DOE/EH-####

DOE Occupational Radiation Exposure

2000 Report

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DOE Occupational Radiation Exposure

2000 Report

The U.S. Department of Energy
Assistant Secretary for Environment, Safety and Health
Office of Safety and Health

Foreword

The goal of the U.S. Department of Energy (DOE) is to conduct its radiological operations to ensure the safety and health of all DOE employees including contractors and subcontractors. The DOE strives to maintain radiation exposures to its workers below administrative control levels and DOE limits and to further reduce these exposures to levels that are "As Low As Reasonably Achievable" (ALARA).

The *2000 DOE Occupational Radiation Exposure Report* provides summary and analysis of the occupational radiation exposure received by individuals associated with DOE activities. The DOE mission includes stewardship of the nuclear weapons stockpile and the associated facilities, environmental restoration of DOE, and energy research.

Collective dose at DOE (as measured by the collective external whole body dose) has declined by 87% from 1985 to 2000 due to a cessation in opportunities for exposure during the transition in DOE mission from weapons production to cleanup, deactivation and decommissioning. In 2000, the collective dose decreased by 2% from the 1999 value due to decreased doses at two of the six highest dose DOE sites. These two sites attributed the decrease in collective dose to a reduction of source material and lowering of ambient dose rates at Rocky Flats, and a change in the biokinetic models used to determine internal dose from uranium intakes at the Oak Ridge Y-12 facility. LANL also reported a reduction in operational activities during corrective actions following the plutonium intake event. The DOE average measurable TEDE increased by 1% from 1999 to 2000. Statistical analysis reveals that the logarithmic mean TEDE decreased in 2000, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose. The decrease in mean TEDE from 1998 to 2000 similarly indicates a lower dose per worker over the last three years, compared to 1996 and 1997.

This report is intended to be a valuable tool for managers in their management of radiological safety programs and commitment of resources. The process of data collection, analysis, and report generation is streamlined to give managers a current assessment of the performance of the Department with respect to radiological operations. The cooperation of the sites in promptly and correctly reporting employee radiation exposure information is key to the timeliness of this report. Your feedback and comments are important to us to make this report meet your needs.

Steven V. Cary
Acting Assistant Secretary
Office of Environment, Safety and Health

C. Rick Jones
Acting Deputy Assistant Secretary
Office of Safety and Health

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10 CFR 835:	Title 10 Code of Federal Regulation Part 835 "Occupational Radiation Protection," December 14, 1993
10 CFR 835, Amendment:	Issued on November 4, 1998
10 CFR 835.402.d:	Amendment to be fully implemented by January 1, 2002
ACL:	Administrative Control Level
AEDE:	Annual Effective Dose Equivalent
ALAP:	As Low As Practicable
ALARA:	As Low As Reasonably Achievable
ANL-E:	Argonne National Laboratory - East
ANL-W:	Argonne National Laboratory - West
ANSI:	American National Standards Institute
ANSI N13.30-1996:	ANSI Note on Performance Criteria for Radioassay
BHI:	Bechtel Hanford, Inc.
BNL:	Brookhaven National Laboratory
CDE:	Committed Dose Equivalent
CEDE:	Committed Effective Dose Equivalent
CEDR:	Comprehensive Epidemiologic Data Resource
DAC:	Derived Air Concentration
D&D:	Decontamination and Decommissioning
DDE:	Deep Dose Equivalent
DNFSB:	Defense Nuclear Facilities Safety Board
DOE:	Department of Energy
DOE HQ:	DOE Headquarters
DOE M 231.1-1:	Manual for Environment, Safety and Health Reporting, September 10, 1995
DOE Notice 441.1:	Radiological Protection for DOE Activities, September 29, 1995
DOE Order 5480.11:	Radiation Protection for Occupational Workers, December, 1988
DOE Order 5484.1:	Environmental Protection, Safety, and Health Protection Information Reporting Requirements", February 24, 1981, Change 7, October 17, 1990
DOELAP:	DOE Laboratory Accreditation Program
EDE:	Effective Dose Equivalent
EH-52:	DOE Office of Worker Protection Policy and Programs
EPA:	Environmental Protection Agency
ES&H:	Environment, Safety & Health
ETTP:	East Tennessee Technology Park (formerly K-25)
EUO:	Enriched Uranium Operations
FERMCO:	Fernald Environmental Research Management Corporation
FERMI:	Enrico Fermi National Accelerator Laboratory
HEPA:	High-Efficiency Particulate Air (Filter)
ICRP:	International Commission on Radiological Protection
INEEL:	Idaho National Engineering & Environmental Laboratory
ISM:	Integrated Safety Management
LANL:	Los Alamos National Laboratory
LBNL:	Lawrence Berkeley National Laboratory
LDE:	Lens (of the eye) Dose Equivalent
LEHR:	Laboratory for Energy-Related Health Research
LLNL:	Lawrence Livermore National Laboratory
LLPIT:	Lessons Learned Process Improvement Team
MDA:	Minimum Detectable Activity
MSR:	Molten Salt Reactor

TABLE OF ACRONYMS (continued)

mSv:	MilliSievert
NAC:	Nuclear Assurance Corporation
NCRP:	National Council on Radiation Protection and Measurements
NRC:	Nuclear Regulatory Commission
NREL:	National Renewable Energy Laboratory
NTS:	Nevada Test Site
ORISE:	Oak Ridge Institute for Science & Education
ORNL:	Oak Ridge National Laboratory
PGDP:	Paducah Gaseous Diffusion Plant
PNNL:	Pacific Northwest National Laboratory
PORTS:	Portsmouth Gaseous Diffusion Plant
PP:	Pantex Plant
PSEs:	Planned Special Exposures
RadCon:	Radiological Control Manual, June 1992
RCS:	Radiological Control Technical Standard
REC:	Radiochemical Engineering Cells
REMS:	Radiation Exposure Monitoring System
RFETS:	Rocky Flats Environmental Technology Site
SDE:	Shallow Dose Equivalent
SDE-ME:	Shallow Dose Equivalent to the Maximally Exposed Extremity
SDE-WB:	Shallow Dose Equivalent to the Skin of the Whole-Body
SLAC:	Stanford Linear Accelerator Center
SNL:	Sandia National Laboratory
SOC:	Standard Occupational Classification
SRS:	Savannah River Site
TEDE:	Total Effective Dose Equivalent
TODE:	Total Organ Dose Equivalent
TRU:	Transuranic
UHPS:	Ultra High Pressure System
UMTRA:	Uranium Mill Tailings Remedial Action
UNSCEAR:	United Nations Scientific Committee on the Effects of Atomic Radiation
WVNS:	West Valley Nuclear Services

Executive Summary

The U.S. Department of Energy (DOE) Office of Safety and Health publishes the annual *DOE Occupational Radiation Exposure Report*. This report is intended to be a valuable tool for DOE and DOE contractor managers in managing radiological safety programs and to assist them in prioritizing resources. We appreciate the efforts and contributions from the various stakeholders within and outside DOE in making this report most useful to them.

This report includes occupational radiation exposure information for all monitored DOE employees, contractors, subcontractors, and visitors. The exposure information is analyzed in terms of aggregate data, dose to individuals, and dose by site. For the purposes of examining trends, data for the past 5 years are included in the analysis.

As shown in *Exhibit ES-1*, between 1999 and 2000, the DOE collective Total Effective Dose Equivalent (TEDE) decreased by 2% primarily due to decreased doses at two of the six sites with the highest radiation dose. The average dose to workers with measurable dose increased by 1% from 0.078 rem (0.78 mSv) in 1999 to 0.079 rem (0.79 mSv) in 2000 as shown in *Exhibit ES-2* because of a 9% decrease in the number of individuals receiving measurable dose. The percentage of monitored individuals receiving measurable dose increased from 15% in 1999 to 16% in 2000, and there were three dose in excess of the DOE 5 rem (50 mSv) annual TEDE limit. All three were the result of intakes of plutonium at LANL. The number of individuals receiving doses above 0.100 rem (1mSv) (the threshold above which monitoring is required) has decreased by 5% between 1999 and 2000, and decreased by 25% over the past five years from 1996 to 2000.

Eighty-three percent of the collective TEDE for the DOE complex was accrued at six DOE sites in 2000. These six sites are (in descending order of collective dose for 2000) Rocky Flats, Hanford, Los Alamos, Savannah River, Oak Ridge, and Idaho. Sites reporting under the category of weapons fabrication and testing account for the highest collective dose. Even though these sites are now primarily involved in nuclear materials stabilization and waste management, they still report under this facility type. For the past 3 years, technicians and production staff have received the highest collective dose of any specified labor category.

Exhibit ES-1:
Collective TEDE Dose (person-rem), 1996-2000.

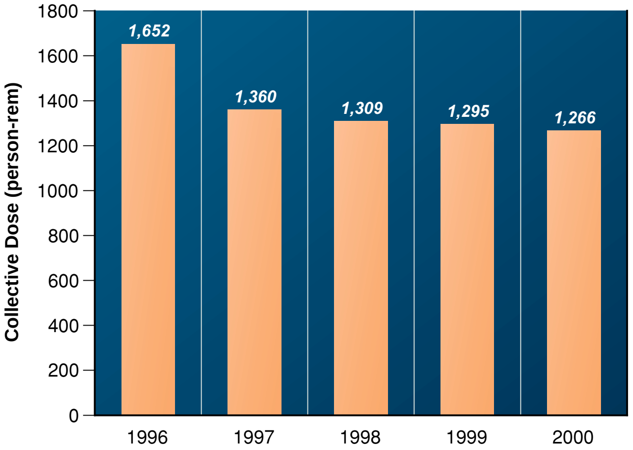
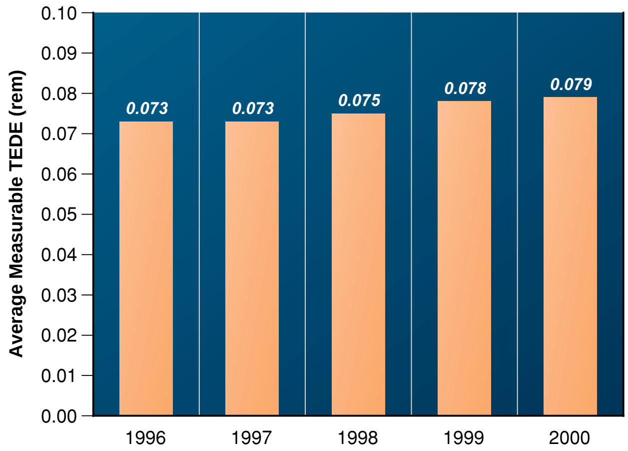


Exhibit ES-2:
Average Measurable TEDE (rem), 1996-2000.



The change in operational status of DOE facilities has had the largest impact on radiation exposure over the past 5 years due to the shift in mission from production to cleanup activities and the shutdown of certain facilities. Reports submitted by two of the sites that experienced decreases in the collective dose (Rocky Flats and Oak Ridge) indicate that decreases in the collective dose were due to a reduction of source material and lowering of ambient dose rates at Rocky Flats, and a change in the biokinetic models used to determine internal dose from uranium intakes at the Oak Ridge Y-12 facility. LANL also reported a reduction in operational activities during corrective actions following the plutonium intake event.

Statistical analysis reveals that the logarithmic mean TEDE in 2000 was 0.003 rem lower than in 1999, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose. The decrease in mean TEDE from 1998 to 2000 similarly indicates a lower dose per worker over the last three years, compared to 1996 and 1997.

Over the past 5 years, few occupational doses at DOE facilities in excess of the 2 rem (20 mSv) Administrative Control Level (ACL) and 5 rem (50 mSv) TEDE regulatory limit have occurred, as shown in *Exhibits ES-3* and *ES-4*. All of the doses in excess of 2 rem (20 mSv) in the past 5 years were due to internal dose, except one, which occurred in 1996 that was due to external dose (DDE). Three individuals received a dose in excess of the 5 rem (50 mSv) TEDE limit in 2000. All three individuals received internal doses (CEDE) from plutonium at LANL during a single event, which was caused by a leaking compression fitting in a glovebox vacuum line.

Exhibit ES-3:
Number of Individuals Exceeding 2 rem TEDE, 1996-2000.

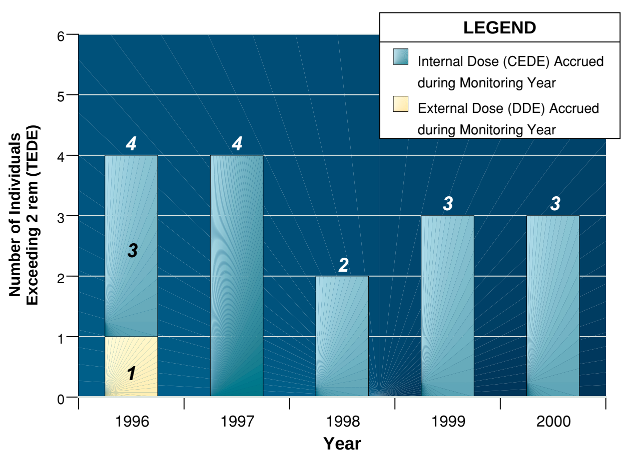
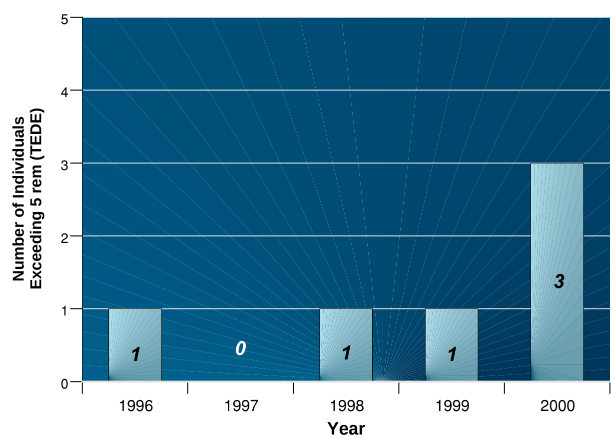


Exhibit ES-4:
Number of Individuals Exceeding 5 rem TEDE, 1996-2000.



An event was reported by LANL in 1999 that occurred during 1998 and had the potential to result in a dose in excess of the DOE annual TEDE limit. At the time of publication, the dose had not been finalized and was therefore not included in the 1999 annual report. Subsequently, LANL has finalized the dose assessment for the individual, and the individual did exceed the DOE annual TEDE limit. The final TEDE assigned was 6.292 rem (62.92 mSv) for the year 1998.

The collective internal dose (CEDE) has increased for the sixth year in a row, with an increase of 70% between 1998 and 1999 and 18% between 1999 and 2000. Due to the increase in the collective CEDE and decrease in the number of internal depositions, the average measurable CEDE increased by 30% from 1999 to 2000 and is double the value for 1998. The primary reason for this increase was the three intakes of plutonium at LANL that were in excess of the 5 rem (50 mSv) DOE annual limit. Combined, these three internal doses account for 60% of the DOE-wide collective CEDE for the year.

An analysis was performed on the transient workforce at DOE. A transient worker is defined as an individual monitored at more than one DOE site in a year. The results of this analysis show that the number of transient workers monitored has increased over the past 5 years, but decreased by 33% from 1999 to 2000. The collective dose for these transients decreased by 40%, resulting in an 18% decrease in the average measurable dose to transients. The average measurable dose to transient workers has been less than the value for the overall DOE workforce for the past 5 years.

The results of a pilot project to collect historical radiation exposure records that was conducted during 1999 and 2000 are included in this report. The objective of the project was to examine the feasibility of collecting historical data that had not previously been reported to the DOE radiation records repository. Twelve sites were involved in the voluntary pilot project where over 4 million records were reported and analyzed for inclusion into the repository. The results of the analysis indicate that 50% of the overall DOE collective dose prior to 1987 was collected from the twelve participating sites in this pilot study. The average career length for individuals with measurable external dose at these sites was 10.5 years, with an average measurable career dose of 1.4 rem (14 mSv).

To access this report and other information on occupational radiation exposure at DOE, visit the web site at:

http://rems.eh.doe.gov

Section One

Introduction

1

Introduction

The *DOE Occupational Radiation Exposure Report, 2000* reports occupational radiation exposures incurred by individuals at DOE facilities during the calendar year 2000. This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and visitors. The 104 DOE organizations submitting radiation exposure reports for 2000 have been grouped into 28 geographic sites across the complex (see Appendix A.2). This information is analyzed and trended over time to provide a measure of DOE's performance in protecting its workers from radiation.

1.1 Report Organization

This report is organized into the five sections listed below. Supporting technical information, tables of data, and additional items that were identified by users as useful are provided in the appendices.

1.2 Report Availability

Requests for additional copies of this report, access to the data files, or individual dose records used to compile this report should be directed to:

Ms. Nirmala Rao
Radiation Exposure Monitoring System (REMS) Project Manager
U.S. Department of Energy
Office of Worker Protection Policy and Programs (EH-52)
Germantown, MD 20874
E-mail: nimi.rao@eh.doe.gov

A discussion of the various methods of accessing DOE occupational radiation exposure information is presented in Appendix E. Visit the DOE Radiation Exposure web site for information concerning occupational radiation exposure in the DOE complex at:

http://rems.eh.doe.gov

Section One	Provides a description of the content and organization of this report.
Section Two	Provides a discussion of the radiation protection and dose reporting requirements and their impacts on data interpretation. Additional information on dose calculation methodologies, personnel monitoring methods and reporting thresholds, regulatory dose limits, and ALARA is included.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 2000. The data are analyzed to show trends over the past 5 years.
Section Four	Includes examples of successful ALARA projects within the DOE complex.
Section Five	Presents conclusions based on the analysis contained in this report.
Appendices	Lists reporting codes and organizations, a detailed breakdown of the data analyzed in this report, limitations of the data, and ways to access the REMS data.

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Standards and Requirements

One of DOE's primary objectives is to provide a safe and healthy workplace for all employees and contractors. To meet this objective, DOE's Office of Worker Protection Policy and Programs establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and the public. In addition to the requirement that radiation doses not exceed the limits, contractors are required to maintain exposures ALARA.

This section discusses the radiation protection standards and requirements that were in effect for the year 2000. The requirements leading up to this time period are also included to facilitate a better understanding of changes that have occurred in the recording and reporting of occupational dose.

2.1 Radiation Protection Requirements

DOE radiation protection standards are based on federal guidance for protection against occupational radiation exposure promulgated by the U.S. Environmental Protection Agency (EPA) in 1987 [1]. These standards are provided to ensure that DOE workers are adequately protected from exposure to ionizing radiation. This guidance, initially implemented by DOE in 1989, is based on the 1977 recommendations of the International Commission on Radiological Protection (ICRP) [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements (NCRP) [3]. This guidance recommended that internal organ dose (resulting from the intake of radionuclides) be added to the external whole-body dose to determine the Total Effective Dose Equivalent (TEDE). Prior to this, the whole-body dose and internal organ dose were each limited separately. The present DOE dose limits based on the TEDE were established from this guidance.

DOE became the first federal agency to implement the EPA guidance when it promulgated DOE Order 5480.11, "Radiation Protection for Occupational Workers," in December 1988 [4]. DOE Order 5480.11 was in effect from 1989 to 1995.

In June 1992, the "DOE Radiological Control (RadCon) Manual" [5] was issued and became effective in 1993. The "RadCon Manual" was the result of a Secretarial initiative to improve and standardize radiological protection practices throughout DOE and to achieve the goal of making DOE the pacesetter for radiological health and safety. The "RadCon Manual" is a comprehensive guidance document written for workers, line managers, and senior management. The "RadCon Manual" states DOE's views on the best practices currently available in the area of radiological control. The "RadCon Manual" was revised in 1994 in response to comments from the field and to enhance consistency with the requirements in 10 CFR 835 "Occupational Radiation Protection" [6]. In July 1999, the "RadCon Manual" was formally reissued as the Radiological Control Standard (RCS) [7]. The RCS incorporates changes resulting from the amendment to 10 CFR 835 issued on November 4, 1998.

10 CFR 835 became effective on January 13, 1994, and required full compliance by January 1, 1996. In general, 10 CFR 835 codified existing radiation protection requirements in DOE Order 5480.11. The rule provides nuclear safety requirements that, if violated, will provide a basis for the assessment of civil and criminal penalties under the Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988 [8] as implemented by 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993. [9]

One and one-half years after the promulgation of 10 CFR 835, DOE Order 5480.11 was canceled and the "RadCon Manual" was made non-mandatory guidance with issuance of DOE Notice 441.1, "Radiological Protection for DOE Activities," [10] (applicable to defense nuclear facilities). This notice was issued to establish radiological protection program requirements that, combined with 10 CFR 835 and its associated non-mandatory implementation guidance, formed the basis for a comprehensive radiological protection program. DOE N 441.1 continued in effect until June 1, 2000 when compliance with the amendment to 10 CFR 835 (issued November 4, 1998) was expected to be fully implemented.

During 1994 and 1995, DOE undertook an initiative to reduce the burden of unnecessary, repetitive, or conflicting requirements on DOE contractors. As a result, DOE Order 5484.1 [11] requirements for reporting radiation dose records are now located in the associated manual, DOE M 231.1-1, “Environment, Safety and Health Reporting” [12], which became effective September 30, 1995.

The requirements of DOE M 231.1-1 are basically the same as Order 5484.1; however, the dose terminology was revised to reflect the changes made in radiation protection standards and requirements. For 1995, DOE Order 5484.1 remained in effect. Most sites reported radiation monitoring results under the new DOE M 231.1-1 for 1996. Each site implemented the new requirements as operating contracts were issued or renegotiated.

2.1.1 Monitoring Requirements

10 CFR 835.402(a) requires that, for external monitoring, personnel dosimetry be provided to general employees likely to receive an effective dose equivalent to the whole-body greater than 0.1 rem (1 mSv) in a year or an effective dose equivalent to the skin or extremities, lens of the eye, or any organ or tissue greater than 10% of the corresponding annual limits. Monitoring for internal radiation exposure is also required when the general employee is likely to receive 0.1 rem (1 mSv) or more Committed Effective Dose Equivalent (CEDE), in a year. Monitoring for minors and the public is required if the TEDE is likely to exceed 50% of the annual limit of 0.1 rem (1 mSv) TEDE. Monitoring of declared pregnant workers is required if the TEDE to the embryo/fetus is likely to exceed 10% of the limit of 0.5 rem (5 mSv) TEDE during the gestation period.

Monitoring for external exposures is also required for any individual entering a high or very high radiation area.

2.1.1.1 External Monitoring

External or personnel dosimeters are used to measure ionizing radiation from sources external to the individual. The choice of dosimeter is based on the type and energy of radiation that the individual is likely to encounter in the workplace. An algorithm is then used to convert the exposure readings into dose. External monitoring devices include thermoluminescent dosimeters, optically stimulated luminescent dosimeters, pocket ionization chambers, electronic dosimeters, personnel nuclear accident dosimeters, bubble dosimeters, plastic dosimeters, and combinations of the above.

Beginning in 1986, the DOE Laboratory Accreditation Program (DOELAP) formalized accuracy and precision performance standards for external dosimeters and quality assurance/quality control requirements for external dosimetry programs at facilities within the DOE complex. All DOE facilities requiring accreditation were DOELAP-accredited by the fall of 1995.

External dosimeters have a lower limit of detection of approximately 0.010 - 0.030 rem (0.10 - 0.30 mSv) per monitoring period. The differences are attributable to the particular type of dosimeter used and the types of radiation monitored. Monitoring periods are usually quarterly for individuals receiving less than 0.300 rem/year (3 mSv/year) and monthly for individuals who may receive higher doses or who enter higher radiation areas.

2.1.1.2 Internal Monitoring

Bioassay monitoring includes in-vitro (outside the body) and in-vivo (inside the body) sampling. In-vitro assays include urine and fecal samples, nose swipes, saliva samples, and hair samples. In-vivo assays include whole-body counting, thyroid counting, lung counting, and wound counting.

Monitoring intervals for internal dosimetry depend on the radionuclides being monitored and their concentrations in the work environment. Routine monitoring intervals may be monthly, quarterly, or annually, whereas special monitoring intervals following an incident may be daily or weekly. Detection thresholds for internal dosimetry are highly dependent on the monitoring methods, the monitoring intervals, the radionuclides in question, and their chemical form. Follow-up measurements and analysis may take many months to confirm preliminary findings. DOE has developed a Radiobioassay Accreditation Program in conjunction with the publication of American National Standards Institute (ANSI) N13.30-1996, "Performance Criteria for Radiobioassay". Implementation of the program began in November 1998 with the issuance of the amendments to 10 CFR 835.402.d, and must be fully implemented by January 1, 2002.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835.202, 204, 206, 207, 208 and are summarized in *Exhibit 2-1*. While some of these sections have been revised, the limits remain the same.

Under 835.204, Planned Special Exposures (PSEs) may be authorized under certain conditions allowing an individual to receive exposures in excess of the dose limits shown in *Exhibit 2-1*. With the appropriate prior authorization, the annual dose limit for an individual may be increased by an additional 5 rems (50 mSv) TEDE above the routine dose limit as long as the individual does not exceed a cumulative lifetime TEDE of 25 rems (250 mSv) from other PSEs and doses above the limits. PSE doses are required to be recorded separately and are only intended to be used in exceptional situations where dose reduction alternatives are unavailable or impractical. No PSEs have occurred during the past 7 years (since the requirement became effective).

Exhibit 2-1:
DOE Dose Limits from 10 CFR 835

Personnel Category	Section of 10 CFR 835	Type of Exposure	Acronym	Annual Limit
General Employees	*§835.202*	*Total Effective Dose Equivalent*	*TEDE*	*5 rems*
		Deep Dose Equivalent + Committed Dose Equivalent to any organ or tissue (except lens of the eye). This is often referred to as the Total Organ Dose Equivalent	*DDE+CDE (TODE)*	*50 rems*
		Lens of the Eye Dose Equivalent	*LDE*	*15 rems*
		Shallow Dose Equivalent to the skin of the Whole-body or to any Extremity	*SDE-WB and SDE-ME*	*50 rems*
*Declared Pregnant Worker **	*§835.206*	*Total Effective Dose Equivalent*	*TEDE*	*0.5 rem per gestation period*
Minors	*§835.207*	*Total Effective Dose Equivalent*	*TEDE*	*0.1 rem*
Members of the Public in a Controlled Area	*§835.208*	*Total Effective Dose Equivalent*	*TEDE*	*0.1 rem*

**Limit applies to the embryo/fetus*

2.2.1 Administrative Control Levels

Administrative Control Levels (ACLs) were initially established in the "RadCon Manual" and retained in the RCS. ACLs are established below the regulatory dose limits to administratively control and help reduce individual and collective radiation dose. ACLs are multi-tiered, with increasing levels of authority needed to approve a higher level of exposure.

The RCS recommends a DOE ACL of 2 rem (20 mSv) per year per person for all DOE activities. Prior to allowing an individual to exceed this level, approval from the appropriate Secretarial Officer or designee should be received. In addition, contractors are encouraged to establish an annual facility ACL. This control level is established by the contractor senior site executive and is based upon an evaluation of historical and projected radiation exposures, workload, and mission. The RCS suggests an annual facility ACL of 0.5 rem (5 mSv) or less; however, the Manual also states that a control level greater than 1.5 rem (15 mSv) is, in most cases, not sufficiently challenging. Approval by the contractor senior site executive must be received prior to an individual exceeding the facility ACL. In addition to the annual ACL, the Manual recommends the establishment of a lifetime ACL of "N" rem, where N is the age of the person in years. Special Control Levels are also recommended to be established for personnel who have doses exceeding N rem.

2.2.2 ALARA Principle

Until the 1970s, the fundamental radiation protection principle was to limit occupational radiation dose to quantities less than the regulatory limits and to be concerned mainly with high dose and high dose rate exposures. During the 1970s, there was a fundamental shift within the radiation protection community to be concerned with low dose and low dose rate exposures because it can be inferred from the linear no-threshold dose response hypothesis that there is an increased level of risk associated with any radiation exposure. The As Low As Practicable (ALAP) concept was initiated and became part of numerous guidance documents and radiation protection good practices. ALAP was eventually replaced by ALARA. DOE Order 5480.11 and 10 CFR 835 require that each DOE facility have an ALARA Program as part of its overall Radiation Protection Program.

The ALARA methodology considers both individual and group doses and generally involves a cost/benefit analysis. The analysis considers social, technical, economic, practical, and public policy aspects of the overall goal of dose reduction. Because it is not feasible to reduce all doses at DOE facilities to zero, ALARA cost/benefit analysis must be used to optimize levels of radiation dose reduction. According to the ALARA principle, resources spent to reduce dose need to be balanced against the risks avoided. Reducing doses below this point results in a misallocation of resources; the resources could be spent elsewhere and have a greater impact on health and safety.

To ensure that doses are maintained ALARA at DOE facilities, the DOE mandated in DOE Order 5480.11 and subsequently in the 10 CFR 835 that ALARA plans and procedures be implemented and documented. To help facilities meet this requirement, DOE developed a manual of good practices and an implementation guide for reducing exposures to ALARA levels [13]. This document includes guidelines for administration of ALARA programs, techniques for performing ALARA calculations based on cost/benefit principles, guidelines for setting and evaluating ALARA goals, and methods for incorporating ALARA criteria into both radiological design and operations. The establishment of ALARA as a required practice at DOE facilities demonstrates DOE's commitment to ensure minimum risk to workers from the operation of its facilities.

2.3 Reporting Requirements

In 1987, DOE promulgated revised reporting requirements in DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements." Previously, contractors were required to report only the number of individuals who received an occupational whole-body dose in one of 16 dose equivalent ranges. The revised Order required the reporting of the results of radiation exposure monitoring for each employee and visitor. Required dose data reporting includes the TEDE, internal dose equivalent, Shallow Dose Equivalent (SDE) to the skin and extremities, and Deep Dose Equivalent (DDE). Other reported data include the individual's age, sex, monitoring status, and occupation, as well as the reporting organization and facility type.

Occupational radiation exposure reporting requirements are now included in DOE M 231.1-1, which became effective September 30, 1995. The reporting requirements under DOE M 231.1-1 are very similar to those under Order 5484.1.

2.4 Change in Internal Dose Methodology

Prior to 1989, intakes of radionuclides into the body were not reported as dose, but as body burden in units of activity of systemic burden, such as the percent of the maximum permissible body burden. The implementation of DOE Order 5480.11 in 1989 specified that the intakes of radionuclides be converted to internal dose and reported using the Annual Effective Dose Equivalent (AEDE) methodology.

With the implementation of the "RadCon Manual" in 1993, the required methodology used to calculate and report internal dose was changed from the AEDE to the 50-year CEDE. The change was made to provide consistency with scientific recommendations, facilitate the transfer of workers between DOE and Nuclear Regulatory Commission (NRC)-regulated facilities, and simplify record keeping by recording all dose in the year of intake. The CEDE methodology is now codified in 10 CFR 835.

Readers should note that the method of calculating internal dose changed from AEDE to CEDE between 1992 and 1993 when analyzing TEDE data prior to 1993.

This report primarily analyzes dose information for the past 5 years, from 1996 to 2000. During these years, the CEDE methodology was used to calculate internal dose; therefore, the change in methodology from AEDE to CEDE between 1992 and 1993 does not affect the analysis contained in this report. Readers should keep in mind the change in methodology if analyzing TEDE data prior to 1993.

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Occupational Radiation Dose at DOE

3.1 Analysis of the Data

Analysis and explanation of observed trends in occupational radiation dose data reveal opportunities to improve safety and demonstrate performance. Several indicators were identified from the data submitted to the central data repository that can be used to evaluate the occupational radiation exposures received at DOE facilities. Analysis of these indicators falls into three categories: aggregate, individual, and site. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

The key indicators for the analysis of aggregate data are: number of monitored individuals and individuals with measurable dose, collective dose, average measurable dose, and the dose distribution. Analysis of individual dose data includes an examination of doses exceeding DOE regulatory limits, and doses exceeding the 2 rem (20 mSv) DOE ACL. Analysis of site data includes comparisons by site, labor category, and facility type. Additional information is provided concerning activities at sites contributing to the collective dose. To determine the significance of trends, statistical analysis was performed on the data.

3.2 Analysis of Aggregate Data

3.2.1 Number of Monitored Individuals

The number of monitored individuals represents the size of the DOE worker population provided with dosimetry. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, subcontractors, visitors, and members of the public. The number of monitored individuals is determined from the number of monitoring records submitted by each site. Individuals may have more than one monitoring record and therefore may be counted more than once. The number of monitored individuals is an indication of the size of a dosimetry program, but it is not necessarily an indicator of the size of the exposed workforce. This is because of the conservative practice at some DOE facilities of providing dosimetry to individuals for reasons other than the potential for exposure to radiation and/or radioactive materials exceeding the monitoring thresholds. Many individuals are monitored for reasons such as security, administrative convenience, and legal liability. Some sites offer monitoring for any individual who requests monitoring, independent of the potential for exposure. For this reason, workers who receive a measurable dose represent the exposed workforce.

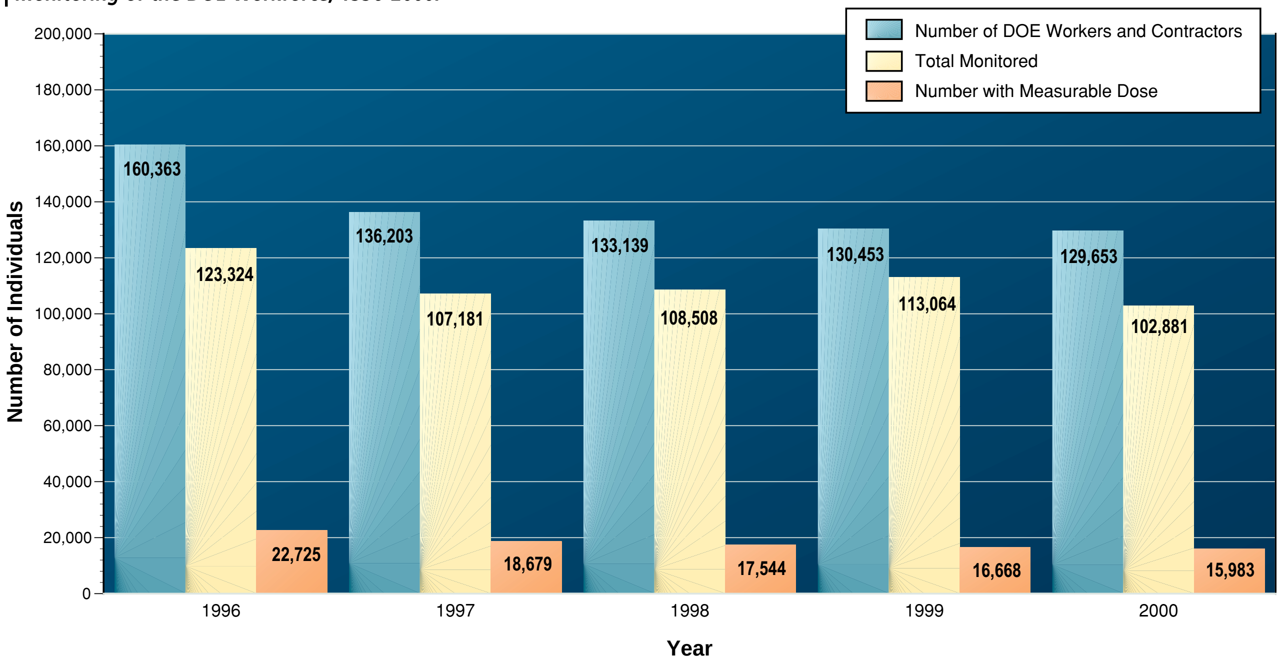
3.2.2 Number of Individuals with Measurable Dose

DOE uses the number of individuals receiving measurable dose to represent the exposed workforce size. The number of individuals with measurable dose includes any individuals with reported TEDE greater than zero.

Exhibit 3-1 shows the number of DOE workers and contractors, the total monitored and the number with measurable dose for the past 5 years. Although the total number of individuals monitored for radiation has decreased over the past 5 years by 17%, the percentage of the DOE workforce monitored for radiation exposure has increased by 2% from 1996 to 2000. However, most (83%) of the monitored individuals over the past 5 years did not receive any measurable radiation dose. An average of 17% of monitored individuals (13% of the DOE workforce) received a measurable dose during the past 5 years. The percentage of monitored workers receiving measurable dose has decreased each year for the past 5 years from 18% in 1996 to 16% in 2000. The

Compared to 1999, a smaller percentage of the DOE workforce was monitored for radiation in 2000, while a larger percentage of monitored individuals received a measurable dose.

Exhibit 3-1:
Monitoring of the DOE Workforce, 1996-2000.



overall DOE workforce has decreased by 19% over the past 5 years with decreases occurring each year. Compared to 1999, a smaller percentage of the DOE workforce was monitored for radiation in 2000, while a larger percentage of monitored individuals received a measurable dose.

Thirteen of 28 of the reporting sites experienced decreases in the number of workers with measurable dose from 1999 to 2000, with the largest decreases occurring at Rocky Flats, Oak Ridge, and Los Alamos National Laboratory (LANL). The largest increase in the number of workers receiving measurable dose occurred at Savannah River and the Stanford Linear Accelerator (SLAC). A discussion of activities at the six highest dose facilities is included in Section 3.5.

The number of workers with measurable dose decreased from 16,668 in 1999 to 15,983 in 2000.

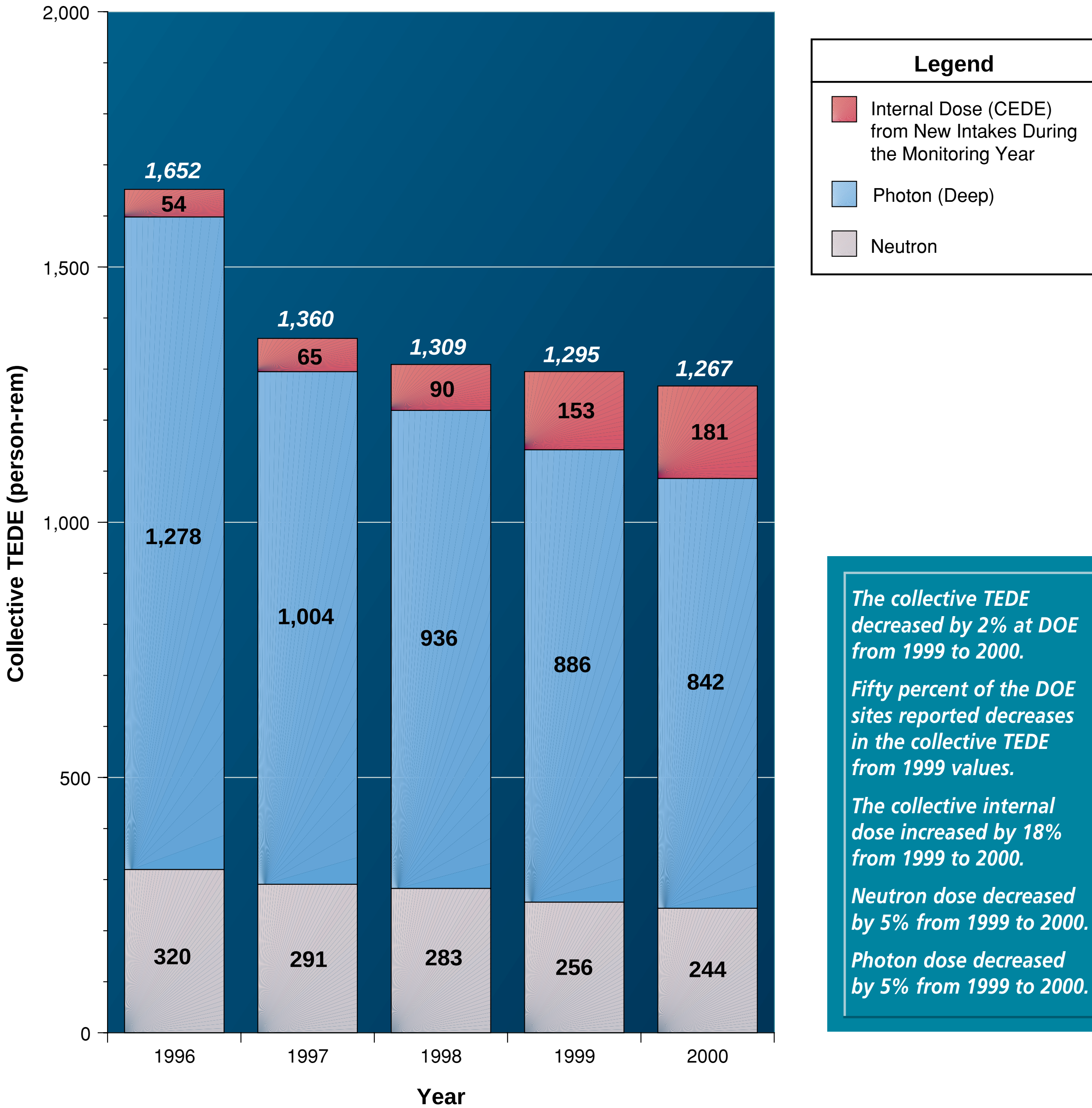
The percentage of monitored workers receiving measurable dose increased by one percentage point from 15% in 1999 to 16% in 2000.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with measurable dose and is measured in units of person-rem. The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and visitors. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

As shown in *Exhibit 3-2*, the collective TEDE decreased at DOE by 2% from 1999 to 2000. Fifty percent of the DOE sites reported decreases in the collective TEDE from the 1999 values. Two out of six of the highest dose sites reported decreases in the collective TEDE. The six highest dose sites are (in descending order of collective dose) Rocky Flats, Hanford, Los Alamos, Savannah River, Oak Ridge, and Idaho. Statistical analysis indicates that the TEDE per worker was significantly lower in 1998-2000 than in prior years, reflecting both a decline in the dose to individual workers, and

Exhibit 3-2:
Components of TEDE, 1996-2000.



The collective TEDE decreased by 2% at DOE from 1999 to 2000.

Fifty percent of the DOE sites reported decreases in the collective TEDE from 1999 values.

The collective internal dose increased by 18% from 1999 to 2000.

Neutron dose decreased by 5% from 1999 to 2000.

Photon dose decreased by 5% from 1999 to 2000.

Photon dose - the component of external dose from gamma or x-ray electromagnetic radiation. (Also includes energetic betas.)

Neutron dose - the component of external dose from neutrons ejected from the nucleus of an atom during nuclear reactions.

Internal dose - radiation dose resulting from radioactive material taken into the body.

fewer individuals with measurable dose. See Section 3.2.6 for more information on the statistical analysis, Section 3.5 for more information on activities contributing to the collective dose, and Section 4 for a discussion of notable ALARA activities.

It is important to note that the collective TEDE includes the components of external dose and internal dose. *Exhibit 3-2* shows the types of radiation and their contribution to the collective TEDE. The internal dose, photon, and neutron components are shown.

It should be noted that the internal dose shown in *Exhibit 3-2* for 1996 through 2000 is based on the 50-year CEDE methodology. The internal dose component increased by 18% from 1999 to 2000. This increase was largely the result of intakes of plutonium for three individuals at LANL that led to CEDE doses in excess of 5 rem (see Section 3.3.1). The collective internal dose can vary from year to year due to the relatively small number of uptakes of radioactive material and the fact that they often involve long-lived radionuclides, such as plutonium, which can result in relatively large committed doses. Due to the sporadic nature of these uptakes, care should be taken when attempting to identify trends from the internal dose records.

The external deep dose (comprised of energetic beta photon and neutron dose) is shown in *Exhibit 3-2* in order to see the contribution of external dose to the collective TEDE. The photon dose decreased by 21% between 1996 and 1997 and 7% between 1997 and 1998 as a result of fewer workers and a reduced scope of work in some locations. The collective photon dose decreased by 5% between 1999 and 2000. Sites attributed the reduction in dose to: a reduction of source material and lowering of background dose at Rocky Flats, and a delay in several projects at LANL due to the plutonium intake event which resulted in corrective actions that delayed certain projects. A discussion of the activities leading to this decrease is included in Section 3.5.

Neutron dose decreased by 24% from 1996 to 2000. This is primarily due to decreases in the neutron dose at LANL and Rocky Flats. LANL contributed 21% of the neutron dose at the DOE during 2000. This is because LANL is one of the few remaining sites to actively handle plutonium. Working with plutonium in gloveboxes results in neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium. Activities involving plutonium at LANL decreased during 2000 due to an accident involving plutonium work in a glovebox, which resulted in a decrease in the neutron dose from 79.6 person-rem (0.796 person-Sv) in 1999 to 50.6 person-rem (0.506 person-Sv) in 2000. The collective neutron dose for 2000 by site is shown in Appendix B-5. External deep dose (DDE) and TEDE for prior years (1974-2000) can be found in Appendix B-3.

3.2.4 Average Measurable Dose

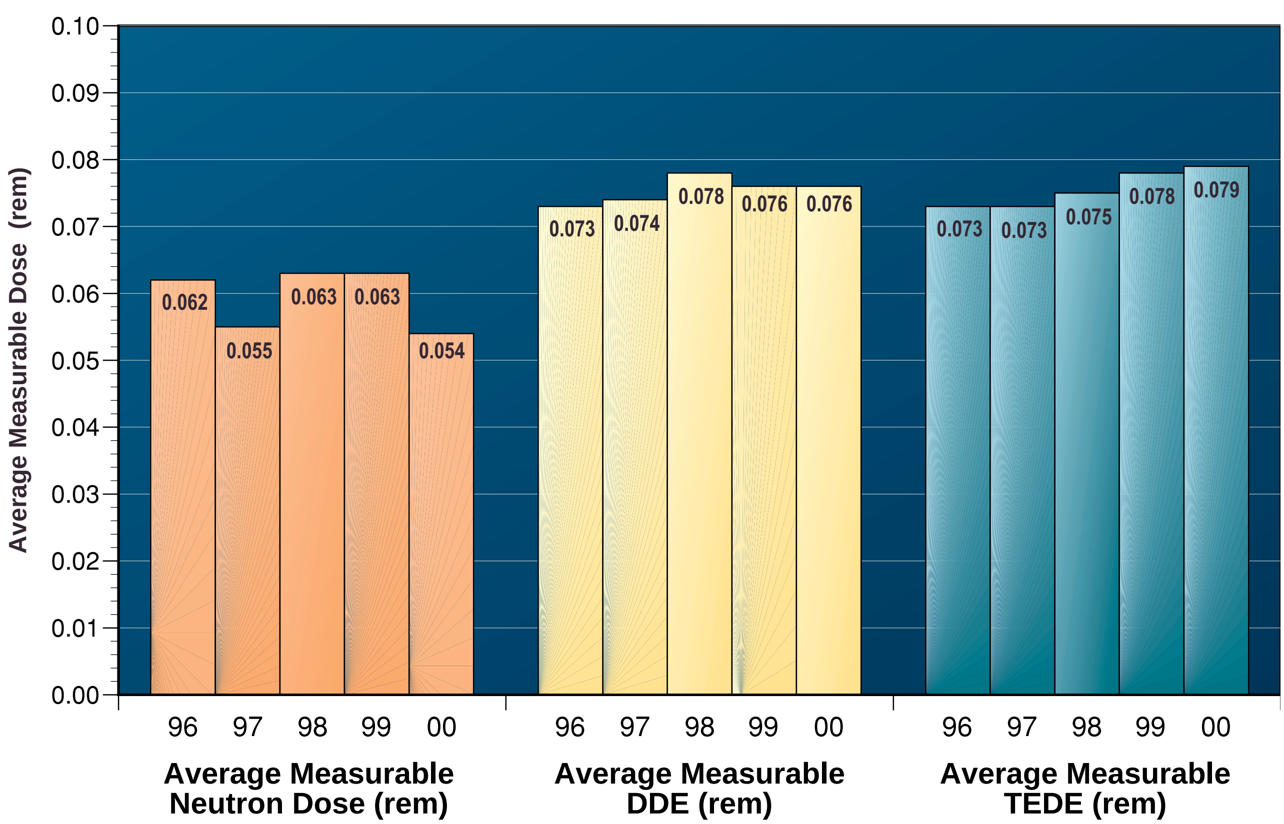
The average measurable dose to DOE workers presented in this report for TEDE, DDE, neutron, extremity, and CEDE are determined by dividing the collective dose for each dose type by the number of individuals with measurable dose for each dose type. This is one of the key indicators of the overall level of radiation dose received by DOE workers.

The average measurable neutron, DDE, and TEDE is shown in *Exhibit 3-3*. The average measurable neutron dose decreased by 14% from 1999 to 2000, primarily due to decreases in neutron dose at LANL and Rocky Flats. The average measurable DDE remained the same from 1999 to 2000 and has remained relatively stable over the past 5 years. While both the collective TEDE and the number with measurable dose decreased, the collective TEDE decreased less relative to the number with measurable dose, which resulted in a 1% increase in the average measurable TEDE. However, statistical analysis indicates that the logarithmic mean TEDE was significantly lower in 1998-2000 than in prior years, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose (see Section 3.2.6). The average measurable neutron, DDE, and TEDE values are provided for trending purposes, not for comparison between them.

While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not indicate the distribution of doses among the worker population.

The average measurable neutron dose decreased by 14%, the average measurable TEDE increased by 1%, while the average measurable DDE remained the same from 1999 to 2000.

Exhibit 3-3:
Average Measurable Neutron, DDE, and TEDE, 1996-2000.



3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the dose distribution among the worker population. *Exhibit 3-4* shows the number of individuals in each of 18 different dose ranges. The dose ranges are presented for the TEDE and DDE. The DDE is shown separately to allow for analysis of the dose independent of changes in internal dose, and includes the photon and neutron dose. The number of individuals receiving doses above 0.1 rem (1 mSv) is also included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c).

Exhibit 3-4 shows that few individuals receive doses in the higher ranges, that the vast majority of doses are at low levels, and that the collective dose has decreased every year for the past 5 years. This is one indication that ALARA principles are being applied to keep doses at low levels. A few examples of successful ALARA practices are included in Section 4. Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value compared to the total collective dose.

The United Nations Scientific Committee on the Effects of Atomic Radiation's (UNSCEAR) 1993 report entitled "Sources and Effects of Ionizing

Exhibit 3-4:
Distribution of Dose by Dose Range, 1996-2000.

Dose Ranges (rem)	1996		1997		1998		1999		2000	
	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE
Number of Individuals in Each Dose Range*										
Less than Measurable	100,599	101,529	88,502	89,805	90,964	92,803	96,396	98,125	86,898	88,621
Measurable < 0.1	18,759	17,903	15,263	14,098	14,066	12,450	13,561	12,137	13,020	11,498
0.10 - 0.25	2,441	2,405	2,142	2,046	2,253	2,120	1,898	1,763	1,873	1,722
0.25 - 0.5	1,003	983	856	830	840	790	770	684	727	690
0.5 - 0.75	339	335	265	258	268	245	238	206	211	203
0.75 - 1.0	99	94	101	99	74	64	118	87	91	93
1 - 2	80	74	48	45	41	36	80	62	58	54
2 - 3	2	1	1		1		1			
3 - 4	1		2				1			
4 - 5			1							
5 - 6										
6 - 7					1		1			
7 - 8										
8 - 9										
9 - 10									1	
10 - 11										
11 - 12		1							1	
> 12									1	
Total Monitored	123,324	123,324	107,181	107,181	108,508	108,508	113,064	113,064	102,881	102,881
Number with Meas. Dose	22,725	21,795	18,679	17,376	17,544	15,705	16,668	14,939	15,983	14,260
Number with Dose >0.1rem	3,966	3,892	3,416	3,278	3,478	3,255	3,107	2,802	2,963	2,762
% of Individuals with Meas. Dose	18%	18%	17%	16%	16%	14%	15%	13%	16%	14%
Collective Dose (person-rem)	1,652	1,598	1,360	1,285	1,309	1,219	1,295	1,142	1,267	1,086
Average Measurable Dose (rem)	0.073	0.073	0.073	0.074	0.075	0.078	0.078	0.076	0.079	0.076

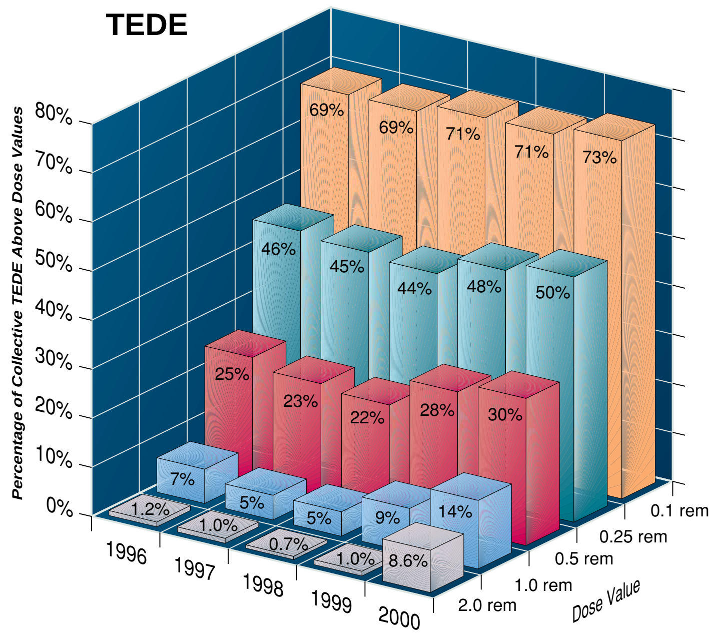
** Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.*

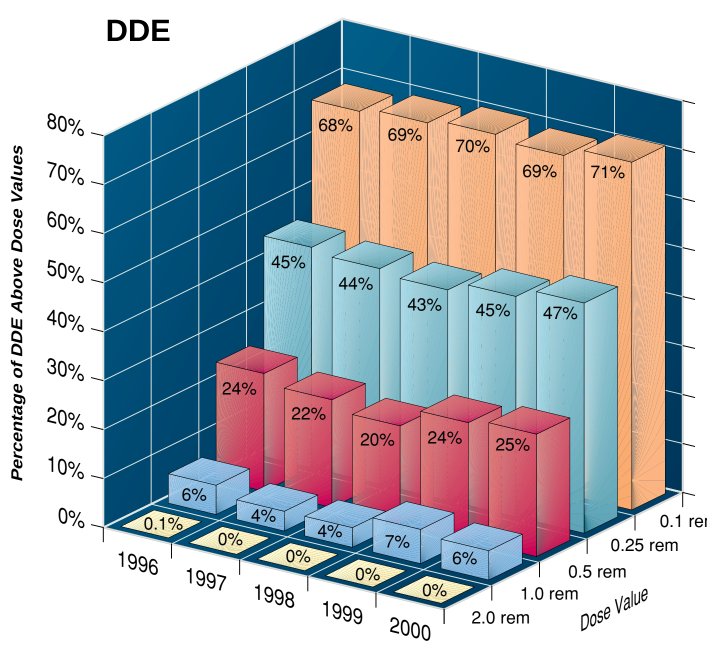
Radiation" [14] recommends the calculation of a parameter "SR" (previously referred to as CR or MR) to aid in the examination of the distribution of radiation dose among workers. SR is defined to be the ratio of the annual collective dose incurred by workers whose annual doses exceed 1.5 rem (15 mSv) to the total annual collective dose. The UNSCEAR report notes that a dose level of 1.5 rem (15 mSv) may not be useful where doses are consistently lower than this level and they recommend that research organizations report SR values lower than 1.5 rem (15 mSv) where appropriate. For this reason, the DOE calculates and tracks the SR ratio at dose levels of 0.100 rem (1 mSv), 0.250 rem (2.5 mSv), 0.500 rem (5 mSv), 1.0 rem (10 mSv), and 2.0 rem (20 mSv). The SR values in this report were calculated by summing the TEDE to each individual that received a TEDE greater than or equal to the specified dose range divided by the total collective TEDE. This ratio is presented as a percentage rather than a decimal fraction.

Ideally, only a small percentage of the collective dose is delivered to individuals in the higher dose ranges. In addition, a trend in the percentage above a certain dose range decreasing over time may indicate the effectiveness of ALARA programs to reduce doses to individuals, or may indicate an overall reduction in activities involving radiation exposure.

Exhibit 3-5 shows the dose distribution given by percentage of collective TEDE and DDE above each of five dose values, from 0.1 rem (1 mSv) to 2 rem (20 mSv). This graph facilitates the examination of two properties described above as the goal of effective ALARA programs at DOE: (1) a relatively small percentage of the collective dose accrued in the high dose ranges, and (2) a decreasing trend over time of the percentage of the collective dose accrued in the higher dose ranges. *Exhibit 3-5* shows that each successively higher dose range is responsible for a lower percentage of the collective dose. The values for the external dose (DDE) have remained relatively unchanged over the past 5 years within a 5% margin for each dose range. In contrast, the

Exhibit 3-5:
Percentage of Collective Dose above Dose Values During 1996-2000.





percentage of the TEDE in each dose range has increased since 1998. This is primarily due to the five internal doses that have exceeded the DOE limit in the last 3 years. This method of analyzing the collective TEDE is particularly sensitive to high individual dose, which can increase the percentages in the higher dose ranges. In 2000, three individuals received a TEDE above 2.0 rem (20 mSv) resulting in a collective TEDE for these three individuals of 108.6 rem (1,086 mSv). This corresponds to 8.6% of the collective TEDE for the year, the highest percentage in this category since 1990. See Section 3.3 for more information on the dose in excess of the DOE limit.

The neutron and extremity dose distributions are shown in *Exhibits 3-6* and *3-7*. The neutron dose is a component of the total DDE. Exposure to neutron radiation is much less common at DOE than photon dose. In 2000, 4,528 individuals received measurable neutron dose, which is 28% of the individuals with measurable TEDE, and 4% of the total monitored individuals. The collective neutron dose in 2000 represents 19% of the collective TEDE. All neutron doses were below 2 rem (20 mSv) for the past 5 years. The collective neutron dose decreased by 5% from 1999 to 2000, and has decreased by 24% since 1996. The average measurable neutron dose decreased by 14% from 1999 to 2000 primarily due to decreases in neutron dose at LANL and Rocky Flats. Statistical analysis of the neutron dose (see Section 3.2.6) reveals that the logarithmic mean neutron dose decreased significantly to its lowest level in 5 years. This indicates that the decrease in the collective neutron dose in 2000 is due to a reduction of neutron dose to individuals rather than merely a reduction in the number of individuals exposed. The neutron dose distribution for 2000 by site is shown in Appendix B-5.

Exhibit 3-7 shows the distribution of extremity dose over the past 5 years. "Extremities" are defined in 10 CFR 835.2 as the hands and arms below the elbow, and the feet and legs below the knee. 10 CFR 835.402(a)(1)(ii) requires monitoring for an SDE to the extremities of 5 rem (50 mSv) or more in a year. As shown in *Exhibit 3-7*, less than 1% of individuals have received doses above the 5 rem (50 mSv) monitoring threshold over the past 5 years. All of these extremity doses above 5 rem in 2000 were for the upper extremities. The DOE annual limit for extremity dose is 50 rem (500 mSv). The higher dose limit is due to the lack of blood-forming organs in the extremities; therefore, extremity dose involves less health risk to the individual. No individual received an extremity dose above the regulatory limit of 50 rem (500 mSv) since 1989. For the past 3 years, no individual has exceeded 30 rem (300 mSv) to the extremities. The number of individuals receiving a measurable extremity dose decreased by 13% from 1999 to 2000. The average extremity dose has increased by 24% from 1999 to

Exhibit 3-6:
Neutron Dose Distribution, 1996-2000.

Year	No Meas. Dose	Meas. <0.100	0.10-0.25	0.25-0.50	0.5-0.75	0.75-1.0	1.0-2.0	>2.0	Total Monitored*	Number of Individuals with Meas. Neutron Dose	Collective Neutron DDE (person-rem)	Average Meas. Neutron DDE (rem)
1996	118,154	4,282	677	156	32	11	12		**123,324** ◄	5,170	**320.320** ◄	0.062
1997	101,862	4,500	631	149	29	6	4		107,181	**5,319** ◄	290.610	0.055
1998	103,998	3,680	629	155	34	4	8		108,508	4,510	283.078	**0.063** ◄
1999	109,007	3,329	559	129	27	7	6		113,064	4,057	256.075	**0.063** ◄
2000	98,353	3,809	554	144	17	4			102,881	4,528	243.802	0.054

Note: Arrowed values indicate the greatest value in each column.

** Represents the total number of records reported. The number of individuals monitored for neutron radiation is not known because there is no distinction made between zero dose and not monitored.*

Exhibit 3-7:
Extremity Dose Distribution, 1996-2000.

Year	No Meas. Dose	Meas. <0.1	0.1-1.0	1-5	5-10	10-20	20-30	30-40	>40	Total Monitored*	Number with Meas. Dose	No. Above Monitoring Threshold (5 rem)**	Collective Extremity Dose (person-rem)	Average Meas. Extremity Dose (rem)
1996	108,458	10,576	3,583	646	50	9	1	1		**123,324** ◂	**14,866** ◂	61	3,272.8	0.220
1997	94,510	8,420	3,569	636	33	9	2	2		107,181	12,671	46	3,057.3	0.241
1998	95,436	8,347	3,938	722	56	8	1			108,508	13,072	65	3,390.1	0.259
1999	99,776	8,759	3,649	750	95	30	2			113,064	13,285	127	3,988.6	0.300
2000	91,329	7,279	3,322	818	88	37	8			102,881	11,552	**133** ◂	**4,309.5** ◂	**0.373** ◂

Note: Arrowed values indicate the greatest value in each column.

** Represents the total number of records reported. The number of individuals monitored for extremity radiation is not known because there is no distinction made between zero dose and not monitored.*

*** DOE annual limit for extremities is 50 rem. 10 CFR 835.402(a)(1)(ii) requires extremity monitoring for a shallow dose equivalent to the extremity of 5 rem or more in 1 year.*

2000. Much of this increase occurred at Hanford, where increases were attributed to increased plutonium stabilization activities at the Plutonium Finishing Plant and increased operational activities on tank waste projects. Statistical analysis indicates that after a significant drop in 1999, the logarithmic mean measurable extremity dose rose slightly in 2000 (see Section 3.2.6). The values for 1997-2000 have been consistently higher than they were in 1996. The extremity dose distribution by site for 2000 is shown in Appendix B-22.

3.2.6 Five-Year Perspective

There are often differences in summary dose numbers from year to year, yet some of these differences may represent normal variations in a stable process, rather than meaningful changes. This section discusses the results of a statistical analysis to determine if there are statistically significant trends detectable over the last 5 years. The collective TEDE, neutron, and extremity doses were analyzed. Internal dose records have not been included because the number of records is too few.

This analysis includes only measurable doses received in each year, and used two types of tests to measure different characteristics of the distributions. The first test used pairwise T-tests to identify significant differences between statistical means for the years analyzed. Because the dose values do not fit a statistically normal distribution, this test used log-transformed data, which were approximately normal. Note that the logarithmic means used here are different from the average measurable dose discussed elsewhere in this report. The T-tests use a 95% confidence level to identify significant differences.

The second approach tested for differences in the distribution of dose (e.g., the shape of the distribution of dose among the worker population) from year to year. This is similar to testing whether the overall distribution of dose in *Exhibit 3-4* differed from year to year. Two non-parametric tests were used: 1) analysis of variance using ranks, and 2) the Kruskall-Wallis test.

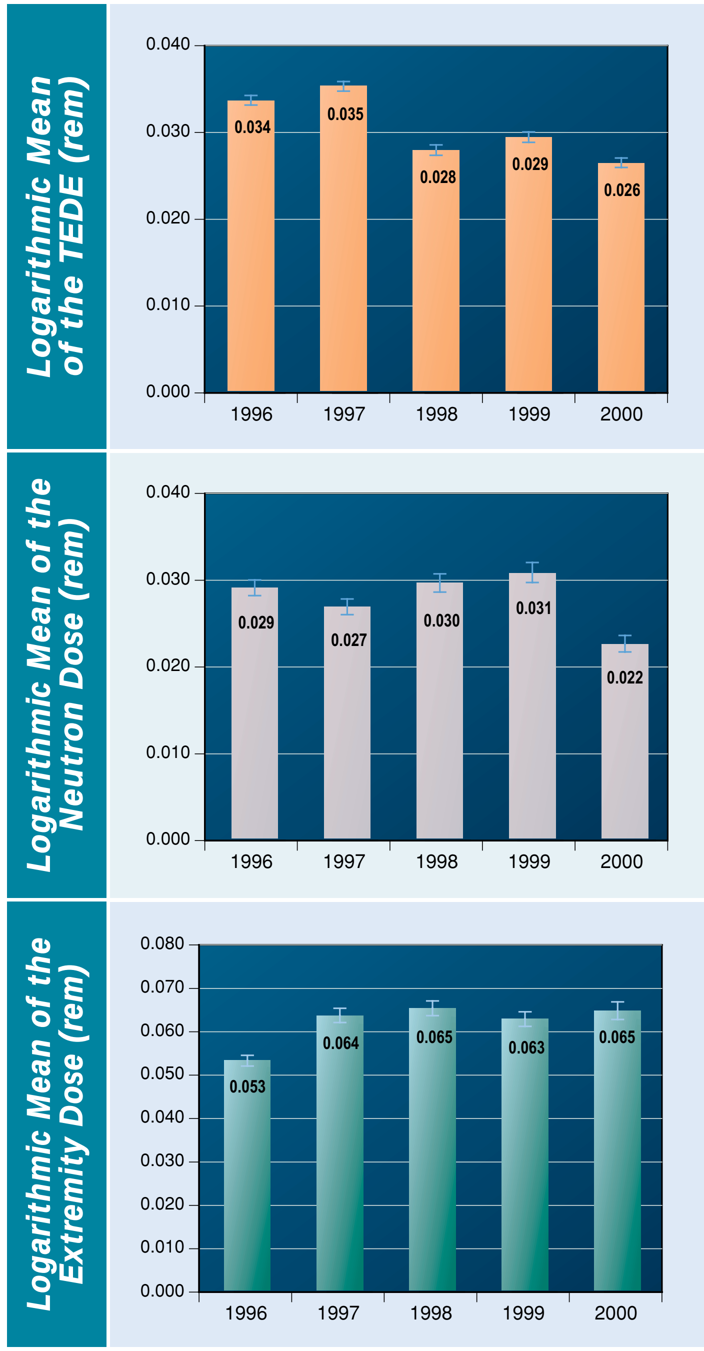
These statistical tests reveal trends that are not apparent when considering only the collective and average doses. In addition, the statistical analysis reveals that some of these trends are significant. *Exhibit 3-8* shows the results of pairwise T-tests for the collective TEDE, neutron, and extremity dose DOE-wide. The error bars surrounding each data point represent the 95% confidence levels.

For the collective TEDE, there were small but significant differences in all years, and the TEDE per worker was significantly lower in 1998-2000 than in earlier years. The mean dose in 2000 was 0.003 rem lower than in 1999, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose. The decrease in mean TEDE from 1998 to 2000 similarly indicates a lower dose per worker over the last 3 years, compared to 1996 and 1997. The nonparametric tests showed no clear change in the distribution of dose among workers.

The mean neutron dose dropped significantly to its lowest level in 5 years — 0.022 rem in 2000 compared to values near 0.030 rem for the other 4 years. Although more individuals received a measurable neutron dose in 2000 than in 1999, the dose per worker was smaller than at any other time in the last 5 years. Nonparametric tests confirmed this change.

After a significant drop in 1999, the logarithmic mean measurable extremity dose rose slightly in 2000. The current increase is not significant compared to the 1999 average, and the nonparametric tests for the same comparison were inconclusive. Yet the values for 1997-2000 have been consistently and significantly higher than they were in 1996. The 1996 mean was itself an increase over 1995 and 1994 values[1]. This suggests that the dose to individual workers has been consistently higher from 1997 through 2000 than it was in earlier years.

Exhibit 3-8:
DOE-Wide Summary Results for Statistical Tests, 1996 -2000.



[1] See DOE Occupational Radiation Exposure 1998 Report.

3.3 Analysis of Individual Dose Data

The above analysis is based on aggregate data for DOE. From an individual worker perspective as well as a regulatory perspective, it is important to closely examine the doses received by individuals in the elevated dose ranges to thoroughly understand the circumstances leading to these doses in the workplace and how these doses may be avoided in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE whole body limit (5 rem TEDE) (50 mSv) and the DOE whole body ACL (2 rem TEDE) (20 mSv).

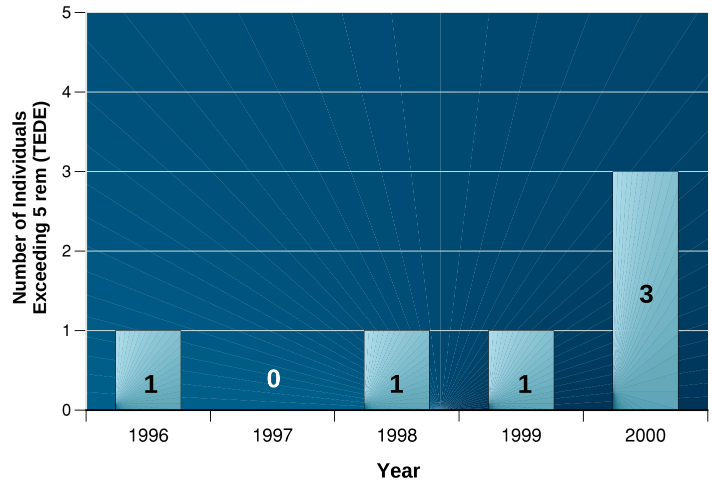
3.3.1 Doses in Excess of DOE Limits

Exhibit 3-9 shows the number of doses in excess of the TEDE regulatory limit (5 rem)(50 mSv) from 1996 through 2000. Further information concerning the individual dose, radionuclides involved, and site where the dose occurred is shown in *Exhibit 3-10*.

In 2000, there were three individuals who exceeded the 5 rem (50 mSv) annual TEDE limit. A brief summary of the event follows.

In March of 2000, an event occurred at the TA-55 facility at LANL that resulted in doses in excess of the DOE TEDE limit for three individuals. On the morning of March 16th, a technician noticed that there did not appear to be the proper flow through the bubbler on a glovebox, indicating that the negative pressure was not being properly maintained. During the evaluation of the glovebox, the glovebox hand monitors and the continuous air monitor (CAM) alarms actuated. There were eight workers in the room at the time, and they immediately evacuated to the central corridor where a positive air pressure is maintained to provide protection from the spread of airborne contamination. Whole body surveys revealed skin contamination on four of the individuals, while five had elevated readings from

Exhibit 3-9:
Number of Individuals Exceeding 5 rem (TEDE), 1996-2000.



Three individuals received doses in excess of the 5 rem (50 mSv) TEDE limit in 2000 during a single event at LANL.

Exhibit 3-10:
Doses in Excess of DOE Limits, 1996-2000.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	Intake Nuclides	Facility Types	Site
1996	11.623	0.123	11.500	Pu-238, Pu-239, Pu-241	Fuel Processing	Savannah River
1997				None Reported		
1998	6.292	0.282	6.010	Pu-238, Pu-239, Pu-240	Maintenance and Support	LANL
1999	6.964	0.245	6.719	Pu-238, Pu-239, Pu-241, Am-241	Weapons Fabrication and Testing	Savannah River
2000 *	9.692	0.322	9.370	Pu-238, Pu-239, Pu-240	Research, General	LANL
	11.745	0.245	11.500	Pu-238, Pu-239, Pu-240	Research, General	LANL
	87.156	0.156	87.000	Pu-238, Pu-239, Pu-240	Maintenance and Support	LANL

* *These three doses were all a result of the same occurrence.*

nasal smears. Four of the individuals underwent precautionary chelation therapy. All eight individuals were placed on bioassay sampling. Three of the individuals were later determined to have exceeded the DOE annual TEDE limit as a result of the internal dose (CEDE) from the intake of plutonium. The individuals received TEDEs of 87.156 rem (871.56 mSv), 11.745 rem (117.45 mSv), and 9.692 rem (96.92 mSv).

The Secretary of Energy appointed a Type A investigation team to investigate this event. The investigation team concluded that the direct cause of the incident was the release of airborne contamination from a leaking compression fitting in a glovebox vacuum line. As a corrective action, the team identified the need for all glovebox compression fittings at TA-55 be tested. Additional corrective actions include regular inspections of the piping systems, increased worker participation in work planning, increased presence of management in work areas to reinforce safe work practices, and conducting additional training to reinforce the department's Integrated Safety Management (ISM) principles. For more information on this event, see the Occurrence Report ALO-LA-LANL-TA55-2000-0009. For a detailed analysis of the investigation, see the report entitled "Type A Accident Investigation of the March 16, 2000 Plutonium-238 Multiple Intake Event at the Plutonium Facility, Los Alamos National Laboratory, New Mexico" (http://tis.eh.doe.gov/oversight/reports/accidents/typea/typea.html).

As noted in the 1999 annual report, an event was reported by LANL in 1999 that had the potential to result in a dose in excess of the DOE annual TEDE limit. At the time of publication, the dose had not been finalized and was therefore not included in the 1999 annual report. Subsequently, LANL has finalized the dose assessment for the individual, and the individual did exceed the DOE annual TEDE limit. The final TEDE assigned was 6.292 rem (62.92 mSv) for the year 1998. The intake was discovered during the examination of routine bioassay information and involved plutonium-239. The individual worked on waste management processing in a glovebox, mixing the sludge from an evaporator with cement and transferring the slurry into 55-gallon drums. In-vivo results indicate the intake occurred via inhalation. According to the occurrence report, an extensive investigation did not determine the source or root cause of the intake event. No corrective actions were identified, but a joint workshop was scheduled between DOE and LANL to review bioassay processing procedures. For more information, see the Occurrence Report ALO-LA-LANL-TA55-1999-0045.

3.3.2 Doses in Excess of Administrative Control Level

The "RadCon Manual" [5] recommends a 2 rem (20 mSv) ACL for TEDE, which is not to be exceeded without prior DOE approval. Each DOE site required to follow the "RadCon Manual" or RCS must establish its own, more restrictive ACL that requires contractor management approval to be exceeded. The number of individuals receiving doses in excess of the 2 rem (20 mSv) ACL is a measure of the effectiveness of DOE's radiation protection program.

As shown in *Exhibit 3-11*, three individuals received a TEDE above 2 rem (20 mSv) during 2000. All three of the individuals also exceeded the 5 rem (50 mSv) TEDE limit as described in Section 3.3.1. There were no additional individuals in 2000 who exceeded 2 rem (20 mSv) who did not also exceed the 5 rem (50 mSv) limit.

Exhibit 3-11:
Number of Doses in Excess of the DOE 2 rem ACL, 1996-2000.

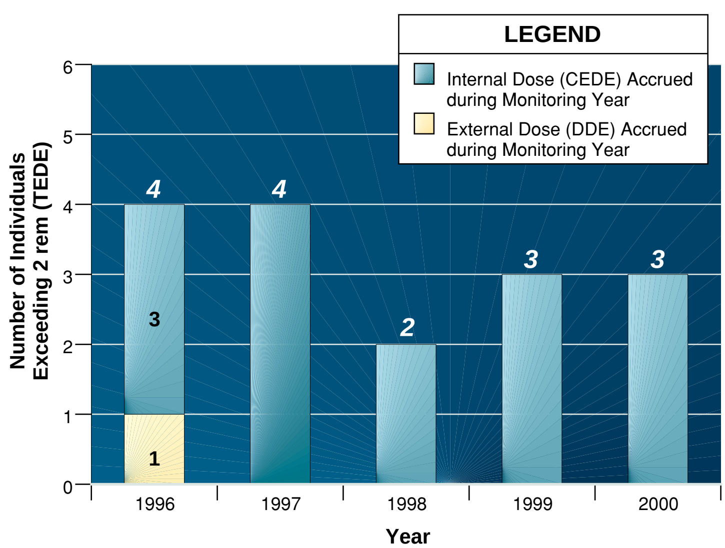
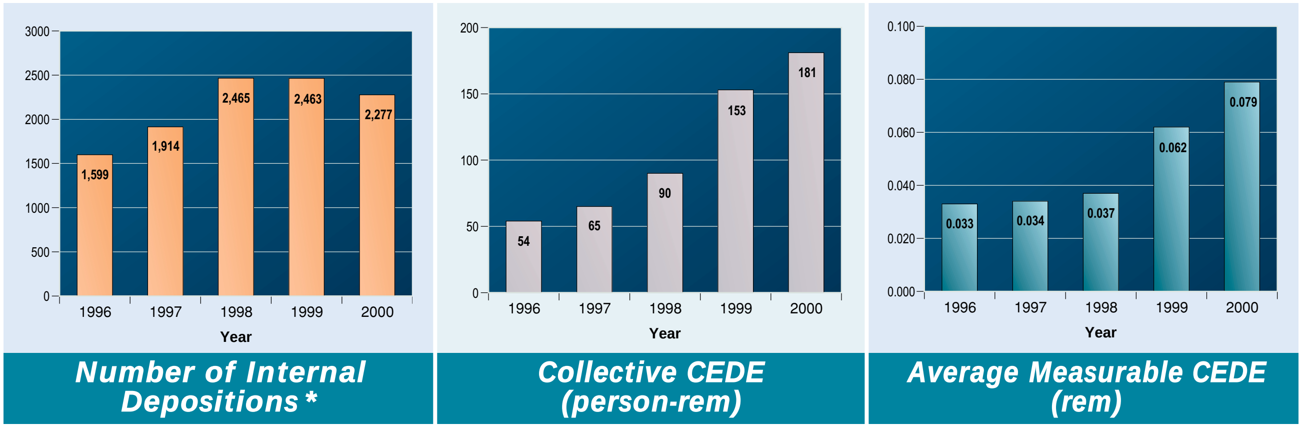


Exhibit 3-12:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE, 1996-2000.



* *The number of internal depositions represents the number of internal dose records reported for each individual. Individuals may have multiple intakes in a year and, therefore, may be counted more than once.*

3.3.3 Internal Depositions of Radioactive Material

As discussed in Section 3.3.1, some of the highest doses to individuals have been the result of intakes of radioactive material. For this reason, DOE emphasizes the need to avoid intakes and tracks the number of intakes as a performance measure.

The number of internal depositions of radioactive material (otherwise known as worker intakes), collective CEDE, and average measurable CEDE for 1996-2000 is shown in *Exhibit 3-12*. The number of internal depositions decreased by 8% from 1999 to 2000. However, the collective CEDE has increased for the sixth year in a row, with an increase of 70% between 1998 and 1999 and 18% between 1999 and 2000. Due to the increase in the collective CEDE and decrease in the number of internal depositions, the average measurable CEDE increased by 27% from 1999 to 2000 and is double the value for 1998.

The number of internal depositions of radioactive material for 1998-2000 is shown in *Exhibit 3-13*. The internal depositions were categorized into nine radionuclide groups. Intakes involving multiple nuclides are listed as "mixed". Nuclides where fewer than 10 individuals had intakes each

Exhibit 3-13:
Number of Intakes, Collective Internal Dose, and Average Dose by Nuclides, 1998-2000.

Nuclide	Number of Internal Depositions*			Collective CEDE (person-rem)			Average CEDE (rem)		
Year	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Hydrogen-3 (Tritium)	673	554	394	3.199	2.438	2.039	0.005	0.004	0.005
Technetium	2	1	0	0.006	0.007	0	0.003	0.007	0
Radon-222	280	39	4	33.840	2.147	0.118	**0.121** ◄	0.055	0.030
Thorium	13	10	62	0.257	0.836	3.838	0.020	0.084	0.062
Uranium	**1,326** ◄	**1,671** ◄	**1,630** ◄	**35.404** ◄	**126.163** ◄	60.226	0.027	0.076	0.037
Plutonium	93	101	123	15.563	19.177	**113.020**** ◄	0.104	**0.190** ◄	**0.919** ◄
Americium-241	15	16	34	1.219	1.681	0.989	0.076	0.105	0.029
Other	62	51	27	0.725	0.196	0.145	0.012	0.004	0.005
Mixed	1	20	3	0.004	0.223	0.205	0.004	0.011	0.068
Totals	**2,466**	**2,463**	**2,277**	**90.217**	**152.868**	**180.580**	**0.034**	**0.062**	**0.079**

Note: Arrowed values indicate the greatest value in each column.
* *The number of internal depositions represents the number of internal dose records reported for each individual.*
** *Primarily the result of an event resulting in three individuals receiving a total of 107.87 person-rem at LANL.*

year over the 3-year period are grouped together as "other". Only those records with internal dose greater than zero are included in this analysis. It should be noted that the different nuclides have different radiological properties, resulting in varying minimum levels of detection and reporting.

The highest collective and average CEDE is due to plutonium (primarily Pu-238) intakes, the majority of which occur at Rocky Flats. However, in 2000, three intakes of plutonium at LANL exceeded the DOE annual limit and these three intakes accounted for 95% of the collective CEDE from plutonium. Due to the radiological characteristics and retention of plutonium (in general plutonium 238) in the body, relatively small intakes result in large dose values when the CEDE is calculated over a 50-year period.

The largest number of intakes for 2000 is attributed to uranium exposures, primarily at the Oak Ridge Y-12 facility. The collective CEDE from uranium intakes decreased 52% from 1999 to 2000 primarily as a result of a change in the biokinetic models used to determine internal dose from uranium intakes at Y-12. The use of the ICRP 66 rather than the ICRP 30 respiratory tract model has been shown to better fit the analytical data and is now being utilized to calculate internal dose. A major modification is the use of a 5 μm rather than 1 μm default particle size for intake assessments.

The number of intakes and collective CEDE for tritium intakes decreased for the fourth year in a row primarily from decreases in intakes at Savannah River and Brookhaven. These two sites account for 50% of the internal dose from tritium for 2000. Intakes from radon decreased from 1998 to 2000 because the Grand Junction site is no longer in operation.

It should be noted that relatively few workers receive measurable internal dose and therefore fluctuations in the number of workers and collective CEDE can occur from year to year.

Exhibit 3-14 shows the distribution of the internal dose from 1996 to 2000. The total number of individuals with intakes in each dose range is the sum of all records of intake in subject dose range. The internal dose does not include doses from prior intakes (legacy AEDE dose). Individuals with multiple intakes during the year may be counted more than once. Doses below 0.020 rem (0.20 mSv) are shown as a separate dose range to show the large number of doses in this low-dose range. All but three of the internal doses were below 1 rem (10 mSv) in 2000. However, the three internal doses above 1 rem (10 mSv) in 2000 were doses in excess of the DOE annual limit and represent 60% of the collective CEDE for the year. See Section 3.3.1 for more information on these internal doses.

Exhibit 3-14:
Internal Dose Distribution from Intakes, 1996-2000.

Number of Individuals with internal dose in each dose range (rem).*

Year	Meas. <0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0	Total No. of Indiv.*	Total Collective Internal Dose CEDE (person-rem)
1996	1,324	202	42	13	9	4	3		1		1	1,599	53.524
1997	1,422	359	100	18	8	1	3	1	2			1,914	65.355
1998	1,909	353	128	43	18	8	5	1			1	2,466	90.217
1999	1,726	443	137	78	32	26	19		1		1	2,463	152.868
2000	1,472	625	136	34	5	2					3	2,277	180.580

Note: Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
*** Individuals may have multiple intakes in a year and, therefore, may be counted more than once.*

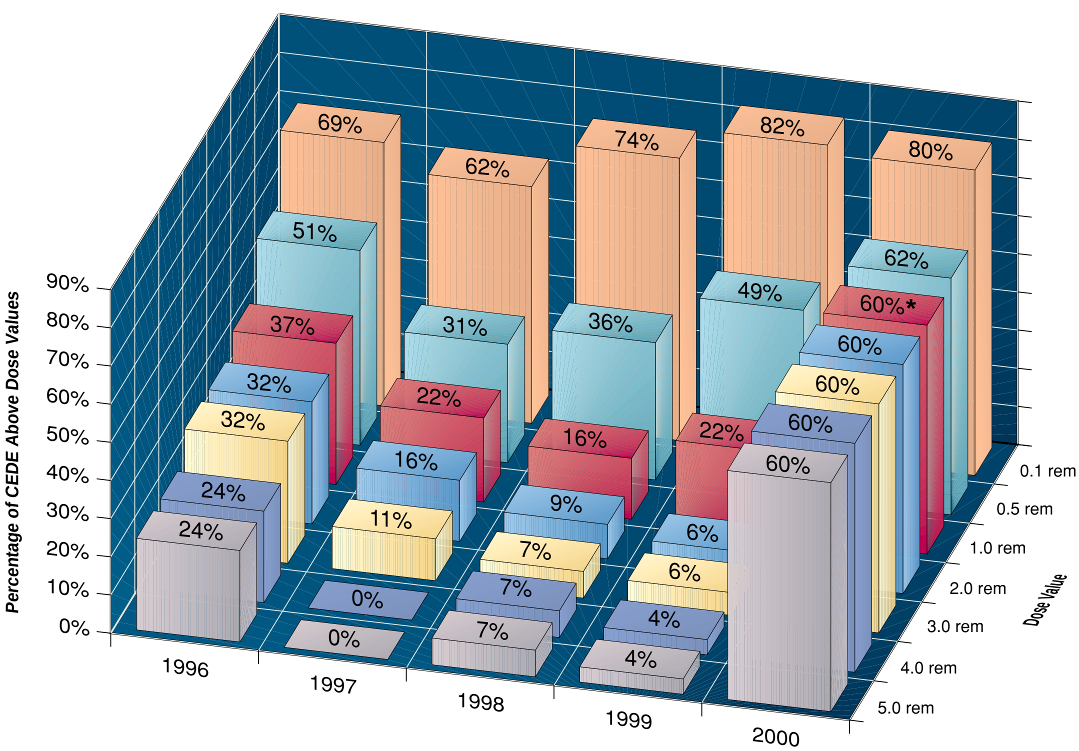
The internal dose records indicate that the majority of the intakes reported are at very low doses. In 2000, 65% of the internal dose records were for doses below 0.020 rem (0.20 mSv) and represent 4% of the collective internal dose. Over the 5-year period, internal doses from new intakes accounted for only 8% of the collective TEDE and only 8% of the individuals who received internal dose were above the monitoring threshold specified (100 mrem) in 10 CFR 835.402(c).

The internal dose records indicate that the majority of the intakes reported are at very low doses.

Over the 5-year period, internal doses accounted for only 8% of the collective TEDE.

The internal dose distribution can also be shown in terms of the percentage of the collective dose delivered above certain dose levels. *Exhibit 3-15* shows this information for the CEDE for each year from 1996 to 2000. While the fluctuations in internal dose prohibit definitive trend analysis, it appears from the graph that internal doses shifted from the higher dose ranges to the lower dose ranges from 1996 to 1997. From 1998 to 2000, the increase in the percentages above 2 rem (20 mSv) has been due to the individuals that exceeded the DOE annual limits. In 2000, the percentages above 2 rem (20 mSv) are dominated by the three doses in excess of the DOE annual limit that occurred at LANL (see Section 3.3.1). The distribution of internal dose by site and nuclide for 2000 is presented in Appendix B-21.

Exhibit 3-15:
Distribution of Collective CEDE vs. Dose Value, 1996-2000.



**** All of the collective CEDE above 1 rem (60% of the total collective CEDE) was received by the 3 individuals at LANL who exceeded the 5 rem annual limit.***

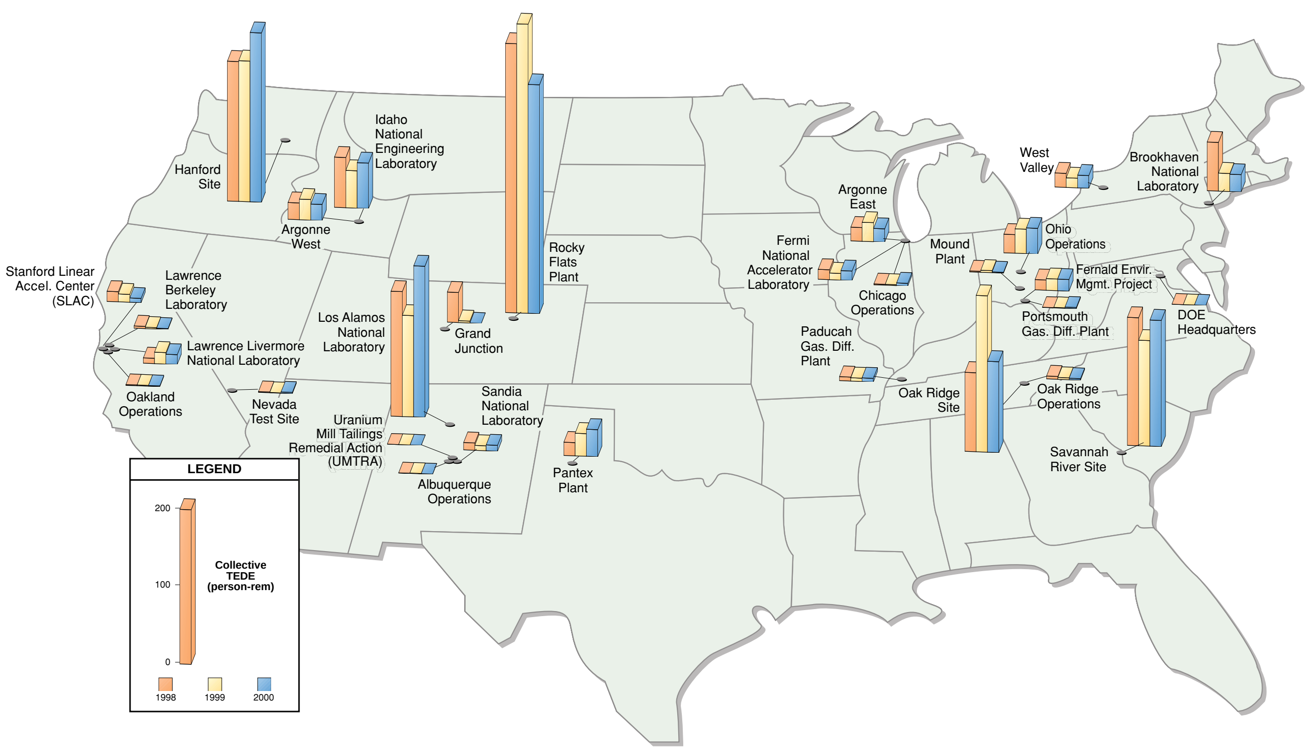
When examining trends involving internal dose, several factors should be considered. Some of the largest changes in the number of reported intakes over the years resulted from changes in internal dosimetry practices. Periodically, sites may change monitoring practices or procedures, which may involve increasing the sensitivity of the detection equipment, thereby increasing the number of individuals with measurable internal doses. Conversely, sites may determine that internal monitoring is no longer required due to historically low levels of internal dose or a decreased potential for intake. There are relatively few intakes each year, and the 50-year dose commitment from the intake of long-lived nuclides can be large. This can result in statistical variability of the internal dose data from year to year.

3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Operations/Field Offices

The relative collective TEDE for 1998-2000 for the major DOE sites and Operations/Field Offices is shown in *Exhibit 3-16*. A list of the collective TEDE and number of individuals with measurable TEDE for the DOE Sites and Operations/Field Offices is shown in *Exhibit 3-17*. Operations/Field Office dose is shown separately from the site dose where it is reported separately. The collective TEDE decreased by 2% between 1999 and 2000, with six of the highest dose sites (Rocky Flats, Hanford, Los Alamos, Savannah River, Oak Ridge, and Idaho) contributing 83% of the total DOE collective TEDE.

Exhibit 3-16:
Relative Collective TEDE by Site for 1998-2000.



Note: More complete details for each site, Operations/Field Office, and reporting organization can be found in Appendix B.

Exhibit 3-17:
Collective TEDE and Number of Individuals with Measurable TEDE by Site, 1998-2000.

Operations/ Field Office	Site	1998 Collective TEDE (person-rem)	1998 Number with Meas. TEDE	1999 Collective TEDE (person-rem)	1999 Number with Meas. TEDE	2000 Collective TEDE (person-rem)	2000 Number with Meas. TEDE
Albuquerque	Ops. and Other Facilities	0.2	11	0.4	26	0.3	38
	Los Alamos National Lab. (LANL)	167.6	1,916	131.0	1,479	195.5	1,365
	Pantex Plant (PP)	17.2	312	29.3	353	35.0	277
	Sandia National Lab. (SNL)	9.5	181	6.4	120	7.6	105
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0.0	0				
	Grand Junction	38.9	295	2.5	48	0.1	6
Chicago	Ops. and Other Facilities	1.2	44	1.5	82	3.5	108
	Argonne Nat'l. Lab. - East (ANL-E)	17.7	182	24.6	187	17.2	183
	Argonne Nat'l. Lab. - West (ANL-W)	21.7	236	26.7	299	20.9	234
	Brookhaven Nat'l. Lab.(BNL)	63.0	1,055	23.4	521	22.4	430
	Fermi Nat'l. Accelerator Lab.(FERMI)	12.8	441	8.7	227	12.3	406
DOE HQ	DOE Headquarters	0.0	2	0.0	4	0.1	11
	DOE North Korea Project	5.4	14				
	DOE Kazakhstan Project	0.4	13	0.1	3		
Idaho	Idaho Site	64.9	743	48.3	729	58.8	795
Nevada	Nevada Test Site (NTS)	1.0	13	0.4	6	1.6	24
Oakland	Ops. and Other Facilities	1.0	45	1.0	85	0.9	133
	Lawrence Berkeley Lab. (LBL)	2.9	76	1.8	46	1.1	44
	Lawrence Livermore Nat'l. Lab. (LLNL)	6.9	107	14.9	137	12.7	145
	Stanford Linear Accelerator Center (SLAC)	13.1	157	10.2	104	5.5	489
Oak Ridge	Ops. and Other Facilities	3.8	195	2.4	109	1.9	125
	Oak Ridge Site	102.7	2,187	202.2	2,493	118.1	2,276
	Paducah Gaseous Diff. Plant (PGDP)	5.3	68	4.3	58	5.0	63
	Portsmouth Gaseous Diff. Plant (PORTS)	0.2	15	0.5	25	1.5	44
Ohio	Ops. and Other Facilities	24.1	78	31.6	104	33.3	256
	Fernald Environmental Management Project	13.3	559	15.1	458	15.0	421
	Mound Plant	1.3	106	2.7	197	1.1	123
	West Valley	18.2	260	12.5	243	16.5	246
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**348.1** ◄	**3,298** ◄	**373.9** ◄	**3,517** ◄	**296.1** ◄	2,331
Richland	Hanford Site	180.9	1,772	182.0	2,013	219.0	1,923
Savannah River	Savannah River Site (SRS)	165.5	3,163	136.5	2,995	163.2	**3,382** ◄
Totals		**1,309.1**	**17,544**	**1,295.2**	**16,668**	**1,266.5**	**15,983**

Note: Arrowed values indicate the greatest value in each column.

Exhibit 3-18:
Collective Dose by Labor Category, 1998-2000.

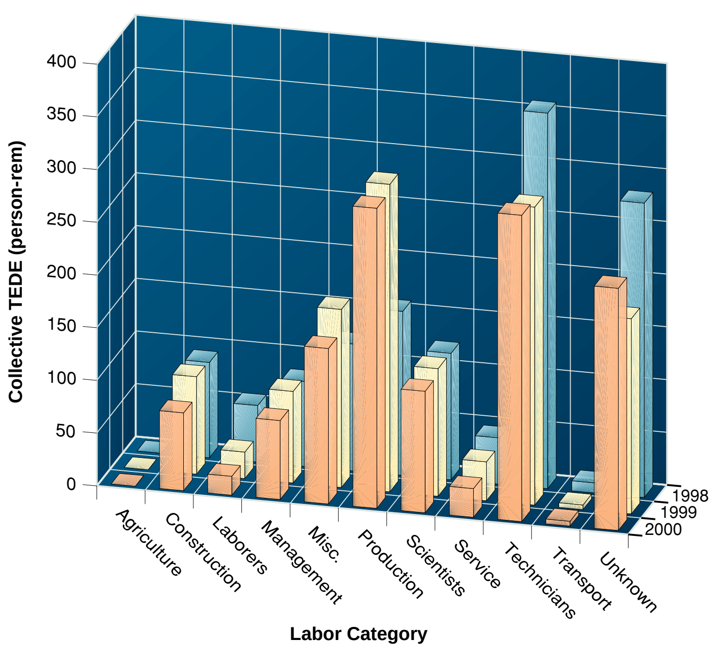
Labor Category	Number with Meas. Dose			Collective TEDE (person-rem)			Average Meas. TEDE (rem)		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Agriculture	0	1	1	0.0	0.0	0.0	0.0	0.020	0.035
Construction	1,664	1,480	1,375	90.4	92.4	73.8	0.054	0.062	0.054
Laborers	492	285	281	53.6	25.2	17.8	0.109	0.089	0.063
Management	1,395	1,755	1,628	80.5	86.9	74.7	0.058	0.050	0.046
Misc.	2,272	2,001	1,563	120.3	168.9	147.4	0.053	0.084	0.094
Production	1,783	2,263	2,214	155.5	**291.6** ◄	284.6	0.087	**0.129** ◄	**0.129** ◄
Scientists	2,784	2,617	**3,001** ◄	120.0	121.0	114.5	0.043	0.046	0.038
Service	665	829	658	43.9	36.8	27.1	0.066	0.044	0.041
Technicians	2,919	**2,690** ◄	2,723	**356.2** ◄	282.6	**290.5** ◄	**0.122** ◄	0.105	0.107
Transport	146	122	112	9.5	4.4	4.6	0.065	0.036	0.041
Unknown	**3,424** ◄	2,625	2,427	279.2	185.2	231.4	0.080	0.071	0.095
Totals	**17,544**	**16,668**	**15,983**	**1,309.1**	**1295.2**	**1266.5**	**0.075**	**0.078**	**0.079**

Note: Arrowed values indicate the greatest value in each column.

3.4.2 Dose by Labor Category

DOE occupational exposures are tracked by labor category at each site to facilitate identification of exposure trends, which assist management in prioritizing ALARA activities. Worker occupation codes are reported in accordance with DOE M 231.1-1 and are grouped into major labor categories in this report. The collective TEDE for each labor category for 1998-2000 is shown in *Exhibits 3-18* and *3-19*. Technicians and production staff have the highest collective TEDE (other than unknown) for the past 3 years because they generally handle more radioactive sources than individuals in the other labor categories. In 2000, 51% of the technician dose was attributed to Radiological Control Technicians. Sixty-three percent of the dose to production personnel is attributed to plant operators.

Exhibit 3-19:
Graph of Collective TEDE by Labor Category, 1998-2000.



The "unknown" and "miscellaneous" categories have the next highest collective TEDE totals. Eighty-four percent of the dose in the "unknown" category for 2000 is attributed to LANL. Currently the LANL computer system does not maintain the data necessary to report occupation codes in accordance with DOE M 231.1-1. Other sites also report individuals with an occupation code of "unknown". Typically, these workers are subcontractors or temporary workers. Information concerning these workers tends to be limited.

An examination of internal dose from intake by labor category from 1998 to 2000 is presented in Appendix B-19. In addition, Appendix B-20 shows the TEDE distribution by labor category and occupation for 2000.

3.4.3 Dose by Facility Type

DOE occupational exposures are tracked by facility type at each site to better understand the nature of exposure trends and to assist management in prioritizing ALARA activities. Contribution of certain facility types to the DOE collective TEDE is shown in *Exhibits 3-20* and *3-21*. The collective dose for each facility type at each major Site of each DOE Operations/Field Office is shown in Appendix B-7c. An examination of internal dose from intake by facility type and nuclide for 1998 to 2000 is presented in Appendix B-17.

The collective TEDE for 1998-2000 was highest at weapons fabrication and testing facilities. Sixty-four percent of this dose was accrued at Rocky Flats, with 15% at the Oak Ridge Y-12 facility and 13% at Savannah River in 2000. It should be noted that, although weapons fabrication and testing facilities account for the highest collective dose, Rocky Flats and Savannah River account for the majority of this dose and these sites are now primarily involved in nuclear materials stabilization and waste management. See Section 3.5 for information concerning the current activities at these sites.

Exhibit 3-20:
Graph of Collective TEDE by Facility Type, 1998-2000.

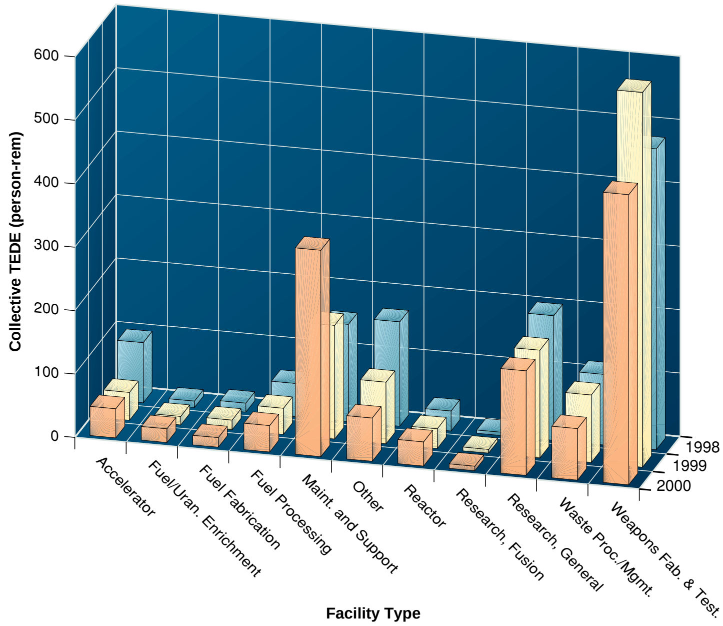


Exhibit 3-21:
Collective Dose by Facility Type, 1998-2000.

Facility Type	Number with Meas. Dose			Collective TEDE (person-rem)			Average Meas. TEDE (rem)		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Accelerator	1,618	907	1,429	94.7	44.0	45.9	0.059	0.049	0.032
Fuel/Uranium Enrichment	256	416	679	10.0	13.6	21.6	0.039	0.033	0.032
Fuel Fabrication	593	459	424	14.3	15.1	15.1	0.024	0.033	0.036
Fuel Processing	1,172	1,107	1,115	52.6	41.2	41.6	0.045	0.037	0.037
Maintenance and Support	1,728	2,083	2,173	153.3	179.5	325.4	0.085	0.086	**0.150** ◄
Other	2,297	1,533	1,434	164.6	97.2	68.2	0.072	0.063	0.048
Reactor	619	629	600	31.4	31.0	38.1	0.051	0.049	0.064
Research, Fusion	75	50	78	5.2	6.0	7.1	0.070	**0.120** ◄	0.092
Research, General	2,410	2,224	2,140	196.6	170.0	164.8	0.082	0.076	0.077
Waste Processing/Mgmt.	1,512	1,475	1,460	111.4	106.6	81.2	0.074	0.072	0.056
Weapons Fab. and Testing	**5,264** ◄	**5,785** ◄	**4,451** ◄	**475.0** ◄	**591.0** ◄	**457.5** ◄	**0.090** ◄	0.102	0.103
Totals	**17,544**	**16,668**	**15,983**	**1,309.1**	**1,295.2**	**1266.5**	**0.075**	**0.078**	**0.079**

Note: Arrowed values indicate the greatest value in each column.

3.4.4 Radiation Protection Occurrence Reports

In addition to the records of individual radiation exposure monitoring required by DOE M 231.1-1, sites are required to report certain unusual or off-normal occurrences involving radiation under DOE Order 232.1A . These reports are submitted to ORPS in accordance with the reporting criteria of DOE M 232.1-1A. Two of the occurrence categories are directly related to occupational exposure and are required to be reported under Section 9.3 as "Group 4" occurrences. Group 4A reports *radiation exposure* occurrences, and Group 4B reports *personnel contamination* occurrences. The occurrence reporting requirements for DOE M 232.1-1A are summarized in *Exhibit 3-22*. These requirements became effective under DOE M 232.1-1 in September 1995, and have remained essentially unchanged under DOE M 232.1-1A which became effective in July 1997.

The number of reports submitted to ORPS is usually indicative of breaches or lapses in radiation protection practices resulting in unanticipated radiation exposure or contamination of personnel or clothing. Significant increases or decreases in the number of occurrences reported may reflect trends in radiation exposures, the effectiveness of DOE radiation protection programs, or changes to the reporting procedure or thresholds. The reporting thresholds and processes have stabilized over the years, and the insignificant increase in the number of radiation exposure occurrences and decrease in the number of contamination occurrences reported in 2000 may reflect statistical variability rather than any performance trend.

It is important to note that reports are submitted to ORPS for an occurrence or event. In some cases, one event could result in the contamination or exposure of multiple individuals. In ORPS, this is counted as one occurrence, even though multiple individuals were exposed. In addition, one report may involve the roll up of similar or multiple occurrences. For the analysis included in this report, only the number of occurrences is considered.

Exhibit 3-22:
Criteria for Radiation Exposure and Personnel Contamination Occurrence Reporting.

Occurrence	Category	DOE M 232.1-1A Criteria
Radiation Exposure	*Unusual*	*Individuals receiving a dose in excess of the occupational exposure limits (see Exhibit 2-1) for on-site exposure or exceeding the limits in DOE 5400.5, Chapter II, Section 1 for off-site exposure to a member of the public.*
	Off-Normal	◆ *Any single occupational exposure that exceeds an expected exposure by 100 mrem.* ◆ *Any single unplanned exposure onsite to a minor, student, or member of the public that exceeds 50 mrem.* ◆ *Any dose that exceeds the limits specified in DOE 5400.5, Chapter II, Section 7 for off-site exposure to a member of the public.*
Personnel Contamination	*Unusual*	◆ *Any single occurrence resulting in the contamination of five or more personnel or clothing at a level exceeding the 10 CFR 835 Appendix D values for total contamination limits.* ◆ *Any occurrence requiring off-site medical assistance for contaminated personnel.* ◆ *Any measurement of personnel or clothing contamination offsite due to DOE operations.*
	Off-Normal	*Any measurement of personnel or clothing contamination at a level exceeding the 10 CFR 835 Appendix D total contamination limits.*

The number of occurrences reported under Group 4 – Personnel Radiological Protection, is broken into two subcategories: Group 4A is *Radiation Exposure*, and Group 4B is *Personnel Contamination*. Results for those two subcategories are presented in *Exhibits 3-23* and *3-25*.

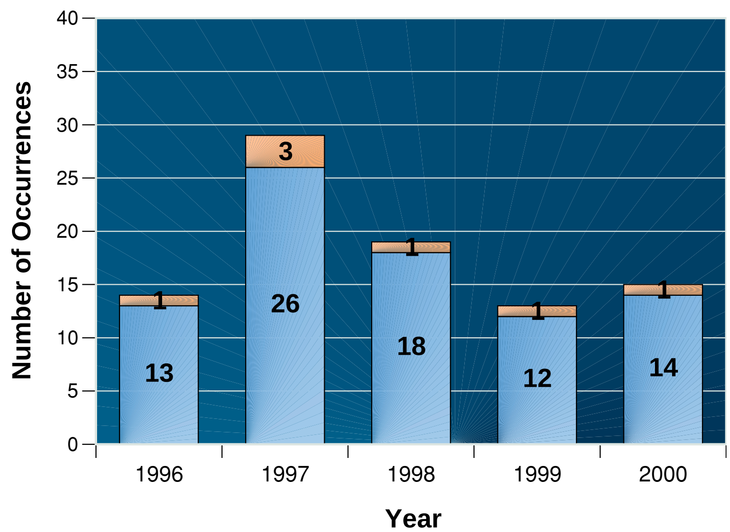
In one case (see Occurrence Report ID-BBWI-PHASEOUT-2000-0002) reported in 2000, an incident where contamination was found on personal clothing (group 4B) was reported as a radiation exposure (group 4A) occurrence. In another case (see Occurrence Report CH-BA-FNAL-FERMILAB 2000-0003), the results of dosimeter analysis indicated a dose of 1.240 rem (12.4 mSv) TEDE to an individual. However, for comfort the individual removed his outer shirt with the dosimeter still attached, temporarily storing the shirt on top of a calibration source instrument, which exposed the dosimeter but not the individual.

3.4.4.1 Radiation Exposure Occurrences

Radiation exposure occurrences are reported when individuals are exposed to radiation above anticipated levels. The number of *radiation exposure* occurrences increased by 15% from 1999 to 2000. In one case (see Occurrence Report ALO-LA-LANL-CMR-2000-0019) at LANL, a radiation exposure was classified as an Unusual Event even though the exposure took place in 1993. In another case a *personnel contamination* event was classified as a *radiation exposure* event. One event (see Occurrence Report ALO-LA-LANL-TA55-2000-0009) at the TA55 facility at Los Alamos contaminated eight workers which resulted in internal dose to three workers in excess of the DOE annual limits (see Section 3.3.1). A skin contamination event (see Occurrence Report ID-BBWI-TRA-2000-0003) involving a particle of Ir-192 at Idaho National Engineering and Environmental Lab was estimated to have resulted in a dose of 354 rem (3,540 mSv) to the skin.

The number of Radiation Exposure occurrences increased by 15% from 1999 to 2000.

Exhibit 3-23:
Number of Radiation Exposure Occurrences, 1996-2000.



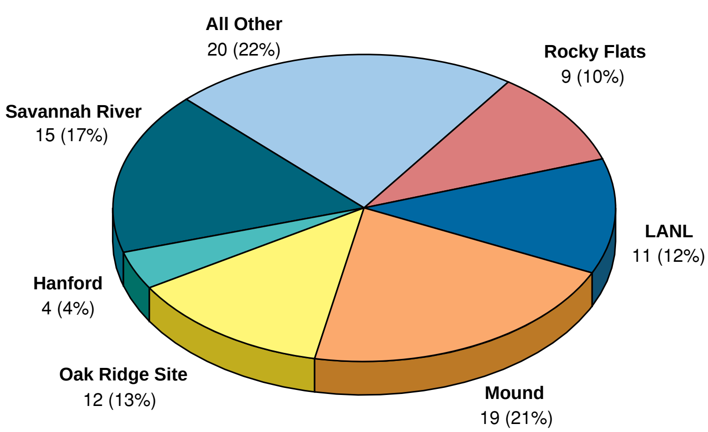
Twelve of the 15 *radiation exposure* occurrences reported in 2000 involved the internal inhalation or ingestion of radioactive material. Of the remaining three, one involved the failure to post a High Radiation Area at Brookhaven National Laboratory, one involved the previously discussed high dosimetry reading from Fermilab, and the last one was the reporting of a *personnel contamination* occurrence as a *radiation exposure*.

The *radiation exposure* occurrence reported as an Unusual Event involved an intake of Americium-241 that occurred at Los Alamos in 1993 and resulted in an individual dose exceeding 5 rem (50mSv) annual TEDE limit. Following the 1993 event, a chest scan suggested that no intake occurred and no dose was assigned then. When the individual turned in a bioassay sample in 2000, the Am-241 concentration exceeded the decision level and the 1993 event was reinvestigated. Estimates for the intake showed that a CEDE of between 7.3 and 13 rem (73 – 130 mSv) resulted from the 1993 intake and the dose was assigned to 1993.

In one event (see Occurrence Report OH-FN-FFI-FEMP-2000-0023) 10 employees were exposed to airborne Th-230 each receiving between 34 mrem to 325 mrem (0.34 to 3.25 mSv) CEDE. In another event (see Occurrence Report RFO-KHLL-771OPS-2000-0057), 11 workers were exposed when a miscalibrated air sampler in their work area failed to alarm and subsequent bioassay results indicated intakes. Final assignments of dose indicate that all but one worker received doses less than 100 mrem (1 mSv) CEDE and the maximum dose assigned was 130 mrem (1.3 mSv) CEDE. (See EH-2 "Special Review of the Rocky Flats Closure Project Site Report, April 2001.)"

None of the 90 *radiation exposure* occurrence reports submitted to the ORPS between 1996 and 2000 have involved exposure to minors, members of the public, or pregnant workers. *Exhibit 3-24* shows the breakdown of occurrences for radiation exposure by site for the 5-year period 1996-2000. Seventy-three percent of the *radiation exposure* occurrences were reported by five sites: Mound, Savannah River, Oak Ridge, Los Alamos, and Rocky Flats.

Exhibit 3-24:
Radiation Exposure Occurrences by Site, 1996-2000.

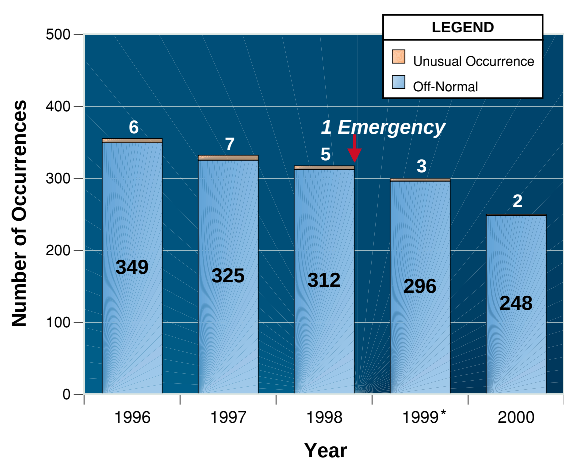


3.4.4.2 Personnel Contamination Occurrences

Personnel contamination occurrences are reported when personnel or clothing are contaminated above established threshold levels. The number of *personnel contamination* occurrences decreased 16% between 1999 and 2000. The 1999 *Personnel Contamination Occurrence*, *Exhibit 3-25*, incorrectly counted the number of reports rather than the number of occurrences. The 2000 *Exhibit 3-25* reflects the correction to the 1999 data. This continues a downward trend that has resulted in an overall reduction in the number of reported personnel contamination cases of 29% since 1996 (see *Exhibit 3-25*). Two *personnel contamination* occurrences were classified as Unusual Events, down from three cases in 1999. The first of these two cases occurred at Los Alamos and involved personnel skin contamination to eight employees who were in a room when a glovebox ventilation system leaked (see Occurrence Report ALO-LA-LANL-TA55-2000-0009). Seven of the workers received intakes in this event, and four of them were given chelation treatment in an effort to quickly reduce the amount of radioactive material that remained in their bodies. Three individuals received internal doses in excess of the DOE annual limit (see Section 3.3.1). The second event involved shoe contamination for five workers (see Occurrence Report RL-BHI-DND-2000-0010) and was declared an Unusual Event because of the number of workers involved in the occurrence.

The three cases described below illustrate the range and types of *personnel contamination* occurrences that were reported during the year. In one case (see Occurrence Report ALO-LA-LANL-CMR-2000-0026), a contamination monitor

Exhibit 3-25:
Number of Personnel Contamination Occurrences, 1996-2000.



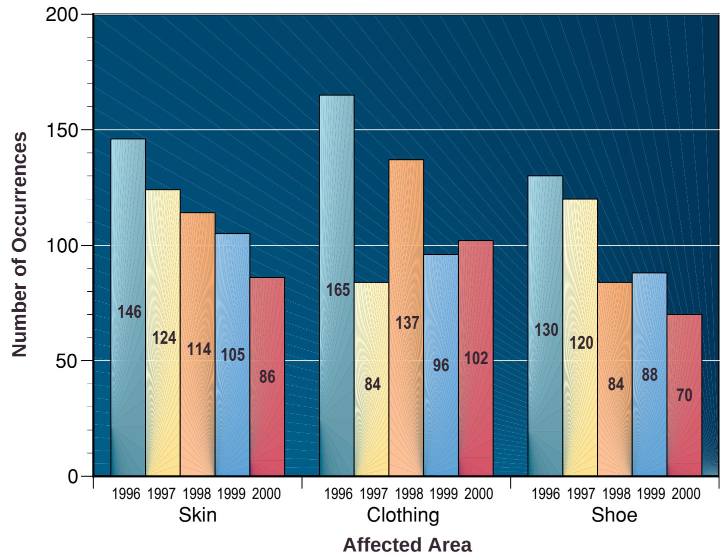
* Corrected 2001

alarmed when an employee was exiting a radiation area. The individual did not remain in the area and did not alert the health physics staff of the contamination alarm. In an effort to locate the employee and prevent the potential spread of contamination, the facility manager evacuated 400 people from the facility and subjected each of them to hand-survey. In another case (see Occurrence Report OH-MB-BWO-BWO01-2000-0012), an employee exhibited skin contamination that was later determined to have been the result of internal contamination. A previous tritium intake by the worker resulted in a very low CEDE to the worker but was of sufficient concentration that when the worker perspired, the perspiration contained measurable radioactive tritium. Finally, weather was considered a prime factor in the contamination of a worker's shoes (see Occurrence Report ID-BBWI-CFA-2000-001) when a windstorm blew a "hot" particle out of a laundry-decontamination building.

The number of Personnel Contamination occurrences has decreased by an average of 6% per year between 1996 and 2000.

Personnel contamination occurrences can involve contamination of the skin, clothing, or shoes. *Exhibit 3-26* shows the breakdown of occurrences by affected area from 1996 through 2000. The affected area is not recorded as part of the ORPS report and must be determined by reviewing the text of each individual report. In at least 28 cases (or nearly 11%) in 2000, the occurrence involved more than one affected area (i.e. protective clothing and the skin beneath it) and was counted in more than one affected area category. From 1998 to 1999 and from 1999 to 2000, *personnel contamination* occurrences involving the skin and the shoes decreased by 18% and 20% respectively while those involving clothing increased by 6%. It should be noted that over the 5-year period 1996-2000, skin contamination occurrences dropped an average of 8% per year, clothing contamination occurrences dropped an average of 8% per year, and shoe contamination

Exhibit 3-26:
Personnel Contamination Occurrences by Affected Area, 1996-2000.

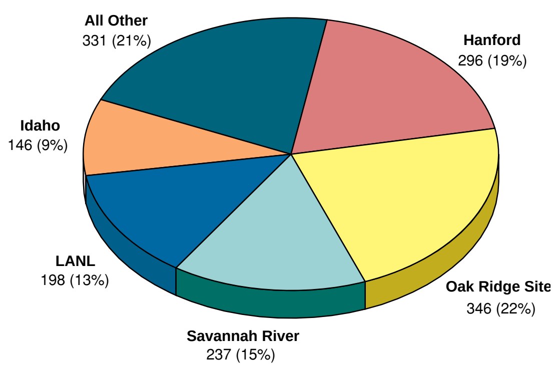


occurrences dropped an average of 9% per year. Much of this improvement can be attributed to recognizing the root cause of the respective occurrence, taking decisive corrective action, and communicating the results throughout the DOE community.

Although fewer in number than in 1999, some skin *personnel contamination* occurrences continue because of residual contamination on protective clothing. Also, in high temperature work areas, perspiration soaks or dampens the outer protective clothing allowing contamination to be wicked onto the workers skin or inner clothing. In some cases (see Occurrence Report ORO-LMES-Y12NUCLEAR-2000-0026), gloves or other protective clothing is considered hazardous to the worker near moving machinery or tools, and skin contamination results from an ungloved worker inadvertently touching a machined part or tool. In 2000, a greater number of skin or clothing contamination occurrences resulted from errors made in removing protective outer clothing thereby cross-contaminating the skin or personal clothes. Clothing contamination events increased 6% over the same category in 1999, in some cases due to the doffing error described above. Contamination on personal (non-company-issued) clothing is relatively rare since many people working in areas requiring protective clothing wear facility-issued modesty clothing or coveralls under their protective outer clothing. Skin contamination is usually not a health issue, although in at least one case a minute radioactive particle was estimated to have delivered a skin dose of 354 rem (3,540 mSv). Shoe contamination was down 20% from 1999, in part due to a reduction in unknown sources of contamination reaching uncontaminated areas where workers do not routinely cover their shoes.

Exhibit 3-27 shows the breakdown of the *personnel contamination* occurrences by site for the 5-year period 1996 to 2000. *Personnel contamination* occurrence reports are distributed among DOE sites with Oak Ridge, Hanford, Savannah River, Los Alamos, and Idaho submitting reports for 79% of the occurrences.

Exhibit 3-27:
Personnel Contamination Occurrences by Site, 1996-2000.



3.4.4.3 Occurrence Cause

Exhibits 3-28 and *3-29* show the breakdown of *radiation exposure* and *personnel contamination* occurrence reports by their root cause. For ORPS, the "root-cause" is defined as that which, if corrected, would prevent recurrences. Only the four significant root causes are considered here, all others are included in the category entitled "All-Other."

In 2000, Management Problem was cited as a root-cause for 6 of the *radiation exposure* occurrences. In 2000, one *radiation exposure* was caused by

Exhibit 3-28:
Radiation Exposure Occurrences by Root Cause, 1998-2000.

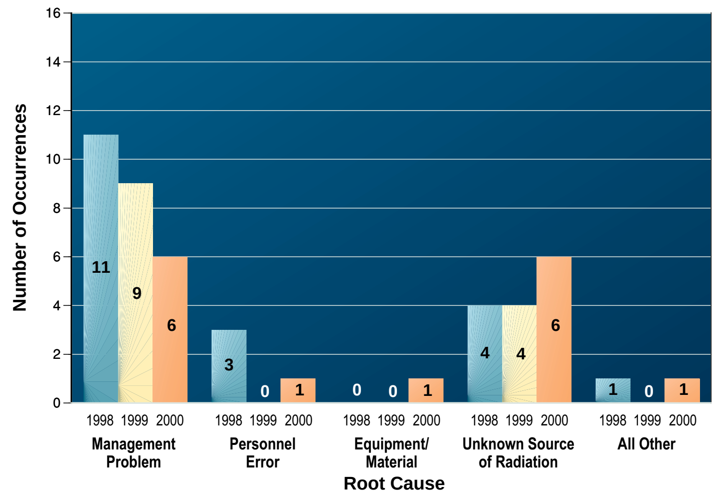
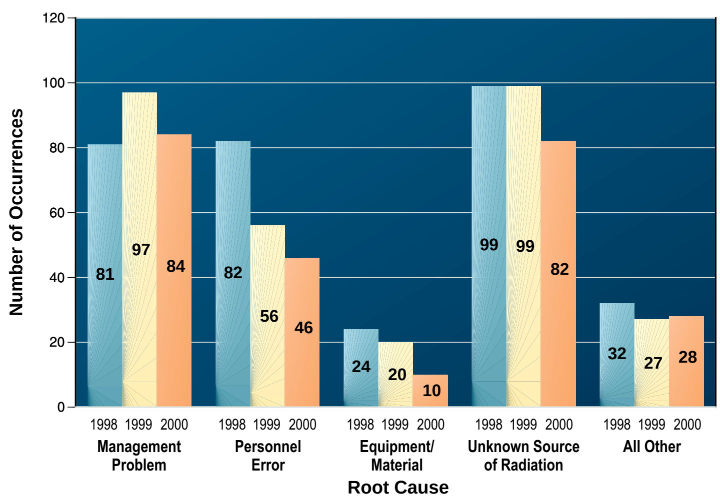


Exhibit 3-29:
Personnel Contamination Occurrences by Root Cause, 1998-2000.



equipment failure when a sample bottle seal failed; this was the only occurrence during the period 1998 to 2000 citing Equipment Failure or Material Deficiency as a root cause. In 2000, Unknown Source was listed as the root cause for six (40%) *radiation exposure* occurrences. During the period 1998 to 2000, Unknown Source has been listed in 14 (30%) of the *radiation exposure* occurrences. Unknown Source means that the investigation could not pinpoint the source of the exposure or that insufficient evidence existed to fully ascribe the cause to Equipment Failure, Personnel Error, or other Management Problem. "All-Other" was the cause cited in one occurrence in 2000. All-Other may be a combination of known or unknown causes.

The number of *personnel contamination* occurrences attributed to Management Problems decreased by 13% from 1999 to 2000. The most often cited management problem was deficient organizational planning and control and inadequate administrative control. Others included improper resource allocation, and "other," a non-specific category. *Personnel contamination* occurrences attributed to Personnel Error decreased 18% between 1999 and 2000. "Inattention to detail" was cited as the predominate personnel error, followed by other non-specific causes and "failure to follow procedure". Many of these cases involve personnel contaminating skin or clothing while removing outer protective clothing and inadvertently touching or brushing a contaminated glove or clothing article on clean skin. Equipment Failure or Material Deficiency was cited in 10 *personnel contamination* occurrences in 2000. This may be the result of a better understanding and more thorough investigation into the root causes of these occurrences. Over the period 1998 to 2000, failure of protective clothing (primarily holes in gloves or protective coveralls) has been the most often cited cause. Several cases involved the failure of a component or piping system unexpectedly releasing airborne or liquid contamination. Although Unknown Source was listed in 17 fewer cases in 2000 than in 1999, it remains the primary root cause listed for *personnel contamination* occurrences between 1998 and 2000. The majority of these occurrences involved personnel who inadvertently picked up loose contamination that migrated from radioactive material handling or contamination areas to uncontrolled (clean) areas. In most cases, that contamination was detected at building or facility monitors set up to screen all employees exiting the area. In the All-Other category, the majority of personnel contamination occurrences were attributed to legacy contamination where the contaminates were thought to be fixed into a surface or otherwise controlled but came loose resulting in personnel contamination.

Further information concerning ORPS can be obtained by contacting Eugenia Boyle, of EH-33 or the ORPS web page at:

http://tis.eh.doe.gov/oeaf

3.5 Activities Contributing to Collective Dose in 2000

In an effort to identify the reasons for changes in the collective dose at DOE, several of the larger sites were contacted to provide information on activities that contributed to the collective dose for 2000. These sites (Rocky Flats, Oak Ridge, Hanford, Savannah River, Los Alamos, and Idaho) were the top six sites in their contribution to the collective TEDE for 2000 and comprised 83% of the total DOE dose. Two of the six sites reported decreases in the collective TEDE, which resulted in a 2% decrease in the DOE collective dose in 2000. The six sites are shown in *Exhibit 3-30*, including a description of activities that contributed to the collective TEDE for 2000.

Exhibit 3-30:
Activities Contributing to Collective TEDE in 2000 for Six Sites.

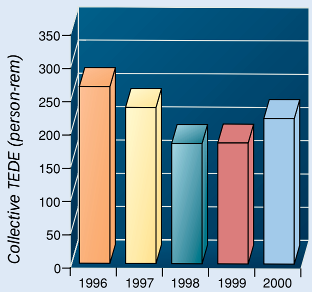
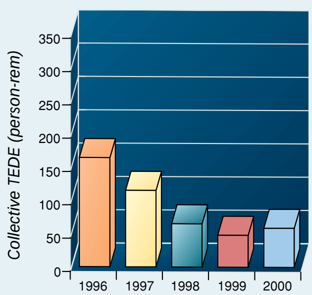
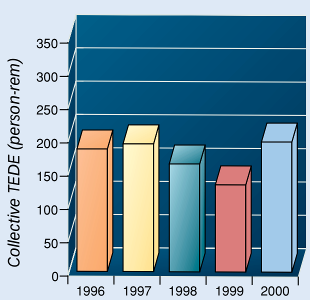
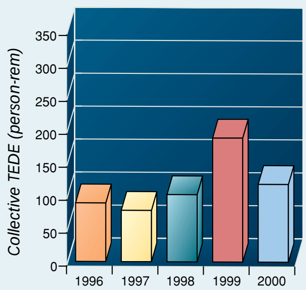
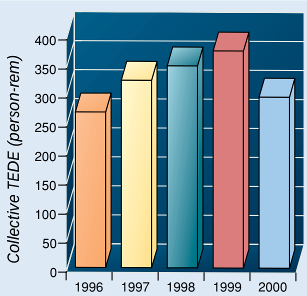
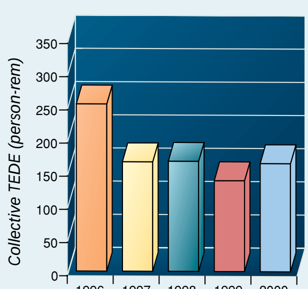
Site	Collective TEDE (person-rem)	Percent Change			Description of Activities at the Site
		1999-2000 (last yr.)	1998-2000 (3 yr.)	Since 1996 (5 yr.)	
Hanford		↑ 20%	↑ 21%	18% ↓	*The collective TEDE at Hanford increased by 20% from 182.0 person-rem in 1999 to 219.0 person-rem in 2000. The largest contributors to the collective TEDE at Hanford were thermal stabilization and repackaging of plutonium-bearing materials at the Plutonium Finishing Plant (PFP) (38%), clean-out activities of the River Corridor/324 Facility B-cell (21%) and Tank Farm work activities (17%). The increase in collective TEDE was due to increased plutonium stabilization activities at PFP and increased operational activities on tank waste projects. The collective dose from neutron radiation increased by 36% due to increased plutonium stabilization activities at PFP.*
Idaho		↑ 22%	9% ↓	64% ↓	*The collective TEDE at INEEL increased by 22% from 48.3 person-rem in 1999 to 58.8 person-rem in 2000. Radiation exposure to INEEL workers is primarily the result of radiological work conducted in support of the operation of the Advanced Test Reactor (ATR) and the Hot Cells at the Test Reactor Area (TRA), and in support of spent fuel operations at Test Area North (TAN) and Idaho Nuclear Technology and Engineering Center (INTEC). Due to a major effort to improve work control processes in 1999, considerable radiological work was deferred into 2000. This caused some milestone work, such as preparing for shipments of waste to WIPP and transferring TMI fuel from wet storage to dry storage to be performed in 2000. A major effort was also started to decontaminate one of the remotely operated hot cells at the TRA with dose rates as high as 50,000 R/hr; this project itself was responsible for over 13 person-rem of collective dose.*
Los Alamos National Lab.		↑ 49%	↑ 21%	↑ 6%	*The collective TEDE at LANL increased by 49% from 131.0 person-rem in 1999 to 195.5 person-rem in 2000. The collective TEDE at LANL was impacted by three major events at LANL in 2000. The first two events, the Cerro Grande wildfire and the national security incident involving the missing computer hard drive, impacted the type and amount of work performed at LANL during the year. These events resulted in an overall decrease in work involving radioactive materials due to safety and security stand-downs, and resulted in a decrease in the collective external dose total for 2000. The collective external dose in 2000 was 86 person-rem, the lowest collective external dose ever recorded at Los Alamos and down 33% from the 1999 value of 128 person-rem.* *However, the third event at LANL resulted in a large increase in the collective internal dose component of the collective TEDE. As a result of an accident at TA-55, three individuals received internal doses from plutonium that were in excess of the DOE annual limit of 5 rem. (See Section 3.3.1 for more information concerning Occurrence Report ALO-LA-LANL-TA55-2000-0009). This single event resulted in an increase in the collective CEDE from 3 person-rem in 1999 to 110 person-rem in 2000 and is responsible for the 49% increase in the collective TEDE at LANL in 2000. Conversely, this event also contributed to a decrease in the collective external dose as work was delayed while site personnel performed safety inspections of glovebox compression fittings throughout TA-55 as a corrective action.*

Exhibit 3-30:
Activities Contributing to Collective TEDE in 2000 for Six Sites (continued).

Site	Collective TEDE (person-rem)	Percent Change 1999-2000 (last yr.)	Percent Change 1998-2000 (3 yr.)	Percent Change Since 1996 (5 yr.)	Description of Activities at the Site
Oak Ridge Site		42% ↓	↑ 15%	↑ 33%	Collective dose at the Oak Ridge Site decreased 42% from 202.2 person-rem in 1999 to 118.1 person-rem in 2000. The Oak Ridge Site includes the Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12 Plant), and East Tennessee Technology Park (ETTP, formerly known as K-25). The collective TEDE for the ORNL increased 10% from 43.7 person-rem in 1999 to 48.2 person-rem in 2000. This low increase in the collective TEDE is due to an aggressive ALARA program that has significantly decreased expected doses associated with environmental remediation projects. Several major restoration projects include the remediation of the FFA and Gunite Tanks, the Molten Salt Reactor, the Metal Recovery Facility, and the Old Hydro Fracture Ponds and Tanks. Activities associated with process operations include the operation of the High Flux Isotope Reactor and radiochemical processing at the Radiochemical Engineering Development Center. The collective TEDE at the Y-12 Plant decreased 55% from 149.8 person-rem to 67.4 person-rem primarily as a result of a change in the biokinetic models used to determine internal dose from uranium intakes. The use of the ICRP 66 rather than the ICRP 30 respiratory tract model has been shown to better fit the analytical data and is now being utilized to calculate internal dose. A major modification is the use of a 5µm rather than 1µm default particle size for intake assessments. External dose also decreased during 2000 due to the completion of work activities associated with Disassembly and Storage Operations and Depleted Uranium Operations. The collective TEDE at the ETTP decreased 71% from 8.6 person-rem in 1999 to 2.5 person-rem in 2000. This reduction is due to the environmental contractor assigning dosimetry to their personnel at each of the Oak Ridge Sites in 2000 rather than having them assigned to the ETTP site, as in past years. This has contributed to the reduction of the collective TEDE reported for the ETTP site in 2000 by assigning the dose to the specific site where the dose was accrued.
Rocky Flats		21% ↓	15% ↓	↑ 10%	The collective TEDE at Rocky Flats decreased 21% from 373.9 person-rem in 1999 to 296.1 person-rem in 2000. This decrease was primarily due to a reduction of source material and lowering of ambient dose rates. The CEDE decreased 50% (6.6 person-rem in 1999 to 3.3 person-rem in 2000) partly because of reductions in risk while reducing the size of gloveboxes and other equipment prior to disposal. Activities involving radiation exposure for calendar year 2000 included processing and shipment of plutonium residues, packaging and shipment of low level waste, and the continued Decontamination and Decommissioning (D&D) of two of the four major plutonium facilities at the site.
Savannah River		↑ 20%	1% ↓	35% ↓	The collective TEDE at SRS increased by 20% from 136.5 person-rem in 1999 to 163.2 person-rem in 2000. An exposure increase was expected in calendar year 2000 due to the planned work scope for routine operations and for special work. The 2000 collective total dose equivalent was lower than the SRS 2000 ALARA goal by approximately 10% when compared to the 2000 collective dose goal of 179.6 person-rem including a 30 person-rem neutron goal. The primary projects and activities contributing to increased 2000 dose totals were associated with SRS's Nuclear Materials Stabilization and High Level Waste Programs. These programs and associated facilities accounted for approximately 75% of the SRS collective dose totals. Repair and maintenance special work activities associated with operation of waste evaporators (designed to reduce the volume of radioactive waste) contributed to increases in exposure totals in High Level Waste. Projects supporting waste removal from waste tanks (e.g., shielding replacements and upgrades, fan upgrades, etc.) were another significant contributor to High Level Waste dose totals. For the Nuclear Materials Stabilization division, the primary contributors to increased 2000 collective dose versus 1999 were vault recovery, and vault surveillance activities as follow-up actions to a 1999 incident at the SRS FB-Line facility (ORPS-SR-WSRC-FBL-1999-0026). Collective dose totals were also impacted by the initiation of ventilation upgrades to return air supply for the same vault. The SRS 2000 increases in neutron dose totals are primarily related to these activities.

3.6 Transient Individuals

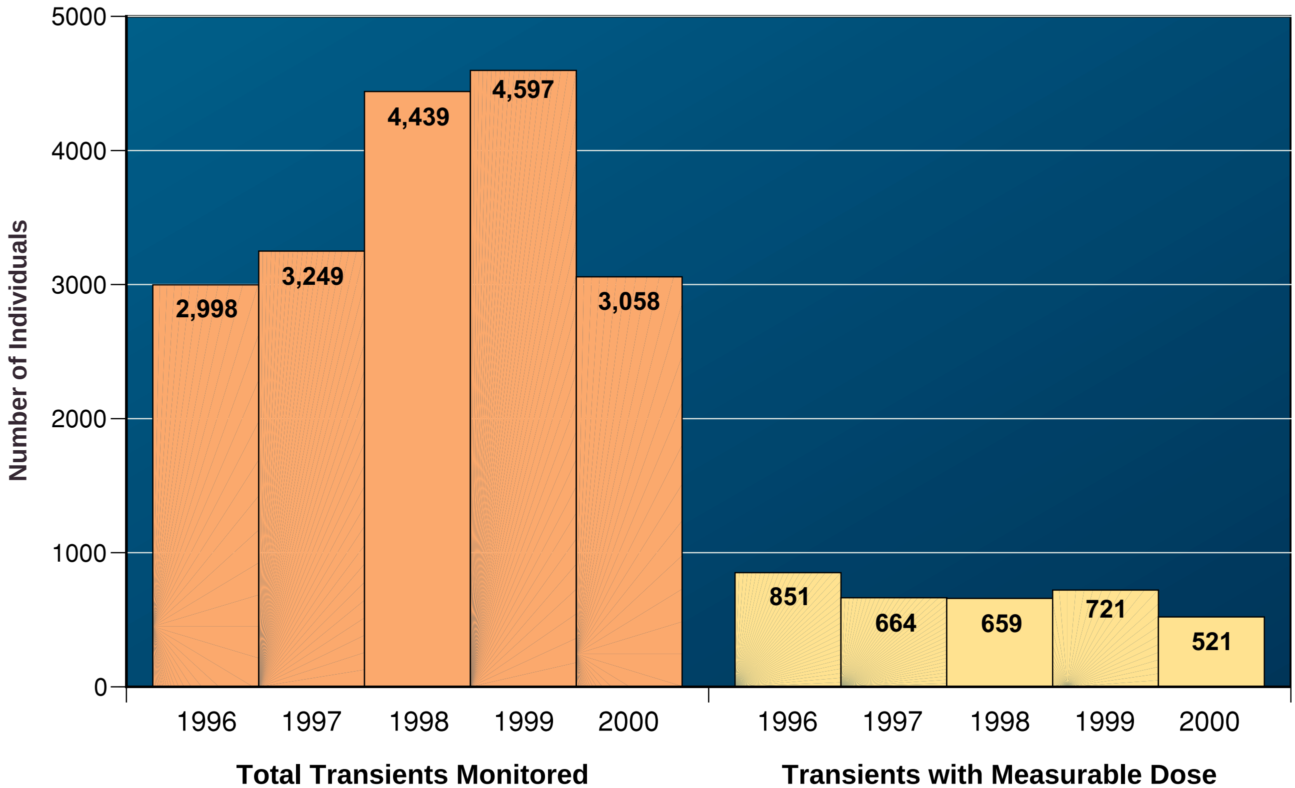
Transient individuals are defined as individuals who are monitored at more than one DOE site during the calendar year. For the purposes of this report, a DOE site is defined as a geographic location. The DOE sites are listed in Appendix A by Operations Office. During the year, some individuals perform work at multiple sites, and therefore have more than one monitoring record reported to the repository. In addition, some individuals transfer from one site to another during the year. This section presents information on transient individual's records to determine the extent to which individuals travel from site to site and examine the dose received by these individuals.

Exhibit 3-31 shows the distribution and total number of transient individuals from 1996 to 2000. Over the past 5 years, transient individuals have accounted for 3% of the total monitored individuals at DOE and received 2.4% of the collective dose. As shown in *Exhibits 3-32* and *3-33*, the number of transients monitored and the number with measurable dose decreased from 1999 to 2000. The collective dose decreased by 40% and the average measurable dose decreased by 18%. The average measurable TEDE for transients in 2000 was 43% less than the average measurable TEDE for all monitored DOE workers. As shown in *Exhibit 3-34*, the site with the largest collective dose to transient workers from 1996 to 2000 occurred at LANL. LANL has a larger percentage of dose to transients because workers at TA-55 (who generally receive elevated doses) tend to perform temporary work at sites such as Nevada Test Site (NTS), Rocky Flats, and Pantex as part of their routine duties.

Exhibit 3-31:
Dose Distribution of Transient Workers, 1996-2000.

	Dose Ranges (rem)	1996	1997	1998	1999	2000
Transients	Less than Measurable Dose	2,147	2,585	3,780	3,876	2,537
	Measurable < 0.1	764	606	585	638	466
	0.10 - 0.25	57	41	49	50	37
	0.25 - 0.5	21	14	14	21	14
	0.5 - 0.75	4	2	8	6	4
	0.75 - 1.0	3		2	6	
	1.0 - 2.0	2	1	1		
	Total Monitored	2,998	3,249	4,439	4,597	3,058
	Number with Measurable Dose	851	664	659	721	521
	% with Measurable Dose	28%	20%	15%	16%	17%
	Collective TEDE (person rem)	41.392	27.426	34.742	39.521	23.632
	Average Measurable TEDE (rem)	0.049	0.041	0.053	0.055	0.045
All DOE	Total Monitored	123,324	107,181	108,508	113,064	102,881
	Number with Meas. Dose	22,725	18,689	17,544	16,668	15,983
	% of Total Monitored who are Transient	2.4%	3.0%	4.1%	4.1%	3.0%
	% of the Number with Measurable Dose Who are Transient	3.7%	3.6%	3.8%	4.3%	3.3%

Exhibit 3-32:
Individuals Monitored at More Than One Site (Transients) During the Year, 1996-2000.



One group of individuals that routinely travel from site to site is DOE employees from Headquarters or the Field Offices who visit or inspect multiple sites during the year. For 2000, this group accounts for 14% of the monitored transient individuals and 5% of the collective dose to transients.

Over the past 5 years, only 12% of the transient individuals were monitored at three or more sites. DOE Headquarters and Field Office personnel make up a large percentage of these individuals. From 1996 to 2000, 30% of the individuals monitored at three or more sites were DOE Headquarters or Field Office employees and 42% of the individuals monitored at four or more facilities were DOE Headquarters or Field Office employees. The maximum number of sites visited by one monitored individual during 2000 was six.

Exhibit 3-33:
Collective and Average Measurable Dose to Transient Individuals, 1996-2000.

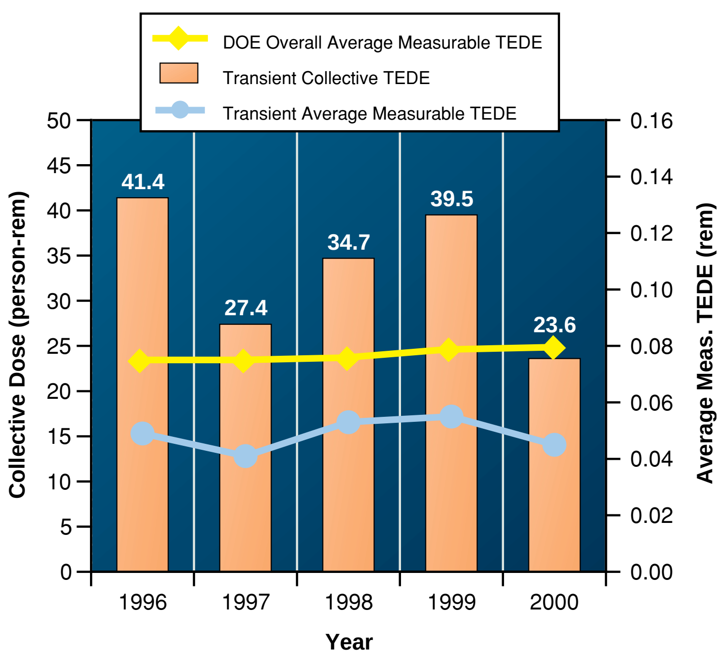
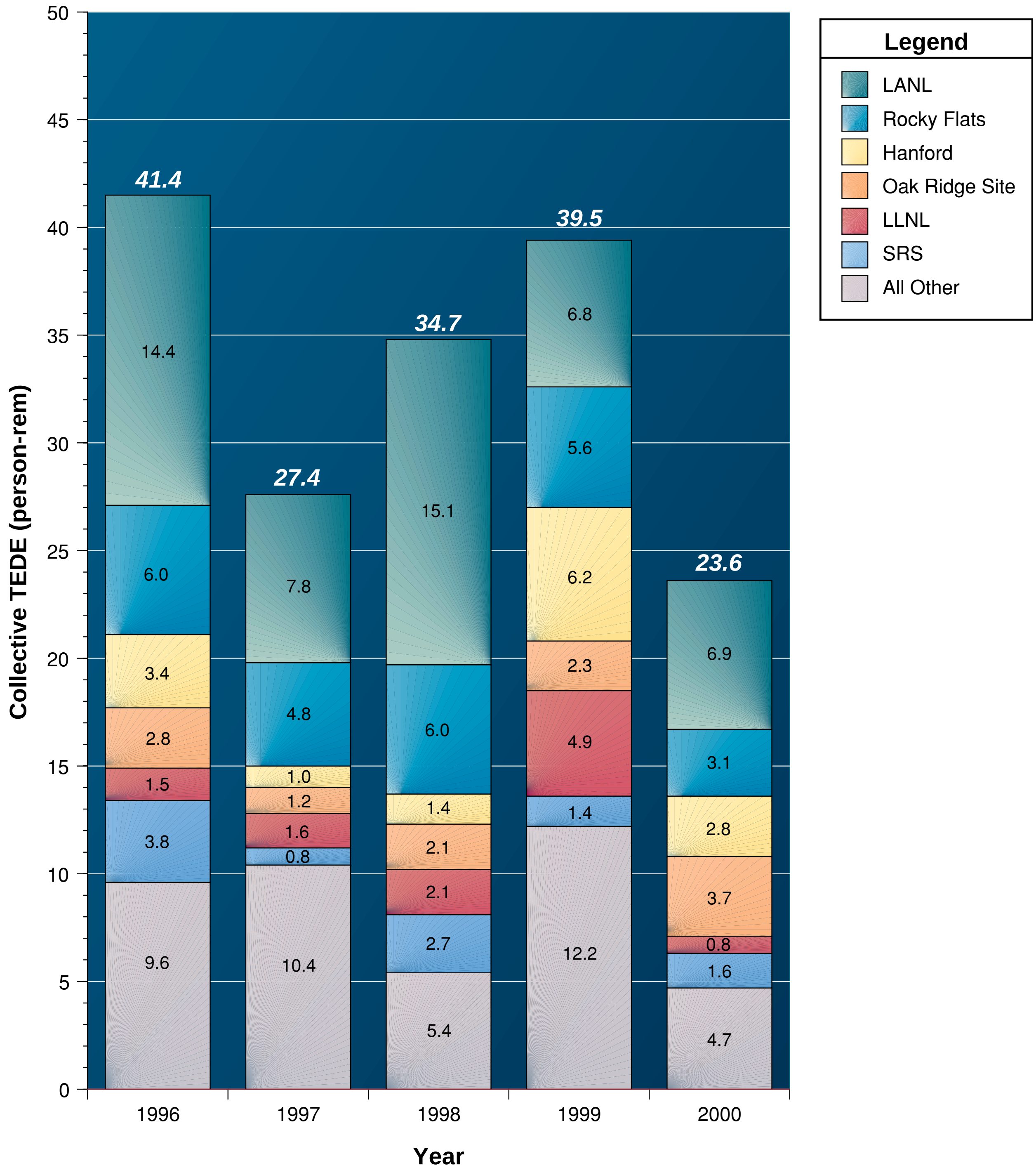


Exhibit 3-34:
Collective TEDE to Transient Workers by Site, 1996-2000.



LANL has a larger percentage of dose to transients because workers at TA-55 (who generally receive elevated doses) tend to perform temporary work at sites such as NTS, Rocky Flats, and Pantex as part of their routine duties.

3.7 Collection and Analysis of Historical Data

3.7.1 Background

In 2000, the DOE Office of Worker Protection Policy and Programs (EH-52) and the Office of Health Studies (EH-6) began a collaborative project to collect historical occupational radiation exposure data from certain DOE sites. The historical data task was designed to pursue the collection of radiation exposure monitoring information at DOE facilities prior to 1987 which is currently not included in the DOE Radiation Exposure Monitoring System (REMS). Prior to 1987, DOE required the reporting of statistical summaries from 1974 to 1986, and termination reports submitted from 1969 to 1986. The collection of the individualized exposure monitoring records prior to 1987 will allow for a more complete understanding of the history of the collective dose at DOE as well as individual career dose histories.

3.7.2 Process

The first phase of the project was to collect voluntary submittals from selected sites that are participating in the DOE epidemiologic studies program with the Office of Health Studies (EH-6). The sites were requested to submit any historical records of radiation exposure monitoring that were available electronically. This approach minimized the reporting burden on the sites and allowed for more detailed analysis of what information had been recorded at these DOE sites. Twelve sites participated in this initial voluntary request:

- Oak Ridge East Tennessee Technology Park,
- Fernald Environmental Management Project,
- Hanford,
- Idaho National Engineering and Environmental Lab,
- Kansas City Plant,
- Lawrence Livermore National Lab,
- Nevada Test Site,
- Pantex Plant,
- Portsmouth Gaseous Diffusion Plant,
- Rocky Flats Environmental Technology Site,
- Sandia National Lab, and
- Savannah River Site.

The data from the twelve sites were analyzed for commonalities with the REMS database, and a plan was developed for integrating the data into REMS. The data will also be maintained "as reported" to allow for future research. The common data set was then analyzed for comparison with known collective dose totals, and in terms of career length and cumulative career dose.

3.7.3 Findings

The initial task was successful in obtaining a large number of historical dose records with minimal impact or effort from the participating sites. Nearly 4 million dose records were reported and processed. This is over twice the amount previously in the REMS database. It is estimated that records containing 50% of the overall DOE collective dose prior to 1987 were collected from the twelve participating sites in this pilot study. Seventy-five percent of the sites submitted annualized dose records, which will allow for an accurate depiction of the accumulation of dose to the worker over time. Although there was a wide variety in the information reported, the primary measures of external dose that are of interest to DOE were recorded and reported. Internal dose was not reported by most sites and is difficult to collect because historical internal dose data is not generally available in electronic format and there is considerable variation in the information that was recorded.

Exhibit 3-35:
Collective External Dose Comparison for Pilot Sites.

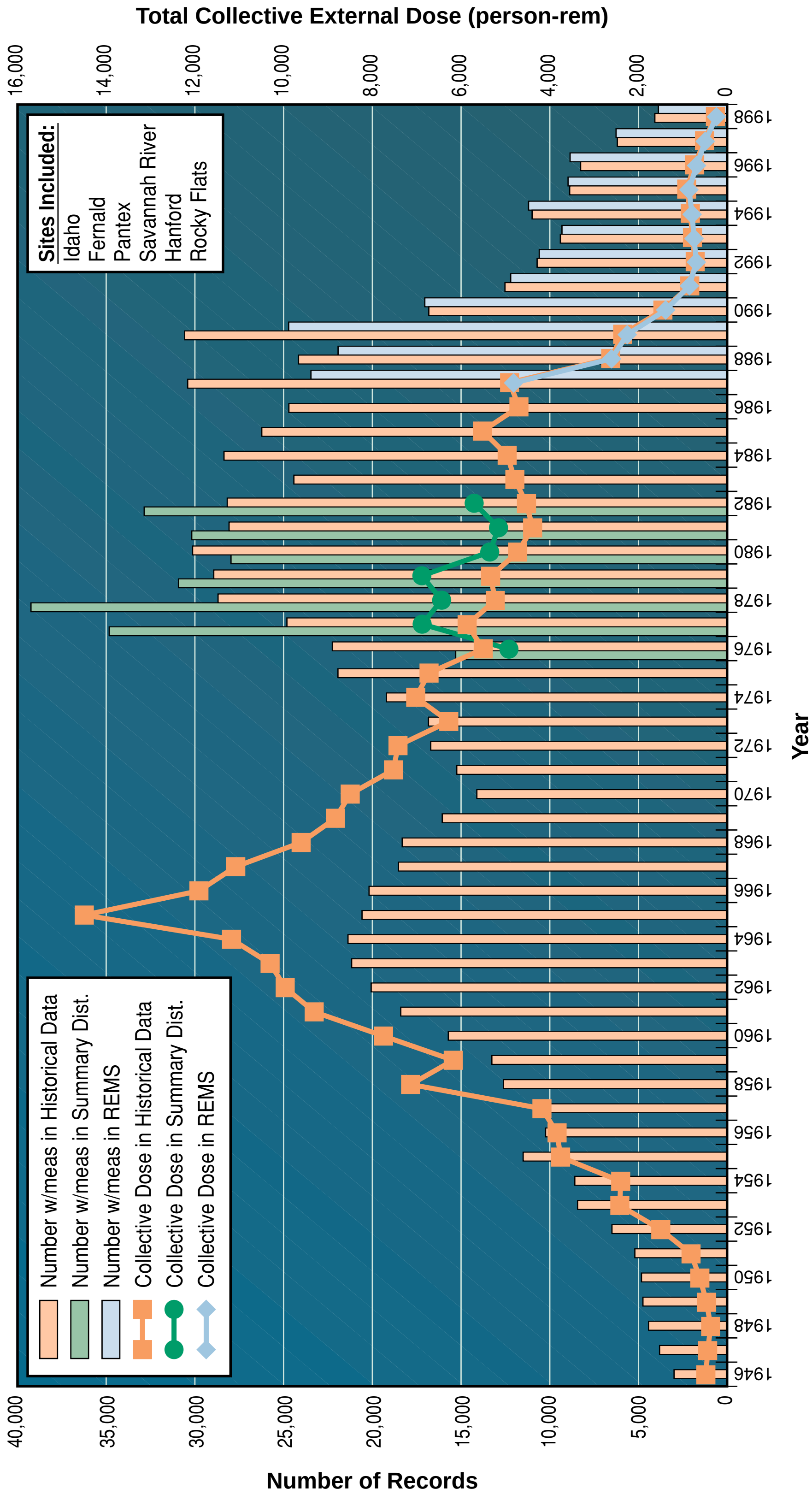


Exhibit 3-36 shows the average career lengths and totals for the historical data collected from 10 sites participating in the project. The data from two of the participating sites did not provide enough information for career analysis. Totals and averages are provided for career length and external whole body dose. The average career length for individuals with measurable external dose at all sites is 10.5 years, with an average measurable career dose of 1.4 rem (14 mSv).

Exhibit 3-37 shows the number of individuals with measurable external dose, the collective external dose, and the average measurable external dose for the years 1945 to 1999. This data set only includes those historical dose records from seven sites where the external whole body dose was greater than zero, and the dose records were reported in annual increments. The graph shows a substantial decrease in average measurable external dose from 1970 to 1980, and another decreasing trend from 1986 to the present. There was a three-fold increase in individuals with a measurable external dose less than 100 mrem from 1970 to 1980 that resulted in the reduction in the average measurable dose. So the decrease was primarily due to an increase in individuals receiving low doses, rather than a reduction in dose to individuals.

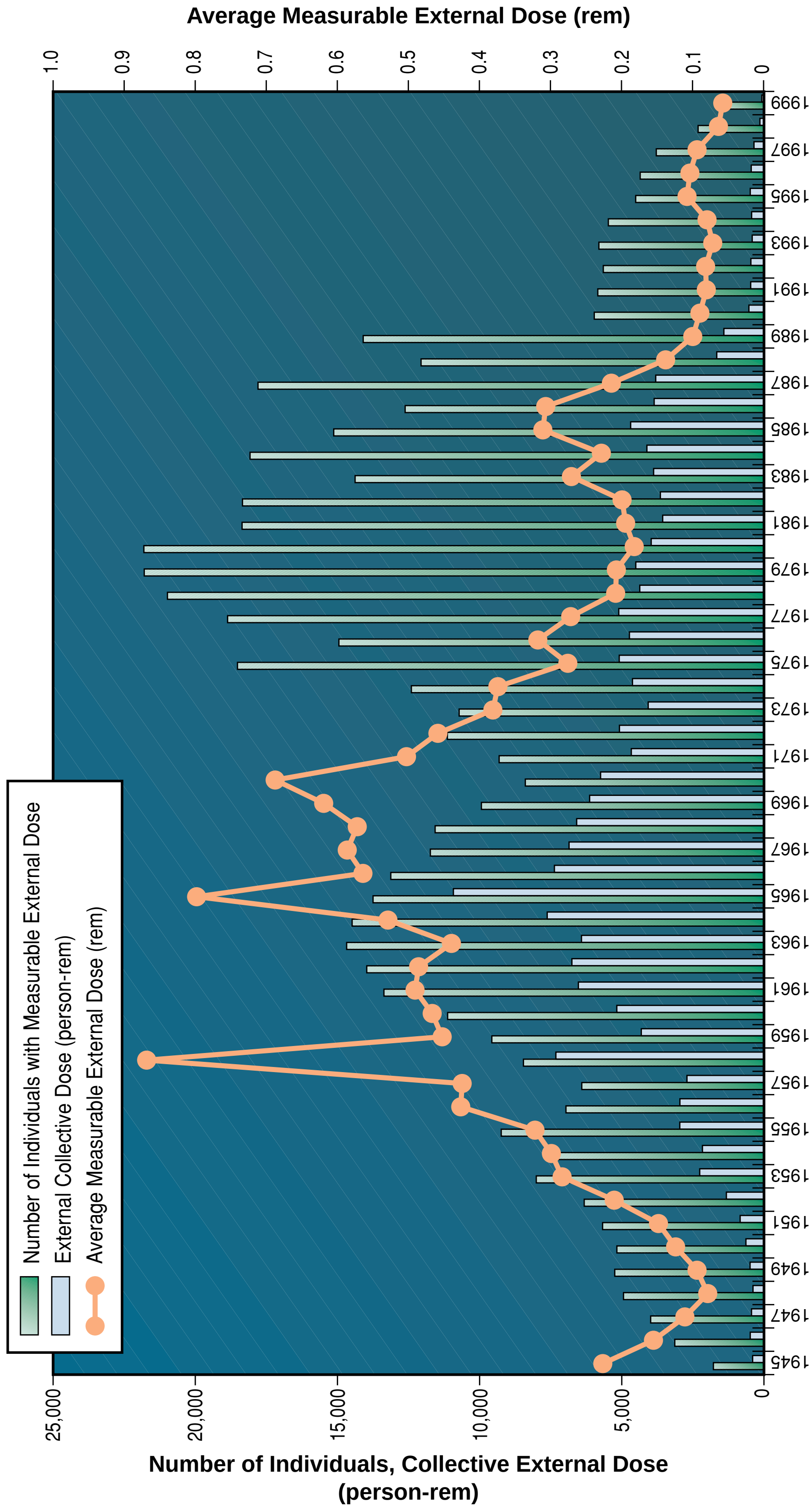
3.7.4 Future Activities

Based on the success and efficacy of the pilot project in gathering historical data, DOE has sent a request to the remaining DOE sites to voluntarily provide available electronic dose records. These data will be collected and processed in the same manner as described above. Ideally, DOE will continue to collect available historical data to gather more complete information of radiation dose for as many sites as possible for the years of operation of each DOE facility.

Exhibit 3-36:
Total Individuals, Average Career Length, and Average Career Dose per Site

Site	Years	Total Monitored Individuals Reported	Total Monitored Average Career Length (Yrs.)	Number with Measurable Career Dose (External)	Average Career Length for Individuals with Measurable Dose (Yrs.)	Average Measurable Career Dose (External in rem)
ETTP	1946 - 1999	17,936	7.4	7,565	12.0	0.646
Fernald	1952 - 1989	8,618	6.5	4,903	9.6	1.599
Hanford	1944 - 1998	182,323	5.1	80,691	9.8	1.428
INEEL	1951 - 1998	112,898	3.2	32,847	8.0	1.469
LLNL	1940 - 1999	17,200	12.8	4,772	22.8	0.687
NTS	1986 - 1999	140,863	1.6	1,346	7.2	0.123
Pantex	1952 - 1998	5,757	9.0	2,273	13.7	1.088
Portsmouth	1954 - 1995	9,901	9.9	6,081	13.8	0.372
Rocky Flats	1949 - 1992	27,736	6.1	16,053	9.1	2.107
Savannah River	1950 - 1999	43,998	10.1	32,043	12.6	1.459
Totals and Averages		**567,230**	**4.7**	**188,574**	**10.5**	**1.397**

Exhibit 3-37:
Annual Average Measurable External Dose from the 7 Pilot Sites.



Section Four
ALARA Activities at DOE

This section on ALARA activities is a vehicle to document successes and to point all DOE sites to those programs whose managers have struggled with radiation protection issues and have used innovative techniques to solve problems common to most DOE sites. DOE program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of Integrated Safety Management and quality are encouraged to provide input to be included in the future reports.

4.1 ALARA Activities at the West Valley Demonstration Project

The West Valley Demonstration Project (WVDP) is located approximately 30 miles south of Buffalo, New York, at the site of a former commercial nuclear fuel reprocessing plant. When the plant operated, more than 600,000 gallons of liquid high-level radioactive waste were generated and stored in an underground tank. The WVDP Act passed by Congress in 1980 directed DOE to solidify the liquid waste in the tank, clean and close the facilities used, and dispose of low-level and transuranic wastes left from Project operations. West Valley Nuclear Services (WVNS) is the contractor at the WVDP site. The New York State Energy Research and Development Authority owns the site property.

4.1.1 Removal and Replacement of a Waste Transfer Pump

Problems with a waste transfer pump began after approximately 2 years of operation and continued for 3 months until it failed. Without the pump, the vitrification (solidification) operation shut down. The pump is 35 feet long supported from a truss above the tank. Because the lower portion of the pump was immersed in the high-level waste, it was expected to be highly contaminated. Initial surveys of the lower section of the pump indicated dose rates of 94 to 150 R/hr.

Extensive prework planning was conducted to incorporate ALARA principles into the job. Principles of time, distance, and source reduction were used to limit personnel exposure. Numerous internal and external water flushes were performed initially. A spray ring that was internal to the pump riser initially washed down both the outside of the pump and the riser interior. Holes were then drilled in the upper flange of the pump and a high-pressure water lance was inserted in the riser. Once again both the exterior of the pump and the interior of the riser were washed down. A third pump wash method was performed using a portable water spray ring installed in the riser. Clean water was also pumped through the internals of the pump to clean out as much contamination as possible. After all of the water washes, the overall dose rates decreased by a factor of three.

In addition to water flushes for source reduction, ALARA procedures also dictated extensive personnel training prior to pump removal. The pump would be lifted by crane from the tank into a metal box lined with plastic and the box placed into a shielded cask. Close personnel contact was required during pump removal. During these evolutions, both a maximum dose rate and maximum work time, and administrative controls were used to limit personnel exposures. Continued practice by workers at a mock-up of the transfer pump refined work techniques and helped minimize the time that workers would be in close proximity to the pump.

The area around the riser was enclosed by a tent as a measure to limit the possible spread of contamination (see *Exhibit 4-1*). Workers in the tent during pump removal used the common ALARA practice of staying the maximum distance away from the pump and the dose source, unless required. When the pump was pulled into the lined metal box, the plastic sheeting lining the box was sealed by workers as a measure to control spread of contamination from the pump.

As a result of the ALARA practices used while completing this work, overall personnel dose was approximately one-half of the estimated dose. The estimated work dose was 257-person-mrem, while the actual dose was only 108-person-mrem. This significant reduction in expected dose can be credited to both the extensive dose reduction work done prior to pump removal and the efficient, well-executed portions of the job as a result of mock-up training and practice.

Tank Farm Engineering and Projects, HLW Tank Farm Operations, Radiation Protection, and Radiological Projects were the primary groups involved in the activity.

For more information about this project, contact Larry Wiedemann of WVNS at 716/942-4227.

Exhibit 4-1:
WVDP workers remove a failed transfer pump from the Project's main high-level waste tank in 1998.

Photo Courtesy of WVNS.

4.1.2 Replacement of the High-Level Waste Off-Gas Filter

During high-level radioactive waste (HLW) vitrification processing at the WVDP, the two vessel off-gas high-efficiency particulate air (HEPA) filters became highly contaminated and developed very high dose rates after a prefilter failed. The off-gas filter system consists of two parallel trains, each with two HEPA filters located in series. The first filter in each train (64-T-009 A1 and 64-T-009 B1) was affected. Based on measured and calculated dose rates through the 6-inch-thick steel shield doors, it was determined that the dose rate on the face of these filters was 47 R/hr and 25 R/hr, respectively. Functionally, both filters were operating properly. Differential pressure across each filter bank was well within limits and in-place filter test results were satisfactory. Environmental stack emissions confirmed that no federal regulatory standards or DOE guidelines had been exceeded. Based on future radiological concerns, it was determined that the filters should be replaced. Changing the filters later, when differential limits required, would likely result in higher dose rates and make the change much more difficult.

Although the operators would be working in close proximity to the filters, they would not have visual access for this hands-on activity. They would essentially be performing the filter removal "in the blind." To address this issue, a full-scale mock-up was designed and constructed. The operators who were to perform the work in the field began training on the primary removal methodology. In addition, the necessary tooling was developed by Engineering. Operator involvement in the development and use of the mock-up was extremely beneficial.

Strict ALARA principles were incorporated in the scope of work. The key to minimizing exposure was rapid removal of the filters into a shielded box. Extensive mock-up use and training were used to develop methods that reduced the time spent in the area and minimize the spread of contamination. Although the ability to maintain distance from the source was limited, the operators were able to implement techniques that allowed them to limit the direct dose paths as much as practical.

The mock-up efforts proved to be invaluable. Both filters were removed and replaced without incident. The total accumulated dose for the removal of both filters was less than 50 percent of the pre-job estimate. Total collective dose was 230 person-mrem while the estimated collective dose was 517 person-mrem.

For more information about this project, contact Dan Stevens of WVNS, 716/942-4437.

4.1.3 Refurbishment of PMC Shield Windows

In the current phase of site cleanup at the WVDP, decontamination efforts are focused on the former fuel reprocessing cells. The Process Mechanical Cell (PMC), from previous operations, contained fines from cutting fuel, unreprocessed fuel assembly sections, contaminated handling equipment, and wastes from areas of the analytical laboratory. Shielding windows had become cloudy and could not support the cleanup unless they were refurbished. The objective of this work was to refurbish five shield windows and restore visual access to allow planning for the removal of failed equipment, installation of new equipment, and eventual decontamination of the cells.

To refurbish the glass in each of the window assemblies, which weighed 15 tons each, the entire assembly had to be removed from the liner in the cell's wall. Dose rates in the cells vary from 100 to 300 R/hr, with hot spots up to 2000 R/hr; accompanying contamination levels were extremely high. Exposure of workers to high doses during window removal and potential release of airborne and contact removal contamination was also possible.

During 1999, a window refurbishment subcontractor was hired to restore the windows to usable condition. The subcontractor worked with WVNS operators to remove and reinstall each window after the contractor portion of the job was finished. Both shielding and containment were employed as ALARA measures to protect workers. A containment tent was constructed around each window and shielding (a 6-inch-thick steel tunnel constructed around the window opening) was installed in the area where the windows were removed while refurbishment work was ongoing. The containment tent for the third window was fabricated out of white herculite with the intent to control contamination and then dispose of the tent as industrial waste. Because of minimal contamination on the tent from the third window removal, the same containment tent was used for the fourth window replacement.

Effective contamination control techniques also were instrumental in the free release of more than 99 percent of the steel used in the project. Additionally, two hot spots were discovered on two of the plates from an extraction table used in the project; attempts to decontaminate them were unsuccessful. However, instead of disposing of the 3- by 4-foot half-inch plates as radioactive waste, the sections of the plates that were contaminated were cut out. As a result, only two 1- by 1-foot pieces of the plates had to be disposed of as radioactive waste. During 1999, more than 30,000 pounds of steel were released for unrestricted use.

Also during window refurbishment, the lead shims that were used to prevent radiation streaming were removed because they could not be reused. Using effective contamination control techniques in 1999, approximately 600 pounds of lead was removed, radiologically surveyed and released, and sent to a lead recycler for reuse.

The actual collective dose for replacement of the PMC windows was 335 person-mrem, while the estimated collective dose was 1045 person-mrem. Also, lessons learned from each of the window replacements allowed workers to reduce the project completion time from 20 days (first window) to 7 days (fourth window). Dose savings can be credited to use of shielding, ALARA controls, planning, and diligence. Site Projects, Radiation Protection, and Radiological Projects were the primary groups involved in the activity.

For more information about this project, contact Mike Fizzano of WVNS at 716/942-4905.

4.1.4 Use of Oxy-Gasoline Cutting Torch

The WVDP successfully used an oxy-gasoline torch in February 2001 to size reduce a challenging bridge crane structure as part of a decontamination project. The oxy-gasoline torch technology is considered to be a safer, faster, and less costly alternative to the common oxy-acetylene torch. WVNS engineers learned about the benefits of the oxy-gasoline torch technology by participating in the Fernald Environmental Management Project technology transfer program. Working closely with the product vendor, WVNS was able to have the original design of the oxy-gasoline torch modified to suit its specific needs.

The actual cutting time using the oxy-gasoline torch was about half of what mechanical means would take; however, setup time was nearly double. The biggest savings was in the radiation dose the operators received using this technology. The operators could stand in a 10 to 15 mR/hr general field versus the 50 to 80 mR/hr general field in the room where the cranes being size reduced were located. The dose estimate for traditional mechanical cutting was 1600 person-millirem. The actual dose received from the first crane (using the oxy-gasoline technology) was 113 person-millirem and less than 100 person-millirem for the second crane.

Exhibit 4-2:
WVDP operators used an oxy-gasoline torch to size reduce failed cranes in the Project's Process Mechanical Cell Crane Room. The work was completed from a room above the cell.

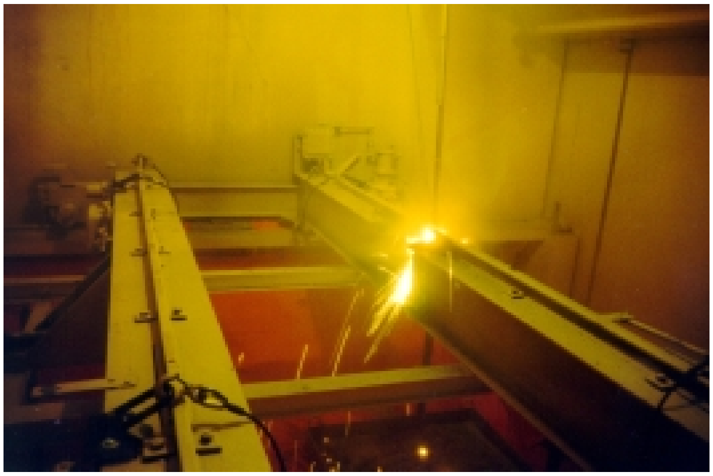


Photo Courtesy of WVNS.

To keep the operators out of the cut area, WVNS worked with a vendor to fabricate a 13-foot cutting torch, which could be inserted into the crane room from a room above it (see *Exhibit 4-2*). This was the first time the vendor had built a torch of this size. The general area dose rate in the cell was 50 mR/hr. Dose rates on the crane varied from 30 to 80 mR/hr with some hot spots of 650 mR/hr.

WVNS removed two cranes—each with a 2-ton capacity. The cranes weighed about 7 tons each and were 16 feet "rail to rail" and approximately 9 feet wide. Four cuts were made to each bridge—two through the end trucks, which took an hour each. The biggest cuts were through the main bridge girders. The girders consisted of two W14x38 beams welded together. Each of these cuts took about 2 hours.

Two key advantages of using the oxy-gasoline torch were: 1) the technology did not produce a significant amount of particulate material, so it was not necessary to install any type of local filtration system; the differential pressure was monitored across the main ventilation filters; and 2) the oxy-gasoline torch is not as gap-sensitive (operators could touch the object being cut with the torch or position the torch up to 1 inch away from the object and still cut it) as either acetylene or plasma arc, so WVNS was able to position the operators out of the cutting area and in a lower dose area to complete the work. The major benefit of using the torch was the significant reduction in dose to workers—1600 person-millirem versus 113 and 100 person-millirem for the first and second cranes, respectively.

Head-End Cell Engineering, D&D Operations, Safety and Emergency Management, and Radiation Protection were the primary groups involved in the activity.

For additional information about this project, contact Ken Schneider of WVNS at 716/942-4671.

4.2 Employee Involvement in Work Planning Reduces Dose at Hanford

Worker involvement in job planning has been an important aspect of implementation of Integrated Safety Management (ISM) at the Hanford site and has contributed significantly in dose reduction. Contributions to ALARA from workers often involve simple solutions that result in cost and radiation dose savings.

For additional information on all Hanford projects, contact Brenda Pangborn of Hanford at 509/372-3841.

4.2.1 River Corridor Project Workers Reduced a High Radiation Area by Almost 92 Percent

Approximately 10,000 square feet of floor space in the basement of the 327 Building was designated as a high radiation area (HRA). All personnel entries required a radiological control technician (RCT) escort and HRA control documentation. Barriers or fences were put up to reduce the size of the HRA area. This released the basement access points, which greatly reduced the HRA controls for personnel who enter the basement for routine tasks. Workers constructed much of the fencing in low dose areas, minimizing radiation exposure for the task. The barriers reduced the HRA by approximately 9,153 square feet. An estimated 400 person-mrem dose and $4,600 costs will be saved yearly because of the reduced HRA controls required to enter the basement area.

4.2.2 Workers Reduce Dose at the Plutonium Finishing Plant (PFP)

Radiation exposure management at PFP is increasingly challenging due to so many plutonium stabilization operations under way. The Fluor Hanford, Inc. RCTs developed and recommended to management new ways to reduce radiation exposure to workers and new approaches to provide ergonomic improvements. The aluminum device is called a "cradle" and holds radioactive material while workers measure radiation, reducing the handling of the radioactive material by the workers. It is used when containers of plutonium-bearing materials in the vault are removed, assayed, and tagged to show radiation readings. A neutron measuring device called a "snoopy", which requires a minute and a half to measure low-dose neutron in a can of material, is also placed on the cradle at two different measuring points – at contact and at 30 centimeters from the can of material. The cradle assures consistent placement of the radioactive material to the snoopy and significantly reduces both extremity and whole-body exposure for radiation workers. The RCTs also developed several temporary shielding applications to reduce gamma radiation. A lead shielded fabric bag was designed into which a can of material could be placed before moving. The bag is quick and easy to use and reduces gamma radiation to the worker by 90 percent. Dose rates from unused portions of gloveboxes were found to contribute significantly to the general area radiation levels. The gamma radiation dose rates are being reduced by more than 50 percent through installation of leaded fabric. Increased worker involvement in ALARA has saved a projected 2.4 person-rem per year to Thermal Operations Team personnel at PFP.

4.2.3 Worker Ideas to Use New Shielding Material and Improve Procedure Saves Estimated 2-3 Person-Rem/Year for Tank Sampling Operations

A team of CH2M HILL Hanford Group employees significantly reduced worker exposure during sampling of Hanford's underground tanks. Sampling on one of the site's most radioactive tanks, double shell Tank AZ-101, began in April 2000. Pulling the samples was a major challenge because of the high dose rates expected from the samples and more than 70 samples were needed from Tank AZ-101. A new approach was needed to provide workers with more protection.

Two RCTs pursued an idea they thought would reduce worker doses. The RCTs had seen an advertisement for a relatively new shielding material – leaded acrylic. While panes of thick leaded glass have been used throughout the world for decades to protect workers from radiation, heavy weight and high cost of the glass makes its use for temporary field applications impractical. Lead-filled "blankets" are used for field applications, but are bulky and obstruct line-of-sight operations. The leaded acrylic was lighter, transparent, and promised a 50 percent reduction in exposure. The RCTs worked with the operators to find a way to use the shielding in the glove bag design. The design placed a large piece of the acrylic shielding between the radioactive sample and the workers. Additional lead shielding was used at waist level where visibility was not a concern (see *Exhibit 4-3*).

To further reduce dose, the operators developed improved procedures to reduce the time it takes to transfer a sample from the glove bag to a leaded container for transportation to the analytical laboratory. A mock-up was used to train workers on the use of the new containment and the improved procedures.

Exhibit 4-3: New shielding.

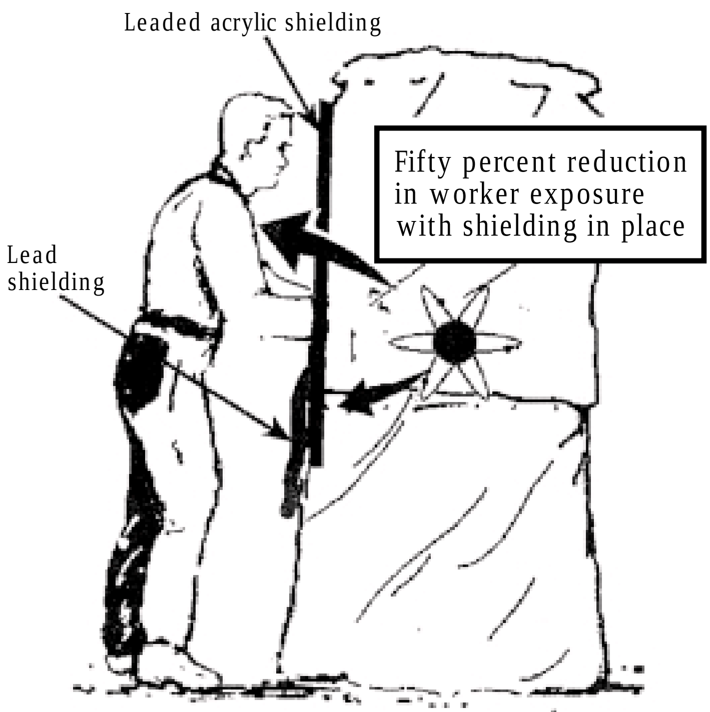


Figure Courtesy of Hanford.

4.2.4 Worker Input Into Re-design of Flow Control Valves Saves 3 Person-rem

In the Waste Technology Engineering Facility (324 Facility), personnel were receiving unnecessary doses while adjusting and replacing flow control valves on the Radiochemical Engineering Cell (REC) airlock cell doors. The flow control valves actuate each door by controlling the exhaust air, which controls the speed at which the doors open and close. The REC is a high-hazard work area, posted as an airborne radioactivity area, high radiation area, and high contamination area.

A Fluor-Hanford, Inc., mechanical engineer believed resizing the flow control valves might enhance the control of the cell doors. The engineer also suggested moving the flow control valves from inside the REC airlock, a high-hazard work area, to outside the REC airlock in the cask handling area, a low-hazard area. The engineer, with help from the cognizant engineer, designed a mock-up that represented the actual system as closely as possible. The mock-up proved that the flow control valves could be repositioned in the system and reduced in size for better door movement control. The modification to the valve design saves an estimated 3 person-rem over the life of the project.

4.2.5 Safe Transfer of Californium Enables More Analysis at 222-S Laboratories at Hanford

The successful transfer that replenished a radioactive source is enabling Fluor Hanford's Analytical Services 222-S Laboratory to meet requests for a wider range of analyses. During the transfer, expertise, good planning, and training were credited with dramatically reducing radiological dose.

The transfer replaced a decayed source of californium-252 with a fresh one prepared at the Oak Ridge National Laboratory. The transfer involved removing the new source from its transport cask, switching it with the old one in the irradiation chamber, and then transferring the old source to the transport cask for return to Oak Ridge. The decayed source was useful for some analyses, but the new one, 100 times stronger, enables a greater variety of analyses to be conducted.

The greatest challenge was to reduce radiological exposure. The californium source is smaller than a pencil, (see *Exhibit 4-4*) but requires a shipping cask three times the size of a human. Closed tubing and remote cable and magnet equipment were used to safely transfer the source between the shipping cask and the facility. Using techniques from the ALARA program, interdisciplinary planning and training resulted in workers being shielded at every step of the process.

The new californium-252 source has a radiological reading of 1,300 rem per hour at 30 centimeters. ALARA efforts resulted in a final collective dose of 70 millirem – a dramatic reduction to less than five one-thousands of 1 percent of the 1,300 rem per hour.

The first step was to review a videotape showing the old sources being placed more than 12 years ago. Comments were incorporated, along with shielding and dose calculations.

An improved method was created. It included facility development of a plastic shielding plug and transfer tubing for the cask, providing shielding while allowing totally remote source retrieval. Materials of either low neutron activation potential or short activation half lives were selected for the transfer equipment. The work team participated in several mockups and planning sessions to ensure the ALARA concepts could be implemented without adversely impacting job performance. An electronic portable area radiation monitoring system was used to remotely monitor movement of the source. This system was tested to ensure that everything worked properly. Then a "hot" mockup was performed in which new procedures and equipment were used to move the old sources to underground storage tubes. Before the new source arrived, a full-scale mockup was performed to ensure all members of the work team understood their parts of the operation.

The success of this project was due to engaging craft, radiological, and operations personnel from the start, in order to develop practical equipment and safe operating techniques. For example, a pipefitter from Fluor Hanford Laboratory Maintenance developed a special access port to the source transfer tube that allowed safe release of the source from the transfer cable end magnet. Another pipefitter developed the actual release technique. As a result, personnel access was only necessary when the sources were in the shielded conditions.

Exhibit 4-4:
Dummy californium capsule next to a dime.

Photo Courtesy of Hanford.

4.2.6 Pacific Northwest National Laboratory Radiological Engineering Reduces Extremity Dose by 57 Rem

Pacific Northwest National Laboratory (PNNL) is developing a plutonium immobilization form for excess weapons plutonium. As part of this project, PNNL is assessing the effects of radiation on the long-term stability of the ceramic form selected for immobilizing the plutonium. PNNL prepared both ^{239}Pu- and ^{238}Pu-forms of the selected ceramic form and each of its constituent ceramic phases. To assess the effects of radiation on the ceramics, laboratory personnel periodically monitor various properties such as geometry, density, and identity of the crystalline ceramic phases.

To calculate the geometric density, the mass and dimensions of the specimen are measured. The initial method used to measure the dimensions of the specimen involved excessive handling of the specimen. The specimen's height and diameter at several locations were measured using a micrometer. To reduce extremity dose and to increase the accuracy of measurement, PNNL designed and built a laser-based system to perform the measurements. The laser-based device uses two orthogonal (90˚ apart) laser curtains to simultaneously measure the height and diameter (or length and width) of the specimen. The specimen is placed on a rotating table and several thousand measurements made with every four averaged and recorded by a computer-based data acquisition system (see *Exhibit 4-5*). The specimen needs only to be handled as it is transferred from its storage container to the table and returned, dramatically reducing the dose to the extremities (48 person-rem for the duration of the project).

X-ray diffraction is used to monitor the identities and amount of crystalline phases in the ceramic. To protect workers from potential internal radiological exposure and to eliminate the need to locate the x-ray diffraction unit in a contamination area (CA), PNNL designed a special x-ray diffraction sample holder that provides sealed containment of both monolithic and powder specimens and provides for the recovery of the sample (see *Exhibit 4-6*). The x-ray diffraction sample holder provides effective containment of the sample, while providing an x-ray transparent window. Because the x-ray diffraction device is able to be used outside of a CA, the need for release surveys is eliminated and the time a worker must spend handling the highly radioactive specimens is reduced. The x-ray diffraction holder is estimated to reduce extremity dose by 9 person-rem over the duration of the project.

Exhibit 4-5:
Rotating Table with Measuring Lasers.

Photo Courtesy of PNNL.

Exhibit 4-6:
X-ray Diffraction Sample Holder with a Mounted Monolithic Specimen.

Photo Courtesy of PNNL.

4.2.7 Bio-barrier Prevents Spread of Contamination

Deep-rooted vegetation, such as the Russian thistle, an annual commonly known as tumbleweed, draws radioactive contamination from the soil up through the roots into the plant stem and flowers. When the plant dies, it breaks off at the stem and tumbles in the wind, spreading contamination as it travels. Additionally, animal and insect intrusion into waste sites spreads contamination.

A unique approach to stopping the spread of contamination through vegetation and wildlife is being tested by Fluor Hanford, Inc., in several places at the Hanford Site. Fabric is placed over the contamination area as shown in *Exhibit 4-7a*. This fabric, called *BioGuard II, is impregnated with a chemical substance that inhibits root growth. After the bio-barrier fabric is laid on the ground, it is covered with 6 inches of gravel as shown in *Exhibit 4-7b*, changing the area from a contamination or soil contamination area to an underground radioactive material area. With no vegetation, wildlife tends to stay out of the area. The fabric shield also impedes burrowing animals.

Because of the cost ($0.86/ft^2$), the bio-barrier is being used sparingly, only covering contaminated areas which have had recurring surface contamination problems. One such area was near the 241-ER-151 diversion box in the 200 East Area. The soil underground was contaminated from a prior leakage of the piping that was part of the old radioactive liquid waste cross-transfer lines. Contamination from underground was being repetitively brought to the surface by ants and deep-rooted vegetation.

The latest soil contamination area to be covered is on the edge of the inactive 216-Z-9 Crib, an underground liquid waste disposal site near the Plutonium Finishing Plant as shown in *Exhibit 4-7c*. Years ago, plutonium waste materials and low-level liquid waste were put into the 216-Z-9 Crib. Harvester ants and deep-rooted vegetation brought contamination up to the surface of the ground, creating a soil contamination area along the perimeter of the crib. Full remediation of the burial site will be expensive and is years away due to funding being allocated to higher priorities.

The bio-barrier is an interim approach to stopping the spread of contamination that will last for at least 15 years until the area can be permanently cleaned up. So far, the bio-barrier material has been very effective. There has been no indication of resurfacing of contamination in the areas where it has been applied.

*BioGuard II is a product of BioGuard Technologies, Inc.

Exhibit 4-7a:
BioGuard II being applied.

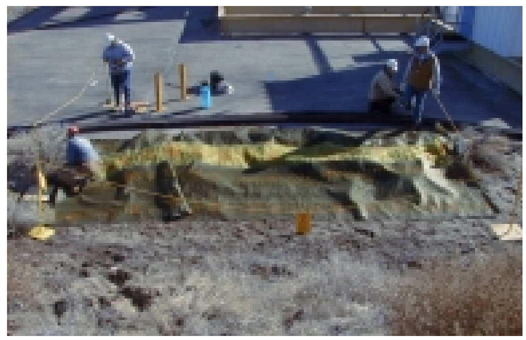


Exhibit 4-7b:
Gravel is applied to cover the fabric.

Exhibit 4-7c:
Finished application.

Photos Courtesy of Hanford.

4.3 ALARA Activities at the Savannah River Site

4.3.1 Robotics Use in Source Recovery at the Savannah River Site

The Department of Energy's Savannah River Site (SRS) in Aiken, South Carolina has a state-of-the art Instrument Calibration facility that supports calibration and repair of an inventory of approximately 8,000 portable radiological monitoring instruments. The Instrument Calibration facility began operations in 1996. The Low Scatter Irradiator (LSI) system is a key part of the facility. The LSI room is a shielded 40-foot by 40-foot by 40-foot room designed to minimize radiation scatter during calibrations and evaluations (See *Exhibit 4-8*). Aluminum floor grating with 1-inch spacing is part of the design to minimize scatter. A shielded source storage carousel is used to select calibration sources via a computer-controlled system. The carousel has eight source slots with seven sources used providing a selection of ^{60}Co, ^{137}Cs, and ^{252}Cf sources of different intensities. During calibrations, instruments are placed on four LSI tracks that move instruments to the proper distance from the source for the desired calibrated exposure rate. Sources are returned to the carousel using gravity with multiple interlocks and safeguards built into the system to ensure that the source has dropped before entry into the LSI after a source exposure. Two room radiation monitors provide a remote reading to the operator from the computer console as another indicator of the source status. Because of the design of the LSI it was assumed that a source could not become lodged in the transfer tube. That proved to be a false assumption when, in May 2000, a source did not return to its home position.

Exhibit 4-8:
The Low Scatter Irradiator Room.

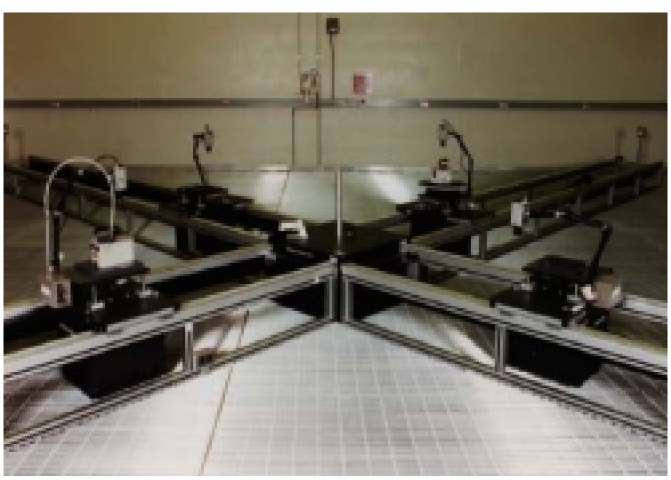


Photo Courtesy of Savannah River Site

Two LSI room radiation monitors located at different positions indicated radiation rates of around 7600 mR/hr and 1100 mR/hr respectively instead of the expected 0 mR/hr when a source has returned to its home position. Radiation rates from an LSI wall radiation monitor and from one underneath the floor grating at a distance of about 8 feet from the source were most consistent with those of a 100 curie ^{137}Cs source.

An ion chamber survey instrument (an Eberline RO-20) was placed on an instrument track. RO-20 results could then be used to establish rates at various positions on the track for comparisons with calibration data to determine the source identity. Exposure rate data observed continued to be consistent with that of the system's 100 curie ^{137}Cs.

Personnel entry into the room in the vicinity of the transfer tube was limited by the exposure rates (about 400 R/hr at 30 cms distance). Because of the aluminum floor grating's weight limitations (150 pounds per square inch), the use of sufficient shielding necessary to minimize exposures ALARA was not feasible or considered reasonable. To access the source, the transport tube setscrew and tube cap required removal. Remote handling of this activity was considered using robotics. The SRS Robotics group selected a remote controlled vehicle. The vehicle was outfitted with custom designed tooling including multiple cameras that would be supplemented by LSI room cameras already in place and cameras on the LSI tracks (See *Exhibit 4-9*).

The vehicle and its tooling were tested on mock-ups, and then were used to enter the LSI and inspect the source. With the cap removed, cameras were used for an inspection of the source to determine why it had jammed.

The source was then dislodged by using air pressure to accelerate the dummy source against the jammed source. This action resulted in knocking both sources into a receiver affixed to the robot arm. The receiver was then transported by the robot to the shielded cask placed at the LSI entranceway for inspection. The inspection confirmed that the setscrew used to secure the cap of the source rabbit was out of the rabbit and had been blown out with the source rabbit. The setscrew apparently had become lodged between the rabbit and the transfer tube preventing the source from returning to its home position.

In summary, all activities in support of the source recovery resulted in only 92-mrem whole body dose - a tribute to the planning involved and the use of robotics. All scenarios evaluated involving personnel entries in the vicinity of the transfer tube had potential high exposure projections that were compounded by restrictive time constraints necessary for room entries to minimize exposures. Shielding placement in sufficient quantities to minimize exposures ALARA would have been difficult due to LSI floor load limitations. Each key step was mocked up in advance, if possible, and then practiced. The robotics process allowed the job evolutions to proceed at a controlled and deliberate pace because work could be controlled from outside the LSI room. Room cameras allowed job steps to be videotaped for review. The success of the source recovery was a result of the planning and coordination among the radiological control staff, the instrument calibrations staff, and the SRS robotics group.

For additional information about this project contact: Athena D. Freeman, Site ALARA Coordinator; (803) 952-9938, e-mail: athena.freeman@srs.gov

Exhibit 4-9:
Remote device with custom tooling – setscrew removal device, cameras, and decapper for removal of transfer tube cap.

Photo Courtesy of Savannah River Site

4.3.2 Savannah River Site F-Area, FB-Line ALARA Initiatives

FB Line, located in F Area on top of F Canyon at SRS, historically converted plutonium-239 nitrate solution produced in F Canyon to a solid form. The facility also recycled plutonium scrap generated during facility operations and from off-site sources to purify and concentrate this material to a solid form. FB-Line stabilizes plutonium-bearing materials remaining from the SRS production era and from other DOE sites to a more stable, manageable form.

CAM upgrades

In FY01 FB-Line began a continuous air monitoring (CAM) upgrade program to improve detection capabilities and provide reductions in personnel exposure and waste generation. New CAMs will replace existing High Volume Air Monitors (HVAMs) and SRS Alpha CAMs in FB-Line. Configuration of the new CAMs will include both installed and portable units that provide better sensitivity to airborne radioactive material while reducing alarms attributed to Radon/Thoron. The new CAM installation will also reduce the number of retrospective air samplers (RAS) in FB-Line because the new CAM uses a filter paper as the collection medium. Based on preliminary testing and the new CAM performance, daily filter paper changes expect to be reduced (e.g., every other day, twice weekly) thus reducing dose and waste associated with entry into radiological areas.

Lead Jacket Use

FB-line has initiated a dose reduction program through the use of lead jackets for select work in the facility. The work assignments where lead jackets are used involve handling of higher dose rate materials (>100 mrem/hr at 30 cm). The lead jackets provide a dose reduction up to 90% for lower energy photons, which are routinely encountered in FB-Line. Because lead jackets are being used, this requires the use of special dosimetry assignment, which verifies the effectiveness of the lead jackets and provides an accurate dose assessment.

Camera Upgrades

FB-Line has permanently installed cameras in selected process areas to reduce personnel exposure and support waste reduction efforts. Prior to the use of cameras, workers were required to continuously enter the process area for alarm watch activities. Camera installations permit workers to perform alarm watch functions from a low dose area. Waste generation associated with entry into the process area is avoided. This has provided a 90% dose reduction of 4 to 5 man-rem/year for this activity.

Mock-Up

FB-Line has implemented facility mockup training that exposes facility personnel to the types of alarms which could be encountered in FB-Line, and allows the workers to demonstrate expected alarm responses. The mockup provides a platform to perform mentoring for targeted work groups and encourages teamwork among the facility personnel. Responses to recent abnormal situations in FB-Line (i.e., CAM alarms, glove rupture) have validated the mockup training process through increased radiological awareness and enhanced radiological worker performance.

For additional information about this project contact: Athena D. Freeman, Site ALARA Coordinator; (803) 952-9938, e-mail: athena.freeman@srs.gov

4.3.3 Containment Fabrication Facility at the Savannah River Site Provides a 320% Return on Investment

SRS uses standard glovebags to enclose contaminated material so workers do not have to wear protective clothing while working. When the size of the contaminated equipment does not allow use of the standard-sized containments/ glovebags, large containment huts are required. Workers must wear protective equipment while working in the contaminated areas. This generates more waste and requires more in-field labor for construction of the hut/containment.

SRS designed and built the Containment Fabrication Facility to provide customized glovebags/containments for contaminated material that wouldn't fit the standard glovebags. (See *Exhibit 4-10*.) This facility contains plastic sealers, sewing machines, and other equipment required for designing and manufacturing custom-made containments.

The facility saves $1 million and avoids 800 ft^3 low level waste and 210 ft^3 transuranic waste annually. Worker safety is improved by eliminating the need to work in contaminated areas.

Exhibit 4-10:
Containment Fabrication Facility

Photo Courtesy of Savannah River Site

Life Cycle Waste Reduction	
Life Cycle Waste Reduction	~300 m3
Operation Commencement Date	12/99
Project Useful Life (Years)	10 years

DOE Monetary Benefits	
Cost	$300,000
Lifecycle Savings	$10,000,000
Return on Investment	320 %

Benefits At-A-Glance

- Expedite in-field construction and reduce installation labor.
- Reduce job waste and associated cleanup waste and labor.
- Reduce risk to workers.

Containment Fabrication Facility Summary Data

ROI Priority Area:	New Waste Generation
ROI Project Type:	Source Reduction
Project Cost:	$300,000
Lifecycle Savings:	$10,000,000
Implementing Group:	EM, SRS Nuclear Materials Stabilization Division
Benefiting Group:	EM, SRS Site
Useful Life Years:	10 Years
Return On Investment:	320 %
Lifecycle Waste Reduction:	300 m3

For additional information about this project contact: Athena D. Freeman, Site ALARA Coordinator; (803) 952-9938, e-mail: athena.freeman@srs.gov

4.4 Innovations in Glovebox Size Reduction Minimize Risk and Maximize Production at Rocky Flats

As Rocky Flats Environmental Technology Site continues Decontamination and Decommissioning (D&D) activities, there has been increased interest in developing new techniques to improve worker safety, while still maintaining a rigorous production schedule. After a worker cut his hand resulting in an intake while size-reducing a glovebox using manual cutting tools in 1997, project managers actively pursued other methods to more safely conduct the work. Size reduction is the process of cutting up a glovebox into smaller pieces to reduce the total volume of the waste prior to disposal of the contaminated glovebox. The first concept was to size reduce the gloveboxes inside a large windowless metal box that controlled the airborne contamination by a high rate of air flow away from the workers. The workers operated standard manual cutting tools such as nibblers and band saws through the openings while they stood outside the windowless metal box. This metal box was given the name Inner Tent Chamber (ITC), since it was located inside of a soft-sided plastic containment, or tent.

Exhibit 4-11:
Outside of the ITC, Series 2, with the doors open at left.

Photo Courtesy of Rocky Flats.

Exhibits 4-11, 4-12, and 4-13 show the new and improved ITC ("Series 2") that is fully enclosed to virtually eliminate the airborne contamination outside the ITC, and which uses a plasma arc cutting torch instead of hand tools. The plasma arc torch is capable of cutting through 3 inches of stainless steel, is lightweight and ergonomically designed. The gloves in the ITC consist of a 30-mil glovebox glove with a plasma arc-approved leather glove on the outside. A standard waste box is contiguous with the ITC, so after the material is cut, it is passed by hand by workers through the gloves to the waste box. As the plasma arc torch cuts the glove box, a very fine particulate is produced, which is largely collected via a self-cleaning Torit™ dust collector prior to going through a HEPA filtration system.

The workers outside the ITC and inside the plastic containment wear flame-retardant Anti-C's and Powered Air Purifying Respirators, which have improved their efficiency over the previously-worn Level B garment and supplied air respirator. The contamination levels outside the ITC and inside the plastic containment have been maintained below 500 dpm/100 cm^2. A follow-on improvement is being built which will use remotely controlled arms to operate the plasma arc and load the cut pieces into the waste box, further reducing the opportunity for potential contamination and injury.

For more information about this project, contact Radiological Engineer Mr. Joe Bianconi, CHP, (303) 966-7262.

Exhibit 4-12:
ITC, Series 2, with the doors open. Gloveboxes to be size reduced are moved through these doors into the ITC. The soft-side containment, or tent, is clearly seen through the roll-up yellow door at top.

Photo Courtesy of Rocky Flats.

Exhibit 4-13:
ITC, Series 2, with a worker size reducing a glovebox with the plasma arc. The workers at far left appear blurred because they are standing outside the plastic tent.

Photo Courtesy of Rocky Flats.

4.5 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Worker Protection Policy and Programs. The submittal should describe the process in sufficient detail to provide a basic understanding of the project, the radiological concerns, and the activities initiated to reduce dose.

The submittal should address the following:

- mission statement,
- project description,
- radiological concerns,
- information on how the process implemented ALARA techniques in an innovative or unique manner,
- estimated dose avoided,
- project staff involved,
- approximate cost of the ALARA effort,
- impact on work processes, in person-hours if possible (may be negative or positive), and
- point-of-contact for follow-up by interested professionals.

4.6 Lessons Learned Process Improvement Team

In March 1994, the Deputy Assistant Secretary for Field Management established a DOE Lessons Learned Process Improvement Team (LLPIT). The purpose of the LLPIT is to develop a complex-wide program to standardize and facilitate identification, documentation, sharing, and use of lessons learned from actual operating experiences throughout the DOE complex. This information sharing and utilization is commonly termed "Lessons Learned" within the DOE community. The LLPIT has now transitioned into the DOE Society for Effective Lessons Learned Sharing.

The collected information is currently located on an Internet World Wide Web (Web) site as part of the Environmental Safety & Health (ES&H) Information Portal. This system allows for shared access to lessons learned across the DOE complex. The information available on the system complements existing reporting systems presently used within DOE. DOE is taking this approach to enhance those existing systems by providing a method to quickly share information among the field elements. Also, this approach goes beyond the typical occurrence reporting to identify good lessons learned. DOE uses the Web site to openly disseminate such information so that not only DOE but other entities will have a source of information to improve the health and safety aspects of operations at and within their facilities. Additional benefits include enhancing the work place environment and reducing the number of accidents and injuries.

The Web site contains several items that are related to health physics. Items range from off-normal occurrences to procedural and training issues. Documentation of occurrences includes the description of events, root-cause analysis, and corrective measures. Several of the larger sites have systems that are connected through this system. DOE organizations are encouraged to participate in this valuable effort.

The Web site address for DOE Lessons Learned is:

http://www.eh.doe.gov/ll

The specific Web site address may be subject to change. ES&H information services can be accessed through the main ES&H Information Portal at:

http://www.eh.doe.gov/portal

Conclusions

5.1 Conclusions

The collective dose at DOE facilities (as measured by the whole body external dose) has experienced a dramatic (87%) decrease since 1985. The main reasons for this large decrease were the shutdown of facilities within the weapons complex and the end of the Cold War era, which shifted the DOE mission from weapons production to shutdown, stabilization, and D&D activities. The DOE weapons production sites have continued to contribute the majority of the collective dose over these years. Sites reporting under the category of weapons fabrication and testing account for the highest collective dose. Even though these sites are now primarily involved in nuclear materials stabilization and waste management, they still report under this facility type. As facilities are shut down and undergo transition from operation to stabilization or D&D, there are significant changes in the opportunities for individuals to be exposed. More modest reductions in collective dose have occurred during the past 5 years at some facilities that have continued to transition to shutdown and stabilization.

The collective TEDE decreased 2% from 1999 to 2000 due to decreases in the collective dose at two of the six highest dose sites. These six sites accounted for 83% of the collective dose at DOE in 2000. Reports submitted by two of the sites that experienced decreases in the collective dose (Rocky Flats and Oak Ridge) indicate that decreases in the collective dose were due to: a reduction of source material and lowering of ambient dose rates at Rocky Flats, and a change in the biokinetic models used to determine internal dose from uranium intakes at the Oak Ridge Y-12 facility. LANL also reported a reduction in operational activities during corrective actions following the plutonium intake event. Statistical analysis reveals that the logarithmic mean TEDE in 2000 was 0.003 rem lower than in 1999, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose. The decrease in mean TEDE from 1998 to 2000 similarly indicates a lower dose per worker over the last three years, compared to 1996 and 1997.

The collective internal dose (CEDE) has increased for the sixth year in a row, with an increase of 70% between 1998 and 1999 and 18% between 1999 and 2000. Due to the increase in the collective CEDE and decrease in the number of internal depositions, the average measurable CEDE increased by 30% from 1999 to 2000 and is double the value for 1998. The primary reason for this increase was the three intakes of plutonium at LANL that were in excess of the 5 rem (50 mSv) DOE annual limit. Combined, these three internal doses account for 60% of the DOE-wide collective CEDE for the year. Due to several factors such as changes in internal dosimetry practices, monitoring and reporting procedures, changes in the dosimetry equipment, and the relatively small number of internal doses, care should be taken in examining trends in internal dose.

An analysis was performed on the transient workforce at DOE. A transient worker is defined as an individual monitored at more than one DOE site in a year. The results of this analysis show that the number of transient workers monitored has increased over the past 5 years, but decreased by 33% from 1999 to 2000. The collective dose for these transients decreased by 40%, resulting in an 18% decrease in the average measurable dose to transients. The average measurable dose to transient workers has been less than the average measurable dose for the overall DOE workforce for the past 5 years.

A pilot project to collect historical radiation dose records was conducted during 1999 and 2000. The objective of the project was to examine the feasibility of collecting historical data that had not previously been reported to the DOE radiation records repository. Twelve sites were involved in the voluntary pilot project where over 4 million records were reported and analyzed for inclusion into the repository. The results of the analysis indicate that 50% of the overall DOE collective dose prior to 1987 was collected from the twelve participating sites in this pilot study. The average career length for individuals with measurable external dose at these sites was 10.5 years, with an average measurable career dose of

1.4 rem (14 mSv). Due to the efficacy of the pilot project, DOE plans to expand the project to collect additional historical information where such information is available.

The detailed nature of the data available has made it possible to investigate distribution and trends in data and to identify and correlate parameters having an effect on occupational radiation exposure at DOE sites. This also revealed the limitations of available data, and identified additional data needed to correlate more definitively trends in occupational exposure to past and present activities at DOE sites. A summary of the findings for 2000 is shown in *Exhibit 5-1*.

Exhibit 5-1:
2000 Radiation Exposure Fact Sheet.

- ❖ The collective TEDE decreased by 2% from 1999 to 2000. Statistical analysis reveals that the logarithmic mean TEDE in 2000 was 0.003 rem lower than in 1999, reflecting both a decline in the dose to individual workers, and fewer individuals with measurable dose.
- ❖ The six highest dose sites (Rocky Flats, Hanford, Los Alamos, Savannah River, Oak Ridge, and Idaho) accounted for 83% of the collective dose at DOE in 2000.
- ❖ Decreases at two of the top six sites (Rocky Flats and Oak Ridge) indicate that decreases in the collective dose were due to a reduction of source material and lowering of ambient dose rates at Rocky Flats, and a change in the biokinetic models used to determine internal dose from uranium intakes at the Oak Ridge Y-12 facility. LANL also reported a reduction in operational activities during corrective actions following the plutonium intake event.
- ❖ The collective internal dose (CEDE) has increased for the sixth year in a row, with an increase of 70% between 1998 and 1999 and 18% between 1999 and 2000. The primary reason for this increase was the three intakes of plutonium at LANL that were in excess of the 5 rem (50 mSv) DOE annual limit. Combined, these three internal doses account for 60% of the DOE-wide collective CEDE for the year.
- ❖ The number of transient workers monitored has increased over the past 5 years, but decreased by 33% from 1999 to 2000. The collective dose for these transients decreased by 40%, resulting in a 18% decrease in the average measurable dose to transients.
- ❖ A pilot project to collect historical radiation dose records was conducted during 1999 and 2000. Fifty percent of the overall DOE collective dose prior to 1987 was collected from the twelve participating sites in this pilot study.

Glossary

Administrative Control Level (ACL)
A dose level that is established below the DOE dose limit in order to administratively control exposures. ACLs are multi-tiered, with increasing levels of authority required to approve a higher level of exposure.

ALARA
Acronym for "As Low As Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the workforce and the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process with the objective of attaining doses as far below the applicable limits as is reasonably achievable.

Annual Effective Dose Equivalent (AEDE)
The summation for all tissues and organs of the products of the dose equivalent calculated to be received by each tissue or organ during the specified year from all internal depositions multiplied by the appropriate weighting factor. Annual effective dose equivalent is expressed in units of rem.

Average Measurable Dose
Dose obtained by dividing the collective dose by the number of individuals who received a measurable dose. This is the average most commonly used in this and other reports when examining trends and comparing doses received by workers because it reflects the exclusion of those individuals receiving a less than measurable dose. Average measurable dose is calculated for TEDE, DDE, neutron dose, extremity dose, and other types of doses.

Collective Dose
The sum of the total annual effective dose equivalent or total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person–rem.

Committed Dose Equivalent (CDE) (H_T,50)
The dose equivalent calculated to be received by a tissue or organ over a 50–year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem.

Committed Effective Dose Equivalent (CEDE) (H_E,50)
The sum of the committed dose equivalents to various tissues in the body (H_T,50), each multiplied by the appropriate weighting factor (w_T)—i.e., $H_E,50 = \Sigma w_T H_T,50$. Committed effective dose equivalent is expressed in units of rem.

CR
CR is defined by the United Nations Scientific Committee on the Effects of Atomic Radiation as the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem to the collective dose.

Deep Dose Equivalent (DDE)
The dose equivalent derived from external radiation at a depth of 1 cm in tissue.

DOE Site
A geographic location operated under the authority of the Department of Energy. The DOE sites considered in this report are listed in Appendix A by Operations Office.

Effective Dose Equivalent (H_E)
The summation of the products of the dose equivalent received by specified tissues of the body (H_T) and the appropriate weighting factor (w_T)—i.e., $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem.

Exposure
As used in this report,'exposure' refers to individuals subjected to, or in the presence of, radioactive materials which may or may not result in occupational radiation dose.

Kruskall-Wallis Test
Uses a test statistic based on rank sums to determine whether two populations are significantly different.

Lens of the Eye Dose Equivalent (LDE)
The radiation dose for the lens of the eye is taken as the external equivalent at a tissue depth of 0.3 cm.

Logarithmic Mean
The mean calculated from log-transformed values.

Minimum Detectable Activity (MDA)
The smallest quantity of radioactive material or level of radiation that can be distinguished from background with a specified degree of confidence. Often used synonymously with minimum detection level (MDL) or lower limit of detection (LLD).

Non-parametric Procedures
Statistical tests that do not depend on a specific parent distribution.

Normal Log-transformed Data
Data that fits a normal distribution after it is transformed to logarithms.

Number of Individuals with Measurable Dose
The subset of all monitored individuals who receive a measurable dose (greater than limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable dose. For this reason, the number of individuals with measurable dose is presented in this report as a more accurate indicator of the exposed workforce. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

Occupational Dose
An individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

Pairwise T-tests
This test compares all possible pairs of means and uses a T-test to determine whether differences are significant.

Shallow Dose Equivalent (SDE)
The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

Statistical Normal Distribution
A distribution that is symmetric and can be described completely by the mean and variance. This property is required for many statistical tests.

Total Effective Dose Equivalent (TEDE)

The sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. Deep dose equivalent to the whole body is typically used as effective dose equivalent for external exposures. The internal dose component of TEDE changed from the Annual Effective Dose Equivalent (AEDE) to the Committed Effective Dose Equivalent (CEDE) in 1993.

Total Monitored Individuals

All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, visitors, and members of the public monitored during a visit to a DOE site. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

Transient Individual

An individual who is monitored at more than one DOE site during the calendar year.

T-test

A statistical test for comparing means from two populations based on the value of t, where

$t = \frac{\overline{y}_1 - \overline{y}_2}{S_{\overline{y}_1 - \overline{y}_2}}$ and $\overline{y}_1$ = sample mean, population 1

$\overline{y}_2$ = sample mean, population 2

$S_{\overline{y}_1 - \overline{y}_2}$ = standard deviation appropriate to the difference between the two means.

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References

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2. ICRP (International Commission on Radiological Protection), 1977. "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, Annals of the ICRP, Vol. 1, No. 3 (Pergamon Press, New York).

3. NCRP (National Council on Radiation Protection and Measurements), 1987. "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP 91; superceded by NCRP Report No. 116.

4. DOE (U.S. Department of Energy), December 21, 1988, Order 5480.11, Radiation Protection for Occupational Workers, Change 3, June 17, 1992.

5. DOE 1994. *Radiological Control Manual.* Revision 1, DOE/EH-0256T, Assistant Secretary for Environment, Safety and Health, April.

6. 10CFR Part 835. "Occupational Radiation Protection." Final Rule; DOE *Federal Register*, November 4, 1998.

7. DOE-STD-1098-99, "Radiological Control Standard," July 1999.

8. The Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988.

9. 10CFR 820. "Procedural Rules for DOE Nuclear Activities." August 17, 1993.

10. DOE Notice 441.1, "Radiological Protection for DOE Activities," September 29, 1995.

11. DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 24, 1981, Change 7, October 17, 1990.

12. DOE M 231.1-1, "Environment, Safety and Health Reporting," September 10, 1995. Revised November 7, 1996. Revised January 28, 2000.

13. Munson, L.H. et al., 1988. *Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable (ALARA)*, PNL-6577, Pacific Northwest Lab.

14. United Nations, *Report of the Scientific Committee on the Effects of Atomic Radiation*, General Assembly of Official Records, United Nations, New York, 1993.

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Appendix A

A

DOE Reporting Sites and Reporting Codes

DOE Reporting Sites and Reporting Codes

A.1 Labor Categories and Occupation Codes

The following is a list of the Occupation Codes that are reported with each individual's dose record to the DOE Radiation Exposure Monitoring System (REMS) in accordance with DOE Manual 231.1-1 [12]. Occupation Codes are grouped into Labor Categories for the purposes of analysis and summary in this report. The occupation codes are listed in DOE M 231.1-1, Appendix G, Table 2 and represent a subset of the occupations listed in the Department of Commerce's Standard Occupational Classification (SOC) Manual (1980).

Exhibit A-1.
Labor Categories and Occupation Codes.

Labor Category	Occupation Code	Occupation Name
Agriculture	*0562*	*Groundskeepers*
	0570	*Forest Workers*
	0580	*Misc. Agriculture*
Construction	*0610*	*Mechanics/Repairers*
	0641	*Masons*
	0642	*Carpenters*
	0643	*Electricians*
	0644	*Painters*
	0645	*Pipe Fitter*
	0650	*Miners/Drillers*
	0660	*Misc. Repair/Construction*
Laborers	*0850*	*Handlers/Laborers/Helpers*
Management	*0110*	*Manager - Administrator*
	0400	*Sales*
	0450	*Admin. Support and Clerical*
Misc.	*0910*	*Military*
	0990	*Miscellaneous*
Production	*0681*	*Machinists*
	0682	*Sheet Metal Workers*
	0690	*Operators, Plant/ System/Utility*
	0710	*Machine Setup/Operators*
	0771	*Welders and Solderers*
	0780	*Misc. Precision/Production*
Scientists	*0160*	*Engineer*
	0170	*Scientist*
	0184	*Health Physicist*
	0200	*Misc. Professional*
	0260	*Doctors and Nurses*
Service	*0512*	*Firefighters*
	0513	*Security Guards*
	0521	*Food Service Employees*
	0524	*Janitors*
	0525	*Misc. Service*
Technicians	*0350*	*Technicians*
	0360	*Health Technicians*
	0370	*Engineering Technicians*
	0380	*Science Technicians*
	0383	*Radiation Monitors/Techs.*
	0390	*Misc. Technicians*
Transport	*0820*	*Truck Drivers*
	0821	*Bus Drivers*
	0825	*Pilots*
	0830	*Equipment Operators*
	0840	*Misc. Transport*
Unknown	*0001*	*Unknown*

A.2 Organizations Reporting to DOE REMS, 1996-2000

The following is a listing of all organizations reporting to the DOE REMS from 1996 to 2000. The Operations Office and Site groupings used in this report are shown in addition to the organization reporting code and name.

Exhibit A-2.
Organizations Reporting to DOE REMS, 1996-2000.

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported *				
				'96	'97	'98	'99	'00
Albuquerque	Ops. and Other Facilities	0501001	Albuquerque Field Office	●	●	●	●	●
		0501006	Albuquerque Office Subs	●				
		0502009	Albuquerque Transportation Division	●	●	●	●	●
		0530001	Kansas City Area Office	●	●	●	●	●
		0531002	Honeywell Federal Manufacturing Tech.	●	●	●	●	●
		0553002	Martin Marietta Specialty Components Inc.	●	●			
		0590001	Waste Isolation Pilot Project (WIPP)	●	●	●	●	●
		0593001	Carlsbad Area Office		●			
		0593004	Carlsbad Area Miscellaneous Contractors	●	●	●	●	●
		2806003	National Renewable Energy Lab (NREL) - GO	●	●	●	●	●
	Grand Junction	0560605	MACTEC - ERS			●	●	●
		0560704	WASTREN				●	●
	Los Alamos National Lab. (LANL)	0540001	Los Alamos Area Office	●	●	●	●	●
		0544003	Los Alamos National Laboratory	●	●	●	●	●
		0544809	Protection Technologies Los Alamos	●	●	●	●	●
		0544904	Johnson Controls, Inc.	●	●	●	●	●
	Pantex Plant (PP)	0510001	Amarillo Area Office	●	●	●	●	●
		0514004	Battelle - Pantex	●	●	●	●	
		0515002	Mason & Hanger - Amarillo	●	●	●	●	●
		0515009	M&H - Amarillo - Security Forces			●	●	●
	Sandia National Lab. (SNL)	0570001	Kirtland Area Office	●	●	●		●
		0575003	Inhalation Toxicology Research	●				
		0578003	Sandia National Laboratory	●	●	●	●	●
	Uranium Mill Tailings Remedial	0582004	MK-Ferguson Subs - UMTRA	●	●			
	Action (UMTRA) Project	0582005	MK-Ferguson Co. - UMTRA	●	●			
Chicago	Ops. and Other Facilities	1000503	Ames Laboratory (Iowa State)	●	●	●	●	●
		1000903	Battelle Memorial Institute - Columbus (Old)	●				
		1001501	Chicago Field Office	●	●	●	●	●
		1001606	Chicago Office Subs				●	●
		1002001	Environmental Meas. Lab. - Research	●	●	●	●	●
		1004031	New Brunswick Laboratory - Research	●	●	●	●	●
		1005003	Princeton Plasma Physics Laboratory	●	●	●	●	●
	Argonne Nat'l Lab. - East (ANL-E)	1000703	Argonne National Laboratory - East	●	●	●	●	●
	Argonne Nat'l Lab. - West (ANL-W)	1000713	Argonne National Laboratory - West	●	●	●	●	●
	Brookhaven Nat'l Lab. (BNL)	1001003	Brookhaven National Laboratory	●	●	●	●	●
	Fermi Nat'l. Accelerator Lab.(FERMI)	1002503	Fermilab	●	●	●	●	●
DOE HQ	DOE Headquarters	1504001	DOE Headquarters	●	●	●	●	●
	N. Korea Project	8009001	DOE North Korea Project	●	●	●		
		8009104	CenTech 21 - North Korea	●	●			
		8009204	Nuclear Assurance Corp. (NAC)	●	●			
		8009304	Pacific Northwest Lab. - Korea	●	●			
		8009401	U.S. Dept. of State - North Korea	●	●			
	Kazakhstan	8010001	DOE Kazakhstan Project				●	

Exhibit A-2.
Organizations Reporting to DOE REMS, 1996-2000. (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported *				
				'96	'97	'98	'99	'00
Idaho	Idaho Site	3000504	Chem-Nuclear Geotech	●				
		3003402	Babcock & Wilcox Idaho, Inc.	●	●	●		
		3004001	Idaho Field Office	●	●	●	●	●
		3004004	Idaho Office Subs	●	●			
		3005004	Bechtel BWXT Idaho, LLC - Services	●	●	●	●	●
		3005005	Lockheed Martin Idaho Tech. Co. - Construction	●	●			
		3005016	Bechtel BWXT Idaho, LLC - Subs - Construction		●	●	●	●
		3005024	LMITCO Subcontractor - Coleman		●	●		
		3005034	LMITCO Subcontractor - Parsons		●	●		
		3005505	MK-Ferguson Company - ID		●			
Nevada	Nevada Test Site (NTS)	3500000	Nevada Operations		●	●	●	●
		3501104	Bechtel Nevada - Amador Valley			●		
		3501304	Bechtel Nevada - Los Alamos			●		
		3501405	Bechtel Nevada - NTS		●	●	●	●
		3501416	Bechtel Nevada - NTS Subcontractors		●	●	●	●
		3501503	Bechtel Nevada - Special Technologies Labs			●	●	●
		3501604	Bechtel Nevada - Washington Aerial Meas.			●		
		3502004	Computer Sciences Corporation		●	●		
		3502504	EG&G Kirtland		●			
		3502804	EG&G Special Technologies Laboratories	●	●			
		3503004	EG&G Las Vegas	●				
		3504504	EG&G Santa Barbara	●	●	●		
		3506004	Raytheon Services - Nevada	●		●		
		3506024	Raytheon Services Subcontractors	●				
		3507501	Nevada Field Office	●	●	●	●	
		3507514	Nevada Miscellaneous Contractors	●	●	●	●	●
		3507521	Air Resources Laboratory			●		
		3507531	Defense Nuclear Agency - Kirtland AFB	●	●	●	●	
		3507551	Environmental Protection Agency (NERC)	●	●	●		
		3508004	Nye County Sheriff		●	●	●	●
		3508504	Bechtel Nevada Services	●	●			
		3508505	Bechtel Nevada - NTS	●	●	●		
		3508703	Science Applications Int'l. Corp. - NV	●	●	●	●	●
		3509009	Wackenhut Services, Inc. - NV	●	●	●	●	●
		3509504	Westinghouse Electric Corp. - NV	●	●	●		
Oak Ridge	Ops. and Other Facilities	4004203	Oak Ridge Inst. for Science & Educ. (ORISE)	●	●	●	●	●
		4004501	Oak Ridge Field Office	●	●	●	●	●
		4004704	Bechtel National, Inc. - (FUSRAP)	●	●			
		4009006	Morrison-Knudsen (WSSRAP)	●	●	●	●	●
		4009503	Thomas Jefferson National Accel. Facility	●	●	●	●	●
		4542005	RMI Company	●	●	●	●	
	Oak Ridge Site	4005105	Lockheed Martin/MK-Ferguson Co.	●				
		4005505	LMES/MK - Ferguson Subcontractors		●	●	●	
		4006002	Bechtel-Jacobs Co., LLC – ETTP	●	●	●	●	●
		4006007	Decontam. & Recovery Services (DRS) (K-25)			●		
		4006302	British Nuclear Fuels Limited (BNFL) (ETTP)			●	●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1996-2000. (continued).

Operations/ Field Office		Organization Code	Organization Name	Year Reported *				
				'96	'97	'98	'99	'00
Oak Ridge	Oak Ridge Site	4006406	Decontamination & Recovery Services-ETTP				●	●
		4006503	UT-Battelle - ORNL	●	●	●	●	●
		4006510	Bechtel Jacobs - ORNL					●
		4007509	Wackenhut Services					●
		4008002	BWXT Y-12, LLC	●	●	●	●	●
		4008010	Bechtel-Jacobs - Y-12					●
	Paducah Gas. Diff. Plant (PGDP)	4007002	Bechtel-Jacobs Co., LLC – Paducah	●	●	●	●	●
	Portsmouth Gaseous Diff. Plant (PORTS)	4002501	LMES Portsmouth	●				
		4002502	Bechtel-Jacobs (Portsmouth)	●		●	●	●
Oakland	Ops. and Other Facilities	8001003	Boeing, Rocketdyne - ETEC	●	●	●	●	●
		8006103	U. of Cal./Davis, Radiobiology Lab. - LEHR	●	●	●	●	●
		8006303	U. of Cal./SF - Lab of Radiobiology	●				
	Lawrence Berkeley Nat'l. Lab. (LBNL)	8003003	Lawrence Berkeley National Laboratory	●	●	●	●	●
	Lawrence Livermore Nat'l. Lab. (LLNL)	8004003	Lawrence Livermore National Laboratory	●	●	●	●	●
		8004004	LLNL Subcontractors		●	●		
		8004009	LLNL Security	●	●	●		
		8004024	LLNL Plant Services	●	●			
	Stanford Linear Acc. Center (SLAC)	8008003	Stanford Linear Accelerator Center	●	●	●	●	●
Ohio	Ops. and Other Facilities	4500001	Ohio Field Office	●	●	●	●	●
		4510001	Miamisburg Area Office	●	●	●	●	●
		4510006	Miamisburg Office Subs	●	●	●	●	●
		4517003	Battelle Memorial Institute - Columbus	●	●	●	●	●
	Fernald Environmental	4521001	Fernald Area Office	●	●	●	●	●
		4521004	Fernald Office Service Subcontractors		●	●	●	●
		4523702	Fernald Envir. Rest. Mgmt. Corp (FERMCO)	●	●	●	●	●
		4523704	FERMCO Service Vendors				●	●
		4523706	FERMCO Subcontractors	●	●	●	●	●
	Mound Plant	4516002	BWX Technologies, Inc.	●	●	●	●	●
		4516004	BWX Technologies, Inc. - Subcontractors	●	●	●	●	●
		4516009	BWX Technologies, Inc. - Security Forces	●	●	●	●	●
	West Valley Project	4530001	West Valley Area Office	●				
		4539004	West Valley Nuclear Services, Inc. (WVNS)	●	●	●	●	●
		4542005	Earthline Technologies					●
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	7700001	Rocky Flats Office	●	●	●	●	●
		7700007	Rocky Flats Office Subs	●	●	●		
		7707002	Rocky Flats Prime Contractors	●	●	●	●	●
		7707004	Rocky Flats Subcontractors	●	●	●	●	●
		4707104	CH2M Hill Hanford Group					●
Richland	Hanford Site	7500503	Battelle Memorial Institute (PNL)	●	●	●	●	●
		7500705	Bechtel Power Co.	●	●	●	●	●
		7501004	Boeing Computer Services	●				
		7502504	Hanford Environmental Health Foundation	●	●	●	●	●
		7503005	Kaiser Engineers Hanford - Cost Const.	●	●		●	
		7505004	Fluor Daniel - Hanford	●	●	●	●	●
		7505005	Fluor Daniel Northwest	●	●	●	●	●
		7505006	Fluor Daniel Northwest Services	●	●	●	●	●
		7505012	Babcock Wilcox Hanford	●	●	●	●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1996-2000. (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported * '96	'97	'98	'99	'00
Richland	Hanford Site	7505013	Babcock Wilcox Protection, Inc.	●	●	●	●	
		7505024	Rust Services Hanford	●	●	●	●	●
		7505025	Rust Federal Services Northwest	●	●	●	●	●
		7505034	Duke Engineering Services Hanford	●	●	●	●	●
		7505035	Duke Engineering & Services Northwest, Inc.	●	●	●	●	●
		7505044	NUMATEC Hanford	●	●	●	●	●
		7505054	Lockheed Martin Hanford	●	●	●	●	
		7505055	Lockheed Martin Services, Inc.	●	●	●	●	●
		7505064	Dyncorp Hanford	●	●	●	●	●
		7505075	SGN Eurisys Services Corp.	●	●		●	●
		7505099	Hanford Security				●	●
		7506001	Richland Field Office	●	●		●	●
		7508805	US Corps of Engineers - RL	●	●			
		7509004	Westinghouse Hanford Services	●	●			
		7509104	Verizon/Qwest	●	●	●	●	●
Savannah River	Savannah River Site (SRS)	8500505	Bechtel Construction - SR	●	●	●	●	●
		8501002	Westinghouse Savannah River Co.	●	●	●	●	●
		8501004	Service America	●	●			
		8501014	Westinghouse S.R. Subcontractors	●	●	●	●	●
		8501024	Diversco	●				
		8503001	S.R. Army Corps of Engineers	●	●	●		
		8505001	S.R. Forest Station	●				
		8505501	Savannah River Field Office	●	●	●	●	●
		8507004	Miscellaneous DOE Contractors - SR	●	●	●	●	●
		8507504	Southern Bell Tel. & Tel.	●	●			
		8509003	Univ. of Georgia Ecology Laboratories	●	●	●	●	●
		8509509	Wackenhut Services, Inc. - SR	●	●	●	●	●

Not included in this report (see Appendix D)

Operations/ Field Office	Site	Organization Code	Organization Name	'96	'97	'98	'99	'00
Pittsburgh Naval Reactor Office	Pittsburgh Naval Reactor Office	6007001	Pittsburgh N.R. Office					
		6007504	Bechtel Plant Apparatus Division					
		6008003	Westinghouse Electric (BAPL)					
		6009003	Westinghouse Electric (NRF)					
Schenectady Naval Reactor Office	Schenectady Naval Reactor Office	6009014	Newport News Reactor Services					
		9004003	LM-KAPL - Kesselring					
		9004005	Gen. Dynam. - Kesselring - Electric Boat					
		9005003	LM-KAPL - Knolls					
		9005004	LM-KAPL - Knolls Subs					
		9007003	LM-KAPL - Windsor					
		9007005	LM-KAPL - Windsor - Electric Boat					
		9009001	Schenectady N.R. Office					

* Those organizations no longer reporting radiation exposure information have either ceased operations requiring the monitoring and reporting of radiation records, are no longer under contract or subcontract at the DOE facility, or have changed organization codes or the name of the organization.

A.3 Facility Type Codes

The following is the list of facility type codes reported to REMS in accordance with DOE Manual 231.1-1 [12]. A facility type code is reported with each individual's dose record indicating the facility type where the majority of the individual's dose was accrued during the monitoring year.

Exhibit A-3. Facility Type Codes.

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

See complete Facility Type descriptions shown in Appendix C.

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Appendix B

B

Additional Data

Page

B-1a: Operations Office/Site Dose Data (1998)

Operations/ Field Office	Site	1998 Collective TEDE (person-rem)	Percent Change from 1997	Number with Meas. Dose	Percent Change from 1997	Avg. Meas. TEDE (rem)	Percent Change from 1997	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1997
Albuquerque	Ops. and Other Facilities	0.2	-57% ▼	11	-56% ▼	0.019	-3% ▼	0%	
	Los Alamos National Lab. (LANL)	167.6	-13% ▼	1,916	-18% ▼	0.087	6% ▲	38%	-6% ▼
	Pantex Plant (PP)	17.2	56% ▲	312	46% ▲	0.055	6% ▲	8%	8% ▲
	Sandia National Lab. (SNL)	9.5	-2% ▼	181	-8% ▼	0.053	6% ▲	42%	6% ▲
	Uranium Mill Tailings Remedial Action (UMTRA) Project*								
	Grand Junction	38.9		295		0.132		17%	17% ▲
Chicago	Ops. and Other Facilities	1.2	-64% ▼	44	-58% ▼	0.028	-14% ▼	0%	
	Argonne National Lab. - East (ANL-E)	17.7	-7% ▼	182	-24% ▼	0.097	22% ▲	22%	1% ▲
	Argonne National Lab. - West (ANL-W)	21.7	15% ▲	236	-5% ▼	0.092	21% ▲	5%	2% ▲
	Brookhaven National Lab. (BNL)	63.0	-9% ▼	1,055	-28% ▼	0.060	27% ▲	20%	6% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.8	-49% ▼	441	-49% ▼	0.029	0%	0%	-5% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	0.0	-86% ▼	2	-60% ▼	0.014	-66% ▼	0%	
	North Korea Project	5.4	-34% ▼	14	-42% ▼	**0.388**	13% ▲	64%	-7% ▼
	Kazakhstan	0.4		13		0.031		0%	
Idaho	Idaho Site	64.9	-44% ▼	743	-35% ▼	0.087	-14% ▼	12%	-13% ▼
Nevada	Nevada Test Site (NTS)	1.0	-26% ▼	13	-48% ▼	0.077	43% ▲	0%	
Oakland	Ops. and Other Facilities	1.0	-28% ▼	45	-10% ▼	0.023	-20% ▼	0%	
	Lawrence Berkeley National Lab. (LBNL)	2.9	-45% ▼	76	-41% ▼	0.038	-7% ▼	0%	
	Lawrence Livermore National Lab. (LLNL)	6.9	-69% ▼	107	-44% ▼	0.065	-44% ▼	36%	-13% ▼
	Stanford Linear Accelerator Center (SLAC)	13.1	-7% ▼	157	34% ▲	0.084	-31% ▼	0%	-17% ▼
Oak Ridge	Ops. and Other Facilities	3.8	-42% ▼	195	44% ▲	0.020	-60% ▼	0%	-25% ▼
	Oak Ridge Site	102.7	32% ▲	2,187	36% ▲	0.047	-2% ▼	28%	14% ▲
	Paducah Gaseous Diff. Plant (PGDP)	5.3	113% ▲	68	89% ▲	0.078	13% ▲	0%	
	Portsmouth Gaseous Diff. Plant (PORTS)	0.2	2% ▲	15	**400%** ▲	0.016	-80% ▼	0%	
Ohio	Ops. and Other Facilities	24.1	**1,951%** ▲	78	152% ▲	0.310	**715%** ▲	**68%**	**68%** ▲
	Fernald Environmental Mgmt. Project	13.3	-27% ▼	559	8% ▲	0.024	-33% ▼	0%	-3% ▼
	Mound Plant	1.3	-78% ▼	106	-46% ▼	0.012	-59% ▼	0%	
	West Valley Project	18.2	162% ▲	260	49% ▲	0.070	76% ▲	4%	-4% ▼
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**348.1**	8% ▲	**3,298**	3% ▲	0.106	4% ▲	20%	6% ▲
Richland	Hanford Site	180.9	-23% ▼	1,772	-14% ▼	0.102	-11% ▼	18%	-19% ▼
Savannah River	Savannah River Site (SRS)	165.5	0%	3,163	-5% ▼	0.052	5% ▲	13%	1% ▲
Totals		**1,309.1**	**-4%** ▼	**17,544**	**-6%** ▼	**0.075**	**2%** ▲	**21%**	**-2%** ▼

* Ceased operations requiring monitoring as of 1/1/98.
Note: Boxed values indicate the greatest value in each column.

B-1b: Operations Office/Site Dose Data (1999)

Operations/ Field Office	Site	1999							
		Collective TEDE (person-rem)	Percent Change from 1998	Number with Meas. Dose	Percent Change from 1998	Avg. Meas. TEDE (rem)	Percent Change from 1998	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1998
Albuquerque	Ops. and Other Facilities	0.4	97% ▲	26	**136%** ▲	0.016	-17% ▼	0%	0%
	Los Alamos National Lab. (LANL)	131.0	-22% ▼	1,479	-23% ▼	0.089	1% ▲	39%	1% ▲
	Pantex Plant (PP)	29.3	70% ▲	353	13% ▲	0.083	50% ▲	11%	3% ▲
	Sandia National Lab. (SNL)	6.4	-33% ▼	120	-34% ▼	0.053	1% ▲	18%	-23% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project *								
	Grand Junction	2.5	-94% ▼	48	-84% ▼	0.052	-60% ▼	0%	-17% ▼
Chicago	Ops. and Other Facilities	1.5	20% ▲	82	86% ▲	0.018	-35% ▼	0%	0%
	Argonne National Lab. - East (ANL-E)	24.6	39% ▲	187	3% ▲	0.131	35% ▲	42%	**20%** ▲
	Argonne National Lab. - West (ANL-W)	26.7	23% ▲	299	27% ▲	0.089	-3% ▼	3%	-3% ▼
	Brookhaven National Lab. (BNL)	23.4	-63% ▼	521	-51% ▼	0.045	-25% ▼	6%	-14% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	8.7	-32% ▼	227	-49% ▼	0.039	33% ▲	14%	14% ▲
DOE HQ	DOE Headquarters (includes DNFSB)	0.0	-18% ▼	4	100% ▲	0.006	-59% ▼	0%	0%
	North Korea Project		-100% ▼					0%	0%
	Kazakhstan	0.1	-78% ▼	3	-77% ▼	0.030	-4% ▼	0%	0%
Idaho	Idaho Site	48.3	-26% ▼	729	-2% ▼	0.066	-24% ▼	5%	-7% ▼
Nevada	Nevada Test Site (NTS)	0.4	-55% ▼	6	-54% ▼	0.075	-3% ▼	0%	0%
Oakland	Ops. and Other Facilities	1.0	-1% ▼	85	89% ▲	0.012	-47% ▼	0%	0%
	Lawrence Berkeley National Lab. (LBNL)	1.8	-37% ▼	46	-39% ▼	0.040	3% ▲	0%	0%
	Lawrence Livermore National Lab. (LLNL)	14.9	**116%** ▲	137	28% ▲	0.109	69% ▲	36%	0%
	Stanford Linear Accelerator Center (SLAC)	10.2	-22% ▼	104	-34% ▼	0.098	17% ▲	11%	11% ▲
Oak Ridge	Ops. and Other Facilities	2.4	-37% ▼	109	-44% ▼	0.022	12% ▲	0%	0%
	Oak Ridge Site	202.2	97% ▲	2,493	14% ▲	0.081	**73%** ▲	38%	10% ▲
	Paducah Gaseous Diff. Plant (PGDP)	4.3	-18% ▼	58	-15% ▼	0.075	-4% ▼	0%	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	0.5	113% ▲	25	67% ▲	0.021	28% ▲	0%	0%
Ohio	Ops. and Other Facilities	31.6	31% ▲	104	33% ▲	**0.304**	-2% ▼	**72%**	4% ▲
	Fernald Environmental Mgmt. Project	15.1	13% ▲	458	-18% ▼	0.033	38% ▲	0%	0%
	Mound Plant	2.7	115% ▲	197	86% ▲	0.014	16% ▲	0%	0%
	West Valley Project	12.5	-31% ▼	243	-7% ▼	0.052	-26% ▼	0%	-4% ▼
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**373.9**	7% ▲	**3,517**	7% ▲	0.106	1% ▲	28%	8% ▲
Richland	Hanford Site	182.0	1% ▲	2,013	14% ▲	0.090	-11% ▼	35%	17% ▲
Savannah River	Savannah River Site (SRS)	136.5	-18% ▼	2,995	-5% ▼	0.046	-13% ▼	10%	-3% ▼
Totals		**1,295.2**	**-1%** ▼	**16,668**	**-5%** ▼	**0.078**	**4%** ▲	**28%**	**7%** ▲

* Ceased operations requiring monitoring as of 1/1/98.
Note: Boxed values indicate the greatest value in each column.

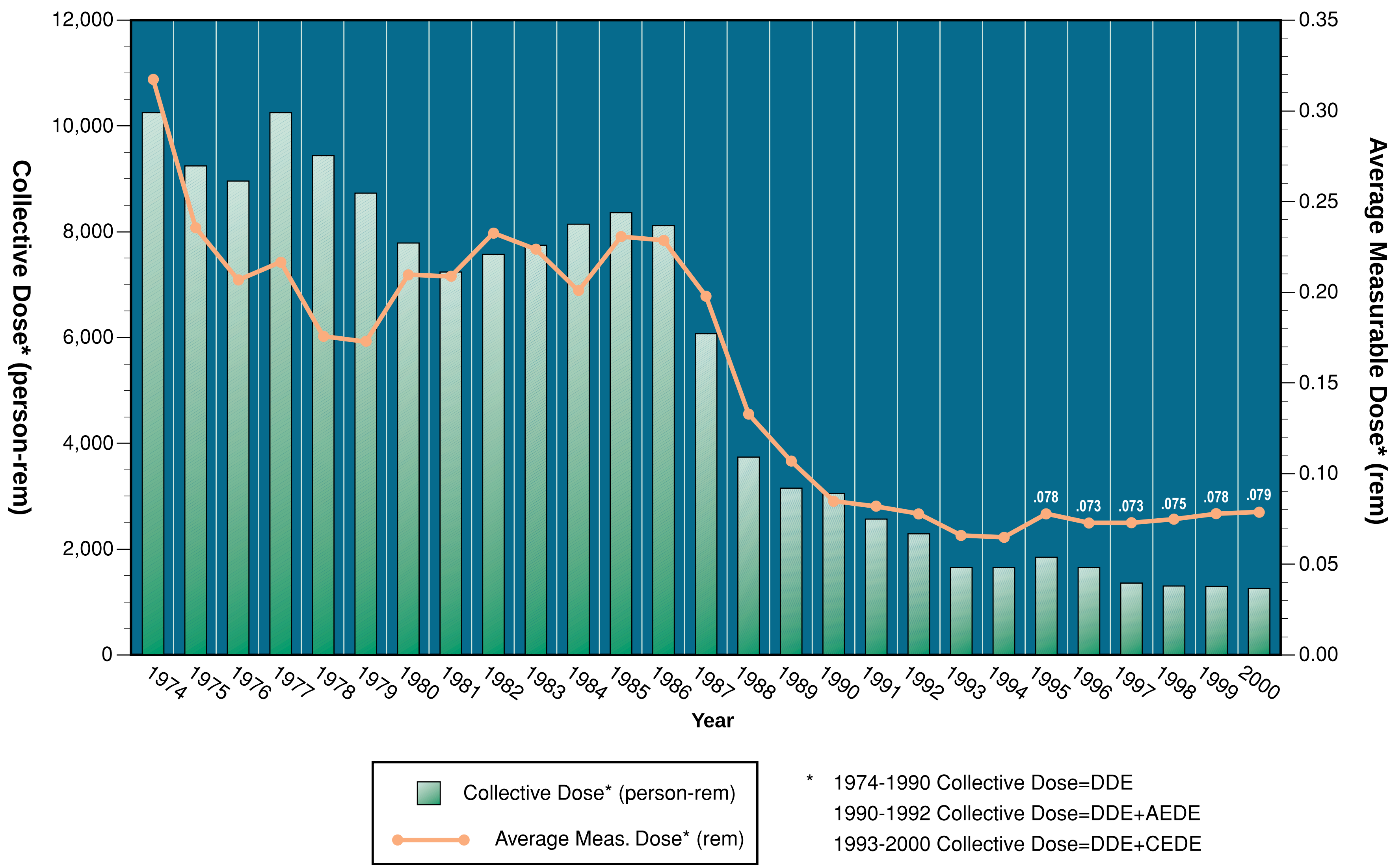
B-1c: Operations Office/Site Dose Data (2000)

Operations/ Field Office	Site	2000 Collective TEDE (person-rem)	Percent Change from 1999	Number with Meas. Dose	Percent Change from 1999	Avg. Meas. TEDE (rem)	Percent Change from 1999	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1999
Albuquerque	Ops. and Other Facilities	0.3	-35% ▼	38	46% ▲	0.007	-55% ▼	0%	0%
	Los Alamos National Lab. (LANL)	195.5	49% ▲	1,365	-8% ▼	**0.143**	62% ▲	**64%**	**25%** ▲
	Pantex Plant (PP)	35.0	19% ▲	277	-22% ▼	0.126	52% ▲	30%	19% ▲
	Sandia National Lab. (SNL)	7.6	19% ▲	105	-13% ▼	0.072	36% ▲	9%	-9% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project							0%	0%
	Grand Junction	0.1	-97% ▼	6	-88% ▼	0.012	-78% ▼	0%	0%
Chicago	Ops. and Other Facilities	3.5	141% ▲	108	32% ▲	0.033	**83%** ▲	0%	0%
	Argonne National Lab. - East (ANL-E)	17.2	-30% ▼	183	-2% ▼	0.094	-28% ▼	37%	-5% ▼
	Argonne National Lab. - West (ANL-W)	20.9	-22% ▼	234	-22% ▼	0.089	0%	5%	2% ▲
	Brookhaven National Lab. (BNL)	22.4	-4% ▼	430	-17% ▼	0.052	16% ▲	5%	-1% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.3	41% ▲	406	79% ▲	0.030	-21% ▼	4%	-10% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	0.1	187% ▲	11	175% ▲	0.006	4% ▲	0%	0%
	North Korea Project								
	Kazakhstan								
Idaho	Idaho Site	58.8	22% ▲	795	9% ▲	0.074	12% ▲	21%	17% ▲
Nevada	Nevada Test Site (NTS)	1.6	**257%** ▲	24	300% ▲	0.067	-11% ▼	0%	0%
Oakland	Ops. and Other Facilities	0.9	-10% ▼	133	56% ▲	0.007	-42% ▼	0%	0%
	Lawrence Berkeley National Lab. (LBNL)	1.1	-39% ▼	44	-4% ▼	0.025	-36% ▼	0%	0%
	Lawrence Livermore National Lab. (LLNL)	12.7	-15% ▼	145	6% ▲	0.088	-19% ▼	30%	-7% ▼
	Stanford Linear Accelerator Center (SLAC)	5.5	-46% ▼	489	**370%** ▲	0.011	-89% ▼	0%	-11% ▼
Oak Ridge	Ops. and Other Facilities	1.9	-20% ▼	125	15% ▲	0.015	-30% ▼	0%	0%
	Oak Ridge Site	118.1	-42% ▼	2,276	-9% ▼	0.052	-36% ▼	8%	-30% ▼
	Paducah Gaseous Diff. Plant (PGDP)	5.0	14% ▲	63	9% ▲	0.079	5% ▲	0%	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	1.5	198% ▲	44	76% ▲	0.035	69% ▲	0%	0%
Ohio	Ops. and Other Facilities	33.3	5% ▲	256	146% ▲	0.130	-57% ▼	63%	-9% ▼
	Fernald Environmental Mgmt. Project	15.0	0%	421	-8% ▼	0.036	8% ▲	0%	0%
	Mound Plant	1.1	-59% ▼	123	-38% ▼	0.009	-34% ▼	0%	0%
	West Valley Project	16.5	32% ▲	246	1% ▲	0.067	30% ▲	0%	0%
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**296.1**	-21% ▼	2,331	-34% ▼	0.127	19% ▲	35%	7% ▲
Richland	Hanford Site	219.0	20% ▲	1,923	-4% ▼	0.114	26% ▲	36%	1% ▲
Savannah River	Savannah River Site (SRS)	163.2	20% ▲	**3,382**	13% ▲	0.048	6% ▲	5%	-5% ▼
Totals		**1,266.5**	**-2%** ▼	**15,983**	**-4%** ▼	**0.079**	**2%** ▲	**30%**	**3%** ▲

Note: Boxed values indicate the greatest value in each column.

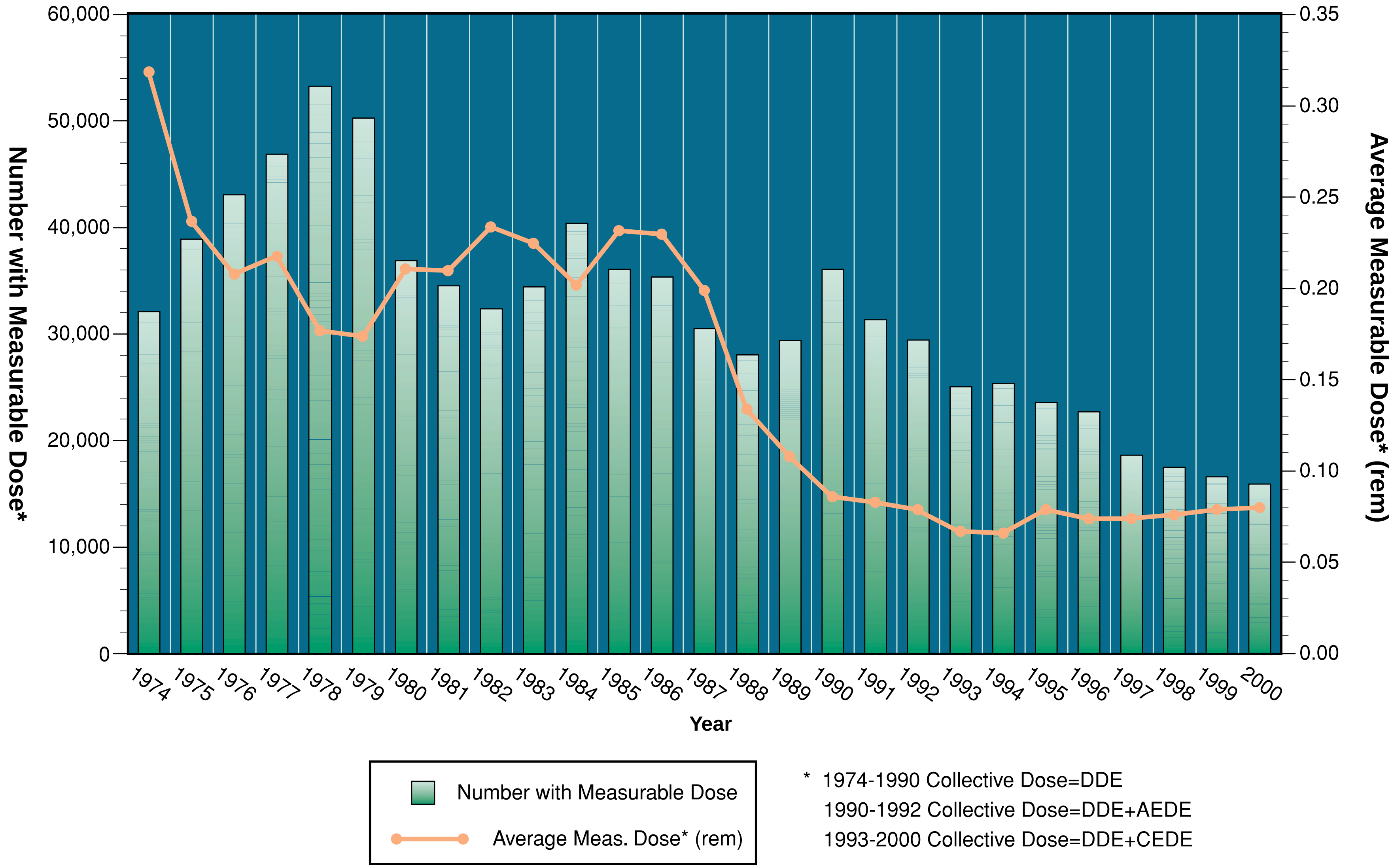
The collective TEDE decreased by 2% from 1999 to 2000. LANL experienced nearly a 50% increase in 2000 due to internal doses for 3 individuals that exceeded the DOE annual limit. Routine operational exposure at LANL actually decreased in 2000.

B-2a: Collective TEDE and Average Measurable Dose 1974-2000



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-2000 Collective Dose=DDE+CEDE

B-2b: Number with Measurable Dose and Average Measurable Dose 1974-2000



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-2000 Collective Dose=DDE+CEDE

B-3: Distribution of Deep Dose Equivalent (DDE) and Total Effective Dose Equivalent (TEDE), 1974-2000

Deep Dose Equivalent (DDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. DDE	Coll. DDE (person-rem)	Avg. Meas. DDE
1974	37,060	29,735	1,531	652	149	40	4								69,171	32,111	**10,202** ◄	**0.318** ◄
1975	41,390	36,795	1,437	541	122	28				1					80,314	38,924	9,202	0.236
1976	38,408	41,321	1,296	387	70	6	1								81,489	43,081	8,938	0.207
1977	41,572	44,730	1,499	540	103	23			1	2				2	88,472	46,900	10,199	0.217
1978	43,317	51,444	1,311	439	53	11									96,575	**53,258** ◄	9,390	0.176
1979	48,529	48,553	1,281	416	33	10	1							2	98,825	50,296	8,691	0.173
1980	43,663	35,385	1,113	387	16										80,564	36,901	7,760	0.210
1981	43,775	33,251	967	263	29	5									78,290	34,515	7,223	0.209
1982	47,420	30,988	990	313	56	28									79,795	32,375	7,538	0.233
1983	48,340	32,842	1,225	294	49	31									82,781	34,441	7,720	0.224
1984	46,056	38,821	1,223	312	31	11									86,454	40,398	8,113	0.201
1985	54,582	34,317	1,362	356	51	8				1					90,677	36,095	8,340	0.231
1986	53,586	33,671	1,279	349	35	1		1					1		88,923	35,337	8,095	0.229
1987	45,241	28,995	1,210	283	36										75,765	30,524	6,056	0.198
1988	48,704	27,492	502	34											76,732	28,028	3,735	0.133
1989	56,363	28,925	428	21											85,737	29,374	3,151	0.107
1990	76,798	31,110	140	17											108,065	31,267	2,230	0.071
1991	92,526	27,149	95												119,770	27,244	1,762	0.065
1992	98,900	24,769	42												123,711	24,811	1,504	0.061
1993	103,905	23,050	86			1									127,042	23,137	1,534	0.066
1994	92,245	24,189	77												116,511	24,266	1,600	0.066
1995	104,793	22,330	153												**127,276** ◄	22,483	1,809	0.080
1996	101,529	21,720	74	1											123,324	21,795	1,598	0.073
1997	89,805	17,331	45												107,181	17,376	1,285	0.074
1998	92,803	15,669	36												108,508	15,705	1,219	0.078
1999	98,125	14,877	62												113,064	14,939	1,142	0.076
2000	88,621	14,206	54												102,881	14,260	1,086	0.076

Total Effective Dose Equivalent (TEDE)*

Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. TEDE	Coll. TEDE (person-rem)	Avg. Meas. TEDE
1990	71,991	35,780	226	47	8	8	1	2		1				1	108,065	**36,074** ◄	**3,052** ◄	**0.085** ◄
1991	88,444	31,086	193	25	9	8		2		1				2	119,770	31,326	2,574	0.082
1992	94,297	29,240	132	22	9	6		2	1		1			1	123,711	29,414	2,295	0.078
1993	101,947	25,002	87			2				1	1			2	127,042	25,095	1,644	0.066
1994	91,121	25,310	79		1										116,511	25,390	1,643	0.065
1995	103,663	23,454	157		1	1									**127,276** ◄	23,613	1,845	0.078
1996	100,599	22,641	80	2	1								1		123,324	22,725	1,652	0.073
1997	88,502	18,627	48	1	2	1									107,181	18,675	1,356	0.073
1998	90,964	17,501	41	1				1							108,508	17,544	1,309	0.075
1999	96,396	16,585	80	1	1			1							113,064	16,668	1,295	0.078
2000	86,898	15,922	58								1		1	1	102,881	15,983	1,267	0.079

* 1990-1992 TEDE=DDE+AEDE   1993-2000 TEDE=DDE+CEDE   Note: Arrowed values indicate the greatest value in each column.

B-4: Internal Dose by Operations/Site, 1998 - 2000

Operations/ Field Office	Site	No. of Individuals with New Intakes*			Collective CEDE Dose from Intake (person-rem)			Average CEDE (rem)		
		1998	1999	2000	1998	1999	2000	1998	1999	2000
Albuquerque	Ops. and Facilities									
	LANL	81	65	90	8.791	3.066	**109.816** ◄	0.109	0.047	**1.220** ◄
	Pantex	4	1	1	0.004	0.025	0.014	0.001	0.025	0.014
	Sandia National Lab		11	2		0.036	0.005		0.003	0.003
	Grand Junction	280	39		33.84	2.147		0.121	0.055	
Chicago	Ops. and Other Facilities	20	12	1	0.24	0.017	0.001	0.012	0.001	0.001
	ANL-E	43	26	33	1.15	0.368	0.704	0.027	0.014	0.021
	ANL-W	1			0.07			0.07		
	BNL	58	36	29	0.623	0.524	0.817	0.011	0.015	0.028
Idaho	Idaho Site	1	1	7	0.016	0.016	0.116	0.016	0.016	0.017
Nevada	NTS	8			0.383			0.048		
Oakland	LBNL	6	7	20	0.31	0.154	0.354	0.052	0.022	0.018
	LLNL	6	1	3	0.041	0.01	0.006	0.007	0.010	0.002
Oak Ridge	Ops. and Other Facilities	33	35		0.301	0.519		0.009	0.015	
	Oak Ridge Site	**1,281** ◄	**1,622** ◄	**1,518** ◄	**35.263** ◄	**125.418** ◄	59.506	0.028	0.077	0.039
	Paducah	1		11	0.012		0.231	0.012		
	Portsmouth			1			0.018			
Ohio	OH	29	35	62	0.062	0.129	0.434	0.002	0.004	0.007
	Fernald	18	35	60	0.083	0.191	3.450	0.005	0.005	0.058
	Mound Plant	97	100	108	0.965	0.602	0.642	0.01	0.006	0.006
	WVNS									
Rocky Flats	Rocky Flats	31	61	76	3.986	6.626	3.398	0.129	**0.109** ◄	0.045
Richland	Hanford Site	11	19	18	1.792	0.226	0.208	**0.163** ◄	0.012	0.012
Savannah River	Savannah River Site	457	357	237	2.285	12.794	0.860	0.005	0.036	0.004
Totals		**2,466**	**2,463**	**2,277**	**90.217**	**152.868**	**180.580**	**0.037**	**0.062**	**0.079**

Facilities with no new intakes reported during the past 3 years: UMTRA, Fermi Lab, DOE-HQ, Oakland Ops., SLAC.

** Only includes intakes that occurred during the monitoring year. Individuals may be counted more than once.*

Note: Arrowed values indicate the greatest value in each column.

The largest number of individuals with measurable CEDE was at the Oak Ridge Y-12 Plant from uranium intakes, the vast majority of which were low doses and all were below 0.75 rem. The three internal doses from plutonium at LANL that exceeded the DOE annual limit account for 98% of the internal dose at LANL, and 60% of the internal dose at DOE for 2000.

B-5: Neutron Dose Distribution by Operations/Site, 2000

Operations	Site	No Meas. Dose	Meas. <0.1	0.1-0.25	0.25-0.5	0.5-0.75	0.75-1.0	1-2	>2	Total Monitored*	No. of Individuals with Meas. Dose	% of Individuals with Meas. Dose	Collective Neutron Dose (person-rem)	Average Meas. Neutron Dose (rem)
Albuquerque	Albuquerque	772	2							774	2	0%	0.026	
	Grand Junction	38								38		0%		
	Los Alamos National Lab. (LANL)	9,453	888	82	35	9	2			10,469	**1,016** ◂	10%	50.639	0.050
	Pantex Plant (PP)	5,199	107	14	3					5,323	124	2%	6.547	0.053
	Sandia National Lab. (SNL)	2,980	3							2,983	3	0%	0.123	0.041
Chicago	Chicago Operations	768								768		0%		
	Argonne Nat'l. Lab. - East (ANL-E)	2,750	68	6						2,824	74	3%	2.825	0.038
	Argonne Nat'l. Lab. - West (ANL-W)	723	9	1						733	10	1%	0.480	0.048
	Brookhaven Nat'l. Lab. (BNL)	5,316	163	5						5,484	168	3%	4.243	0.025
	Fermi Nat'l. Accelerator Lab. (FERMI)	1,361								1,361		0%		
DOE HQ	DOE Headquarters	143	3							146	3	2%	0.026	0.009
Idaho	Idaho Site	5,521	79							5,600	79	1%	1.117	0.014
Nevada	Nevada Test Site (NTS)	2,995	2							2,997	2	0%	0.055	0.028
Oakland	Oakland Operations	227								227		0%		
	Lawrence Berkeley National Lab. (LBNL)	1,826	9							1,835	9	0%	0.220	0.024
	Lawrence Livermore National Lab. (LLNL)	9,070	44	2	3					9,119	49	1%	2.224	0.045
	Stanford Linear Accelerator Center (SLAC)	2,024	399	1						2,424	400	**17%** ◂	2.275	0.006
Oak Ridge	Oak Ridge Operations	1,829	2							1,831	2	0%	0.070	0.035
	Oak Ridge Site	13,774	61	19	8	2				**13,864** ◂	90	1%	8.821	**0.098** ◂
	Paducah Gaseous Diff. Plant (PGDP)	869	40	3						912	43	5%	1.856	0.043
	Portsmouth Gaseous Diff. Plant (PORTS)	408	12	1						421	13	3%	0.412	0.032
Ohio	Ohio Field Office	963								963		0%		
	Fernald Environmental Mgmt. Project	3,464								3,464		0%		
	Mound Plant	1,000	16							1,016	16	2%	0.187	0.012
	West Valley	1,036								1,036		0%		
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	5,320	603	250	51	4				6,228	908	15%	**83.250** ◂	0.092
Richland	Hanford Site	9,235	722	59	28	2	2			10,048	813	8%	35.741	0.044
Savannah River	Savannah River Site (SRS)	9,289	577	111	16					9,993	704	7%	42.665	0.061
	Totals	**98,353**	**3,809**	**554**	**144**	**17**	**4**	**0**	**0**	**102,881**	**4,528**	**4%**	**243.802**	**0.054**

* Represents the total number of monitoring records. The number of individuals specifically monitored for neutron radiation cannot be determined.
Note: Arrowed values indicate the greatest value in each column.

LANL, Rocky Flats, Hanford, and Savannah River account for 76% of the individuals with measurable neutron dose and 87% of the collective neutron dose.

B-6a: Distribution of TEDE by Facility Type - 1998

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	9,786	1,384	133	76	17	6	2					11,404	14%	1,618	94.744	0.059
Fuel/Uran. Enrich.	3,474	225	23	8								3,730	7%	256	9.953	0.039
Fuel Fabrication	4,037	562	31									4,630	13%	593	14.252	0.024
Fuel Processing	2,889	1,045	98	27	1	1						4,061	29%	1,172	52.585	0.045
Maint. and Support	11,272	1,344	224	99	46	9	5		1			13,000	13%	1,728	153.326	0.089
Other	19,244	1,859	285	100	37	8	8					21,541	11%	2,297	164.633	0.072
Reactor	1,434	543	49	16	7	4						2,053	**30%** ◄	619	31.410	0.051
Research, General	16,098	1,917	308	126	29	15	15					18,508	13%	2,410	196.596	0.082
Research, Fusion	482	67	3	1	4							557	13%	75	5.243	0.070
Waste Proc./Mgmt.	5,575	1,179	229	90	12	2						7,087	21%	1,512	111.354	0.074
Weapons Fab. & Test	16,673	3,941	870	297	115	29	11	1				**21,937** ◄	24%	**5,264** ◄	**474.990** ◄	**0.090** ◄
Totals	**90,964**	**14,066**	**2,253**	**840**	**268**	**74**	**41**	**1**	**1**	**0**	**0**	**108,508**	**16%**	**17,544**	**1,309.086**	**0.075**

Note: Arrowed values indicate the greatest value in each column.

B-6b: Distribution of TEDE by Facility Type - 1999

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	9,866	797	86	19	4	1						10,773	8%	907	44.024	0.049
Fuel/Uran. Enrich.	3,463	382	27	6	1							3,879	11%	416	13.626	0.033
Fuel Fabrication	3,760	420	26	13								4,219	11%	459	15.081	0.033
Fuel Processing	3,865	1,019	74	14								4,972	22%	1,107	41.187	0.037
Maint. and Support	17,123	1,665	239	89	54	23	13					19,206	11%	2,083	179.522	0.086
Other	18,795	1,358	91	45	20	12	7					**20,328◄**	8%	1,533	97.156	0.063
Reactor	2,121	554	45	22	7	1						2,750	23%	629	30.958	0.049
Research, General	17,260	1,759	312	108	24	10	11					19,484	11%	2,224	170.016	0.076
Research, Fusion	618	40	3	3	1	2	1					668	7%	50	6.000	**0.120◄**
Waste Proc./Mgmt.	5,664	1,223	175	40	17	8	12					7,139	21%	1,475	106.617	0.072
Weapons Fab. & Test	13,861	4,344	820	411	110	62	35	1	1		1	19,646	**29%◄**	**5,785◄**	**590.993◄**	0.102
Totals	**96,396**	**13,561**	**1,898**	**770**	**238**	**119**	**79**	**1**	**1**	**0**	**1**	**113,064**	**15%**	**16,668**	**1,295.180**	**0.078**

Note: Arrowed values indicate the greatest value in each column.

B-6c: Distribution of TEDE by Facility Type - 2000

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	9,591	1,327	81	17	4							11,020	13%	1,429	45.932	0.032
Fuel/Uran. Enrich.	4,169	627	37	14	1							4,848	14%	679	21.591	0.032
Fuel Fabrication	3,048	395	24	5								3,472	12%	424	15.121	0.036
Fuel Processing	2,908	1,025	80	9	1							4,023	28%	1,115	41.609	0.037
Maint. and Support	14,810	1,614	294	150	56	30	28				1	16,983	13%	2,173	325.407	**0.150** ◄
Other	16,948	1,280	93	49	9	2	1					**18,382** ◄	8%	1,434	68.201	0.048
Reactor	1,355	506	59	20	9	6						1,955	**31%** ◄	600	38.123	0.064
Research, General	15,023	1,721	288	101	23	1	4				2	17,163	12%	2,140	164.751	0.077
Research, Fusion	522	62	12	1		2	1					600	13%	78	7.149	0.092
Waste Proc./Mgmt.	4,701	1,246	172	30	4	3	5					6,161	24%	1,460	81.168	0.056
Weapons Fab. & Test	13,823	3,217	733	331	104	47	19					18,274	24%	**4,451** ◄	**457.482** ◄	0.103
Totals	**86,898**	**13,020**	**1,873**	**727**	**211**	**91**	**58**	**0**	**0**	**0**	**3**	**102,881**	**16%**	**15,983**	**1,266.534**	**0.079**

Note: *Arrowed values indicate the greatest value in each column.*

Weapons Fabrication and Testing remains the facility type with the highest collective dose. It should be noted that Rocky Flats and Savannah River account for the majority of the dose reported under this facility type even though these sites are no longer actively involved in this activity. Maintenance and Support facilities received the highest average measurable TEDE since individuals reported under this facility type tend to perform maintenance and support work at multiple facility types involving work with radiological materials.

B-7a: Collective TEDE by Facility Type, 1998

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities									0.1	0.1	0.0	**0.2**
	Los Alamos National Lab. (LANL)	15.3				54.8	0.3	**71.2** ◀	0.8	2.1	0.1	23.2	**167.6**
	Pantex Plant (PP)										17.2	-	**17.2**
	Sandia National Lab. (SNL)	0.1				0.2	4.6	2.8		0.2	0.4	1.2	**9.5**
	Grand Junction											38.9	**38.9**
Chicago	Ops. and Other Facilities		0.1					0.1	1.1			0.0	**1.2**
	Argonne Nat'l. Lab. - East (ANL-E)	5.4				0.2		8.3		3.7		0.1	**17.7**
	Argonne Nat'l. Lab. - West (ANL-W)			0.2		0.5	0.7	20.2				0.1	**21.7**
	Brookhaven Nat'l. Lab. (BNL)	**45.9** ◀				4.8	2.7	7.6		0.8		1.2	**63.0**
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.8											**12.8**
DOE HQ	DOE Headquarters					0.0		0.0					**0.0**
	North Korea											5.4	**5.4**
	Kazakhstan											0.4	**0.4**
Idaho	Idaho Site				22.0	4.3	**14.3** ◀	4.0		7.2		13.1	**64.9**
Nevada	Nevada Test Site (NTS)										1.0	0.0	**1.0**
Oakland	Ops. and Other Facilities							1.0					**1.0**
	Lawrence Berkeley National Lab. (LBNL)	1.1						1.8					**2.9**
	Lawrence Livermore National Lab. (LLNL)	0.0	0.5			0.4		0.8	**3.4** ◀		0.6	1.2	**6.9**
	Stanford Linear Accelerator Center (SLAC)	13.1											**13.1**
Oak Ridge	Ops. and Other Facilities	1.0			0.1			0.0		2.1		0.6	**3.8**
	Oak Ridge Site		3.9					53.0			41.2	4.6	**102.7**
	Paducah Gaseous Diff. Plant (PGDP)		**5.3** ◀										**5.3**
	Portsmouth Gaseous Diff. Plant (PORTS)		0.2										**0.2**
Ohio	Ops. and Other Facilities					24.1						0.0	**24.1**
	Fernald Environmental Mgmt. Project			**13.3** ◀									**13.3**
	Mound Plant					0.1					0.0	1.2	**1.3**
	West Valley											18.2	**18.2**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**346.5** ◀	1.5	**348.1** ◀
Richland	Hanford Site			0.1	1.5	**55.2** ◀	5.2	13.8		**51.7** ◀		**53.4** ◀	**180.9**
Savannah River	Savannah River Site (SRS)			0.6	**29.0** ◀	8.7	3.7	11.8		43.5	67.9	0.4	**165.5**
	Totals	**94.7**	**10.0**	**14.3**	**52.6**	**153.3**	**31.4**	**196.6**	**5.2**	**111.4**	**475.0**	**164.6**	**1,309.1**

Note: Arrowed values indicate the greatest value in each column.

B-7b: Collective TEDE by Facility Type, 1999

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities									0.3	0.1	0.1	**0.4**
	Los Alamos National Lab. (LANL)	4.8				42.5	0.0	**51.9** ◄	0.1	1.8	0.0	**30.0** ◄	**131.0**
	Pantex Plant (PP)										29.3	-	**29.3**
	Sandia National Lab. (SNL)	0.2				0.2	3.1	1.9		0.5	0.2	0.3	**6.4**
	Grand Junction											2.5	**2.5**
Chicago	Ops. and Other Facilities							0.6	0.8			0.0	**1.5**
	Argonne Nat'l. Lab. - East (ANL-E)	4.9				0.3		10.0		2.2		7.2	**24.6**
	Argonne Nat'l. Lab. - West (ANL-W)				0.5	0.0	0.2	26.0		0.1			**26.7**
	Brookhaven Nat'l. Lab. (BNL)	**13.0** ◄				1.5	1.3	3.6		3.5		0.4	**23.4**
	Fermi Nat'l. Accelerator Lab. (FERMI)	8.7											**8.7**
DOE HQ	DOE Headquarters							0.0				0.0	**0.0**
	North Korea												
	Kazakhstan											0.1	**0.1**
Idaho	Idaho Site				13.4	3.6	**18.3** ◄	4.3		7.6		1.1	**48.3**
Nevada	Nevada Test Site (NTS)					0.4							**0.4**
Oakland	Ops. and Other Facilities							1.0					**1.0**
	Lawrence Berkeley National Lab. (LBNL)	0.8						1.1					**1.8**
	Lawrence Livermore National Lab. (LLNL)	0.1	0.1			0.5		1.4	**5.1** ◄		3.9	3.8	**14.9**
	Stanford Linear Accelerator Center (SLAC)	10.2											**10.2**
Oak Ridge	Ops. and Other Facilities	1.4						0.0		0.3		0.7	**2.4**
	Oak Ridge Site		**8.6** ◄					43.7			127.6	22.2	**202.2**
	Paducah Gaseous Diff. Plant (PGDP)		4.3										**4.3**
	Portsmouth Gaseous Diff. Plant (PORTS)		0.5										**0.5**
Ohio	Ops. and Other Facilities					31.6							**31.6**
	Fernald Environmental Mgmt. Project			**15.1** ◄									**15.1**
	Mound Plant					2.1				0.0	0.6	0.0	**2.7**
	West Valley											12.5	**12.5**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**372.7** ◄	1.2	**373.9** ◄
Richland	Hanford Site			0.0	1.2	**86.8** ◄	4.6	10.8		**64.3** ◄		14.5	**182.0**
Savannah River	Savannah River Site (SRS)				**26.2** ◄	9.9	3.5	13.5		26.1	56.7	0.6	**136.5**
	Totals	**44.0**	**13.6**	**15.1**	**41.2**	**179.5**	**31.0**	**170.0**	**6.0**	**106.6**	**591.0**	**97.2**	**1,295.2**

Note: Arrowed values indicate the greatest value in each column.

B-7c: Collective TEDE by Facility Type, 2000

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities									0.1	0.0	0.1	**0.3**
	Los Alamos National Lab. (LANL)	7.5				117.0	0.0	**50.1** ◄	0.2	1.1		19.6	**195.5**
	Pantex Plant (PP)										35.0	-	**35.0**
	Sandia National Lab. (SNL)	0.1				0.3	4.1	1.8		0.2	0.3	0.8	**7.6**
	Grand Junction											0.1	**0.1**
Chicago	Ops. and Other Facilities							0.6	2.9			0.0	**3.5**
	Argonne Nat'l. Lab. - East (ANL-E)	6.0				0.1		8.4		2.3		0.4	**17.2**
	Argonne Nat'l. Lab. - West (ANL-W)							20.9					**20.9**
	Brookhaven Nat'l. Lab. (BNL)	**12.8** ◄				1.7	1.6	3.0		2.7		0.7	**22.4**
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.3											**12.3**
DOE HQ	DOE Headquarters											0.1	**0.1**
Idaho	Idaho Site				6.8	3.0	**26.9** ◄	15.6		5.6		0.9	**58.8**
Nevada	Nevada Test Site (NTS)					1.6							**1.6**
Oakland	Ops. and Other Facilities							0.9					**0.9**
	Lawrence Berkeley National Lab. (LBNL)	0.1						1.0					**1.1**
	Lawrence Livermore National Lab. (LLNL)	0.0	0.1			0.9		1.6	**4.0** ◄	0.0	2.6	3.4	**12.7**
	Stanford Linear Accelerator Center (SLAC)	5.5											**5.5**
Oak Ridge	Ops. and Other Facilities	1.6						0.3					**1.9**
	Oak Ridge Site		**15.0** ◄					35.8			67.3		**118.1**
	Paducah Gaseous Diff. Plant (PGDP)		5.0										**5.0**
	Portsmouth Gaseous Diff. Plant (PORTS)		1.5										**1.5**
Ohio	Ops. and Other Facilities					31.4						1.9	**33.3**
	Fernald Environmental Mgmt. Project			**15.0** ◄									**15.0**
	Mound Plant					0.9					0.2	0.0	**1.1**
	West Valley											16.5	**16.5**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**294.8** ◄	1.3	**296.1** ◄
Richland	Hanford Site			0.1	0.4	**157.7** ◄	2.2	10.1		26.7		**21.8** ◄	**219.0**
Savannah River	Savannah River Site (SRS)				**34.4** ◄	10.8	3.3	14.6		**42.3** ◄	57.3	0.5	**163.2**
	Totals	**45.9**	**21.6**	**15.1**	**41.6**	**325.4**	**38.1**	**164.8**	**7.1**	**81.2**	**457.5**	**68.2**	**1,266.5**

Note: Arrowed values indicate the greatest value in each column.

The largest increase in collective TEDE between 1999 and 2000 occurred at Maintenance and Support facilities primarily due to one individual at LANL who received 87 rem from an intake of plutonium. See Section 3.3.1.

B-8: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Accelerator Facilities, 2000

ACCELERATORS

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
CH	Argonne National Laboratory - East	516	66	11	6	1				600	14%	84	6.040	**0.072**◄	**10%**◄
CH	Brookhaven National Laboratory	3,022	176	35	5	2				**3,240**◄	7%	218	**12.771**◄	0.059	9%
AL	Los Alamos National Laboratory	587	137	14	5					743	21%	156	7.498	0.048	
CH	Fermilab	955	390	14	1	1				1,361	**30%**◄	406	12.340	0.030	4%
AL	Sandia National Laboratory	290	3							293	1%	3	0.081	0.027	
OR	Thomas Jefferson Nat'l. Accel. Facil.	1,425	66	1						1,492	4%	67	1.616	0.024	
OAK	Lawrence Berkeley National Laboratory	594	5							599	1%	5	0.111	0.022	
OAK	Stanford Linear Accelerator Center	1,935	483	6						2,424	20%	**489**◄	5.464	0.011	
OAK	Lawrence Livermore National Lab	259	1							260	0%	1	0.011	0.011	
RL	Battelle Memorial Institute (PNNL)	2								2	0%				
AL	Johnson Controls, Inc.	2								2	0%				
OR	Oak Ridge Field Office	4								4	0%				
	Totals	**9,591**	**1,327**	**81**	**17**	**4**	**0**	**0**	**0**	**11,020**	**13%**	**1,429**	**45.932**	**0.032**	**5%**

Note: Arrowed values indicate the greatest value in each column.

Measurable doses continue to remain relatively low at accelerator facilities with an increase in individual doses below 0.1 rem at SLAC which resulted in a reduction in the overall measurable TEDE from 1999 to 2000.

B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 2000

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
FUEL FACILITIES	*Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)*														
ENRICHMENT															
OR	Bechtel-Jacobs Co., LLC – Paducah	849	50	8	5					912	7%	63	4.959	**0.079** ◄	0%
OR	Bechtel-Jacobs Co., LLC – ORNL	349	155	26	9	1				540	35%	191	**12.311** ◄	0.064	**4%** ◄
OR	Bechtel-Jacobs Co., LLC – Portsmouth	377	41	3						421	10%	44	1.529	0.035	0%
OAK	Lawrence Livermore National Laboratory	511	5							516	1%	5	0.141	0.028	0%
OR	Bechtel-Jacobs Co., LLC – ETTP	1,269	62							**1,331** ◄	5%	62	1.537	0.025	0%
OR	Bechtel-Jacobs Co., LLC – Y-12	134	9							143	6%	9	0.112	0.012	0%
OR	British Nuclear Fuels Limited (BNFL)-ETTP	597	210							807	26%	**210** ◄	0.728	0.003	0%
OR	Decontamination & Recovery Services-ETTP	31	95							126	**75%** ◄	95	0.274	0.003	0%
	Totals	**4,169**	**627**	**37**	**14**	**1**	**0**	**0**	**0**	**4,848**	**14%**	**679**	**21.591**	**0.032**	**3%**
FABRICATION															
OH	FERMCO Subcontractors	671	110	8	4					793	15%	122	5.096	**0.042** ◄	0%
OH	Fernald Envir. Rest. Mgmt. Corp. (FERMCO)	2,254	280	16	1					**2,551** ◄	12%	**297** ◄	**9.918** ◄	0.033	0%
RL	Fluor Daniel – Hanford	2	3							5	**60%** ◄	3	0.085	0.028	0%
OH	Fernald Office Services Subcontractors	24	1							25	4%	1	0.017	0.017	0%
OH	FERMCO Service Vendors	50	1							51	2%	1	0.005	0.005	0%
RL	CH2M Hill Hanford Group	3								3	0%				0%
OH	Fernald Area Office	44								44	0%				0%
	Totals	**3,048**	**395**	**24**	**5**	**0**	**0**	**0**	**0**	**3,472**	**12%**	**424**	**15.121**	**0.036**	**0%**

Note: *Arrowed values indicate the greatest value in each column.*

The parameters for Fuel Enrichment and Fuel Fabrication remain nearly the same for 2000 as for 1999 with the Oak Ridge facilities contributing the majority of dose for Enrichment facilities, and Fernald contributing the majority of dose for Fuel Fabrication facilities.

B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 2000 (Continued)

FUEL FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
PROCESSING															
RL	Fluor Daniel - Hanford	13	3	3						19	32%	6	0.440	**0.073** ◄	0%
ID	Bechtel BWXT Idaho, LLC – Services	1,060	139	10						1,209	12%	149	5.959	0.040	0%
SR	Westinghouse Savannah River Co.	1,340	690	62	8					**2,100** ◄	36%	**760** ◄	**28.878** ◄	0.038	0%
SR	Bechtel Construction – SR	213	130	4	1	1				349	**39%** ◄	136	4.597	0.034	**13%** ◄
SR	Wackenhut Services, Inc., – SR	68	25							93	27%	25	0.743	0.030	0%
ID	Bechtel BWXT Idaho, LLC – Constr.	117	30	1						148	21%	31	0.855	0.028	0%
SR	Westinghouse S.R. Subcontractors	56	5							61	8%	5	0.100	0.020	0%
SR	Savannah River Field Office	38	3							41	7%	3	0.037	0.012	0%
CH	Argonne National Laboratory – West	1								1	0%				0%
RL	CH2M Hill Hanford Group	1								1	0%				0%
AL	Johnson Controls, Inc.	1								1	0%				0%
	Totals	**2,908**	**1,025**	**80**	**9**	**1**	**0**	**0**	**0**	**4,023**	**28%**	**1,115**	**41.609**	**0.037**	**1%**

Note: Arrowed values indicate the greatest value in each column.

The parameters for Fuel Processing remain nearly the same for 2000 as for 1999 with Savannah River contributing the majority of the collective dose.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 2000

MAINTENANCE AND SUPPORT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less Than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	>4.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
AL	Los Alamos National Laboratory	1,037	153	28	14	5	1	1			1	1,240	16%	203	105.671	**0.521** ◄	**87%** ◄
OH	Battelle Memorial Institute - Columbus	308	45	10	20	18	12					413	25%	105	31.342	0.298	67%
RL	Fluor Daniel - Hanford	1,443	512	118	84	28	16	27				2,228	35%	**785** ◄	**127.836** ◄	0.163	50%
RL	CH2M Hill Hanford Group	522	188	57	20	1						788	34%	266	23.145	0.087	2%
RL	Battelle Memorial Institute (PNL)	19	1									20	5%	1	0.077	0.077	
RL	Fluor Daniel Northwest Services	58	58	14	4							134	57%	76	5.630	0.074	
AL	Johnson Controls, Inc.	1,282	126	22	3	4	1					1,438	11%	156	11.025	0.071	31%
NV	Bechtel Nevada - NTS	1,789	18	4	1							1,812	1%	23	1.573	0.068	
SR	Westinghouse Savannah River Co.	226	150	32	2							410	45%	184	9.827	0.053	
OAK	Lawrence Livermore National Laboratory	2,772	17	-	1							**2,790** ◄	1%	18	0.877	0.049	
AL	Sandia National Laboratory	616	6	1								623	1%	7	0.317	0.045	
RL	Rust Services Hanford	67	2									69	3%	2	0.088	0.044	
CH	Argonne National Laboratory - East	356	3									359	1%	3	0.120	0.040	
SR	Savannah River Field Office	2	1									3	33%	1	0.035	0.035	
ID	Bechtel BWXT Idaho - Services	544	81	3	1							629	14%	85	2.940	0.035	
SR	Bechtel Construction - SR	41	22	2								65	37%	24	0.830	0.035	
RL	Rust Federal Services Northwest	23	2									25	8%	2	0.067	0.034	
RL	Fluor Daniel Northwest	116	14									130	11%	14	0.458	0.033	
RL	Hanford Security	89	12	1								102	13%	13	0.384	0.030	
CH	Brookhaven National Laboratory	910	60	2								972	6%	62	1.707	0.028	
NV	Science Applications Int'l Corp. -NV	19	1									20	5%	1	0.025	0.025	
OH	BWX Technologies, Inc. - Security Forces	22	1									23	4%	1	0.024	0.024	
SR	Wackenhut Services, Inc. - SR	1	2									3	**67%** ◄	2	0.034	0.017	
RL	Lockheed Martin Services, Inc.	40	2									42	5%	2	0.033	0.017	
SR	Westinghouse S.R. Subcontractors	23	6									29	21%	6	0.095	0.016	
AL	Los Alamos Area Office	30	6									36	17%	6	0.091	0.015	
ID	Bechtel BWXT Idaho - Construction	23	5									28	18%	5	0.066	0.013	
OH	Miamisburg Area Office	21	1									22	5%	1	0.013	0.013	

Note: Arrowed values indicate the greatest value in each column.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 2000 (Continued)

MAINTENANCE AND SUPPORT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	>4.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	Dyncorp Hanford	88	1									89	1%	1	0.012	0.012	
OH	BWX Technologies, Inc.	385	70									455	15%	70	0.658	0.009	
OH	BWX Technologies, Inc. - Subcont.	254	22									276	8%	22	0.190	0.009	
AL	Protection Technologies Los Alamos	373	26									399	7%	26	0.217	0.008	
NV	Bechtel Nevada - NTS Subcontractors	570										570	0%				
RL	Babcock Wilcox Hanford	15										15	0%				
NV	Bechtel Nevada - Special Tech. Lab.	1										1	0%				
RL	Bechtel Power Co.	21										21	0%				
HQ	DOE Headquarters	1										1	0%				
RL	Duke Engineering Services Hanford	22										22	0%				
OH	Miamisburg Office Subs	23										23	0%				
NV	Nevada Miscellaneous Contractors	119										119	0%				
NV	Nevada Operations	285										285	0%				
RL	NUMATEC Hanford	22										22	0%				
NV	Nye County Sheriff	5										5	0%				
OH	Ohio Field Office	18										18	0%				
RL	Richland Field Office	11										11	0%				
RL	SGN Eurisys Services Corp.	15										15	0%				
SR	Univ. of Georgia Ecology Laboratory	2										2	0%				
RL	Verizon/Qwest	2										2	0%				
NV	Wackenhut Services, Inc. - NV	178										178	0%				
OH	West Valley Nuclear Services, Inc.	1										1	0%				
	Totals	**14,810**	**1,614**	**294**	**150**	**56**	**30**	**28**	**0**	**0**	**1**	**16,983**	**13%**	**2,173**	**325.407**	**0.150**	**56%**

Note: Arrowed values indicate the greatest value in each column.

The largest increase in collective TEDE between 1999 and 2000 occurred at Maintenance and Support facilities primarily due to one individual at LANL who received 87 rem from an intake of plutonium. See Section 3.3.1 for more information on this event. Battelle Memorial Institute in Columbus, and Fluor Daniel at Hanford also reported an average measurable TEDE above the average for all of DOE.

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Reactor Facilities, 2000

REACTOR FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
ID	Bechtel BWXT Idaho - Construction	18	15	4	3	4	3			47	62% ◄	29	7.557	0.261 ◄	69% ◄
AL	Sandia National Laboratory	43	13	7	5	1				69	38%	26	4.108	0.158	18%
RL	CH2M HILL HANFORD GROUP	19	2	1	1					23	17%	4	0.533	0.133	
ID	Bechtel BWXT Idaho - Services	319	137	39	10	4	3			512	38%	193 ◄	19.366 ◄	0.100	25%
CH	Brookhaven National Laboratory	196	27	3	1					227	14%	31	1.561	0.050	
RL	Fluor Daniel - Hanford	120	31	5						156	23%	36	1.586	0.044	
RL	Hanford Security	8	1							9	11%	1	0.036	0.036	
SR	Wackenhut Services, Inc. - SR	83	65							148	44%	65	1.162	0.018	
AL	Los Alamos National Laboratory	4	2							6	33%	2	0.035	0.018	
SR	Bechtel Construction - SR	60	23							83	28%	23	0.354	0.015	
SR	Westinghouse Savannah River Co.	423	186							609 ◄	31%	186	1.794	0.010	
SR	Westinghouse S.R. Subcontractors	17	3							20	15%	3	0.024	0.008	
SR	Miscellaneous DOE Contractors - SR	1	1							2	50%	1	0.007	0.007	
CH	Argonne National Laboratory - West	1								1	0%				
RL	Battelle Memorial Institute (PNL)	1								1	0%				
RL	Bechtel Power Co.	1								1	0%				
RL	Dyncorp Hanford	5								5	0%				
RL	Fluor Daniel Northwest	7								7	0%				
RL	Lockheed Martin Services, Inc.	1								1	0%				
RL	NUMATEC Hanford	3								3	0%				
RL	Richland Field Office	1								1	0%				
RL	Rust Federal Services Northwest	2								2	0%				
RL	Rust Services Hanford	2								2	0%				
SR	Savannah River Field Office	14								14	0%				
RL	SGN Eurisys Services Corp.	6								6	0%				
	Totals	**1,355**	**506**	**59**	**20**	**9**	**6**	**0**	**0**	**1,955**	**31%**	**600**	**38.123**	**0.064**	**29%**

Note: Arrowed values indicate the greatest value in each column.

The majority of the collective dose at reactor facilities in 2000 was received at Bechtel BWXT Idaho.

B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 2000

RESEARCH, GENERAL

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	>4.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
CH	Argonne National Laboratory - East	1,728	36	5	2	4		3				1,778	3%	50	8.386	**0.168** ◄	**69%** ◄
ID	Bechtel BWXT Idaho - Construction	35	8	4	2	1						50	30%	15	2.112	0.141	28%
AL	Los Alamos National Laboratory	1399	312	50	26	4		1			2	1,794	22%	**395** ◄	**50.027** ◄	0.127	49%
ID	Bechtel BWXT Idaho - Services	744	77	32	12	3						868	14%	124	13.439	0.108	13%
OR	UT-Battelle: ORNL	5583	258	77	27	8	1					**5,954** ◄	6%	371	35.848	0.097	16%
CH	Argonne National Laboratory - West	496	162	57	13	2						730	32%	234	20.937	0.089	5%
RL	Battelle Memorial Institute (PNL)	581	94	16	11	1						703	17%	122	10.076	0.083	5%
OAK	Lawrence Livermore National Lab.	808	17	4	1							830	3%	22	1.572	0.071	
AL	Johnson Controls, Inc.	7	1									8	13%	1	0.070	0.070	
AL	Sandia National Laboratory	531	25	4	2							562	6%	31	1.819	0.059	
CH	Brookhaven National Laboratory	653	48	8	1							710	8%	57	3.031	0.053	
CH	New Brunswick Laboratory - Research	35	2									37	5%	2	0.105	0.053	
SR	Westinghouse Savannah River Co.	736	328	29	4							1,097	33%	361	13.242	0.037	
OAK	Lawrence Berkeley Laboratory	1197	37	2								1,236	3%	39	1.003	0.026	
SR	Bechtel Construction - SR	50	24									74	32%	24	0.589	0.025	
SR	Wackenhut Services, Inc. - SR	12	12									24	50%	12	0.290	0.024	
CH	Ames Laboratory (Iowa State)	109	13									122	11%	13	0.311	0.024	
SR	Savannah River Field Office	42	17									59	29%	17	0.207	0.012	

Note: Arrowed values indicate the greatest value in each column.

B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 2000 (Continued)

RESEARCH, GENERAL

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	>4.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
SR	Westinghouse S.R. Subcontractors	41	18									59	31%	18	0.215	0.012	
AL	Los Alamos Area Office	1	1									2	50%	1	0.009	0.009	
SR	Univ. of Georgia Ecology Laboratory	24	9									33	27%	9	0.065	0.007	
RL	Fluor Daniel Northwest	5	1									6	17%	1	0.007	0.007	
OAK	Boeing, Rocketdyne -ETEC	88	133									221	60%	133	0.924	0.007	
CH	Chicago Office Subs	26	30									56	54%	30	0.168	0.006	
OR	Oak Ridge Inst. for Sci. & Educ. (ORISE)	36	58									94	**62%** ◀	58	0.299	0.005	
RL	CH2M Hill Hanford Group	2										2	0%				
HQ	DOE Headquarters	1										1	0%				
RL	Fluor Daniel - Hanford	15										15	0%				
AL	Nat. Renewable Energy Lab (NREL)-GO	17										17	0%				
RL	NUMATEC Hanford	3										3	0%				
AL	Protection Technologies Los Alamos	9										9	0%				
RL	Rust Services Hanford	1										1	0%				
RL	SGN Eurisys Services Corp.	8										8	0%				
	Totals	**15,023**	**1,721**	**288**	**101**	**23**	**1**	**4**	**0**	**0**	**2**	**17,163**	**12%**	**2,140**	**164.751**	**0.077**	**24%**

Note: Arrowed values indicate the greatest value in each column.

The collective dose and number of individuals with measurable dose for General Research decreased from 1999 to 2000. Two of the individuals at LANL received doses in excess of the DOE annual limit (See Section 3.3.1).

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, Fusion, 2000

RESEARCH, FUSION

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
OAK	*Lawrence Livermore National Laboratory*	47	3	4	1		2	1		58	**19%** ◄	11	**4.046** ◄	**0.368** ◄	**71%** ◄
CH	*Princeton Plasma Physics Laboratory*	407	51	8						**466** ◄	13%	**59** ◄	2.941	0.050	0%
AL	*Los Alamos National Laboratory*	42	8							50	16%	8	0.162	0.020	0%
AL	*Sandia National Laboratory*	26								26	0%				0%
	Totals	**522**	**62**	**12**	**1**	**0**	**2**	**1**	**0**	**600**	**13%**	**78**	**7.149**	**0.092**	**40%**

Note: Arrowed values indicate the greatest value in each column.

Fusion Research accounted for only 0.6% of the collective TEDE in 2000 with only four organizations reporting in this category.

B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 2000

WASTE PROCESSING

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	SGN Eurisys Services Corp.	22			1					23	4%	1	0.279	**0.279** ◄	
RL	Fluor Daniel - Hanford	399	149	31	8	4	3	5		599	33%	200	23.602	0.118	**48%** ◄
RL	Fluor Daniel Northwest Services	1		1						2	50%	1	0.110	0.110	
RL	CH2M Hill Hanford Group	205	19	5	4					233	12%	28	2.668	0.095	
CH	Argonne National Laboratory - East	41	17	9						67	39%	26	2.321	0.089	
CH	Brookhaven National Laboratory	176	43	7	1					227	22%	51	2.656	0.052	
AL	Los Alamos National Laboratory	93	18	3	1					115	19%	22	1.124	0.051	
ID	Bechtel BWXT Idaho - Services	364	105	12						481	24%	117	5.450	0.047	
SR	Bechtel Construction - SR	177	159	17	5					358	51%	181	8.079	0.045	
SR	Westinghouse Savannah River Co.	1,831	657	87	9					**2,584** ◄	29%	**753** ◄	**33.381** ◄	0.044	
OAK	Lawrence Livermore National Lab	68	1							69	1%	1	0.043	0.043	
RL	Hanford Security	1	1							2	50%	1	0.033	0.033	
AL	Sandia National Laboratory	161	8							169	5%	8	0.221	0.028	
ID	Bechtel BWXT Idaho - Construction	57	8							65	12%	8	0.184	0.023	
SR	Westinghouse S.R. Subcontractors	173	41		1					215	20%	42	0.789	0.019	
RL	Duke Engineering Services Hanford		1							1	**100%** ◄	1	0.017	0.017	
AL	Carlsbad Area Misc. Contractors	497	8							505	2%	8	0.132	0.017	
SR	Miscellaneous DOE Contractors - SR	5	3							8	38%	3	0.026	0.009	

Note: Arrowed values indicate the greatest value in each column.

B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 2000 (Continued)

WASTE PROCESSING		Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)													
Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
SR	Wackenhut Services, Inc. - SR	1	1							2	50%	1	0.007	0.007	
SR	Savannah River Field Office	42	5							47	11%	5	0.033	0.007	
RL	Fluor Daniel Northwest	14	2							16	13%	2	0.013	0.007	
CH	Argonne National Laboratory - West	1								1	0%				
RL	Babcock Wilcox Hanford	2								2	0%				
RL	Bechtel Power Co.	7								7	0%				
RL	Dyncorp Hanford	18								18	0%				
AL	Johnson Controls, Inc.	1								1	0%				
AL	Los Alamos Area Office	1								1	0%				
OR	Morrison-Knudsen (WSSRAP)	241								241	0%				
RL	NUMATEC Hanford	15								15	0%				
RL	Richland Field Office	2								2	0%				
RL	Rust Federal Services Northwest	3								3	0%				
RL	Rust Services Hanford	15								15	0%				
AL	Waste Isolation Pilot Project (WIPP)	17								17	0%				
OH	West Valley Area Office	4								4	0%				
OH	West Valley Nuclear Services, Inc.	46								46	0%				
	Totals	**4,701**	**1,246**	**172**	**30**	**4**	**3**	**5**	**0**	**6,161**	**24%**	**1,460**	**81.168**	**0.056**	**14%**

Note: Arrowed values indicate the greatest value in each column.

Westinghouse Savannah River reports the largest number of individuals monitored, individuals with measurable dose, and collective dose in this category during 2000. However, the top 4 organizations with the highest average measurable dose were at the Hanford site.

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Weapons Fabrication, 2000

WEAPONS FABRICATION

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	>3	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RFO	Rocky Flats Prime Contractors	1,162	921	381	180	65	39	19			2,767	58%	**1,605** ◄	**252.742** ◄	**0.157** ◄	**38%** ◄
SR	Westinghouse Savannah River Co.	240	164	57	63	13					537	55%	297	45.399	0.153	17%
AL	Mason & Hanger - Amarillo	4,395	171	51	26	11	5				4,659	6%	264	34.075	0.129	31%
AL	M&H - Amarillo - Security Forces	560	5	4							569	2%	9	0.815	0.091	
SR	Wackenhut Services, Inc. - SR	56	84	28							168	**67%** ◄	112	8.116	0.072	
OAK	Lawrence Livermore National Lab	1,094	30	6	1						1,131	3%	37	2.643	0.071	
RFO	Rocky Flats Subcontractors	1,643	521	60	25	9	3				2,261	27%	618	40.230	0.065	20%
SR	Bechtel Construction - SR	52	55	7	3						117	56%	65	3.498	0.054	
OR	BWXT Y-12, LLC	3,433	1,166	133	33	6					**4,771** ◄	28%	1,338	67.301	0.050	5%
AL	Sandia National Laboratory	557	7	1							565	1%	8	0.301	0.038	
RFO	Rocky Flats Office	201	46	5							252	20%	51	1.816	0.036	
SR	Savannah River Field Office	12	8								20	40%	8	0.161	0.020	
AL	Amarillo Area Office	91	4								95	4%	4	0.066	0.017	
SR	Westinghouse S.R. Subcontractors	13	5								18	28%	5	0.081	0.016	
OH	BWX Technologies, Inc. - Subs	35	4								39	10%	4	0.063	0.016	
AL	Alburquerque Operations Office	148	2								150	1%	2	0.026	0.013	
OH	BWX Technologies, Inc.	87	24								111	22%	24	0.149	0.006	
AL	Los Alamos National Laboratory	10									10	0%				
OH	Miamisburg Area Office	4									4	0%				
OH	Miamisburg Office Subs	5									5	0%				
SR	Miscellaneous DOE Contractors - SR	1									1	0%				
OH	Ohio Field Office	3									3	0%				
	Totals	**13,823**	**3,217**	**733**	**331**	**104**	**47**	**19**	**0**	**0**	**18,274**	**24%**	**4,451**	**457.482**	**0.103**	**27%**

Note: Arrowed values indicate the greatest value in each column.

It should be noted that Rocky Flats and Savannah River account for the majority of the dose reported under this facility type even though these sites are no longer actively involved in this activity. The collective dose at Rocky Flats under this category decreased by 19% from 1999 to 2000.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2000

OTHER

Ops. Office	Site/Contractor	Number of Individuals Receiving Radiation Doses in Each Dose Range (rem): Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	Battelle Memorial Institute (PNL)	619	38	4	7	2				670	8%	51	5.225	0.102 ◄	22%
RL	Fluor Daniel Northwest Services	80	59	13	5					157	49%	77	5.652	0.073	
OAK	Lawrence Livermore National Lab	3,360	44	2	3		1			3,410	1%	50	3.397	0.068	26%
OH	West Valley Nuclear Services, Inc.	739	207	23	16					985	25%	246	16.548	0.067	
RL	Bechtel Power Co.	910	83	17	2	1				1,013	10%	103	6.694	0.065	8%
CH	Brookhaven National Laboratory	95	9	2						106	10%	11	0.658	0.060	
RL	CH2M Hill Hanford Group	103	6	1						110	6%	7	0.377	0.054	
AL	Los Alamos National Laboratory	4,062	326	22	11	6	1	1		4,429 ◄	8%	367 ◄	18.874 ◄	0.051	30% ◄
AL	Johnson Controls, Inc.	58	11	1	1					71	18%	13	0.634	0.049	
RL	Richland Field Office	894	15	1						910	2%	16	0.617	0.039	
RL	SGN Eurisys Services Corp.	71	1							72	1%	1	0.037	0.037	
RL	Fluor Daniel - Hanford	894	55	1	3					953	6%	59	2.168	0.037	
AL	Sandia National Laboratory	634	21		1					656	3%	22	0.763	0.035	
RL	Rust Services Hanford	47	3							50	6%	3	0.102	0.034	
SR	Savannah River Field Office	8	2							10	20%	2	0.065	0.033	
RL	Hanford Security	20	10							30	33%	10	0.291	0.029	
ID	Idaho Field Office	366	3							369	1%	3	0.086	0.029	
RL	Fluor Daniel Northwest	200	19	1						220	9%	20	0.564	0.028	
OH	BWX Technologies, Inc. - Subs	2	1							3	33%	1	0.026	0.026	

Note: Arrowed values indicate the greatest value in each column.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2000 (Continued)

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RFO	Rocky Flats Office	891	55	2						948	6%	57	1.334	0.023	
ID	Bechtel BWXT Idaho - Services	1,128	35	1						1,164	3%	36	0.833	0.023	
CH	Argonne National Laboratory - East		18	2						20	**100%** ◄	20	0.377	0.019	
RL	Babcock Wilcox Hanford	47	6							53	11%	6	0.089	0.015	
SR	Bechtel Construction - SR	32	8							40	20%	8	0.112	0.014	
OH	BWX Technologies, Inc.	108	1							109	1%	1	0.013	0.013	
OH	Earthline Technologies	325	150							475	32%	150	1.918	0.013	
AL	Wastren/Grd Jtn	26	4							30	13%	4	0.050	0.013	
AL	Protection Technologies Los Alamos	86	9							95	9%	9	0.108	0.012	
SR	Westinghouse Savannah River Co.	396	32							428	7%	32	0.345	0.011	
AL	Mactec - ERS/Grd Jtn	6	2							8	25%	2	0.020	0.010	
CH	Chicago Operations Office	68	1							69	1%	1	0.010	0.010	
SR	Wackenhut Services, Inc. - SR	15	2							17	12%	2	0.018	0.009	
SR	Westinghouse S.R. Subcontractors	33	1							34	3%	1	0.008	0.008	
HQ	DOE Headquarters	119	11							130	8%	11	0.066	0.006	
AL	Honeywell, Fed. Mfg. & Technology	50	27							77	35%	27	0.116	0.004	
CH	Environmental Meas. Lab. - Research	15	3							18	17%	3	0.004	0.001	
AL	Kansas City Area Office	6	1							7	14%	1	0.001	0.001	
RL	Rust Federal Services Northwest	54	1							55	2%	1	0.001	0.001	

Note: Arrowed values indicate the greatest value in each column.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2000 (Continued)

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
ID	Bechtel BWXT Idaho - Construction	30								30	0%				
OR	Bechtel Jacobs - Y-12	45								45	0%				
NV	Bechtel Nevada - NTS	7								7	0%				
OR	BWXT Y-12, LLC	85								85	0%				
RL	Duke Engr. & Services Northwest, Inc.	1								1	0%				
RL	Duke Engineering Services Hanford	7								7	0%				
RL	Dyncorp Hanford	5								5	0%				
RL	Hanford Envir. Health Foundation	29								29	0%				
OAK	LLNL Plant Services	50								50	0%				
RL	Lockheed Martin Services, Inc.	14								14	0%				
AL	Los Alamos Area Office	19								19	0%				
SR	Miscellaneous DOE Contractors - SR	9								9	0%				
RL	NUMATEC Hanford	9								9	0%				
OAK	U. of Cal./Davis, Radiobiology Lab-LEHR	6								6	0%				
SR	Univ. of Georgia Ecology Laboratory	2								2	0%				
RL	Verizon/Qwest	30								30	0%				
	Totals	**16,948**	**1,280**	**93**	**49**	**9**	**2**	**1**	**0**	**18,382**	**8%**	**1,434**	**68.201**	**0.048**	**12%**

Note: Arrowed values indicate the greatest value in each column.

The collective dose in this category decreased by 30% from 1999 to 2000, while the average measurable dose decreased by 24%.

B-17: Internal Dose by Facility Type and Nuclide, 1998-2000

Facility Type	Nuclide*	No. of Individuals with New Intakes**			Collective CEDE (person-rem)			Average CEDE (rem)		
		1998	1999	2000	1998	1999	2000	1998	1999	2000
Accelerator	Americium			1			0.015			0.015
	Hydrogen-3	6	5	3	0.078	0.091	0.092	0.013	0.018	0.031
	Uranium	2	1	2	0.010	0.007	0.009	0.005	0.007	0.005
	Total	**8**	**6**	**6**	**0.088**	**0.098**	**0.116**	**0.011**	**0.016**	**0.019**
Fuel Fabrication	Hydrogen-3	6			0.012			0.002		
	Thorium	9	5	46	0.057	0.060	3.376	0.006	0.012	0.073
	Uranium	9	30	14	0.026	0.131	0.074	0.003	0.004	0.005
	Total	**24**	**35**	**60**	**0.095**	**0.191**	**3.450**	**0.004**	**0.005**	**0.058**
Fuel Processing	Hydrogen-3	115	123	93	0.234	0.222	0.194	0.002	0.002	0.002
	Plutonium	1	2	1	0.322	0.042	0.011	0.322	0.021	0.001
	Total	**116**	**125**	**94**	**0.556**	**0.264**	**0.205**	**0.005**	**0.002**	**0.002**
Fuel/Uranium Enrichment	Americium	1			0.055			0.055		
	Hydrogen-3	2			0.003			0.002		
	Other			1			0.017			0.017
	Technetium	2			0.006			0.003		
	Thorium			7			0.159			0.023
	Uranium	86	177	308	0.321	0.560	0.929	0.004	0.003	0.003
	Total	**91**	**177**	**316**	**0.385**	**0.560**	**1.105**	**0.004**	**0.003**	**0.003**
Maintenance and Support	Americium	3	4	6	0.039	0.015	0.104	0.013	0.004	0.017
	Hydrogen-3	78	81	55	0.238	0.399	0.142	0.003	0.005	0.003
	Mixed and Other	16	18	13	0.039	0.203	0.082	0.002	0.011	0.006
	Plutonium	16	25	25	7.690	0.293	**87.224** ◄	**0.481** ◄	0.012	**3.489** ◄
	Thorium	2	4	9	0.089	0.091	0.303	0.045	0.023	0.034
	Uranium	10	16	43	0.038	0.055	0.103	0.004	0.003	0.002
	Total	**125**	**148**	**151**	**8.133**	**1.056**	**87.958**	**0.065**	**0.007**	**0.583**
Other	Americium	4	2	5	0.297	0.055	0.262	0.074	0.028	0.052
	Hydrogen-3	80	45	31	0.313	0.195	0.119	0.004	0.004	0.004
	Mixed and Other	1	1	2	0.300	0.007	0.191	0.300	0.007	0.096
	Plutonium	5	5	10	0.378	0.360	1.229	0.076	0.072	0.123
	Radon-222	280	39	2	33.840	2.147	0.020	0.121	0.055	0.010
	Thorium	2			0.111			0.056		
	Uranium	141	190	42	0.601	13.726	0.409	0.004	0.072	0.010
	Total	**513**	**282**	**92**	**35.840**	**16.490**	**2.230**	**0.070**	**0.058**	**0.024**
Reactor	Hydrogen-3	287	212	136	1.433	0.949	0.761	0.005	0.004	0.006
	Total	**287**	**212**	**136**	**1.433**	**0.949**	**0.761**	**0.005**	**0.004**	**0.006**
Research, Fusion	Hydrogen-3	26	14	3	0.309	0.038	0.008	0.012	0.003	0.003
	Total	**26**	**14**	**3**	**0.309**	**0.038**	**0.008**	**0.012**	**0.003**	**0.003**
Research, General	Americium	8	3	6	0.828	0.111	0.129	0.104	0.037	0.022
	Hydrogen-3	44	31	37	0.500	0.336	0.602	0.011	0.011	0.016
	Mixed & Other	46	49	13	0.390	0.185	0.046	0.008	0.004	0.004
	Plutonium	11	4	8	1.391	1.465	21.108	0.126	0.366	2.639
	Radon-222			2			0.098			0.049
	Thorium		1			0.685			**0.685** ◄	
	Uranium	17	19	22	0.083	0.088	0.096	0.005	0.005	0.004
	Total	**126**	**107**	**88**	**3.192**	**2.870**	**22.079**	**0.025**	**0.027**	**0.251**
Waste Processing	Americium		2	16		0.013	0.479		0.007	0.030
	Hydrogen-3	15	20	9	0.028	0.058	0.016	0.002	0.003	0.002
	Mixed & Other		3			0.006			0.002	
	Plutonium	22	1	3	0.957	0.002	0.050	0.044	0.002	0.017
	Uranium	5	10		0.157	0.786		0.031	0.079	
	Total	**42**	**36**	**28**	**1.142**	**0.865**	**0.545**	**0.027**	**0.024**	**0.019**
Weapons Fab. and Testing	Americium		5			1.487			0.297	
	Hydrogen-3	14	23	27	0.051	0.150	0.105	0.004	0.007	0.004
	Mixed and Other		1	1		0.025	0.014		0.025	0.014
	Plutonium	38	64	76	4.825	17.015	3.398	0.127	0.266	0.045
	Uranium	**1,056** ◄	**1,228** ◄	**1,199** ◄	**34.168** ◄	**110.810** ◄	58.606	0.032	0.090	0.049
	Total	**1,108**	**1,321**	**1,303**	**39.044**	**129.487**	**62.123**	**0.035**	**0.098**	**0.048**
	Totals	**2,466**	**2,463**	**2,277**	**90.217**	**152.868**	**180.580**	**0.037**	**0.062**	**0.079**

* Intakes grouped by nuclide. Intakes involving multiple nuclides were grouped into "mixed". Nuclides where fewer than 10 individuals had intakes were grouped as "other".
** Individuals may be counted more than once.
Note: Arrowed values indicate the greatest value in each column.

In 2000, there were three individuals that received internal dose (CEDE) from plutonium intakes at LANL that were in excess of the DOE annual limit of 5 rem. These plutonium intakes are readily apparent in this exhibit. The highest dose was 87 rem at a Maintenance facility and the other two doses (11.5 rem and 9.4 rem) were reported under General Research. These three doses account for 60% of the collective CEDE for 2000. Thirty-two percent of the collective CEDE was due to uranium intakes at the Oak Ridge Y-12 Plant.

B-18a: Distribution of TEDE by Labor Category, 1998

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	>4	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	35											35	0%			
Construction	4,549	1,422	173	47	18	4						6,213	27%	1,664	90.422	0.054
Laborers	658	353	78	37	14	6	4					1,150	**43%** ◄	492	53.594	0.109
Management	10,612	1,215	122	43	9	4	2					12,007	12%	1,395	80.521	0.058
Misc.	10,499	1,947	254	57	12	2						12,771	18%	2,272	120.281	0.053
Production	2,717	1,351	266	117	36	10	3					4,500	40%	1,783	155.513	0.087
Scientists	24,359	2,512	200	53	11	6	2					27,143	10%	2,784	120.005	0.043
Service	3,468	531	116	13	3	2						4,133	16%	665	43.872	0.066
Technicians	5,994	1,877	607	308	104	14	9					8,913	33%	2,919	**356.160** ◄	**0.122** ◄
Transport	1,315	122	13	8	3							1,461	10%	146	9.521	0.065
Unknown	26,758	2,736	424	157	58	26	21	1			1	**30,182** ◄	11%	**3,424** ◄	279.197	0.082
Totals	**90,964**	**14,066**	**2,253**	**840**	**268**	**74**	**41**	**1**	**0**	**0**	**1**	**108,508**	**16%**	**17,544**	**1,309.086**	**0.075**

Note: Arrowed values indicate the greatest value in each column.

B-18b: Distribution of TEDE by Labor Category, 1999

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	>4	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	58	1										59	2%	1	0.020	0.020
Construction	5,008	1,255	141	57	16	3	8					6,488	23%	1,480	92.392	0.062
Laborers	781	222	38	17	4	3	1					1,066	27%	285	25.243	0.089
Management	10,954	1,574	129	31	10	6	5					12,709	14%	1,755	86.947	0.050
Misc.	8,477	1,613	223	107	30	17	10		1			10,478	19%	2,001	168.940	0.084
Production	2,827	1,592	343	186	67	48	26				1	5,090	**44%** ◄	2,263	**291.609** ◄	**0.129** ◄
Scientists	22,972	2,352	187	58	15	2	3					25,589	10%	2,617	120.966	0.046
Service	3,745	760	57	9	2			1				4,574	18%	829	36.828	0.044
Technicians	5,415	1,886	507	206	58	23	10					8,105	33%	**2,690** ◄	282.647	0.105
Transport	1,094	109	13									1,216	10%	122	4.408	0.036
Unknown	35,065	2,197	260	99	36	16	17					**37,690** ◄	7%	2,625	185.180	0.071
Totals	**96,396**	**13,561**	**1,898**	**770**	**238**	**118**	**80**	**1**	**1**	**0**	**1**	**113,064**	**15%**	**16,668**	**1,295.180**	**0.078**

Note: Arrowed values indicate the greatest value in each column.

B-18c: Distribution of TEDE by Labor Category, 2000

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	>4	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	56	1										57	2%	1	0.035	0.035
Construction	3,729	1,203	117	34	13	5	3					5,104	27%	1,375	73.837	0.054
Laborers	720	228	40	12		1						1,001	28%	281	17.825	0.063
Management	10,392	1,452	134	35	5	1	1					12,020	14%	1,628	74.672	0.046
Misc.	4,823	1,207	207	83	34	20	12					6,386	24%	1,563	147.378	0.094
Production	2,747	1,520	354	212	61	38	29					4,961	**45%** ◄	2,214	284.647	**0.129** ◄
Scientists	22,880	2,754	176	50	15	3	3					25,881	12%	**3,001** ◄	114.503	0.038
Service	3,629	588	60	8	2							4,287	15%	658	27.101	0.041
Technicians	5,551	1,848	574	213	61	20	7					8,274	33%	2,723	**290.474** ◄	0.107
Transport	1,091	103	8	1								1,203	9%	112	4.622	0.041
Unknown	31,280	2,116	203	79	20	3	3				3	**33,707** ◄	7%	2,427	231.440	0.095
Totals	**86,898**	**13,020**	**1,873**	**727**	**211**	**91**	**58**	**0**	**0**	**0**	**3**	**102,881**	**16%**	**15,983**	**1,266.534**	**0.079**

Note: Arrowed values indicate the greatest value in each column.

The Unknown labor category comprises 33% of the monitored individuals in 2000. This labor category typically represents subcontractors for whom detailed information, such as labor classification, may not be available. In addition, LANL reports all personnel under the Unknown labor category which accounts for 31% of the monitored individuals and 84% of the collective dose in this category.

B-19: Internal Dose by Labor Category, 1998 - 2000

Labor Category	Number of Individuals with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Construction	**488** ◀	537	453	7.808	22.710	8.269	0.016	0.042	0.018
Laborers	66	34	37	9.305	8.888	2.005	0.141	**0.261** ◀	0.054
Management	173	239	182	7.053	14.917	7.565	0.041	0.062	0.042
Misc.	253	70	88	4.829	5.408	2.077	0.019	0.077	0.024
Production	412	**563** ◀	**541** ◀	15.942	**63.049** ◀	23.883	0.039	0.112	0.044
Scientists	297	276	254	1.974	5.003	7.543	0.007	0.018	0.030
Service	80	73	56	0.925	3.071	1.828	0.012	0.042	0.033
Technicians	287	265	269	7.113	13.769	11.727	0.025	0.052	0.044
Transport	8	3	2	1.882	0.008	0.008	**0.235** ◀	0.003	0.004
Unknown	402	403	395	**33.386** ◀	16.045	**115.675** ◀	0.083	0.040	**0.293** ◀
Totals	**2,466**	**2,463**	**2,277**	**90.217**	**152.868**	**180.580**	**0.037**	**0.062**	**0.079**

* Only included intakes that occurred during the monitoring year. Individuals may be counted more than once.

Note: Arrowed values indicate the greatest value in each column.

Production staff had the largest number of individuals with measurable CEDE in 2000, the majority (72%) of which were monitored at the Oak Ridge Y-12 Plant. The Unknown labor category had the highest collective CEDE, primarily due to the three individuals that exceeded the 5 rem DOE annual limit at LANL from intakes of plutonium. These three individuals accounted for 93% of the collective CEDE in the Unknown labor category.

B-20: Dose Distribution by Labor Category and Occupation, 2000

Labor Category	Occupation	Less Than Meas.	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent with Meas.	No. with Meas.	Collective TEDE	Average Meas. TEDE
Agriculture	Groundskeepers	34											34	0%			
	Misc. Agriculture	22	1										23	4%	1	0.035	0.035
Construction	Carpenters	197	63	5	1								266	26%	69	2.656	0.038
	Electricians	883	314	22	4	3	1						1,227	28%	344	16.632	0.048
	Masons	22	5	1	1								29	24%	7	0.564	0.081
	Mechanics/Repairers	785	279	26	6	4	4	1					1,105	29%	320	20.328	0.064
	Miners/Drillers	46	1										47	2%	1	0.012	0.012
	Misc. Repair/Construction	1,346	367	26	17	6		2					1,764	24%	418	20.728	0.050
	Painters	114	31	4	1								150	24%	36	1.888	0.052
	Pipe Fitters	336	143	33	4								516	35%	180	11.029	0.061
Laborers	Handlers/Laborers/Helpers	720	228	40	12		1						1,001	28%	281	17.825	0.063
Management	Admin. Support and Clerical	4,124	794	76	9								5,003	18%	879	35.196	0.040
	Manager - Administrator	6,223	657	58	26	5	1	1					6,971	11%	748	39.463	0.053
	Sales	45	1										46	2%	1	0.013	0.013
Misc.	Military		4										4	**100%** ◄	4	0.172	0.043
	Miscellaneous	4,823	1,203	207	83	34	20	12					6,382	24%	1,559	147.206	0.094
Production	Machine Setup/Operators	125	178	36	15	3							357	65%	232	17.945	0.077
	Machinists	394	45	8	4		1						452	13%	58	4.757	0.082
	Misc. Precision/Production	375	191	62	61	29	20	6					744	50%	369	80.660	**0.219** ◄
	Operators, Plant/ System/Util.	1,669	1,042	242	132	29	17	23					3,154	47%	1,485	178.849	0.120
	Sheet Metal Workers	99	40	1									140	29%	41	1.252	0.031
	Welders and Solderers	85	24	5									114	25%	29	1.184	0.041
Scientists	Doctors and Nurses	151	9										160	6%	9	0.151	0.017
	Engineers	8,232	1,099	81	19	2							9,433	13%	1,201	43.085	0.036
	Health Physicists	481	148	12	1	1							643	25%	162	5.984	0.037
	Misc. Professionals	5,174	659	51	14	5	3						5,906	12%	732	31.419	0.043
	Scientists	8,842	839	32	16	7		3					9,739	9%	897	33.864	0.038
Service	Firefighters	516	41	1	2								560	8%	44	1.696	0.039
	Food Service Employees	41	4										45	9%	4	0.059	0.015
	Janitors	589	40	6	5	1							641	8%	52	4.216	0.081
	Misc. Service	497	71	11									579	14%	82	3.729	0.045
	Security Guards	1,986	432	42	1	1							2,462	19%	476	17.401	0.037
Technicians	Engineering Technicians	965	175	31	19	4	1	2					1,197	19%	232	22.100	0.095
	Health Technicians	218	48	17	6	1	4	1					295	26%	77	11.898	0.155
	Misc. Technicians	2,006	327	75	27	13	9						2,457	18%	451	46.489	0.103
	Radiation Monitors/Techs.	980	805	339	123	32	1	1					2,281	57%	1,301	146.766	0.113
	Science Technicians	334	101	31	7	5	2	3					483	31%	149	20.317	0.136
	Technicians	1,048	392	81	31	6	3						1,561	33%	513	42.904	0.084
Transport	Bus Drivers	20	1										21	5%	1	0.017	0.017
	Equipment Operators	205	58	6	1								270	24%	65	3.261	0.050
	Misc. Transport	349	16	2									367	5%	18	0.711	0.040
	Pilots	1											1	0%			
	Truck Drivers	516	28										544	5%	28	0.633	0.023
Unknown	Unknown	31,280	2,116	203	79	20	3	3				3	**33,707** ◄	7%	**2,427** ◄	**231.440** ◄	0.095
Totals		**86,898**	**13,020**	**1,873**	**727**	**211**	**91**	**58**	**0**	**0**	**0**	**3**	**102,881**	**16%**	**15,983**	**1,266.534**	**0.079**

Note: Arrowed values indicate the greatest value in each column.

The Unknown labor category comprises 33% of the monitored individuals in 2000. This labor category typically represents subcontractors for whom detailed information, such as labor classification, may not be available. In addition, LANL reports all personnel under the Unknown labor category, which accounts for 31% of the monitored individuals and 84% of the collective dose in this category. Miscellaneous Production personnel had the highest average measurable TEDE, which was also true in 1999. Rocky Flats comprises 82% of the collective dose in the Miscellaneous Production category.

B-21: Internal Dose Distribution by Site and Nuclide, 2000

Operations/ Field Office	Site	Nuclide	Number of Individuals Receiving Doses in Each Dose Range											Total Individuals with Meas. CEDE	Collective CEDE (person-rem)	Average CEDE (rem)
			Meas. -0.02	0.02-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0			
Albuquerque	Los Alamos National Lab (LANL)	Hydrogen-3	34	5										39	0.468	0.012
		Plutonium	1	1	1	3							3	9	**109.190** ◄	**12.132** ◄
		Uranium	41	1										42	0.158	0.004
	Pantex Plant (PP)	Mixed	1											1	0.014	0.014
	Sandia National Laboratory	Other	2											2	0.005	0.003
Chicago	Ops. and Other Facilities	Hydrogen-3	1											1	0.001	0.001
	Argonne National Lab - East (ANL-E)	Americium	6	4	1									11	0.306	0.028
		Hydrogen-3	12											12	0.014	0.001
		Mixed & Other	1		1									2	0.191	0.096
		Radon-222	3	1										4	0.118	0.030
		Plutonium	3	1										4	0.075	0.019
	Brookhaven National Lab (BNL)	Americium	9	5	1									15	0.516	0.034
		Other	1											1	0.002	0.002
		Hydrogen-3	6	7										13	0.299	0.023
Idaho	Idaho Site	Plutonium	1											1	0.011	0.011
		Uranium	3	3										6	0.105	0.018
Oakland	Lawrence Berkeley National Lab. (LBNL)	Hydrogen-3	16	3	1									20	0.354	0.018
	Lawrence Livermore National Lab. (LLNL)	Hydrogen-3	3											3	0.006	0.002
Oak Ridge	Oak Ridge Site	Hydrogen-3	4											4	0.015	0.004
		Other	12											12	0.046	0.004
		Uranium	817	535	118	27	5							**1,502** ◄	59.445	0.040
	Paducah	Thorium	3	4										7	0.159	0.023
		Uranium	2	2										4	0.072	0.018
	Portsmouth	Uranium	1											1	0.018	0.018
Ohio	Ops. and Other Facilities	Americium	3											3	0.007	0.002
		Other	8											8	0.017	0.002
		Uranium	24	5										29	0.292	0.010
		Plutonium	22											22	0.118	0.005
	Fernald Environmental Mgmt. Project	Thorium	20	15	7	4								46	3.376	0.073
		Uranium	13	1										14	0.074	0.005
	Mound Plant	Hydrogen-3	63	1										64	0.159	0.002
		Americium	1											1	0.012	0.012
		Plutonium		2										2	0.106	0.053
		Thorium	2	7										9	0.303	0.034
		Uranium	32											32	0.062	0.002
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	Plutonium	52	16	6			2						76	3.398	0.045
Richland	Hanford Site	Hydrogen-3	4											4	0.006	0.002
		Americium		3										3	0.078	0.026
		Mixed	2											2	0.002	0.001
		Plutonium	8	1										9	0.122	0.014
Savannah River	Savannah River Site (SRS)	Americium		1										1	0.070	0.070
		Hydrogen-3	234											234	0.717	0.003
		Other	1	1										2	0.073	0.037
Totals			**1,472**	**625**	**136**	**34**	**5**	**2**	**0**	**0**	**0**	**0**	**3**	**2,277**	**180.580**	**0.079**

Note: Arrowed values indicate the greatest value in each column.

This exhibit shows the two largest contributors to the collective internal CEDE at DOE in 2000. The three individuals involved in the plutonium event at LANL account for 60% of the collective CEDE. Thirty-two percent of the collective CEDE was due to uranium intakes at the Oak Ridge Y-12 Plant where a large number of individuals received relatively low doses from uranium.

B-22: Extremity Dose Distribution by Operations/Site, 2000

Operations	Site	No Meas. Dose	Meas. –0.1	0.1-1	1-5	5-10	10-20	20-30	>30	Total Monitored*	No. with Meas.	No. Above Monitoring Threshold. (5 rem)**	Collective Extremity Dose (person-rem)	Average Meas. Extremity Dose (rem)
Albuquerque	Albuquerque	772	2							774	2	-	0.096	0.048
	Grand Junction	30	8							38	8	-	0.186	0.023
	Los Alamos National Lab. (LANL)	10,035	177	218	39					10,469	434	-	152.165	0.351
	Pantex Plant (PP)	5,179	26	70	47	1				5,323	144	1	127.268	**0.884** ◄
	Sandia National Lab. (SNL)	2,931	18	28	6					2,983	52	-	23.388	0.450
Chicago	Chicago Operations	744	24							768	24	-	0.757	0.032
	Argonne Nat'l. Lab. - East (ANL-E)	2,649	140	24	9	1	1			2,824	175	2	48.030	0.274
	Argonne Nat'l. Lab. - West (ANL-W)	488	150	82	12	1				733	245	1	58.272	0.238
	Brookhaven National Lab. (BNL)	5,052	355	77						5,484	432	-	26.174	0.061
	Fermi Nat'l. Accelerator Lab. (FERMI)	1,358		1	2					1,361	3	-	2.630	0.877
DOE HQ	DOE Headquarters	146								146	-	-	-	-
Idaho	Idaho Site	4,737	663	188	12					5,600	863	-	100.525	0.116
Nevada	Nevada Test Site (NTS)	2,986	5	3	3					2,997	11	-	4.996	0.454
Oakland	Oakland Operations	74	152	1						227	153	-	1.188	0.008
	Lawrence Berkeley National Lab. (LBNL)	1,819	6	7	3					1,835	16	-	11.535	0.721
	Lawrence Livermore Nat'l. Lab. (LLNL)	9,062	14	33	10					9,119	57	-	38.090	0.668
	Stanford Linear Accelerator Center (SLAC)	2,424								2,424	-	-	-	-
Ohio	Ohio Field Office	851	49	22	41					963	112	-	82.990	0.741
	Fernald Environmental Mgmt. Project	3,453	9	2						3,464	11	-	0.709	0.064
	Mound Plant	1,016								1,016	-	-	-	-
	West Valley	786	199	51						1,036	250	-	21.430	0.086
Oak Ridge	Oak Ridge Operations	1,831								1,831	-	-	-	-
	Oak Ridge Site	13,691	35	97	39	2				**13,864** ◄	173	2	117.519	0.679
	Paducah Gaseous Diff. Plant (PGDP)	898	5	9						912	14	-	2.019	0.144
	Portsmouth Gaseous Diff. Plant (PORTS)	421								421	-	-	-	-
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	3,814	1,422	712	223	44	13			6,228	2,414	57	1,264.975	0.524
Richland	Hanford Site	7,569	1,502	722	191	33	23	8		10,048	2,479	**64** ◄	**1,459.794** ◄	0.589
Savannah River	Savannah River Site (SRS)	6,513	2,318	975	181	6				9,993	**3,480** ◄	6	764.792	0.220
	Totals	**91,329**	**7,279**	**3,322**	**818**	**88**	**37**	**8**	**0**	**102,881**	**11,552**	**133**	**4,309.528**	**0.373**

* Represents the total number of monitoring records. The number of individuals provided extremity monitoring cannot be determined.

** All extremity doses above 5 rem were for the upper extremities (hands and forearms). DOE annual limit for extremities is 50 rem. 10 CFR 835.402(a)(1)(ii) requires extremity monitoring for a shallow dose equivalent to the skin or extremity of 5 rem or more in a year.

Note: Arrowed values indicate the greatest value in each column.

The Oak Ridge Site reports the largest number of individuals monitored for extremity dose. However, Hanford, Rocky Flats, and Savannah River contribute 81% of the collective extremity dose. At Hanford, the majority of extremity dose is received by plant operations personnel.

Facility Type Code Descriptions

Appendix C

C

DOE M 231.1-1 [12] requires contractors to indicate for each reported individual the facility contributing the predominant portion of that individual's effective dose equivalent. In cases when this cannot be distinguished, the facility type indicated should represent the facility type wherein the greatest portion of work service was performed.

The facility type indicated must be one of 11 general facility categories shown in *Exhibit C-1*. Because it is not always a straightforward procedure to determine the appropriate facility type for each individual, the assignment of an individual to a particular facility type is a judgement by each contractor.

The facility descriptions that follow indicate the types of facilities included in each category. Also included are the types of work performed at the facilities and the sources of the majority of the radiation exposures.

Exhibit C-1: Facility Type Codes

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

See complete Facility Type descriptions shown in Appendix C.

Accelerator

The DOE administers approximately a dozen laboratories that perform significant accelerator-based research. The accelerators range in size from small single-room electrostatic devices to a 4-mile circumference synchrotron, and their energies range from keV to TeV.

In general, radiation doses received by occupational workers at accelerator facilities are largely attributable to the beta/gamma radiation emitted from the activated structural and mechanical components. The nature of the radiation fields and the magnitude of dose rates inside the primary shielding vary considerably depending upon the operational parameters of the machine, the types of particles accelerated, and the energies achieved. Doses received by personnel who enter the accelerator enclosures are dependent upon these factors. In many cases dependent upon the radiological conditions, personnel are prevented from entering the accelerator enclosures when the beam is operational. Outside of the shielding, exposure rates due to prompt radiation from the accelerator are typically very low. Average annual doses of exposed personnel at these facilities are comparable to the overall average for DOE. However, the collective dose is lower than the collective dose for most other DOE facilities categories because of the relatively small number of employees at accelerator facilities who work on or around the activated components. Regarding internal exposures, tritium and short-lived airborne activation products exist at some accelerator facilities, although annual internal doses are generally quite low.

Fuel/Uranium Enrichment

The DOE involvement in the nuclear fuel cycle generally begins with uranium enrichment operations and facilities. The current method of enrichment is isotopic separation using the gaseous diffusion process, which involves diffusing uranium through a porous membrane and using the different atomic weights of the uranium isotopes to achieve separation.

Although current facility designs and physical controls result in low doses from internally deposited uranium, the primary radiological hazard is the potential for inhalation of airborne uranium and transuranics from recycled uranium. Because of the low specific activity of uranium, external dose rates are usually a few millirem per hour or less. Most of the external doses that are received are attributable to gamma exposures, although neutron exposures can occur, especially when work is performed near highly enriched uranium.

Fuel Fabrication

Activities at fuel fabrication facilities involve the physical conversion of uranium compounds to usable forms, usually rod-shaped metal. Radiation exposures to personnel at these facilities are attributable almost entirely to gamma and beta radiation. However, beta radiation is considered the primary external radiation hazard because of high beta dose rates (up to several hundred mrad per hour) at the surface of uranium rods. For example, physical modification of uranium metal by various metalworking operations, such as machining and lathing operations, requires protection against beta radiation exposures to the skin, eyes, and extremities.

Fuel Processing

The DOE administers several facilities that reprocess spent reactor fuel. These facilities separate the plutonium produced in reactors. They also separate the fission products and uranium; the fission products are normally designated as radioactive waste products, while the uranium can be refabricated for further use as fuel.

Penetrating doses are attributable primarily to gamma photons, although some neutron exposures do occur. Skin and extremity doses can result from handling samples. Strict controls are in place at fuel reprocessing facilities to prevent internal depositions; however, several measurable intakes typically occur per year. Plutonium isotopes represent the majority of the internal depositions.

Maintenance and Support

Most DOE sites have facilities dedicated to maintaining and supporting the site. In addition, some employees may be classified under this facility type if their main function is to provide site maintenance and support, even though they may not be located at a single facility dedicated to that purpose.

The sources of ionizing radiation exposure are primarily gamma photons. However, variations in the types of work performed and work locations result in exposures of all types, including exposures to beta particles, x-rays, neutrons, and airborne radioactivity.

Reactor

The DOE and its predecessors have built and operated dozens of nuclear reactors since the mid-1940s. These facilities have included plutonium and tritium production reactors, prototype reactors for energy production, research reactors, reactors designed for special purposes such as production of medical radioisotopes, and reactors designed for the propulsion of naval vessels.

By 1992, many of the DOE reactors were not operating. As a result, personnel exposures at DOE reactor facilities were attributable primarily to gamma photons and beta particles from contaminated equipment and plant areas, spent reactor fuel, activated reactor components, and other areas containing fission or activation products encountered during plant maintenance and decommissioning operations. Neutron exposures do occur at operating reactors, although the resulting doses are a very small fraction of the collective penetrating doses. Gamma dose rates in some plant areas can be very high (up to several rems per hour), requiring extensive protective measures.

Research, General

The DOE contractors perform research at many DOE facilities, including all of the national laboratories. Research is performed in general areas including biology, biochemistry, health physics, materials science, environmental science, epidemiology, and many others. Research is also performed in more specific areas such as global warming, hazardous waste disposal, energy conservation, and energy production.

The spectrum of research involving ionizing radiation or radioactive materials being performed at DOE facilities results in a wide variety of radiological conditions. Depending on the research performed, personnel may be exposed to virtually any type of external radiation, including beta particles, gamma photons, x-rays, and neutrons. In addition, there is the potential for inhalation of radioactive material. Area dose rates and individual annual doses are highly variable.

Research, Fusion

DOE currently operates both major and small facilities that participate in research on fusion energy. In general, both penetrating and shallow radiation doses are minimal at these facilities because the dose rates near the equipment are both low and intermittent. The external doses that do occur are attributable primarily to x-rays from energized equipment.

Waste Processing/Management

Most DOE sites have facilities dedicated to the processing and disposal of radioactive waste. In general, the dose rates to employees when handling waste are very low because of the low specific activities or the effectiveness of shielding materials. As a result, very few employees at these facilities receive annual doses greater than 0.1 rem. At two DOE sites, however, large-scale waste processing facilities exist to properly dispose of radioactive waste products generated during the nuclear fuel cycle. At these facilities, radiation doses to some employees can be elevated, sometimes exceeding 1 rem/year. Penetrating doses at waste processing facilities are attributable primarily to gamma photons; however, neutron exposures also occur at the large-scale facilities.

Weapons Fabrication and Testing

The primary function of a facility in this category is to fabricate weapons-grade material for the production or testing of nuclear weapons. At these facilities, workers can receive neutron radiation dose when processing plutonium isotopes as well as penetrating dose from gamma photons and plutonium x-rays, and skin and extremity dose from plutonium x-rays. An additional pathway for radiation exposure at these facilities is the inhalation of plutonium, where the inhalation of material can result in some of the highest individual doses based on the calculation of the 50-year committed effective dose equivalent. To prevent plutonium intakes, strict controls are in place including process containment, contamination control procedures, and air monitoring and bioassay programs.

There are no DOE facilities currently involved in weapons testing. Several of the sites reporting under this category are no longer actively involved in weapons fabrication and testing, but are in the process of stabilization and waste management.

Other

Individuals included in this facility type can be generally classified under three categories: (1) those who worked in a facility that did not match one of the ten facility types described above; (2) those who did not work for any appreciable time at any specific facility, such as transient workers; or (3) those for whom facility type was not indicated on the report forms. Examples of a facility type not included in the ten described above include construction and irradiation facilities. Although exposures to gamma photons are predominant, some individuals may be exposed to beta particles, x-rays, neutrons, or airborne radioactive material.

Appendix D
Limitations of Data

The following is a description of the limitations of the data currently available in the DOE Radiation Exposure Monitoring System (REMS). While these limitations have been taken into consideration in the analysis presented in this report, readers should be alert to these limitations and consider their implications when drawing conclusions from these data.

Individual Dose Records vs Dose Distribution

Prior to 1987, exposure data were reported from each facility in terms of a statistical dose distribution wherein the number of individuals receiving a dose within specific dose ranges was reported. The collective dose was then calculated from the distribution by multiplying the number of individuals in each dose range by the midpoint value of the dose range. Starting in 1987, reports of individual exposures were collected that recorded the specific dose for each monitored individual. The collective dose can be accurately determined by summing the total dose for each individual. The dose distribution reporting method prior to 1987 resulted in up to a 20% overestimation of collective dose. The reason is that the distribution of doses within a range is usually skewed toward the lower end of the range. If the midpoint of the range is multiplied by the number of people in the range, the product overestimates the collective dose. This overestimation only affects the data prior to 1987 presented in Appendix B-4, B-5, and B-6.

The dose distributions presented in this report are based on the individual dose records reported to REMS. Individuals may be counted more than once as some sites report multiple dose records for an individual that visits the site more than once, or the individual may visit more than one site during the year. (See Section 3.6).

Monitoring Practices

Radiation monitoring practices vary from site to site and are based on the radiation hazards and work practices at each site. Sites use different dosimeters and have different policies to determine which workers are monitored. All sites have achieved compliance with the DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurements. The number of monitored individuals can significantly impact the site's collective dose. Some sites supply dosimeters to virtually all workers. While this tends to increase the number of monitored workers with no dose, it also can add an increased number of very low dose workers to the total number of workers with measurable dose, thereby lowering the site's average measurable dose. Even at low doses, these workers increase the site's collective dose. In contrast, other sites only monitor workers who exceed the monitoring requirement threshold (as specified in 10 CFR 835.402). This tends to reduce the number of monitored workers and reports only those workers receiving doses above the monitoring threshold. This can decrease the site's collective dose while increasing the average measurable dose.

AEDE vs CEDE

Prior to 1989, intakes of radionuclides into the body were not reported as dose, but as body burden in units of activity of systemic burden. The implementation of DOE Order 5480.11 in 1989 specified that the intakes of radionuclides be converted to internal dose and reported using the Annual Effective Dose Equivalent (AEDE) methodology. The AEDE methodology requires the calculation of the summation of dose for all tissues and organs multiplied by the appropriate weighting factor for a specified year. In addition to the calculation of AEDE, the DOE required the reporting of the Total Effective Dose Equivalent (TEDE) which is the summation of the external whole body dose and the AEDE from 1989 through 1992.

With the implementation of the RadCon Manual in 1993, the required methodology used to calculate and report internal dose was changed from the AEDE to the 50-year CEDE. The CEDE represents the dose equivalent delivered to all organs and tissues over the next 50 years and the 50 year CEDE is reported to REMS and assigned to the individual in the year of intake. The change was made to provide consistency with scientific recommendations, facilitate the transfer of workers between DOE and NRC regulated facilities, and simplify record keeping by recording all dose in the year of intake. The CEDE methodology is now codified in 10 CFR 835. From 1993 to the present, the TEDE is defined as the summation of the Deep Dose Equivalent (DDE) to the whole body and the CEDE.

This report primarily analyzes dose information for the past 5 years, from 1996 to 2000. During these years, the CEDE methodology was used to calculate internal dose; therefore, the change in methodology from AEDE to CEDE between 1992 and 1993 does not affect the analysis contained in this report. Readers should keep in mind the change in methodology if analyzing TEDE data prior to 1993 in Exhibit B-4 through Exhibit B-6.

Occupation Codes

Each individual's dose record includes the occupation code for the individual while he worked at the DOE site during the monitoring year. Occupational codes typically represent the occupation the individual held at the end of the calendar year and may not represent the occupation where the majority of dose was received if the individual held multiple occupations during the year. The occupation codes are very broad categorizations and are grouped into nine general categories. Each year a percentage (up to 20%) of the occupations is listed as unknown, or as miscellaneous. The definitions of each of the labor categories are subject to interpretation by the reporting organization and/or the individual's employer.

Facility Type

The facility type is also recorded with each dose record for the monitoring year. It is intended to reflect the type of facility where the individual received most of their occupational radiation exposure during the monitoring year. While the facility types are clearly defined (see Appendices A and C), the reporting organizations often have difficulty tracking which facility type contributed to the majority of the individual's exposure. Certain individuals tend to work in the proximity of several different facility types throughout the monitoring year and are often included in the "Maintenance and Support (Site-wide)" facility type. The facility type for temporary contract workers and visitors is often not reported and is defaulted to "unknown."

In addition to these uncertainties, the phase of operation of the facility types is not currently reported. A facility type of "accelerator" may be reported when in fact, the accelerator has not been in operation for a considerable time and may be in the process of stabilization, decommissioning, or decontamination. In addition, several sites have commented that they have difficulty assigning the facility type, because many of the facilities are no longer operational. For example, some sites commented that a reactor that is being decommissioned is no longer considered a "reactor" facility type. Other sites continue to categorize a facility based on the original intent or design of the facility, regardless of its current status.

DOE Headquarters will be reviewing the Facility Type codification scheme and modifying the reporting requirements to standardize the use of facility type classifications and improve the quality of the data and the data analysis. DOE will also pursue the usefulness of collecting data on the operational phase of facilities with end-users of this report.

Organization Code

Facilities report data to the central repository based on an "organization code." This code identifies the Operations or Field Office, the reporting facility, and the contractor or subcontractor that is reporting the exposure information. The organization code changes over time as DOE Offices are reorganized. In some cases, new Operations or Field Offices are created, in other cases a Field Office may change organizations and begin reporting with another Field Office. An example of this change is that the Mound Plant and West Valley Project changed Operations Office during the past 3 years and are now shown under the Ohio Field Office. Footnotes indicate the change in Operations Offices.

Occurrence Reports

Occurrence reports involving radiation exposure and personnel contamination events are additional indicators of the effectiveness of radiation protection efforts at DOE. These events will continue to be analyzed and presented in this report.

Additional Data Requirements

To provide analysis of the activities at DOE sites with respect to radiation exposure (see Section 3.5), it is necessary to augment the information reported to the REMS database. For the past 5 years, DOE Headquarters has requested additional information from the six sites with the highest collective dose. This information includes a summary of activities, project descriptions, and ALARA planning documentation. DOE Headquarters will continue to request this information in subsequent years. It is recommended that sites submit this information with their annual records.

Naval Reactor Facilities

The exposure information for the Schenectady and Pittsburgh Naval Reactor facilities is not included in this report. Readers should note that the dose information for the overall DOE complex presented in this report may differ from other reports or sources of information because of the exclusion of these data.

Exposure information for Naval Reactor programs can be found in the most recent version of the following series of reports (where XX represents the report year):

- NT-XX-2 – "Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities",
- NT-XX-3 – "Occupational Radiation Exposure from U.S. Naval Reactors' Department of Energy Facilities".

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Access to Radiation Exposure Information

Appendix E

E

Access to Radiation Exposure Information

Radiation Exposure Monitoring System

The data used to compile this report were obtained from the DOE Radiation Exposure Monitoring System (REMS), which serves as the central repository of radiation exposure information for DOE Headquarters. The database consists of individual monitoring records of occupational exposure for DOE workers from 1987 to the present. In 1995, REMS underwent an extensive redesign effort in combination with the efforts involved in revising the annual report. One of the main goals of the redesign effort is to allow researchers better access to the REMS data. However, there is considerable diversity in the goals and needs of these researchers. For this reason, a multi-faceted approach has been developed to allow researchers flexibility in accessing the REMS data.

A brief summary of the methods of accessing REMS information is shown in *Exhibit E-1*.

Exhibit E-1 lists the various ways of accessing the DOE radiation exposure information contained in REMS. A description is given for each access method as well as requirements for access. To obtain further information, a contact name and phone number are provided.

The data contained in the REMS system are subject to periodic update. Data for the current or previous years may be updated as corrections or additions are submitted by the sites. For this reason, the data presented in published reports may not agree with the current data in the REMS database. These updates typically have a relatively small impact on the data and should not affect the general conclusions and analysis of the data presented in this report.

Comprehensive Epidemiologic Data Resource

Of interest to researchers in radiation exposure are the health effects associated with worker exposure to radiation. While the health effects from occupational exposure are not treated in this report, it has been extensively researched by DOE. The Comprehensive Epidemiologic Data Resource (CEDR) serves as a central resource for radiation health effects studies at the DOE.

Epidemiologic studies on health effects of radiation exposures have been supported by the DOE for more than 30 years. The results of these studies, which initially focused on the evaluation of mortality among workers employed in the nuclear weapons complex, have been published in scientific literature. However, the data collected during the conduct of the studies were not widely shared. CEDR has now been established as a public-use database to broaden independent access and use of these data. At its introduction in 1993, CEDR included primarily occupational studies of the DOE workforce, including demographic, employment, exposure, and mortality follow-up information on more than 420,000 workers. The program's holdings have been expanded to include data from both occupational and historical community health studies, such as those examining the impact of fallout from atmospheric nuclear weapons testing, community dose reconstructions, and data from the decades of follow-up on atomic bomb survivors.

CEDR accomplishes this by a hierarchical structure that accommodates analysis and working files generated during a study, as well as files of documentation that are critical for understanding the data. CEDR provides easy access to its holdings through the Internet or phone and mail interchanges, and provides an extensive catalog of its holdings. CEDR has become a unique resource comprising the majority of data that exist on the health risks of occupational radiation exposure.

For further information about CEDR, access the CEDR internet web page at:

http://cedr.lbl.gov

Or the CEDR Program Manager may be contacted at:

barbara.brooks@eh.doe.gov

Exhibit E-1: Methods of Accessing REMS Information

REMS Information Access Method	Information Available	Eligibility Requirements	Software Requirements	To Get Access
Hardcopy Annual Report	*Analysis and data for annual occupational exposure information, primarily for the past 5 years. Tables and graphs present data and trends for the most commonly asked questions concerning exposure information at DOE facilities.*	***None.***	***None.***	*Contact EH-52* to request that you be added to the Annual Report mailing list.*
Web Page	• *Annual reports from1992 to the most recent report.* • *Information on reporting exposure data to DOE.* • *How to request information from REMS.* • *A query tool for extracting summary data from REMS.* • *DOE Orders and Standards on radiation exposure.* • *Links to other related sites.*	***None.***	*Internet access. Web browser client software.*	*Connect to http://rems.eh.doe.gov*
Access to REMS database	*Individual annualized dose records submitted to REMS from 1987 to the present. In addition, dose records are available for individuals who terminated employment at a DOE facility from 1969 to 1986.*	*Records are subject to the privacy Act of 1974. Records are only available to researchers within DOE or other governmental agency upon approval by the REMS Project Manager in accordance with System of Records #35. Contact the REMS Project Manager* for further information on accessing individual dose records in REMS.*	*Internet access (TCP/IP). Oracle SQLNet and encryption software (provided). Database access tool for querying data that can connect to an Oracle database.*	*Contact EH-52* to request access.*

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