 CFR Part 61, Subpart T.

Subpart H requires the use of the effective dose equivalent (EDE) for evaluation of public exposure, as recommended by the International Commission on Radiological Protection in its Publication 26 (ICRP 1977). The EDE is the sum of the annual dose resulting from external exposure to radionuclides and the 50-year committed dose from internal exposure to radionuclides inhaled or ingested during the year. Internal dose is calculated by combining doses to specific organs, with each dose weighted by a factor related to the risk of radiation-induced health effects in that organ. The standard requires that annual doses from radionuclide emissions to the air at DOE facilities (excluding radon) shall not exceed 10 mrem (0.1 mSv) EDE to the MEI.

DOE facilities are required to provide EPA with an annual report describing radionuclide emissions and calculated doses to the public (40 CFR 61.94). Each report must include a description of the physical site, the types of radionuclides handled there, and any process involving radionuclides that are conducted at the facility. The report also must include a list of all stacks or vents that have a potential for airborne radionuclide emissions, the type and efficiency of effluent control systems used at each release point, and the distance to the nearest off-site receptors from each point. DOE has agreed to identify its diffuse or non-point sources, and to include the results of their emission estimates as part of this annual report.

In order to demonstrate compliance with the protective requirements of 40 CFR Part 61, each site must estimate the total quantity of radionuclides released (for both point and non-point sources) from its facilities during the calendar year, and evaluate the impact of those emissions on the dose to the MEI. In general, the point source emissions are reported separately and are used to document compliance with the standard. EPA does not specify acceptable methods or procedures for assessing the diffuse or non-point source emissions in the regulations. DOE has utilized its own methods and approaches to evaluate these emissions as appropriate for each source and location. These methods are described in the site-specific Subpart H reports. The diffuse source results are generally reported separately from the point-source results and the two results are compared to demonstrate that the 10 mrem/year (0.1 mSv/y) dose standard is not exceeded when all emission sources are considered. Some sites have combined the results and reported the sum in cases where either one or the other dominates the overall site emissions, or where such sources can be considered as a part of the site’s normal operations.

1.2 Radionuclide Emissions to the Atmosphere During Normal Operations

In general, emissions resulting from normal operations are defined as releases from facility stacks. Certain releases from diffuse (non-point) sources have resulted from normal, routine activities at some sites and are included in the routine dose estimates for those sites. Historic production operations at many DOE sites have ceased, such as those associated with nuclear weapons production and testing. In some of these cases, emissions from non-point sources exceeded the site emission from stacks (see Section 1.5 and Tables 2 and 4). Radionuclide emissions to the atmosphere resulting from normal operations during 1998 to 2001 are summarized in Table 2, and are divided into four categories: tritium, noble gases, transuranics, and all other radionuclides (Figure 1). Detailed site-specific information on releases by radionuclides is contained in the NESHAPs air emission reports for each individual site. During 1998, 130,000 Ci (4.8×10^3 TBq) were released to the atmosphere from normal operations at DOE facilities. The following two years the normal operation releases decreased to 120,000 Ci (4.4×10^3 TBq); then releases increased to approximately 140,000 Ci (5.2×10^3 TBq) during 2001. This is about a 16% increase in radioactivity released to the atmosphere from the previous year. This was due primarily to increased releases of radionuclides from normal operations at BNL, LANL, and SRS. Over the course of the four-years, the amount of noble gasses released approached that of tritium until they were approximately equal, both contributing 48% and 42%, respectively, of the annual releases. The majority of which was released from SRS (up to 110,000 Ci [4.1×10^3 TBq] total in 2001). Tritium is a prominent component of airborne emissions, with two-thirds of the DOE sites reporting some level of tritium release. For all the sites, with the exception of SNLT and NTS, the emission of transuranic isotopes, which present more of a radiation hazard than tritium per activity released to the environment, were at a level of less than 0.01 Ci (3.7×10^{-4} TBq). At SNLT and NTS, the diffuse releases of transuranic isotopes did not exceed 0.4 Ci (1.4×10^{-2} TBq).

Emissions from non-point sources such as waste disposal sites, contaminated soil areas, or inactive facilities under the Formerly Used Sites Remedial Action Program (FUSRAP) are discussed separately in Section 1.5 of this annex.

For the calendar years 1998 to 2001, all DOE facilities demonstrated compliance with the 10 mrem/year (0.1 mSv/yr) EDE dose standard specified by Subpart H. The doses reported by DOE facilities for compliance purposes primarily are based on point-source emissions. The point-source assessments are conducted in accordance with the EPA approved methods and procedures specified in Subpart H.

1.3 Dosimetry Models and Codes

The dosimetry model required by EPA is implemented through the use of computer software packages specified by the regulations, and which are used by DOE sites to demonstrate compliance with the dose standard. The EPA approved code packages include CAP88, CAP88-PC, COMPLY, and AIRDOS-PC. Approval of alternate methods for demonstrating compliance with the dose standard may be requested from EPA on a case-by-case basis. The models used by individual DOE sites to demonstrate compliance with the standard for 1998 to 2001 are indicated in Table 3.

The CAP88 code package (Beres 1990) implements a steady-state gaussian plume atmospheric dispersion model, and comes with a set of radionuclide-specific data that generally corresponds to the data used in the internal dosimetry models described in ICRP Publication 30 (ICRP 1979-1982). It provides the most flexibility of the four EPA approved codes in terms of

ability to input site-specific data, however, it also is the most difficult and expensive of the codes to operate because it requires a mainframe computer system. This code was used by eleven of the reporting DOE sites to demonstrate compliance with the NESHAPs standard in 1998, six in 1999, and eight in 2000 and 2001. A MS-DOS-based personal computer version of the CAP88 code, developed by EPA with DOE funding, was released in March 1992 under the name CAP88-PC (Parks 1992). This code provides most of the features of the CAP88 code in a personal computer format. It retains the complete radionuclide library and the capability to perform collective dose calculation. CAP88-PC was used by 20 DOE sites to assess the dose to the public and demonstrate compliance with the dose standard for 1998 and 2000; 23 DOE sites used the code in 1999, and fifteen sites used it in 2001. A windows-compatible version was developed in 2000, called CAP88-PC v2.0 (Chaki and Parks 2000). Version 2 includes the addition of decay chains for six radionuclides, a correction of a minor error in the uranium decay chain, and correction of a typographical error in the concentration report. CAP88-PC V2.0 was approved for demonstrating compliance with 40 CFR 61.93 in October 1999 and was used by four sites in 2001.

The COMPLY code (EPA 1989c) is a screening model consisting of four levels, each of which requires increasingly detailed site-specific data to produce a more realistic (and less conservative) dose estimate. COMPLY is used for comparatively small sites because it does not require extensive site-specific data. It has a large radionuclide library comparable to that for CAP88, and may be used for situations where the receptor is located nearer the site than is appropriate for other codes. However, lower screening levels of COMPLY will provide more conservative results. Four DOE sites (EML, PPPL, KCP, and NREL) used COMPLY to estimate doses for their air emissions reports because the MEI receptor was located within 3 km of the site. Three sites used COMPLY at level 4 (the least conservative option using a maximum of site-specific data), while KCP used COMPLY at level 2. EML also estimated doses for isotopes not included in the COMPLY library.

Another code, AIRDOS-PC is available, but because of its limited radionuclide library, which contains about 40 isotopes compared to several hundred in CAP88, and the lack of capability to estimate collective dose, no DOE sites utilized AIRDOS-PC for demonstrating compliance with the dose standard in the four year period.

The models used to demonstrate compliance with Subpart H contain varying degrees of conservatism, which vary with the approach, the code used, and specific conditions at the site to which it is applied. In general, the more simplistic models utilize fewer site-specific parameters as input and produce more conservative results. Because doses from radionuclide emissions at many DOE facilities are very low, the degree of conservatism in the resulting dose estimates does not significantly impact the ability of sites to demonstrate compliance with the dose standard. However, because of this varied conservatism, direct comparison of results from different sites does not necessarily reflect differences in public dose. With greater than 78% of the DOE sites using CAP88 and CAP88-PC between 1998 and 2001, some internal consistency is established among results reported by different sites.

1.4 Status of Compliance with the Subpart H Standard

Table 3 lists the calculated doses for routine site operations, based in general on point-source emissions. The doses are calculated from exposures of the MEI to atmospheric radionuclide emissions at DOE sites during calendar years 1998 to 2001. The EPA-approved computer codes used to produce the dose estimate for each site and the approximate distance to the nearest receptor for each site also are indicated in Table 3. Figures 2 through 5 show

graphically how the dose at each DOE site compares with the 10 mrem/yr (0.1 mSv/yr) standard. Over the four-year period, the estimated doses ranged from about 1.2×10^{-9} mrem/yr to 3.4 mrem/yr (1.2×10^{-11} mSv/yr to 3.4×10^{-2} mSv/yr).

Of the 37 operational DOE sites subject to Subpart H, 85% or more of the sites reported doses below 0.1 mrem/yr (0.001 mSv/yr) or 1% of the standard over the four-year period. The highest estimated dose from normal operations was in 1998 at 34% of the standard at 110 meters (NREL). In 1998, NREL used conservative assumptions in EPA's COMPLY computer model to determine effective dose equivalent to the public. In following years, the dose at NREL decreased to 0.02 % of the standard. In 2001, NREL used version 1.5d of COMPLY to calculate potential doses. Although still conservative, this model used more realistic distances from sources to potential receptors. These distances were greater than in previous years due to a land acquisition and resulting changes in site boundaries. In addition, fewer point sources were used in the COMPLY model dose calculations in 2002 than in previous years due to consolidation of site laboratory operations. On average, six sites reported doses between 0.1 and 1 mrem/yr (0.001 and 0.01 mSv/yr), at distances ranging from 110 to 3,720 meters. The general trend of the reported dose estimates between 1998 and 2001 was for doses to decrease. For a few sites however, dose estimates increased (e.g., GJO, HANF, PGDP, and RFETS), but doses remained well within applicable limits.

Diffuse sources of radionuclide emissions (other than radon) generally result from secondary processes such as the resuspension of contaminated soil and contribute only a small fraction to the facility emissions. Because the reported results demonstrate that radionuclide emissions from DOE facilities are generally several orders of magnitude below the standard, the inclusion of non-point source emissions in dose estimates does not impact DOE facility compliance with the 10 mrem/yr (0.1 mSv/yr) standard. At most sites, the dose from diffuse sources is lower than that from point sources. The exceptions to this are inactive sites such as NTS, where large areas of surface contamination contribute most if not all of the off-site dose, or sites such as LANL, NTS, and Hanford, where both point and diffuse sources are present. For sites such as Hanford where the defense materials production mission has ceased, the diffuse dose now comprises a larger fraction of the total site MEI dose.

1.5 Emissions from Diffuse or Non-Point Sources (Other than Radon)

The radionuclide emission requirements in Subpart H do not specifically address non-point or diffuse source emissions such as resuspension of radionuclides from contaminated surfaces or the atmospheric emissions of radionuclides from contaminated ponds and lagoons. Because the primary sources of exposure for operating DOE facilities are emissions from stacks and vents, the regulations and associated guidance emphasize point sources. DOE has been evaluating radionuclide emissions associated with non-point or diffuse sources and has provided this data along with the dose assessment results as part of the 1998 to 2001 air emissions reports. Because the diffuse source and point source dose estimates are carried out independently using very different methods, the calculated doses may not be directly comparable. In addition, because these major emission sources may not be at the same location, the maximally exposed individuals may be at different off-site locations and their doses are not necessarily additive.

In 1998 and 1999, fifteen DOE sites reported doses from non-point or diffuse source emissions. Seventeen DOE sites reported diffuse sources in 2000 and in 2001 (Table 4). Several of these sites included part or all of the diffuse source emission estimates in the total dose that was reported for NESHAPs compliance. The dose estimates from these emissions are presented in Table 7. Combined radionuclide emissions to the atmosphere in 1998 from all diffuse sources

identified at DOE sites amounted to approximately 1900 curies (70 TBq); in 1999, 2000 and 2001 the releases were approximately 880, 2000, and 2800 Ci (32.6, 74, and 104 TBq), respectively. This is generally comparable to levels released in past years, although the 2001 figure is higher. The emissions from diffuse sources amount to less than 2% of the total DOE emissions from point sources for the four-year period. The maximum potential dose to an off-site individual from diffuse sources was approximately 1.1 mrem (0.011 mSv) at the site boundary at FEMP in 2000.

The methods used to generate release estimates for diffuse sources varied from site to site. These methods often utilized conservative assumptions when measured data were not available. The results are further complicated by the variety of diffuse sources at DOE facilities, ranging from contaminated soil areas to evaporation ponds used for temporary storage of radioactive liquid wastes. DOE is continuing to identify and characterize non-point or diffuse sources at its facilities. EPA has proposed various approaches to evaluating emissions from diffuse sources, and they are being evaluated by DOE for use in assessing the non-point source emissions. DOE will continue to provide information and data on diffuse source emission to EPA. DOE will utilize environmental surveillance measurements, where available, for verification purposes and source term development.

At some time during 1998 to 2001, diffuse or non-point sources were the major contributor to dose at ten sites (ETEC, FEMP, GJO, HANF, INEEL, LEHR, LLNL, MEMP, NTS, and SNLT). Several of these sites (ETEC, FEMP, GJO, HANF, LEHR, NTS, and SNLT) no longer operate according to their historic mission within the Department and are conducting activities associated with environmental remediation and waste management. At NTS and SNLT, large area sources are the primary contributors to off-site doses and these sites report the results of diffuse source dose assessments to demonstrate compliance with the Subpart H standard. On a year-by-year basis, diffuse source emissions from sites conducting remediation activities will vary, and the number of sites with diffuse emissions will likewise vary as these projects are initiated or completed. In addition, some sites modeled remediation releases as point sources because they were associated with specific hot spots, while some modeled those types of activities as diffuse emissions (or area sources), while still others, such as HANF, did not model remediation activities and resuspension of surface soil as either point sources or area sources, but estimated total diffuse emissions from environmental monitoring results. GJO has a remedial action project where buildings were demolished. Removal of contaminated soils resulted in the diffuse release of 7.4×10^{-6} Ci (2.7×10^{5} Bq) from the ^{238}U decay chain. Individual nuclide emissions were calculated based on activity-per-unit mass for each radionuclide. The resulting dose did not exceed the 2001 dose of 0.047 mrem/yr (4.7×10^{-4} mSv/yr).

The West Valley Demonstration Project (WVDP) identified two potential non-point sources. These are the low-level waste treatment lagoons and the contaminated soil containment area. The total non-point source term is primarily composed of 0.0053 Ci (2.0×10^{8} Bq) of tritium. The estimated doses from diffuse sources did not exceed the 2001 dose of 4.3×10^{-4} mrem (4.3×10^{-6} mSv).

The primary diffuse radiological effluents at the Nevada Test Site (NTS) are plutonium, noble gases and tritium. These radionuclide emissions originate from underground nuclear testing, firing sites, containment and evaporation ponds, and waste management facilities. Tritium evaporates from containment ponds that hold radiologically contaminated water seeping from the tunnels in Area 12. The maximum annual tritium emissions for NTS were 560 Ci (2.0×10^{13} Bq) modeled as a diffuse source in 2001. Small amounts of Pu are also present in

surface soil. Air samples detected quantities slightly greater than the minimum detectable concentration of $^{239/240}$Pu. In addition, two containment ponds were modeled as point sources, and their dose was included in the point source dose. CAP88 was used to back-calculate the total release. Because these activities are part of normal operations, the MEI dose was combined for all sources, which was 0.17 mrem (1.7×10^{-3} mSv). The distance to the MEI was over 42,000 m, by far the longest distance to the MEI for any DOE site.

The Laboratory for Energy-Related Health Research (LEHR) was used for studying bone-seeking radionuclides (strontium and radium) in dogs, and is now undergoing D&D and environmental restoration. Several areas with known or potential soil contamination contribute to diffuse emissions: two leach fields, two chemical dispensing areas, septic tanks, seepage pits, two dog pen areas, and several trenches used to bury radioactive waste. Peak annual 1998 diffuse emissions were low (4.4×10^{-9} Ci, 1.6×10^{2} Bq). The diffuse emissions consisted primarily of Ra-226 decay products. The dose to the MEI did not exceed the 1998 dose of approximately 4.2×10^{-3} mrem (4.2×10^{-5} mSv).

Diffuse sources at LLNL include tritium and plutonium in soil in two locations, tritium outgassing from hazardous waste processing, and other operations that store and treat a variety of liquid and solid radioactive and mixed waste. Waste processing operations included packaging of tritium-contaminated equipment during decommissioning activities, a tank farm, and an outdoor area where waste containers are stored. Except for the tank farm, all release estimates were based on environmental measurements. Tank farm emissions were estimated from radionuclide inventories in the facility. The Southeast Quadrant of LLNL has elevated levels of ^{239}Pu in the surface soil, resulting in an estimated annual dose from airborne particulates as measured by direct environmental sampling. Estimated emissions from the site consisted of about 12 Ci (0.44 TBq) of tritium and small quantities of transuranic and other radionuclides. The dose to a maximally exposed individual from diffuse emissions was estimated to not exceed about 2.8×10^{-2} mrem (2.8×10^{-4} mSv) in 1999.

Diffuse sources at LLNL site 300 contain mainly tritium and uranium. Tritium evaporation occurs from landfills, firing table soils, and groundwater. Doses to the site maximally exposed individual were estimated directly from air concentrations measured at the receptor location. The maximum annual estimated dose from diffuse tritium emissions was 3.7×10^{-3} mrem (3.7×10^{-5} mSv) in 2000. Depleted uranium isotopes also were released from resuspension of surface soils at several locations. The average concentration of depleted uranium in air (corrected for contributions from natural uranium in resuspended soil) was used to calculate dose to the MEI, estimated at 5.0×10^{-3} mrem (5.0×10^{-5} mSv) in 1998.

Nuclear material production facilities at the Hanford Site have been shut down, and the site is proceeding with deactivation of the facilities and environmental restoration. Therefore, radionuclide emissions from diffuse sources have become a significant contributor to the overall air emissions from Hanford activities. Diffuse sources include several kinds of active and inactive waste handling, storage and disposal facilities as well as operating and standby facilities and contaminated surface soil. Hanford uses environmental monitoring data from site perimeter air sampling stations to estimate radionuclide emissions and dose from diffuse sources. Measured radionuclide concentrations at the site perimeter were corrected for background levels and contributions from stack sources, and any excess was attributed to diffuse sources. Although the annual average ambient air concentrations for several radionuclides at the perimeter were numerically greater than stack plus background levels, those concentrations were generally not statistically different from concentrations at distant community stations that are unaffected by Hanford effluents. Estimated diffuse source

emissions consisted of 0.5 Ci (2.9×10^{10} Bq) of uranium and mixed fission products during 2001, resulting in a maximum MEI dose of 0.37 mrem (3.7×10^{-3} mSv) in 2001.

Diffuse sources at INEEL include contaminated soil areas, fuel storage pools, evaporation ponds, and miscellaneous other sources. Soils that were posted as contaminated areas for the purposes of radiological control were considered potential source terms for diffuse emissions using estimates of resuspension releases from undisturbed soils. Up to 230 Ci/yr (8.5 TBq) of tritium were estimated in diffuse emissions, along with small amounts of transuranics and other isotopes. In order to locate the MEI at this large site, doses from the major release points were modeled at 63 potential receptor locations, and the location with the highest combined dose was selected as the MEI. Once the MEI was located, emissions from all point and diffuse sources were modeled at this location. The annual diffuse source dose to this hypothetical MEI did not exceed 3.0×10^{-3} mrem (3×10^{-5} mSv) between 1998 and 2001.

There are a variety of non point sources at LANL, including surface impoundments, shallow land burial sites, open burn sites, firing sites, outfall, container storage areas, unvented buildings, waste treatment areas, solid waste management units, and tanks. The Los Alamos Neutron Science Center (LANSCE), a proton linear accelerator, was the source of most of the fugitive emissions in 1998 releasing 413 Ci (15 TBq) of ^{11}C and 17 Ci (0.63 TBq) of ^{41}Ar. Non-point sources also included open-air explosive tests involving depleted uranium, transuranic waste handling, liquid waste effluent that empties into a canyon, and decommissioning of a facility. Annual average ambient concentrations of important airborne radionuclides were measured at 17 potential MEI locations, while each point source was modeled to its nearest off-site receptor. Background concentrations were subtracted. The compliance MEI was located at an office building 800 m from the major source, and non-point doses were added to the point source dose. Although it was not a major contributor to dose for that year, the highest dose from diffuse emissions for the evaluation period was 0.33 mrem (3.5×10^{-3} mSv). Since 1998, the annual dose has been approximately two orders of magnitude less.

Remedial activity at Rocky Flats (RFETS) was the primary source of diffuse emissions between 1998 and 2001. Since normal operations ceased in 1989, the resuspension of contaminated soil by wind erosion, and by mechanical disturbance due to well drilling, excavation, handling, and vehicle traffic, is usually the primary source of radionuclide emissions, however, installation of plume treatment systems, tank removals, and building demolition may have resulted in suspension of transuranic material. Non-point sources were greatest in 1998, and were composed of 1.1×10^{-4} Ci (4.1×10^{6} Bq) mixed uranium and transuranics. The highest off-site dose from all sources was calculated to be 0.04 mrem (4.1×10^{-4} mSv) in 1998.

At SRS, a variety of filters, tanks, basins, and over 30 individual waste sites are listed as non point sources. Unidentified beta-gamma emissions were assumed to be Sr-90, and alpha emissions were assumed to be Pu-239. The diffuse emissions were primarily tritium (930 Ci [3.4×10^{13} Bq] in 1998), which was two orders of magnitude below the point source releases of tritium. Later on, the peak diffuse dose was 6.2×10^{-3} mrem (6.2×10^{-5} mSv) in 2001, due primarily from 470 Ci (17 TBq) tritium.

The Energy Technology Engineering Center (ETEC) has been undergoing D&D activities since operations ceased in 1988. Small amounts of residual contamination remain on the site. Potential diffuse sources include one contaminated soil area covered with dense brush, therefore, not assumed to be a diffuse source, and a water retention sump bottom, which released an estimated 9.9×10^{-5} Ci (3.7×10^{5} Bq) due to resuspension of contaminated soil. The dose from this diffuse source to an off-site individual was 2.5×10^{-3} mrem (2.5×10^{-5}

mSv/yr). The dose from non-point source was greater than the dose reported from the single stack, but the sum of the two was still much lower than the Subpart H standard. The non-point emissions have been steadily decreasing since 1998, such that no diffuse doses were reported for years 2000, and 2001.

All emissions at the Pantex Plant originated primarily from diffuse sources but were modeled and reported with point sources. In 1999, a total of 0.039 Ci (1.4 GBq) of tritium was released from equipment calibrations, a past accident site, D&D activities at a reservoir, the Burning Ground, and operational tests. Single release points were assumed for each location in calculating the dose to the nearest MEI. The total dose from tritium has not exceeded 2.0×10^{-3} mrem (2.0×10^{-5} mSv).

Mound (MEMP) had low-level diffuse emissions of ^{238}Pu and ^{239}Pu due to resuspension from D&D activities. Environmental measurements were used to obtain the resulting value of not more than 2.1×10^{-4} Ci (7.8 MBq) being released from the Mound Site between 1998 and 2001. Doses from diffuse sources were estimated by subtracting modeled point source doses from estimates of doses based on environmental measurements. The highest estimated total off-site committed EDE to the MEI was 0.61 mrem (0.0061 mSv) in 2000.

No DOE-owned or -leased remedial action sites are operated under the Formerly Utilized Sites Remedial Action Program (FUSRAP) or the Surplus Facilities Management Program (SFMP) anymore. This program assessed diffuse source emission as the primary contributor to the off-site dose to the public. FUSRAP/SFMP sites reduced off-site migration of radioactive materials by utilizing vegetation and impermeable covers over contaminated soil areas. Weldon Springs (WSSRAP), the last site to issue reports, used environmental monitoring data to demonstrate compliance with the Subpart H standard. Methodology described in EPA (1985) was used to estimate atmospheric emissions, and CAP88-PC was used to model dispersion and the dose to the off-site MEI. Estimated EDE resulting from the evaluations was less than the 1999 dose of 0.4 mrem (4×10^{-3} mSv).

1.6 Unplanned Releases to the Atmosphere

Eight DOE facilities reported unplanned releases between 1998 and 2001. Each unplanned release exposed an off-site receptor to a dose of less than 0.053 mrem (5.3×10^{-4} mSv), well below the dose standard specified in 40 CFR Part 61, Subpart H. Each unplanned release is summarized below; further details can be found in the Annual Site Environmental Reports.

During the period from 1998 to 2001, there were no new unplanned releases at NTS. There was, however, the continuance of a 1995 incident, which resulted in a total of 16 mCi/yr of tritium released. Environmental tritium oxide (HTO, or tritiated water) samplers were installed in 1995 to monitor the progress of cleanup. The dose to the MEI was calculated to be no more than the 7.7×10^{-5} mrem (7.7×10^{-7} mSv) in 1998.

In addition to NTS, five DOE facilities reported unplanned releases during 1998. The 1998 release levels are summarized in Table 5 and amount to 3.3×10^{2} Ci (12 TBq) of tritium. Each unplanned release exposed an off-site receptor to a dose of less than 0.053 mrem (5.3×10^{-4} mSv), well below the dose standard specified in 40 CFR Part 61, Subpart H. Each unplanned release is summarized below. Further details can be found in the Annual Site Environmental Reports.

At the Paducah Gaseous Diffusion Plant (PGDP), there were nine unplanned releases from USEC facilities occurring outside a building not included in the health physics (HP) air sampling program during 1998. The estimated total quantity of uranium released was less than 71 g. These releases were included in the point-source estimates.

Two unplanned releases of radionuclides occurred in 1998 at LANL. Two events involved the release of of tritium from an exhaust stack at TA-21-209: the first a release of 60 Ci (2.2 TBq) and the second of 23 Ci (0.85 TBq). The total estimated dose to the MEI resulting from the releases was 1.7×10^{-2} mrem (1.7×10^{-4} mSv).

At ORR, there was one unplanned release at the East Tennessee Technology Park (ETTP) in 1998. During the refurbishment of a depleted uranium hexafluoride (UF_6) storage cylinder (during grit blasting of an old cylinder coating), a minor breach occurred. The amount of released uranium was calculated based on the pressure change of the cylinder and the radiological characterization of its contents. The amount was not specified in the report, but was included in the total site dose.

During 1998, three unplanned releases occurred at Hanford with a total release of 211 Ci (7.8 TBq) of tritium. On April 14, up to 20 Ci (0.74 TBq) of tritium was released through a stack during a classified experiment at the 324 Building. Tritium monitors were turned off for security reasons. On August 26, during a sample collection process in a hot cell, 123 Ci (4.6 TBq) of tritium were released from the 325 Building. The resulting dose to the MEI was estimated to be no more than 0.05 mrem (5.0×10^{-4} mSv), however, because at the time of release the wind was blowing away from the direction of the MEI. Hot cell procedures were reviewed and modified to prevent another such event. On December 8, an operator opened a valve that led to the release of 68 Ci (2.5 TBq). The resulting dose to the nearest off-site MEI was 0.003 mrem (3.0×10^{-5} mSv).

At LBNL, on July 24, 1998, an unplanned tritium emission of 35 Ci (1.3 TBq) took place at the National Tritium Labeling Facility. Silica gel containing tritium was heated in a process kiln with an unfiltered but monitored exhaust, causing release of tritium oxide to the environment. The calculated doses to the off-site MEI from this emission were 0.03 mrem (3.0×10^{-4} mSv). Corrective actions were implemented in 1998 to prevent recurrence of this type of unplanned tritium emission.

Four DOE facilities reported unplanned releases during 1999. The 1999 release levels are summarized in Table 5 and amount to 0.3 Ci (11.0 GBq) of primarily tritium. Each unplanned release exposed an off-site receptor to a dose of less than 0.002 mrem (2.0×10^{-5} mSv), well below the dose standard specified in 40 CFR Part 61, Subpart H. Each unplanned release is summarized below; further details can be found in the Annual Site Environmental Reports.

At PGDP, there were seven unplanned releases from USEC facilities occurring outside a building not included in the HP air sampling program during 1999. The estimated total quantity of uranium released was less than 30 g. These releases were included in the point source estimates.

Two unplanned releases of radionuclides occurred in 1999 at LANL. One event involved the release of 5 μCi (0.18 MBq) of Si-32 from the radiochemistry facility, a second release of 50 μCi (1.8 MBq) of Tc-99 was released from the exhaust stack of the Chemistry and Metallurgical Research facility. The total estimated dose to the MEI resulting from the releases was less than 0.001 mrem (1.0×10^{-5} mSv) from either event.

As summarized above, there were no unplanned releases at NTS, however there was a continuance of the 1995 incident. Environmental tritium oxide (HTO, or tritiated water) samplers were installed in 1995 to monitor the progress of cleanup. The estimated 1999 release resulted in a total of 301 mCi (11 GBq) of tritium released. The dose to the MEI was calculated to be 1.4×10^{-3} mrem (1.4×10^{-5} mSv) in 1999.

At ORR, there were three unplanned releases at ETTP in 1999. All occurred at the K-1435 TSCA Incinerator while burning radiologically-contaminated waste. In two incidences, disruptions caused automatic feed and systems shutdowns with subsequent thermal relief vent openings. In the third incident, the kiln surge vent opened again causing automatic feed and system shutdowns. Radiological emission calculations were performed for each event and included as part of the TSCA Incinerator source term incorporated in the 1999 ORR dose assessment.

Six facilities reported unplanned releases during 2000. The 2000 release levels are summarized in Table 5 and amount to 310 Ci (1.1×10^{4} GBq) of primarily tritium. Each unplanned release exposed an off-site receptor to a dose of less than 0.003 mrem (3.0×10^{-5} mSv), well below the dose standard specified in 40 CFR Part 61, Subpart H. Each unplanned release is summarized below; further details can be found in the Annual Site Environmental Reports.

At LANL, two unplanned releases of radionuclides occurred in 2000. The first event involved an equipment malfunction at a decommissioned radiochemistry site resulting in the release of 215 Ci of tritium. The second event occurred over a 6-hour period at the Weapons Engineering Tritium Facility resulting in a release of 90 Ci of tritium. These releases resulted in dose estimates that were below the threshold of required reporting to EPA.

At SRS, two releases occurred in September 2000 at the tank farms. The F-Area Tank Farm released 3.54×10^{-5} Ci of ^{137}Cs. No specific cause was identified. The second release was of 2.51×10^{-4} Ci of ^{137}Cs and occurred at the H-Area Tank Farm due to shutdown of the HEPA filter after moisture entered the ventilation duct through a tear. The tear was subsequently repaired.

At PGDP, there were fifteen unplanned releases in USEC facilities occurring outside a building not included in HP air sampling program during 2000. The estimated total quantity of uranium released was less than 47 g. These releases and resulting doses were included with the point source data.

There were no new unplanned releases at NTS; however, there was a continuance of the 1995 incident. Environmental HTO samplers were installed in 1995 to monitor the progress of cleanup. The estimated 2000 release resulted in a total of 370 mCi of tritium released. The dose to the MEI was calculated to be 1.8×10^{-3} mrem (1.8×10^{-5} mSv) in 2000.

At ORR, there were two unplanned releases at ETTP in 2000. In the first incident, the surge vent on the K-1435 TSCA Incinerator opened, causing automatic feed and system shutdowns. Radiological emission calculations were performed for the event and included as part of the TSCA Incinerator source term incorporated in the 2000 ORR dose assessment. In the second incident, a UF_6 cylinder breach was discovered in the K-1066-E storage yard. An emissions assessment was performed and included as a point source in the total site dose.

At ANL-E, there was an unplanned release of ^{22}Rn from Building 11 in December 2000 during decontamination and decommissioning activities. An accidental release of 0.008 Ci of ^{22}Rn occurred during the opening of sealed solutions of ^{226}Ra.

There were four unplanned releases from DOE sites during 2001. The 2001 release levels are summarized in Table 5 and amount to 7,565 Ci (2.76×10^5 GBq) of tritium. Each unplanned release exposed an off-site receptor to a dose of less than 0.042 mrem (4.2×10^{-4} mSv), well below the dose standard specified in 40 CFR Part 61, Subpart H. Each unplanned release is summarized below; further details can be found in the Annual Site Environmental Reports.

There were no new unplanned releases at NTS; however, there was a continuance of the 1995 incident. Environmental HTO samplers were installed in 1995 to monitor the progress of cleanup. The estimated 2001 release resulted in a total of 200 mCi of tritium released. The dose to the MEI was calculated to be 9.6×10^{-4} mrem (9.6×10^{-6} mSv) in 2001.

At PGDP, there were eight unplanned releases in USEC facilities occurring outside a building not included in HP air sampling program during 2001. The estimated total quantity of uranium released was less than 29 g. These releases and resulting doses were included with the point source data.

At LANL, over the course of one hour, 7,565 Ci (280 TBq) of tritium were released from the Weapons Engineering Tritium Facility. Alarms were activated, and the release was isolated and shut off. The total dose from releases to the off-site MEI was calculated to be less than 0.042 mrem (4.2×10^{-4} mSv).

The fourth event was at WVDP. It was discovered by survey that the waste tank farm ventilation system had a small amount of unexpected condensate of ^{137}Cs deposited from the stack. The area was isolated, and contamination removed. No releases occurred as a result of this event. No dose was calculated.

2.0 Supplemental Information

DOE radionuclide emissions to the atmosphere that are subject to Subpart H of 40 CFR Part 61 include point source or stack emissions from routine operations and non-point source or diffuse emissions such as resuspended material from contaminated soil areas. Most point source effluents are routinely monitored, whereas many of the diffuse sources and potentially low-emission point sources are monitored only through ambient air sampling. The emissions from these non-point sources are either calculated using computer modeling or derived using area air sampling. There are other sources of radionuclide emissions reported under Subpart H that are unplanned but are assessed and included as part of the overall site emissions. Additionally, some DOE sites have radionuclide releases to the atmosphere that are not covered under Subpart H. These sources involve radon emissions which are covered by other sections of the NESHAPs and subject to environmental protection limits other than the 10 mrem/yr (0.1 mSv/yr) standard of Subpart H. The radon emissions from DOE sites are discussed in subsection 3.1 and summarized in Tables 6 and 7.

Other supplemental information provided in this section includes the reported collective doses for each DOE site. The collective dose is the sum of the per capita dose over the number of individuals exposed within 50 miles (80 km) of the DOE site boundary, and is reported in person-rem. The collective doses for DOE sites are discussed in subsection 3.2.

Subsection 3.3 presents a summary of the supplemental information provided by DOE sites on their compliance activities and the status of compliance with 40 CFR Part 61 Subpart H. Information is presented on DOE efforts to comply with the emission monitoring requirements.

2.1 Radon Emissions

Emissions of radon-222 (the decay product of radium-226 and uranium-238) from DOE storage and disposal sites are regulated under Subpart Q of 40 CFR Part 61. Sites containing uranium mill tailings are regulated under Subpart T. The standards for radon emissions under Subparts Q and T are expressed in terms of radon flux and are averaged over area of the radon source. The radon source is considered to be an isolated pile, impoundment or structure containing radium. Unlike Subpart H, Subpart Q contains no reporting requirements but identifies the Federal Facilities Agreement under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as a means of demonstrating compliance with its requirements. Subpart T requires pre-closure radon flux measurements at uranium mill tailings disposal sites, which must be reported to EPA during various stages of the final disposal process. DOE sites subject to Subpart T are exempt from Subpart H for radionuclide particulate emissions.

The regulations under NESHAPs do not address sources of radon-220 (a decay product of radium-224, thorium-232, and uranium-232). Because of its short half-life (55 sec), radon-220 is a smaller contributor to the public dose than radon-222, which has a 3.8-d half-life. Nevertheless, DOE has collected radon-220 emission data and associated dose estimates from its sites. This effort included flux measurements at storage or disposal facilities that handle wastes containing significant concentrations of thorium-232 and uranium-232. In addition to waste management operations, DOE has also investigated the contribution of radon-220 to doses associated with its normal operations.

Doses from radon-220 result primarily from exposure to its decay products (polonium-216, lead-212, bismuth-212, thallium-208, and polonium-212). Both CAP88 and CAP88-PC model

the dose from radon-220 emissions, however the doses are generally negligible because of its short half-life (55 sec), and the code does not include the dose from longer-lived decay products. The methods and assumptions used to calculate the radon-220 doses are not detailed in all site reports. However, doses attributable to radon-220 are typically estimated by assuming that all radon-220 has decayed to its first relatively long-lived decay product (lead-212) prior to transport beyond the site boundary. This assumption may provide a conservative estimate of the radon-220 dose depending on the location of the receptor.

The Mound Plant has one source of radon-222 in addition to natural emissions from soil and building material. This source results from residual radium-226 associated with an operation that was terminated in the early 1950s. The radon-222 emission rate from this source and from natural sources is estimated to be no more than 4.6 Ci/yr (170 GBq), over the years 1998 to 2001. The dose from radon-222 to a member of the public calculated for 1998 to 2001 did not exceed calendar year 2000's dose of approximately 0.004 mrem (4.0×10^{-5} mSv).

The majority of all radon-220 emitted from DOE sites during 1998 to 2001 was released from the WVDP, which released 14.9 Ci/day (0.56 TBq/day) in 1998 from THOREX waste. This amounted to a release of 5400 Ci/yr (141 TBq/yr) and contributed more than 50% to the site's total 1998 off-site dose of 0.096 mrem (9.6×10^{-4} mSv). Subsequent releases have decreased to as low as 6.2 Ci (0.23TBq) in 2001.

Another significant source of radon-220 was Argonne National Laboratory-East. A decreasing trend in radon emissions from 1998 to 2001 began with total of 240 Ci (9 TBq) released from the M-Wing of Building 200 in 1998. This source resulted in a MEI dose of 0.015 mrem/yr (1.5×10^{-4} mSv/yr) in 1998.

The Bettis Site indicated that it had released radon-220 in the years 1998 to 2001. Annual releases from Bettis ranged from 256 Ci (9 TBq) in 2001 to the 1999 peak of 390 Ci (14 TBq). Doses to the MEI from radon releases did not exceed 0.28 mrem (2.8×10^{-3} mSv).

At GJO, Rn-222 emissions were calculated by summing the dose contributed from four groups of radium containing calibration pads at the location of the closest business in DOE-leased buildings. Specific emissions were not reported, but the dose from radon did not exceed the 1999 dose of 0.12 mrem (.0012 mSv).

FEMP released 0.83 Ci (31 GBq) of radon-222 in 2001. As a result of the conservative method of dose calculation, the resulting MEI dose from this release is the highest for 2001 among all sites with radon releases. The MEI dose for this radon release was estimated to be 5.4 mrem (0.054 mSv), which is about 6 times greater than the FEMP MEI dose.

2.2 Collective Dose Estimates

In addition to the dose to the MEI for each DOE site, DOE requires, through DOE O 5400.5, that the collective dose to populations within 50 miles (80 km) of the sites to be evaluated and reported annually. Although this information is not required in the radionuclide air emissions reports that are submitted to EPA under the NESHAPs, all facilities were requested by DOE headquarters to provide collective dose data as available for inclusion in this summary report. Collective doses to these populations are also reported for all pathways (including effluents released to air and water) in Annual Site Environmental Reports.

The collective dose for radionuclide air emissions may be obtained from several of the EPA-approved computer codes such as CAP88 and CAP88-PC, as well as from a number of other

models used by DOE sites. The collective population dose is typically obtained by computing the average dose for a central point in a given geographical sector, multiplying that dose by the number of persons residing in that sector, and summing the doses from all sectors. The collective dose is expressed in person-rem (person-Sv) and is a quantity that may be used as a basis for assessing collective risk. The results given in Table 8 indicate that the collective dose from all DOE operations is in a generally decreasing trend from a high of 57 person-rem (0.57 person-Sv) in the year 1998 to 45 person-rem (0.45 person-Sv) in 2001. Twelve sites (ORR, LLNL-300, SRS, BNL, PPPL, FEMP, MEMP, ANLE, RFETS, LBNL, LLNL, and Bettis) accounted for 95% of the total collective dose from DOE operations during the evaluation period from 1998 to 2001. Together, the first two account for almost 50%.

Many of the collective doses reported in the table include both normal operating releases and all other sources of airborne radionuclide emissions. Several DOE sites are located in close proximity to each other, near major urban areas, and therefore some individuals within these areas may be exposed to emissions from more than one DOE site. Although the reporting requirements are for annual doses, each annual dose may be evaluated for its contribution to total lifetime excess cancer risk. According to risk estimates currently used by EPA (EPA, 1989a), the annual collective dose from DOE facilities is much lower than that which would be expected to produce a single cancer death during the lifetimes of the exposed populations. The cumulative population risks over time are not addressed by these reporting requirements. The annual doses are also many orders of magnitude lower than the dose received by the exposed populations from natural background radiation, which is approximately 300,000 person-rem per year in a population of one million.

2.3 Four-Year Trends

Overall, there has been little change across DOE sites in total releases (Figure 6) and a downward trend in MEI and collective doses to individuals and populations. The releases from stacks have remained relatively constant, while diffuse releases have climbed slightly due to remediation at sites where production has ceased. No trend would be expected in the unplanned releases as it represents a summation of generally discrete events. However, the 1999 releases were particularly low, and the 2001 releases are high due to a one-time tritium event at LANL. The total CEDE across all DOE sites has decreased from 57 person-rem in 1998 to 45 person-rem in 2001 (Figure 7). The maximum MEI dose never exceeded the 10 mrem (0.1 mSv) dose limit (Figure 8). Only 3 sites exceeded 1.0 mrem (1.0×10^{-2} mSv) over the course of the four-year period. The maximum MEI dose in 1998 was 3.4 mrem (0.034 mSv) at NREL, but the MEI dose decreased to 0.2 mrem (0.002 mSv) by 2001. By 2001, the highest MEI dose (LANL) was 1.8 mrem (0.018 mSv). Also, the number of sites reporting values in the higher dose ranges has declined, with an associated rise in the number of sites reporting MEI values in the 0.01 to 0.1 mrem (1×10^{-4} to 1×10^{-3} mSv) range over the four-year reporting period (Figure 9).

3.0 Summary of DOE and EPA Activities and Initiatives

Calendar years 2000 and 2001 had a great deal of activity regarding changes and new initiatives in the Subpart H compliance program. Perhaps the largest and most resource intensive initiative was the effort to amend Subpart H and adopt a new American National Standards Institute (ANSI) standard, ANSI N13.1-1999, for monitoring of emissions from stacks and vents. EPA's May 2000 proposed rule led to disagreements within the regulated community and was followed by a July 2000 public hearing to discuss and resolve the differences. The central issue was that certain groups, including DOE, agreed with EPA's proposed rule that the new standard should apply to new or modified stacks; other parties felt that the standard should apply to all stacks and vents, including existing ones. After the public hearing on the Subpart H amendment there was an open period to supply data on the issue to EPA. DOE was able to show, through performance data from the DOE complex, that there would be no health or environmental benefit to offset the substantial cost of applying the new standard to existing stacks. Nonetheless, in part because of an alarm with Hanford's Plutonium Finishing Plant stack, and in part because existing stacks appeared to remain under the old standard, more stringent inspection and QA/QC requirements were considered by EPA. Separately, issues of the definitions of the "MEI" and "off-site" also arose, in part because certain DOE sites, such as Hanford and Oak Ridge, were becoming more open, re-industrialized and privatized.

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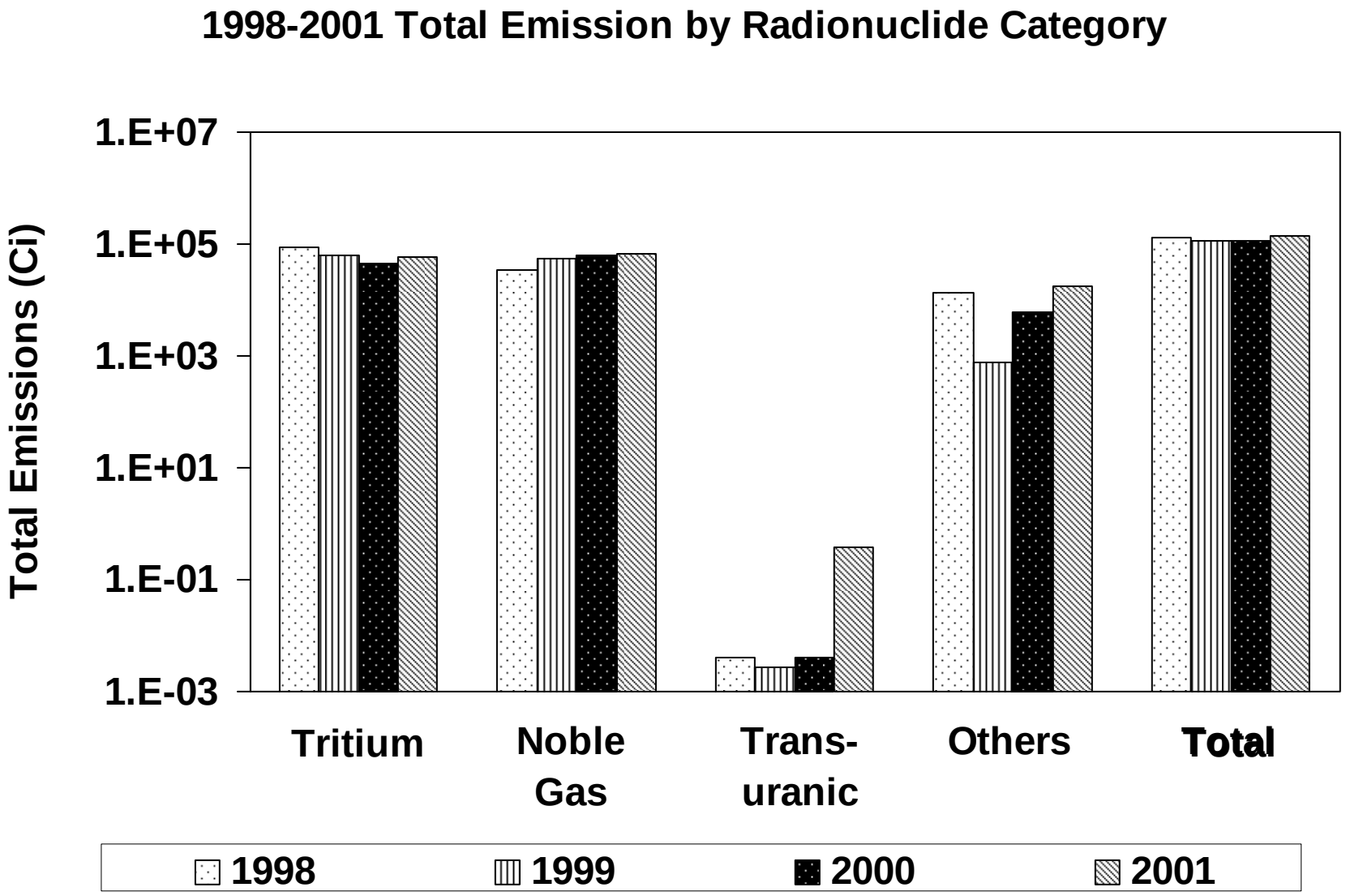

Figure 1. Total Emissions from U.S. Department of Energy Facilities from 1998 to 2001 by Radionuclide Category.

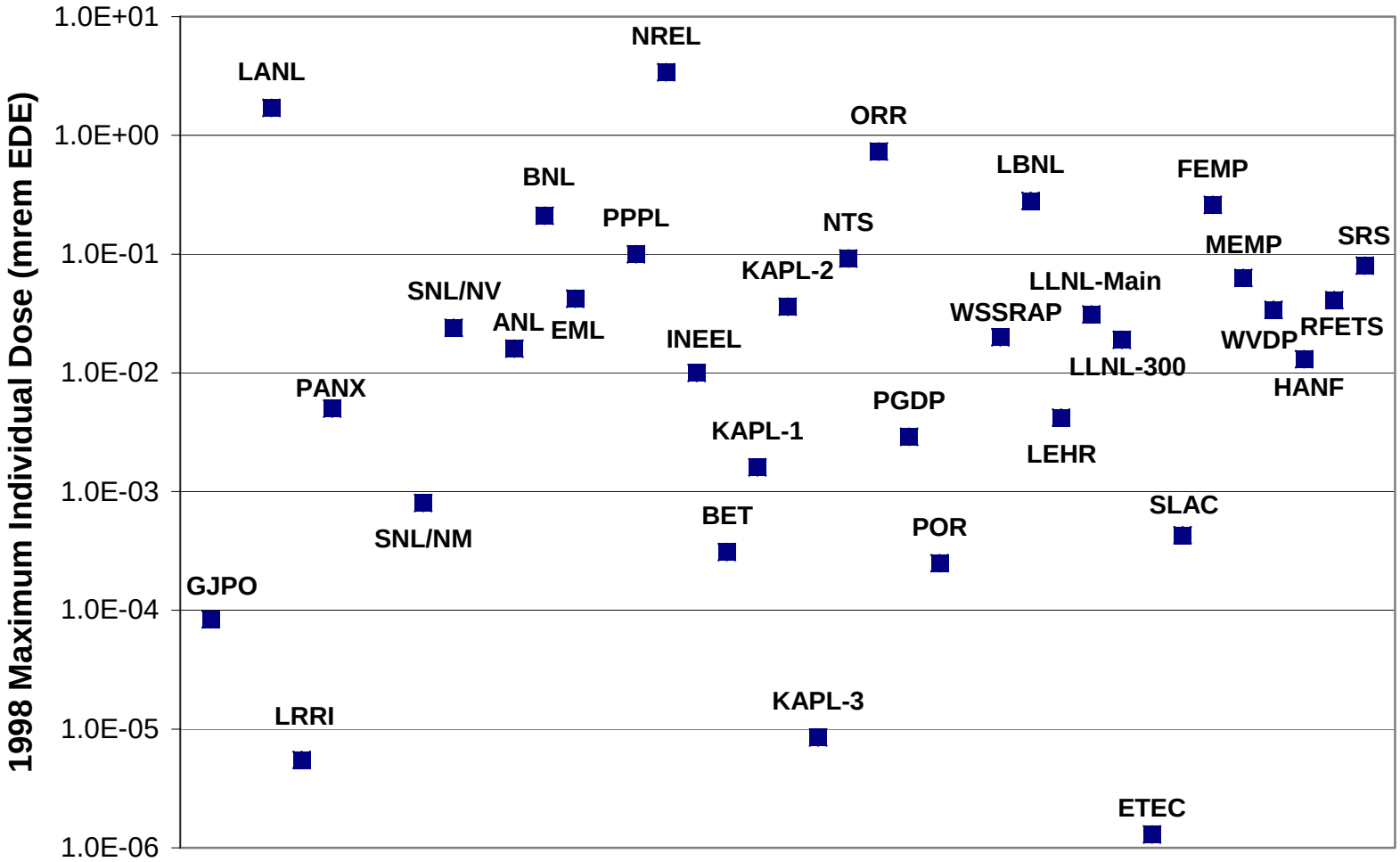

Figure 2. Maximum Individual Dose Reported for Each U.S. Department of Energy Facility for 1998.

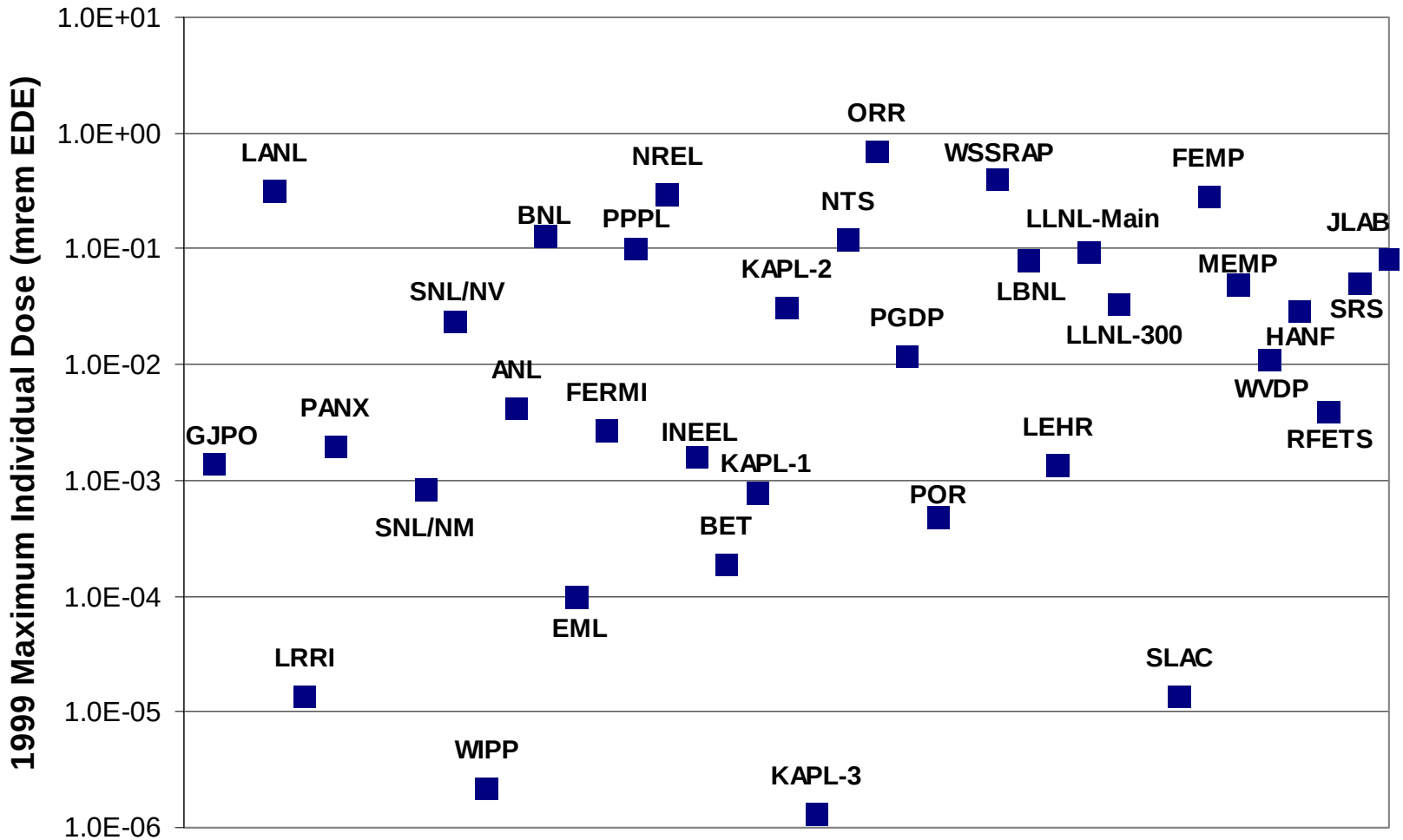

Figure 3. Maximum Individual Dose Reported for Each U.S. Department of Energy Facility for 1999.

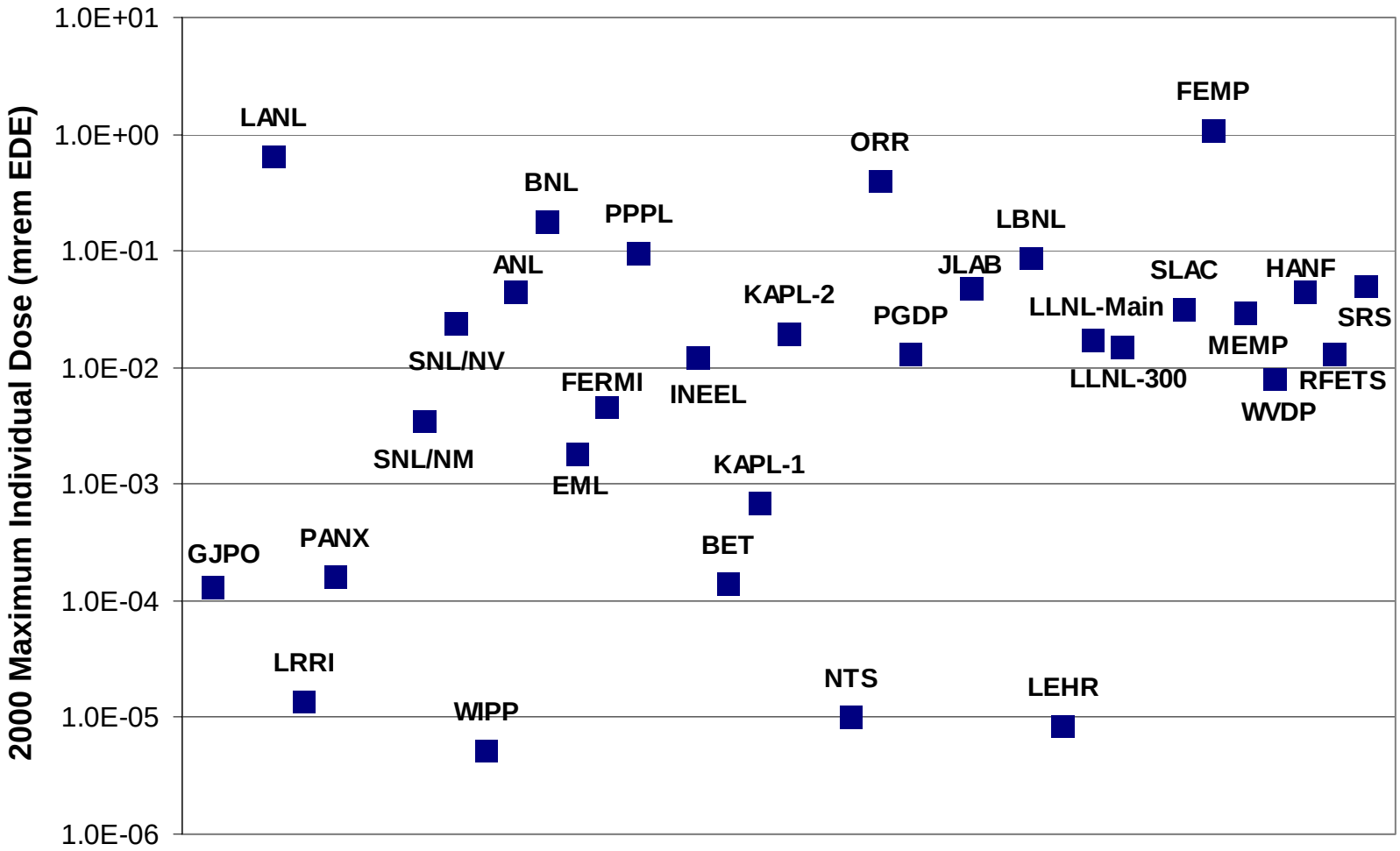

Figure 4. Maximum Individual Dose Reported for Each U.S. Department of Energy Facility for 2000.

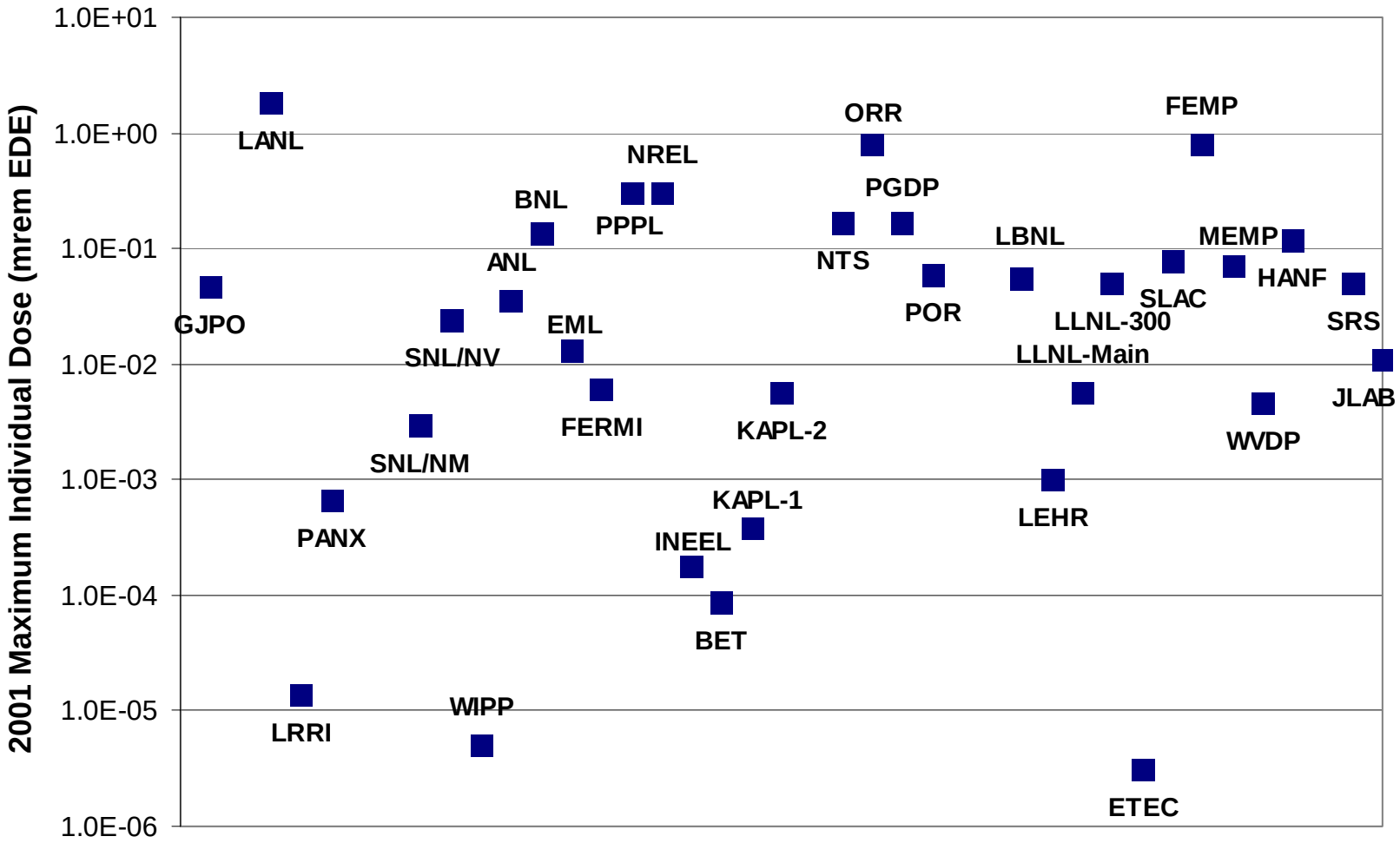

Figure 5. Maximum Individual Dose Reported for Each U.S. Department of Energy Facility for 2001.

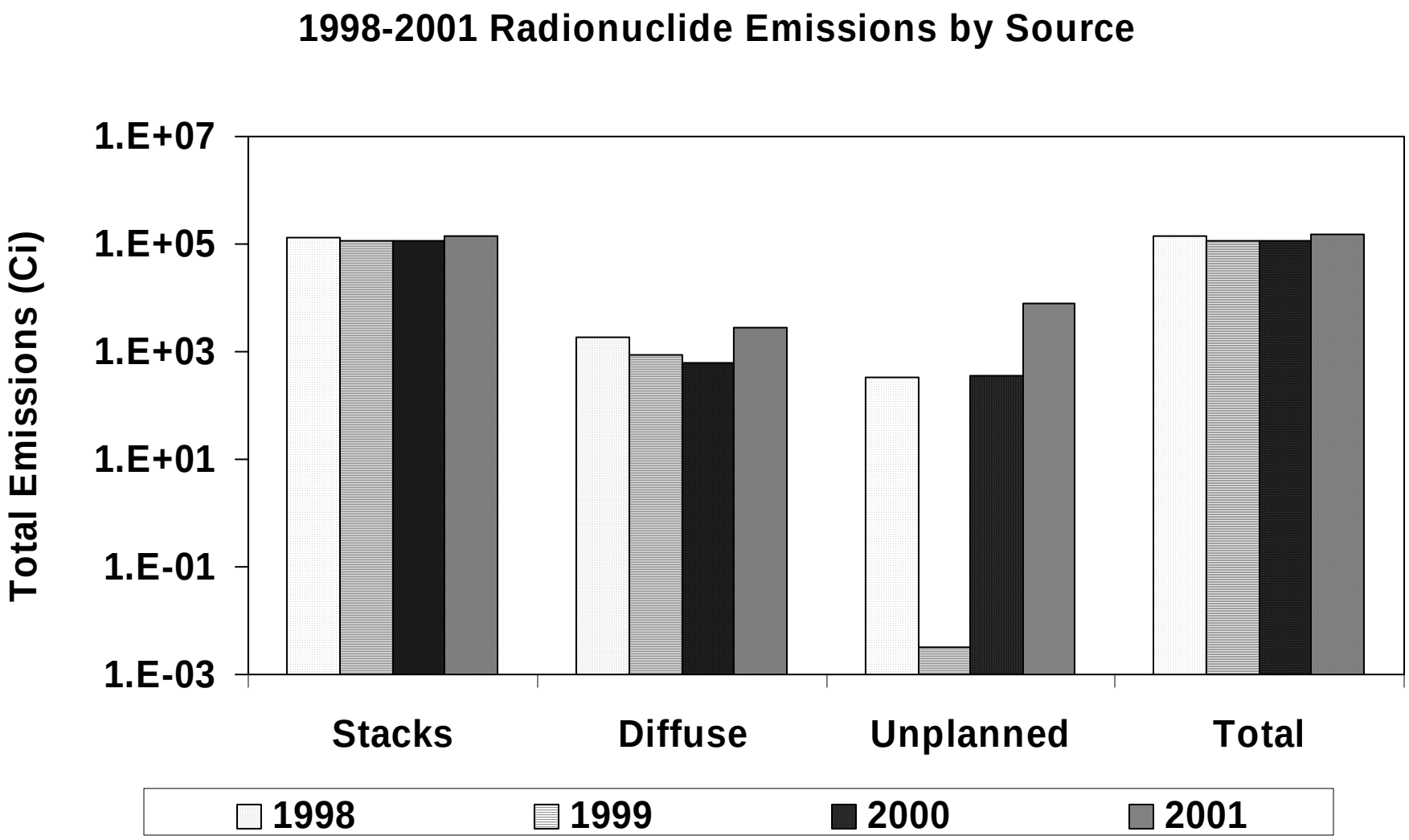

Figure 6. Trends in Radionuclide Emissions by Source Type from 1998 to 2001.

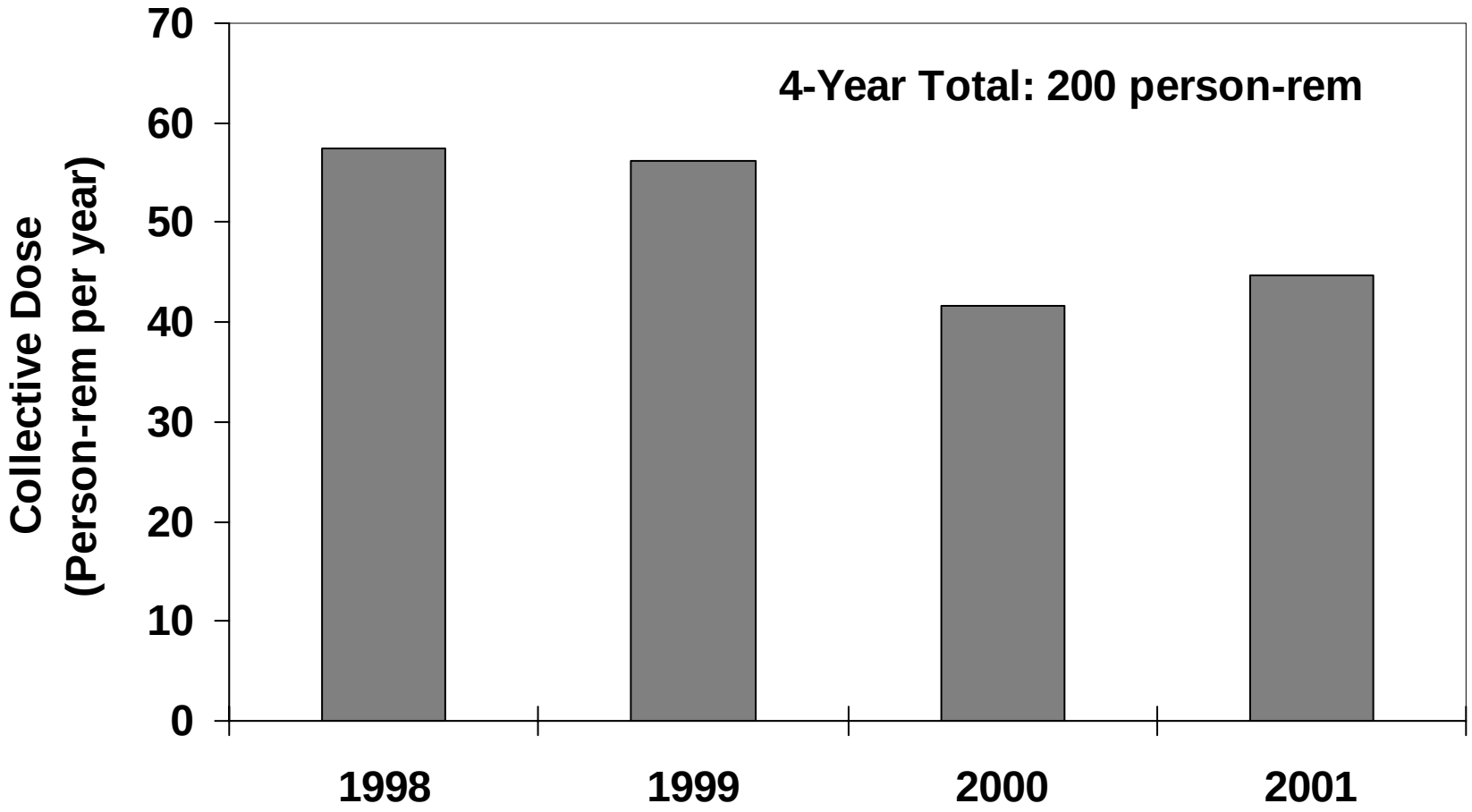

Figure 7. Total Collective Effective Dose Equivalent for all DOE Sites for Calendar Years 1998 Through 2001.

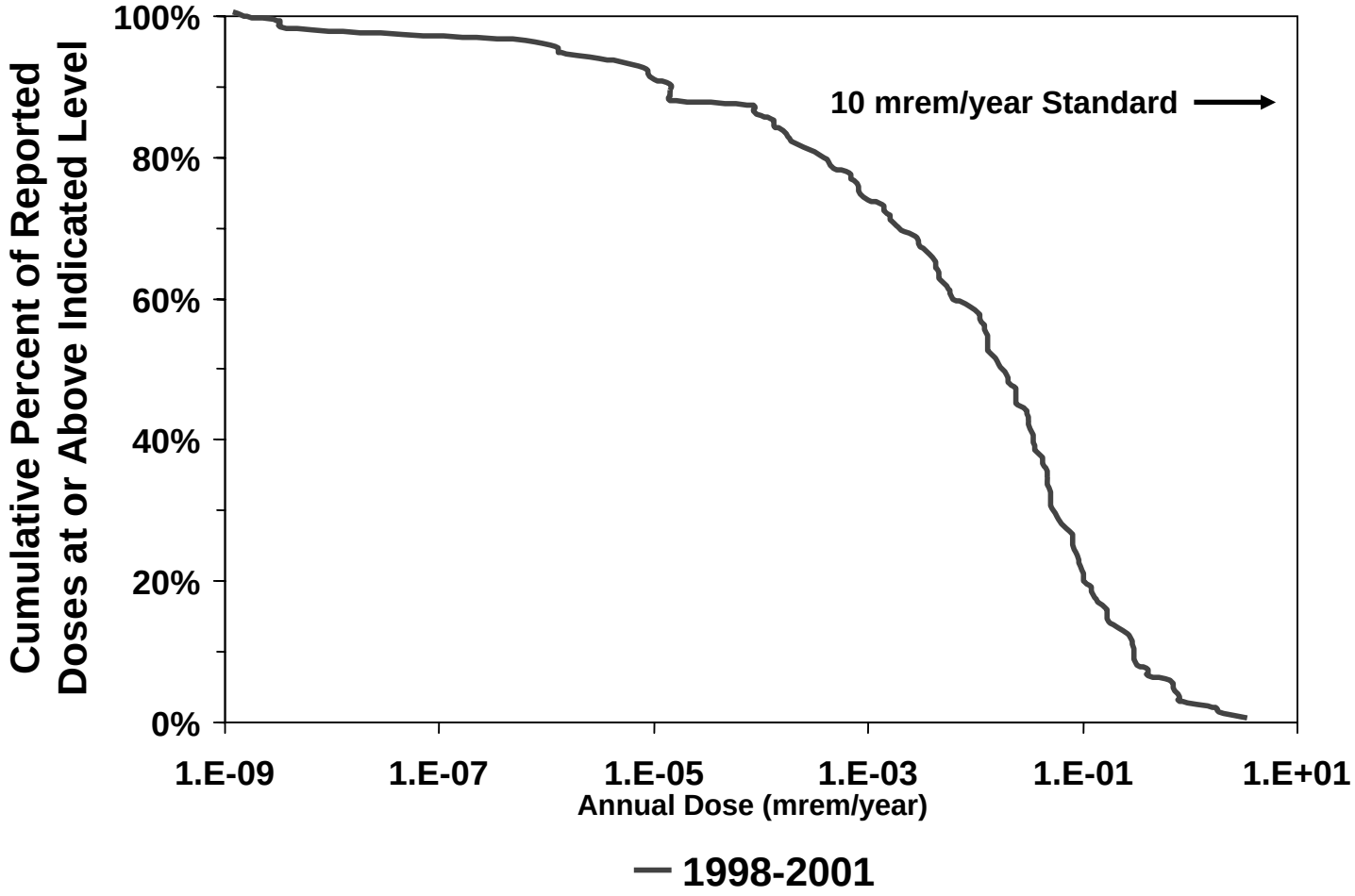

Figure 8. Annual MEI Doses from 1998 Through 2001 as a Function of Cumulative Percent at or Above Given Level.

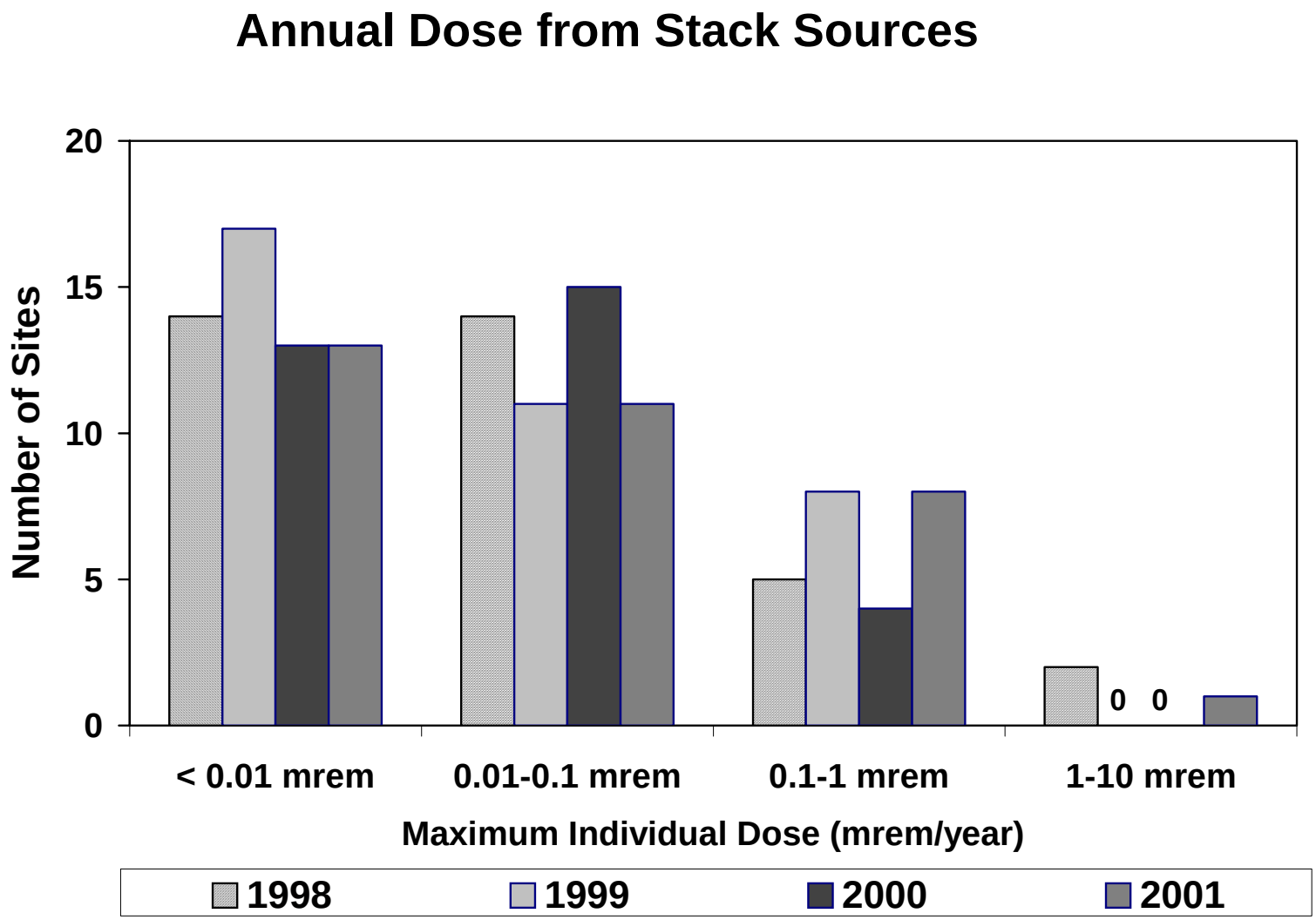

Figure 9. Number of U.S. Department of Energy Facilities Reporting Doses within Specified Dose Ranges for 1998 through 2001.

Table 1. U.S. Department of Energy Sites by Operations Office and Location (Page 1 of 1)

DOE Operations Office	Site Abbreviation	Site Name, State	Notes
Albuquerque (AL)	GJO	Grand Junction Office, Colorado	1
	KCP	Kansas City Plant, Missouri	
	LANL	Los Alamos National Laboratory, New Mexico	
	LRRI	Lovelace Respiratory Research Institute, New Mexico	2
	MEMP	Miamisburg Environmental Management Project, Ohio	7
	PANX	Pantex Plant, Texas	
	SNLA	Sandia National Laboratories, Albuquerque, New Mexico	
	SNLT	Sandia National Laboratories, Tonopah, Nevada	
Chicago (CH)	ANLE	Argonne National Laboratory-East, Illinois	
	BNL	Brookhaven National Laboratory, New York	
	EML	Environmental Measurements Laboratory, New York	
	FERMI	Fermi National Accelerator Laboratory, Illinois	
	PPPL	Princeton Plasma Physics Laboratory, New Jersey	
Golden (GOL)	NREL	National Renewable Energy Laboratory, Colorado	
Idaho (ID)	INEEL	Idaho National Engineering and Environmental Laboratory, Idaho	
	GJO	*Grand Junction Office, Colorado*	1
Naval Reactors (NR)	BET	Bettis Atomic Power Laboratory, Bettis-Pittsburgh Site, Pennsylvania	3
	KAPL-1	Knolls Atomic Power Laboratory, Knolls Site, New York	
	KAPL-2	Knolls Atomic Power Laboratory, Kesselring Site, New York	
	KAPL-3	Knolls Atomic Power Laboratory, Windsor Site, Connecticut	
Nevada (NV)	NTS	Nevada Test Site, Nevada	
Oak Ridge (OR)	JLAB	Thomas Jefferson National Accelerator Facility, Virginia	
	ORR	Oak Ridge Reservation, Tennessee	
	PGDP	Paducah Gaseous Diffusion Plant, Kentucky	4
	POR	Portsmouth Gaseous Diffusion Plant, Ohio	4
Oak Ridge Remedial Action Projects (OR-RAP)	WSSRAP	Weldon Spring Site Remedial Action Project, Missouri	5
Oakland (OAK)	ETEC	Energy Technology Engineering Center, California	6
	LBNL	Ernest Orlando Lawrence Berkeley National Laboratory, California	
	LEHR	Laboratory for Energy-Related Health Research, California	
	LLNL	Lawrence Livermore National Laboratory, California	
	LLNL-300	Lawrence Livermore Explosive Test Site (Site 300), California	
	SLAC	Stanford Linear Accelerator Center, California	
Ohio (OH)	FEMP	Fernald Environmental Management Project, Ohio	
	MEMP	*Miamisburg Environmental Management Project, Ohio*	7
	WVDP	West Valley Demonstration Project, New York	
Richland (RL)	HANF	Hanford Site, Washington	
Rocky Flats (RFO)	RFETS	Rocky Flats Environmental Technology Site, Colorado	8
Savannah River (SR)	SRS	Savannah River Site, South Carolina	

(1) DOE Operations Office transferred from AL to ID in 2001.
(2) Formerly Inhalation Toxicology Research Institute.
(3) Naval Reactors is not an operations office. During 1998, it was a component of the Department of Energy Office of Nuclear Energy Programs; it was subsequently transferred to the National Nuclear Security Administration.
(4) Uranium enrichment operations at these sites were transferred to the U.S. Enrichment Corporation (USEC) in 1993. Regulatory authority for USEC operations was transferred to the U.S. Nuclear Regulatory Commission beginning in 1997. DOE operations at these sites currently consist of environmental remediation activities.
(5) WSSRAP issued its final NESHAP Annual Report in 2000.
(6) Formerly Rockwell International.
(7) Formerly Mound Plant; DOE Operations Office transferred from AL to OH in 1999.
(8) Formerly Rocky Flats Plant.

Table 2. Summary of Airborne Radionuclide Releases from Point Sources During Normal Operations at DOE Facilities – Calendar Years 1998 through 2001 (Page 1 of 4)

		CY 1998 Radionuclide Releases (Ci) (1)					
DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	GJO	–	–	–	3.1×10^{-7}	3.1×10^{-7}	
	KCP	–	–	–	2.2×10^{-12}	2.2×10^{-12}	
	LANL	8.1×10^{2}	1.5×10^{2}	1.2×10^{-5}	7.8×10^{3}	8.8×10^{3}	2
	LRRI	7.6×10^{-7}	–	9.7×10^{-8}	8.5×10^{-7}	1.7×10^{-6}	
	PANX	5.3×10^{-2}	–	–	1.8×10^{-4}	5.3×10^{-2}	3
	SNLA	7.7×10^{0}	4.8×10^{0}	2.0×10^{-13}	1.4×10^{-3}	1.3×10^{1}	
CH	ANLE	2.0×10^{2}	1.1×10^{1}	7.3×10^{-5}	5.7×10^{2}	7.8×10^{2}	
	BNL	3.9×10^{1}	2.4×10^{3}	–	5.8×10^{1}	2.5×10^{3}	3
	EML	2.0×10^{-7}	–	1.1×10^{-6}	9.2×10^{-6}	1.1×10^{-5}	4
	FERMI	1.5×10^{-4}	–	–	–	1.5×10^{-4}	
	PPPL	7.7×10^{1}	–	–	–	7.7×10^{1}	
GOL	NREL	5.1×10^{-4}	–	–	6.3×10^{-3}	6.8×10^{-3}	5
ID	INEEL	2.4×10^{2}	5.9×10^{3}	8.9×10^{-5}	2.1×10^{0}	6.2×10^{3}	6
NR	BET	–	–	1.3×10^{-8}	3.1×10^{-6}	3.1×10^{-6}	
	KAPL-1	–	8.7×10^{-1}	3.6×10^{-7}	6.6×10^{-5}	8.7×10^{-1}	
	KAPL-2	1.4×10^{-1}	1.2×10^{0}	–	7.6×10^{-1}	2.1×10^{0}	
	KAPL-3	–	–	–	3.6×10^{-7}	3.6×10^{-7}	
NV	NTS	6.1×10^{0}	2.7×10^{-6}	–	1.0×10^{-6}	6.1×10^{0}	
OAK	LBNL	1.2×10^{2}	–	–	1.0×10^{0}	1.2×10^{2}	2
	LLNL	1.1×10^{2}	–	2.2×10^{-7}	1.8×10^{0}	1.1×10^{2}	
	LLNL-300	3.9×10^{-1}	1.5×10^{-4}	–	2.5×10^{-1}	6.4×10^{-1}	
	ETEC	1.9×10^{-5}	–	3.6×10^{-9}	2.0×10^{-6}	2.1×10^{-5}	
	SLAC	–	6.4×10^{-2}	–	2.6×10^{-1}	3.2×10^{-1}	
OH	FEMP	–	–	–	5.2×10^{-7}	5.2×10^{-7}	
	MEMP	7.4×10^{2}	–	1.5×10^{-5}	1.5×10^{-8}	7.4×10^{2}	
	WVDP	3.5×10^{-2}	–	5.5×10^{-7}	5.1×10^{-3}	4.0×10^{-2}	
OR	ORR	1.3×10^{2}	1.0×10^{4}	9.9×10^{-4}	4.7×10^{3}	1.5×10^{4}	
	PGDP	–	–	–	1.4×10^{-2}	1.4×10^{-2}	2, 7
	POR	–	–	7.7×10^{-11}	1.6×10^{-4}	1.6×10^{-4}	6, 8
OR-RAP	WSSRAP	–	–	–	5.5×10^{-5}	5.5×10^{-5}	3
RL	HANF	1.6×10^{2}	–	3.2×10^{-4}	9.3×10^{-4}	1.6×10^{2}	
RFO	RFETS	3.9×10^{-5}	–	4.5×10^{-6}	2.3×10^{-6}	4.6×10^{-5}	
SR	SRS	8.3×10^{4}	1.7×10^{4}	2.5×10^{-3}	1.2×10^{-1}	1.0×10^{5}	3
	Total	**8.6×10^{4}**	**3.6×10^{4}**	**4.0×10^{-3}**	**1.3×10^{4}**	**1.3×10^{5}**	

Table 2. Summary of Airborne Radionuclide Releases from Point Sources During Normal Operations at DOE Facilities – Calendar Years 1998 through 2001 (Page 2 of 4)

		CY 1999 Radionuclide Releases (Ci) (1)					
DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	GJO	–	–	–	3.4×10^{-7}	3.4×10^{-7}	
	KCP	–	–	–	5.5×10^{-12}	5.5×10^{-12}	
	LANL	1.6×10^{3}	1.3×10^{1}	2.4×10^{-5}	2.9×10^{2}	1.9×10^{3}	2
	LRRI	7.0×10^{-5}	–	3.6×10^{-8}	2.0×10^{-7}	7.0×10^{-5}	
	PANX	4.6×10^{-1}	–	1.3×10^{-9}	8.2×10^{-5}	4.6×10^{-1}	
	SNLA	3.5×10^{0}	5.3×10^{0}	2.0×10^{-13}	7.9×10^{-4}	8.8×10^{0}	
CH	ANLE	1.4×10^{2}	3.0×10^{0}	2.4×10^{-7}	1.2×10^{2}	2.6×10^{2}	
	BNL	2.0×10^{1}	1.6×10^{3}	–	1.2×10^{1}	1.6×10^{3}	3
	EML	–	–	1.7×10^{-9}	5.4×10^{-8}	5.6×10^{-8}	
	FERMI	–	5.4×10^{-1}	–	6.9×10^{0}	7.4×10^{0}	
	PPPL	8.2×10^{1}	–	–	–	8.2×10^{1}	
GOL	NREL	5.1×10^{-4}	–	–	5.7×10^{-3}	6.2×10^{-3}	5
ID	INEEL	2.5×10^{2}	3.1×10^{3}	1.4×10^{-5}	5.7×10^{-1}	3.4×10^{3}	
NR	BET	–	–	1.3×10^{-8}	2.1×10^{-6}	2.1×10^{-6}	
	KAPL-1	–	1.6×10^{0}	1.9×10^{-7}	6.2×10^{-5}	1.6×10^{0}	
	KAPL-2	1.4×10^{-1}	1.2×10^{0}	–	6.0×10^{-1}	1.9×10^{0}	
	KAPL-3	–	–	–	5.5×10^{-8}	5.5×10^{-8}	
NV	NTS	3.0×10^{1}	1.1×10^{-3}	–	1.5×10^{-6}	3.0×10^{1}	
OR	ORR	5.4×10^{3}	1.3×10^{4}	3.6×10^{-4}	2.9×10^{2}	1.9×10^{4}	2, 3
	PGDP	–	–	1.8×10^{-4}	8.7×10^{-3}	8.9×10^{-3}	7
	POR	–	–	2.0×10^{-10}	6.4×10^{-5}	6.4×10^{-5}	
	JLAB	–	4.4×10^{0}	–	3.5×10^{1}	3.9×10^{1}	
OAK	LBNL	3.1×10^{1}	2.0×10^{-5}	–	3.3×10^{0}	3.5×10^{1}	
	LLNL	2.8×10^{2}	–	1.1×10^{-6}	1.8×10^{0}	2.8×10^{2}	
	LLNL-300	1.9×10^{1}	1.5×10^{-4}	–	2.4×10^{-1}	1.9×10^{1}	
	ETEC	3.8×10^{-6}	–	–	3.6×10^{-7}	4.2×10^{-6}	
	SLAC	–	3.8×10^{0}	–	2.3×10^{1}	2.7×10^{1}	
OH	FEMP	–	–	–	1.3×10^{-4}	1.3×10^{-4}	
	MEMP	8.0×10^{2}	–	1.1×10^{-5}	1.5×10^{-8}	8.0×10^{2}	
	WVDP	7.2×10^{-3}	–	7.7×10^{-7}	2.1×10^{-3}	9.3×10^{-3}	
RL	HANF	1.9×10^{2}	–	4.4×10^{-4}	6.9×10^{-4}	1.9×10^{2}	
RFO	RFETS	4.2×10^{-6}	–	4.6×10^{-4}	5.1×10^{-12}	4.6×10^{-4}	
SR	SRS	5.2×10^{4}	3.7×10^{4}	1.2×10^{-3}	8.1×10^{-2}	8.9×10^{4}	3
	Total	**6.1×10^{4}**	**5.5×10^{4}**	**2.7×10^{-3}**	**7.8×10^{2}**	**1.2×10^{5}**	

Table 2. Summary of Airborne Radionuclide Releases from Point Sources During Normal Operations at DOE Facilities – Calendar Years 1998 through 2001 (Page 3 of 4)

		CY 2000 Radionuclide Releases (Ci) (1)					
DOE Office	**Site**	**Tritium**	**Noble Gas**	**Trans-uranic**	**All Other**	**Total**	**Notes**
AL	GJO	–	–	–	2.1×10^{-7}	2.1×10^{-7}	
	KCP	–	–	–	5.5×10^{-12}	5.5×10^{-12}	
	LANL	9.0×10^{0}	2.3×10^{1}	4.8×10^{-6}	6.6×10^{2}	6.9×10^{2}	
	LRRI	7.0×10^{-5}	–	2.2×10^{-7}	2.1×10^{-7}	7.0×10^{-5}	
	PANX	2.7×10^{0}	–	1.8×10^{-7}	4.0×10^{-6}	2.7×10^{0}	
	SNLA	9.9×10^{0}	1.9×10^{1}	1.0×10^{-13}	1.3×10^{-3}	2.9×10^{1}	
CH	ANLE	1.3×10^{2}	1.2×10^{2}	3.2×10^{-6}	1.6×10^{3}	1.9×10^{3}	
	BNL	4.8×10^{0}	2.2×10^{3}	–	1.1×10^{3}	3.3×10^{3}	
	EML	–	–	9.4×10^{-10}	6.3×10^{-6}	6.3×10^{-6}	
	FERMI	5.9×10^{-5}	3.8×10^{-2}	–	9.6×10^{0}	9.6×10^{0}	
	PPPL	7.8×10^{1}	–	–	–	7.8×10^{1}	
GOL	NREL	5.0×10^{-4}	–	–	6.2×10^{-3}	6.7×10^{-3}	
ID	INEEL	4.5×10^{2}	4.0×10^{3}	1.1×10^{-4}	3.3×10^{-1}	4.5×10^{3}	
NR	BET	–	–	2.5×10^{-9}	1.5×10^{-6}	1.5×10^{-6}	
	KAPL-1	–	5.7×10^{-1}	1.9×10^{-7}	1.0×10^{-5}	5.7×10^{-1}	
	KAPL-2	1.2×10^{-1}	9.1×10^{-1}	–	3.2×10^{-1}	1.3×10^{0}	
NV	NTS	6.0×10^{0}	2.1×10^{-6}	–	5.4×10^{-7}	6.0×10^{0}	
OR	ORR	1.7×10^{2}	4.6×10^{3}	2.6×10^{-4}	2.5×10^{3}	7.3×10^{3}	
	PGDP	–	–	1.1×10^{-6}	1.1×10^{-2}	1.1×10^{-2}	9
	JLAB	–	–	–	7.2×10^{0}	7.2×10^{0}	
OAK	LBNL	2.4×10^{1}	–	4.3×10^{-8}	9.0×10^{-1}	2.5×10^{1}	
	LLNL	4.0×10^{1}	–	4.6×10^{-8}	9.1×10^{-1}	4.1×10^{1}	
	LLNL-300	–	1.5×10^{-4}	–	1.8×10^{0}	1.8×10^{0}	
	ETEC	2.7×10^{-5}	–	6.1×10^{-7}	1.3×10^{-6}	2.9×10^{-5}	
	SLAC	–	3.7×10^{0}	–	2.3×10^{1}	2.7×10^{1}	
OH	MEMP	3.8×10^{2}	–	9.4×10^{-6}	2.0×10^{-8}	3.8×10^{2}	
	WVDP	5.1×10^{-3}	–	7.3×10^{-7}	1.3×10^{-3}	6.4×10^{-3}	
RL	HANF	1.2×10^{2}	–	1.0×10^{-3}	1.7×10^{-3}	1.2×10^{2}	
RFO	RFETS	1.0×10^{-3}	–	2.4×10^{-6}	2.7×10^{-7}	1.0×10^{-3}	
SR	SRS	4.5×10^{4}	5.3×10^{4}	2.6×10^{-3}	1.5×10^{-1}	9.8×10^{4}	
	Total	**4.6×10^{4}**	**6.4×10^{4}**	**4.0×10^{-3}**	**5.9×10^{3}**	**1.2×10^{5}**	

Table 2. Summary of Airborne Radionuclide Releases from Point Sources During Normal Operations at DOE Facilities – Calendar Years 1998 through 2001 (Page 4 of 4)

		CY 2001 Radionuclide Releases (Ci) (1)					
DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	KCP	–	–	–	7.3×10^{-12}	7.3×10^{-12}	
	LANL	9.4×10^{3}	1.6×10^{1}	9.6×10^{-6}	5.9×10^{3}	1.5×10^{4}	
	LRRI	7.0×10^{-5}	–	3.5×10^{-8}	2.1×10^{-7}	7.0×10^{-5}	
	PANX	2.7×10^{0}	–	1.8×10^{-7}	1.1×10^{-5}	2.7×10^{0}	
	SNLA	4.2×10^{0}	1.6×10^{1}	2.5×10^{-7}	7.6×10^{-4}	2.0×10^{1}	
CH	ANLE	7.9×10^{1}	9.4×10^{1}	1.8×10^{-6}	1.3×10^{3}	1.4×10^{3}	
	BNL	3.6×10^{0}	–	–	9.8×10^{3}	9.8×10^{3}	
	EML	–	–	3.6×10^{-7}	4.9×10^{-9}	3.6×10^{-7}	
	FERMI	–	1.6×10^{-2}	–	1.5×10^{1}	1.5×10^{1}	
	PPPL	2.6×10^{2}	–	–	–	2.6×10^{2}	
GOL	NREL	–	–	–	–	–	
ID	GJO	–	–	–	5.4×10^{-8}	5.4×10^{-8}	
	INEEL	9.0×10^{-2}	6.7×10^{-1}	5.3×10^{-6}	9.5×10^{-1}	1.7×10^{0}	2
NR	BET	–	–	4.2×10^{-9}	1.1×10^{-6}	1.1×10^{-6}	
	KAPL-1	–	1.9×10^{-1}	1.6×10^{-7}	5.4×10^{-6}	1.9×10^{-1}	
	KAPL-2	1.0×10^{-1}	6.1×10^{-1}	–	1.2×10^{-1}	8.4×10^{-1}	
NV	NTS	5.6×10^{2}	–	3.7×10^{-1}	–	5.6×10^{2}	3
OH	MEMP	8.3×10^{2}	–	5.7×10^{-6}	2.9×10^{-8}	8.3×10^{2}	
	WVDP	2.7×10^{-2}	–	3.3×10^{-6}	2.4×10^{-3}	2.9×10^{-2}	
OR	ORR	3.9×10^{2}	1.8×10^{3}	1.7×10^{-4}	1.4×10^{3}	3.6×10^{3}	
	PGDP	–	–	3.6×10^{-3}	5.2×10^{-2}	5.6×10^{-2}	10
	POR	–	–	4.3×10^{-5}	5.8×10^{-4}	6.2×10^{-4}	
	JLAB	2.2×10^{-2}	2.1×10^{-3}	–	1.4×10^{1}	1.4×10^{1}	
OAK	LBNL	2.0×10^{1}	–	–	2.7×10^{0}	2.3×10^{1}	
	LLNL	2.0×10^{1}	–	4.4×10^{-7}	1.8×10^{0}	2.2×10^{1}	
	LLNL-300	–	1.5×10^{-4}	–	6.5×10^{-2}	6.5×10^{-2}	
	ETEC	–	–	–	5.8×10^{-6}	5.8×10^{-6}	
	SLAC	–	4.7×10^{0}	–	2.8×10^{1}	3.3×10^{1}	
RL	HANF	1.1×10^{2}	–	5.1×10^{-4}	1.3×10^{-3}	1.1×10^{2}	11
RFO	RFETS	–	–	2.5×10^{-6}	4.2×10^{-7}	2.9×10^{-6}	
SR	SRS	4.7×10^{4}	6.5×10^{4}	2.6×10^{-3}	2.3×10^{-1}	1.1×10^{5}	
	Total	**5.9×10^{4}**	**6.7×10^{4}**	**3.8×10^{-1}**	**1.8×10^{4}**	**1.4×10^{5}**	

(1) Unless otherwise noted, reported emissions are from point sources, excluding radon and unplanned emissions. To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7×10^{10} Bq.
(2) Estimates for this Site include unplanned releases.
(3) Estimates for this Site include emissions from diffuse sources.
(4) Emissions based on inventory in use during 1998.
(5) Estimates for this Site include 100% release of contents from unsealed sources in inventory.
(6) Emissions estimates for the site were revised after the annual report was issued.
(7) Reported emissions are for DOE operations only. Total emissions including USEC operations amounted to 3.010^{-4} Ci transuranic and 2.3×10^{-2} Ci other radionuclides in 1998.
(8) Reported emissions are for DOE operations only.
(9) Releases include both DOE and USEC sources.
(10) Includes releases from both DOE and USEC (33% and 67% of total, respectively).
(11) Includes 89 Ci from HT modeled as HTO.

Table 3. Dose to the Maximally Exposed Off-site Individual from Point Source Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Normal Operations (Page 1 of 4) (1)

DOE Office	Site	CY 1998 Maximum Off-site EDE (mrem)	Receptor Distance (2) (meters)	Compliance Code	Notes
AL	GJO	8.4×10^{-5}	500	CAP88-PC	
	KCP	1.5×10^{-9}	547	COMPLY Level 2	
	LANL	1.7×10^{0}	800	CAP88	3, 4
	LRRI	5.5×10^{-6}	3,500	CAP88-PC	
	PANX	5.0×10^{-3}	1,526	CAP88-PC	3
	SNLA	8.0×10^{-4}	1,866	CAP88-PC	3
	SNLT	2.4×10^{-2}	16,500	Air Concentrations	3, 5
CH	ANLE	1.6×10^{-2}	2,400	CAP88	
	BNL	2.1×10^{-1}	2,500	CAP88-PC	
	EML	4.2×10^{-2}	44	COMPLY	
	FERMI	9.4×10^{-9}	2,200	CAP88-PC	6
	PPPL	1.0×10^{-1}	351	COMPLY Level 4	
GOL	NREL	3.4×10^{0}	168	COMPLY Level 4	
ID	INEEL	1.0×10^{-2}	7,976	CAP88	6
NR	BET	3.1×10^{-4}	341	CAP88-PC	
	KAPL-1	1.6×10^{-3}	500	CAP88-PC	
	KAPL-2	3.6×10^{-2}	1,500	CAP88-PC	
	KAPL-3	8.5×10^{-6}	700	CAP88-PC	
NV	NTS	9.2×10^{-2}	>42,000	CAP88-PC	3, 4
OR	ORR	7.3×10^{-1}	3,720	CAP88	
	PGDP	2.9×10^{-3}	1,080	CAP88	8
	POR	5.3×10^{-5}	>760	CAP88	7, 9
OR-RAP	WSSRAP	2.0×10^{-2}	>700	Air Concentrations	3, 5
OAK	LBNL	2.8×10^{-1}	110	CAP88-PC	4
	LEHR	4.2×10^{-3}	30	CAP88-PC	10
	LLNL	3.1×10^{-2}	957	CAP88-PC	
	LLNL-300	1.9×10^{-2}	2,380	CAP88-PC	
	ETEC	1.3×10^{-6}	2,867	CAP88-PC	
	SLAC	4.3×10^{-4}	305	CAP88-PC	
OH	FEMP	2.6×10^{-1}	610	Air Concentrations	3, 12
	MEMP	6.3×10^{-2}	900	CAP88	
	WVDP	3.4×10^{-2}	1,800	CAP88-PC	3
RL	HANF	1.3×10^{-2}	1,500	CAP88-PC	
RFO	RFETS	4.1×10^{-2}	3,686	CAP88-PC	3, 12
SR	SRS	8.0×10^{-2}	16,420	CAP88	3

Table 3. Dose to the Maximally Exposed Off-site Individual from Point Source Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Normal Operations (Page 2 of 4) (1)

DOE Office	Site	CY 1999 Maximum Off-site EDE (mrem)	Receptor Distance (2) (meters)	Compliance Code	Notes
AL	GJO	1.4×10^{-3}	500	CAP88-PC	3
	KCP	3.3×10^{-9}	547	COMPLY Level 2	
	LANL	3.2×10^{-1}	800	CAP88	3, 4
	LRRI	1.4×10^{-5}	3,500	CAP88-PC	
	PANX	2.0×10^{-3}	1,526	CAP88-PC	3
	SNLA	8.5×10^{-4}	1,866	CAP88-PC	3
	SNLT	2.4×10^{-2}	16,500	Air Concentrations	3, 5
	WIPP	2.2×10^{-6}			
CH	ANLE	4.3×10^{-3}	2,400	CAP88	
	BNL	1.3×10^{-1}	2,500	CAP88-PC	
	EML	1.0×10^{-4}	44	COMPLY	
	FERMI	2.7×10^{-3}	2,200	CAP88-PC	6
	PPPL	1.0×10^{-1}	351	COMPLY Level 4	
GOL	NREL	3.0×10^{-1}	168	COMPLY Level 4	
ID	INEEL	1.6×10^{-3}	7,976	CAP88	3
NR	BET	1.9×10^{-4}	341	CAP88-PC	
	KAPL-1	7.8×10^{-4}	500	CAP88	
	KAPL-2	3.1×10^{-2}	1,500	CAP88	
	KAPL-3	1.3×10^{-6}	700	CAP88	
NV	NTS	1.2×10^{-1}	>42,000	CAP88-PC	3, 4
OR	JLAB	8.2×10^{-2}	500	CAP88-PC	
	ORR	7.0×10^{-1}	3,720	CAP88	3
	PGDP	1.7×10^{-3}	1,080	CAP88	8
	POR	4.8×10^{-4}	>760	CAP88	9
OR-RAP	WSSRAP	4.0×10^{-1}	>700	Air Concentrations	3, 5
OAK	LBNL	8.1×10^{-2}	110	CAP88-PC	
	LEHR	1.4×10^{-3}	30	CAP88-PC	3, 10, 11
	LLNL	9.4×10^{-2}	957	CAP88-PC	
	LLNL-300	3.4×10^{-2}	2,380	CAP88-PC	
	ETEC	2.2×10^{-7}	2,867	CAP88-PC	
	SLAC	1.4×10^{-5}	305	CAP88-PC	
OH	FEMP	2.9×10^{-1}	610	Air Concentrations	3, 12
	MEMP	5.0×10^{-2}	900	CAP88	3
	WVDP	1.1×10^{-2}	2,400	CAP88-PC	3
RL	HANF	2.9×10^{-2}	1,500	CAP88-PC	
RFO	RFETS	4.0×10^{-3}	3,686	CAP88-PC	3, 13
SR	SRS	5.1×10^{-2}	16,200	CAP88	3

Table 3. Dose to the Maximally Exposed Off-site Individual from Point Source Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Normal Operations (Page 3 of 4) (1)

DOE Office	Site	CY 2000 Maximum Off-site EDE (mrem)	Receptor Distance (2) (meters)	Compliance Code	Notes
AL	GJO	1.3×10^{-4}	500	CAP88-PC	
	KCP	3.3×10^{-9}	547	COMPLY Level 2	
	LANL	6.4×10^{-1}	800	CAP88	3, 4
	LRRI	1.4×10^{-5}	3,500	CAP88-PC	3
	PANX	1.6×10^{-4}	1,526	CAP88-PC	3
	SNLA	3.5×10^{-3}	1,866	CAP88-PC	3
	SNLT	2.4×10^{-2}	16,500	Air Concentrations	3
	WIPP	5.2×10^{-6}			
CH	ANLE	4.6×10^{-2}	2,400	CAP88	
	BNL	1.8×10^{-1}	2,500	CAP88-PC	3
	EML	1.8×10^{-3}	44	COMPLY	
	FERMI	4.6×10^{-3}	2,200	CAP88-PC	
	PPPL	9.8×10^{-2}	351	COMPLY Level 4	
GOL	NREL	3.0×10^{-1}	168	COMPLY Level 4	
ID	INEEL	1.2×10^{-2}	7,976	CAP88	
NR	BET	1.4×10^{-4}	341	CAP88-PC	
	KAPL-1	6.9×10^{-4}	500	CAP88-PC	
	KAPL-2	2.0×10^{-2}	1500	CAP88-PC	
NV	NTS	1.0×10^{-5}	>42,000	CAP88-PC	3
OR	JLAB	4.8×10^{-2}	500	CAP88-PC	
	ORR	4.0×10^{-1}	3,720	CAP88	2, 3, 4
	PGDP	3.0×10^{-3}	1,080	CAP88	8
OAK	LBNL	8.9×10^{-2}	110	CAP88-PC	
	LEHR	8.7×10^{-6}	30	CAP88-PC	3, 10, 11
	LLNL	1.7×10^{-2}	957	CAP88-PC	3
	LLNL-300	1.5×10^{-2}	3,170	CAP88-PC	3
	ETEC	7.7×10^{-7}	2,867	CAP88-PC	
	SLAC	3.2×10^{-2}	305	CAP88-PC	
OH	FEMP	1.1×10^{0}	610	Air Concentrations	3, 12
	MEMP	3.0×10^{-2}	900	CAP88	
	WVDP	8.1×10^{-3}	1,800	CAP88-PC	
RL	HANF	4.6×10^{-2}	1,500	CAP88-PC	
RFO	RFETS	1.3×10^{-2}	3,686	CAP88-PC	3
SR	SRS	5.0×10^{-2}	16,200	CAP88	

Table 3. Dose to the Maximally Exposed Off-site Individual from Point Source Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Normal Operations (Page 4 of 4) (1)

DOE Office	Site	CY 2001 Maximum Off-site EDE (mrem)	Receptor Distance (2) (meters)	Compliance Code	Notes
AL	KCP	1.2×10^{-9}	547	COMPLY Level 2	
	LANL	1.8×10^{0}	800	CAP88	3, 4
	LRRI	1.4×10^{-5}	3,500	CAP88-PC v.2.0	
	PANX	6.6×10^{-4}	1,526	CAP88-PC v.2.0	
	SNLA	3.0×10^{-3}	1,866	CAP88-PC	3
	SNLT	2.4×10^{-2}	16,500	Air Concentrations	3
	WIPP	5.0×10^{-6}			
CH	ANLE	3.6×10^{-2}	2,400	CAP88	
	BNL	1.4×10^{-1}	2,500	CAP88-PC	
	EML	1.3×10^{-2}	44	COMPLY	
	FERMI	6.1×10^{-3}	2,200	CAP88-PC	
	PPPL	3.0×10^{-1}	351	COMPLY Level 4	
GOL	NREL	2.0×10^{-1}	168	COMPLY Level 4	
ID	GJO	4.7×10^{-2}	500	CAP88-PC	
	INEEL	1.8×10^{-4}	7,976	CAP88	
NR	BET	8.6×10^{-5}	341	CAP88-PC	
	KAPL-1	3.8×10^{-4}	500	CAP88	
	KAPL-2	5.7×10^{-3}	1,500	CAP88	
NV	NTS	1.7×10^{-1}	>42,000	CAP88-PC	3
OR	JLAB	1.1×10^{-2}	500	CAP88-PC	
	ORR	8.0×10^{-1}	3,720	CAP88	3
	PGDP	3.7×10^{-3}	1,080	CAP88	8
	POR	1.4×10^{-2}	>760	CAP88	9
OAK	LBNL	5.6×10^{-2}	110	CAP88-PC	3
	LEHR	1.0×10^{-3}	30	CAP88-PC	3, 7, 11
	LLNL	5.7×10^{-3}	957	CAP88-PC	
	LLNL-300	5.0×10^{-2}	3,170	CAP88-PC	
	ETEC	3.1×10^{-6}	2,867	CAP88-PC	
	SLAC	8.0×10^{-2}	305	CAP88-PC v.2.0	
OH	FEMP	8.0×10^{-1}	610	Air Concentrations	3, 12
	MEMP	7.0×10^{-2}	900	CAP88	
	WVDP	4.6×10^{-3}	1,900	CAP88-PC v.2.0	3
RFO	RFETS	<10 mrem	3,686	CAP88-PC	14
RL	HANF	1.2×10^{-1}	1,500	CAP88-PC	15
SR	SRS	5.1×10^{-2}	16,200	CAP88	

(1) Dose estimates include point sources only unless otherwise indicated.
(2) Receptor distance represents distance from the maximally exposed member of the public to the facility which is the major contributor to dose, or to a central reference point for site.
(3) Estimates for this site include emissions from diffuse sources (see Table 7).
(4) Estimates for this site include emissions from unplanned releases (see Table 7).
(5) Dose based on air concentrations at monitored receptor location.
(6) Dose is at a receptor location 800 m S selected by CAP88-PC; location of the emission source is 2,200 m from nearest receptor.
(7) Estimates for this site were revised after the annual report was issued.
(8) The reported dose represents the dose from DOE activities; the total contribution from DOE and USEC activities is 1.4×10^{-2} mrem in 1998, 1.2×10^{-2} mrem in 1999, 1.3×10^{-2} in 2000, and 1.7×10^{-1} in 2001.
(9) The reported dose represents the dose from DOE activities; the total contribution from DOE and USEC activities is 1.7 mrem in 1998, 2.8×10^{-1} mrem in 1999, and 6.0×10^{-2} in 2001. No dose was reported for 2000.
(10) The location of the MEI describes non-LEHR staff connected with UC-Davis.
(11) All dose from diffuse sources (see Table 7).

(12) Compliance based on comparison of monitored air concentrations at site perimeter with 40 CFR Part 61, Appendix E, Table 2.
(13) Estimates from monitored air concentrations at site perimeter compared with 40 CFR Part 61, Appendix E, Table 2 values yielded a somewhat higher dose – 0.14 mrem – due to naturally occurring uranium isotopes.
(14) Sum of Fractions using 40 CFR Part 61, Appendix E, Table 2.
(15) MEI is on-site worker who does not work for DOE contractor.

Table 4. Summary of Airborne Radionuclide Releases from Diffuse Sources at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 1 of 4)

DOE Office	Site	CY 1998 Diffuse Source Radionuclide Emissions (Ci) (1, 2) Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	GJO	–	–	–	4.2×10^{-6}	4.2×10^{-6}	
	LANL	–	1.9×10^{1}	–	4.6×10^{2}	4.8×10^{2}	
	PANX	3.9×10^{-2}	–	–	1.8×10^{-4}	3.9×10^{-2}	3
	SNLA	2.9×10^{-1}	–	–	6.2×10^{-7}	2.9×10^{-1}	
	SNLT						4
CH	BNL	–	–	–	–	–	5
ID	INEEL	1.7×10^{2}	3.6×10^{-4}	6.9×10^{-8}	8.4×10^{-2}	1.7×10^{2}	
NR	KAPL-1	–	–	–	–	–	6
NV	NTS	2.9×10^{2}	–	2.4×10^{-1}	–	2.9×10^{2}	
OAK	LEHR	4.4×10^{-9}	–	3.4×10^{-9}	8.8×10^{-7}	8.9×10^{-7}	
	LLNL	1.1×10^{1}	–	8.9×10^{-8}	9.2×10^{-6}	1.1×10^{1}	
	LLNL-300	3.9×10^{-4}	–	–	5.5×10^{-8}	3.9×10^{-4}	
	ETEC	–	–	1.6×10^{-7}	9.9×10^{-5}	9.9×10^{-5}	
OH	FEMP						4, 7
	MEMP	–	–	2.1×10^{-4}	3.2×10^{-6}	2.1×10^{-4}	
	WVDP	1.2×10^{-2}	–	5.3×10^{-10}	1.0×10^{-4}	1.2×10^{-2}	
RL	HANF	–	–	–	3.2×10^{-1}	3.2×10^{-1}	
RFO	RFETS	–	–	1.0×10^{-3}	7.0×10^{-5}	1.1×10^{-3}	
SR	SRS	9.3×10^{2}	–	2.0×10^{-3}	3.2×10^{-2}	9.3×10^{2}	3
	Total	**1.4×10^{3}**	**1.9×10^{1}**	**2.4×10^{-1}**	**4.6×10^{2}**	**1.9×10^{3}**	

Table 4. Summary of Airborne Radionuclide Releases from Diffuse Sources at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 2 of 4)

DOE Office	Site	CY 1999 Diffuse Source Radionuclide Emissions (Ci) (1, 2) Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	GJO	–	–	–	1.2×10^{-6}	1.2×10^{-6}	
	LANL	–	1.2×10^{0}	–	1.7×10^{1}	1.8×10^{1}	
	SNLA	2.9×10^{-1}	3.0×10^{0}	–	3.0×10^{-6}	3.3×10^{0}	4
CH	BNL	–	–	–	–	–	5
ID	INEEL	1.5×10^{2}	5.0×10^{-5}	1.1×10^{-7}	9.9×10^{-2}	1.5×10^{2}	
NR	KAPL-1	–	–	–	–	–	6
NV	NTS	2.3×10^{2}	–	2.4×10^{-1}	–	2.3×10^{2}	
OAK	LEHR	1.1×10^{-10}	–	2.6×10^{-9}	4.6×10^{-8}	4.9×10^{-8}	
	LLNL	1.2×10^{1}	–	1.0×10^{-6}	8.8×10^{-6}	1.2×10^{1}	
	LLNL-300	3.9×10^{-4}	–	–	5.5×10^{-8}	3.9×10^{-4}	
	ETEC	–	–	–	4.0×10^{-7}	4.0×10^{-7}	
OH	FEMP	–	–	–	1.1×10^{-4}	1.1×10^{-4}	4, 7
	MEMP	–	–	9.4×10^{-5}	6.3×10^{-5}	1.6×10^{-4}	
	WVDP	5.8×10^{-3}	–	6.8×10^{-10}	1.5×10^{-4}	6.0×10^{-3}	
OR-RAP	WSSRAP	–	–	–	–	–	
RL	HANF	–	–	–	5.0×10^{-1}	5.0×10^{-1}	
RFFO	RFETS	–	–	1.0×10^{-4}	2.0×10^{-5}	1.2×10^{-4}	
SR	SRS	4.7×10^{2}	–	2.9×10^{-3}	3.7×10^{-2}	4.7×10^{2}	3
	Total	**8.6×10^{2}**	**4.2×10^{0}**	**2.4×10^{-1}**	**1.8×10^{1}**	**8.8×10^{2}**	

Table 4. Summary of Airborne Radionuclide Releases from Diffuse Sources at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 3 of 4)

		CY 2000 Diffuse Source Radionuclide Emissions (Ci) (1, 2)					
DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	GJO	–	–	–	2.4×10^{-6}	2.4×10^{-6}	
	LANL	–	6.5×10^{0}	–	1.4×10^{2}	1.5×10^{2}	
	PANX	1.8×10^{-5}	–	–	–	1.8×10^{-5}	
	SNLA	2.9×10^{-1}	–	–	7.9×10^{-4}	2.9×10^{-1}	
	SNLT	–	–	–	–	–	11, 12
CH	BNL	–	–	–	–	–	12
ID	INEEL	2.3×10^{2}	7.1×10^{0}	1.1×10^{-3}	8.8×10^{-1}	2.4×10^{2}	
NR	KAPL-1	–	–	–	3.6×10^{-7}	3.6×10^{-7}	
NV	NTS	4.3×10^{2}	–	3.6×10^{-1}	–	4.3×10^{2}	
OAK	LEHR	–	–	8.0×10^{-11}	4.5×10^{-8}	4.5×10^{-8}	
	LLNL	8.8×10^{0}	–	2.8×10^{-7}	1.1×10^{-7}	3.6×10^{0}	
	LLNL-300	3.9×10^{-4}	–	–	1.8×10^{-2}	4.9×10^{1}	
	ETEC	–	–	–	–	–	
OH	FEMP	–	–	–	–	–	7, 12
	MEMP	–	–	3.2×10^{-5}	5.8×10^{-5}	9.0×10^{-5}	
	WVDP	4.6×10^{-3}	–	3.8×10^{-10}	1.3×10^{-4}	4.7×10^{-3}	
OR-RAP	WSSRAP	–	–	–	–	–	13
RL	HANF	4.8×10^{2}	–	5.4×10^{-4}	4.9×10^{-1}	4.8×10^{2}	
RFO	RFETS	–	–	6.9×10^{-5}	4.5×10^{-6}	7.4×10^{-5}	
SR	SRS	6.1×10^{2}	2.0×10^{-3}	2.0×10^{-3}	9.7×10^{-3}	6.1×10^{2}	
	Total	**1.8×10^{3}**	**1.4×10^{1}**	**3.6×10^{-1}**	**1.4×10^{2}**	**2.0×10^{3}**	

Table 4. Summary of Airborne Radionuclide Releases from Diffuse Sources at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 4 of 4)

DOE Office	Site	CY 2001 Diffuse Source Radionuclide Emissions (Ci) (1, 2) Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	LANL	–	6.5×10^{0}	–	1.5×10^{2}	1.6×10^{2}	
	MEMP	–	–	5.7×10^{-5}	2.7×10^{-7}	5.7×10^{-5}	
	SNLA	2.9×10^{-1}	–	5.5×10^{-8}	2.9×10^{-5}	2.9×10^{-1}	
	SNLT	–	–	–	–	–	14
CH	BNL	–	–	–	–	–	12
ID	GJO	–	–	–	7.4×10^{-6}	7.4×10^{-6}	
	INEEL	–	–	–	–	–	
OH	FEMP	–	–	–	–	–	7, 12
	WVDP	5.3×10^{-3}	–	2.7×10^{-10}	1.2×10^{-4}	5.4×10^{-3}	
NR	KAPL-1	–	–	–	3.6×10^{-7}	3.6×10^{-7}	
	KAPL-2	–	–	–	8.9×10^{-9}	8.9×10^{-9}	
NV	NTS	5.6×10^{2}	–	1.3×10^{3}	–	1.9×10^{3}	
OAK	LBNL	5.0×10^{-4}	–	–	–	5.0×10^{-4}	3
	LEHR	1.8×10^{-9}	–	–	1.6×10^{-7}	1.6×10^{-7}	
	LLNL	3.0×10^{0}	–	1.9×10^{-7}	2.8×10^{-6}	3.0×10^{0}	
	LLNL-300	3.9×10^{-4}	–	–	5.4×10^{-8}	3.9×10^{-4}	
RL	HANF	1.2×10^{2}	–	-4.7×10^{-4}	5.1×10^{-1}	1.2×10^{2}	15
RFO	RFETS	–	–	1.0×10^{-4}	1.8×10^{-5}	1.2×10^{-4}	
SR	SRS	6.1×10^{2}	–	2.1×10^{-3}	4.1×10^{-2}	6.1×10^{2}	
	Total	$\mathbf{1.3\times10^{3}}$	$\mathbf{6.5}\times10^{0}$	$\mathbf{1.3\times10^{3}}$	$\mathbf{1.5\times10^{2}}$	$\mathbf{2.8\times10^{3}}$	

(1) To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7×10^{10} Bq.
(2) Diffuse source emissions do not include radon.
(3) Part or all of these estimates also were included in the emissions reported in Table 2.
(4) Compliance based on monitored air concentrations at site perimeter or receptor location; no release estimates available for diffuse sources.
(5) Emissions from a potential diffuse source of tritium were not detectable. A conservative estimate of dose from this source is included in Table 7.
(6) Dose estimates obtained using soil concentrations and RESRAD software; no release estimates were available.
(7) Diffuse source releases estimated from monitored air concentrations.
(8) Unplanned release was an ongoing result of a 1995 event.
(9) Unplanned release consists of an unspecified quantity of depleted uranium hexafluoride.
(10) Unplanned release consists of < 30 g U, which is included in the point source totals for USEC.
(11) Unreported quantities of Pu and Am were released from SNLT facilities
(12) Diffuse sources were not quantified.
(13) Diffuse sources were not quantified at Weldon Springs. Quarterly concentrations in air were presented with annual dose.
(14) Unquantified emissions of ^{241}Am, ^{238}Pu, and $^{239/240}$Pu; continued release from 2000 unplanned release.
(15) Negative value for transuranic emissions based on monitoring results.

Table 5. Summary of Unplanned Airborne Radionuclide Releases at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 1 of 2)

CY 1998 Unplanned Radionuclide Emissions (Ci) (1)

DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	LANL	8.3×10^{1}	–	–	–	8.3×10^{1}	
NV	NTS	1.6×10^{-2}	–	–	–	1.6×10^{-2}	2, 3
OR	ORR	–	–	–	–	–	4
	PGDP	–	–	–	–	–	5
OAK	LBNL	3.5×10^{1}	–	–	–	3.5×10^{1}	2
RL	HANF	2.1×10^{2}	–	–	–	2.1×10^{2}	2
	Total	**3.3×10^{2}**	**–**	**–**	**–**	**3.3×10^{2}**	

CY 1999 Unplanned Radionuclide Emissions (Ci) (1)

DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	LANL	–	–	–	5.5×10^{-5}	5.5×10^{-5}	
NV	NTS	3.0×10^{-1}	–	–	–	3.0×10^{-1}	2, 3
OR	ORR	–	–	–	–	–	4
	PGDP	–	–	–	3.2×10^{-3}	3.2×10^{-3}	6
	Total	**3.0×10^{-1}**	**–**	**–**	**3.3×10^{-3}**	**3.0×10^{-1}**	

CY 2000 Unplanned Radionuclide Emissions (Ci) (1)

DOE Office	Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
AL	LANL	3.1×10^{2}	–	–	–	3.1×10^{2}	
CH	ANLE	–	8.0×10^{-3}	–	–	8.0×10^{-3}	
NV	NTS	3.7×10^{-1}	–	–	–	3.7×10^{-1}	2, 3
OR	ORR	–	–	–	–	–	8
	PGDP	–	–	–	–	–	7
SR	SRS	–	–	–	2.9×10^{-4}	2.9×10^{-4}	
	Total	**3.1×10^{2}**	**8.0×10^{-3}**	**–**	**2.9×10^{-4}**	**3.1×10^{2}**	

Table 5. Summary of Unplanned Airborne Radionuclide Releases at Department of Energy Facilities During Calendar Years 1998 through 2001 (Page 2 of 2)

		CY 2001 Unplanned Radionuclide Emissions (Ci) (1)					
DOE Office	**Site**	**Tritium**	**Noble Gas**	**Trans-uranic**	**All Other**	**Total**	**Notes**
AL	LANL	7.6×10^{3}	–	–	–	7.6×10^{3}	
NV	NTS	2.0×10^{-1}	–	–	–	2.0×10^{-1}	2, 3
OR	PGDP	–	–	–	–	–	9
OH	WVDP	–	–	–	–	–	10
	Total	**7.6×10^{3}**	**–**	**–**	**–**	**7.6×10^{3}**	

(1) To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7×10^{10} Bq.
(2) Part or all of these estimates also were included in the routine emissions reported in Table 2.
(3) Unplanned release was an ongoing result of a 1995 event.
(4) Unplanned release consists of an unspecified quantity of depleted uranium hexafluoride.
(5) Unplanned release consists of < 71 g U, which is included in the point source totals for USEC.
(6) Unplanned release consists of < 30 g U, which is included in the point source totals for USEC.
(7) Unplanned release consists of < 47 g U, which is included in the point source totals for USEC.
(8) Release amount of transuranics not specified, but is included with point sources.
(9) Unplanned release consists of < 29 g U, which is included in the point source totals for USEC.
(10) Small local deposition of ^{137}Cs from ventilation system condensate.

Table 6. Summary of Airborne Radon Releases from DOE Facilities During Calendar Years 1998 through 2001 (Page 1 of 2)

CY 1998 Radon Emissions (Ci) (1)

DOE Office	Site	Rn-220	Rn-222	Total	Notes
CH	ANLE	2.4×10^{2}	–	2.4×10^{2}	2
NR	BET	3.2×10^{2}	4.8×10^{-1}	3.2×10^{2}	
OH	MEMP	–	1.9×10^{0}	1.9×10^{0}	
	WVDP	5.4×10^{3}	–	5.4×10^{3}	3
OR-RAP	WSSRAP	1.4×10^{1}	2.8×10^{0}	1.7×10^{1}	4
	Total	**6.0×10^{3}**	**5.2×10^{0}**	**6.0×10^{3}**	

CY 1999 Radon Emissions (Ci) (1)

DOE Office	Site	Rn-220	Rn-222	Total	Notes
CH	ANLE	1.9×10^{2}	–	1.9×10^{2}	2
NR	BET	3.9×10^{2}	3.5×10^{-1}	3.9×10^{2}	
OH	FEMP	–	3.9×10^{-3}	3.90×10^{-3}	
	MEMP	–	1.0×10^{0}	1.0×10^{0}	
	WVDP	3.3×10^{3}	–	3.3×10^{3}	3
OR-RAP	WSSRAP	–	–	–	4
	Total	**5.8×10^{2}**	**1.4×10^{0}**	**5.8×10^{2}**	

Table 6. Summary of Airborne Radon Releases from DOE Facilities During Calendar Years 1998 through 2001 (Page 2 of 2)

CY 2000 Radon Emissions (Ci) (1)

DOE Office	Site	Rn-220	Rn-222	Total	Notes
AL	GJO	–	–	–	5
CH	ANLE	4.70×10^{1}	8.0×10^{-3}	4.7×10^{1}	2
FN	FEMP	–	–	1.85×10^{-1}	6
NR	BET	2.5×10^{2}	4.4×10^{-1}	2.5×10^{2}	
OH	MEMP	–	3.2×10^{0}	3.2×10^{0}	
	WVDP	2.6×10^{3}	–	2.6×10^{3}	
	Total	**2.65×10^{3}**	**3.2×10^{0}**	**2.65×10^{3}**	

CY 2001 Radon Emissions (Ci) (1)

DOE Office	Site	Rn-220	Rn-222	Total	Notes
CH	ANLE	3.56×10^{1}	–	3.56×10^{1}	2
ID	GJO	–	–	–	5
NR	BET	2.56×10^{2}	4.1×10^{-1}	2.56×10^{2}	
OH	FEMP	–	8.26×10^{-1}	8.26×10^{-1}	
	MEMP	–	4.6×10^{0}	4.6×10^{0}	7
	WVDP	2.3×10^{3}	–	2.3×10^{3}	
	Total	**2.98×10^{2}**	**5.84×10^{0}**	**3.04×10^{2}**	

(1) To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7×10^{10} Bq.
(2) Radon emissions were not included in the site's annual air emission reports, but were provided after the reports were issued.
(3) Value represents release rate of 14.9 Ci/d in 1998 and 9.1 Ci/d in 1999 applied for the full year.
(4) Part or all of these estimates were also included in the routine emissions reported in Table 2.
(5) Amount not specified.
(6) Release rate of 5.1×10^{2} uCi/d reported for "Total Radon." It was assumed to be over a period of 365 d for this annex.
(7) Includes natural ^{222}Rn.

Table 7. Dose to the Maximally Exposed Off-site Individual from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Diffuse Sources, Unplanned Releases, and Radon. (Page 1 of 4)

		CY 1998 Dose (mrem) (1)			
DOE Office	**Site**	**Diffuse Sources (2)**	**Unplanned Releases**	**Radon**	**Notes**
AL	GJO	3.3×10^{-3}	–	–	
	LANL	3.3×10^{-1}	1.7×10^{-2}	–	3
	PANX	–	–	–	3
	SNLA	–	–	–	3
	SNLT	2.4×10^{-2}	–	–	3
CH	ANLE	–	–	1.5×10^{-2}	4
	BNL	2.5×10^{-6}	–	–	
ID	INEEL	2.9×10^{-3}	–	–	
NR	BET	–	–	2.0×10^{-1}	
	KAPL-1	7.0×10^{-7}	–	–	
NV	NTS	9.2×10^{-2}	7.7×10^{-5}	–	3
OR	ORR	–	–	–	5
	PGDP	–	–	–	3
OAK	LBNL	–	3.0×10^{-2}	–	3
	LEHR	4.2×10^{-3}	–	–	3
	LLNL	2.4×10^{-2}	–	–	
	LLNL-300	5.0×10^{-3}	–	–	
	ETEC	2.5×10^{-3}	–	–	3
OR-RAP	WSSRAP	–	–	7.6×10^{0}	3
OH	FEMP	2.6×10^{-1}	–	–	3
	MEMP	–	–	3.0×10^{-3}	6
	WVDP	1.7×10^{-4}	–	6.4×10^{-2}	3
RL	HANF	4.0×10^{-2}	5.3×10^{-2}	–	7
RFO	RFETS	–	–	–	3
SR	SRS	4.4×10^{-3}	–	–	3

Table 7. Dose to the Maximally Exposed Off-site Individual from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Diffuse Sources, Unplanned Releases, and Radon. (Page 2 of 4)

		CY 1999 Dose (mrem) (1)			
DOE Office	**Site**	**Diffuse Sources (2)**	**Unplanned Releases**	**Radon**	**Notes**
AL	GJO	1.2×10^{-3}	–	1.2×10^{-1}	
	LANL	3.3×10^{-5}	1.0×10^{-3}	–	3
	PANX	–	–	–	3
	SNLA	–	–	–	3
	SNLT	–	–	–	3
CH	ANLE	–	–	1.2×10^{-2}	4
	BNL	2.5×10^{-6}	–	–	
ID	INEEL	2.9×10^{-3}	–	–	3
NR	BET	–	–	2.8×10^{-1}	
	KAPL-1	7.0×10^{-7}	–	–	
NV	NTS	1.2×10^{-1}	1.4×10^{-3}	–	3
OR	ORR	–	–	–	3, 8
	PGDP	–	–	–	8
OAK	LBNL	–	–	–	
	LEHR	1.4×10^{-3}	–	–	3
	LLNL	2.8×10^{-2}	–	–	3
	LLNL-300	1.2×10^{-3}	–	–	3
	ETEC	6.6×10^{-7}	–	–	
OR-RAP	WSSRAP	4.0×10^{-1}	–	–	2
OH	FEMP	5.5×10^{-3}	–	2.3×10^{-1}	3
	MEMP	–	–	1.0×10^{-3}	9
	WVDP	8.2×10^{-5}	–	7.5×10^{-2}	3
RL	HANF	3.9×10^{-2}	–	–	7
RFO	RFETS	–	–	–	3
SR	SRS	5.2×10^{-3}	–	–	3

Table 7. Dose to the Maximally Exposed Off-site Individual from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Diffuse Sources, Unplanned Releases, and Radon. (Page 3 of 4)

		CY 2000 Dose (mrem) (1)			
DOE Office	**Site**	**Diffuse Sources (2)**	**Unplanned Releases**	**Radon**	**Notes**
AL	GJO	1.1×10^{-2}	–	8.7×10^{-2}	
	LANL	8.8×10^{-2}	–	–	16
	PANX	–	–	–	
	SNLA	2.1×10^{-4}	–	–	
	SNLT	2.4×10^{-2}	–	–	
CH	ANLE	NS	2.9×10^{-3}	–	4
	BNL	1.8×10^{-3}	–	–	
ID	INEEL	2.1×10^{-2}	–	–	
NR	BET	–	–	1.3×10^{-1}	
	KAPL-1	6.7×10^{-6}	–	–	
NV	NTS	1.7×10^{-1}	1.8×10^{-3}	–	
OR	ORR	–	–	–	10, 11, 16
	PGDP	–	–	–	
OAK	LEHR	7.5×10^{-4}	–	–	
	LLNL	2.1×10^{-2}	–	–	
	LLNL-300	3.7×10^{-3}	–	–	
OH	FEMP	1.1×10^{-3}	–	1.3×10^{0}	3
	MEMP	1.6×10^{-1}	–	4.1×10^{-3}	11
	WVDP	2.5×10^{-4}	–	3.1×10^{-2}	
RL	HANF	4.9×10^{-2}	–	–	
RFO	RFETS	–	–	–	10
SR	SRS	5.5×10^{-3}	–	–	

Table 7. Dose to the Maximally Exposed Off-site Individual from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001 – Diffuse Sources, Unplanned Releases, and Radon. (Page 4 of 4)

		CY 2001 Dose (mrem) (1)			
DOE Office	Site	Diffuse Sources (2)	Unplanned Releases	Radon	Notes
AL	LANL	4.0×10^{-2}	4.2×10^{-2}	–	
	PANX	–	–	–	12
	SNLA	4.6×10^{-4}	–	–	13
	SNLT	2.4×10^{-2}	–	–	
CH	ANLE	–	–	2.0×10^{-3}	4
	BNL	5.5×10^{-6}	–	–	14
ID	GJO	4.7×10^{-2}	–	9.1×10^{-2}	
	INEEL	1.8×10^{-4}	–	–	
NR	BET	–	–	1.4×10^{-1}	
	KAPL-1	6.7×10^{-6}	–	–	
	KAPL-2	2.9×10^{-8}	–	–	
NV	NTS	1.7×10^{-1}	9.6×10^{-4}	–	
OR	ORR	5.0×10^{-2}	–	–	15
	PGDP	–	–	–	
OAK	LBNL	2.1×10^{1}	-	-	3
	LEHR	1.1×10^{-3}	–	–	
	LLNL	1.1×10^{-2}	–	–	
	LLNL-300	3.7×10^{-3}	–	–	
OH	FEMP	–	–	5.4×10^{0}	3
	MEMP	4.4×10^{-2}	–	–	
	WVDP	4.3×10^{-4}	–	2.2×10^{-2}	16
RL	HANF	3.7×10^{-1}	–	–	
RFO	RFETS	<10 mrem	–	–	
SR	SRS	6.2×10^{-3}	–	–	

(1) To convert doses to SI units, use the conversion factor: 1 mrem = 0.01 mSv.
(2) Doses from diffuse emissions do not include ^{220}Rn and ^{222}Rn.
(3) Part or all of these estimates were included in the site's compliance dose (see Table 3).
(4) Doses from radon emissions were not included in the site's annual air emission reports, but were provided after the reports were issued.
(5) The maximum dose from point and diffuse sources combined was 0.019 mrem based on average air concentrations at potential receptor locations. That estimate is lower than the calculated dose from point source emissions reported in Table 3.
(6) The dose from point and diffuse sources combined was 0.04 mrem based on average air concentrations at the site perimeter. That estimate is lower than the calculated dose from point source emissions reported in Table 3.
(7) Dose from unplanned emissions represents the maximum from a tritium release that occurred while wind was blowing away from the MEI location for routine emissions. Two other unplanned releases were smaller and were included in the dose from routine stack emissions.
(8) Dose from unplanned release not quantified.
(9) Dose from both point and diffuse sources estimated using monitored air concentrations. The dose was 0.05 mrem based on average air concentrations at the site perimeter, which is lower than the calculated dose from point source emissions reported in Table 3.
(10) The dose from diffuse sources at this site was not specifically estimated. Ambient air sampling at potential receptor locations was used to demonstrate that the total dose to any individual from both point and non-point sources was lower than the CAP88 model estimate for stack sources reported in Table 3.
(11) Includes doses from point sources.
(12) All sources modeled as point sources.
(13) Combined doses from 2 diffuse sources and 2 MEIs.
(14) Unplanned release from 2000 is still releasing tritium.
(15) Calculated from fenceline monitoring stations with background subtracted.
(16) Dose from unplanned release not specified, is small part of total site dose.

Table 8. Collective Dose to the 80-km Population from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001. (Page 1 of 4)

DOE Office	Site	CY 1998 Collective Dose (person-rem)	Population within 80 km (1)	Notes
AL	GJO	1.5×10^{-3}	1.2×10^{5}	2
	LANL	8.0×10^{-1}	2.6×10^{5}	
	LRRI	2.6×10^{-4}	5.0×10^{5}	
	PANX	1.1×10^{-2}	2.7×10^{5}	
	SNLA	4.1×10^{-2}	7.0×10^{5}	
CH	ANLE	1.7×10^{0}	8.4×10^{6}	3
	BNL	7.6×10^{0}	5.1×10^{6}	
	FERMI	1.5×10^{-6}	7.8×10^{6}	
ID	INEEL	7.5×10^{-2}	1.2×10^{5}	4, 5
NR	BET	1.4×10^{0}	3.0×10^{6}	3
	KAPL-1	3.5×10^{-3}	1.3×10^{6}	4
	KAPL-2	3.0×10^{-1}	1.2×10^{6}	4
	KAPL-3	4.9×10^{-5}	3.4×10^{6}	4
NV	NTS	2.7×10^{-1}	3.7×10^{4}	
OR	ORR	1.2×10^{1}	8.8×10^{5}	
	PGDP	2.7×10^{-3}	5.4×10^{5}	6
	POR	2.3×10^{-1}	6.0×10^{5}	4
OAK	LBNL	2.5×10^{0}	5.0×10^{6}	
	LEHR	1.8×10^{-4}	1.0×10^{5}	3, 7
	LLNL	8.4×10^{-1}	6.3×10^{6}	3
	LLNL-300	1.1×10^{1}	5.4×10^{6}	3
	ETEC	8.5×10^{-2}	1.0×10^{7}	3
	SLAC	3.3×10^{-3}	4.9×10^{6}	
OR-RAP	WSSRAP	1.4×10^{0}	2.9×10^{5}	3, 8
OH	MEMP	2.3×10^{0}	3.0×10^{6}	3
	WVDP	2.6×10^{-1}	1.3×10^{6}	
RL	HANF	8.4×10^{-2}	3.8×10^{5}	
RFFO	RFETS	6.5×10^{0}	2.1×10^{6}	
SR	SRS	8.1×10^{0}	6.2×10^{5}	
	Total	**5.7×10^{1}**	**7.4×10^{7}**	

Table 8. Collective Dose to the 80-km Population from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001. (Page 2 of 4)

DOE Office	Site	CY 1999 Collective Dose (person-rem)	Population within 80 km (1)	Notes
AL	GJO	6.3×10^{-4}	1.2×10^{5}	2
	KCP	–	–	
	LANL	3.2×10^{-1}	2.6×10^{5}	
	LRRI	7.7×10^{-4}	5.0×10^{5}	
	PANX	3.7×10^{-3}	2.7×10^{5}	
	SNLA	2.2×10^{-2}	7.0×10^{5}	
	SNLT	–	6.7×10^{3}	
CH	ANLE	9.7×10^{-1}	8.4×10^{6}	3
	BNL	4.8×10^{0}	5.1×10^{6}	
	EML	–	–	
	FERMI	6.6×10^{-3}	8.0×10^{6}	
	PPPL	2.7×10^{0}	–	
ID	INEEL	3.7×10^{-2}	1.2×10^{5}	
NR	BET	1.4×10^{0}	3.0×10^{6}	
	KAPL-1	1.9×10^{-3}	1.3×10^{6}	
	KAPL-2	2.4×10^{-1}	1.2×10^{6}	
	KAPL-3	7.5×10^{-6}	3.4×10^{6}	
NV	NTS	3.8×10^{-1}	3.7×10^{4}	
OR	ORR	1.9×10^{1}	1.9×10^{5}	
	PGDP	6.5×10^{-2}	5.4×10^{5}	9
	POR	–	6.0×10^{5}	
	JLAB	–	–	NR
OAK	LBNL	7.4×10^{-1}	5.0×10^{6}	
	LEHR	4.0×10^{-5}	1.0×10^{5}	3, 7
	LLNL	2.2×10^{0}	6.3×10^{6}	3
	LLNL-300	1.1×10^{1}	5.4×10^{6}	3
	ETEC	9.5×10^{-5}	1.0×10^{7}	3
	SLAC	7.7×10^{-4}	4.9×10^{6}	
OR-RAP	WSSRAP	1.8×10^{-1}	2.9×10^{5}	8
OH	FEMP	1.3×10^{0}	2.7×10^{6}	
	MEMP	2.1×10^{0}	3.0×10^{6}	3
	WVDP	1.1×10^{-1}	1.3×10^{6}	
RL	HANF	1.9×10^{-1}	3.8×10^{5}	
RFFO	RFETS	9.8×10^{-1}	2.1×10^{6}	10
SR	SRS	5.1×10^{0}	6.2×10^{5}	
	Total	**5.4×10^{1}**	**7.6×10^{7}**	

Table 8. Collective Dose to the 80-km Population from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001. (Page 3 of 4)

DOE Office	Site	CY 2000 Collective Dose (person-rem)	Population within 80 km (1)	Notes
AL	GJO	6.1×10^{-4}	1.2×10^{5}	2
	LANL	1.0×10^{0}	2.5×10^{5}	
	LRRI	7.7×10^{-4}	5.0×10^{5}	
	PANX	1.6×10^{-3}	2.7×10^{5}	
	SNLA	8.0×10^{-2}	7.0×10^{5}	
	SNLT		6.9×10^{3}	
CH	ANLE	3.2×10^{0}	8.4×10^{6}	
	BNL	6.7×10^{0}	5.1×10^{6}	3
	FERMI	6.1×10^{-3}	8.0×10^{6}	
	PPPL	1.6×10^{0}	1.6×10^{7}	
ID	INEEL		1.2×10^{5}	
NR	BET	1.0×10^{0}	3.0×10^{6}	3
	KAPL-1	1.7×10^{-3}	1.3×10^{6}	
	KAPL-2	1.7×10^{-1}	1.2×10^{6}	
NV	NTS	4.4×10^{-1}	3.8×10^{4}	
OR	JLAB	2.5×10^{-1}		
	ORR	1.3×10^{1}	9.5×10^{5}	
	PGDP	1.3×10^{-2}	5.4×10^{5}	6
OR-RAP	WSSRAP	1.0×10^{-1}	2.1×10^{5}	8
OAK	LBNL	5.6×10^{-1}	5.0×10^{6}	
	LEHR	2.6×10^{-5}	1.0×10^{5}	7
	LLNL	5.2×10^{-1}	6.3×10^{6}	
	LLNL-300	2.5×10^{0}	5.4×10^{6}	
	ETEC	2.2×10^{-6}	1.0×10^{7}	
	SLAC	1.9×10^{-1}	4.9×10^{6}	
OH	FEMP	3.9×10^{0}	2.7×10^{6}	
	MEMP	1.1×10^{0}	3.0×10^{6}	
	WVDP	6.9×10^{-2}	1.4×10^{6}	
RL	HANF	1.8×10^{-1}	3.8×10^{5}	
RFO	RFETS	2.8×10^{-1}	2.8×10^{6}	
SR	SRS	4.9×10^{0}	6.2×10^{5}	
	Total	**4.2×10^{1}**	**9.0×10^{7}**	

Table 8. Collective Dose to the 80-km Population from Radionuclide Emissions to Air at Department of Energy Sites During Calendar Years 1998 through 2001. (Page 4 of 4)

DOE Office	Site	CY 2001 Collective Dose (person-rem)	Population within 80 km (1)	Notes
AL	LANL	1.6×10^{0}	2.7×10^{5}	
	PANX	2.1×10^{-3}	2.9×10^{5}	
	SNLA	6.8×10^{-2}	7.0×10^{5}	
CH	ANLE	2.4×10^{0}	8.9×10^{6}	
	BNL	5.7×10^{-1}	5.1×10^{6}	3
	FERMI	1.4×10^{-2}	8.0×10^{6}	
	PPPL	5.3×10^{0}	1.6×10^{7}	
ID	GJO	2.6×10^{-3}	1.2×10^{5}	2
	INEEL	5.9×10^{-1}	2.3×10^{5}	4
NR	BET	1.2×10^{0}	3.0×10^{6}	
	KAPL-1	1.2×10^{-3}	1.3×10^{6}	
	KAPL-2	3.5×10^{-2}	1.2×10^{6}	
NV	NTS	4.4×10^{-1}	3.8×10^{4}	
OAK	LBNL	4.8×10^{-1}	5.0×10^{6}	
	LEHR	2.2×10^{-4}	1.0×10^{5}	7
	LLNL	1.6×10^{-1}	6.9×10^{6}	
	LLNL-300	9.4×10^{0}	6.0×10^{6}	
	ETEC	7.5×10^{-4}	1.0×10^{7}	
	SLAC	2.3×10^{-1}	4.9×10^{6}	
OH	FEMP	3.5×10^{0}	2.7×10^{6}	
	MEMP	2.7×10^{0}	3.1×10^{6}	3
	WVDP	5.9×10^{-2}	1.4×10^{6}	
OR	JLAB	2.2×10^{-2}		
	ORR	8.3×10^{0}	1.0×10^{6}	
	PGDP	1.1×10^{0}	5.0×10^{5}	11
	POR	1.8×10^{-1}	6.7×10^{5}	
RFO	RFETS	3.4×10^{-1}	2.9×10^{6}	
RL	HANF	4.0×10^{-1}	4.9×10^{5}	
SR	SRS	5.6×10^{0}	7.1×10^{5}	
	Total	**4.5×10^{1}**	**9.2×10^{7}**	

(1) To convert doses to SI units, use the conversion factor: 1 person-rem = 0.01 person-Sv.
(2) Population estimate includes only Mesa County.
(3) Dose estimates at these sites include doses from normal operations in addition to other releases such as unplanned releases, radon, or emissions from diffuse sources.
(4) Collective dose was not included in the site air emissions report; it was provided to DOE after the annual report was issued.
(5) Site emissions estimates were revised after the air emissions report was issued; collective dose has not been updated to reflect the revised emissions.
(6) Reported dose is for DOE operations only. Total dose including USEC was 6.1×10^{-2} person-rem. 3.4×10^{-2} person-rem in 2000.
(7) Population estimate includes people within 10 km of the site.
(8) Population for collective dose estimate includes only nearby businesses and recreational users.
(9) Reported dose including US Enrichment Corp. contributions.
(10) Population estimates includes people within 52 miles (83.7 km) of the site.
(11) Dose is total dose for the site. Not clear if this includes USEC or not.