DOE Occupational Radiation Exposure

2005 Report

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DEPARTMENT OF ENERGY • UNITED STATES OF AMERICA

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DOE Occupational Radiation Exposure

2005 Report

The U.S. Department of Energy
Office of Health, Safety and Security
Office of Corporate Safety Analysis

#

Foreword

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One of the priorities of the U.S. Department of Energy (DOE) is to ensure the health, safety, and security of DOE employees, contractors, and subcontractors. To provide the corporate-level leadership and strategic vision necessary to better coordinate and integrate health, safety, environment, security, enforcement, and independent oversight programs, the Secretary of Energy officially established the office of Health, Safety and Security (HSS) on August 30, 2006. The HSS is committed to excellence in protecting the health and safety of our workers, the public, the environment, and our national security assets.

A key safety focus for DOE is to maintain radiation exposures of 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 *2005 DOE Occupational Radiation Exposure Report* provides a summary and analysis of the occupational radiation exposure received by individuals associated with DOE activities. This report is intended to be a valuable tool for managing radiological safety programs, epidemiologists, researchers, and national and international agencies involved in developing policies to protect individuals from harmful effects of radiation. The overall radiation dose decreased during 2005 in terms of the collective dose and average dose. A primary reason for this decrease was a reduction in activities involving radioactive materials due to completion of several major projects and the closure of Rocky Flats. In addition to the reduction in the overall collective dose, fewer individuals received doses at higher dose levels. No one received doses in excess of DOE limits.

One of the objectives of this report is to provide timely, useful, accurate, and complete information to its target audience. As part of a continuing improvement process, we would like to evaluate the process in order to streamline data collection, analysis and report generation. We would appreciate your response to the user survey included in Appendix A to assist us in making this report better meet your needs.

Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

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LIST OF EXHIBITS

TABLE OF ACRONYMS

10 CFR 835	Title 10 Code of Federal Regulations Part 835 "Occupational Radiation Protection," December 14, 1993
10 CFR 835, Amendment	Issued on November 4, 1998
ACL	Administrative Control Level
AEDE	Annual Effective Dose Equivalent
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
BNL	Brookhaven National Laboratory
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DOE	Department of Energy
DOE Manual 231.1-1A	Manual for Environment, Safety and Health Reporting, March 19, 2004
DOE Order 231.1A	Environment, Safety and Health Reporting, August 19, 2003
ETGS	Encapsulation Technology Glycerin Solution
Fermilab	Fermi National Accelerator Laboratory
HPT	Health Physics Technician
INEEL	Idaho National Engineering & Environmental Laboratory
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LAW	Large Area Wipes
LBNL	Lawrence Berkeley National Laboratory
LDC	Large Diameter Containers
LDE	Lens (of the Eye) Dose Equivalent
LLNL	Lawrence Livermore National Laboratory
mSv	Millisieverts
NLOP	North Load Out Pit
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORP	Office of River Protection
PGDP	Paducah Gaseous Diffusion Plant
PORTS	Portsmouth Gaseous Diffusion Plant
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
SNL	Sandia National Laboratory
SRS	Savannah River Site
Sv	Sieverts
TEDE	Total Effective Dose Equivalent
TODE	Total Organ Dose Equivalent
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WIPP	Waste Isolation Pilot Plant
Y-12 NSC	Y-12 National Security Complex

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Executive Summary

The U.S. Department of Energy (DOE) Office of Corporate Safety Analysis (HS-30) within the Office of Health Safety and Security (HSS) publishes the annual *DOE Occupational Radiation Exposure Report* to provide an overview of the status of radiation protection practices at DOE*. This report provides a summary and an analysis of occupational radiation exposure information for all monitored individuals associated with the DOE activities. The occupational radiation exposure information is analyzed in terms of aggregate data, dose to individuals, and dose by site over the past 5 years.

One of the report's features includes the collective total effective dose equivalent (TEDE)—an indicator of the overall amount of radiation dose received while conducting operations at the DOE. The DOE collective TEDE decreased by 10% between the years 2004 and 2005 as shown in *Exhibit ES-1*. This is the second consecutive year that the collective TEDE has decreased. The decrease in 2005 is due primarily to decreases in the amount of work performed that directly involves radioactive materials. In addition, several facilities completed cleanup operations and, therefore, no longer contribute to worker exposure. One of the largest reasons for the reduction of dose in the past 2 years has been the closure of Rocky Flats.

The TEDE is comprised of the external deep dose equivalent (DDE) which includes neutron and photon radiation, and the internal committed effective dose equivalent (CEDE) which results from the intake of radioactive material into the body. All of the components of the collective TEDE (photon, neutron, and CEDE) decreased from 2004 to 2005.

Another primary indicator of the level of radiation exposure covered in this report is the average measurable dose, which normalizes the collective dose over the population of workers that actually received a measurable dose. The average measurable dose decreased by 13% from 2004 to 2005, as shown in *Exhibit ES-2* and is the lowest value in the past five years. The number of individuals that received a measurable dose increased, while the collective dose decreased, so that on average, individuals received a lower average dose.

Exhibit ES-1:
Collective TEDE (person-rem), 2001–2005.

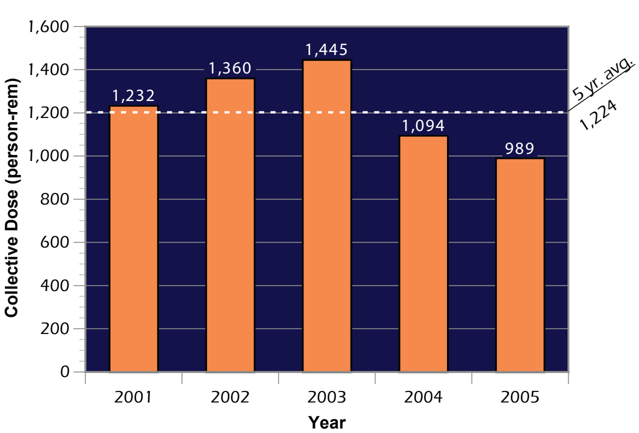
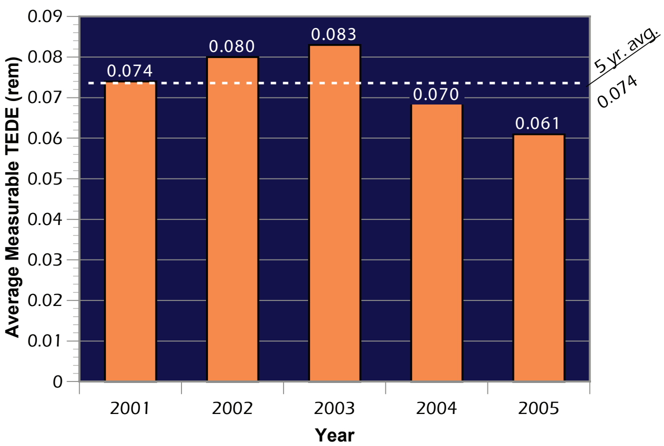


Exhibit ES-2:
Average Measurable TEDE (rem), 2001–2005.



* DOE is defined to include the National Nuclear Security Administration sites.

Additional analysis shows that there were fewer individuals receiving doses at the higher dose levels in 2005, thereby confirming that workers received lower doses on an individual basis. No individuals received a dose in excess of the annual occupational limits during 2005. One individual received an exposure in excess of the DOE administrative control level of 2 rem, down from the two individuals reported in 2004.

In conclusion, the assessment of occupational radiation exposure for 2005 shows a declining trend in collective, average, and individual doses. While the reduction in activities involving radiation at DOE sites is a primary factor in the decline in dose, it is also shown that the remaining work was performed at lower individual doses and well within the DOE occupational dose limits.

To access this report and other information on occupational radiation exposure at DOE, visit DOE's Health, Safety and Security web site at

http://www.hss.energy.gov

Select "HSS Reporting Databases" from the HSS Quick Reference, and then select the Radiation Exposure Monitoring System (REMS).

Section One

Introduction

1

Introduction

The *U.S. Department of Energy (DOE) Occupational Radiation Exposure Report, 2005*, reports occupational radiation exposures incurred by individuals at DOE facilities during the calendar year 2005. This report includes occupational radiation exposure information for all DOE employees, contractors, and subcontractors, as well as members of the public who are monitored for exposure to radiation. The 101 DOE organizations submitting radiation exposure reports for 2005 have been grouped into 26 geographic sites across the complex. 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. This year, in an effort to further streamline the printed report, most of the supporting technical information, tables of data, and additional items that were previously provided in the report and the appendices will be available on DOE's Web page for "Information on Occupational Radiation Exposure."

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 and suggestions and comments should be directed to

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1000 Independence Avenue, SW
Washington, D.C. 20585-0270
E-mail: nimi.rao@hq.doe.gov

Visit the DOE Web page at http://www.hss.energy.gov for more information on occupational radiation exposure, such as the following:

- Annual Occupational Radiation Exposure Reports in pdf format since 1974
- Guidance on reporting radiation exposure information to the DOE Headquarters REMS repository
- Guidance on how to request a dose history for an individual
- Statistical data since 1987 for analysis
- Applicable DOE Orders and Manuals for the recordkeeping and reporting of occupational radiation exposure at DOE
- ALARA activities at DOE

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.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 2005. The data are analyzed to show trends over the past 5 years.
Section Four	Includes instructions to submit successful ALARA projects within the DOE complex.
Section Five	Presents conclusions based on the analysis contained in this report.
Appendices	In an effort to streamline this publication, the appendices are now offered in color on the DOE Radiation Exposure Web site. Please visit http://www.hss.energy.gov and select "Annual Reports" to review.

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Section Two

Standards and Requirements

2

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 Health, Safety and Security establishes comprehensive and integrated programs for the protection of workers from hazards, including ionizing radiation, in the workplace. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and members of the public. In addition to the requirement that radiation doses not exceed the limits, contractors and subcontractors are required to maintain exposures as low as reasonably achievable (ALARA).

This section discusses the radiation protection standards and requirements in effect for the year 2005. For more information on past requirements, visit DOE's Web page for "Information on Occupational Radiation Exposure" at http://www.hss.energy.gov.

2.1 Radiation Protection Requirements

Current 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] 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 recommends that internal organ dose 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.

In summary, the current laws and requirements for occupational radiation protection pertaining to the information collected and presented in this report are shown in *Exhibit 2-1*.

Exhibit 2-1:
Current Laws and Requirements Pertaining to This Report.

Title	Date	Description
10 CFR 835 "Occupational Radiation Protection." [4]	Issued 12/14/93. Amended 11/4/98.	Establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.
DOE Order 231.1A [5]	Approved 8/19/03. Cancelled DOE O 231.1.	Requires the annual reporting of occupational radiation exposure records to the DOE Radiation Exposure Monitoring System (REMS) Repository.
DOE Manual 231.1-1A [6]	Approved 3/19/04. Cancelled DOE M 231.1-1.	Specifies the format and content of the reports required by DOE Order 231.1A. Readers should note that the revisions of this manual affect the content and reporting of radiation exposure records that will be reported to the DOE REMS Repository in March 2006.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835.202, 206, 207, and 208 and are summarized in *Exhibit 2-2*.

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 2-2*. With the appropriate prior authorization, the annual dose limit for an individual may be increased by an additional 5 rem [50 millisievert (mSv)] TEDE above the routine dose limit as long as the individual does not exceed a cumulative lifetime TEDE of 25 rem (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 since the requirement became effective.

2.3 Reporting Requirements

On August 19, 2003, DOE approved and issued the revised DOE Order 231.1A. The DOE Manual 231.1-1A, which details the format and content of reporting radiation exposure records to the DOE, was approved on March 19, 2004. The revisions affect the content and reporting of radiation exposure records for the 2005 monitoring year. This report is the first report in the series to include data from the new DOE Manual 231.1-1A. However, it should be noted that several DOE sites were not yet required to report under the revised requirements, as they were exempted due to imminent closure or an undue impact on the dosimetry program at sites with relatively small numbers of monitored individuals. Ninety-two out of the one hundred and one organizations reported under the revised Manual 231.1-1A, while the remaining nine organizations reported under the previous DOE Manual 231.1-1. Ninety-three percent of the monitored individuals were reported under the revised manual.

Exhibit 2-2:
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 rem
		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 rem
		Lens (of the eye) dose equivalent	LDE	15 rem
		Shallow dose equivalent to the skin of the whole body or to any extremity	SDE-WB and SDE-ME	50 rem
Declared pregnant workers*	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.

Section Three

Occupational Radiation Dose at DOE

3

Occupational Radiation Dose at DOE

3.1 Analysis of the Data

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. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

Key indicators for the analysis of aggregate data are number of records for monitored individuals and individuals with measurable dose, collective dose, average measurable dose, and 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 administrative control level (ACL). Additional information is provided concerning activities at sites contributing to the collective dose.

3.2 Analysis of Aggregate Data

3.2.1 Number of Records for Monitored Individuals

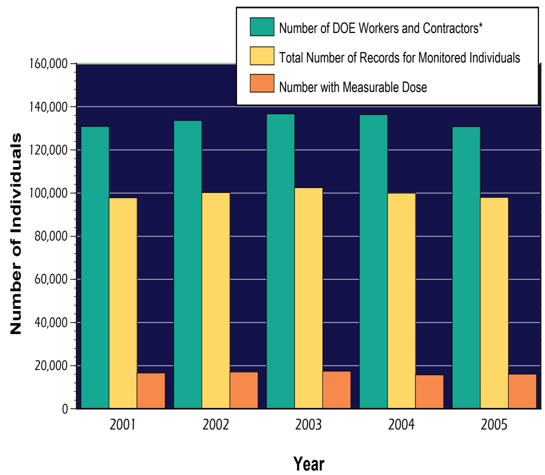
The number of records for monitored individuals represents the size of the DOE worker population provided with radiation dose monitoring. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, and subcontractors, as well as members of the public. The number of monitored individuals is determined from the number of monitoring records submitted by each site. Because individuals may have more than one monitoring record, they may be counted more than once. Although an individual may be counted more than once, the overall effect on the numbers and analysis is minimal. The number of records for 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 radiation dose monitoring 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, the number of records for workers who receive a measurable dose best represents the exposed workforce.

3.2.2 Number of Records for 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.

Exhibits 3-1a and *3-1b* show the number of DOE and contractor workers, the total number of workers monitored for radiation dose, the number of individuals with measurable dose, and the relative percentages for the past 5 years. For 2005, 75% of the DOE workforce was

Exhibit 3-1a:
Monitoring of the DOE Workforce, 2001–2005.



*The number of DOE and contractor workers was determined from the total annual workhours at DOE (Ref. #7) converted to full-time equivalents (FTEs).

For 2005, 75% of the DOE workforce was monitored for radiation dose, and 16% of monitored individuals received a measurable dose .

monitored for radiation exposure. Sixteen percent of monitored individuals received a measurable dose, and 84% of the monitored individuals did not receive any measurable radiation dose. Over the past five years, the percentage of individuals monitored for radiation exposure has remained within 2% of the five-year average; the percentage of monitored individuals receiving any measurable radiation dose each year was within 1% of the five-year average. The size of the overall DOE workforce each year has been within 3% of the five-year average.

Fourteen of the 26 reporting sites experienced decreases in the number of workers with measurable dose from 2004 to 2005. The largest decrease in total number of workers with measurable dose occurred at the Savannah River Site. The largest increase in the number of workers receiving measurable dose occurred at the Idaho National Laboratory. A discussion of activities at the highest-dose facilities is included in Section 3.4.3.

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 [person-sieverts (Sv)]. The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and subcontractors, as well as members of the public. 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 10% from 1,094 person-rem (10.94 person-Sv) in 2004 to 989 person-rem (9.89 person-Sv) in 2005. Only 31% of the DOE sites (8 out of 26 sites) reported increases in the collective TEDE from the 2004 values. Three out of five of the sites that contributed to the majority of the DOE collective TEDE in 2005 reported decreases in the collective TEDE. The sites are (in descending order of collective dose for 2005) Hanford, Idaho, Los Alamos, Savannah River, and Oak Ridge.

These highest-dose sites attributed decreases in the collective dose to the following:

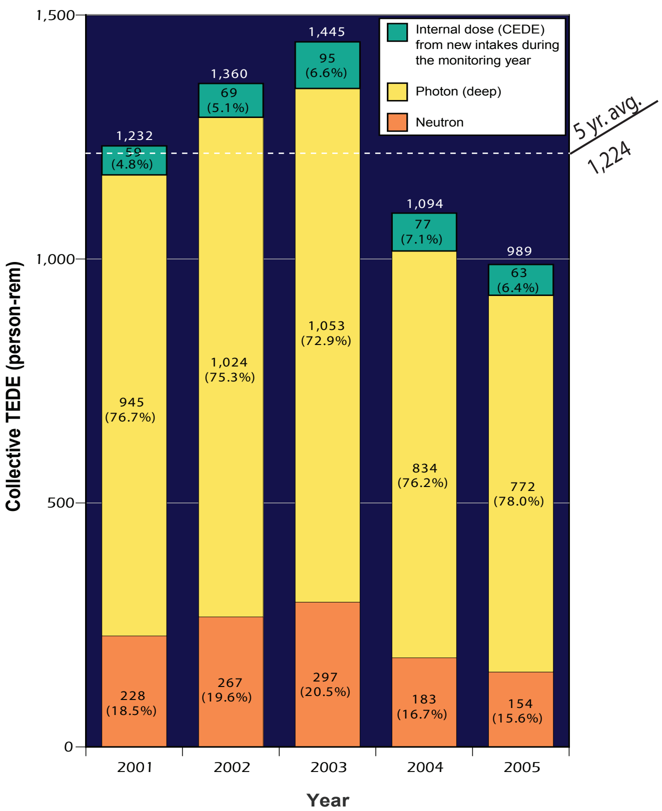
- ❖ Inactive sites were removed from the inventory and the completion of several projects ahead of schedule at plutonium facilities at the Savannah River Site
- ❖ Decrease in the amount of work performed for the TVA Off-Specification Fuel Repackaging Project at the Oak Ridge Y-12 NSC
- ❖ Decrease in dose as a result of the completion of plutonium stabilization activities at the Plutonium Finishing Plant at Hanford (See Section 3.4.3.)

Exhibit 3–1b:
Monitoring of the DOE Workforce, 2001-2005.

Year	DOE & Contractor Workforce	Number of Workers Monitored	Percent of Workers Monitored	Number Monitored w/Measurable Dose	Percent Monitored w/Measurable Dose
2001	130,884	97,818	75% ▼	16,687	17% ▲
2002	133,703	100,221	76% ▲	17,051	17%
2003	136,710	102,509	75% ▼	17,484	17%
2004	136,353	100,011	73% ▼	15,739	16% ▼
2005	130,795	98,040	75% ▲	16,136	16%
5-Year Average	**133,689**	**99,720**	**75%**	**16,619**	**17%**

Note: Up arrows indicate an increase from the previous year's value. Down arrows indicate a decrease from the previous year's value.

Exhibit 3–2:
Components of TEDE, 2001-2005.



Note: The percentages in parentheses represent the percentage of each dose component to the collective TEDE.

The collective TEDE decreased by 10% at DOE from 2004 to 2005.

The collective internal dose decreased by 18% from 2004 to 2005.

Neutron dose decreased by 16% from 2004 to 2005.

Photon dose decreased by 7% from 2004 to 2005.

Photon dose (deep)—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.

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. Internal dose, photon, and neutron components are shown.

It should be noted that the internal dose shown in *Exhibit 3-2* for 2001 through 2005 is based on the 50-year CEDE methodology. The internal dose component decreased by 18% from 77 person-rem (770 person-mSv) in 2004 to 63 person-rem (630 person-mSv) in 2005. The collective internal dose can vary from year to year due to the relatively small number of intakes of radioactive material and the fact that the intakes often involve long-lived radionuclides, such as plutonium, which can result in relatively large committed doses. Due to the infrequent nature of these intakes, care should be taken when attempting to identify trends from the internal dose records.

The external deep dose (comprised of photon, energetic beta, and neutron dose) is shown in *Exhibit 3-2* in order to see the contribution of external dose to the collective TEDE. The collective photon dose decreased by 7% from 834 person-rem (8.34 person-Sv) in 2004 to 772 person-rem (7.72 person-Sv) in 2005. The site that reported the largest increase in the external deep dose (Idaho) attributed the increase to cleanup/decontamination and decommissioning (D&D) work at Idaho Nuclear Technology and Engineering Center (INTEC) and Test Area North (TAN).

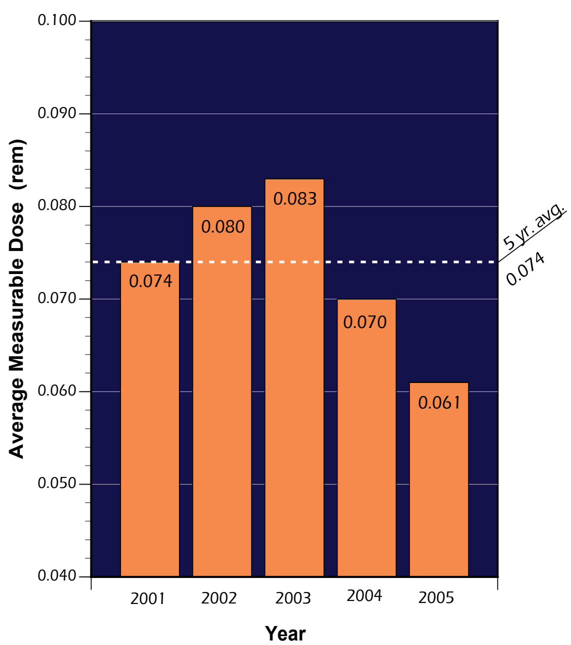
The neutron component of the TEDE decreased by 16% from 183 person-rem (1.83 person-Sv) in 2004 to 154 person-rem (1.54 person-Sv) in 2005. This is due primarily to decreases in the neutron dose at Savannah River Site (SRS) and Hanford. SRS and Hanford process plutonium, which can result in a neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium.

3.2.4 Average Measurable Dose

The average measurable dose to DOE workers presented in this report for TEDE and CEDE is 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 TEDE is shown in *Exhibit 3-3*. The average measurable TEDE decreased from 0.070 rem (0.70 mSv) in 2004 to 0.061 rem (0.61 mSv) in 2005. The average measurable TEDE in 2005 is the lowest value in the past 5 years and the lowest value recorded in the occupational dose reports since 1974. 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.

Exhibit 3-3:
Average Measurable TEDE, 2001–2005.



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 number of individuals receiving doses above 0.1 rem (1 mSv) is 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 received doses in the higher ranges, that the vast majority of doses are at low levels, and that the collective TEDE increased from 2001 to 2003 but decreased from 2003 to 2005. Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value as compared to the total collective dose.

The United Nations' *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes, Volume I [8]* recommends the calculation of a parameter "SR" (previously referred to as CR) to aid in the examination of the distribution of radiation exposure 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, 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 shown in Exhibit 3-5 were calculated by summing the TEDE to each individual who received a TEDE greater than or equal to the specified dose level divided by the total collective TEDE. This ratio is presented as a percentage rather than a decimal fraction.

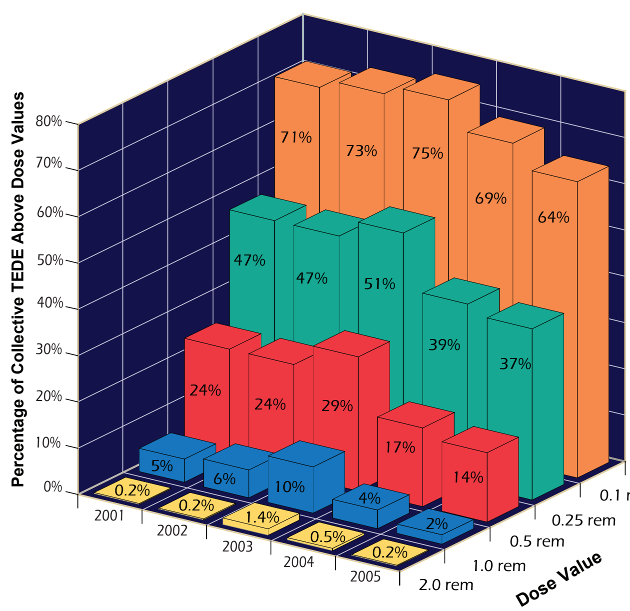
Exhibit 3-4:
Distribution of TEDE by Dose Range, 2001–2005.

	TEDE Range (rem)	2001	2002	2003	2004	2005
Number of individuals in each dose Range*	Less than measurable	81,131	83,170	85,025	84,272	81,904
	measurable < 0.1	13,559	13,500	13,865	12,700	13,537
	0.10 - 0.25	1,891	2,202	2,205	2,086	1,753
	0.25 - 0.5	840	919	910	703	644
	0.5 - 0.75	259	269	287	157	141
	0.75 - 1.0	89	95	117	63	42
	1 - 2	48	65	97	28	18
	2 - 3	1	1	1	1	1
	3 - 4				1	
	4 - 5					
	5 - 6					
	6 - 7					
	7 - 8					
	8 - 9			1		
	9 - 10					
	10 - 11			1		
	11 - 12					
	> 12					
Total number of records for monitored Individuals		97,818	100,221	102,509	100,011	98,040
Number with measurable dose		16,687	17,051	17,484	15,739	16,136
Number with dose >0.1 rem		3,128	3,551	3,619	3,039	2,599
% of individuals with measurable dose		17%	17%	17%	16%	16%
Collective TEDE (person-rem)		1,232	1,360	1,445	1,094	989
Average measurable TEDE (rem)		0.074	0.080	0.083	0.070	0.061

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

Exhibit 3-5 shows the dose distribution given by percentage of collective TEDE 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 that may be used as indications 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* also shows that each successively higher dose range is responsible for a lower percentage of the collective dose. The values for TEDE in each dose range increased from 2002 to 2003 and then decreased to the lowest values in the past 5 years for 2005. The decrease in the values shown in the dose distribution indicate that, in addition to a decrease in the collective dose, individuals received doses at lower dose values.

Exhibit 3-5:
Percentage of Collective TEDE Above Dose Values During 2001–2005.



3.3 Analysis of Individual Dose Data

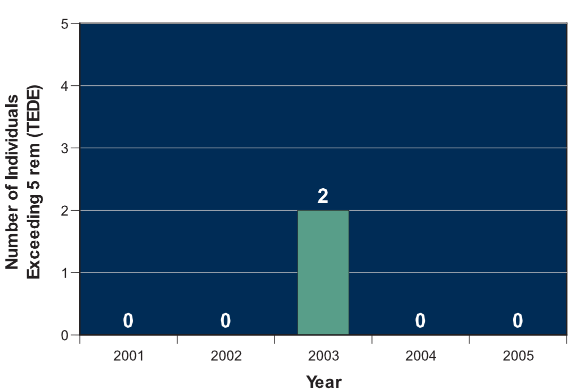
The previous analysis is based on aggregate data for DOE. From an individual worker perspective, as well as a regulatory perspective, it is important to closely examine the doses received by individuals in the elevated dose ranges to thoroughly understand the circumstances leading to these doses in the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

3.3.1 Doses in Excess of DOE Limit

Exhibit 3-6 shows the number of doses in excess of the TEDE regulatory limit (5 rem) or (50 mSv) from 2001 through 2005.

In 2005, no individual received a dose in excess of the 5 rem (50 mSv) TEDE limit.

Exhibit 3-6:
Number of Individuals Exceeding 5 rem (TEDE), 2001–2005.



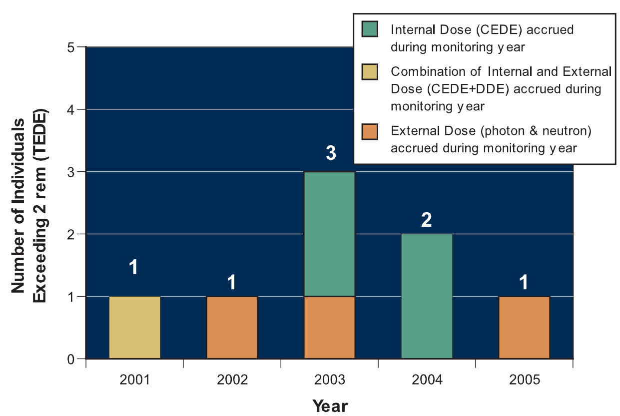
3.3.2 Doses in Excess of Administrative Control Level

The Radiological Control Standard (RCS) recommends a 2 rem (20 mSv) ACL for TEDE, which should not be exceeded without prior DOE approval. The RCS recommends that each DOE site establish its own, more restrictive ACL that would require 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 3-7*, one individual received a TEDE above 2 rem (20 mSv) during 2005. The individual received an external dose of 2.051 rem (20.51 mSv) at LANL, of which 1.584 rem (15.84 mSv) was from neutrons. This dose exceeded the Laboratory's performance goal of 2 rem without the required approvals. Investigations revealed a number of issues involving dose tracking procedures and software. The repeat nature of the software issue led LANL to include this in the Price Anderson Amendments Act (PAAA) report NTS-LANL-LANL-2005–0001, Delayed Radiological Dose Assessment. Although the recorded dose was not consistent with the exposure conditions, it has been assigned in the absence of refuting information. It was also found that there were procedures in place to identify unusual photon exposure but not neutron exposure. Corrective actions were taken to address the process and software for notification of unusual doses and doses in excess of administrative limits.

In 2005, one individual received a dose in excess of the 2 rem (20 mSv) TEDE Administrative Control Level.

Exhibit 3–7:
Number of Doses in Excess of the DOE 2 rem ACL, 2001–2005.



3.3.3 Internal Depositions of Radioactive Material

As shown in *Exhibit 3-8*, 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 numbers of internal depositions of radioactive material (otherwise known as worker intakes), collective CEDE, and average measurable CEDE for 2001–2005 are shown in *Exhibit 3-9*. The number of internal depositions

Exhibit 3-8:
Doses in Excess of DOE Limits, 2001–2005.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	SDE Extremity (rem)	Intake Nuclides	Facility Types	Site
2001					None Reported		
2002	0.080	0.080	-	111		Research, General	LLNL
2003	8.170	0.949	7.221	1.302	Pu-238	Other	LANL
	10.197	0.609	9.588	0.834	Pu-238	Waste Processing	LANL
2004					None Reported		
2005					None Reported		

decreased by 24% from 2,094 in 2004 to 1,600 in 2005, while the collective CEDE decreased by 18%. The average measurable CEDE increased from 0.037 rem (0.37 mSv) in 2004 to 0.040 rem (0.40 mSv) in 2005.

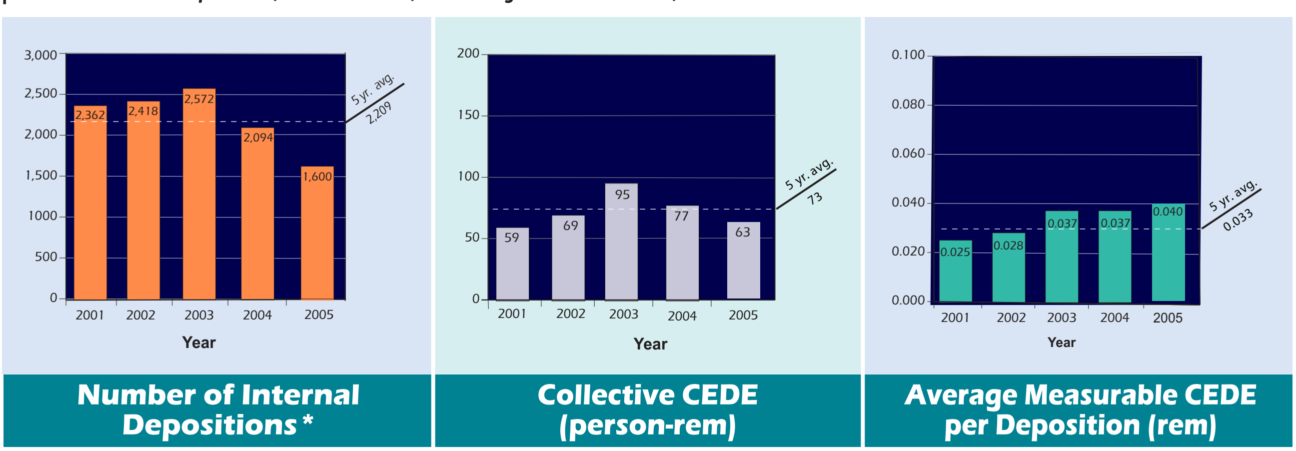
During the past 5 years, there have been several intakes from plutonium or uranium in excess of 2 rem (20 mSv) each year, with some of the doses in excess of 5 rem (50 mSv). While the numbers of internal depositions above 5 rem (20 mSv) have been few, they contributed significantly to the collective internal dose in 2003. In 2005, there were no individuals with internal dose above 2 rem (20 mSv).

The highest collective CEDE and number of depositions in 2005 are due to uranium intakes. A majority (81%) of the collective CEDE was from uranium intakes at the Oak Ridge Y-12 NSC during the operation and management of Enriched Uranium Operations (EUO) facilities at the site. Because relatively few workers receive measurable internal dose, fluctuations in the number of workers and collective CEDE can occur from year to year.

Exhibit 3-10 shows the distribution of the internal dose from 2001 to 2005. The total number of individuals with intakes in each dose range is the sum of all records of intake in the subject dose range. 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. There were no internal doses above 2 rem (20 mSv) in 2005.

The internal dose records indicate that the majority of the intakes result in very low doses. In 2005, 54% of the internal dose records were for doses below 0.020 rem (0.20 mSv). Over the 5-year period, internal doses from intakes accounted for 8% of the collective TEDE, and 7% of the individuals who received internal doses were above the monitoring threshold specified [100 millirem (mrem) or 1 mSv] in 10 CFR 835.402(c).

Exhibit 3-9:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE, 2001–2005.



* 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.

Exhibit 3-10:
Internal Dose Distribution from Intakes, 2001–2005.

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)
2001	1,673	574	90	19	4		2					2,362	58.954
2002	1,534	734	131	16	3							2,418	68.690
2003	1,622	763	163	18	3		1				2	2,572	94.502
2004	1,364	521	184	12	7	3	1	1	1			2,094	77.311
2005	858	562	156	22	1	1						1,600	63.461

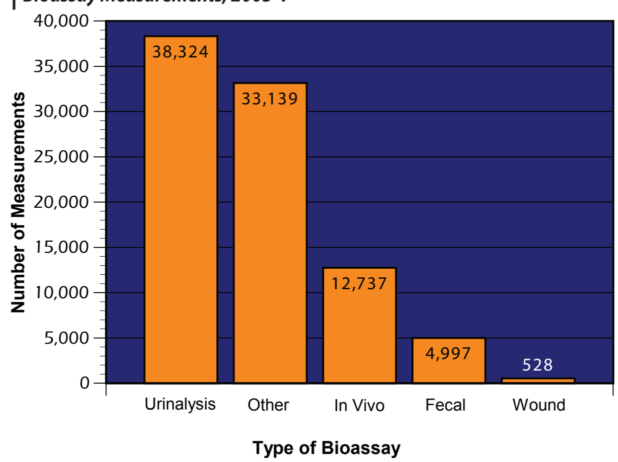
Note: Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
*Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

3.3.4 Bioassay and Intake Summary Information

The revised DOE Manual 231.1-1A was issued on 3/19/04. 2005 was the first year of reporting of bioassay and intake summary data under the revised DOE M 231.1-1A. Since this is the first year of reporting of CEDE by radionuclide, type of bioassay, and number of bioassay performed for the reporting year, there are not sufficient data to do a multiyear comparison or trend analysis. Urinalysis is the most common method of bioassay measurements used to determine internal doses to the individuals. *Exhibit 3-11* shows the breakdown of bioassay measurements by measurement type. Fifty-five percent of the urinalysis measurements were performed at three sites: LANL, Oak Ridge (Y-12 NSC), and Fernald. All of the bioassay measurements reported as "Other" were from air sampling, primarily at Fernald (74% of the measurements), Hanford, Pantex, and Mound. Note that the numbers shown are based on the number of measurements taken, not the number of individuals monitored. Individuals may have measurements taken more than once during the year.

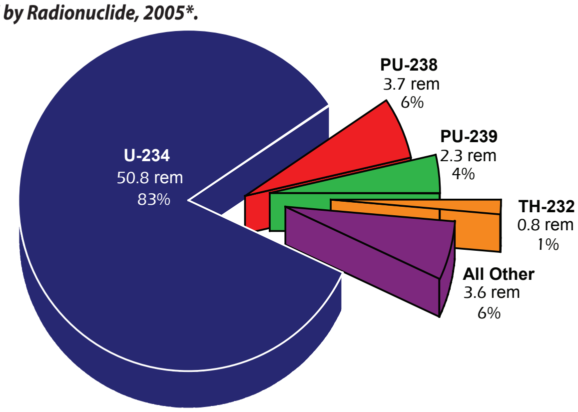
Exhibit 3-12 shows the breakdown of the collective CEDE by radionuclide for 2005. Under the previous requirements, sites reported the radionuclides included in the determination of the CEDE, but they often reported groups or mixtures of radionuclides. Uranium-234 accounts for the largest percentage of the collective dose with over 99% of this dose accrued at the Oak Ridge Y-12 NSC plant.

Exhibit 3-11:
Bioassay Measurements, 2005*.



*Note: Data include only those sites that reported under DOE M 231.1-1A.

Exhibit 3-12:
CEDE by Radionuclide, 2005*.



*Note: Data include only those sites that reported under DOE M 231.1-1A.

3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Operations/Field Offices

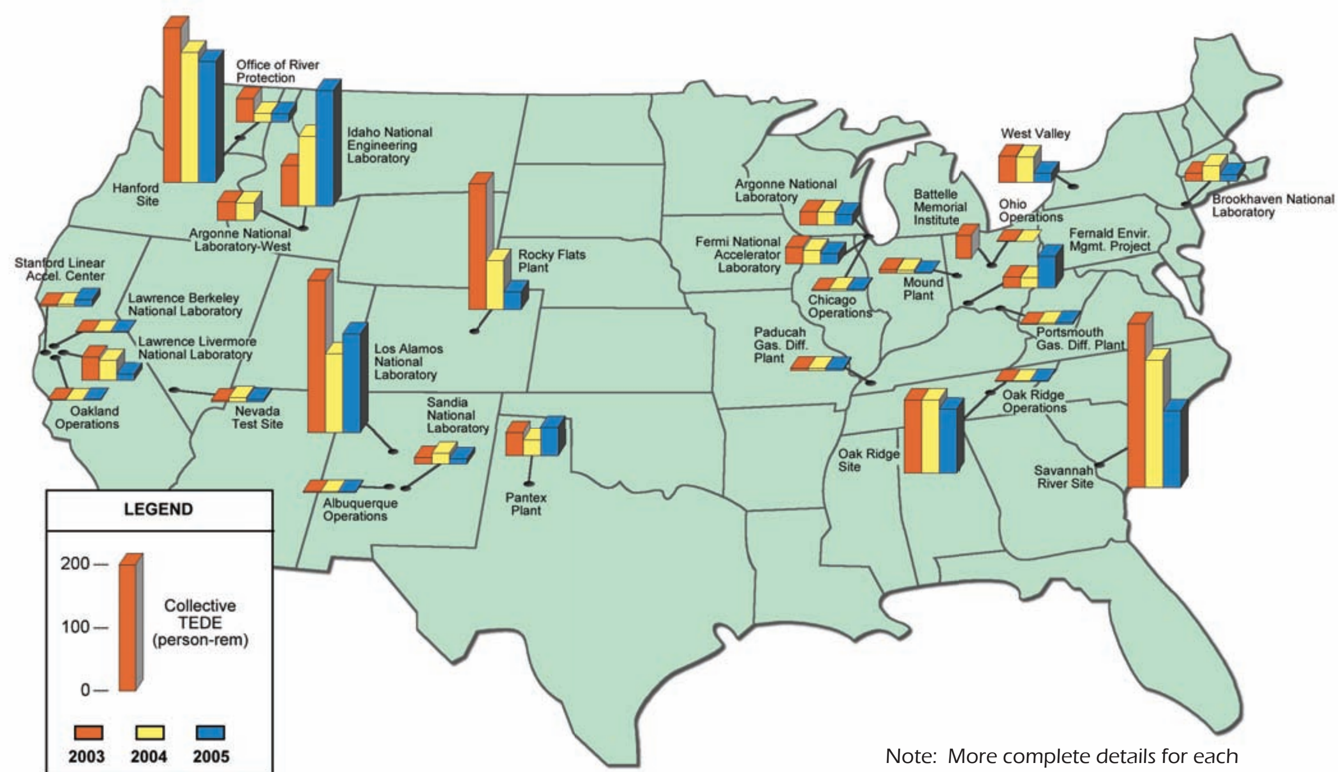
The collective TEDE for 2003 through 2005 for the major DOE sites, and operations/field offices is shown graphically in *Exhibit 3-13*. A list of the collective TEDE and number of individuals with measurable TEDE for the DOE sites and operations/field offices is shown in *Exhibit 3-14*. Operations/field office dose is shown separately from the site dose wherever it is reported separately. Other small sites and facilities that do not contribute significantly to the collective dose are included within the numbers shown for "Ops. and other facilities." The collective TEDE decreased by 10% from 1,094 person-rem (10.94 person-Sv) in 2004 to 989 person-rem (9.89 person-Sv) in 2005, with the sites (Hanford, Idaho, Los Alamos, Savannah River, and Oak Ridge) contributing 77% of the total DOE collective TEDE.

3.4.2 Changes by Operations Office and Site from 2004 to 2005

Exhibit 3-15 shows the collective TEDE, the number with measurable dose, the average measurable TEDE, and the percentage of the collective TEDE delivered above 0.500 rem by site for 2005, as well as the percentage change in these values from the previous year. Some of the largest percentages of change occur at relatively small facilities where conditions may fluctuate from year to year. The changes that have the most impact in the overall values at DOE occur at sites with a relatively large collective dose in addition to a large percentage change, such as Rocky Flats, Idaho, and Savannah River in 2005.

The percentage of the collective TEDE above 0.500 rem is an indicator of the distribution of dose to individuals. As this value increases, more individuals are receiving doses above 0.500 rem. See Section 3.2.5 for more information on the characteristics of the distribution of doses to individuals above a certain dose value.

Exhibit 3-13:
Collective TEDE by DOE Site for 2003–2005.



Note: More complete details for each site, operations/field office, and reporting organization can be found on the Web site. Please visit http://www.hss.energy.gov and select "Annual Reports" to review the appendices.

Exhibit 3-14:
Collective TEDE and Number of Individuals with Measurable TEDE by DOE Site, 2003–2005.

Site	2003 Collective TEDE (person-rem)	2003 Number with Meas. TEDE	2004 Collective TEDE (person-rem)	2004 Number with Meas. TEDE	2005 Collective TEDE (person-rem)	2005 Number with Meas. TEDE
Albuquerque Site Office and other facilities	1.3	107	1.3	116	1.2	98
Los Alamos National Lab. (LANL)	240.0	2,047	124.5	1,709	155.4	2,168
Pantex Plant (PP)	35.9	290	24.3	270	44.2	334
Sandia National Lab. (SNL)	10.2	250	17.1	317	8.5	222
Chicago Site Office and other facilities	1.2	153	2.5	173	2.0	160
Argonne Nat'l. Lab. - East (ANL-E)	21.4	231	20.5	172	17.0	267
Argonne Nat'l. Lab. - West (ANL-W)*	28.8	277	28.0	326	—	—
Brookhaven Nat'l. Lab.(BNL)	12.2	306	23.7	301	10.2	216
Fermi Nat'l. Accelerator Lab.(FERMI)	25.7	612	20.6	498	16.1	425
Idaho Site	64.0	1,141	109.5	1,471	181.6	2,054
Nevada Test Site (NTS)	3.2	69	6.6	116	3.6	71
Oakland Site Office and other facilities**	0.9	64	—	—	1.1	29
Lawrence Berkeley Nat'l. Lab. (LBNL)	1.0	20	0.7	18	1.2	22
Lawrence Livermore Nat'l. Lab. (LLNL)	36.4	202	31.2	232	10.0	185
Stanford Linear Accelerator Center (SLAC)	3.1	109	3.9	149	10.4	359
Oak Ridge Site Office and other facilities	1.3	98	1.3	91	1.8	110
Oak Ridge Site	116.0	2,389	115.5	2,132	101.4	1,988
Paducah Gaseous Diff. Plant (PGDP)	3.2	38	3.4	41	2.8	45
Portsmouth Gaseous Diff. Plant (PORTS)	0.6	26	1.9	32	2.6	45
Ohio Site Office and other facilities	0.7	47	0.2	14	—	2
Battelle Memorial Institute-Columbus***	35.9	100	—	—	—	—
Fernald Environmental Management Project	16.2	631	15.5	615	48.8	846
Mound Plant	5.8	237	4.6	152	1.0	119
West Valley	41.7	207	39.7	241	14.5	210
Rocky Flats Env. Tech. Site (RFETS)	198.6	1,761	77.4	1,021	28.3	1,507
Hanford Site	243.5	2,177	**205.2** ◀	2,278	**190.9** ◀	2,022
Office of River Protection	37.3	449	14.0	288	13.2	272
Savannah River Site (SRS)	**258.6** ◀	**3,446** ◀	201.2	**2,966** ◀	121.3	**2,360** ◀
Totals	**1,444.6**	**17,484**	**1,094.4**	**15,739**	**989.2**	**16,136**

* In 2005, Argonne National Laboratory - West (ANL-W) was integrated into the Idaho National Laboratory and no longer reports as a separate facility.

** The Oakland Site Office is no longer in operation but reported under this organization in 2005. These services were transferred to the NNSA Service Center in Albuquerque, NM.

*** No longer required to report to DOE.

Note: Arrowed values indicate the greatest value in each column. DOE headquarters personnel are included in the data submitted by the site where the dose was accrued.

Exhibit 3-15:
Site Dose Data, 2005.

	2005							
Site	Collective TEDE (person-rem)	Percent Change from 2004	Number with Meas. Dose	Percent Change from 2004	Avg. Meas. TEDE (rem)	Percent Change from 2004	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 2004
Albuquerque Site Office and other facilities	1.2	-9% ▼	98	-16% ▼	0.012	7% ▲	0%	
Los Alamos National Lab. (LANL)	155.4	25% ▲	2,168	27% ▲	0.072	-2% ▼	27%	0% ▲
Pantex Plant (PP)	44.2	82% ▲	334	24% ▲	$\boxed{0.132}$	47% ▲	$\boxed{35\%}$	$\boxed{128\%}$ ▲
Sandia National Lab. (SNL)	8.5	-50% ▼	222	-30% ▼	0.038	-29% ▼	0%	
Chicago Site Office and other facilities	2.0	-22% ▼	160	-8% ▼	0.012	-16% ▼	0%	
Argonne National Lab. - (ANL)*	17.0	-17% ▼	267	55% ▲	0.064	-47% ▼	13%	-68% ▼
Brookhaven National Lab. (BNL)	10.2	-57% ▼	216	-28% ▼	0.047	-40% ▼	0%	-100% ▼
Fermi Nat'l. Accelerator Lab. (FERMI)	16.1	-22% ▼	425	-15% ▼	0.038	-8% ▼	0%	
Idaho Site	181.6	66% ▲	2,054	40% ▲	0.088	19% ▲	13%	51% ▲
Nevada Test Site (NTS)	3.6	-46% ▼	71	-39% ▼	0.050	-11% ▼	0%	
Oakland Site Office and other facilities**	1.1		29		0.039		0%	
Lawrence Berkeley National Lab. (LBNL)	1.2	60% ▲	22	22% ▲	0.054	31% ▲	0%	
Lawrence Livermore National Lab. (LLNL)	10.0	-68% ▼	185	-20% ▼	0.054	-60% ▼	23%	-58% ▼
Stanford Linear Accelerator Center (SLAC)	10.4	165% ▲	359	$\boxed{141\%}$ ▲	0.029	10% ▲	0%	
Oak Ridge Site Office and other facilities	1.8	32% ▲	110	20% ▲	0.016	11% ▲	0%	
Oak Ridge Site	101.4	-12% ▼	1,988	-7% ▼	0.051	-6% ▼	2%	-66% ▼
Paducah Gaseous Diff. Plant (PGDP)	2.8	-18% ▼	45	10% ▲	0.062	-25% ▼	0%	
Portsmouth Gaseous Diff. Plant (PORTS)	2.6	38% ▲	45	41% ▲	0.058	-2% ▼	0%	
Ohio Site Office and other facilities	0.0	-89% ▼	2	-86% ▼	0.011	-22% ▼	0%	100% ▲
Battelle Memorial Institute - Columbus***							0%	
Fernald Environmental Mgmt. Project	48.8	$\boxed{216\%}$ ▲	846	38% ▲	0.058	$\boxed{130\%}$ ▲	0%	100% ▲
Mound Plant	1.0	-78% ▼	119	-22% ▼	0.008	-72% ▼	0%	
West Valley Project	14.5	-63% ▼	210	-13% ▼	0.069	-58% ▼	4%	-83% ▼
Rocky Flats Env. Tech. Site (RFETS)	28.3	-63% ▼	1,507	48% ▲	0.019	-75% ▼	0%	
Hanford Site	$\boxed{190.9}$	-7% ▼	2,022	-11% ▼	0.094	5% ▲	24%	34% ▲
Office of River Protection	13.2	-6% ▼	272	-6% ▼	0.049	0% ▼	0%	
Savannah River Site (SRS)	121.3	-40% ▼	$\boxed{2,360}$	-20% ▼	0.051	-24% ▼	3%	-85% ▼
Totals	**989.2**	**-10%** ▼	**16,136**	**3%** ▲	**0.061**	**-12%** ▼	**14%**	**-17%** ▼

* In 2005, Argonne National Laboratory - West (ANL-W) was integrated into the Idaho National Laboratory and no longer reports as a separate facility.

** The Oakland Site Office is no longer in operation but reported under this organization in 2005. These services were transferred to the NNSA Service Center in Albuquerque, NM.

*** No longer required to report to DOE.

Note: Boxed values indicate the greatest value in each column. Up arrows indicate an increase in change. Down arrows indicate a decrease in change. DOE headquarters personnel are included in the data submitted by the site where the dose was accrued.

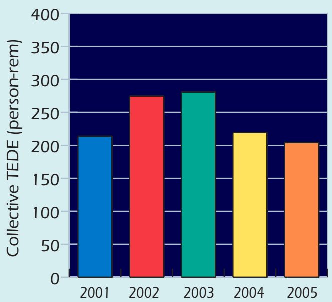
3.4.3 Activities Significantly Contributing to Collective Dose in 2005

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 significantly contributed to the collective dose for 2005. These sites (Hanford, Idaho, Los Alamos, Savannah River, and Oak Ridge) exceeded 100 person-rem and were the top contributors to the collective TEDE in 2005. These sites comprised 77% of the total collective TEDE at DOE. Three of the sites reported decreases in the collective TEDE, which contributed to a 10% decrease in the DOE collective TEDE from 1,094 person-rem (10.94 person-Sv) in 2004 to 989 person-rem (9.89 person-Sv) in 2005. The sites significantly contributing to the collective TEDE in 2005 are shown in Exhibit 3-16, including a description of activities that affected the collective TEDE.

In descending order of collective dose, Fernald was the next highest contributor after the Oak Ridge Site. Although the collective dose for 2005 was 48.8 person-rem (well below 100 person-rem), it is significant that the site experienced a 216% increase from 2004 to 2005. Since May 2005, Fernald has been treating the radioactive material from two storage silos, which was one of the largest sources of occupational exposure at the site. As of May 2006, the last of 3,776 waste canisters were shipped off site. Since the work is now completed, the 2006 collective dose at Fernald is anticipated to decrease significantly.

In previous annual reports, Rocky Flats has been included among the top contributors to the collective TEDE. During 2005, the site ceased all operations involving radioactive material and will no longer be reporting occupational exposure information to DOE in subsequent years.

Exhibit 3-16:
Activities Significantly Contributing to Collective TEDE in 2005.

Hanford	Percent Change 2004-2005 (last yr.)	2003-2005 (3 yr.)	Since 2001 (5 yr.)	Description of Activities at the Site
	7% ↓	27% ↓	4% ↓	The collective dose at the Hanford Site (including dose from Richland Operation Office, Office of River Protection, and Pacific Northwest Site Office) decreased 7% from 2004 to 2005. The largest contributors to the collective TEDE at Hanford were the K Basins Closure Project (removal of contaminated equipment from the basins and retrieval of sludge) (35%), the Plutonium Finishing Plant (PFP) Closure Project (decontamination and decommissioning of PFP facilities) (24%), Waste Stabilization and Disposal Project (retrieval, processing, and shipment of Transuranic (TRU) waste and the solidification of K Basins sludge) (13%), Pacific Northwest National Laboratories activities (10%), Tank Farm activities (6%) and River Corridor Closure Project (remediation of burial grounds and cribs and decontamination and demolition of facilities along the Columbia River)(4%). The neutron dose at the Hanford site decreased 48%. The majority of the site's neutron dose is from work activities at the PFP. Overall dose at the PFP decreased as a result of the completion of plutonium stabilization activities. Deactivation and decommissioning of the PFP facilities slowed down as priorities were shifted to the K Basins Closure Project.

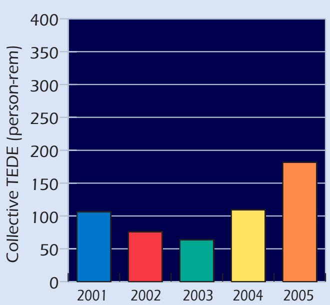
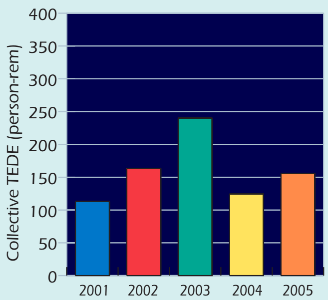
Idaho	2004-2005 (last yr.)	2003-2005 (3 yr.)	Since 2001 (5 yr.)	Description of Activities at the Site
	↑ 66%	↑ 184%	↑ 70%	The primary Idaho Cleanup Project (ICP) activities performed by CH2M-WG Idaho, LLC, leading to radiation exposure included cleanup activities at CPP-603 (including basin sludge removal and Basin Water Treatment System closure); removal of lead from the Power Burst Facility; activities in support of Filter Leaching and Debris Treatment at CPP-659; cleanup and D&D activities at TAN, including disposal of deactivated tanks at Idaho CERCLA Disposal Facility; Voluntary Consent Order activities at Reactor Technology Complex (RTC), including cleaning and isolation of the TRA-730 Catch Tank; activities in support of closure of tank farm vessels; D&D of the CPP-627 building; and the removal and safe storage of drums from the Intermediate Level Transuranic Storage Facility (ILTSF) at the Radioactive Waste Management Complex (RWMC). The primary Idaho National Laboratory (INL) activities performed by Battelle Energy Alliance (BEA) leading to radiation exposure were Advanced Test Reactor operations, the completion of the Core Internals Changeout, reactor experiment programs at the RTC and Radioisotope Thermoelectric Generator (RTG) (Space Battery), and WIPP TRU waste characterization at the Materials and Fuels Complex. Bechtel BWXT Idaho's (BBWI's) work activities during 2005 were in direct support of the 1995 Idaho/U.S. Navy/U.S. DOE Settlement Agreement requiring the DOE to remove transuranic waste from Idaho disposal sites within the INL. The AMWTP work that contributed to workforce dose included training of new personnel to support necessary TRU waste retrieval from burial, waste characterization, waste super compaction treatment process throughput, facility maintenance, and the direct shipment of the transuranic and by-product waste materials from the state to the U.S. DOE's Waste Isolation Pilot Plant and other commercial disposal facilities. These activities resulted in the shipping of about 4,500 cubic meters of transuranic waste out of Idaho.

Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2005.

Los Alamos National Lab.	Percent Change 2004-2005 (last yr.)	Percent Change 2003-2005 (3 yr.)	Percent Change Since 2001 (5 yr.)	Description of Activities at the Site
	↑ 25%	35% ↓	↑ 38%	LANL CY 2005 radiological operations were relatively steady and executed as planned in comparison to previous years. On July 16, 2004, the LANL Director suspended operations across the Laboratory except those deemed "essential," which generally did not involve significant occupational exposure (see 2004 LANL Annual Occupational Exposure Summary). Operations that typically contribute most of the occupational dose at LANL (primarily in the plutonium facility) did not resume until the end of CY 2004 or beginning of CY 2005. Consequently, CY 2004 doses were significantly lower than anticipated. After resuming subject operations, workloads became more typical across LANL, and accumulated dose was correspondingly higher for CY 2005. In addition to typical plutonium facility operations, significant portions of LANL dose were accrued by workers performing maintenance at LANSCE (the linear accelerator), and those supporting retrieval, repackaging, and shipping radioactive solid waste to the Waste Isolation Pilot Plant. In terms of internal dose, there was a 36% decrease in dose from 2004 to 2005; this reflects an improving trend in significant radiological incidents.

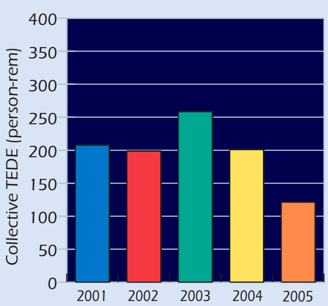
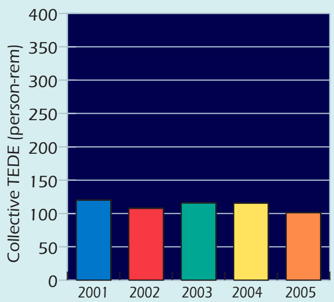
Savannah River Site	Percent Change 2004-2005 (last yr.)	Percent Change 2003-2005 (3 yr.)	Percent Change Since 2001 (5 yr.)	Description of Activities at the Site
	40% ↓	53% ↓	42% ↓	The collective TEDE at Savannah River decreased 40% from 2004 to 2005. As in 2004 when SRS saw the benefits of removing inactive sites from the inventory, similar benefits were realized in 2005 as additional facilities were removed. While exposures were anticipated to be less in 2005, substantial dose decreases were noted in the plutonium facilities when projects to complete stabilization, repackaging, and removal from inventory were completed ahead of schedule. The early project completions also decreased the analytical sample load in the process laboratories, resulting in lower technician exposures. Missions in other site facilities resulted in doses in anticipated ranges for activities, such as removal from inventory and decommissioning of older high-level waste storage tanks; disposing of legacy shipping casks; reprocessing unneeded reactor fuel and target materials; reprocessing neptunium solutions for future missions; dispositioning plutonium scrap; D&D of excess radiological facilities; and maintaining facility infrastructure. Some anticipated higher doses occurred in facilities where most transuranic waste containers with lower source terms had already been processed, and containers with known higher source terms were repackaged for off-site disposition at Waste Isolation Pilot Plant (WIPP).

Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2005.

<table>
<tr><th rowspan="2">Oak Ridge Site</th><th colspan="3">Percent Change</th><th rowspan="2">Description of Activities at the Site</th></tr>
<tr><th>2004-2005 (last yr.)</th><th>2003-2005 (3 yr.)</th><th>Since 2001 (5 yr.)</th></tr>
<tr><td>
</td><td>12% ↓</td><td>13% ↓</td><td>16% ↓</td><td>For the purposes of this report, the Oak Ridge Site is comprised of the Y-12 National Security Complex (Y-12 NSC), East Tennessee Technology Park (ETTP), the Oak Ridge National Laboratory (ORNL), and certain activities at the Portsmouth and Paducah sites. These facilities are grouped together due to the organizational reporting of radiation exposure monitoring.

Y-12: The 2005 collective deep dose equivalent for the Y-12 Complex decreased by 16.1% from 16.1 person-rem in 2004 to 13.5 person-rem in 2005. This decrease is a result of a decrease in the amount of work performed associated with the TVA Off-Specification Fuel repackaging project. There was a single occurrence that impacted the collective deep dose in the year 2004. Average deep-dose equivalent remained the same with 0.003 rem in 2004 and 0.003 rem in 2005.

Collective CEDE increased 6.9% from 48.0 person-rem in 2004 to 51.3 person-rem in 2005, while the average CEDE increased 11% from 0.018 rem in 2004 to 0.020 rem in 2005. There were 141 workers who received an internal dose in excess of 100 mrem (CEDE). There was an increase in work activity in most of the process areas within Y-12.

Collective TEDE increased 1.1% from 2004 (64.1 person-rem) to 2005 (64.8 person-rem), while the total persons monitored decreased by less than 1% from 5,260 to 5,228. The average TEDE remained essentially constant at 0.012 rem. Maximum TEDE decreased 66.8% from 1.483 rem to 0.493 rem.

ORNL: The collective TEDE at ORNL decreased by 5.6% from 2004 to 2005. The decrease is attributed to a decrease in activities at the isotope production facility.

ETTP: No unusual events or specific changes in operations related to radiation exposures were reported for 2005 at the ETTP.

Portsmouth and Paducah: The activities performed at the Bechtel Jacobs Co. (BJC) projects consisted of environmental restoration and clean-up work. The exposure information for BJC activities at the Portsmouth site covers only through June 26, 2005. After that date, LATA/Parallex Portsmouth assumed the DOE contract for environmental restoration activities at the site. In addition, the responsibility for management of depleted uranium cylinders was transferred from BJC to Uranium Disposition Services at both the Paducah and Portsmouth sites on that date.</td></tr>
</table>

3.5 Transient Individuals

Transient individuals, or transients, 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. During the year, some individuals performed work at multiple sites and, therefore, had more than one monitoring record reported to the repository. In addition, some individuals transferred from one site to another. This section presents information on transient individuals to determine the extent to which individuals travelled from site to site and to examine the dose received by these individuals.

Exhibit 3-17 shows the distribution and total number of transient individuals from 2001 to 2005. Over the past 5 years, the records of transient individuals have averaged 2.8% of the total records for all monitored individuals at DOE, who received, on an average, 3% of the collective dose. The collective dose for transients increased by 55% from 25.6 person-rem (256 person-mSv) in 2004 to 39.8 person-rem (398 person-mSv) in 2005. The increase was due primarily to an increases in dose to transient workers at Idaho and LANL. The average measurable TEDE decreased from 0.051 rem (0.51 mSv) in 2004 to 0.049 rem (0.49 mSv) in 2005. Since 1993, these parameters have remained relatively constant, even though DOE has become extensively involved in D&D activities and other types of operations.

3.6 Historical Data

3.6.1 Prior Years

In order to analyze recent radiation exposure data in the context of the history of radiation exposure at DOE, it is useful to include information prior to the past five years as presented in this report. For this reason, the following exhibits are presented to show a summary of occupational exposure back to 1974, when the Atomic Energy Commission (AEC) split into the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which subsequently became the DOE.

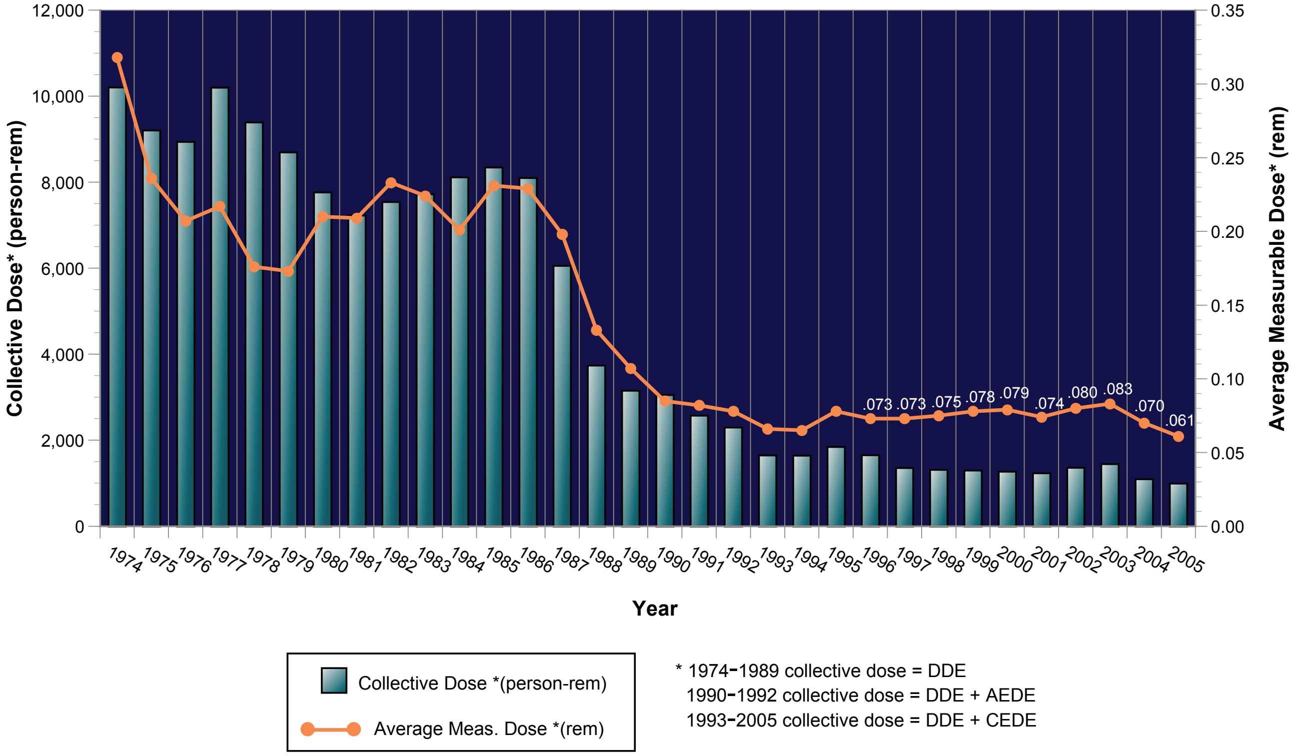
Exhibits 3-18 and *3-19* show the collective dose, average measurable dose, and number of workers with measurable dose from 1974 to 2005. As can be seen from the graph, all three parameters decreased dramatically between 1986 and 1993. The main reasons for this large decrease were the shutdown of facilities 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.

Exhibit 3-17:
Dose Distribution of Transient Workers, 2001–2005.

	Dose Ranges (TEDE in rem)	2001	2002	2003	2004	2005
Transients	Less than measurable dose	2,696	2,298	2,063	1,917	2,067
	Measurable < 0.1	439	470	492	439	715
	0.10–0.25	31	50	59	52	79
	0.25–0.5	13	12	23	9	13
	0.5–0.75	1	11	9	4	3
	0.75–1.0	1	5	7		2
	1.0–2.0	2	2	12	1	1
	Total number of individuals monitored*	3,183	2,848	2,665	2,422	2,880
	Number with measurable dose	487	550	602	505	813
	% with measurable dose	15%	19%	23%	21%	28%
	Collective TEDE (person rem)	25.138	36.477	56.141	25.609	39.757
	Average measurable TEDE (rem)	0.052	0.066	0.093	0.051	0.049
All DOE	Total number of records for monitored individuals	97,818	100,221	102,509	100,011	98,040
	Number with measurable dose	16,687	17,051	17,484	15,739	16,136
	% of total monitored who are transient	3.2%	2.8%	2.6%	2.4%	2.9%
	% of the number with measurable dose who are transient	2.9%	3.2%	3.4%	3.2%	5.0%

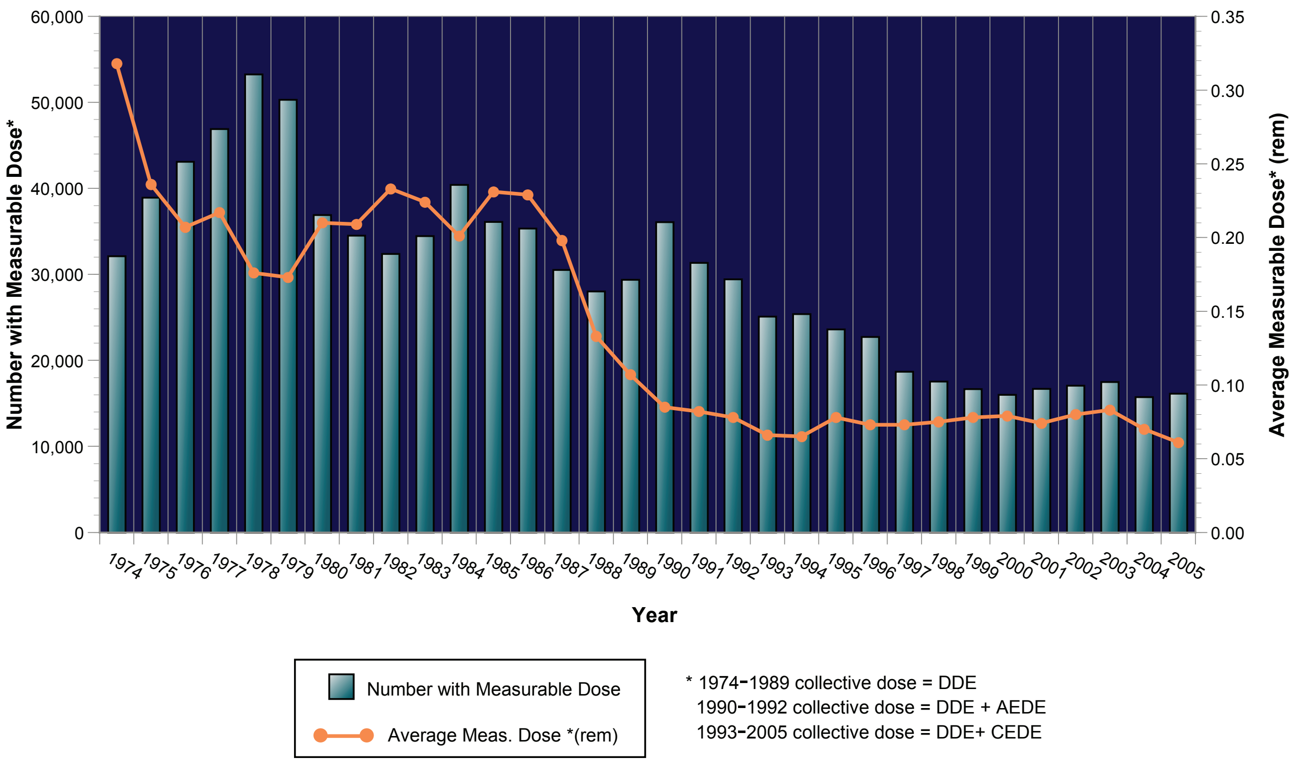
* Total number of individuals represents the number of individuals monitored and not the number of records.

Exhibit 3-18:
Collective Dose and Average Measurable Dose, 1974–2005.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2005 collective dose = DDE + CEDE

Exhibit 3–19
Number with Measurable Dose and Average Measurable Dose, 1974–2005.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2005 collective dose = DDE+ CEDE

3.6.2 Historical Data Collection

In Section 3.7 of the 2000 and 2001 annual reports on occupational exposure, information was presented on historical data that had been collected to date. The DOE requested the sites volunteer to provide historical exposure data. No additional sites have reported historical data during the year 2005.

Sites that have not yet reported historical dose records are encouraged to contact Ms. Nirmala Rao at DOE to obtain further information on reporting these records. This is a voluntary request to report historical data (records prior to 1987) that are available in electronic form in whatever format that is most convenient for the site. The data will be stored as reported in the REMS, and, wherever possible, data will be extracted and loaded into the REMS database for analysis and retrieval. For detailed analysis, read Section 3.7 of the 2000 report.

Sites that have voluntarily reported historical data are as follows:

- Fernald
- Hanford
- Idaho
- Kansas City Plant
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Nevada Test Site
- Oak Ridge K-25 Site
- Pantex
- Portsmouth
- Rocky Flats
- Sandia National Laboratory
- Savannah River Site

Section Four
ALARA Activities at DOE

4

ALARA Activities at DOE

In past years, the published annual report has included descriptions of ALARA activities at DOE for the purposes of sharing strategies and techniques that have shown promise in the reduction of radiation exposure. For 2005, these ALARA activity descriptions have been moved to the HSS REMS web page to facilitate the dissemination among DOE radiation protection managers and others interested in these project descriptions. Readers should be aware that the project descriptions are voluntarily submitted from the sites and are not independently verified or endorsed by 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.

4.1 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Corporate Safety Analysis. 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
- ❖ Total collective dose for the project
- ❖ Dose rate to exposed workers before and after exposure controls were implemented
- ❖ 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)
- ❖ Figures and/or photos of the project or equipment (electronic images if available)
- ❖ Point-of-contact for follow-up by interested professionals

4.2 Lessons Learned Process

DOE has a mature lessons learned process that was initially developed in 1994. The current DOE lessons learned process is described in DOE Technical Standard, DOE-STD-7501-99. The purpose of the DOE lessons learned process is to facilitate the identification, documentation, sharing, and utilization of lessons learned from a review of actual operating experiences throughout the DOE complex. This is accomplished by lessons sharing among DOE sites through a common corporate database. A recent review of the lessons learned process has led to a redesign of the process to add a more corporate component to the process. This new corporate component, modeled after the Institute of Nuclear Power Operations Significant Event Evaluation and Information Network program, has introduced an additional corporate role in the review of DOE site performance and crosscutting operating experience and has started to provide additional lessons learned information to the DOE community in addition to that already provided by DOE field sites.

The collected information is currently located on an Internet Web site. 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 also 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 workplace 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 specific Web site address may be subject to change. Information services can be accessed through the Office of Health, Safety and Security Web page as follows:

http://www.hss.energy.gov

Section Five

Conclusions

5

Conclusions

The collective dose at DOE facilities has experienced a dramatic (88%) decrease since 1986. The main reasons for this large decrease are 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. Since 1993, collective dose has remained relatively constant. The DOE weapons production sites have continued to contribute the majority of the collective dose over these years, even though DOE is actively engaged in D&D operations. 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 or undergo transition from operation to stabilization or D&D, there are significant changes in the opportunities for worker radiation exposure.

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. A summary of the findings for 2005 is shown in *Exhibit 5-1*.

Exhibit 5-1:
2005 Radiation Exposure Fact Sheet.

- ❖ The collective TEDE decreased 10% from 1,094 person-rem (10.94 person-Sv) in 2004 to 989 person-rem (9.89 person-Sv) in 2005.
- ❖ Sites contributing significantly to collective dose were (in descending order of collective dose) Hanford, Idaho, Los Alamos, Savannah River, and Oak Ridge. These sites accounted for 77% of the collective dose at DOE in 2005.
- ❖ Decreases in collective dose at three of the highest dose sites were attributed to the removal of inactive sites from the inventory and the completion of several projects ahead of schedule at plutonium facilities at the Savannah River Site; decrease in the amount of work performed for the TVA Off-Specification Fuel Repackaging Project at the Oak Ridge Y-12 NSC; and decrease in dose as a result of the completion of plutonium stabilization activities at the Plutonium Finishing Plant at Hanford.
- ❖ There were no exposures in excess of the DOE 5 rem (50 mSv) annual TEDE limit.
- ❖ There was one exposure in excess of the DOE ACL of 2 rem (20 mSv) TEDE. The individual received an external dose of 2.051 rem (20.51 mSv) at LANL primarily from neutron radiation.
- ❖ The collective internal dose (CEDE) decreased by 18% between 2004 and 2005.
- ❖ The collective dose for transient workers increased by 55% from 25.6 person-rem (256 mSv) in 2004 to 39.8 person-rem (398 mSv) in 2005. The increase was due primarily to increases in dose to transient workers at Idaho and LANL.
- ❖ The revised reporting requirements of DOE Manual 231.1-1A went into effect for the first time with the reporting of 2005 exposure data. The most significant change is in the reporting of bioassay and intake information. A total of 89,725 bioassay measurements were performed in 2005, with urinalysis accounting for 43% of those measurements. Eighty-three percent of the collective CEDE was attributed to Uranium-234, with over 99% of this dose accrued at the Oak Ridge Y-12 NSC.

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User Survey

DOE and DOE Contractor Employees Annual Radiation Exposure Report

User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the DOE and DOE Contractor Employees Annual Radiation Exposure Report. **Your feedback is important.** Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to:

Ms. Niramala Rao
DOE HS-31 270/cc
19901 Germantown Road
Germantown, MD 20874
nimi.rao@hq.doe.gov
Fax: 301-903-1257

Questions concerning this survey should be directed to Ms. Rao at (301) 903-2297.

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1. Identification:

Name:...

Title:...

Mailing Address:...

....

....

....

2. Distribution:

2.1 Do you wish to remain on the distribution for the report? _____ yes _____ no

2.2 Do you wish to be added to the distribution? _____ yes _____ no

(continued on back)

Please circle one.

	Not Useful				Very Useful
Please rate the usefulness of this report overall:	1	2	3	4	5

Please rate the usefulness of the analysis presented in the following sections:

Executive Summary	1	2	3	4	5
Aggregate Data Analysis	1	2	3	4	5
Collective dose	1	2	3	4	5
Average measurable dose	1	2	3	4	5
Dose distribution	1	2	3	4	5
Dose to Individuals	1	2	3	4	5
Doses above 2 rem ACL	1	2	3	4	5
Doses in excess of 5 rem	1	2	3	4	5
Internal depositions of radioactive material	1	2	3	4	5
Analysis of Site Data	1	2	3	4	5
Collective dose by site	1	2	3	4	5
Description of activities related to dose	1	2	3	4	5
Historical data	1	2	3	4	5
ALARA activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

Please rate the importance of the timeliness of the publication of this report as it relates to your professional need for the information on occupational radiation exposure at DOE:

Not important				Critical
1	2	3	4	5

Please provide any additional input or comments on the report.

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Glossary

Glossary

Administrative Control Level (ACL)
A dose level that is established below the DOE dose limit in order to administratively control exposures. ACLs are multitiered 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. AEDE 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. CDE 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., $H_E,50 = \Sigma w_T H_T,50$. CEDE is expressed in units of rem.

CR
See SR.

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 (DOE). The DOE sites considered in this report are listed by operations office in Appendix A. Please visit http://www.hss.energy.gov to view the appendices.

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 that may or may not result in occupational radiation dose.

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.

Members of the Public
Individuals who are not occupationally exposed to radiation or radioactive material. This includes visitors and visiting dignitaries.

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.

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

SR (formerly CR)
SR is defined by UNSCEAR as the ratio of the annual collective dose delivered at individual doses exceeding a specified dose value to the collective dose. UNSCEAR uses a subscript to denote the dose value (in mSv) used in the calculation of the ratio. Therefore, SR_{15} would be the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem (15 mSv) to the total annual collective dose.

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 Number of Records for Monitored Individuals
All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, subcontractors, 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.

Urinalysis
The technique of determining the radiation dose received by an individual from an intake by the measurement of the amount of radioactive material in the urine excreted from the body.

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References

References

1. EPA (U.S. Environmental Protection Agency), 1987. "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," *Federal Register* 52, No. 17, 2822; with corrections published in the *Federal Registers* of Friday, January 30, and Wednesday, February 4, 1987.

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

5. DOE Order 231.1A, "Environment, Safety and Health Reporting," August 19, 2003.

6. DOE Manual 231.1-1A, "Environment, Safety and Health Reporting Manual," Approved March 19, 2004.

7. Computerized Accident and Incident Reporting System (CAIRS), "DOE and Contractor Injury and Illness Data by Year by Quarter" report. Online at http://www.hss.energy.gov.

8. United Nations, *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with scientific annexes, Volume I*, General Assembly of Official Records, United Nations, New York, 2000.

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