DOE/EH-0564

DOE Occupational Radiation Exposure

1996 Report

NEUTRON • AEDE • ELECTRON • TEDE • INTERNAL • CEDE • GAMMA • BETA • SHIELD • ALARA

Foreword

The goal of the U.S. Department of Energy (DOE) is to conduct its radiological operations to ensure the health and safety 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 and releases to levels that are "As Low As Reasonably Achievable" (ALARA).

The DOE Occupational Radiation Exposure Report, 1996 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 precursor agency sites, and energy research.

Collective exposure at DOE has declined by 80% over the past decade due to a cessation in opportunities for exposure during the transition in DOE mission from weapons production to cleanup, deactivation and decommissioning, and changes in reporting requirements and dose calculation methodology. In 1996, the collective dose decreased by 10% from the 1995 value due to decreased doses at five of the seven highest-dose DOE sites. For 1996, these sites attributed the reduction in collective dose to the completion of several decontamination and decommissioning projects, reduced spent fuel storage activities, and effective ALARA practices.

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. A user survey form is included in Appendix F to collect your suggestions to improve this report.

Peter Brush
Acting Assistant Secretary
Environment, Safety and Health

Joseph Fitzgerald, Jr.
Deputy Assistant Secretary
Office of Worker Health and Safety

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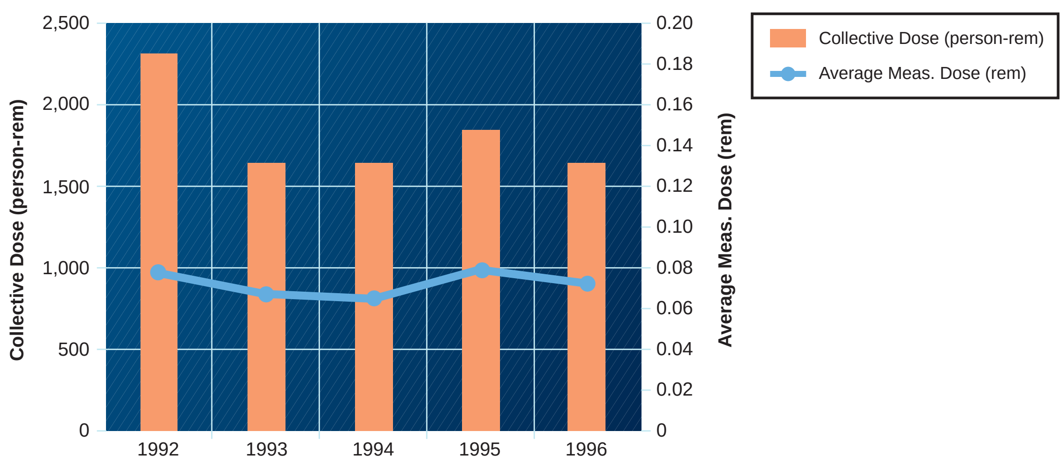
Executive Summary

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health publishes the DOE Occupational Radiation Exposure Report. This report is intended to be a valuable tool for DOE/DOE contractor managers in their management of radiological safety programs and to assist them in the prioritization of resources. We appreciate the efforts and contributions from the various stakeholders within and outside the DOE and hope we have succeeded in making the report more useful.

This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and visitors. The exposure information is analyzed in terms of collective 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 the figure below, between 1995 and 1996, the DOE collective total effective dose equivalent (TEDE) decreased by 10% due to decreased doses at five of the seven dose sites with the highest radiation dose. In addition, the average dose to workers with measurable dose decreased by 6%, the number of individuals receiving measurable dose dropped by 4%, and there was one exposure over the DOE 5 rem TEDE limit.

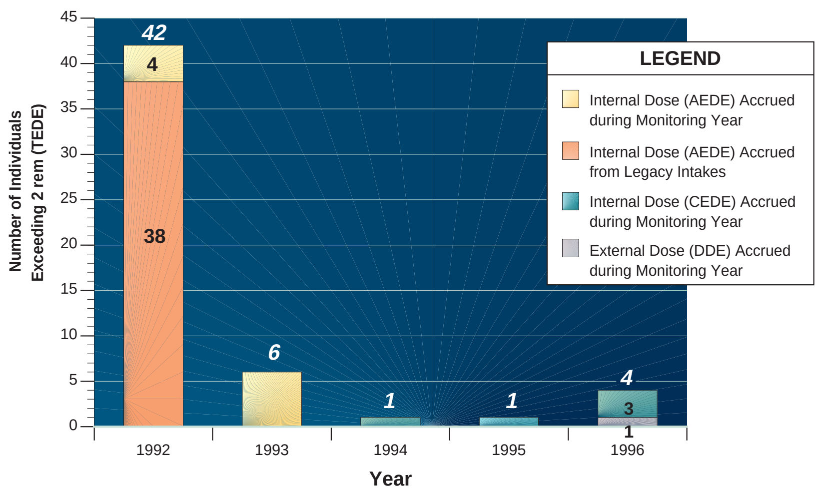


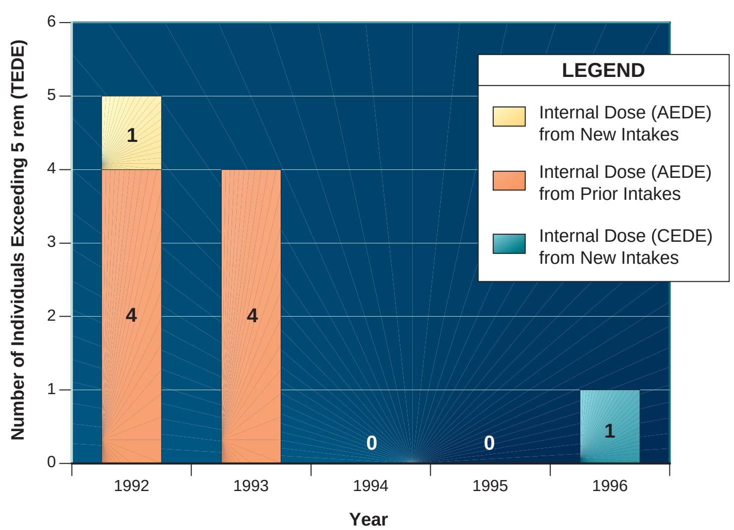
Nearly 81% of the collective TEDE for the DOE complex was accrued at seven DOE sites in 1996. These seven sites are (in descending order of collective dose) Rocky Flats, Hanford, Savannah River, Los Alamos, Idaho, Brookhaven, and Oak Ridge. Weapons fabrication and testing facilities account for the highest collective dose. It should be noted that Rocky Flats and Savannah River account for the majority of this dose. These sites are now primarily involved in nuclear materials stabilization and waste management but still report under this facility type. For the past 4 years, technicians received the highest collective dose of any specified labor category.

Occupational radiation exposure at DOE has been impacted over the past 5 years by changes in:

- reporting requirements,
- operational status and activities resulting in radiation exposure at DOE facilities, and
- radiation protection standards and practices.

A change in the reporting requirements had a significant impact on the collective dose at DOE between 1992 and 1993. The change in internal dose methodology from annual effective dose equivalent (AEDE) to committed effective dose equivalent (CEDE) between 1992 and 1993 resulted in an apparent reduction of the collective dose by up to 28% because the dose to individuals from intakes from previous years is no longer reported in the current year. Also, the operational status of DOE facilities has had an impact on radiation exposure due to the shift in mission from production to cleanup activities and the shutdown of certain facilities. Radiation protection practices have changed during the past 5 years because of the implementation of the DOE Radiological Control (RadCon) Manual. The RadCon Manual established Administrative Control Levels (ACL), standardized radiation protection programs, and formalized "As Low As Reasonably Achievable" (ALARA) practices.





Occupational doses at DOE facilities in excess of 2 rem ACL and 5 rem TEDE regulatory limit have decreased over the past 5 years, as shown in the figures on the previous page. There was one individual in 1996 who received a dose in excess of the 5 rem TEDE limit. This individual received an internal dose of 11.5 rem due to an unanticipated intake of plutonium at the Savannah Site. The intake occurred in December of 1996, but was discovered and reported in 1997 after a special follow-up bioassay was performed. This overexposure led to an enforcement action and fine against the contractor under the provisions of the Price-Anderson Act for violations of 10 CFR 835.

As a result of the analysis presented in this report, several recommendations are made.

- The DOE mission has changed over the years from weapons production, operation, and stabilization to environmental restoration and surveillance. This shift in DOE mission has made it necessary to track and analyze occupational radiation exposure data in relation to the phase of operation of the DOE facilities. It is recommended that Sites and Operations Offices begin reviewing their data collection process in anticipation of collecting the phase of operation data (see Appendix A.)
- It is recommended that sites review their recordkeeping and reporting processes in order to improve the reporting of occupation codes in accordance with DOE Manual 231.1-1 and, as a result, improve the analysis of radiation exposure information by occupation.
- Analysis of occurrence reports indicates an increase in exposure occurrences due to unknown sources of radiation in 1996. While this became a new root cause category for 1995, the increasing trend requires continued monitoring. It is recommended that sites reporting these occurrences review and remediate situations that result in these exposure occurrences.
- To provide a more complete analysis of the radiation exposure data reported to DOE Headquarters, it is necessary to collect additional information from the highest dose sites. It is recommended that these highest dose sites provide a brief annual summary of activities and descriptions of ALARA projects in addition to their annual radiation records submittals.
- The data in the REMS database are subject to correction and update on a continuous basis. Data for prior years are subject to correction as well as the data for the most recent year included in this report. The most common reason for correction to a dose record is because of a final dose determination of an internal dose long after the original dose record was submitted to REMS. This delay is due to the time needed to assess the bioassay results and determine the dose from long-lived radionuclides. It is recommended that sites review their dose record update and reporting process, specifically for internal dose determination, and consider the addition of a mechanism whereby they report dose updates to REMS in a timely fashion when updates occur.
- DOE should investigate the feasibility, cost, and benefit of establishing a historical repository of intake information to track and access radiation dose from intakes in prior years.

Introduction

Section One

1

Introduction

The *DOE Occupational Radiation Exposure Report, 1996* reports occupational radiation exposures incurred by individuals at U.S. Department of Energy (DOE) facilities during the calendar year 1996. This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and visitors. This information is analyzed and trended over time to provide a measure of the DOE's performance in protecting its workers from radiation.

The analysis of trends is complicated by recent changes in internal dose reporting methodology and the shifting of the DOE mission from weapons production to stabilization and cleanup activities across the DOE complex. The change in internal dose reporting and its impact on the occupational exposure data are examined in Sections 2 and 3.

In general, the occupational radiation exposure received by DOE workers is low compared to DOE exposures in prior years, particularly during the Cold War era, and in comparison with occupational exposure received in the commercial nuclear industry.

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 or access to the data files used to compile this report should be directed to Ms. Nirmala Rao, REMS Project Manager, U.S. Department of Energy, Office of Worker Protection Programs and Hazards Management (EH-52), Germantown, MD 20874 or by calling the ES&H InfoCenter at 1-800-473-4375. A discussion of the various methods of accessing the DOE occupational radiation exposure information is presented in Appendix E. Visit the DOE Radiation Exposure web site for information concerning occupational radiation exposure at the DOE 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 are included.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 1996. 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	Conclusions are presented based on the analysis contained in this report. Where applicable, recommendations are included to address issues that require attention.

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Section Two

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 Programs and Hazards Management 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 visitors. In addition to the requirement that radiation doses not exceed the limits, it is DOE's policy that doses also be maintained as low as reasonably achievable (ALARA).

This section discusses the radiation protection standards and requirements that were in effect for the year 1996. 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 workers at DOE are adequately protected from exposure to ionizing radiation. This guidance, initially implemented by DOE in 1989, is based on the 1976 recommendations of the International Commission on Radiological Protection [2] and the National Council on Radiation Protection and Measurements [3]. The new guidance required 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 new DOE dose limits based on the TEDE were established from this guidance.

DOE became the first federal agency to implement the revised guidance when it promulgated DOE Order 5480.11, "Radiation Protection for Occupational Workers," in December 1988 [4]. DOE Order 5480.11 was effective from 1989 through 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 [6].

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 [7] as implemented by 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993. [8] 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.

DOE Notice 441.1, "Radiological Protection for DOE Activities," [9] (applicable to defense nuclear facilities) was issued to establish radiological protection program requirements that, combined with 10 CFR 835 and its associated non-mandatory implementation guidance, the RadCon Manual, forms the basis for a comprehensive radiological protection program.

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 [10] requirements for reporting radiation dose records are now located in the associated manual, DOE M 231.1-1, "Environment, Safety and Health Reporting" [11], 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 under the new DOE M 231.1-1 for 1996. Because each site implements the new requirements as operating contracts are issued or renegotiated, complete implementation will take several years.

2.1.1 Monitoring Requirements

10 CFR §835.402 requires that, for external monitoring, personnel dosimetry be provided to general employees expected to receive an effective dose equivalent to the whole-body greater than 0.1 rem 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 required when the general employee is likely to receive 0.1 rem or more Committed Effective Dose Equivalent (CEDE), and/or 5 rems or more Committed Dose Equivalent (CDE) to any organ or tissue. Monitoring for minors and members of the public is required if the dose (internal or external) is likely to exceed 50% of the annual limit of 0.1 rem TEDE. Monitoring of declared pregnant females is required if the dose (internal or external) to the embryo/fetus is likely to exceed 10% of the limit of 0.5 rem TEDE.

Monitoring for external exposures is required for any individuals 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 photographic film (film badges), thermoluminescent dosimeters, pocket ionization chambers, electronic dosimeters, personnel nuclear accident dosimeters, bubble dosimeters, plastic dosimeters, and combinations of the above.

Beginning in 1990, the DOE Laboratory Accreditation Program (DOELAP) formalized accuracy and precision performance standards for external dosimeters and quality assurance/quality control requirements on the overall external dosimetry programs for facilities within the DOE complex. All DOE facilities were DOELAP-accredited by the fall of 1995.

External dosimeters have a lower limit of detection of approximately 0.010 - 0.030 rem 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 and monthly for individuals who routinely 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 are dependent 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 radionuclides in question, and their chemical form. Follow-up measurements and analysis may take many months to confirm preliminary findings. With the advent of the publication of American National Standards Institute (ANSI) N13.30-1996, "Performance Criteria for Radiobioassay," DOE has developed a Radiobioassay Accreditation Program with scheduled implementation in 1998.

2.2 Radiation Dose Limits

Radiation dose limits are now codified in 10 CFR § 835.202, 204, 206, 207, 208 and are summarized in *Exhibit 2-1*.

Under § 835.204, Planned Special Exposures (PSEs) may be authorized in 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 to an additional 5 rems TEDE above the routine dose limit as long as the individual does not exceed a cumulative lifetime TEDE of 25 rems 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

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	§835.208	Total Effective Dose Equivalent	TEDE	0.1 rem

impractical. Restrictions on the use of PSEs are extensive and, for this reason, they are expected to be rarely used at DOE.

2.2.1 Administrative Control Levels

Administrative Control Levels (ACLs) were included in the RadCon Manual. 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 required to approve a higher level of exposure.

The RadCon Manual established a DOE ACL of 2 rem 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 must be received. In addition, contractors were required 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 RadCon Manual suggests an annual facility ACL of 0.5 rem or less; however, the Manual also states that a control level greater than 1.5 rem 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.

ACLs are not specified in 10 CFR 835. However, they are specified under DOE Notice 441.1. Administrative controls are required to be implemented to keep doses below the dose limits and to keep doses ALARA. DOE N 441.1 establishes the following administrative control limits: a 2 rem annual TEDE, a 1 rem cumulative TEDE per year of age, and requires that a facility-specific ACL be established for each site.

2.2.2 ALARA Principle

Up 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 ALAP (As Low As Practicable) 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, the RadCon Manual, and 10 CFR 835 formalized the guidance and required 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 to 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 needs 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 RadCon Manual that ALARA plans and procedures be implemented and documented. To help facilities meet this requirement, the DOE developed a manual of good practices for reducing exposures to ALARA levels [12]. 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, the 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 exposure in one of 16 dose equivalent ranges. The revised Order requires the reporting of exposure records for each employee and visitor. Required dose data reporting includes the TEDE, internal dose equivalent, shallow dose equivalent to the skin and extremities, and Deep Dose Equivalent (DDE). Other reported data included the individual's age, sex, employment status, and occupation, as well as the relevant 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 (µCi) of intake. 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 conform with Federal Guidance Report #11 (1987) which was based upon International Commission on Radiologic Protection (ICRP) and National Council on Radiation Protection and Measurements (NCRP) recommendations. These recommendations were also the driver behind the revised 10 CFR 20 [13], which was implemented in 1994 regulating commercial nuclear power plants and other commercial uses of radiation and radioactive materials. 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.

The following is a description of these methodologies and a discussion of how this change has impacted the DOE dose data.

2.4.1 Annual Effective Dose Equivalent

The AEDE method of determining internal dose involves calculating the annual dose to the worker for each year since the original intake event. Because many of the radionuclides used at DOE are long-lived, workers can receive a dose from past intakes for many years, even a lifetime. DOE adopted the AEDE method for calculating internal dose equivalent because the annual dose resulting from an intake was more representative of the actual dose received by the worker during each calendar year.

The AEDE method is problematic from a radiological control viewpoint. It does not account for the dose that would be received by an individual when not employed by DOE. Facilities must keep track of prior year intakes to determine the dose for the current year. The AEDE method does not consider the future dose to the worker resulting from a current year intake. The AEDE method may also adversely impact the individual's future job potential. The accumulation of prior year AEDE doses (legacy doses) may result in a current year dose in excess of the facility's ACL and restrict the individual's current year radiation work opportunities.

2.4.2 Committed Effective Dose Equivalent

The CEDE method assigns all of the dose the individual will receive from an intake for the next 50 years to the year the intake occurred. The sum of all AEDE doses over 50 years from a given intake of radionuclides is equal to the CEDE from the same intake. By assigning all of the future dose to the year of intake, even small intakes of long-lived radioactive material can result in a relatively large dose being assigned to a single year in the year of intake. The CEDE increases the pressure on facilities to limit such exposures because the internal dose does not have to be considered in future years. DOE can limit internal dose during the year of occurrence while not unduly impacting the worker's future employability.

2.4.3 Impact on the Dose Data

This change in internal dose accounting and reporting has two main impacts on the DOE dose data. First and foremost is that "legacy doses" (internal AEDE dose resulting from intakes in years prior to the dose report year) are included in the collective TEDE shown in this report for 1991 and 1992. Legacy doses represent a significant amount of dose to the DOE worker population during these years.

In 1992, nearly 5,500 individuals were receiving 65% of their annual dose from intakes that occurred in prior years, many having occurred 20 to 30 years before. In the analysis of exposures in excess of the DOE limits and the 2 rem ACL presented in Sections 3.3.1 and 3.3.2, readers should note that most of the exposures for 1991 and 1992 were because of the inclusion of the AEDE from prior year intakes.

Beginning in 1993, internal dose was reported using the CEDE methodology. Legacy doses were no longer included or reported because the CEDE is calculated only from new intakes occurring during the year of the report. The new reporting requirements did not require the reporting of internal dose resulting from intakes during prior monitoring years.

Because these legacy doses are no longer reported, there is an apparent large drop from 1992 to 1993 in the total collective dose for all workers, and in the number of workers who received high doses. Where applicable, the contribution from legacy dose has been highlighted in this report. Readers should be alert to the significance of this change to correctly interpret the data.

The second major impact of the change from AEDE to CEDE is in the internal dose for 1993 through 1995. As noted previously, the CEDE includes the dose to the individual for the next 50 years. This greatly magnifies the impact of small intakes of long-lived radionuclides. Intakes that would have resulted in an AEDE below ACLs prior to 1993 now may result in a CEDE above the regulatory limits. For long-lived radionuclides, the difference in values between AEDE and CEDE may be up to 50 times.

It is important to note that the change from AEDE to CEDE impacted the calculation of dose from only long-lived isotopes, such as uranium and plutonium. Internal dose from the intake of isotopes with retention periods of less than a year, such as tritium, were not impacted. For short-lived isotopes or isotopes with short retention periods, AEDE is equal to the CEDE because the entire dose is accrued during the year of intake.

2.4.4 External Dose

The change from the AEDE to CEDE for internal dose does not affect the reporting of external dose. The only changes in the DDE data from 1987 through 1996 have been the continuing improvements in dosimeter detection levels and standardization through accreditation by DOELAP. Interpreting the trends of DDE during this period is, therefore, consistent.

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Occupational Radiation Dose at DOE

3.1 Analysis of the Data

The purpose of analyzing occupational radiation dose data is to reveal opportunities to improve safety and to demonstrate performance. This is accomplished through analysis and explanation of observed trends. 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: collective, 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 collective data are: collective dose, number of monitored individuals and individuals with measurable dose, average measurable dose, and the distribution of dose. Analysis of individual dose data includes an examination of doses exceeding DOE regulatory limits, and doses exceeding the 2 rem 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.

3.2 Analysis of Collective Data

3.2.1 Number of Monitored Individuals

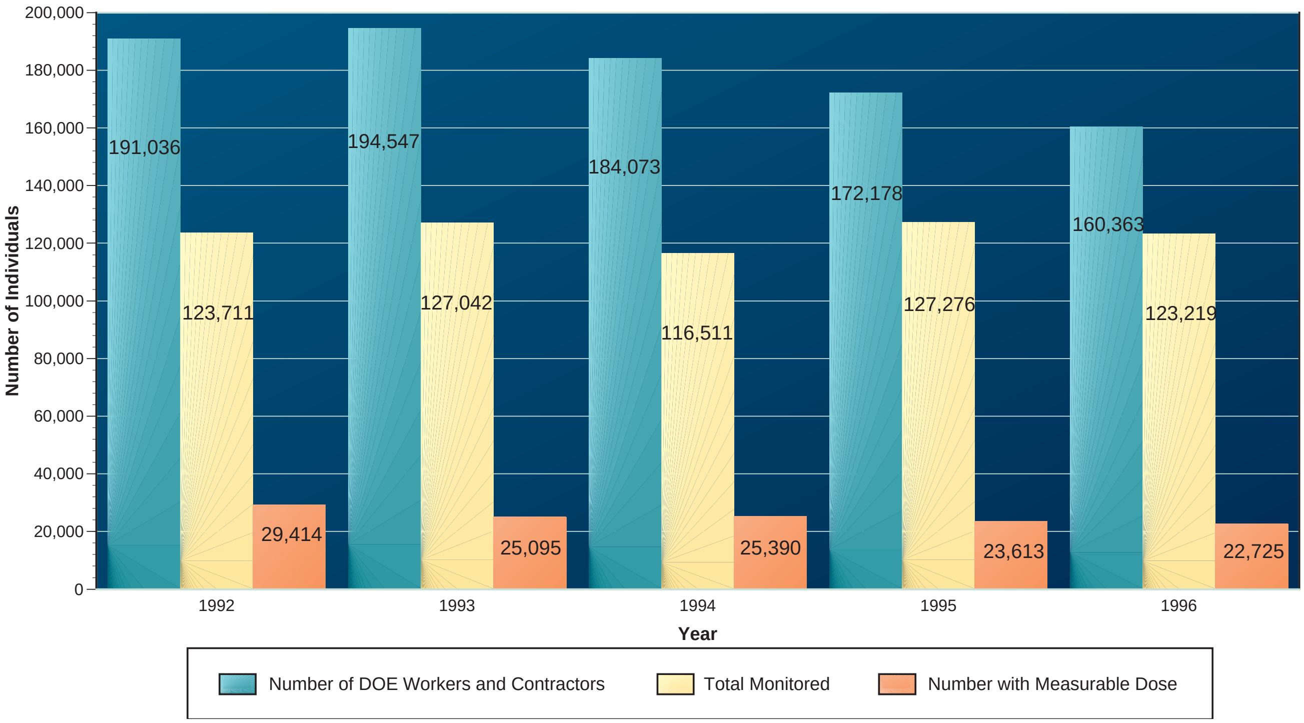
The number of monitored individuals represents the size of the worker population at DOE provided with dosimetry. This number represents the sum of all monitored individuals, including all DOE employees, contractors, and visitors. The number of monitored individuals is an indication of the size of a dosimetry 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 receiving measurable dose better represent the exposed workforce.

3.2.2 Number of Individuals with Measurable Dose

The 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 total number of workers at DOE, the total number monitored, and the number with measurable dose for the past 5 years. The percentage of the DOE workforce monitored for radiation exposure has increased by 12% from 1992 to 1996. However, most of the monitored individuals do not receive any measurable radiation dose. Only 20% of monitored individuals (14% of the DOE workforce) received a measurable dose during the past 5 years. The number of individuals receiving a measurable dose has decreased by 23% from 1992 to 1996. The percentage of monitored workers that received measurable dose has decreased by 5% from 1992 to 1996. In summary, a larger percentage of the DOE workforce was monitored for radiation in 1996, while a smaller percentage of the monitored individuals received a measurable dose.

Exhibit 3-1:
Monitoring of the DOE Workforce



Twenty percent of monitored workers received a measurable dose over the past 5 years.

The number of workers with measurable dose has decreased by 23% over the past 5 years.

The number of workers with a measurable dose decreased by 4% between 1995 and 1996.

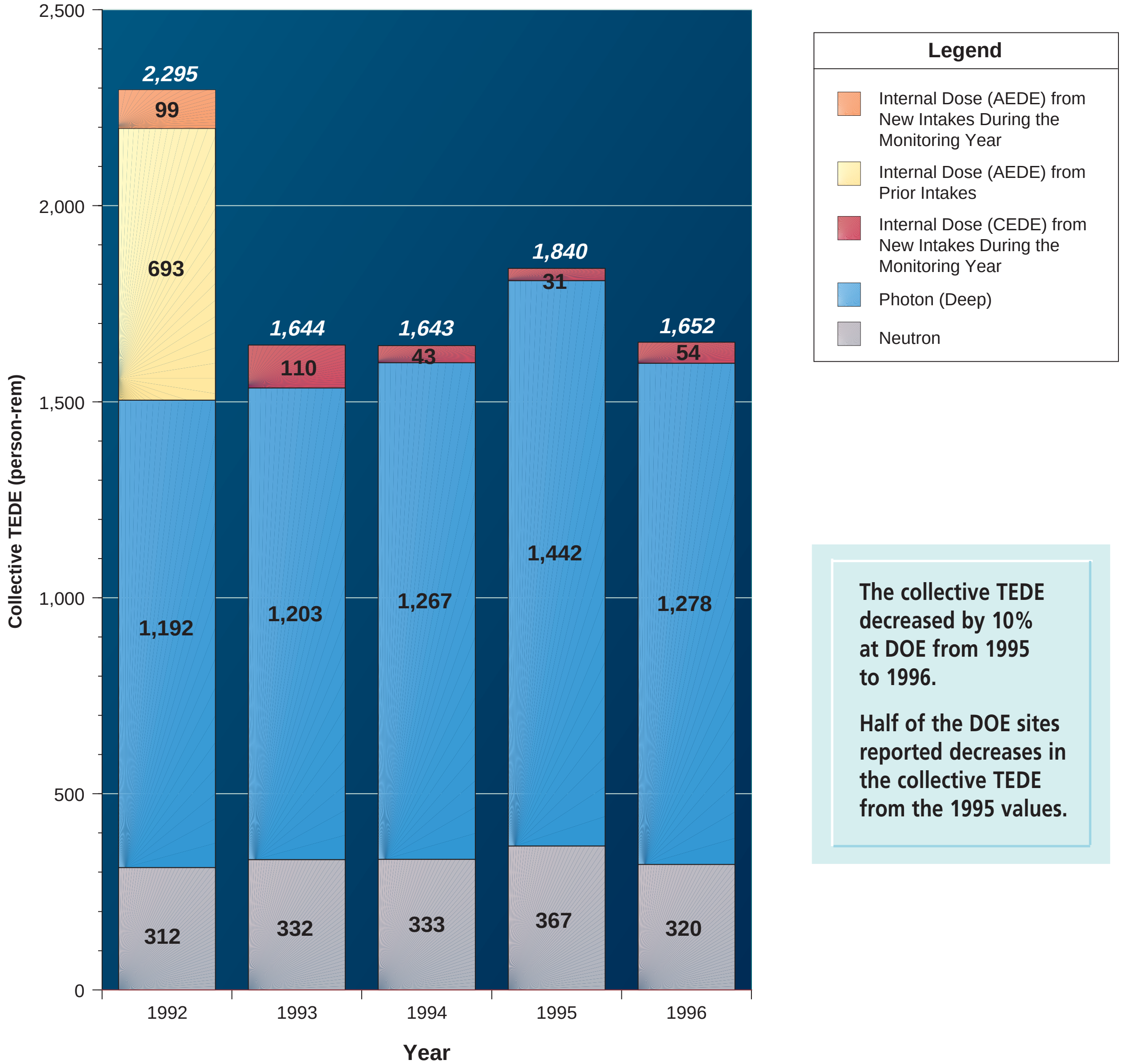
About half (15) of the 28 sites experienced decreases in the number of workers with measurable dose from 1995 to 1996, with the largest decreases occurring at the Portsmouth Gaseous Plant (PORTS) and Los Alamos National Laboratory (LANL) sites. Overall, the number of individuals with a measurable dose decreased by 4% between 1995 and 1996. A discussion of activities at various facilities is included in Section 3.5.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with measurable dose (*Exhibit 3-1*) 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 a 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 1995 to 1996. Half of the DOE sites reported decreases in the collective TEDE from the 1995 values. Five out of seven of the highest dose sites reported decreases in the collective TEDE. These seven sites are (in descending order of collective dose) Rocky Flats, Hanford, Savannah River, Los Alamos, Idaho, Brookhaven, and Oak Ridge. A discussion of the activities leading to this decrease is included in Section 3.5.

Exhibit 3-2:
Components of TEDE, 1992-1996



The collective TEDE decreased by 10% at DOE from 1995 to 1996.

Half of the DOE sites reported decreases in the collective TEDE from the 1995 values.

Photon dose - the component of external dose from gamma or x-ray electromagnetic radiation.

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. The photon, neutron, and internal dose components are shown.

The large decrease in the internal dose from 1992 to 1993 was due to the change in calculating and reporting of the internal dose from AEDE to CEDE. It must be noted that the internal dose shown in *Exhibit 3-2* for 1993 through 1996 is based on the CEDE and therefore should not be compared with the AEDE internal dose from 1992. The internal dose component increased by 74% from 1995 to 1996, primarily due to the single internal dose of 11.5 rem at SRS as well as increases in internal dose at Oak Ridge, Portsmouth and LANL.

Because the reporting of internal dose changed in 1993 (see Section 2.4), it is necessary to analyze the collective external dose during this time period in order to examine the collective dose trend across the past 5 years. External dose is comprised of radiation dose from photons (gamma or x-ray) and neutrons.

The photon dose remained fairly stable at about 1,200 person-rem during the years 1992-1994, but increased by 14% to 1,442 person-rem in 1995 due to increased activities at several of the highest dose sites. Activities responsible for increased dose at these sites included work on power sources for the National Aeronautics and Space Administration (NASA), increased research at an accelerator facility, nuclear materials stabilization activities, and decontamination and decommissioning work. In 1996, the photon dose decreased by 11% to a value of 1,278 person-rem. Sites attributed the reduction in dose to the completion of several decontamination and decommissioning projects, reduced spent fuel storage activities, and effective ALARA practices. A discussion of the activities leading to this decrease is included in Section 3.5.

The neutron component of the TEDE decreased by 13% from 1995 to 1996. This is primarily due to decreases in the neutron dose at LANL and Brookhaven National Laboratory (BNL). LANL contributed 40% of the neutron dose at the DOE. 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 in 1996, which resulted in decreased neutron dose by 30% from 174.1 person-rem in 1995 to 121.6 person-rem in 1996. The collective neutron dose by site is shown in Appendix B-3.

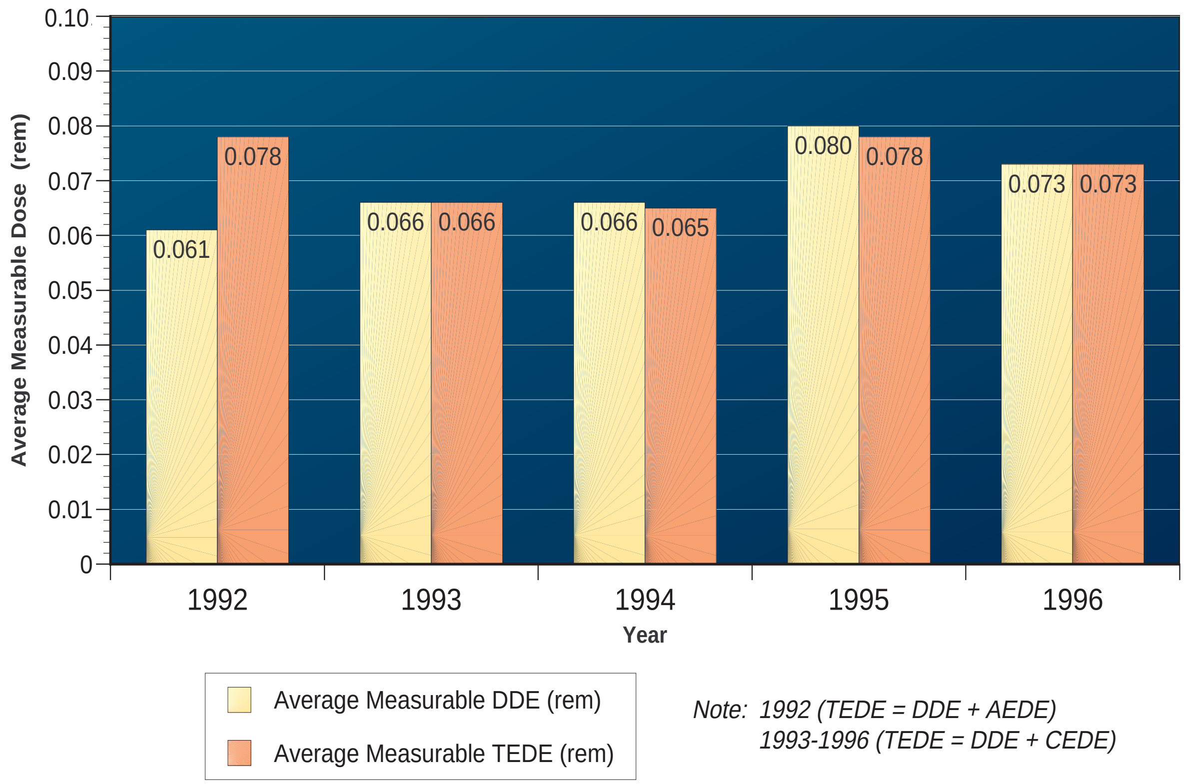
Collective dose information for prior years can be found in Appendix B-4.

3.2.4 Average Measurable Dose

The average measurable dose to DOE workers is determined by dividing the collective dose by the number of individuals with measurable dose. This is considered a key indicator 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

Exhibit 3-3:
Average Measurable DDE Dose and Average Measurable TEDE



decreased by 17% from 1992 to 1994, increased by 20% from 1994 to 1995, and decreased by 6% from 1995 to 1996. The decrease in the average measurable TEDE from 1995 to 1996 is due to the 10% decrease in the collective TEDE combined with the 4% decrease in the number of individuals with measurable TEDE. The average measurable DDE also decreased by 9% from 1995 to 1996. The average measurable DDE and TEDE values are provided for trending purposes, not for comparison between DDE and TEDE values.

While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by workers at DOE, they do not provide any indication of how each dose was distributed across the worker population. An effective measure of ALARA is the reduction in dose to individuals, as well as to the overall workforce.

3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the manner in which the dose is distributed 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 to allow analysis of the dose independent of the change in internal dose reporting from 1992 to 1993 (see Section 2.3). The number of individuals

The average measurable TEDE decreased by 6% from 1995 to 1996.

Exhibit 3-4:
Dose Distributions, 1992-1996

Number of Individuals in Each Dose Range*

Dose Ranges (rem)	1992		1993		1994		1995		1996	
	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE
Less than Measurable	94,297	98,900	101,947	103,905	91,121	92,245	103,663	104,793	100,494	101,424
Measurable < 0.1	23,896	21,019	21,210	19,356	21,511	20,469	19,273	18,191	18,761	17,903
0.10 - 0.25	3,581	2,585	2,487	2,437	2,437	2,389	2,543	2,513	2,440	2,405
0.25 - 0.5	1,252	852	1,017	985	934	920	1,134	1,124	1,003	983
0.5 - 0.75	346	235	195	183	329	317	374	371	339	335
0.75 - 1.0	165	78	93	89	99	94	131	131	99	94
1 - 2	132	42	87	86	79	77	157	153	80	74
2 - 3	22								2	1
3 - 4	9				1		1		1	
4 - 5	6		2	1						
5 - 6										
6 - 7	2									
7 - 8	1									
8 - 9			1							
9 - 10	1		1							
10 - 11										
11 - 12									1	
> 12	1		2							
Total Monitored	123,711	123,711	127,042	127,042	116,511	116,511	127,276	127,276	123,219	123,219
Number with Meas. Dose	29,414	24,811	25,095	23,137	25,390	24,266	23,613	22,483	22,725	21,795
Number with Dose >0.1rem	5,518	3,792	3,885	3,781	3,879	3,797	4,340	4,292	3,966	3,892
% of Individuals with Meas. Dose	24%	20%	20%	18%	22%	21%	19%	18%	18%	18%
Collective Dose (person-rem)	2,295	1,504	1,644	1,534	1,643	1,600	1,840	1,809	1,652	1,598
Average Measurable Dose (rem)	0.078	0.061	0.066	0.066	0.065	0.066	0.078	0.080	0.073	0.073

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

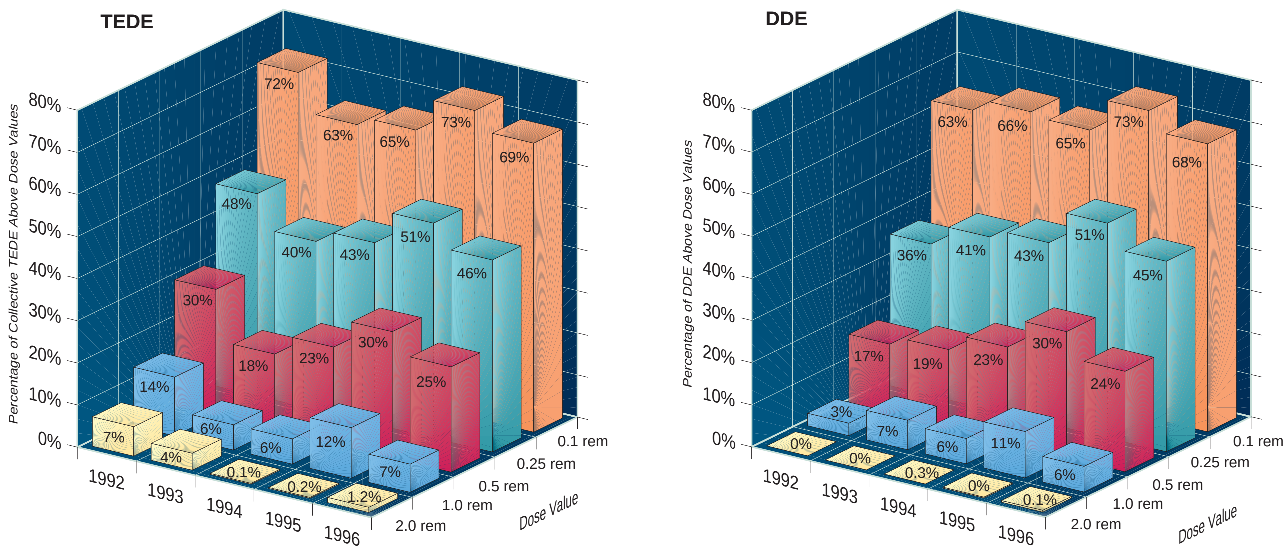
receiving doses above 0.1 rem is also included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c).

Exhibit 3-4 shows that few individuals receive doses in the higher ranges and that the vast majority of doses are at low levels. 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.

In 1982, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [14] defined CR as the fraction of the collective dose delivered above 1.5 rem. UNSCEAR identified this parameter as an indicator of the efforts to reduce high doses. The DOE has adapted this approach to allow a quantification and analysis of the dose distribution at DOE.

Ideally, only a small percentage of the collective dose is delivered to individuals in the higher dose ranges. In addition, a

Exhibit 3-5:
Distribution of Collective Dose vs Dose Values, 1992-1996



trend in the percentage above a certain dose range decreasing over time indicates the effectiveness of ALARA programs to reduce doses to individuals in the higher dose ranges.

Exhibit 3-5 shows the distribution ratio given by percentage of collective TEDE and DDE above each of five dose values, from 0.1 rem to 2 rem. This graph shows the 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. Much of the observed trend that occurred from 1992 to 1993 coincides with the change from AEDE to CEDE.

The data for 1996 indicate that the percentage of the collective dose accrued above 0.1 rem has decreased from 1995 in all dose ranges except for the dose above 2.0 rem, which experienced a small increase. The increase in the percentage above 2.0 rem was due to three individuals receiving doses in excess of 2.0 rem (see Section 3.3.2) and one individual in excess of the 5 rem TEDE limit (see Section 3.3.1). The 1995 distribution exhibited an increase in all of the dose ranges, which corresponds with the 12% increase in the collective dose in 1995. In addition, the collective dose increase in 1995 tended to be accrued among individuals in the dose ranges from 0.1 rem to 2.0 rem. Most of this increased dose was accrued by individuals in the operations, scientists, and technicians labor categories. The distribution of the collective dose in 1996 reflects the 10% decrease in the collective dose from 1995 to 1996 and is similar to the distribution in 1994.

Over the past 4 years, the general trend has been an increase in the percentage of dose above each dose range from 1993 to 1995 and then a decrease in 1996. This coincides

There was one individual with a dose in excess of the 5 rem TEDE limit in 1996.

All of the events resulting in doses in excess of DOE limits in 1992 and 1993 were from internal dose.

with the increase in the collective dose reported in 1995 and the increase in activities resulting in radiation exposures at the highest dose sites during 1995. Most of these sites reported decreases in the collective dose and radiological activities in 1996 (see Section 3.5), which coincides with the observed decreases in *Exhibit 3-5*.

3.3 Dose to Individuals

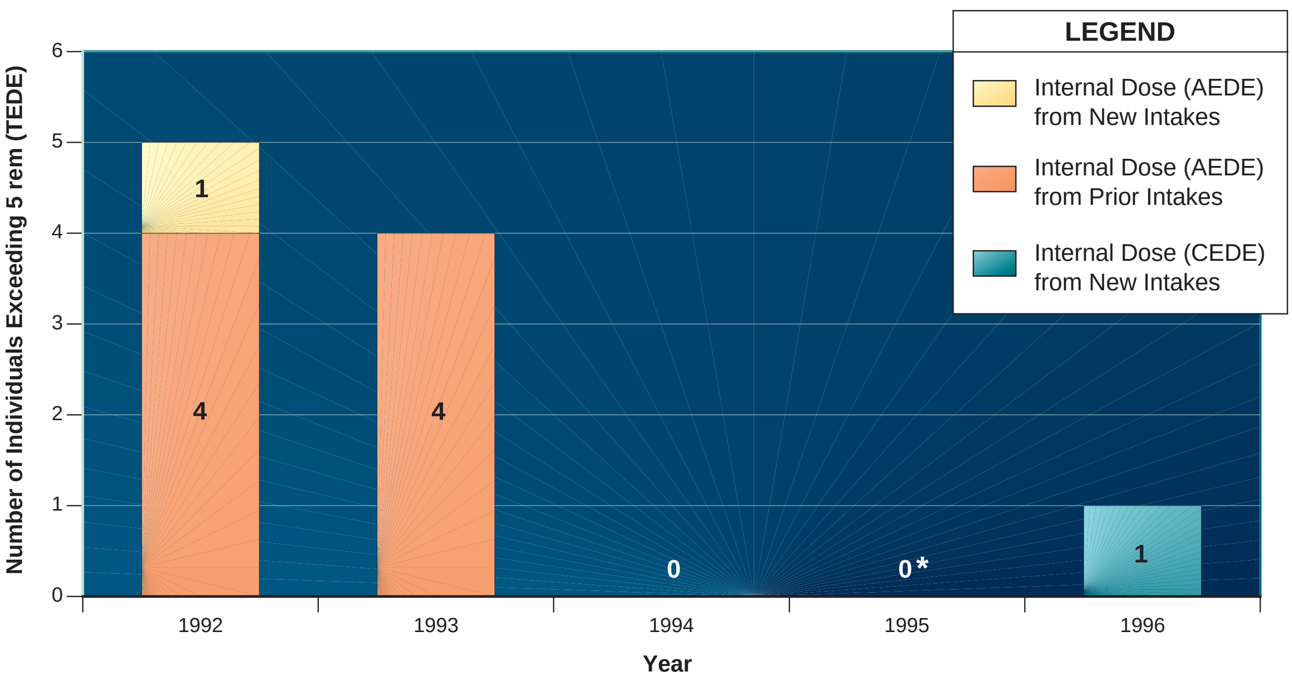
The above analyses are all based on collective dose data for DOE. From an individual worker perspective as well as a regulatory perspective, it is important to more closely examine the doses received by individuals in the high dose ranges to more thoroughly understand the circumstances leading to high doses in the workplace and how these doses may be mitigated in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rem TEDE) and the DOE ACL (2 rem TEDE).

3.3.1 Doses in Excess of DOE Limits

Exhibit 3-6 shows the number of doses in excess of the regulatory limit (5 rem TEDE) from 1992 through 1996. Further information concerning the individual doses, radionuclides involved, and site where the doses occurred is shown in *Exhibit 3-7*. Most of the doses in excess of the limit shown for 1992 were from legacy intakes as noted in the exhibit.

There was one individual in 1996 who received a dose in excess of the 5 rem TEDE limit (see *Exhibit 2-1*). This individual received an internal CEDE dose of 11.5 rem due to an unanticipated intake of plutonium at the Savannah River Site. The intake occurred in December of 1996, but was discovered and reported in 1997

Exhibit 3-6: Number of Individuals Exceeding 5 rem (TEDE), 1992-1996



* *One potential dose was reported to ORPS in 1997. See Section 3.3.1.*

Exhibit 3-7:
Doses in Excess of DOE Limits, 1992-1996

Year	Year Uptake	TEDE (rem)	DDE (rem)	Internal Dose*	Intake Nuclides	Facility Types	Site
1992	1952	6.400	0	6.400	Pu238	Research, General	Los Alamos Nat'l. Lab.
1992	<1992	14.490	0.013	14.477	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	<1992	6.526	0.019	6.507	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	<1992	7.789	0.019	7.770	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	1992	9.855	0	9.855	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1993	1993	17.220	0	17.220	Pu239, Pu240	Maint. & Support	Los Alamos Nat'l. Lab.
1993	1993	22.068	0.189	21.879	Pu239, Pu240	Research, General	Los Alamos Nat'l. Lab.
1993	1993	8.709	0.209	8.500	Pu239, Pu240	Research, General	Los Alamos Nat'l. Lab.
1993	1993	9.218	0.058	9.160	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1994					None Reported		
1995					None Reported**		
1996	1996	11.623	0.123	11.500	Pu238, Pu239, Pu241	Fuel Processing	Savannah River

* *AEDE for 1992, CEDE for 1993-1996.*
** *One potential dose was reported to ORPS in 1997. See Section 3.3.1.*
< *Year of uptake is unknown, but is known to be prior to the year indicated.*

after a special follow-up bioassay was performed. After a thorough review, it was concluded that the individual received the intake during the removal of a radiological containment hut. The operator walked through an area of elevated levels of airborne contamination without the use of respiratory protection. Causes cited for this event were personnel error, management problems, and procedural problems. Corrective actions included briefings and personnel training, a Job Hazards Analysis review, and procedural modifications. For more information on this occurrence, see the Occurrence Report SR-WSRC-FCAN-1997-0009.

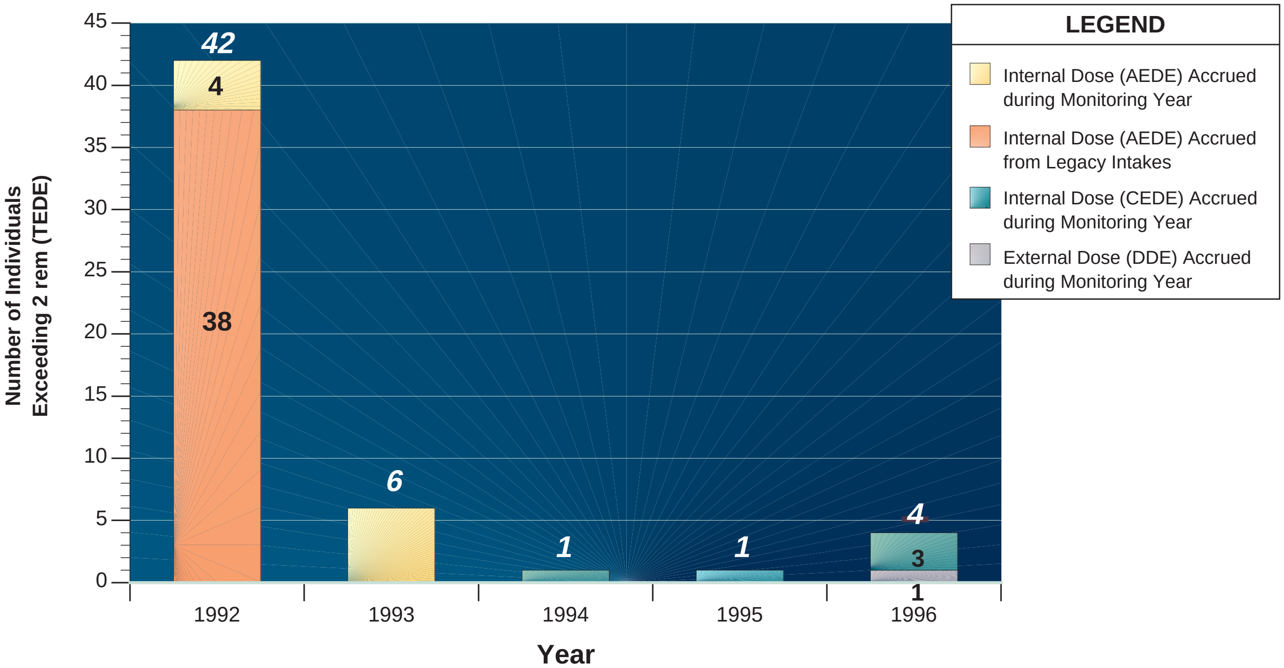
There has been an occurrence report submitted to ORPS by Rocky Flats as of December 1997 that indicates that an individual received an intake in 1995 that may result in a CEDE dose in excess of 5 rem. The interim dose assessment resulted in an assigned CEDE of 5 rem for 1995. The final dose assessment has not yet been determined, nor has the cause of the intake. For further information, see Occurrence Report RFO-KHLL-371OPS-1997-0106. Due to the interim nature of this exposure information, this dose has not been included in the tables presented in this report. Upon final dose determination, subsequent annual reports will reflect this 1995 dose.

3.3.2 Doses in Excess of Administrative Control Level

The RadCon Manual recommends a 2 rem ACL for TEDE, which is not to be exceeded without prior DOE approval. Each DOE site is required to establish its own, more restrictive ACLs that require contractor management approval to be exceeded. The number of individuals receiving doses in excess of the 2 rem ACL is a measure of the effectiveness of DOE's radiation protection program.

The number of individuals with exposures above 2 rem dropped considerably from 1992 to 1993, as shown in *Exhibit 3-8*. However, nearly all of this decrease occurred between 1992 and 1993 because of the change in internal dose

Exhibit 3-8:
Number of Doses in Excess of the DOE 2 rem ACL, 1992-1996



reporting. Legacy internal doses contributed to the vast majority of the individuals above 2 rem prior to 1993.

If one excludes the legacy doses from prior years, it should be noted that the number of doses in excess of 2 rem in 1996 is the same as the number in 1992. In 1993 the number increased to six. This was also the first year of reporting the 50-year CEDE, which results in the calculation of higher internal doses from long-lived nuclides. Four of these six doses in 1993 also exceeded the 5 rem TEDE limit as described in Section 3.3.1.

There were four TEDE doses in excess of the 2 rem ACL in 1996. One of the doses was from external dose, and the second and third were due to internal dose from the intake of radioactive material. The fourth TEDE dose above the 2 rem ACL was due to a combination of internal and external dose. One of the internal doses also exceeded the 5 rem TEDE limit as described in Section 3.3.1.

The one external exposure above 2 rem was received by an individual working on DOE's North Korea Project. This individual received a dose of 2.025 rem. The project is in support of the President of the United States nonproliferation initiative. The Office of Nonproliferation and Arms Control (NN-40), is securing the nuclear spent fuel located in the Democratic Peoples Republic of Korea (DPRK) and placing it under International Atomic Energy Agency safeguards. The work is being performed under the US/DPRK Agreed Framework, which requires the DPRK to cease their nuclear weapons program in return for two Light Water Reactors (LWR) and Heavy Fuel Oil during the construction of the LWRs. The project has the potential for higher than average doses due to the highly radioactive nature of the spent fuel.

Two of the internal doses in excess of 2 rem occurred at LANL and involved intakes of plutonium-239 at the TA-55 Plutonium Processing Facility. One individual received a CEDE dose of 3.5 rem while the other received a CEDE dose of 1.3 rem in addition to an external deep dose of 0.849 rem. The two intakes occurred during separate events, but both of them involved glovebox failures. In one event a glove failed during transfer of materials from one glovebox to another. In the other event, a large gasket around a glovebox failed. In both events the contamination was detected and the exposed individuals were subjected to bioassay programs, and the activities involving the gloveboxes were suspended until they could be repaired or replaced. Because these exposures were unplanned, there was no advanced DOE approval for exceeding the DOE ACL. For more information concerning these events, see the Occurrence Reports ALO-LA-LANL-TA55-1996-0027 and ALO-LA-LANL-TA55-1997-0021. The other internal dose in excess of the 2 rem ACL was the 11.5 CEDE exposure at Savannah River; see section 3.3.1 for more details.

3.3.3 Internal Depositions of Radioactive Material

As discussed in Section 3.3.1, in the past, some of the most significant 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) for 1994-1996 is shown in *Exhibit 3-9*. The internal depositions were categorized into one of eight radionuclide groups. Intakes involving multiple nuclides are listed as "mixed" nuclides. Nuclides where fewer than ten individuals had intakes over the 3-year period were grouped together as "other" nuclides. 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.

Exhibit 3-9 shows the intakes that occurred during the past 3 years that were reported using the CEDE internal dose calculation methodology. For an analysis of legacy doses from prior years, see the annual report for the period 1992 - 1994.

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

Exhibit 3-9:
Number of Intakes, Collective Internal Dose, and Average Dose by Nuclides, 1994-1996

Nuclide	Number of Workers with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
Year	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**
Hydrogen-3 (Tritium)	908	810	**797** ◄	10.680	6.995	6.353	0.012	0.009	0.008
Technetium	27	-	2	0.281	-	0.006	0.010	-	0.003
Thorium	280	31	148	2.918	1.192	9.633	0.010	0.038	0.065
Uranium	**914** ◄	**880** ◄	539	10.660	**11.354** ◄	12.380	0.012	0.013	0.023
Plutonium	66	72	66	**18.290** ◄	9.682	**24.297** ◄	0.277	**0.134** ◄	**0.368** ◄
Americium-241	3	20	16	1.560	0.457	0.572	**0.520** ◄	0.023	0.036
Other	14	34	31	0.072	0.918	0.283	0.005	0.027	0.009
Mixed	16	4	-	1.139	0.166	-	0.071	0.042	-
Totals	**2,228**	**1,851**	**1,599**	**45.600**	**30.764**	**53.524**	**0.020**	**0.017**	**0.033**

Note: Arrowed values indicate the greatest value in each column.
* Individuals may have received intakes of more than one nuclide and therefore may be counted more than once.

Most intakes of radioactive material during the 3-year period were the result of exposure to tritium or uranium. The average CEDE doses from these intakes are quite low because of the radiological and biological characteristics of these radionuclides and the large number of monitored individuals with low CEDE dose from these radionuclides.

The highest average and collective CEDE dose for 1996 was from plutonium. Plutonium yields particularly high values for CEDE because of the long radiological half-life and the long-term deposition of the material in the bone. Americium intakes have a high average CEDE for similar reasons, but the number of intakes and collective dose are much smaller than for plutonium. Both the collective and average doses for plutonium increased in 1996 primarily due to two individuals who received doses above 2 rem (see Section 3.3.2) and one individual who received a dose of 11.5 rem CEDE (see Section 3.3.1). The collective CEDE from thorium increased due to an increase in intakes at the Portsmouth Gaseous Diffusion Plant.

The internal dose records indicate that the majority of the intakes reported are at very low doses. In 1996, 83% of the internal dose records were for doses below 0.020 rem. These records represent only 12% of the collective internal dose. The other 17% of the internal dose records had doses above 0.020 rem and accounted for 88% of the collective internal dose. Over the 5-year period, internal doses from new intakes accounted for only 4% of the collective TEDE. Only 3% of the individuals who received internal dose were above the monitoring threshold specified in 10 CFR 835.402 (c).

Exhibit 3-10 shows the distribution of the internal dose from 1992 to 1996. The total number of individuals with doses in each dose range is for each record of intake. 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 in *Exhibit 3-9* and, for this reason, the totals in *Exhibit 3-10* may not correspond to those in *Exhibit 3-9*. Doses below 0.020 rem are shown as a separate dose range to show the large number of doses in this low-dose range. Even with the change in methodology from AEDE to CEDE in 1993, all but nine of the doses are below the 2 rem ACL and all but five are below the 5 rem DOE dose limit for the years 1993-1996. All but two of the internal doses were below 2 rem in 1996. The distribution of internal dose by site and nuclide for 1996 is presented in Appendix B-22.

When examining trends involving internal dose, several factors should be considered. Some of the largest changes

Exhibit 3-10:
Internal Dose Distribution from Intakes, 1992-1996

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 ** (person-rem)
1992	2,970	537	70	12	13	8	4	1	2		1	3,618	99.386
1993	2,533	354	56	22	6	2	1			1	4	2,979	109.913
1994	1,712	224	29	18	7	2	2		1			1,995	45.600
1995	1,564	245	33	4	1		3	1				1,851	30.764
1996	1,324	202	42	13	9	4	3		1		1	1,599	53.524

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.
** Collective internal dose = AEDE for 1992, CEDE for 1993-1996.

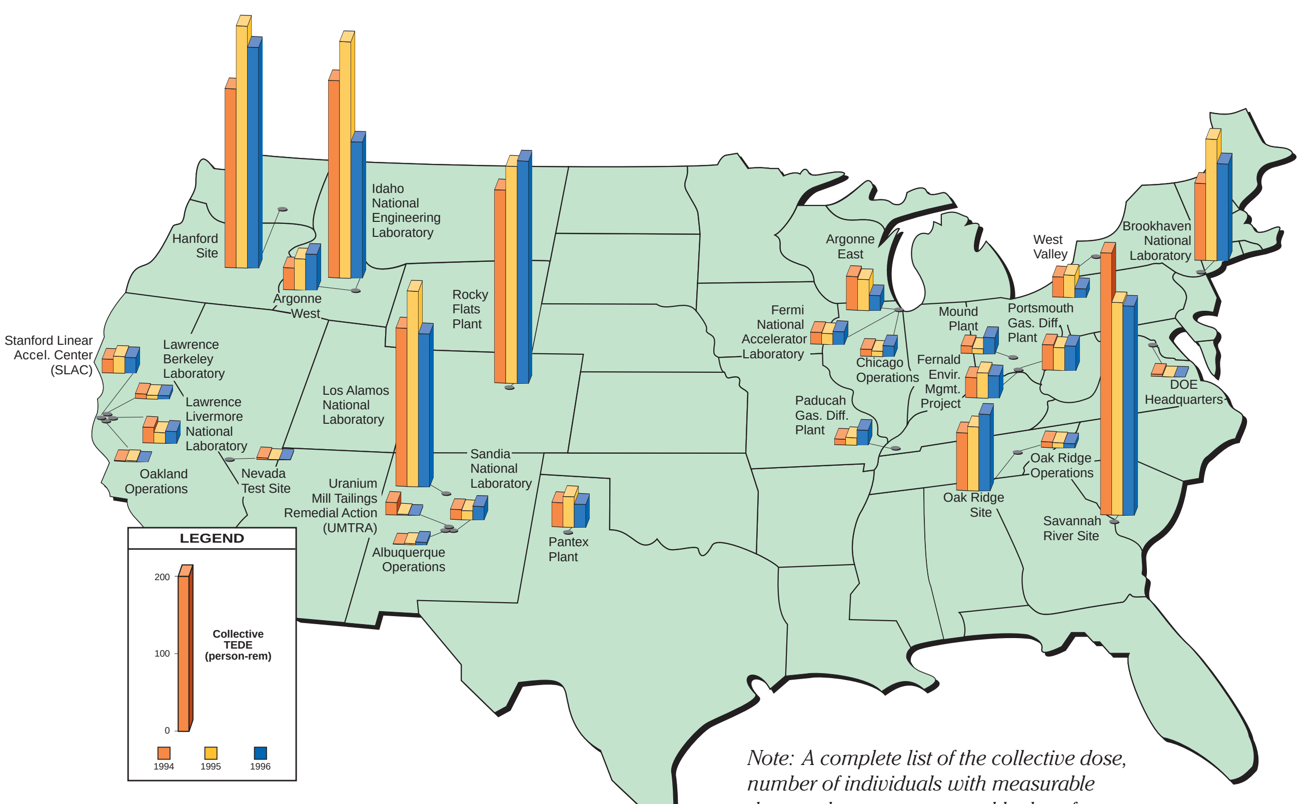
in the number of reported intakes over the years were the result of changes in internal dosimetry practices. Periodically, sites will change monitoring practices or procedures, which may involve increasing the sensitivity of the detection equipment, thereby increasing the number of individuals with measurable 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 CEDE method of calculating internal dose can result in large internal doses from the intake of long-lived nuclides. This can result in significant statistical variability of the internal dose data from year to year.

3.4 Site Analysis

3.4.1 Collective TEDE by Operations/Field Offices

The collective TEDE for 1994-1996 for the major DOE sites and Operations/Field Offices is shown in *Exhibit 3-11*. A list of the collective TEDE and number of individuals with measurable TEDE for the DOE Operations/Field Offices and sites is shown in *Exhibit 3-12*. The collective TEDE decreased by 10% between 1995 and 1996 with seven of the highest dose sites (LANL, BNL, Idaho, Oak Ridge, Rocky Flats, Hanford, and Savannah River) contributing 81% of the total DOE collective TEDE.

Exhibit 3-11:
Relative Collective TEDE by Site/Facility



Note: A complete list of the collective dose, number of individuals with measurable dose, and average measurable dose for each Operations/Field Office can be found in Appendix B.

Exhibit 3-12:
Collective TEDE and Number of Individuals with Measurable TEDE by Site/Facility, 1994-1996

Operations/ Field Office	Site/Facility	1994 Collective TEDE (person-rem)	1994 Number with Meas. TEDE	1995 Collective TEDE (person-rem)	1995 Number with Meas. TEDE	1996 Collective TEDE (person-rem)	1996 Number with Meas. TEDE
Albuquerque	Ops. and Other Facilities	0.4	26	1.6	40	3.6	37
	Los Alamos National Lab. (LANL)	190.0	2,448	234.9	2,583	184.1	1,984
	Pantex Plant (PP)	29.1	347	36.9	329	28.1	327
	Sandia National Lab. (SNL)	12.0	250	11.1	343	16.7	485
	Uranium Mill Tailings Remedial Action (UMTRA) Project	15.0	390	1.3	58	0.4	26
Chicago	Ops. and Other Facilities	8.3	233	6.5	135	13.5	182
	Argonne Nat'l. Lab. - East (ANL-E)	40.3	280	37.2	297	18.5	202
	Argonne Nat'l. Lab. - West (ANL-W)	26.3	343	37.6	335	43.6	331
	Brookhaven Nat'l. Lab.(BNL)	92.3	865	145.8	973	116.8	1,448
	Fermi Nat'l. Accelerator Lab.(FERMI)	14.3	526	13.4	473	16.2	538
DOE HQ	DOE Headquarters	2.7	43	0.1	8	0.3	6
	DOE North Korea Project					13.3	36
Idaho	Idaho Site	236.8	1,659	284.0	1,501	164.1	1,299
Nevada	Nevada Test Site (NTS)	2.0	20	0.5	9	1.0	19
Oakland	Ops. and Other Facilities	0.8	20	1.3	20	0.0	6
	Lawrence Berkeley Lab. (LBL)	5.7	92	4.5	76	4.6	100
	Lawrence Livermore Nat'l. Lab. (LLNL)	18.8	146	13.0	159	14.9	187
	Stanford Linear Accelerator Center (SLAC)	16.3	219	20.2	236	19.3	312
Oak Ridge	Ops. and Other Facilities	6.8	255	6.2	167	11.9	200
	Oak Ridge Site	69.2	1,613	76.9	1,804	88.6	1,582
	Paducah Gaseous Diff. Plant (PGDP)	6.8	151	9.0	225	18.6	290
	Portsmouth Gaseous Diff. Plant (PORTS)	30.3	836	27.5	1,623	29.9	758
Ohio	Ops. and Other Facilities	0.0	2	0.0	5	0.0	5
	Fernald Environmental Management Project	24.2	925	30.4	955	27.4	804
	Mound Plant	9.1	299	6.4	175	20.1	403
	West Valley	24.3	292	26.9	311	11.2	231
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	231.9	3,660	260.8	3,427	**267.6** ◄	3,430
Richland	Hanford Site	214.8	3,166	**290.7** ◄	2,500	265.7	2,761
Savannah River	Savannah River Site (SRS)	**314.5** ◄	**6,284** ◄	255.5	**4,846** ◄	251.8	**4,736** ◄
Totals		**1,643.1**	**25,390**	**1,840.2**	**23,613**	**1,651.9**	**22,725**

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

Exhibit 3-13:
Doses by Labor Category, 1994-1996

Labor Category	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
Agriculture	7	9	8	0.7	0.5	0.4	**0.100** ◀	0.058	0.047
Construction	2,335	2,300	2,588	149.0	164.2	176.8	0.064	0.071	0.068
Laborers	807	729	542	55.2	76.3	49.0	0.068	0.105	0.090
Management	2,003	1,629	1,212	80.6	74.4	57.2	0.040	0.046	0.047
Misc.	1,655	3,496	**5,012** ◀	77.5	169.4	259.8	0.047	0.048	0.052
Production	3,090	2,779	2,434	284.5	282.0	267.4	0.092	0.101	0.110
Scientists	**5,201** ◀	3,513	3,828	197.7	153.7	164.4	0.038	0.044	0.043
Service	1,201	962	569	51.8	37.0	31.7	0.043	0.038	0.056
Technicians	4,238	3,929	3,576	**393.8** ◀	429.1	**416.6** ◀	0.093	0.109	**0.117** ◀
Transport	478	313	401	21.1	18.0	18.8	0.044	0.057	0.047
Unknown	4,375	**3,954** ◀	2,555	331.2	**435.4** ◀	209.9	0.076	**0.110** ◀	0.082
Totals	**25,390**	**23,613**	**22,725**	**1,643.1**	**1,840.2**	**1,651.9**	**0.065**	**0.078**	**0.073**

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

* *1994-1996 TEDE = CEDE + DDE*

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 Order 5484.1 (or the new DOE M 231.1-1) and are grouped into major labor categories in this report. The collective TEDE to each labor category for 1994-1996 are shown in *Exhibits 3-13* and *3-14*. Technicians and production staff have the highest collective TEDE for 1996 because they generally handle more radioactive sources than individuals in the other labor categories. Thirty-six percent of the technician dose is attributed to radiation monitoring technicians.

The collective TEDE is also high for the "unknown" and "miscellaneous" categories. One of the reasons this occupation category contains a large number of individuals is because LANL reports all of their workers in this category. Thirty-nine percent of the dose in this category is attributed to LANL. The LANL computer system does not currently maintain the data necessary to report occupation codes in accordance with DOE M 231.1-1. LANL is addressing this

Exhibit 3-14:
Graph of Doses by Labor Category, 1994-1996

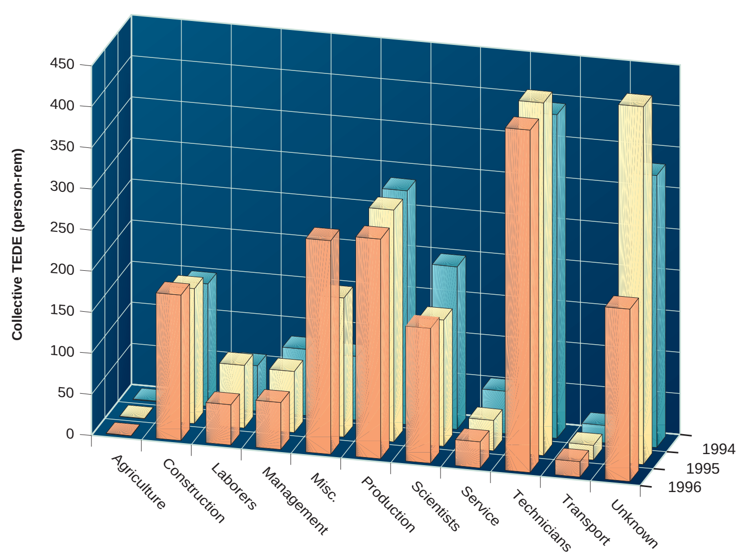
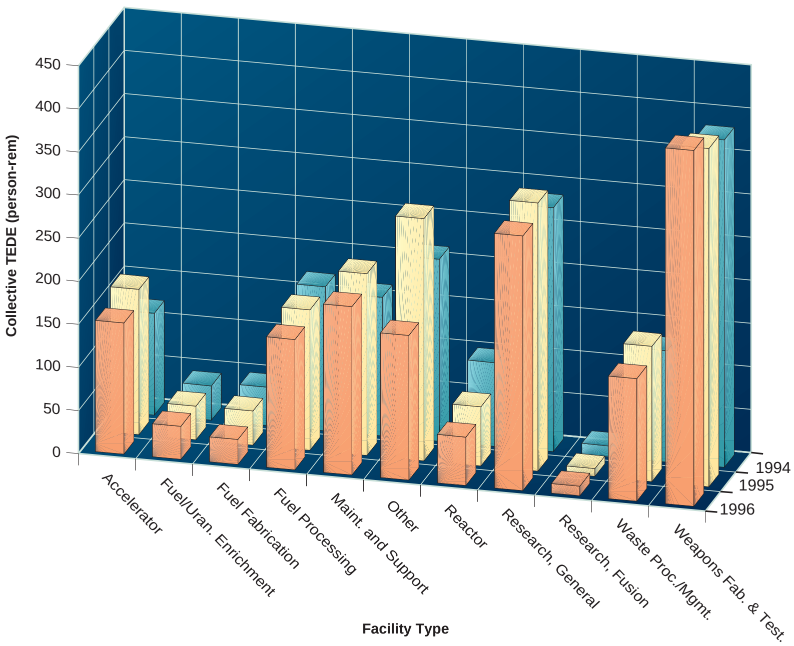


Exhibit 3-15:
Graph of Dose by Facility Type, 1994-1996



issue. Other sites also report large numbers of individuals with an occupation code of "unknown." Typically these workers are subcontractors or temporary workers. Information concerning these workers tends to be limited.

To examine internal dose by labor category, the dose from intake is presented in Appendix B-20. In addition, Appendix B-21 shows the distribution of TEDE by labor category and occupation for 1996. The dose distribution for each occupation included under each labor category is presented.

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 assist management in prioritizing ALARA activities. Contribution of certain facility types to the DOE collective TEDE is shown in *Exhibits 3-15* and *3-16*. The collective dose for each facility type at each Operations/Field Office is shown in Appendix B-7.

Exhibit 3-16:
Doses by Facility Type, 1994-1996

Facility Type	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
Accelerator	1,750	1,718	2,345	118.1	168.5	152.0	0.068	0.098	0.065
Fuel/Uranium Enrichment	1,121	1,915	908	40.1	39.2	38.3	0.036	0.020	0.042
Fuel Fabrication	1,140	1,055	864	44.3	39.5	29.0	0.039	0.037	0.034
Fuel Processing	2,049	1,505	1,498	167.0	163.0	151.2	**0.082◄**	0.108	**0.101◄**
Maintenance and Support	3,189	2,820	2,886	160.8	210.9	195.2	0.050	0.075	0.068
Other	2,889	2,510	2,514	211.1	280.9	168.1	0.073	**0.110◄**	0.067
Reactor	1,280	896	912	97.0	68.7	56.1	0.076	0.077	0.062
Research, General	3,435	3,269	3,095	283.0	311.1	295.7	**0.082◄**	0.095	0.096
Research, Fusion	160	134	163	12.6	9.0	11.4	0.079	0.067	0.070
Waste Processing/Mgmt.	2,923	2,458	2,422	129.2	156.9	142.1	0.044	0.064	0.059
Weapons Fab. and Testing	**5,454◄**	**5,333◄**	**5,118◄**	**379.8◄**	**392.5◄**	**412.8◄**	0.070	0.074	0.081
Totals	**25,390**	**23,613**	**22,725**	**1,643.1**	**1,840.2**	**1,651.9**	**0.065**	**0.078**	**0.073**

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

* *1994-1996 TEDE = CEDE + DDE*

Exhibit 3-17:
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 for off-site exposures 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 for off-site exposures 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 RadCon Manual 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 RadCon Manual total contamination limits.

The highest collective TEDE for 1994-1996 were those at weapons fabrication and testing facilities. Sixty-four percent of this dose was accrued at Rocky Flats, with 22% and 7% from Savannah River and Pantex, respectively. 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.

To examine internal dose by facility type, the internal dose from intake is presented in Appendix B-18.

3.4.4 Radiation Protection Occurrence Reports

In addition to the records of individual radiation exposure monitoring required by DOE M 231.1-1 (previously DOE Order 5484.1), sites are required to report certain unusual or off-normal occurrences involving radiation under DOE Order 232.1 (previously DOE Order 5000.3B). These reports are submitted to the Occurrence Reporting and Processing Service (ORPS) in accordance with the reporting criteria of DOE M 232.1-1A. Two of the categories of occurrences are directly related to occupational exposure and are required to be reported under Section 9.3 as "Group 4" occurrences. Group 4A reports are *radiation exposure* occurrences, and Group 4B are *personnel contamination* occurrence reports. The occurrence reporting requirements for DOE M 232.1-1A are summarized in *Exhibit 3-17*. These requirements became effective in July of 1997.

In summary, *radiation exposure* occurrences are reported in instances where individuals were exposed to radiation above anticipated levels. *personnel contamination* occurrences are reported when personnel or clothing are

Exhibit 3-18:
Radiation Exposure Occurrence Reports, 1994-1996

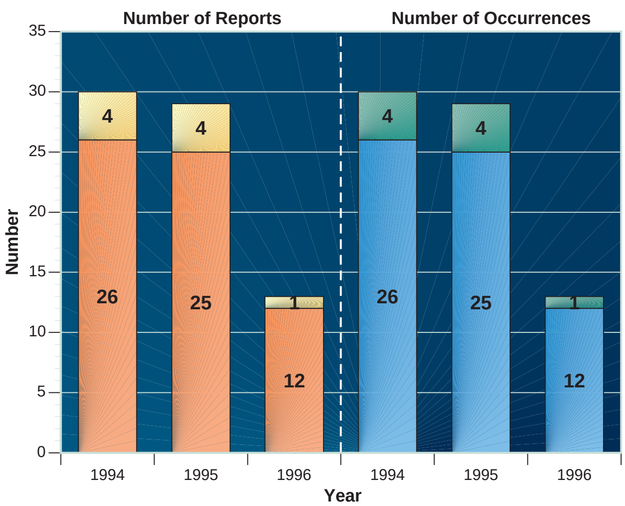
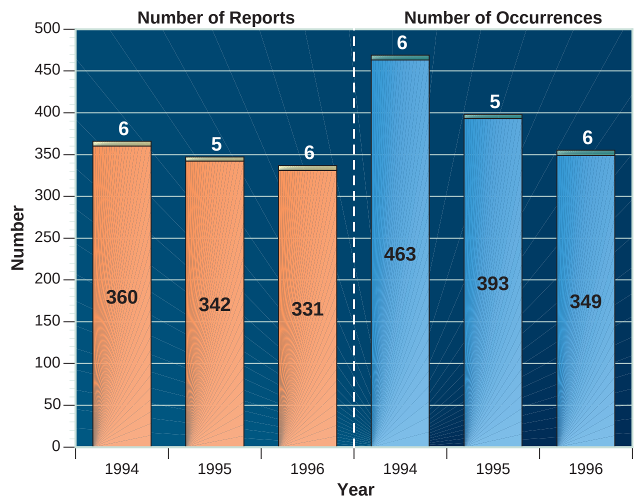
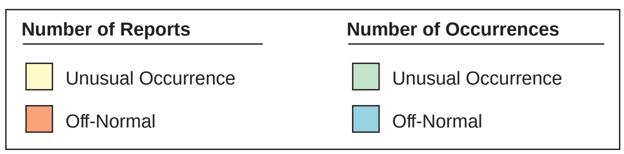


Exhibit 3-19:
Personnel Contamination Occurrence Reports, 1994-1996





The number of *Radiation Exposure* occurrences has decreased by 57% from 1994 to 1996.

The number of *Personnel Contamination* occurrences has decreased by 24%.

contaminated above certain thresholds. The number of reports submitted to ORPS is indicative of breaches or lapses in radiation protection practices resulting in unanticipated radiation exposure or contamination of personnel or clothing. Increases or decreases in the number of these occurrences may reflect trends in activities that result in radiation exposures and the effectiveness of radiation protection programs at DOE.

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 occurrence report may involve multiple similar occurrences. For this reason, the number of occurrences and the number of occurrence reports are considered here.

The number of occurrences and occurrence reports for *radiation exposures* and *personnel contaminations* is presented in *Exhibits 3-18* and *3-19*. The number of occurrence reports for both types of events has decreased over the past 3 years. The number of *radiation exposure* occurrence reports has decreased by 57% over the past 3 years, while the number of *personnel contamination* reports has decreased by 8%.

For *radiation exposure* occurrences, there is no difference in the number of reports and the number of occurrences, indicating that no reports were submitted that included multiple occurrences. Therefore the number of occurrences and occurrence reports decreased by 57%. For *personnel contamination* occurrences, there have been several reports that contain multiple occurrences that have been submitted over the past 3 years, but only for "off-normal" occurrences. All of the occurrence reports that were categorized as "unusual" dealt with a single occurrence. The number of *personnel contamination* occurrences has decreased by 24% from 1994 to 1996.

The decrease in the number of *radiation exposure* occurrences is primarily due to decreases in the number of occurrences at the Rocky Flats, Hanford, and Savannah River sites between 1995 and 1996. A potential factor in the change in the number of *radiation exposure* occurrences is the change in reporting requirements in 1996. DOE 232.1-1 became effective at the end of 1995 and was in effect for 1996. Under the previous requirements of DOE Order 5000.3B, any exposure in excess of the facility administrative limits or 10 percent of the annual limit (e.g., 500 millirem TEDE), whichever is lower, must be reported as an off-normal *radiation exposure* occurrence. The new reporting requirements of DOE 232.1-1A specify any single exposure that exceeds the expected exposure by 100 millirem. The reporting threshold is generally lower under the new requirements, but for sites that have low facility administrative control levels, the reporting threshold may be higher. The significance of this change in reporting requirements is difficult to determine because sites vary in the implementation date of the requirements and sites vary in facility ACLs.

The decrease in the number of *personnel contamination* reports is primarily due to decreases for the Oak Ridge site (mainly the Y-12 Plant) and Argonne National Lab., West (ANL-W). Three factors contributed to the decrease at the Oak Ridge site. In 1994, Y-12 began combining multiple occurrences into one report, called "roll-up" reports. The Y-12 Plant also underwent an operational stand-down during 1994 that reduced the opportunities for these types of occurrences. In addition, the reporting requirements in effect for Oak Ridge facilities changed from DOE Order 5000.3A to Order 5000.3B during 1993. The reporting threshold for *personnel contamination* occurrences under 5000.3A was much lower than 5000.3B, and therefore, more occurrences were reportable.

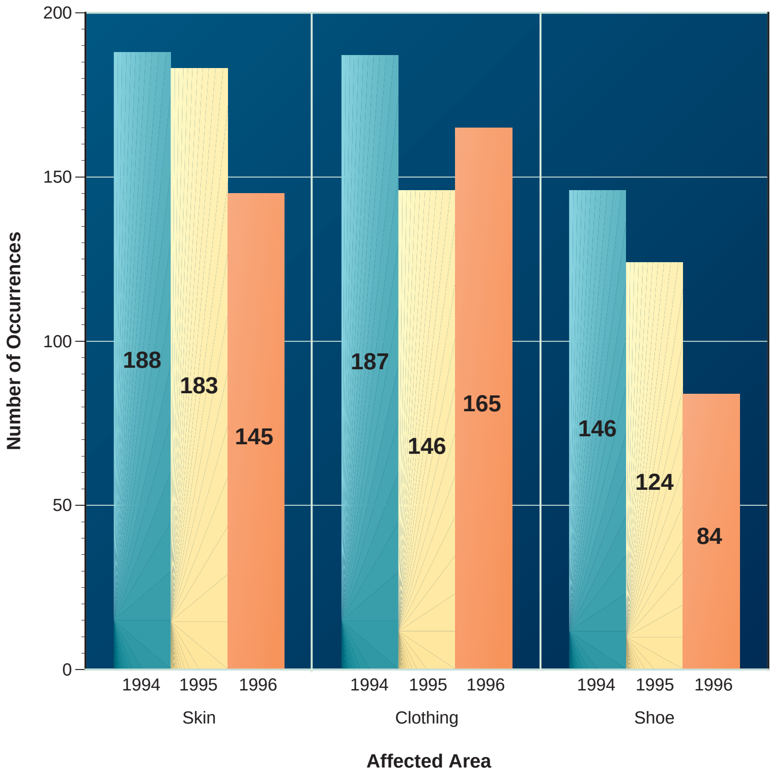
At ANL-W, the decrease in *personnel contamination* reports is due to the completion of decontamination activities at two 30-year old facilities – the Fuel Cycle Facility, completed in 1993, and the Analytical Laboratory, completed during 1995.

For 1996, 12 of the 13 occurrence reports (92%) shown in *Exhibit 3-18* involved "off-normal" occurrences. Seven of the 13 reports (54%) involved internal dose, while 6 of the 13 reports (46%) involved external dose. Of the seven reports involving internal dose, one report was categorized as an "unusual" occurrence, although it does not meet the criteria of an unusual occurrence specified in DOE Order 232.1-1A. The individual did exceed the 2 rem TEDE ACL, but did not exceed the DOE occupational dose limit of 5 rem TEDE. This occurrence is described in Section 3.3.2. Five of the reports were for unanticipated internal doses greater than 100 millirem. One report was for a contamination event that did not result in internal dose. The six reports involving external radiation were for unanticipated doses of greater than 100 millirem of the planned dose.

No *radiation exposure* occurrence reports submitted to ORPS from 1994 to 1996 have involved exposures to minors or members of the public.

Personnel contamination occurrences can involve contamination of the skin, clothing, or shoes. *Exhibit 3-20* shows the breakdown of occurrences by affected area from 1994 to 1996. The affected area is not recorded as part of the ORPS report

Exhibit 3-20:
Personnel Contamination Occurrences by Affected Area, 1994-1996



and must be determined by reviewing the text of each report. Some occurrences may involve more than one affected area and therefore may be counted more than once. Between 1995 and 1996, contamination occurrences involving the skin and shoes have decreased by 21% and 32% respectively. Clothing contaminations increased by 13% from 1995 to 1996, but the 1996 value was 12% below the 1994 value.

Exhibits 3-21 and *3-22* show the breakdown of occurrence reports for *radiation exposure* and *personnel contamination* by site for the 3-year period 1994 to 1996. Forty-eight percent of the *radiation exposure* occurrences were reported by two sites, Rocky Flats and Hanford. *Personnel contamination* occurrence reports are distributed among the sites, with Hanford and the Oak Ridge sites submitting 45% of the reports. Almost all of the sites submitted fewer reports for both types of exposure occurrence for 1996 with the exception of Hanford and LANL, which submitted more *personnel contamination* reports in 1996.

Exhibit 3-21:
Radiation Exposure Occurrences by Site, 1994-1996

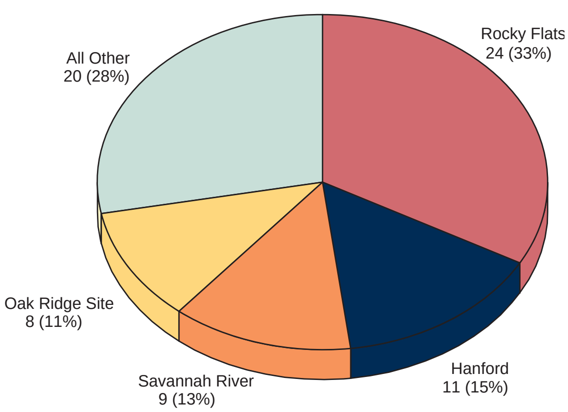
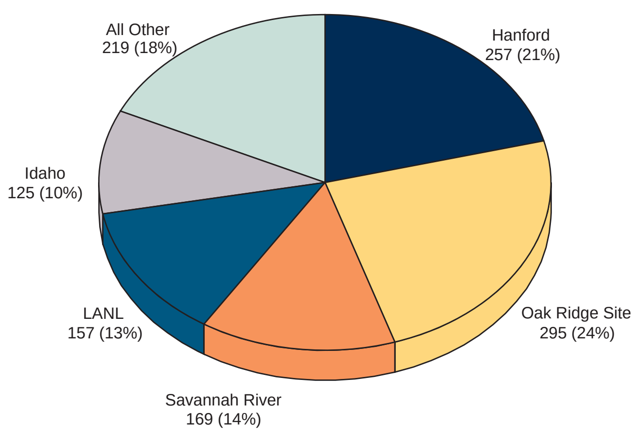


Exhibit 3-22:
Personnel Contamination Occurrences by Site, 1994-1996



Exhibits 3-23 and *3-24* show the breakdown of occurrence reports by root cause. For ORPS, the "root cause" is defined as the cause that, if corrected, would prevent recurrence of this and similar occurrences. Only the four significant main root cause categories are considered here. Over the past 3 years, management problems were the identified root cause for 43% of the *radiation exposure* and *personnel contamination* occurrences. The most often-cited management problem is inadequate administrative control. Other management problems include inadequate policy definition and dissemination, and planning deficiencies. While there were considerable decreases in the number of occurrences attributed to management problems over the past 3 years, it was the largest contributor over the 3-year period and therefore deserves continued attention.

The other root cause categories also experienced decreases with one exception. The number of occurrences attributed to unknown sources of radiation have increased for both *radiation exposure* and *personnel contamination* occurrences. This category is assigned whenever the source of exposure from radiological material cannot be reasonably determined. This root cause represented the highest number of reports for both types of occurrences in 1996. This category of root cause was added to the reporting requirements of DOE M 232.1-1A and was not a cause code under the previous DOE Order 5000.3B, so the sites began reporting this cause code in 1995.

Exhibit 3-23:
Radiation Exposure Occurrences by Root Cause, 1994-1996

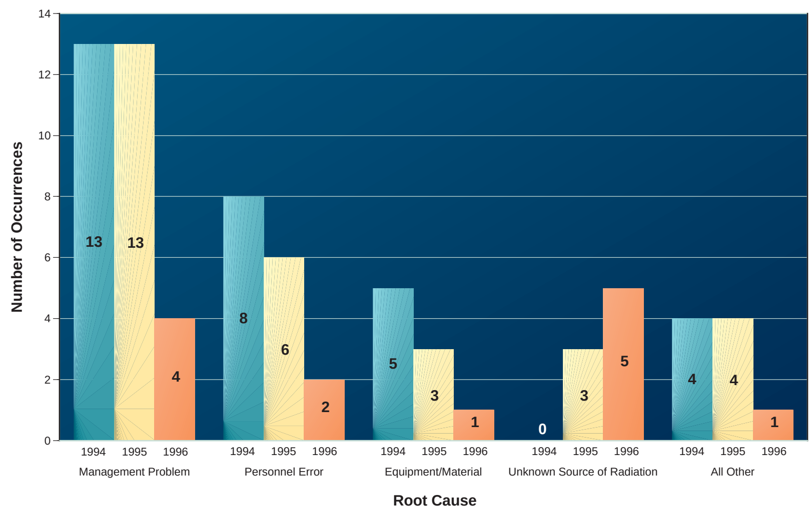
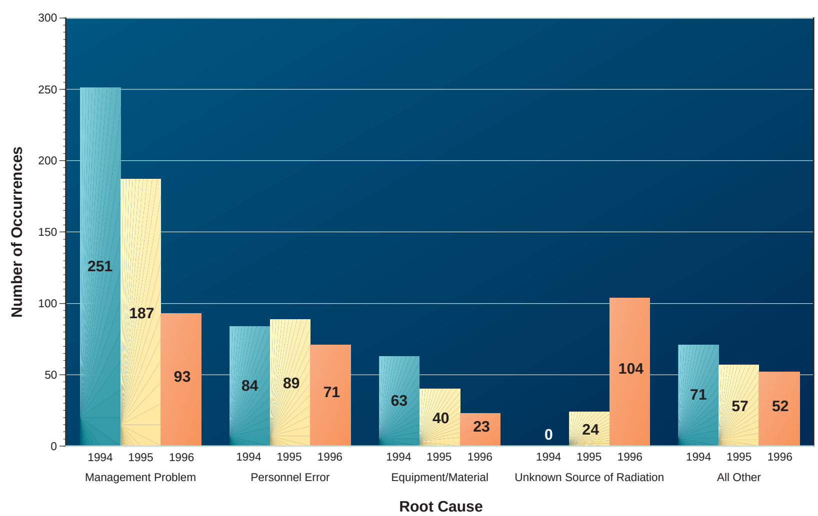


Exhibit 3-24:
Personnel Contamination by Root Cause, 1994-1996



For this reason, the increase in occurrences attributed to this root cause is a result of the change in requirements. In previous years this root cause may have been categorized as a management problem or other root cause. However, due to the large number of occurrences attributed to this root cause in 1996, attention should be given to these occurrences and actions taken in the field to ensure that previously unidentified sources of exposure and contamination are identified and remediated. The sites reporting the majority of these types of *personnel contamination* occurrences in 1996 were Hanford (31), Savannah River (17), and LANL (14). The Mound Project reported 3 of the 5 *radiation exposure* occurrences attributed to unknown sources in 1996.

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

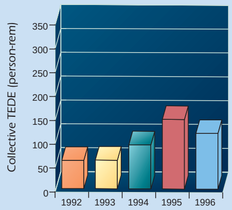
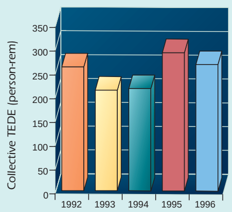
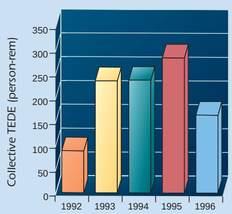
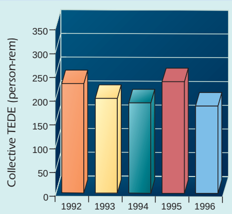
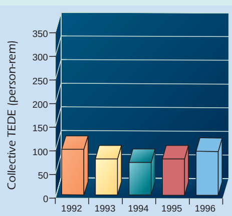
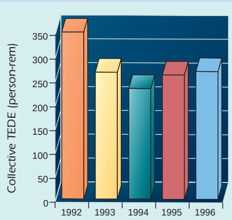
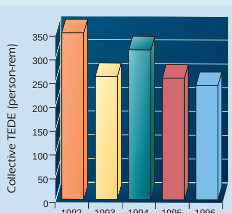
http://tis.eh.doe.gov/web/oeaf/orps/

3.5 Activities Contributing to Collective Dose in 1996

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 1996. The sites were: BNL, Hanford, Idaho, LANL, Oak Ridge, Rocky Flats, and Savannah River. These sites were the top seven sites in their contribution to the collective TEDE for 1996 and comprise 81% of the total DOE dose. Five of the seven sites reported decreases in the collective TEDE, which resulted in an 10% decrease in the DOE collective dose in 1996. The seven sites are shown in *Exhibit 3-25* including a description of activities at the site that contributed to the collective TEDE for 1996.

A historical analysis of events and trends over the past 10 years is included in Appendix B-23.

Exhibit 3-25:
Activities Contributing to Collective TEDE in 1996 for Seven Sites

Site	Collective TEDE (person-rem)	% Change from 1995 to 1996	Description of Activities at the Site
Brookhaven National Lab.		-20%▼	The site collective TEDE decreased by 20% from 1995 to 1996. This follows a 58% increase from 1994 to 1995. Nearly 75% of the collective dose at BNL was attributed to the Alternating Gradient Synchrotron (AGS) in 1996 and about 10% to the High Flux Beam Reactor and the Brookhaven Medical Research Reactor (HFBR/BMRR). AGS dose for 1996 remained about the same as for 1995 even though the intensity and operational periods increased. This was accomplished by efforts to reduce proton losses in transport lines, dosimetry improvements, and optimizing mission schedules to take advantage of radioactive decay factors. HFBR/BMRR dose also remained about the same from 1995 to 1996. The remainder of the collective dose at BNL decreased.
Hanford		-9%▼	The site collective TEDE decreased by 9% in 1996. The K Basins account for approximately 33% of the total collective TEDE for the site, the Plutonium Finishing Plant (PFP) accounts for approximately 24%, and the East Tank Farm, 14%. While activities at K Basins increased in 1996, the collective dose was significantly reduced due to the installation of the perimeter shielding and completion of the "clean and coat" project.
Idaho		-42%▼	The site collective TEDE decreased by 42% in 1996. At the Idaho site, the Idaho Chemical Processing Plant (ICPP) contributes about 80% of the site dose. The reduction in the exposure from 1995 was due to the completion of major radiological work performed at the ICPP and the deactivation of two key facilities at the ICPP.
Los Alamos National Lab.		-22%▼	The site collective TEDE decreased by 22% for 1996. Fifty percent of the site collective dose is attributed to TA-55. Principal operations conducted at TA-55 include fabrication of plutonium metal components, plutonium processing, and basic research on TRU materials. Doses at TA-55 were reduced in 1996 due to ALARA activities. In preparation for seismic upgrades to the vault at TA-55, mock-up practice runs were carried out that enabled the work to be done at a considerably reduced dose.
Oak Ridge Site		15%▲	The site collective TEDE increased by 15% in 1996 primarily due to activities in support of the restart of the Y-12 Plant involving enriched uranium operations. Y-12 has been shut down since 1994. Environmental restoration activities increased at all three facilities (Y-12, ORNL, and K-25).
Rocky Flats		3%▲	At Rocky Flats the collective TEDE increased by 3% in 1996 due to increased activities and decontamination and decommissioning cleanup at the site. These activities included tank drainings of enriched uranium and plutonium solutions, plutonium residue stabilization, and plutonium residue repackaging. These activities occurred in the criticality research facility Building 886 and the plutonium operations areas, mainly Buildings 371, 771, 707, 776/777, and 779.
Savannah River		-1%▼	The site collective TEDE decreased by 1% in 1996. The major contributors to the site collective TEDE continue to be in the nuclear materials stabilization and high-level waste areas. Stabilization activities increased in 1996 resulting in a 10% increase in the collective TEDE for the FB Line, 2% increase for the HB Line, and 2% decrease for the H Tank Farm compared to 1995 collective dose. The largest decrease to the site collective TEDE is found in the storage of spent fuel. With the shutdown of the reactors, activities in spent fuel storage areas decreased dramatically, resulting in a 95% decrease in the collective dose for the M Area, a 90% decrease for C-Reactor, and 46% decrease for K-Reactor.

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ALARA Activities at DOE

Section Four

4

ALARA Activities at DOE

This section recognizes highly successful ALARA projects and encourages the use of similar innovative ideas at other locations in the DOE complex. In future years, ALARA success stories, such as those described below, will be included in the *DOE Occupational Radiation Exposure Report*. Sites are encouraged to submit material on successful ALARA activities for publication in future annual reports.

4.1 Successful ALARA Projects

The following are descriptions of several successful ALARA projects submitted by Pantex, Savannah River, Fermilab, and Grand Junction concerning projects that reduced radiation exposure.

4.2 W79 Contamination Control System at Pantex

The W79 is an artillery fired atomic projectile (AFAP) scheduled to be dismantled at the Pantex plant in Amarillo, Texas. The W79 is the first weapon with potential for plutonium contamination to be dismantled at Pantex. Title 10 CFR 835.1001 requires the use of design features to control contamination at its source. The physical size of the W79, in conjunction with the size of the tools used on W79, make it impractical to use a glove box. Therefore a team was assembled to design, develop, procure, test, and implement the "close capture" contamination control system.

The contamination control system design specifications were developed and tested for compliance with applicable health physics and industrial hygiene requirements (including air flow, noise levels and average face velocity) while effectively controlling contamination. The system was also required to be reused to decontaminate successive units while not interfering with the work of technicians dismantling the weapon.

The system consists of a down-draft type fixture, *(Exhibit 4-1)* to draw air from an

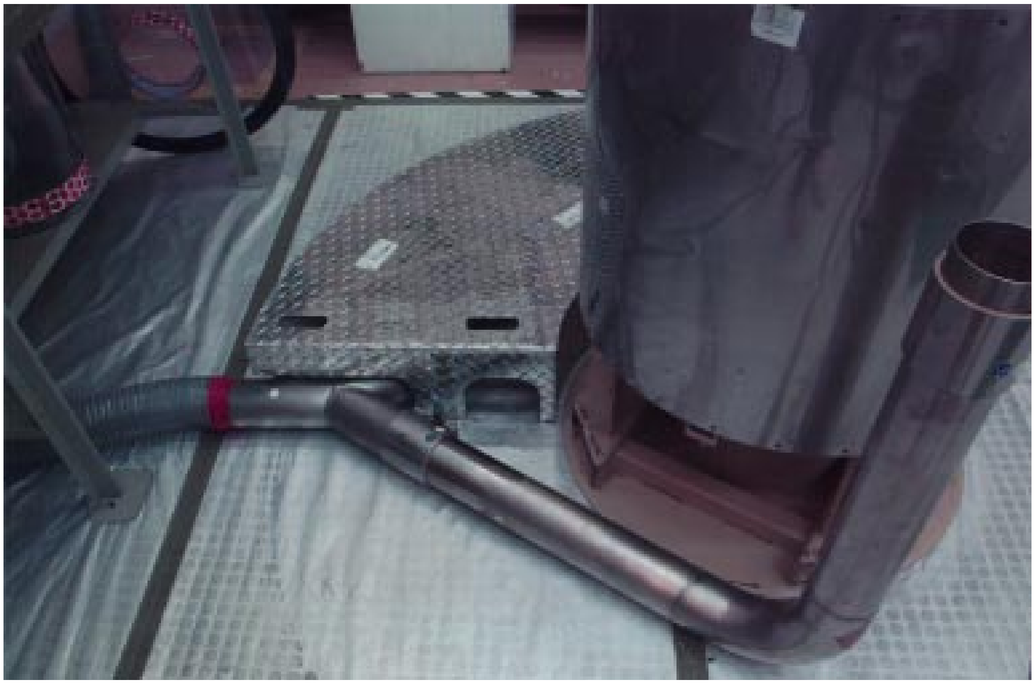
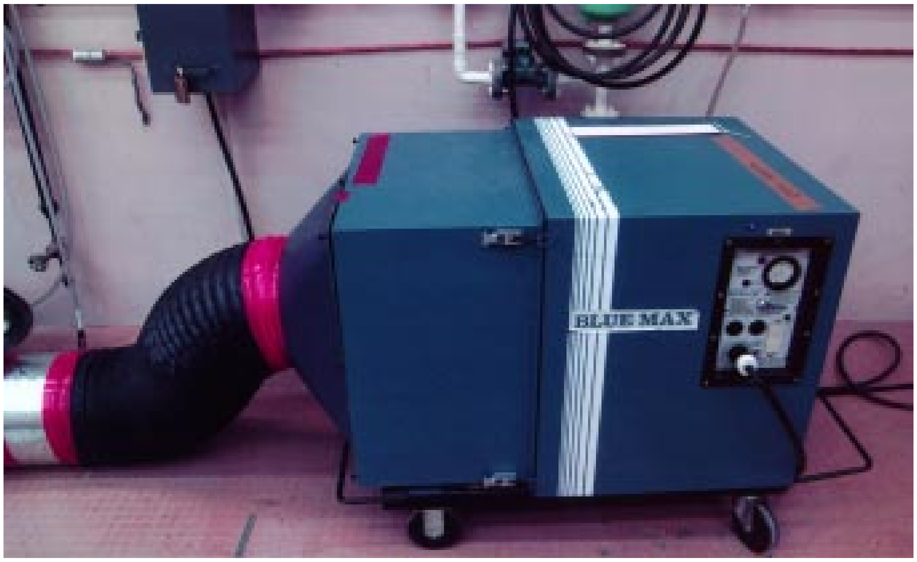


Exhibit 4-1: Ventilation Ductwork for Close Capture System

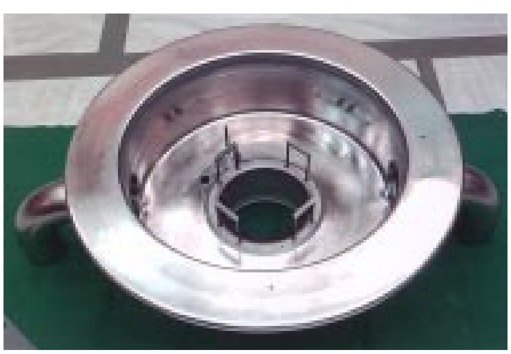
Exhibit 4-2: Optima 2000 Blower Unit



Optima 2000 blower unit *(Exhibit 4-2)* through two sets of external high efficiency particulate air (HEPA) filters and one HEPA filter internal to the blower. Behind each HEPA filter and in general room air, continuous air sampling was performed. The exhaust of the blower was monitored using a passive air sampler. A metal screen was used to allow for more even distribution of air flow across the system face without restricting the total air flow. The design of the contamination control system allows the entire weapon to be surrounded by air flow, while allowing for 360 degree access to the work area. Smooth aluminum surfaces were incorporated to provide easy decontamination of the removable portion of the system, as shown in *Exhibit 4-3*.

The custom designed contamination control system provides for the efficient dismantling of contaminated W79 units, while minimizing the risk of internal exposure to Pantex employees.

Exhibit 4-3: W79 Close Capture Contamination Control System



4.3 FB Line Vault at Savannah River

The FB Line Vault door locking device needed repair to meet DOE and fire protection requirements. This task had been delayed numerous times based upon the predicted high radiation exposures for this job.

A team consisting of Westinghouse Savannah River Company Operations, Bechtel Savannah River Inc. (BSRI), and the Radiological Control Organization evaluated the task of installing the locking device on the door. The team involved Engineering, Security, Health Protection Technology, and Criticality Safety in resolving the various issues that arose. The goal of the team was to reduce exposure to personnel performing the task.

The team was proactive in finding material that would help reduce neutron exposures. They decided on borated poly sheets that are used in the commercial nuclear power industry, and encapsulated the sheets in 16 gauge stainless steel (for fire protection requirements) and configured the material to fit into the vault.

A vault door mockup was used for training personnel on the installation of the locking device. Also, the personnel wore light-weight lead jackets and the work activity was distributed among the personnel involved. Electronic Personnel Dosimeters (EPDs) were issued to control the time spent in the High Radiation Area. The job was estimated to take 8.5 hours and the total individual dose was estimated at 3.16 rem. All personnel were wearing respiratory protection. The job was completed in the time planned and the total individual dose for the job was 0.276 rem, a reduction of 91% over the estimated dose.

Contact Bradley Eichorst, (803) 725-2042, Radiation Protection Division at the Savannah River Site for more information.

4.4 K-Basin Superstructure Removal at Savannah River

The superstructure is an underwater stainless steel structure used for removing and supporting lids of irradiated fuel shipping casks during loading and unloading in the 105-K Reactor Disassembly Basin. The basin contains approximately 3,500,000 gallons of water and is used to store irradiated components. A weld failure caused the structure to become inoperable suspending all fuel handling activities until it could be removed. Continued operation of the basin was tied to several critical site activities, the delay of which would have resulted in significant additional costs.

Several significant radiological concerns were associated with the activity. First, the Disassembly Basin water contains tritium and various fission and activation products. Second, high levels of alpha and beta-gamma contamination are present on the surfaces of all basin structures due to the accumulation of sludge. Third, external exposure hazards exist due to various components present in the basin. And lastly, once the structure was removed from the basin the potential for airborne activity existed during cutting and disposal.

Several options for removing the superstructure were examined. The initial planning involved the lowering of the basin water level to allow for direct access to the structure. While minimizing the technical difficulties associated with conducting the work underwater, this approach would have resulted in a significant increase in radiological hazards due to the exposure of highly contaminated surfaces and sources of penetrating radiation. After a thorough review of the options, it was determined that the use of divers using underwater cutting equipment was the most sound approach from a radiological perspective.

ALARA activities associated with the work included extensive underwater radiation surveys to determine the potential exposure to the divers. Field survey instrumentation was used for initial determinations followed by the placement of test dosimetry underwater near the superstructure and other potential sources of radiation. Results from these surveys allowed the Radiological Control Organization to establish stay times for each of the divers entering the basin. A detailed review of the divers' suits and associated equipment was conducted to ensure that the potential for exposure from contact with tritiated water was minimized.

Preplanning for the basin entry was extensive and included the members of the dive team along with personnel from all organizations involved in the work. Detailed work instructions were developed and reviewed well in advance of the basin entry to ensure that all workers fully understood their role in the activity. The structure was wrapped immediately upon removal from the water to minimize the potential for airborne activity. Several key cuts were made using local exhaust systems to "section" the structure at specially prepared locations. These sections were then placed in specially ordered containments and transported to a large prefabricated containment hut for further cutting.

The initial estimate was approximately 0.700 person-rem. A total of 0.020 rem collective dose was received during this job representing a dose reduction of 97%. There were no personnel contamination events, no spread of contamination outside of the posted areas and no airborne activity in excess of 10% of the limit for airborne activity. The project team consisted of approximately 20 individuals from all involved organizations.

Contact Bradley Eichorst, (803) 725-2042, Radiation Protection Division at the Savannah River Site for more information.

4.5 Antiproton Target Assembly Replacement at Fermilab

The Fermi National Accelerator Laboratory (Fermilab) produces antiprotons by targeting 120 GeV protons on a nickel disc. This disc is housed with several other target discs in a cylindrical titanium shell.

Exhibit 4-4: Technicians removing target module while monitoring dose.

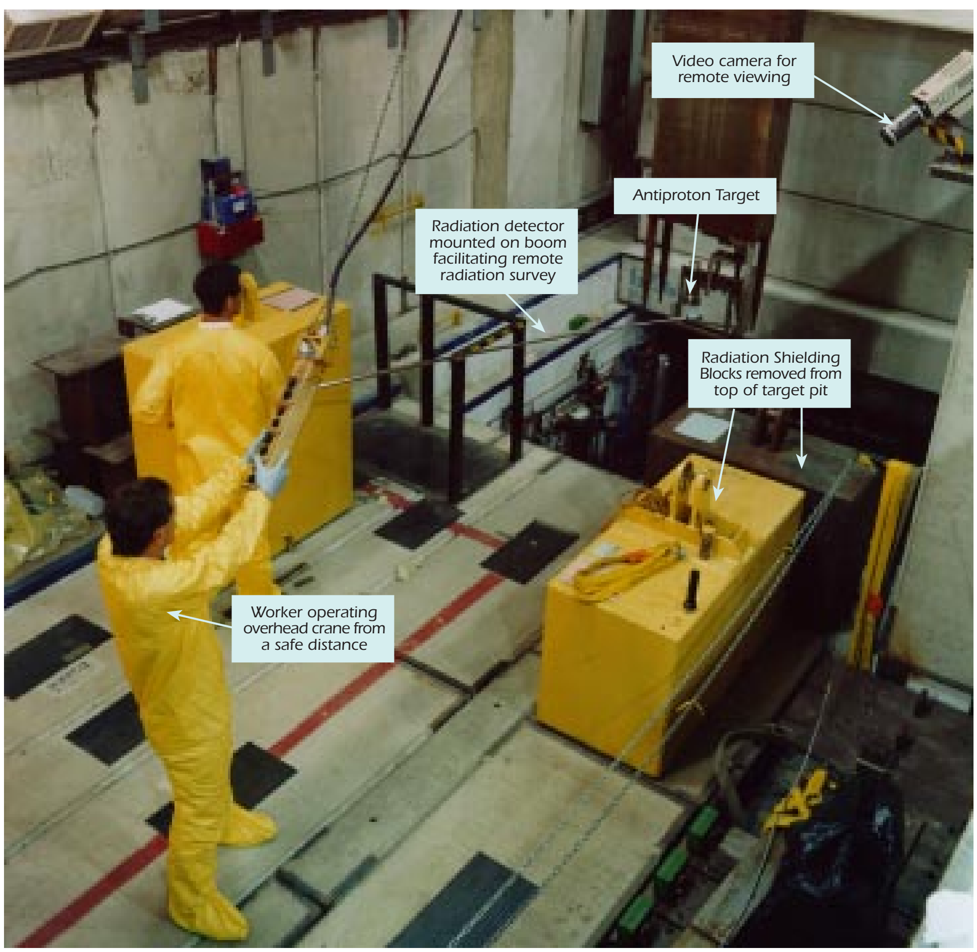


Photo Courtesy of Fermilab

Photo Courtesy of Fermilab

Exhibit 4-5: Technician observes hot target from behind lead glass shielding.

This target assembly is about 4 inches in diameter and 11 inches in height. It is attached to a large module that serves to position the target assembly in the beam and provide electrical, mechanical, and cooling connections. Exposure rates from these target assemblies can be several R/hr at 1 foot after the beam is shut off after a long period of operations. The target assembly is engineered with these high-exposure rates in mind and as a result many components can be disassembled and manipulated remotely.

It became necessary to replace this target assembly in September 1996. In accordance with well established procedures at Fermilab, ALARA planning meetings were held before commencing work. The planning meetings included detailed steps describing what was necessary to replace the target, along with the estimated time to complete each step. Each step was thoroughly discussed to ensure that workers could complete the step in an efficient manner with the least exposure. The use of shielding in certain steps was also discussed to ensure that it was used appropriately so as not to adversely compromise efficiency. Estimates of the collective dose equivalent and individual dose equivalents were made, along with a collective dose equivalent limit for the entire job. All individuals involved in the work participated in drafting the ALARA plan.

Fermilab requires Radiological Control Technicians (RCTs) to provide radiological job coverage for high-exposure jobs. Their function is to ensure that the job proceeds according to the ALARA plan and to ensure that accumulated dose equivalents do not exceed pre-determined limits.

The actual exposure rate from the target assembly was 20 R/hr at 1 foot. The estimated collective dose equivalent to replace the target was 0.120 person-rem. The entire job took about 6 hours to complete. The times to complete each step were estimated conservatively to allow for minor problems, but the job proceeded extremely well so that the actual collective dose equivalent was only 0.017 rem for eight workers and two RCTs.

The actual dose equivalent received was much lower than the estimated dose because of the following five factors:

- Engineering and design of the facility and the target module to accommodate the anticipated high-exposure rates.
- Detailed ALARA planning before the job commenced.
- Use of workers who were experienced with target assembly replacement.
- Good communication and cooperation between workers and RCTs during the job.
- Job steps were completed with less difficulty than conservatively anticipated.

For more information on this project, contact Berlin Moore, (630) 840-4197, at Fermilab.

4.6 Sample Preparatory Laboratory Dustbag Replacement at Grand Junction

The project involved the replacement of the dustbags in the Sample Preparatory Laboratory effluent filter baghouse. The primary radiological exposure concerns associate with this project included airborne radioparticulate inhalation and radiological contamination of personnel, clothing, equipment, and materials. External radiation exposure was not a significant concern.

The area where the dustbags are located is a confined space due to restricted access. The adjacent walls needed to be wrapped to prevent major decontamination problems. This situation presented an additional and potentially more significant hazard of fire adjacent to a confined space from the potential ignition of the wall wrapping material.

Plastic sheeting is normally used for temporary containment wrapping but because this increases fire and smoke loading, wall coverings of sheet plastic with low values for "smoke-developed value" and "flame spread index" were sought. Ultimately, a material called Tyvek® HomeWrap™ was selected for the containment.

Tyvek® HomeWrap™ has been widely used for the past 15 years as a component in external walls of new houses. DuPont specifications show no flame spread and a very low amount of developed smoke from this material. Ease of handling also resulted in time savings for installation and removal. Waste disposal personnel were confident that the HomeWrap™ would meet waste acceptance criteria.

During disassembly, the material released particles that had collected on its surface. A fixation spray such as the kind used in asbestos abatement would likely have prevented that occurrence.

As an ALARA consideration, DOE Operating Experience Weekly lessons-learned were used to avoid the potential permeation of contamination through cloth coveralls when soaked with perspiration. Because this project required a double set of protective clothing and was to be performed under conditions that are conducive to heat buildup, excessive perspiring was anticipated. As a result, alternative protective covering materials were analyzed where cloth material normally would have been selected.

Upon review of protective clothing material options, a nonporous, film-coated, non-woven fabric material, which still exhibited good heat removal characteristics, was selected for the exterior set of coveralls. Although the workers' interior set of cloth coveralls were consistently saturated with perspiration, no personnel or clothing contamination problems were experienced. In addition, the workers expressed satisfaction with the comfort of the protective clothing ensemble. Although this outcome cannot be quantitatively and exclusively linked to the protective material choice, the awareness of previous problems and revised approach in planning ensured maximum probability of preventing radiological contamination of skin and clothing.

Approximately 20 person-hours were saved.

For more information contact Jeff Warga, RRPT, OHST, 970-248-7661 or jeffreywarga@doegjpo.com

4.7 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Worker Protection Programs and Hazards Management. 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.

4.8 Lessons Learned Process Improvement Team

In March 1994, the Deputy Associate 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) Technical Information System (TIS). 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.tis.eh.doe.gov:80/others/11/11.html

The specific Web site address may be subject to change. This Web site can always be accessed through the main ES&H TIS Web site at:

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

Section Five
Conclusions and Recommendations

5

Conclusions and Recomendations

5.1 Conclusions

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.

During the past 5 years, the occupational radiation dose at DOE has been impacted by three factors: changes in reporting requirements, changes in operational status, and changes in radiation protection standards and practices. These factors and their impact are discussed below in order of their significance.

The change in methods to determine internal dose from AEDE to CEDE between 1992 and 1993 resulted in an overall reduction of the reported annual collective TEDE of approximately 700 person-rem (about 30%) because of the exclusion in the annual reporting of the legacy internal dose. This represents a significant change in how dose is accounted for in the collective dose reported to DOE Headquarters. This change in methodology resulted in the largest impact on collective TEDE in the past 5 years.

In 1996, the collective TEDE decreased by 10% due to decreases in the collective dose at five of the seven highest dose sites. These seven sites accounted for more than 81% of the collective dose at DOE. Most of the decrease in dose was attributed to a decrease in cleanup and material stabilization activities as well as dose reduction due to successful ALARA activities. The two remaining sites that experienced increases in collective dose attributed the increase to cleanup activities (see Section 3.5).

The collective dose at DOE facilities has experienced a dramatic (80%) decrease over the past decade (see Appendix B-5 and B-23). 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 decommissioning and decontamination activities. The DOE weapons production sites have continued to contribute the majority of the collective dose over these years. As facilities are shut down and undergo transition from operation to stabilization or decommissioning and decontamination, 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 implementation of the RadCon Manual and 10 CFR 835 has resulted in changes in radiation protection practices. As described previously, the RadCon Manual changed the methodology concerning internal dose. While it is not possible to quantify the impact of the RadCon Manual on the collective dose, it did establish ACLs, standardized radiation protection programs, engineering controls, and formalized ALARA practices.

5.2 Recommendations

DOE will pursue the usefulness of collecting data on the operational phase of facilities with end-users of this report. A "phase of operation" status code could be added to the occupational radiation reporting requirements for individual dose records (see Appendix A.4). In combination with the facility type codes already reported, this would provide an indication of the operational mode and type of activities being conducted at a given facility. This will become increasingly important as more facilities transition from stabilization activities into decommissioning and decontamination. It is recommended that Sites and Operations Offices begin reviewing their data collection process in anticipation of collecting the phase of operation data in the future.

Many sites do not report the occupation codes for monitored individuals or report them as "miscellaneous" or "unknown". This results in a large number of individuals grouped into the "unknown" labor category. Sites have indicated that it is often difficult to obtain the occupation code for subcontract workers. It is recommended that Sites and Operations Offices evaluate their recordkeeping and reporting process and report the information to the Radiation Exposure Monitoring System (REMS) system as specified in DOE 231.1-1 to improve the analysis of radiation exposure by occupation, and thus make this report more useful to line manager and worker protection decision makers.

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. Particular attention will be given to exposure events that were categorized as having resulted from management problems and unknown sources of radiation. This root cause category was added to the occurrence reporting requirements in 1995, so insufficient data exist to identify a trend at this time. However, these events are of particular concern due to the potential for exposure and the increase in the number of these occurrences in 1996. It is recommended that sites reporting these occurrences review and remediate situations that result in these exposure occurrences.

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. In 1995 and 1996, DOE Headquarters requested additional information from the seven sites with the highest collective dose. This information included 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.

The data in the REMS database are subject to correction and update on a continuous basis. Data for prior years are subject to correction as well as the data for the most recent year included in this report. The most common reason for correction to a dose record is because of a final dose determination of an internal dose long after the original dose record was submitted to REMS. This delay is due to the time needed to assess the bioassay results and determine the dose from long-lived radionuclides. It is recommended that sites review their dose record update and reporting process, specifically for internal dose determination, and consider the addition of a mechanism whereby they report dose updates to REMS in a timely fashion when updates occur.

DOE should investigate the feasibility, cost, and benefit of establishing a historical repository of intake information to track and access radiation dose from intakes in prior years.

References

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

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Glossary

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.

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.

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.

Lens of the Eye Dose Equivalent (LDE)

The radiation exposure for the lens of the eye is taken as the external equivalent at a tissue depth of 0.3 cm.

Lower Limit of Detection (LLD)

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 minimum detectable activity (MDA).

Number of individuals with measurable exposure

The subset of all monitored individuals who receive a measurable exposure (greater than limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable exposure. For this reason, the number of individuals with measurable exposure is presented in this report as a more accurate indicator of the exposed workforce.

Occupational exposure

An individual's exposure to ionizing radiation (external and internal) as a result of that individual's work assignment. Occupational exposure does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

Shallow Dose Equivalent (SDE)

The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

Total Effective Dose Equivalent (TEDE)

The sum of the effective dose equivalent for external exposures and the 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, and visitors.

Appendix A

DOE Reporting Sites and Reporting Codes

A

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 [11]. Occupation Codes are grouped into Labor Categories for the purposes of analysis and summary in this report.

Exhibit A-1.
Labor Categories and Occupation Codes.

Labor Category	Occupation Code (5484.1)	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, 1992-1996

The following is a listing of all organizations reporting to the DOE REMS from 1992 to 1996. 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, 1992-1996.

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'92	'93	'94	'95	'96
Albuquerque	Ops. and Other Facilities	0501001	Albuquerque Field Office	●	●	●	●	●
		0501006	Albuquerque Office Subs.	●			●	●
		0502009	Albuquerque Transportation Division	●	●	●	●	●
		0530001	Kansas City Area Office	●	●		●	●
		0531002	Allied-Signal, Inc.	●	●	●	●	●
		0553002	Martin Marietta Specialty Components Inc.	●	●	●	●	●
		0590001	WIPP Project Integration Office	●	●	●	●	●
		0593004	Carlsbad Area Miscellaneous Contractors	●	●	●	●	●
		2806003	National Renewable Energy Lab (NREL)-GO			●	●	●
	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	●	●	●	●	●
		0515006	M&H - Amarillo - Subcontractors		●	●		
		0515009	M&H - Amarillo - Security Forces		●	●	●	
	Sandia National Lab. (SNL)	0570001	Kirtland Area Office		●	●	●	●
		0575003	Inhalation Toxicology Research	●	●	●	●	●
		0577004	Ross Aviation, Inc.	●	●	●	●	
		0578003	Sandia National Laboratory	●	●	●	●	●
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0580001	UMTRA Project Office	●	●			
		0582004	MK-Ferguson Subs - UMTRA	●	●	●	●	●
		0582005	MK-Ferguson Co. - UMTRA	●	●	●	●	●
		0583004	Jacobs-Weston Team	●	●			
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.	●	●	●	●	●
		1004031	New Brunswick Laboratory	●	●	●	●	●
		1004503	Mass. Inst. of Tech.	●				
		1005003	Princeton Plasma Physics Laboratory	●	●	●	●	●
		1006003	National Renewable Energy Lab (NREL)-CH	●	●			
		1000703	Argonne National Laboratory - East	●	●	●	●	●
		1000713	Argonne National Laboratory - West	●	●	●	●	●
		1001003	Brookhaven National Laboratory	●	●	●	●	●
	Fermi Nat'l. Accelerator Lab.(FERMI)	1002503	Fermilab	●	●	●	●	●
DOE HQ	DOE Headquarters	1504001	DOE Headquarters	●	●	●	●	●
		1504506	DOE Office Subs	●	●	●		
	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					●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1992-1996 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'92	'93	'94	'95	'96
Idaho	Idaho Site	3000209	Protection Technology - INEL	●	●	●		
		3000504	Chem-Nuclear Geotech	●	●	●	●	●
		3003003	EG&G Idaho, Inc.	●	●	●		
		3003402	Babcock & Wilcox Idaho, Inc.	●	●	●		●
		3003502	Westinghouse Idaho Nuclear Co.	●	●	●		
		3004001	Idaho Field Office	●	●	●	●	●
		3004004	Idaho Office Subs	●	●	●	●	●
		3005004	Lockheed Idaho Tech. Co. - Services				●	●
		3005016	LITCO Subcontractors - Construction					●
		3005505	MK-Ferguson Company - ID	●	●	●		
		3005506	MK-Ferguson Subcontractors - ID	●	●	●		
Nevada	Nevada Test Site (NTS)	3502504	EG&G Kirtland			●		
		3502804	EG&G Special Technologies Laboratories	●	●	●	●	●
		3502904	EG&G Washington D.C.	●	●	●	●	
		3503004	EG&G Las Vegas	●	●	●	●	●
		3503504	EG&G Los Alamos		●	●	●	
		3504504	EG&G Santa Barbara	●	●	●	●	●
		3505007	Fenix & Scisson, Inc.	●				
		3506004	Raytheon Services - Nevada	●	●	●	●	●
		3506024	Raytheon Services Subcontractors		●	●	●	●
		3507501	Nevada Field Office	●	●	●	●	●
		3507514	Nevada Miscellaneous Contractors	●	●	●	●	●
		3507531	Defense Nuclear Agency - Kirtland AFB	●	●	●	●	●
		3507551	Environmental Protection Agency (NERC)	●	●	●	●	●
		3508504	Reynolds Elec. & Engr. Co. Services	●	●	●	●	●
		3508505	Reynolds Elec. & Engr. Co. - NTS	●	●	●	●	●
		3508703	Science Applications Internat'l. Corp.-NV	●	●	●	●	●
		3509009	Wackenhut Services, Inc. - NV		●	●	●	●
		3509504	Westinghouse Electric Corp. - NV	●	●			
Oak Ridge	Ops. and Other Facilities	4001117	Jacobs Environmental Restoration Team				●	●
		4004203	Oak Ridge Inst. for Science & Educ. (ORISE)	●	●	●	●	●
		4004501	Oak Ridge Field Office				●	●
		4004704	Bechtel National, Inc. - (FUSRAP)	●	●	●	●	●
		4005002	RMI Company	●	●	●	●	●
		4009006	Morrison-Knudsen (WSSRAP)	●	●	●	●	●
		4009503	Thomas Jefferson National Accel. Facility			●	●	●
	Oak Ridge Site	4005105	Lockheed Martin/MK-Ferguson Co.		●	●	●	●
		4006002	Lockheed Martin Energy Systems (K-25)	●	●	●	●	●
		4006503	Lockheed Martin Energy Systems (ORNL)	●	●	●	●	●
		4008002	Lockheed Martin Energy Systems (Y-12)	●	●	●	●	●
	Paducah Gas. Diff. Plant (PGDP)	4007002	Martin Marietta (Paducah)	●	●	●	●	●
	Portsmouth Gaseous Diff. Plant (PORTS)	4002502	Martin Marietta (Portsmouth)	●	●	●	●	●
		4002504	M.M. Portsmouth Subcontractors	●	●	●	●	
		4002506	M.M. Portsmouth Subcontractors	●	●	●	●	

Exhibit A-2.
Organizations Reporting to DOE REMS, 1992-1996 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'92	'93	'94	'95	'96
Oakland	Ops. and Other Facilities	8001003	Rockwell International, Rocketdyne - ETEC	•	•	•	•	•
		8006103	U. of Cal./Davis, Radiobiology Lab. - LEHR	•	•	•	•	•
		8006303	U. of Cal./SF - Lab of Radiobiology	•	•	•	•	•
		8007001	Oakland Field Office	•	•			
	Lawrence Berkeley Lab. (LBL)	8003003	Lawrence Berkeley Laboratory	•	•	•	•	•
	Lawrence Livermore Nat'l. Lab. (LLNL)	8004003	Lawrence Livermore National Laboratory	•	•	•	•	•
		8004004	LLNL Subcontractors	•	•	•	•	
		8004009	LLNL Security	•	•	•	•	•
		8004024	LLNL Plant Services	•	•	•	•	•
		8005003	Lawrence Livermore Nat'l Lab. - Nevada	•	•	•	•	
	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*	4003702	Westinghouse Envir. Mgmt. Co. of Ohio (REM)	•				
		4521001	Fernald Area Office			•	•	•
		4521004	Fernald Office Service Subcontractors			•	•	
		4523702	Fernald Envir. Rest. Mgmt. Corp (FERMCO)			•	•	•
		4523706	FERMCO Subcontractors				•	•
		2503702	Fernald Envir. Rest. Mgmt. Corp.		•			
	Mound Plant**	0520001	Dayton Area Office	•	•			
		0526002	EG&G Mound Applied Technologies	•	•			
		4516002	EG&G Mound Applied Technologies			•	•	•
		4516004	EG&G Mound Subcontractors			•	•	•
		4516009	EG&G Mound Security Forces			•	•	•
	West Valley Project***	3009004	West Valley Nuclear Services, Inc.	•	•			
		4530001	West Valley Area Office					•
		4539004	West Valley Nuclear Services, Inc.			•	•	•
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	7700001	Rocky Flats Office	•	•	•	•	•
		7700006	Rocky Flats Office Subs	•	•	•		
		7700007	Rocky Flats Office Subs	•	•	•	•	•
		7707002	Rocky Flats Prime Contractors	•	•	•	•	•
		7707004	Rocky Flats Subcontractors	•	•	•	•	•
		7707005	J.A. Jones – Rocky Flats	•	•	•		
		7707006	EG&G Rocky Flats Subcontractors	•	•	•		
		7707009	EG&G Rocky Flats Security Forces			•		
		7709009	Wackenhut Services – Rocky Flats	•	•	•		
		7711004	Kaiser-Hill RFETS				•	
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					•

Exhibit A-2.
Organizations Reporting to DOE REMS, 1992-1996 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'92	'93	'94	'95	'96
Richland	Hanford Site	7505012	Babcock Wilcox Hanford					●
		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.					●
		7506001	Richland Field Office	●	●	●	●	●
		7508805	US Corps of Engineers - RL	●	●	●	●	
		7509004	Westinghouse Hanford Services	●	●	●	●	●
		7509104	Westinghouse Hanford Service Subs	●	●	●	●	●
Savannah River	Savannah River Site (SRS)	8500204	American Telephone & Telegraph	●	●			
		8500505	Bechtel Construction - SR	●	●	●	●	●
		8501002	Westinghouse Savannah River Co.	●	●	●	●	●
		8501004	Service America	●	●	●	●	●
		8501014	Westinghouse S.R. Subcontractors	●	●	●	●	●
		8501024	Diversco	●	●	●	●	●
		8501034	Industrial Phases - SR	●	●			
		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)					
Pittsburgh Naval Reactor Office	Pittsburgh Naval Reactor Office	6007001	Pittsburgh N.R. Office					
		6007504	Westinghouse 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					

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field 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 [11]. 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.

A.4 Phase of Operation

In addition to the Facility Type listing that has been reported in the past, the DOE Office of Environment Safety and Health is interested in obtaining information on the operational status of these facilities. This information will be codified in terms of a Phase of Operation to describe the operating status of a facility. The listing that follows covers each of the phases of operation from construction to the final stage of surveillance and maintenance once a site has undergone environmental restoration.

The phase of operation will be recorded for the calendar year for which the phase of operation is most appropriate. For facilities that transition between phases during a year, the phase that is appropriate for the majority of the calendar year should be recorded. The Phase of Operation will be recorded and submitted along with the Facility Type as part of the monitored individual's dose record. Reporting format and specifications will be included in subsequent revisions to DOE M231.1-1 [11].

Each DOE facility falls into one of the Phase of Operations shown in *Exhibit A-2*. In general, each phase follows in sequential order, although a facility may forgo one or more phases or may not follow the order listed here.

This is the proposed table for the phases of operation of DOE facilities. Please submit comments, additions, or revisions to this table, to EH-52 (see Appendix E for address). If end users feel this additional supporting information will be useful to them, then DOE M231.1-1 will be so modified.

Exhibit A-4.
Phase of Operation - Lifecycle for a DOE Facility.

Code	Phase of Operation	Definition
A	Construction (includes Major Renovation)	New facilities that are brought on line to replace or augment existing facilities. This phase includes major renovations for existing facilities but does not include environmental restoration construction.
B	Operation/ Maintenance	Includes the normal, mission-related operations and maintenance of the reported Facility Type.
C	Stabilization	Facilities that have been declared to be surplus (assigned to the environment restoration program). This includes facilities where all operations have been suspended but environmental restoration activities have not begun. This may include periods of surveillance and maintenance prior to environmental restoration activities.
D	Remediation	Period during which corrective actions that are necessary to bring the facility into regulatory compliance are being performed.
E	Decontamination and Decommissioning	Decontamination is the act of removing a chemical, biological, or radiologic contaminant from, or neutralizing its potential effect on, a person, object or environment by washing, chemical action, mechanical cleaning, or other techniques. Decommissioning is the process of closing and securing a facility.
F	Waste Management	This phase includes the management of wastes generated during the environment restoration process. (D,E)
G	Surveillance and Maintenance	This phase includes those activities that provide for the safety and protection of a facility after the environmental restoration phase.
Z	Other	All DOE facilities should fit into one of the above categories. "Other" should be used only in highly unusual circumstance.

These phases comprise Environmental Restoration [bracketing rows D and E]

Appendix B

Additional Data

B-1a: Operations Office/Site Dose Data (1994)

Operations/ Field Office	Site	1994 Collective TEDE (person-rem)	Percent Change from 1993	Number with Meas. Dose	Percent Change from 1993	Avg. Meas. TEDE (rem)	Percent Change from 1993	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1993
Albuquerque	Ops. and Other Facilities	0.4	-10% ▼	26	-7% ▼	0.016	-3% ▼	0%	-
	Los Alamos Nat'l. Lab. (LANL)	190.0	-5% ▼	2,448	76% ▲	0.078	-46% ▼	44%	-12% ▼
	Pantex Plant (PP)	29.1	-37% ▼	347	-22% ▼	0.084	-19% ▼	15%	-54% ▼
	Sandia Nat'l. Lab. (SNL)	12.0	1% ▲	250	-20% ▼	0.048	26% ▲	24%	182% ▲
	Uranium Mill Tailings Remedial Action (UMTRA) Project	15.0	63% ▲	390	6% ▲	0.039	56% ▲	0%	-
Chicago	Ops. and Other Facilities	8.3	-23% ▼	233	-27% ▼	0.036	6% ▲	6%	100% ▲
	Argonne Nat'l. Lab. - East (ANL-E)	40.3	**93%** ▲	280	51% ▲	**0.144**	27% ▲	**48%**	57% ▲
	Argonne Nat'l. Lab. - West (ANL-W)	26.3	-7% ▼	343	30% ▲	0.077	-29% ▼	11%	-24% ▼
	Brookhaven Nat'l. Lab. (BNL)	92.3	54% ▲	865	21% ▲	0.107	27% ▲	29%	41% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	14.3	-11% ▼	526	**121%** ▲	0.027	**-60%** ▼	0%	-100% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	2.7	-20% ▼	43	-30% ▼	0.064	14% ▲	0%	-100% ▼
Idaho	Idaho Site	236.8	1% ▲	1,659	41% ▲	0.143	-29% ▼	42%	-8% ▼
Nevada	Nevada Test Site (NTS)	2.0	20% ▲	20	0% ▼	0.099	20% ▲	0%	-
Oakland	Ops. and Other Facilities	0.8	-72% ▼	20	-38% ▼	0.042	-56% ▼	0%	-100% ▼
	Lawrence Berkeley Lab. (LBL)	5.7	-17% ▼	92	-33% ▼	0.062	24% ▲	9%	-10% ▼
	Lawrence Livermore Nat'l. Lab. (LLNL)	18.8	-38% ▼	146	-25% ▼	0.129	-17% ▼	47%	-19% ▼
	Stanford Linear Accelerator Center (SLAC)	16.3	-63% ▼	219	-64% ▼	0.074	4% ▲	10%	-28% ▼
Oak Ridge	Ops. and Other Facilities	6.8	-20% ▼	255	49% ▲	0.027	-47% ▼	0%	-
	Oak Ridge Site	69.2	-9% ▼	1,613	-17% ▼	0.043	9% ▲	7%	-28% ▼
	Paducah Gaseous Diff. Plant(PGDP)	6.8	5% ▲	151	-12% ▼	0.045	19% ▲	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	30.3	-10% ▼	836	0% ▲	0.036	-10% ▼	4%	-31% ▼
Ohio	Ops. and Other Facilities	0.0		2		0.023		0%	-
	Fernald Environmental Mgmt. Project	24.2	-7% ▼	925	-9% ▼	0.026	2% ▲	0%	-
	Mound Plant	9.1	37% ▲	299	16% ▲	0.030	18% ▲	6%	100% ▲
	West Valley Project	24.3	39% ▲	292	17% ▲	0.083	19% ▲	20%	28% ▲
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	231.9	-13% ▼	3,660	-35% ▼	0.063	34% ▲	3%	-73% ▼
Richland	Hanford Site	214.8	2% ▲	3,166	1% ▲	0.068	1% ▲	21%	20% ▲
Savannah River	Savannah River Site (SRS)	**314.5**	22% ▲	**6,284**	39% ▲	0.050	-12% ▼	22%	**245%** ▲
Totals		**1,643.1**	**1%** ▲	**25,390**	**6%** ▲	**0.065**	**-4%** ▼	**23%**	**4%** ▲

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

B-1b: Operations Office/Site Dose Data (1995)

Operations/ Field Office	Site	1995 Collective TEDE (person-rem)	Percent Change from 1994	Number with Meas. Dose	Percent Change from 1994	Avg. Meas. TEDE (rem)	Percent Change from 1994	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1994
Albuquerque	Ops. and Other Facilities	1.6	**300%** ▲	40	54% ▲	0.040	**150%** ▲	0%	-
	Los Alamos Nat'l. Lab. (LANL)	234.9	24% ▲	2,583	6% ▲	0.091	17% ▲	49%	10% ▲
	Pantex Plant (PP)	36.9	27% ▲	329	-5% ▼	0.112	33% ▲	24%	62% ▲
	Sandia Nat'l. Lab. (SNL)	11.1	-8% ▼	343	37% ▲	0.032	-33% ▼	0%	-100% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project	1.3	-91% ▼	58	-85% ▼	0.022	-43% ▼	0%	-
Chicago	Ops. and Other Facilities	6.5	-21% ▼	135	-42% ▼	0.048	35% ▲	0%	-100% ▼
	Argonne Nat'l. Lab. - East (ANL-E)	37.2	-8% ▼	297	6% ▲	0.125	-13% ▼	36%	-24% ▼
	Argonne Nat'l. Lab. - West (ANL-W)	37.6	43% ▲	335	-2% ▼	0.112	46% ▲	10%	-5% ▼
	Brookhaven Nat'l. Lab. (BNL)	145.8	58% ▲	973	12% ▲	0.150	40% ▲	33%	15% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	13.4	-6% ▼	473	-10% ▼	0.028	5% ▲	0%	-
DOE HQ	DOE Headquarters (includes DNFSB)	0.1	-96% ▼	8	-81% ▼	0.012	-81% ▼	0%	-
Idaho	Idaho Site	284.0	20% ▲	1,501	-10% ▼	**0.189**	32% ▲	**62%**	49% ▲
Nevada	Nevada Test Site (NTS)	0.5	-77% ▼	9	-55% ▼	0.051	-48% ▼	0%	-
Oakland	Ops. and Other Facilities	1.3	60% ▲	20	0%	0.064	53% ▲	0%	-
	Lawrence Berkeley Lab. (LBL)	4.5	-21% ▼	76	-17% ▼	0.059	-5% ▼	17%	89% ▲
	Lawrence Livermore Nat'l. Lab. (LLNL)	13.0	-31% ▼	159	9% ▲	0.082	-37% ▼	14%	-71% ▼
	Stanford Linear Accelerator Center (SLAC)	20.2	24% ▲	236	8% ▲	0.086	16% ▲	10%	-2% ▼
Oak Ridge	Ops. and Other Facilities	6.2	-9% ▼	167	-35% ▼	0.037	37% ▲	0%	-
	Oak Ridge Site	76.9	11% ▲	1,804	12% ▲	0.043	0%	16%	135% ▲
	Paducah Gaseous Diff. Plant (PGDP)	9.0	33% ▲	225	49% ▲	0.040	-11% ▼	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	27.5	-9% ▼	1,623	94% ▲	0.017	-53% ▼	4%	4% ▲
Ohio	Ops. and Other Facilities	0.0	0%	5	**150%** ▲	0.007	-70% ▼	0%	-
	Fernald Environmental Mgmt. Project	30.4	26% ▲	955	3% ▲	0.032	23% ▲	0%	-
	Mound Plant	6.4	-30% ▼	175	-41% ▼	0.036	21% ▲	9%	45% ▲
	West Valley Project	26.9	11% ▲	311	7% ▲	0.087	4% ▲	14%	-28% ▼
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	260.8	12% ▲	3,427	-6% ▼	0.076	21% ▲	11%	**252%** ▲
Richland	Hanford Site	**290.7**	35% ▲	2,500	-21% ▼	0.116	71% ▲	34%	62% ▲
Savannah River	Savannah River Site (SRS)	255.5	-19% ▼	**4,846**	-23% ▼	0.053	5% ▲	13%	-40% ▼
Totals		**1,840.2**	**12%** ▲	**23,613**	**-7%** ▼	**0.078**	**20%** ▲	**30%**	**30%** ▲

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

B-1c: Operations Office/Site Dose Data (1996)

Operations/ Field Office	Site	1996 Collective TEDE (person-rem)	Percent Change from 1995	Number with Meas. Dose	Percent Change from 1995	Avg. Meas. TEDE (rem)	Percent Change from 1995	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1995
Albuquerque	Ops. and Other Facilities	3.6	126% ▲	37	-8% ▼	0.098	144% ▲	28%	-
	Los Alamos Nat'l. Lab. (LANL)	184.1	-22% ▼	1,984	-23% ▼	0.093	2% ▲	44%	-10% ▼
	Pantex Plant (PP)	28.1	-24% ▼	327	-1% ▼	0.086	-23% ▼	13%	-45% ▼
	Sandia Nat'l. Lab. (SNL)	16.7	51% ▲	485	41% ▲	0.034	7% ▲	25%	-
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0.4	-67% ▼	26	-55% ▼	0.016	-27% ▼	0%	-
Chicago	Ops. and Other Facilities	13.5	106% ▲	182	35% ▲	0.074	53% ▲	4%	-
	Argonne Nat'l. Lab. - East (ANL-E)	18.5	-50% ▼	202	-32% ▼	0.092	-27% ▼	31%	-14% ▼
	Argonne Nat'l. Lab. - West (ANL-W)	43.6	16% ▲	331	-1% ▼	0.132	17% ▲	18%	70% ▲
	Brookhaven Nat'l. Lab. (BNL)	116.8	-20% ▼	1,448	49% ▲	0.081	-46% ▼	40%	20% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	16.2	21% ▲	538	14% ▲	0.030	6% ▲	4%	-
DOE HQ	DOE Headquarters (includes DNFSB)	0.3	180% ▲	6	-25% ▼	0.044	**273%** ▲	0%	-
	North Korea Project	13.3	-	36	-	**0.370**	-	**78%**	-
Idaho	Idaho Site	164.1	-42% ▼	1,299	-13% ▼	0.126	-33% ▼	52%	-17% ▼
Nevada	Nevada Test Site (NTS)	1.0	120% ▲	19	111% ▲	0.054	4% ▲	0%	-
Oakland	Ops. and Other Facilities	0.0	-99% ▼	6	-70% ▼	0.003	-95% ▼	0%	-
	Lawrence Berkeley Lab. (LBL)	4.6	3% ▲	100	32% ▲	0.046	-21% ▼	0%	-100% ▼
	Lawrence Livermore Nat'l. Lab. (LLNL)	14.9	15% ▲	187	18% ▲	0.080	-2% ▼	24%	76% ▲
	Stanford Linear Accelerator Center (SLAC)	19.3	-4% ▼	312	32% ▲	0.062	-28% ▼	3%	-66% ▼
Oak Ridge	Ops. and Other Facilities	11.9	93% ▲	200	20% ▲	0.060	61% ▲	33%	-
	Oak Ridge Site	88.6	15% ▲	1,582	-12% ▼	0.056	31% ▲	21%	30% ▲
	Paducah Gaseous Diff. Plant (PGDP)	18.6	106% ▲	290	29% ▲	0.064	60% ▲	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	29.9	9% ▲	758	-53% ▼	0.039	133% ▲	12%	191% ▲
Ohio	Ops. and Other Facilities	0.0	0%	5	0%	0.007	0%	0%	-
	Fernald Environmental Mgmt. Project	27.4	-10% ▼	804	-16% ▼	0.034	7% ▲	6%	-
	Mound Plant	20.1	**216%** ▲	403	**130%** ▲	0.050	37% ▲	41%	**372%** ▲
	West Valley Project	11.2	-59% ▼	231	-26% ▼	0.048	-44% ▼	6%	-61% ▼
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	**267.6**	3% ▲	3,430	0%	0.078	3% ▲	8%	-22% ▼
Richland	Hanford Site	265.7	-9% ▼	2,761	10% ▲	0.096	-17% ▼	18%	-46% ▼
Savannah River	Savannah River Site (SRS)	251.8	-1% ▼	**4,736**	-2% ▼	0.053	1% ▲	21%	61% ▲
Totals		**1,651.9**	**-10%** ▼	**22,725**	**-4%** ▼	**0.073**	**-7%** ▼	**24%**	**-20%** ▼

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

B-2: Internal Dose by Operations/Site, 1994 - 1996

Operations/ Field Office	Site	No. of Individuals with New Intakes*			Collective CEDE Dose from Uptake (person-rem)			Average CEDE (rem)		
		1994	1995	1996	1994	1995	1996	1994	1995	1996
Albuquerque	Ops. and Facilities	6	17	9	0.015	0.214	0.085	0.003	0.013	0.009
	LANL	112	134	90	**15.810** ◄	1.264	5.287	**0.141** ◄	0.009	0.059
	Pantex	50	48	7	0.115	0.101	0.016	0.002	0.002	0.002
	Sandia	12	-	-	0.192	-	-	0.016	-	-
Chicago	Ops. and Other Facilities	52	50	91	0.477	0.478	0.474	0.009	0.010	0.005
	ANL-E	61	28	13	1.708	0.391	0.301	0.028	0.014	0.023
	ANL-W	-	-	-	-	-	-	-	-	-
	BNL	50	61	72	5.090	3.157	2.962	0.102	0.052	0.041
Idaho	Idaho Site	8	16	17	0.133	0.398	3.729	0.017	0.025	**0.219** ◄
Oakland	LBL	4	5	2	0.327	0.237	0.112	0.082	0.047	0.056
	LLNL	4	3	6	0.004	0.006	0.013	0.001	0.002	0.002
Oak Ridge	Ops. and Other Facilities	21	45	27	1.741	3.227	6.802	0.083	**0.072** ◄	0.252
	Oak Ridge Site	511	**673** ◄	399	4.327	**12.904** ◄	4.661	0.008	0.019	0.012
	Paducah	27	17	40	0.086	0.048	0.651	0.003	0.003	0.016
	Portsmouth	280	6	112	5.817	0.049	8.628	0.021	0.008	0.077
Ohio	Fernald	32	108	65	0.261	0.684	1.050	0.008	0.006	0.016
	Mound Plant	70	78	72	0.254	1.141	0.355	0.004	0.015	0.005
Rocky Flats	Rocky Flats	24	16	27	2.916	0.367	1.736	0.122	0.023	0.064
Richland	Hanford Site	12	13	22	1.553	0.709	0.822	0.129	0.055	0.037
Savannah River	Savannah River Site	**613** ◄	533	**528** ◄	4.726	5.389	**15.840** ◄	0.008	0.010	0.030
Totals		**1,949**	**1,851**	**1,599**	**45.552**	**30.764**	**53.524**	**0.023**	**0.017**	**0.033**

Facilities with no new intakes: UMTRA, ANL-W, Fermi Lab, DOE-HQ, NTS, Oakland Ops., SLAC, Ohio Ops., West Valley Project.

* 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.

B-3: Neutron Dose by Site, 1994-1996

Operations/ Field Office	Site/Facility	1994 Collective DDE Neutron Dose (person-rem)	1995 Collective DDE Neutron Dose (person-rem)	1996 Collective DDE Neutron Dose (person-rem)	Percentage of Total DOE Neutron Dose
Albuquerque	Ops. and Other Facilities	0.1	0.1	2.5	1%
	Los Alamos Nat'l. Lab. (LANL)	**132.5**	**174.1**	**121.6**	**38%**
	Pantex Plant (PP)	6.6	10.2	6.0	2%
	Sandia Nat'l. Lab. (SNL)	0.4	0.4	0.1	0%
	Uranium Mill Tailings Remedial Action (UMTRA) Project	-	-	-	0%
Chicago	Ops. and Other Facilities	-	-	0.1	0%
	Argonne Nat'l. Lab. - East (ANL-E)	2.0	4.6	5.0	2%
	Argonne Nat'l. Lab. - West (ANL-W)	0.3	0.3	0.3	0%
	Brookhaven Nat'l. Lab. (BNL)	11.4	42.1	26.0	8%
	Fermi Nat'l. Accelerator Lab. (FERMI)	-	-	-	0%
DOE HQ	DOE Headquarters (includes DNFSB)	1.9	0.1	0.2	0%
	North Korea Project			-	0%
Idaho	Idaho Site	2.0	1.3	2.9	1%
Nevada	Nevada Test Site (NTS)	0.5	0.2	0.6	0%
Oakland	Ops. and Other Facilities	-	-	-	0%
	Lawrence Berkeley Lab. (LBL)	0.3	0.1	-	0%
	Lawrence Livermore Nat'l. Lab. (LLNL)	3.5	5.2	2.4	1%
	Stanford Linear Accelerator Center (SLAC)	2.7	-	7.9	2%
Oak Ridge	Ops. and Other Facilities	0.7	-	-	0%
	Oak Ridge Site	11.7	10.5	16.7	5%
	Paducah Gaseous Diff. Plant (PGDP)	0.0	-	-	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	-	-	-	0%
Ohio	Ops. and Other Facilities	0.0	-	-	0%
	Fernald Environmental Mgmt. Project	-	-	-	0%
	Mound Plant	5.4	3.1	6.9	2%
	West Valley Project	-	0.0	-	0%
Richland	Hanford Site	49.8	26.5	20.2	6%
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	26.4	38.9	42.8	13%
Savannah River	Savannah River Site (SRS)	74.7	43.9	58.1	18%
	Totals	**332.9**	**361.8**	**320.3**	**100%**

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

B-4: Distribution of Deep Dose Equivalent (DDE) and Total Effective Dose Equivalent (TEDE), 1974-1996

Deep Dose Equivalent (DDE)

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

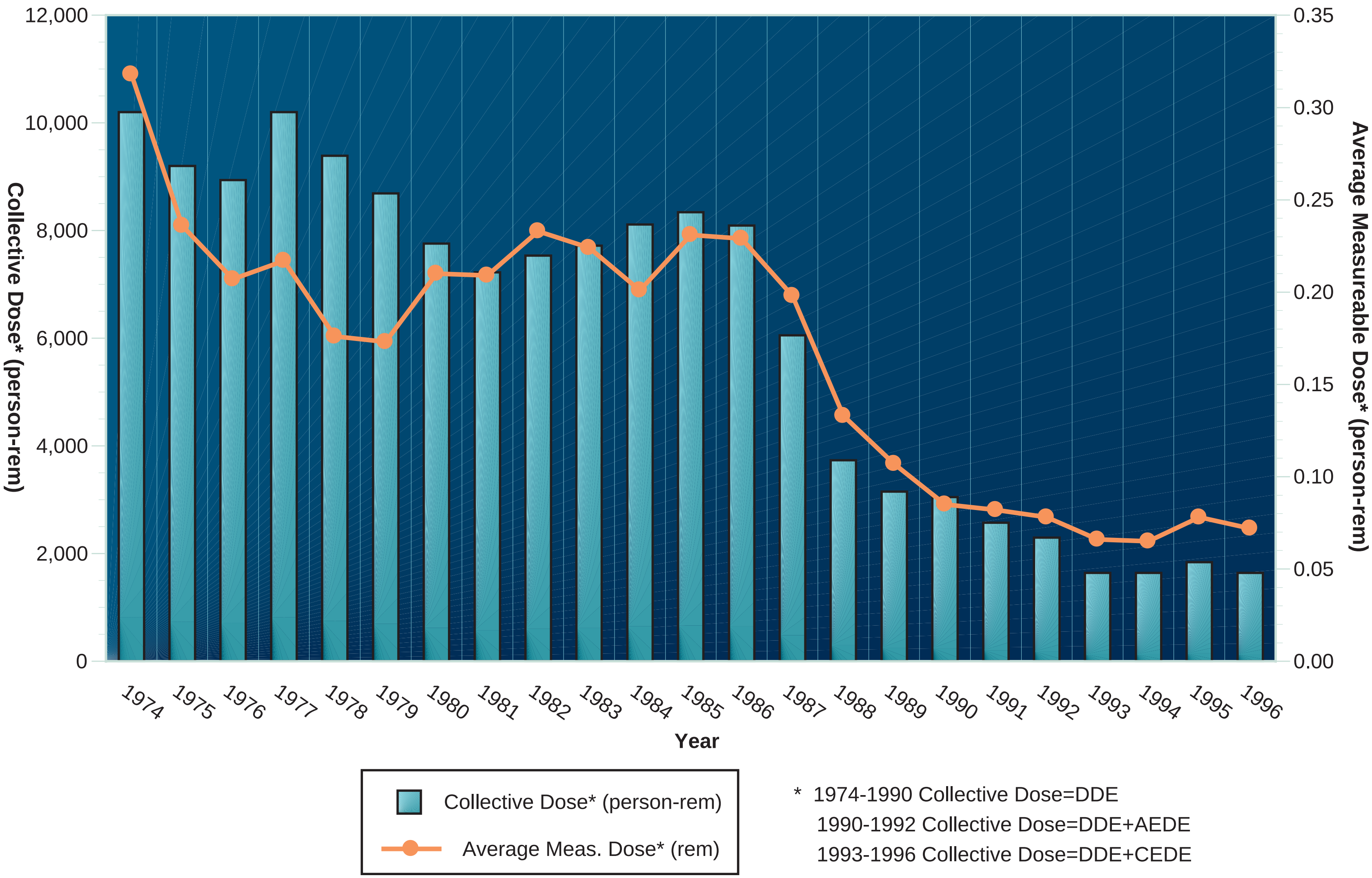
Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. DDE	Coll. DDE (person-rem)	Avg. Meas. DDE
1974	37,060	29,735	1,531	652	149	40	4								69,171	32,111	**10,202**	**0.318**
1975	41,390	36,795	1,437	541	122	28				1					80,314	38,924	9,202	0.236
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	101,424	21,720	74	1											123,219	21,795	1,598	0.073

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	23,455	157		1										**127,276**	23,613	1,840	0.078
1996	100,494	22,641	80	2	1								1		123,219	22,725	1,652	0.073

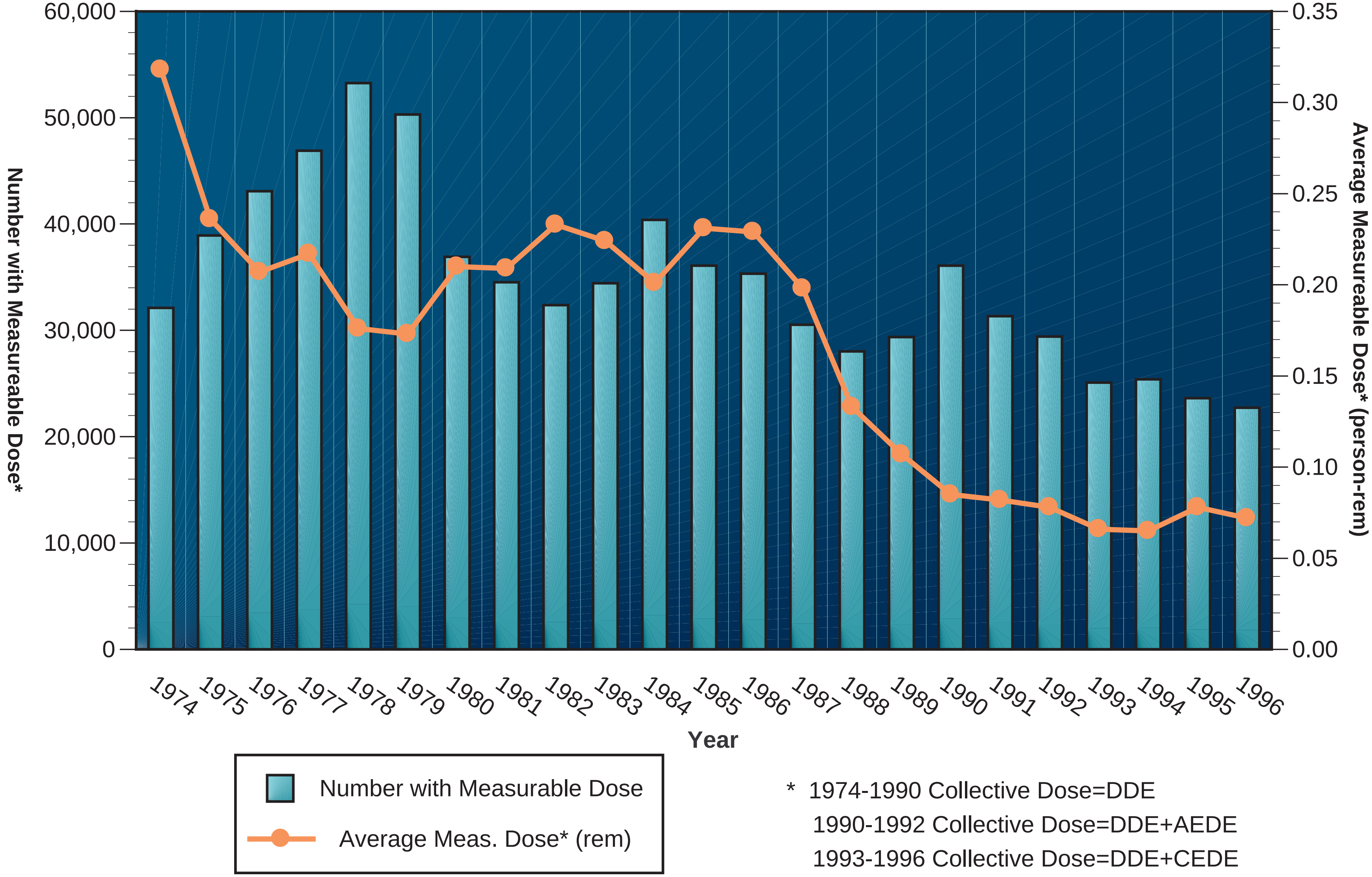
* 1990-1992 TEDE=DDE+AEDE 1993-1996 TEDE=DDE+CEDE Note: Arrowed values indicate the greatest value in each column.

B-5: Collective TEDE and Average Measurable Dose 1974-1996



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1996 Collective Dose=DDE+CEDE

B-6: Number with Measurable Dose and Average Measurable Dose 1974-1996



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1996 Collective Dose=DDE+CEDE

B-7a: Distribution of TEDE by Facility Type - 1994

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	6,458	1,463	171	83	20	8	5					8,208	21%	1,750	118.135	0.068
Fuel/Uran. Enrich.	10,072	1,037	62	20	1	1						11,193	10%	1,121	40.055	0.036
Fuel Fabrication	2,793	1,074	41	9	8	8						3,933	29%	1,140	44.315	0.039
Fuel Processing	3,441	1,641	204	123	69	11	1					5,490	37%	2,049	167.049	**0.082** ◀
Maint. and Support	16,734	2,796	242	115	25	9	2					19,923	16%	3,189	160.756	0.050
Other	11,956	2,462	244	82	45	16	40					14,845	19%	2,889	211.054	0.073
Reactor	1,911	1,019	140	94	25	1	1					3,191	**40%** ◀	1,280	97.025	0.076
Research, General	16,776	2,776	373	157	65	37	26		1			**20,211** ◀	17%	3,435	283.028	**0.082** ◀
Research, Fusion	983	133	12	8	3	2	2					1,143	14%	160	12.602	0.079
Waste Proc./Mgmt.	5,974	2,582	257	71	11	1	1					8,897	33%	2,923	129.249	0.044
Weapons Fab. & Test	14,023	4,528	691	172	57	5	1					19,477	28%	**5,454** ◀	**379.796** ◀	0.070
Totals	**91,121**	**21,511**	**2,437**	**934**	**329**	**99**	**79**	**0**	**1**	**0**	**0**	**116,511**	**22%**	**25,390**	**1,643.064**	**0.065**

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

B-7b: Distribution of TEDE by Facility Type - 1995

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	6,921	1,277	238	136	38	20	9					8,639	20%	1,718	168.527	0.098
Fuel/Uran. Enrich.	11,669	1,825	72	16	2							13,584	14%	1,915	39.230	0.020
Fuel Fabrication	2,673	986	46	19	4							3,728	28%	1,055	39.545	0.037
Fuel Processing	3,257	1,123	173	119	61	17	12					4,762	32%	1,505	162.958	0.108
Maint. and Support	16,576	2,324	285	135	42	18	16					19,396	15%	2,820	210.894	0.075
Other	17,464	2,035	203	120	51	30	70	1				19,974	13%	2,510	280.871	**0.112** ◄
Reactor	1,724	705	115	59	15	2						2,620	**34%** ◄	896	68.710	0.077
Research, General	18,280	2,579	366	193	54	29	48					21,549	15%	3,269	311.100	0.095
Research, Fusion	909	111	10	10	3							1,043	13%	134	8.953	0.067
Waste Proc./Mgmt.	6,580	2,019	311	98	25	3	2					9,038	27%	2,458	156.936	0.064
Weapons Fab. & Test	17,610	4,289	724	229	79	12						**22,943** ◄	23%	**5,333** ◄	**392.522** ◄	0.074
Totals	**103,663**	**19,273**	**2,543**	**1,134**	**374**	**131**	**157**	**1**				**127,276**	**19%**	**23,613**	**1,840.246**	**0.078**

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

B-7c: Distribution of TEDE by Facility Type - 1996

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	8,948	1,998	217	65	40	20	5					11,293	21%	2,345	152.025	0.065
Fuel/Uran. Enrich.	8,400	817	67	20	1	2	1					9,308	10%	908	38.301	0.042
Fuel Fabrication	2,300	815	32	14	3							3,164	27%	864	28.970	0.034
Fuel Processing	2,634	1,163	177	96	36	13	12				1	4,132	36%	1,498	151.224	**0.101** ◄
Maint. and Support	14,226	2,388	304	148	30	7	9					17,112	17%	2,886	195.230	0.068
Other	21,665	2,173	179	82	49	13	17	1				**24,179** ◄	10%	2,514	168.074	0.067
Reactor	1,437	768	85	47	10	2						2,349	**39%** ◄	912	56.119	0.062
Research, General	17,866	2,390	382	199	73	20	29	1	1			20,961	15%	3,095	295.711	0.096
Research, Fusion	656	133	19	7	2	2						819	20%	163	11.366	0.070
Waste Proc./Mgmt.	7,016	2,031	278	96	14	2	1					9,438	26%	2,422	142.080	0.059
Weapons Fab. & Test	15,346	4,083	701	229	81	18	6					20,464	25%	**5,118** ◄	**412.830** ◄	0.081
Totals	**100,494**	**18,759**	**2,441**	**1,003**	**339**	**99**	**80**	**2**	**1**	**0**	**1**	**123,219**	**18%**	**22,725**	**1,651.930**	**0.073**

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

Weapons Fabrication and Testing remains the facility type with the highest collective dose and number of individuals with measurable dose. The highest average measurable TEDE was Fuel Processing.

B-8a: Collective TEDE by Facility Type, 1994

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			0.2	0.1	**0.4**
	Los Alamos National Lab. (LANL)	23.7				44.0	0.2	**114.3** ◄	0.7	1.6	0.0	5.5	**190.0**
	Pantex Plant (PP)										29.1		**29.1**
	Sandia National Lab. (SNL)	0.4				0.8	5.4	2.8	0.0	0.2	0.4	2.0	**12.0**
	Uranium Mill Tailings Remedial Action (UMTRA) Project											15.0	**15.0**
Chicago	Ops. and Other Facilities					1.8		3.3	3.2			0.0	**8.3**
	Argonne Nat'l. Lab. - East (ANL-E)	5.7				1.0		9.5		2.2		21.9	**40.3**
	Argonne Nat'l. Lab. - West (ANL-W)			0.2		0.8	2.6	22.5				0.1	**26.3**
	Brookhaven Nat'l. Lab. (BNL)	**53.7** ◄				2.7	7.5	13.3		1.5		13.7	**92.3**
	Fermi Nat'l. Accelerator Lab. (FERMI)	14.3											**14.3**
DOE HQ	DOE Headquarters											2.7	**2.7**
Idaho	Idaho Site				73.4	8.0	**51.2** ◄	8.1		5.5		**90.6** ◄	**236.8**
Nevada	Nevada Test Site (NTS)	0.1									1.9		**2.0**
Oakland	Ops. and Other Facilities							0.8					**0.8**
	Lawrence Berkeley Lab.(LBL)	1.9						3.8					**5.7**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.3	1.2			1.0		1.7			2.2	3.6	**10.0**
	Stanford Linear Accelerator Center (SLAC)	16.3							**8.8** ◄				**25.1**
Oak Ridge	Ops. and Other Facilities	1.9			0.5			0.7		1.7		2.0	**6.8**
	Oak Ridge Site		1.8					44.9			14.7	7.9	**69.2**
	Paducah Gaseous Diff. Plant (PGDP)		6.8										**6.8**
	Portsmouth Gaseous Diff. Plant (PORTS)		**30.3** ◄										**30.3**
Ohio	Ops. and Other Facilities					0.0							**0.0**
	Fernald Environmental Mgmt. Project			**24.2** ◄									**24.2**
	Mound Plant					6.4					2.4	0.2	**9.1**
	West Valley											24.3	**24.3**
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										**231.9** ◄		**231.9**
Richland	Hanford Site			0.4	4.9	**77.7** ◄	13.4	43.8		56.0		18.7	**214.8**
Savannah River	Savannah River Site (SRS)			19.5	**88.3** ◄	16.4	16.8	13.3		**60.7** ◄	96.9	2.6	**314.5** ◄
	Totals	**118.1**	**40.1**	**44.3**	**167.1**	**160.8**	**97.0**	**283.0**	**12.6**	**129.2**	**379.8**	**211.1**	**1,643.1**

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

B-8b: Collective TEDE by Facility Type, 1995

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	1.3	**1.6**
	Los Alamos National Lab. (LANL)	23.6				68.7	0.1	**130.0** ◄	1.0	2.6	0.1	8.9	**235.0**
	Pantex Plant (PP)										36.9		**36.9**
	Sandia National Lab. (SNL)	0.3				1.5	3.3	4.0		0.4	0.3	1.2	**11.0**
	UMTRA											1.3	**1.3**
Chicago	Ops. and Other Facilities					2.8		0.4	3.3			0.1	**6.6**
	Argonne Nat'l. Lab. - East (ANL-E)	6.7				2.6		11.9		4.1		12.0	**37.3**
	Argonne Nat'l. Lab. - West (ANL-W)			0.3		0.8	5.5	31.0					**37.6**
	Brookhaven Nat'l. Lab. (BNL)	**102.1** ◄				6.0	9.9	8.9		1.3		17.6	**145.8**
	Fermi Nat'l. Accelerator Lab. (FERMI)	13.4											**13.4**
DOE HQ	DOE Headquarters											0.1	**0.1**
Idaho	Idaho Site				**94.2** ◄	9.0	**19.2** ◄	6.7		6.6		**148.3** ◄	**284.0**
Nevada	Nevada Test Site (NTS)										0.5		**0.5**
Oakland	Ops. and Other Facilities							1.2				0.1	**1.3**
	Lawrence Berkeley Lab.(LBL)	1.2						3.3					**4.5**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.4	1.9		1.1			1.2	**4.7** ◄		2.0	1.7	**13.0**
	Stanford Linear Accelerator Center (SLAC)	20.2											**20.2**
Oak Ridge	Ops. and Other Facilities	0.8						0.5		1.8		3.1	**6.2**
	Oak Ridge Site		0.9					42.1			12.6	21.4	**77.0**
	Paducah Gaseous Diff. Plant (PGDP)		9.0										**9.0**
	Portsmouth Gaseous Diff. Plant (PORTS)		**27.5** ◄										**27.5**
Ohio	Ops. and Other Facilities												**0.0**
	Fernald Environmental Mgmt. Project			**30.4** ◄									**30.4**
	Mound Plant					4.1					1.9	0.3	**6.3**
	West Valley											26.9	**26.9**
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										**260.6** ◄	0.2	**260.8**
Richland	Hanford Site				7.0	**97.5** ◄	17.4	54.9		**81.5** ◄		32.4	**290.7** ◄
Savannah River	Savannah River Site (SRS)			8.8	61.8	16.7	13.4	14.9		58.7	77.4	3.9	**255.6**
	Totals	**168.7**	**39.3**	**39.5**	**164.1**	**209.7**	**68.8**	**311.0**	**9.0**	**157.0**	**392.6**	**280.8**	**1,840.5**

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

B-8c: Collective TEDE by Facility Type, 1996

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	0.5	3.1	**3.6**
	Los Alamos National Lab. (LANL)	15.9				55.7	0.1	**100.4**◄	0.3	2.4	0.0	9.3	**184.1**
	Pantex Plant (PP)										28.1	0.0	**28.1**
	Sandia National Lab. (SNL)	0.7				0.6	5.4	4.5	0.1	0.6	4.2	0.6	**16.7**
	UMTRA											0.4	**0.4**
Chicago	Ops. and Other Facilities					7.1		0.3	**6.0**◄			0.1	**13.5**
	Argonne Nat'l. Lab. - East (ANL-E)	7.5				0.4		8.4		1.5		0.7	**18.5**
	Argonne Nat'l. Lab. - West (ANL-W)			0.5		1.0	5.7	36.3				0.0	**43.6**
	Brookhaven Nat'l. Lab. (BNL)	**87.0**◄				6.0	9.8	7.2		1.3		5.5	**116.8**
	Fermi Nat'l. Accelerator Lab. (FERMI)	16.2											**16.2**
DOE HQ	DOE Headquarters					0.0						0.3	**0.3**
	North Korea											13.3	**13.3**
Idaho	Idaho Site				**78.6**◄	6.1	**15.5**◄	9.0		6.0		**49.0**◄	**164.1**
Nevada	Nevada Test Site (NTS)										1.0		**1.0**
Oakland	Ops. and Other Facilities											0.0	**0.0**
	Lawrence Berkeley Lab.(LBL)	2.4						2.2					**4.6**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.0	2.3			1.6		1.2	4.9	0.0	1.9	3.0	**14.9**
	Stanford Linear Accelerator Center (SLAC)	19.3											**19.3**
Oak Ridge	Ops. and Other Facilities	2.9						0.4		7.8		0.9	**11.9**
	Oak Ridge Site		1.1					60.1			10.9	16.5	**88.6**
	Paducah Gaseous Diff. Plant (PGDP)		5.0									13.5	**18.6**
	Portsmouth Gaseous Diff. Plant (PORTS)		**29.9**◄										**29.9**
Ohio	Ops. and Other Facilities					0.0							**0.0**
	Fernald Environmental Mgmt. Project			**27.4**◄									**27.4**
	Mound Plant					6.7					11.7	1.7	**20.1**
	West Valley											11.2	**11.2**
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										**265.7**◄	2.0	**267.6**◄
Richland	Hanford Site			0.3	5.5	**94.0**◄	13.0	45.0		**74.6**◄		33.4	**265.7**
Savannah River	Savannah River Site (SRS)			0.8	67.1	15.7	6.9	20.8		47.8	89.0	3.7	**251.8**
	Totals	**152.0**	**38.3**	**29.0**	**151.2**	**195.2**	**56.1**	**295.7**	**11.4**	**142.1**	**412.8**◄	**168.1**	**1,651.9**

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

Collective TEDE at Rocky Flats increased for 1996 and was the largest contributor to the Weapons Fabrication and Testing facility type, although it should be noted that Rocky Flats and SRS are no longer active in the fabrication and testing of weapons but is currently involved in materials stabilization and cleanup activities. Fusion Research was the only other facility type that increased for 1996.

B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Accelerator Facilities, 1996

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	Brookhaven National Laboratory	2,156	776	95	36	35	20	5	-	**3,123**	31%	**967**	**87.009**	**0.090**	**51%**
AL	Los Alamos National Laboratory	318	188	45	8	3	-	-	-	562	43%	244	15.901	0.065	11%
CH	Argonne National Laboratory - East	569	96	18	5	-	-	-	-	688	17%	119	7.490	0.063	0%
OAK	Stanford Linear Accelerator Center	2,286	268	29	14	1	-	-	-	2,598	12%	312	19.320	0.062	3%
AL	Sandia National Laboratory	234	14	-	1	-	-	-	-	249	6%	15	0.706	0.047	0%
OAK	Lawrence Berkeley Laboratory	10	51	3	-	-	-	-	-	64	**84%**	54	2.441	0.045	0%
OR	Thomas Jefferson Nat'l. Accel. Facil.	1,060	90	4	-	-	-	-	-	1,154	8%	94	2.880	0.031	0%
CH	Fermilab	2,002	513	23	1	1	-	-	-	2,540	21%	538	16.230	0.030	4%
OAK	Lawrence Livermore National Lab.	302	2	-	-	-	-	-	-	304	1%	2	0.048	0.024	0%
RL	Battelle Memorial Institute (PNL)	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
NV	EG&G Special Technologies Lab.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
AL	Johnson Controls, Inc.	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
OR	Oak Ridge Field Office	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
	Totals	**8,948**	**1,998**	**217**	**65**	**40**	**20**	**5**	-	**11,293**	**21%**	**2,345**	**152.025**	**0.065**	**31%**

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

The largest percentage of collective dose at accelerator facilities accrued at Brookhaven National Laboratory (BNL) where doses increased due to increased accelerator operations. BNL was also highest in terms of the total monitored, number with measurable dose, average measurable dose, and the percentage of the collective TEDE above 0.5 rem.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 1996

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
ENRICHMENT															
OR	Lockheed Martin Utility Services (Paducah)	376	35	10	6	-	-	-	-	427	12%	51	5.045	**0.099** ◄	0%
OAK	Lawrence Livermore National Lab.	617	21	2	3	-	-	-	-	643	4%	26	2.254	0.087	0%
OR	Lockheed Martin Utility Services (Portsmouth)	3,230	688	55	11	1	2	1	-	3,988	**19%** ◄	**758** ◄	**29.909** ◄	0.039	**12%** ◄
OR	Lockheed Martin Energy Sys. (K-25)	4,177	73	-	-	-	-	-	-	**4,250** ◄	2%	73	1.093	0.015	0%
	Total	**8,400**	**817**	**67**	**20**	**1**	**2**	**1**	-	**9,308**	**10%**	**908**	**38.301**	**0.042**	**9%**
FABRICATION															
RL	Westinghouse Hanford Services	3	2	1	-	-	-	-	-	6	**50%** ◄	3	0.241	**0.080** ◄	0%
CH	Argonne National Lab. – West	24	7	-	1	-	-	-	-	32	25%	8	0.518	0.065	0%
RL	Babcock Wilcox Hanford	1	1	-	-	-	-	-	-	2	**50%** ◄	1	0.038	0.038	0%
OH	FERMCO	1,398	490	23	7	3	-	-	-	**1,921** ◄	27%	**523** ◄	**19.103** ◄	0.037	**8%** ◄
OH	FERMCO Subcontractors	633	264	7	6	-	-	-	-	910	30%	277	8.267	0.030	0%
SR	Westinghouse Savannah River Co.	155	44	1	-	-	-	-	-	200	23%	45	0.740	0.016	0%
OH	Fernald Area Office	68	4	-	-	-	-	-	-	72	6%	4	0.040	0.010	0%
SR	Westinghouse S.R. Subcontractors	6	2	-	-	-	-	-	-	8	25%	2	0.017	0.009	0%
SR	Wackenhut Services, Inc., – SR	2	1	-	-	-	-	-	-	3	33%	1	0.006	0.006	0%
SR	Bechtel Construction – SR	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Duke Engineering Services Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	DynCorp Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Fluor Daniel – Hanford	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	Lockheed Martin Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	NUMATEC Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Savannah River Field Office	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
	Total	**2,300**	**815**	**32**	**14**	**3**	-	-	-	**3,164**	**27%**	**864**	**28.970**	**0.034**	**6%**

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 Fuel Facilities, 1996 (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	Westinghouse Hanford Services	7	5	2	9	1	-	-	-	24	71% ◄	17	4.795	**0.282** ◄	11%
ID	Lockheed Idaho Tech. Co. – Services	1,047	237	76	36	32	12	12	-	1,452	28%	405	**78.428** ◄	0.194	**58%** ◄
SR	Service America	3	2	10	-	-	-	-	-	15	**80%** ◄	12	1.760	0.147	0%
RL	Fluor Daniel – Hanford	5	9	1	-	-	-	-	-	15	67%	10	0.695	0.070	0%
SR	Westinghouse Savannah River Co.	1,153	739	82	51	3	1	-	1	**2,030** ◄	43%	**877** ◄	61.420	0.070	23%
ID	Idaho Field Office	17	2	-	-	-	-	-	-	19	11%	2	0.097	0.049	0%
ID	LITCO Subcontractors – Construction	24	2	-	-	-	-	-	-	26	8%	2	0.056	0.028	0%
SR	Bechtel Construction – SR	140	120	6	-	-	-	-	-	266	47%	126	3.247	0.026	0%
SR	Westinghouse S.R. Subcontractors	72	29	-	-	-	-	-	-	101	29%	29	0.529	0.018	0%
SR	Wackenhut Services, Inc., – SR	102	10	-	-	-	-	-	-	112	9%	10	0.114	0.011	0%
RL	Duke Engineering Services Hanford	8	1	-	-	-	-	-	-	9	11%	1	0.011	0.011	0%
SR	Savannah River Field Office	51	7	-	-	-	-	-	-	58	12%	7	0.072	0.010	0%
RL	Babcock Wilcox Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Bechtel Power Co.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Miscellaneous DOE Contractors – SR	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Rust Services Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
	Total	**2,634**	**1,163**	**177**	**96**	**36**	**13**	**12**	**1**	**4,132**	**36%**	**1,498**	**151.224**	**0.101**	**40%**

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

Enrichment facilities at Portsmouth accounted for 79% percent of the collective dose and Fuel Fabrication facilities at Fernald accounted for 93% in 1996. Processing facilities at Lockheed Martin (Idaho) and Westinghouse Savannah River accounted for 92% of the collective dose at this facility type.

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 1996

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	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	1,230	222	32	25	14	4	8	-	1,535	20%	305	42.296	**0.139** ◄	**57%** ◄
RL	Battelle Memorial Institute (PNL)	15	7	1	1	1	-	-	-	25	40%	10	1.249	0.125	46%
RL	Kaiser Eng. Hanford - Cost Const	606	182	60	43	3	2	-	-	896	32%	290	34.557	0.119	10%
CH	Battelle Mem. Inst. - Columbus (Old)	455	44	10	12	-	-	-	-	521	13%	66	7.131	0.108	0%
RL	Westinghouse Hanford Services	950	302	84	37	9	1	-	-	1,383	31%	**433** ◄	**43.592** ◄	0.101	14%
OAK	Lawrence Livermore National Lab.	2,379	17	3	1	-	-	-	-	**2,400** ◄	1%	21	1.468	0.070	0%
CH	Brookhaven National Laboratory	658	73	7	8	1	-	-	-	747	12%	89	6.021	0.068	9%
CH	Argonne National Laboratory - West	25	13	4	-	-	-	-	-	42	40%	17	1.048	0.062	0%
RL	Lockheed Martin Hanford	183	5	1	-	-	-	-	-	189	3%	6	0.347	0.058	0%
AL	Johnson Controls, Inc.	927	205	31	10	-	-	-	-	1,173	21%	246	13.072	0.053	0%
RL	Fluor Daniel - Hanford	840	176	20	3	-	-	-	-	1,039	19%	199	9.553	0.048	0%
CH	Argonne National Laboratory - East	398	9	-	-	-	-	-	-	407	2%	9	0.420	0.047	0%
SR	Bechtel Construction - SR	195	77	7	3	1	-	-	-	283	31%	88	3.973	0.045	13%
ID	Lockheed Idaho Tech. Co. - Services	544	130	4	2	-	-	1	-	681	20%	137	5.712	0.042	19%
RL	Lockheed Martin Services, Inc.	54	1	-	-	-	-	-	-	55	2%	1	0.041	0.041	0%
AL	Los Alamos Area Office	37	1	-	-	-	-	-	-	38	3%	1	0.038	0.038	0%
RL	Babcock Wilcox Hanford	148	13	2	-	-	-	-	-	163	9%	15	0.558	0.037	0%
SR	Service America	12	8	1	-	-	-	-		21	43%	9	0.328	0.036	0%
RL	Fluor Daniel Northwest Services	334	55	3	-	-	-	-		392	15%	58	2.017	0.035	0%
OH	EG&G Mound Subcontractors	313	39	2	1	-	-	-		355	12%	42	1.414	0.034	0%
SR	Westinghouse Savannah River Co.	506	323	22	-	-	-	-		851	41%	345	10.555	0.031	0%
SR	Westinghouse S.R. Subcontractors	77	24	1	1	-	-	-		103	25%	26	0.718	0.028	0%
RL	Rust Services Hanford	237	10	-	-	-	-	-		247	4%	10	0.271	0.027	0%
RL	Bechtel Power Co.	164	10	-	-	-	-	-		174	6%	10	0.256	0.026	0%
RL	Fluor Daniel Northwest	349	44	-	-	-	-	-		393	11%	44	1.086	0.025	0%
RL	Duke Engineering Services Hanford	68	14	-	-	-	-	-		82	17%	14	0.335	0.024	0%
OAK	LLNL Plant Services	346	5	-	-	-	-	-		351	1%	5	0.104	0.021	0%
OH	EG&G Mound Applied Technologies	378	255	8	1	1	-	-		643	41%	265	5.212	0.020	10%

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

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 1996 (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	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	Idaho Field Office	105	19	1	-	-	-	-	-	125	16%	20	0.393	0.020	0%
OH	EG&G Mound Security Forces	37	6	-	-	-	-	-	-	43	14%	6	0.111	0.019	0%
AL	Sandia National Laboratory	574	35	-	-	-	-	-	-	609	6%	35	0.633	0.018	0%
RL	Boeing Computer Services	108	3	-	-	-	-	-	-	111	3%	3	0.052	0.017	0%
RL	DynCorp Hanford	102	5	-	-	-	-	-	-	107	5%	5	0.082	0.016	0%
SR	Wackenhut Services, Inc. - SR	6	1	-	-	-	-	-	-	7	14%	1	0.015	0.015	0%
RL	Babcock Wilcox Protection, Inc.	83	3	-	-	-	-	-	-	86	3%	3	0.039	0.013	0%
AL	Protection Technologies Los Alamos	311	29	-	-	-	-	-	-	340	9%	29	0.339	0.012	0%
SR	Savannah River Field Office	10	10	-	-	-	-	-	-	20	50%	10	0.103	0.010	0%
SR	Miscellaneous DOE Contractors - SR	8	6	-	-	-	-	-	-	14	43%	6	0.044	0.007	0%
OH	Miamisburg Area Office	22	4	-	-	-	-	-	-	26	15%	4	0.028	0.007	0%
OH	Miamisburg Office Subs	27	1	-	-	-	-	-	-	28	4%	1	0.007	0.007	0%
HQ	DOE Headquarters	1	1	-	-	-	-	-	-	2	50%	1	0.006	0.006	0%
SR	S.R. Forest Station	-	1	-	-	-	-	-	-	1	**100%** ◄	1	0.006	0.006	0%
RL	Duke Eng. & Serv. Northwest, Inc.	9	-	-	-	-	-	-	-	9	0%	-	-	-	0%
ID	Idaho Office Subs	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
OAK	LLNL Security	273	-	-	-	-	-	-	-	273	0%	-	-	-	0%
RL	NUMATEC Hanford	25	-	-	-	-	-	-	-	25	0%	-	-	-	0%
OH	Ohio Field Office	17	-	-	-	-	-	-	-	17	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. Services	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
RL	Richland Field Office	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
RL	Rust Federal Services Northwest	29	-	-	-	-	-	-	-	29	0%	-	-	-	0%
RL	SGN Eurisys Services Corp.	19	-	-	-	-	-	-	-	19	0%	-	-	-	0%
SR	Southern Bell Tel. & Tel.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Univ. of Georgia Ecology Lab.	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Wackenhut Services, Inc. – NV	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
RL	Westinghouse Hanford Service Subs	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
	Total	**14,226**	**2,388**	**304**	**148**	**30**	**7**	**9**	-	**17,112**	**17%**	**2,886**	**195.230**	**0.068**	**19%**

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

These individuals tend to provide maintenance and support services site-wide and may be located at more than one facility type during the year. Note that, overall, only 17% of monitored individuals received any measurable TEDE and that these doses primarily occurred at Hanford (Westinghouse and Kaiser Engineers) and LANL. These three organizations accounted for 62% of the collective dose at these facilities types. The organization with the largest number of monitored individuals was LLNL, but less than 1% received a measurable dose.

B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Reactor Facilities, 1996

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
AL	Sandia National Laboratory	50	17	2	1	4	2	-	-	76	34%	26	5.354	**0.206**	**77%**
CH	Argonne National Laboratory – West	93	16	3	9	2	-	-	-	123	24%	30	5.676	0.189	21%
RL	Westinghouse Hanford Services	116	34	14	11	3	-	-	-	178	35%	62	9.094	0.147	20%
RL	Battelle Memorial Institute (PNL)	-	-	1	-	-	-	-	-	1	**100%**	1	0.133	0.133	0%
ID	Lockheed Idaho Tech. Co. - Services	266	118	36	13	1	-	-	-	434	39%	168	**15.437**	0.092	4%
RL	Kaiser Eng. Hanford - Cost Const	37	5	3	-	-	-	-	-	45	18%	8	0.677	0.085	0%
CH	Brookhaven National Laboratory	80	87	21	12	-	-	-	-	200	60%	120	9.763	0.081	0%
RL	Fluor Daniel – Hanford	68	31	2	1	-	-	-	-	102	33%	34	1.683	0.050	0%
RL	Babcock Wilcox Hanford	74	7	1	-	-	-	-	-	82	10%	8	0.373	0.047	0%
RL	Babcock Wilcox Protection, Inc.	12	1	-	-	-	-	-	-	13	8%	1	0.041	0.041	0%
RL	Duke Engineering Services Hanford	37	21	1	-	-	-	-	-	59	37%	22	0.709	0.032	0%
SR	Wackenhut Services, Inc. – SR	15	46	-	-	-	-	-	-	61	75%	46	1.371	0.030	0%
RL	Lockheed Martin Hanford	32	1	-	-	-	-	-	-	33	3%	1	0.026	0.026	0%
RL	Bechtel Power Co.	18	5	-	-	-	-	-	-	23	22%	5	0.099	0.020	0%
RL	NUMATEC Hanford	5	1	-	-	-	-	-	-	6	17%	1	0.019	0.019	0%
SR	Bechtel Construction - SR	27	42	-	-	-	-	-	-	69	61%	42	0.699	0.017	0%
RL	Fluor Daniel Northwest Services	13	4	-	-	-	-	-	-	17	24%	4	0.063	0.016	0%
SR	Westinghouse Savannah River Co.	386	303	1	-	-	-	-	-	**690**	44%	**304**	4.596	0.015	0%
RL	SGN Eurisys Services Corp.	8	2	-	-	-	-	-	-	10	20%	2	0.030	0.015	0%
ID	Idaho Field Office	6	1	-	-	-	-	-	-	7	14%	1	0.014	0.014	0%
SR	Westinghouse S.R. Subcontractors	44	13	-	-	-	-	-	-	57	23%	13	0.152	0.012	0%
AL	Los Alamos National Laboratory	4	5	-	-	-	-	-	-	9	56%	5	0.056	0.011	0%
RL	Rust Services Hanford	16	1	-	-	-	-	-	-	17	6%	1	0.011	0.011	0%
SR	Savannah River Field Office	13	7	-	-	-	-	-	-	20	35%	7	0.043	0.006	0%
RL	DynCorp Hanford	9	-	-	-	-	-	-	-	9	0%	-	-	-	0%
AL	Johnson Controls, Inc.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	LITCO Subcontractors – Construction	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Lockheed Martin services, Inc.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Miscellaneous DOE Contractors – SR	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Richland Field Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Rust Federal Services Northwest	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
	Total	**1,437**	**768**	**85**	**47**	**10**	**2**	-	-	**2,349**	**39%**	**912**	**56.119**	**0.062**	**14%**

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

Lockheed Idaho Tech. Services had the highest collective TEDE, but only the 5th highest average measurable TEDE. Westinghouse Savannah River Co. had the largest number of individuals monitored and number with measurable TEDE, although their collective TEDE and average measurable TEDE were very low. Sandia National Lab had the highest average measurable dose as well as the highest percent TEDE above 0.5 rem indicating that individuals at this site received the highest doses.

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 1996

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	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	1,843	27	6	3	-	2	3	-	1,884	2%	41	8.417	**0.205** ◄	**69%** ◄
RL	Battelle Memorial Institute (PNL)	738	162	37	32	11	5	10	-	995	26%	257	44.310	0.172	49%
CH	Argonne National Laboratory – West	391	171	49	42	11	-	-	-	664	41%	273	36.292	0.133	18%
AL	Los Alamos National Laboratory	2,210	687	109	50	32	8	13	2	3,111	29%	**901** ◄	**100.435** ◄	0.111	51%
RL	Westinghouse Hanford Services	47	2	3	-	-	-	-	-	52	10%	5	0.534	0.107	0%
OR	Lockheed Martin Energy Sys. (ORNL)	6,669	429	103	44	14	4	3	-	**7,266** ◄	8%	597	60.137	0.101	26%
ID	Lockheed Idaho Tech. Co. - Services	590	79	5	8	4	1	-	-	687	14%	97	8.955	0.092	33%
OAK	Lawrence Livermore National Lab.	938	14	4	-	-	-	-	-	956	2%	18	1.186	0.066	0%
CH	New Brunswick Laboratory	46	2	-	-	-	-	-	-	48	4%	2	0.130	0.065	0%
CH	Brookhaven National Laboratory	555	102	19	5	1	-	-	-	682	19%	127	7.247	0.057	8%
OAK	Lawrence Berkeley Laboratory	11	41	3	2	-	-	-	-	57	**81%** ◄	46	2.201	0.048	0%
SR	Westinghouse S.R. Subcontractors	21	13	2	-	-	-	-	-	36	42%	15	0.658	0.044	0%
SR	Westinghouse Savannah River Co.	621	386	36	8	-	-	-	-	1,051	41%	430	17.333	0.040	0%
SR	Bechtel Construction - SR	39	42	1	1	-	-	-	-	83	53%	44	1.638	0.037	0%
AL	Inhalation Toxicology Research Inst.	22	6	1	-	-	-	-	-	29	24%	7	0.250	0.036	0%
RL	Fluor Daniel Northwest Services	11	2	-	-	-	-	-	-	13	15%	2	0.066	0.033	0%
AL	Sandia National Laboratory	2,694	126	4	4	-	-	-	-	2,828	5%	134	4.228	0.032	0%
RL	Babcock Wilcox Hanford	5	1	1	-	-	-	-	-	6	17%	1	0.026	0.026	0%
OR	Oak Ridge Inst. for Sci. & Educ. (ORISE)	45	16	-	-	-	-	-	-	61	26%	16	0.350	0.022	0%
SR	Miscellaneous DOE Contractors – SR	26	20	-	-	-	-	-	-	46	43%	20	0.360	0.018	0%
CH	Ames Laboratory (Iowa State)	105	7	-	-	-	-	-	-	112	6%	7	0.120	0.017	0%
SR	Savannah River Field Office	39	34	-	-	-	-	-	-	73	47%	34	0.580	0.017	0%
SR	Wackenhut Services, Inc. – SR	14	11	-	-	-	-	-	-	25	44%	11	0.168	0.015	0%

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

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 1996 (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	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.	10	1	-	-	-	-	-	-	11	9%	1	0.013	0.013	0%
RL	Duke Engineering Services Hanford	22	2	-	-	-	-	-	-	24	8%	2	0.020	0.010	0%
ID	Idaho Field Office	18	1	-	-	-	-	-	-	19	5%	1	0.010	0.010	0%
SR	Univ. of Georgia Ecology Laboratory	19	6	-	-	-	-	-	-	25	24%	6	0.047	0.008	0%
RL	Babcock Wilcox Protection, Inc.	1	-	-	-	-	-	-	-	1	0%	11	-	-	0%
RL	Bechtel Power Co.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Diversco	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	DynCorp Hanford	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	Fluor Daniel – Hanford	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
RL	Fluor Daniel Northwest	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
AL	Johnson Controls, Inc.	8	-	-	-	-	-	-	-	8	0%	-	-	-	0%
RL	Kaiser Eng. Hanford - Cost Const	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
ID	LITCO Subcontractors – Construction	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Lockheed Martin Hanford	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
AL	Los Alamos Area Office	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
AL	Nat. Renewable Energy Lab (NREL) - GO	19	-	-	-	-	-	-	-	19	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	12	-	-	-	-	-	-	-	12	0%	-	-	-	0%
RL	NUMATEC Hanford	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
AL	Protection Technologies Los Alamos	12	-	-	-	-	-	-	-	12	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. – NTS	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Rust Services Hanford	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
OAK	Univ. of Cal./SF – Lab of Radiology	31	-	-	-	-	-	-	-	31	0%	-	-	-	0%
	Total	**17,866**	**2,390**	**382**	**199**	**73**	**20**	**29**	**2**	**20,961**	**15%**	**3,095**	**295.711**	**0.096**	**35%**

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

The collective TEDE and the highest number of individuals with measurable TEDE was highest at LANL. The highest average measurable TEDE and highest percent above 0.5 rem was at ANL-East. ORNL had the highest number of employees monitored (7,266) but only 8% of these individuals received a measurable dose.

B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, Fusion, 1996

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	239	22	5	2	1	2	-	-	271	12%	32	4.928	**0.154** ◄	**50%** ◄
CH	Princeton Plasma Physics Laboratory	320	84	14	5	1	-	-	-	**424** ◄	25%	**104** ◄	**6.023** ◄	0.058	9%
AL	Sandia National Laboratory	45	7	-	-	-	-	-	-	52	13%	7	0.143	0.020	0%
AL	Los Alamos National Laboratory	52	20	-	-	-	-	-	-	72	**28%** ◄	20	0.272	0.014	0%
	Total	**656**	**133**	**19**	**7**	**2**	-	-	-	**819**	**20%**	**163**	**11.366**	**0.070**	**26%**

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

LLNL and the Princeton Plasma Physics Laboratory were the primary contributors to the collective TEDE in 1996. The collective dose for this facility type is the lowest for all facility types.

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 1996

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	DynCorp Hanford	28	-	-	1	-	-	-	-	29	3%	1	0.260	**0.260** ◄	0%
OR	Bechtel National, Inc. – (FUSRAP)	457	19	8	4	3	1	1	-	493	7%	36	7.123	0.198	55%
RL	Bechtel Power Co.	136	34	8	12	2	-	-	-	192	29%	56	8.576	0.153	15%
RL	Duke Engineering Services Hanford	35	3	1	1	-	-	-	-	40	13%	5	0.557	0.111	0%
RL	Westinghouse Hanford Services	1,053	311	77	49	7	-	-	-	1,497	30%	444	**44.980** ◄	0.101	10%
RL	Kaiser Eng. Hanford - Cost Const	148	35	13	5	-	-	-	-	201	26%	53	4.807	0.091	0%
SR	Service America	11	3	2	-	-	-	-	-	16	31%	5	0.367	0.073	0%
ID	Lockheed Idaho Tech. Co. - Services	194	68	17	-	1	-	-	-	280	31%	86	5.930	0.069	13%
CH	Brookhaven National Laboratory	9	13	6	-	-	-	-	-	28	68%	19	1.261	0.066	0%
OR	Morrison-Knudsen (WSSRAP)	184	8	3	-	-	-	-	-	195	6%	11	0.673	0.061	0%
CH	Argonne National Laboratory – East	64	23	3	-	-	-	-	-	90	29%	26	1.462	0.056	0%
RL	Fluor Daniel – Hanford	703	184	31	4	-	-	-	-	922	24%	219	11.841	0.054	0%
AL	Los Alamos National Laboratory	233	41	4	1	1	-	-	-	280	17%	47	2.422	0.052	**22%** ◄
RL	Babcock Wilcox Hanford	309	34	4	1	-	-	-	-	348	11%	39	1.938	0.050	0%
RL	Rust Federal Services Northwest	5	1	-	-	-	-	-	-	6	17%	1	0.049	0.049	0%
AL	Sandia National Laboratory	133	12	-	1	-	-	-	-	146	9%	13	0.607	0.047	0%
SR	Westinghouse Savannah River Co.	1,874	806	84	12	-	-	-	-	**2,777** ◄	33%	**903** ◄	36.316	0.040	0%
RL	Lockheed Martin Hanford	239	9	2	-	-	1	-	-	250	4%	11	0.435	0.040	0%
OAK	Lawrence Livermore National Lab.	77	1	-	-	-	-	-	-	78	1%	1	0.038	0.038	0%
RL	SGN Eurisys Services Corp.	24	2	-	-	-	-	-	-	26	8%	2	0.075	0.038	0%
RL	Fluor Daniel Northwest Services	37	4	-	-	-	-	-	-	41	10%	4	0.144	0.036	0%
RL	Rust Services Hanford	164	18	1	-	-	-	-	-	183	10%	19	0.675	0.036	0%
SR	Bechtel Construction - SR	304	248	13	5	-	-	-	-	570	47%	266	9.142	0.034	0%
RL	NUMATEC Hanford	52	7	-	-	-	-	-	-	59	12%	7	0.235	0.034	0%

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

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 1996 (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
AL	Carlsbad Area Misc. Contractors	198	4	-	-	-	-	-	-	202	2%	4	0.102	0.026	0%
ID	Idaho Field Office	6	2	-	-	-	-	-	-	8	25%	2	0.042	0.021	0%
RL	Fluor Daniel Northwest	22	2	-	-	-	-	-	-	24	8%	2	0.040	0.020	0%
SR	Westinghouse S.R. Subcontractors	123	94	1	-	-	-	-	-	218	44%	95	1.577	0.017	0%
SR	Wackenhut Services, Inc. – SR	4	1	-	-	-	-	-	-	5	20%	1	0.014	0.014	0%
SR	Southern Bell Tel. & Tel.	-	1	-	-	-	-	-	-	1	**100%** ◄	1	0.012	0.012	0%
SR	Savannah River Field Office	82	37	-	-	-	-	-	-	119	31%	37	0.340	0.009	0%
SR	Miscellaneous DOE Contractors – SR	12	5	-	-	-	-	-	-	17	29%	5	0.034	0.007	0%
SR	Diversco	1	1	-	-	-	-	-	-	2	50%	1	0.006	0.006	0%
RL	Babcock Wilcox Protection, Inc.	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	Battelle Memorial Institute (PNL)	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Duke Eng. & Services Northwest, Inc.	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
AL	Johnson Controls, Inc.	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Lockheed Martin Services, Inc.	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
AL	Los Alamos Area Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Nevada Field Office	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	57	-	-	-	-	-	-	-	57	0%	-	-	-	0%
NV	Raytheon Services – Nevada	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Richland Field Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	S.R. Forest Station	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Science Applications Int'l. Corp.- NV	11	-	-	-	-	-	-	-	11	0%	-	-	-	0%
AL	WIPP Project Integration Office	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
	Total	**7,016**	**2,031**	**278**	**96**	**14**	**2**	**1**	-	**9,438**	**26%**	**2,422**	**142.080**	**0.059**	**8%**

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

Westinghouse Savannah River Company (WSRC) and Westinghouse Hanford Services were the two highest contributors of collective TEDE. WSRC had the highest number of employees monitored as well as the highest number with measurable TEDE although their average measurable dose ranked 17th. DynCorp Hanford had the highest average measurable dose due to having only one person with measurable dose.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Weapons Fabrication, 1996

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	0.75-1.00	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	Westinghouse Savannah River Co.	269	173	48	65	37	9	6	-	607	56%	338	74.622	0.221 ◄	50%
OH	EG&G Mound Applied Technologies	37	44	3	7	9	3	-	-	103	64%	66	11.678	0.177	66% ◄
RFO	Rocky Flats Prime Contractors	373	1,918	480	116	28	6	-	-	2,921	87% ◄	2,548 ◄	227.836 ◄	0.089	10%
AL	Mason & Hanger – Amarillo	2,770	242	55	23	6	-	-	-	3,096	11%	326	28.069	0.086	13%
SR	Westinghouse S.R. Subcontractors	15	10	4	1	-	-	-	-	30	50%	15	1.265	0.084	0%
SR	Wackenhut Services, Inc. – SR	53	92	18	-	-	-	-	-	163	67%	110	7.379	0.067	0%
SR	Bechtel Construction - SR	32	66	19	2	-	-	-	-	119	73%	87	5.676	0.065	0%
OAK	Lawrence Livermore National Lab.	711	29	1	1	1	-	-	-	743	4%	32	1.854	0.058	29%
NV	Reynolds Elec. & Engr. Co. – NTS	594	15	4	-	-	-	-	-	613	3%	19	1.019	0.054	0%
RFO	Rocky Flats Subcontractors	686	554	49	14	-	-	-	-	1,303	47%	617	30.085	0.049	0%
RFO	Rocky Flats Office	171	152	7	-	-	-	-	-	330	48%	159	6.997	0.044	0%
AL	Albuquerque Field Office	160	7	1	-	-	-	-	-	168	5%	8	0.301	0.038	0%
SR	Miscellaneous DOE Contractors – SR	2	1	-	-	-	-	-	-	3	33%	1	0.022	0.022	0%
OR	Lockheed Martin Energy Sys. (Y-12)	8,637	510	12	-	-	-	-	-	9,159 ◄	6%	522	10.899	0.021	0%
RFO	Rocky Flats Office Subs	31	38	-	-	-	-	-	-	69	55%	38	0.749	0.020	0%
AL	Sandia National Laboratory	302	209	-	-	-	-	-	-	511	41%	209	4.100	0.020	0%
AL	Kirtland Area Office	28	6	-	-	-	-	-	-	34	18%	6	0.078	0.013	0%
AL	Martin Marietta Specialty Comp. Inc.	183	12	-	-	-	-	-	-	195	6%	12	0.155	0.013	0%
OH	EG&G Mound Subcontractors	52	2	-	-	-	-	-	-	54	4%	2	0.022	0.011	0%
SR	Savannah River Field Office	30	2	-	-	-	-	-	-	32	6%	2	0.019	0.010	0%
AL	Los Alamos National Laboratory	19	1	-	-	-	-	-	-	20	5%	1	0.005	0.005	0%
AL	Albuquerque Transportation Division	12	-	-	-	-	-	-	-	12	0%	-	-	-	0%
AL	Amarillo Area Office	131	-	-	-	-	-	-	-	131	0%	-	-	-	0%
AL	Battelle – Pantex	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Defense Nuclear Agency-Kirtland AFB	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
NV	EG&G Las Vegas	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Environmental Prot. Agency (NERC)	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
OH	Miamisburg Area Office	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
OH	Miamisburg Office Subs	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	15	-	-	-	-	-	-	-	15	0%	-	-	-	0%
OH	Ohio Field Office	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Raytheon Services – Nevada	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
NV	Raytheon Services Subcontractors	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. Services	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
	Total	**15,346**	**4,083**	**701**	**229**	**81**	**18**	**6**	**-**	**20,464**	**25%**	**5,118**	**412.830**	**0.081**	**17%**

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

Rocky Flats Prime Contractors were responsible for the highest collective TEDE while keeping the average measurable dose at 0.089 rem. WSRC had the highest average measurable dose and second highest collective dose indicating that individuals received the highest doses at this organization. Y-12 continued to have the highest number monitored with only 6% actually receiving a measurable dose.

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1996

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
HQ	Nuclear Assurance Corp. (NAC)	1	3	5	1	3	1	4	1	19	95%	18	11.750	**0.653**◄	**88%**◄
RL	Kaiser Eng. Hanford - Cost Const	155	4	-	3	2	1	-	-	165	6%	10	3.374	0.337	63%
AL	Albuquerque Office Subs	1	1	2	4	2	-	-	-	10	90%	9	3.016	0.335	34%
ID	Lockheed Idaho Tech. Co. - Services	1,102	80	14	9	16	7	10	-	1,238	11%	136	**35.567**◄	0.262	77%
RL	Battelle Memorial Institute (PNL)	832	61	11	13	7	1	1	-	926	10%	94	15.079	0.160	40%
HQ	CenTech 21 – North Korea	-	2	3	-	-	-	-	-	5	**100%**◄	5	0.530	0.106	0%
CH	Argonne National Laboratory - East	1	5	-	2	-	-	-	-	8	88%	7	0.727	0.104	0%
HQ	DOE North Korea Project	5	5	2	-	-	-	-	-	12	58%	7	0.675	0.096	0%
RL	Bechtel Power Co.	727	76	14	13	-	-	-	-	830	12%	103	9.353	0.091	0%
AL	Johnson Controls, Inc.	176	24	4	1	2	-	-	-	207	15%	31	2.670	0.086	42%
OH	EG&G Mound Applied Technologies	173	14	4	2	-	-	-	-	193	10%	20	1.642	0.082	0%
HQ	Pacific Northwest Lab. - Korea	-	4	-	-	-	-	-	-	4	**100%**◄	4	0.320	0.080	0%
RL	Westinghouse Hanford Services	885	40	5	2	1	-	-	-	933	5%	48	3.043	0.063	22%
OAK	Lawrence Livermore National Lab.	2,509	44	3	2	1	-	-	-	2,559	2%	50	3.013	0.060	20%
ID	LITCO Subcontractors - Construction	455	197	8	2	10	1	-	-	673	32%	218	13.021	0.060	53%
AL	Los Alamos Area Office	24	4	1	-	-	-	-	-	29	17%	5	0.289	0.058	0%
OR	Martin Marietta (Paducah)	2,404	195	35	9	-	-	-	-	2,643	9%	239	13.537	0.057	0%
HQ	DOE Headquarters	5	4	1	-	-	-	-	-	10	50%	5	0.260	0.052	0%
AL	Protection Technologies Los Alamos	70	2	1	-	-	-	-	-	73	4%	3	0.153	0.051	0%
OH	West Valley Nuclear Services, Inc.	1,131	208	20	2	1	-	-	-	1,362	17%	231	11.153	0.048	6%
RL	Fluor Daniel – Hanford	233	17	2	-	-	-	-	-	252	8%	19	0.851	0.045	0%
CH	Brookhaven National Laboratory	1,021	113	11	-	1	-	1	-	1,147	11%	126	5.470	0.043	29%
OR	Lockheed Martin/MK Ferguson Co.	2,529	354	16	14	2	1	1	-	**2,917**◄	13%	**388**◄	16.466	0.042	21%
AL	Los Alamos National Laboratory	1,004	130	11	3	1	1	-	-	1,150	13%	146	6.141	0.042	26%
RL	Duke Engineering Services Hanford	45	6	1	-	-	-	-	-	52	13%	7	0.263	0.038	0%
ID	Idaho Field Office	19	3	-	-	-	-	-	-	22	14%	3	0.103	0.034	0%
RL	Babcock Wilcox Hanford	238	6	-	-	-	-	-	-	244	2%	6	0.182	0.030	0%
RFO	Rocky Flats Office	383	65	3	-	-	-	-	-	451	15%	68	1.952	0.029	0%
CH	Chicago Field Office	98	1	-	-	-	-	-	-	99	1%	1	0.028	0.028	0%

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

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1996 (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
AL	Mason & Hanger - Amarillo	92	1	-	-	-	-	-	-	93	1%	1	0.024	0.024	0%
RL	Babcock Wilcox Protection, Inc.	12	3	-	-	-	-	-	-	15	20%	3	0.072	0.024	0%
OR	RMI Company	96	39	-	-	-	-	-	-	136	29%	40	0.857	0.021	0%
RL	Richland Field Office	1,527	53	-	-	-	-	-	-	1,580	3%	53	1.108	0.021	0%
CH	Battelle Memorial Inst. - Columbus (Old)	11	1	-	-	-	-	-	-	12	8%	1	0.020	0.020	0%
RL	Westinghouse Hanford Service Subs	40	1	-	-	-	-	-	-	41	2%	1	0.019	0.019	0%
AL	Sandia National Laboratory	440	33	-	-	-	-	-	-	473	7%	33	0.610	0.018	0%
RL	Rust Services Hanford	44	2	-	-	-	-	-	-	46	4%	2	0.036	0.018	0%
HQ	US Dept. of State - North Korea	3	2	-	-	-	-	-	-	5	40%	2	0.035	0.018	0%
AL	MK-Ferguson Subs - UMTRA	662	22	-	-	-	-	-	-	684	3%	22	0.377	0.017	0%
SR	Bechtel Construction - SR	37	7	-	-	-	-	-	-	44	16%	7	0.115	0.016	0%
ID	Chem-Nuclear Geotech	47	21	-	-	-	-	-	-	68	31%	21	0.344	0.016	0%
SR	Wackenhut Services, Inc. – SR	55	15	-	-	-	-	-	-	70	21%	15	0.243	0.016	0%
CH	Argonne National Laboratory – West	-	3	-	-	-	-	-	-	3	**100%** ◄	3	0.044	0.015	0%
AL	Allied-Signal, Inc.	91	4	-	-	-	-	-	-	95	4%	4	0.050	0.013	0%
AL	MK-Ferguson Co. - UMTRA	94	4	-	-	-	-	-	-	98	4%	4	0.050	0.013	0%
SR	Westinghouse S.R. Subcontractors	157	46	-	-	-	-	-	-	203	23%	46	0.572	0.012	0%
SR	Westinghouse Savannah River Co.	954	196	1	-	-	-	-	-	1,151	17%	197	2.391	0.012	0%
SR	Savannah River Field Office	96	25	-	-	-	-	-	-	121	21%	25	0.298	0.012	0%
OR	Jacobs Environmental Restoration Team	123	3	-	-	-	-	-	-	126	2%	3	0.034	0.011	0%
SR	Miscellaneous DOE Contractors – SR	18	10	-	-	-	-	-	-	28	36%	10	0.092	0.009	0%
SR	S.R. Army Corps of Engineers	6	1	-	-	-	-	-	-	7	14%	1	0.008	0.008	0%
RL	Fluor Daniel Northwest	140	1	-	-	-	-	-	-	141	1%	1	0.005	0.005	0%
SR	University of Georgia Ecology Lab.	13	1	-	-	-	-	-	-	14	7%	1	0.005	0.005	0%
OH	EG&G Mound Subcontractors	22	2	-	-	-	-	-	-	24	8%	2	0.008	0.004	0%
OR	Lockheed Martin Energy Systems (K-25)	6	2	-	-	-	-	-	-	8	25%	2	0.008	0.004	0%
CH	Environmental Meas. Lab.	11	1	-	-	-	-	-	-	12	8%	1	0.003	0.003	0%
OAK	Rockwell International, Rocketdyne-ETEC	85	6	-	-	-	-	-	-	91	7%	6	0.018	0.003	0%
ID	Babcock & Wilcox Idaho, Inc.	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%

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

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1996 (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
OH	Battelle Memorial Institute - Columbus	20	-	-	-	-	-	-	-	20	0%	-	-	-	0%
RL	Boeing Computer Services	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
NV	Defense Nuclear Agency-Kirtland AFB	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Duke Eng. & Services Northwest, Inc.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	DynCorp Hanford	8	-	-	-	-	-	-	-	8	0%	-	-	-	0%
NV	EG&G Las Vegas	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	EG&G Santa Barbara	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	Fluor Daniel Northwest Services	15	-	-	-	-	-	-	-	15	0%	-	-	-	0%
RL	Hanford Environmental Health Foun.	46	-	-	-	-	-	-	-	46	0%	-	-	-	0%
AL	Kansas City Area Office	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
OR	Lockheed Martin Energy Systems (Y-12)	252	-	-	-	-	-	-	-	252	0%	-	-	-	0%
RL	Lockheed Martin Hanford	16	-	-	-	-	-	-	-	16	0%	-	-	-	0%
RL	Lockheed Martin Services, Inc.	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
OH	Miamisburg Area Office	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
OH	Miamisburg Office Subs	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Nevada Field Office	39	-	-	-	-	-	-	-	39	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	19	-	-	-	-	-	-	-	19	0%	-	-	-	0%
RL	NUMATEC Hanford	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. - NTS	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. Services	22	-	-	-	-	-	-	-	22	0%	-	-	-	0%
RL	Rust Federal Services Northwest	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
SR	Service America	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
RL	SGN Eurisys Services Corp.	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
SR	Southern Bell Tel. & Tel.	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
OAK	U. of Cal./Davis, Radiobiology Lab-LEHR	60	-	-	-	-	-	-	-	60	0%	-	-	-	0%
OH	West Valley Area Office	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
	Total	**21,665**	**2,173**	**179**	**82**	**49**	**13**	**17**	**1**	**24,179**	**10%**	**2,514**	**168.074**	**0.067**	**38%**

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

Lockheed Martin/MK Ferguson (MKF), Lockheed Martin Utility Services (Paducah), and LLNL reported large numbers of monitored individuals at "Other" facility types in 1996. Lockheed Idaho Tech Co. Services had the highest collective dose and Nuclear Assurance Corp (NAC) had the highest average measurable TEDE and highest percentage above 0.5 rem. NAC, Lockheed Idaho, PNL, MKF and BNL all had individuals who received dose greater than 1.0 rem. This facility type accounted for approximately 20% of the monitored employees, which has continued to escalate over the past 3 years. Many organizations report cleanup activities under this facility type as well as subcontractor personnel monitored at multiple facility types during the year.

B-18: Internal Dose by Facility Type and Nuclide, 1994-1996

Facility Type	Nuclide*	No. of Individuals with New Intakes**			Collective CEDE (person-rem)			Average CEDE (rem)		
		1994	1995	1996	1994	1995	1996	1994	1995	1996
Accelerator	Hydrogen-3		15	13		0.272	0.191		0.018	0.015
	Other		6			0.008			0.001	
	Uranium		1	1		0.014	0.014		0.014	0.014
	Total	**11**	**22**	**14**	**1.843**	**0.294**	**0.205**	**0.168**	**0.013**	**0.015**
Fuel Fabrication	Hydrogen-3		2	2		0.008	0.009		0.004	0.005
	Thorium		25	31		0.180	0.612		0.007	0.020
	Uranium		83	34		0.504	0.438		0.006	0.013
	Total	**34**	**110**	**67**	**0.579**	**0.692**	**1.059**	**0.017**	**0.006**	**0.016**
Fuel Processing	Americium		1	126		0.059	0.299		0.059	0.002
	Hydrogen-3		83			0.261			0.003	
	Mixed		1			0.042			0.042	
	Plutonium		8	7		1.478	**11.955** ◄		0.185	1.708
	Total	**157**	**93**	**133**	**1.527**	**1.840**	**12.254**	**0.010**	**0.020**	**0.092**
Fuel/Uranium Enrichment	Other			1			0.002			0.002
	Technetium			2			0.006		0.009	0.003
	Thorium		3	112		0.027	8.628		0.009	0.077
	Uranium		43	33		0.231	0.176		0.005	0.005
	Total	**390**	**46**	**148**	**6.239**	**0.258**	**8.812**	**0.016**	**0.006**	**0.060**
Maintenance and Support	Americium		19	12		0.398	0.031		0.021	0.003
	Hydrogen-3		104	121		0.357	0.654		0.003	0.005
	Mixed and Other		2	8		0.122	0.040		0.061	0.005
	Plutonium		12	8		1.664	0.273		0.139	0.034
	Thorium		2			0.645			**0.323** ◄	
	Uranium		48	28		0.372	0.176		0.008	0.006
	Total	**167**	**187**	**177**	**4.680**	**3.558**	**1.174**	**0.028**	**0.019**	**0.007**
Other	Hydrogen-3		9	10		0.022	0.038		0.002	0.004
	Other		8	5		0.042	0.025		0.042	0.005
	Plutonium		15	5		0.243	3.334		0.302	0.667
	Uranium		40	70		3.124	1.475		0.078	0.021
	Total	**139**	**75**	**90**	**4.018**	**3.431**	**4.872**	**0.029**	**0.115**	**0.054**
Reactor	Hydrogen-3		338	**328** ◄		4.787	4.049		0.014	0.012
	Total	**384**	**338**	**328**	**7.828**	**4.787**	**4.049**	**0.020**	**0.014**	**0.012**
Research, Fusion	Hydrogen-3		48	87		0.251	0.477		0.005	0.005
	Total	**63**	**48**	**87**	**0.506**	**0.251**	**0.477**	**0.008**	**0.005**	**0.005**
Research, General	Americium			4			0.541			0.135
	Hydrogen-3		52	36		0.286	0.294		0.006	0.008
	Mixed		1			0.002			0.002	
	Other		20	14		0.868	0.201		0.043	0.014
	Plutonium		8	6		0.577	5.022		0.072	**0.837** ◄
	Uranium		41	33		0.345	0.208		0.008	0.006
	Total	**96**	**122**	**92**	**11.208**	**2.078**	**6.079**	**0.117**	**0.017**	**0.066**
Waste Processing	Hydrogen-3		38	20		0.133	0.469		0.004	0.023
	Mixed			3			0.015			0.005
	Other		10	12		0.468	1.600		0.047	0.133
	Plutonium			5			0.393			0.079
	Uranium		17	22		0.585	6.409		0.034	0.291
	Total	**24**	**65**	**62**	**0.765**	**1.186**	**8.886**	**0.032**	**0.018**	**0.143**
Weapons Fab. and Testing	Hydrogen-3		121	54		0.618	0.210		0.005	0.004
	Plutonium		17	28		0.362	2.113		0.021	0.075
	Uranium		**607** ◄	318		**6.179** ◄	3.484		0.010	0.011
	Total	**485**	**745**	**400**	**6.359**	**7.159**	**5.807**	**0.013**	**0.010**	**0.015**
Totals		**1,950**	**1,848**	**1,599**	**45.552**	**25.534**	**53.524**	**0.023**	**0.017**	**0.033**

* 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.

The nuclide with the highest collective CEDE and average CEDE is for Plutonium at Fuel Processing facilities. This is primarily due to the single CEDE dose of 11.5 rem which occurred at Savannah River. The second highest collective CEDE for a nuclide was for Thorium intakes which occurred at Portsmouth which reported under Fuel/Uranium Enrichment facilities. Trends concerning internal doses may be misleading due to the relatively small number of individuals receiving dose and the tendency for any intake to result in a significant CEDE dose.

B-19a: Distribution of TEDE by Labor Category, 1994

Total Effective Dose Equivalent (TEDE)

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

Laobr Category	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)	Average Meas. TEDE (rem)
Agriculture	63	4	2	1								70	10%	7	0.688	**0.098**
Construction	6,218	1,964	232	97	34	4	4					8,553	27%	2,335	148.978	0.064
Laborers	1,141	660	101	36	7	2	1					1,948	41%	807	55.208	0.068
Management	16,143	1,855	113	28	7							18,146	11%	2,003	80.552	0.040
Misc.	7,703	1,488	107	35	16	7	2					9,358	18%	1,655	77.546	0.047
Production	3,524	2,343	426	203	96	21	1					6,614	**47%**	3,090	284.523	0.092
Scientists	28,106	4,848	256	69	15	8	5					**33,307**	16%	**5,201**	197.716	0.038
Service	4,279	1,099	86	10	5	1						5,480	22%	1,201	51.849	0.04
Technicians	8,691	3,118	739	281	62	21	17					12,929	33%	4,238	**393.785**	0.093
Transport	1,176	426	44	7	1							1,654	29%	478	21.055	0.044
Unknown	14,077	3,706	331	167	86	35	49		1			18,45	24%	4,375	331.164	0.076
Totals	**91,121**	**21,511**	**2,437**	**934**	**329**	**99**	**79**	**0**	**1**	**0**	**0**	**116,511**	**22%**	**25,390**	**1,643.064**	**0.065**

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

B-19b: Distribution of TEDE by Labor Category, 1995

Total Effective Dose Equivalent (TEDE)

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

Labor Category	Less than	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Measurable TEDE	Collective TEDE (person-rem)	Average Measurable TEDE (rem)
Agriculture	51	7	1	1					60	15%	9	0.521	0.058
Construction	5,935	1,887	263	110	20	8	12		8,235	28%	2,300	164.232	0.071
Laborers	1,113	516	125	59	17	10	2		1,842	40%	729	76.317	0.105
Management	15,762	1,493	88	31	12	3	2		17,391	9%	1,629	74.446	0.046
Misc.	22,173	3,141	259	69	19	4	3	1	25,669	14%	3,496	169.447	0.048
Production	3,388	2,061	358	226	113	18	3		6,167	**45%** ◄	2,779	282.010	0.101
Scientists	27,343	3,173	231	81	15	3	10		**30,856** ◄	11%	3,513	153.724	0.044
Service	4,236	880	63	15	3	0	1		5,198	19%	962	37.031	0.038
Technicians	8,219	2,705	780	304	83	31	26		12,148	32%	3,929	429.095	0.109
Transport	1,172	279	18	10	6				1,485	21%	313	17.979	0.057
Unknown	14,271	3,131	357	228	86	54	98		18,225	22%	**3,954** ◄	**435.444** ◄	**0.110** ◄
Totals	**103,663**	**19,273**	**2,543**	**1,134**	**374**	**131**	**157**	**1**	**127,276**	**19%**	**23,613**	**1,840.246**	**0.078**

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

B-19c: Distribution of TEDE by Labor Category, 1996

Total Effective Dose Equivalent (TEDE)

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

Labor Category	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	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	53	7	1								61	13%	8	0.379	0.047
Construction	8,200	2,129	304	108	28	10	9				10,788	24%	2,588	176.814	0.068
Laborers	867	429	49	49	11	2	2				1,409	**38%** ◄	542	48.967	0.090
Management	15,448	1,083	94	29	6						16,660	7%	1,212	57.154	0.047
Misc.	16,801	4,503	362	86	31	19	11				21,813	23%	**5,012** ◄	259.840	0.052
Production	4,281	1,790	324	217	80	14	8			1	6,715	36%	2,434	267.423	0.110
Scientists	28,472	3,503	228	63	17	9	8				**32,300** ◄	12%	3,830	164.366	0.043
Service	4,418	501	44	18	3	1	2				4,987	11%	569	31.678	0.056
Technicians	7,945	2,364	758	315	94	25	19	1			11,521	31%	3,576	**416.612** ◄	**0.117** ◄
Transport	1,179	371	13	8	6	3					1,580	25%	401	18.760	0.047
Unknown	12,830	2,079	264	110	63	16	21	1	1		15,385	17%	2,555	209.937	0.082
Totals	**100,494**	**18,759**	**2,441**	**1,003**	**339**	**99**	**80**	**2**	**1**	**1**	**123,219**	**18%**	**22,725**	**1,651.930**	**0.073**

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

Scientists continue to be the largest number of monitored individuals by labor category while laborers and production workers have the highest percentage monitored individuals receiving measurable dose. Technicians received the highest collective TEDE and highest average measurable dose. "Unknown" and "Miscellaneous" categories contribute large numbers of workers and collective dose. These individuals tend to be subcontractors who do not provide information on occupational categories to the reporting organizations.

B-20: Internal Dose by Labor Category, 1994 - 1996

Labor Category	Number of Individuals with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
	1994	**1995**	**1996**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**
Construction	211	206	226	2.521	1.739	7.707	0.012	0.008	0.034
Laborers	67	73	41	1.334	0.517	0.900	0.020	0.007	0.022
Management	110	120	105	2.455	2.389	1.472	0.022	0.020	0.014
Misc.	184	217	219	2.527	**7.297** ◄	12.655	0.014	**0.034** ◄	**0.058** ◄
Production	**571** ◄	**549** ◄	**370** ◄	6.454	5.881	**16.286** ◄	0.011	0.011	0.044
Scientist	159	157	200	4.862	4.879	4.366	0.031	0.031	0.022
Service	109	50	46	2.186	0.329	0.282	0.020	0.007	0.006
Technicians	241	245	219	6.182	4.946	3.705	0.026	0.020	0.016
Transport	8	5	10	0.047	0.040	0.504	0.006	0.008	0.050
Unknown	289	229	163	**16.984** ◄	2.747	5.647	**0.059** ◄	0.012	0.035
Totals	**1,949**	**1,851**	**1,599**	**45.552**	**30.764**	**53.524**	**0.023**	**0.017**	**0.033**

* 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.

The two primary collective dose contributors by labor category for 1994-96 were Miscellaneous and Unknown. Production and technician workers receive the highest dose for specified labor category. In 1996, the construction category is increasing due to construction/demolition work in progress. Production was the highest collective CEDE in 1996 due to a single intake of Plutonium at SRS resulting in a dose of 11.5 rem. Trends concerning internal doses may be misleading due to the relatively small number of individuals receiving dose and the tendency for any intake to result in a significant committed dose (CEDE).

B-21: Dose Distribution by Labor Category and Occupation, 1996

Labor Category	Occupation	Less Than Meas.	Meas. <0.1	0.1-0.25	0.25-0.5	0.5-0.75	0.75-1.0	1-2	2-3	3-4	>4	Total Monitored	Percent with Meas.	No. with Meas.	Collective TEDE	Average Meas. TEDE
Agriculture	Forest Workers	1	1	-	-	-	-	-	-	-	-	2	50%	1	0.006	0.006
	Groundskeepers	51	6	1	-	-	-	-	-	-	-	58	12%	7	0.373	0.053
	Misc. Agriculture	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-
Construction	Carpenters	251	136	22	11	2	1	1	-	-	-	424	41%	173	14.377	0.083
	Electricians	1,760	430	69	23	3	1	1	-	-	-	2,287	23%	527	34.117	0.065
	Masons	28	13	-	-	-	-	-	-	-	-	41	32%	13	0.241	0.019
	Mechanics/Repairers	1,064	548	64	21	9	1	-	-	-	-	1,707	38%	643	37.112	0.058
	Miners/Drillers	71	-	1	-	-	-	-	-	-	-	72	1%	1	0.192	**0.192**
	Misc. Repair/Construction	4,255	652	86	21	9	3	-	-	-	-	5,026	15%	771	43.228	0.056
	Painters	187	53	9	7	-	-	-	-	-	-	256	27%	69	5.889	0.085
	Pipe Fitter	584	297	53	25	5	4	7	-	-	-	975	40%	391	41.658	0.107
Laborers	Handlers/Laborers/Helpers	867	429	49	49	11	2	2	-	-	-	1,409	38%	542	48.967	0.090
Management	Admin. Support and Clerical	5,908	311	29	7	2	-	-	-	-	-	6,257	6%	349	15.947	0.046
	Manager - Administrator	9,524	771	65	22	4	-	-	-	-	-	10,386	8%	862	41.190	0.048
	Sales	16	1	-	-	-	-	-	-	-	-	17	6%	1	0.017	0.017
Misc.	Military	7	-	-	-	-	-	-	-	-	-	7	0%	-	-	-
	Miscellaneous	16,794	4,503	362	86	31	19	11	-	-	-	**21,806**	23%	**5,012**	**259.840**	0.052
Production	Machine Setup/Operators	78	17	8	2	-	-	-	-	-	-	105	26%	27	2.492	0.092
	Machinists	282	48	16	2	2	1	2	-	-	-	353	20%	71	9.990	0.141
	Misc. Precision/Production	183	7	-	1	-	1	-	-	-	-	192	5%	9	1.474	0.164
	Operators, Plant/System/Util.	3,479	1,620	275	208	75	12	6	-	-	1	5,676	39%	2,197	242.849	0.111
	Sheet Metal Workers	143	64	22	2	1	-	-	-	-	-	232	38%	89	7.139	0.080
	Welders and Solderers	116	34	3	2	2	-	-	-	-	-	157	26%	41	3.479	0.085
Scientists	Doctors and Nurses	352	16	2	1	-	-	-	-	-	-	371	5%	19	1.124	0.059
	Engineer	11,128	1,603	102	34	9	6	2	-	-	-	12,884	14%	1,756	77.838	0.044
	Health Physicist	441	159	21	6	3	-	1	-	-	-	631	30%	190	12.682	0.067
	Misc. Professional	7,181	828	30	7	2	1	2	-	-	-	8,051	11%	870	28.924	0.033
	Scientist	9,370	897	73	15	3	2	3	-	-	-	10,363	10%	993	43.798	0.044
Service	Firefighters	539	30	-	-	-	-	-	-	-	-	569	5%	30	0.486	0.016
	Food Service Employees	26	3	-	-	-	-	-	-	-	-	29	10%	3	0.069	0.023
	Janitors	592	53	10	5	-	-	-	-	-	-	660	10%	68	4.537	0.067
	Misc. Service	589	66	5	2	1	-	1	-	-	-	664	11%	75	5.502	0.073
	Security Guards	2,672	349	29	11	2	1	1	-	-	-	3,065	13%	393	21.084	0.054
Technicians	Engineering Technicians	1,464	284	64	47	30	7	7	1	-	-	1,904	23%	440	71.443	0.162
	Health Technicians	893	146	42	24	10	7	4	-	-	-	1,126	21%	233	36.301	0.156
	Misc. Technicians	2,587	493	87	30	6	2	-	-	-	-	3,205	19%	618	47.226	0.076
	Radiation Monitors/Techs.	1,129	892	395	120	23	2	-	-	-	-	2,561	**56%**	1,432	152.355	0.106
	Science Technicians	816	278	111	61	18	2	-	-	-	-	1,286	37%	470	61.188	0.130
	Technicians	1,056	271	59	33	7	5	8	-	-	-	1,439	27%	383	48.099	0.126
Transport	Bus Drivers	22	3	-	-	-	-	-	-	-	-	25	12%	3	0.065	0.022
	Equipment Operators	412	98	12	6	6	2	-	-	-	-	536	23%	124	11.688	0.094
	Misc. Transport	224	213	1	2	-	1	-	-	-	-	441	49%	217	5.998	0.028
	Pilots	3	3	-	-	-	-	-	-	-	-	6	50%	3	0.037	0.012
	Truck Drivers	518	54	-	-	-	-	-	-	-	-	572	9%	54	0.972	0.018
Unknown	Unknown	12,830	2,079	264	110	63	16	21	1	1	-	15,385	17%	2,555	209.937	0.082
Totals		**100,494**	**18,759**	**2,441**	**1,003**	**339**	**99**	**80**	**2**	**1**	**1**	**123,219**	**18%**	**22,725**	**1,651.930**	**0.073**

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

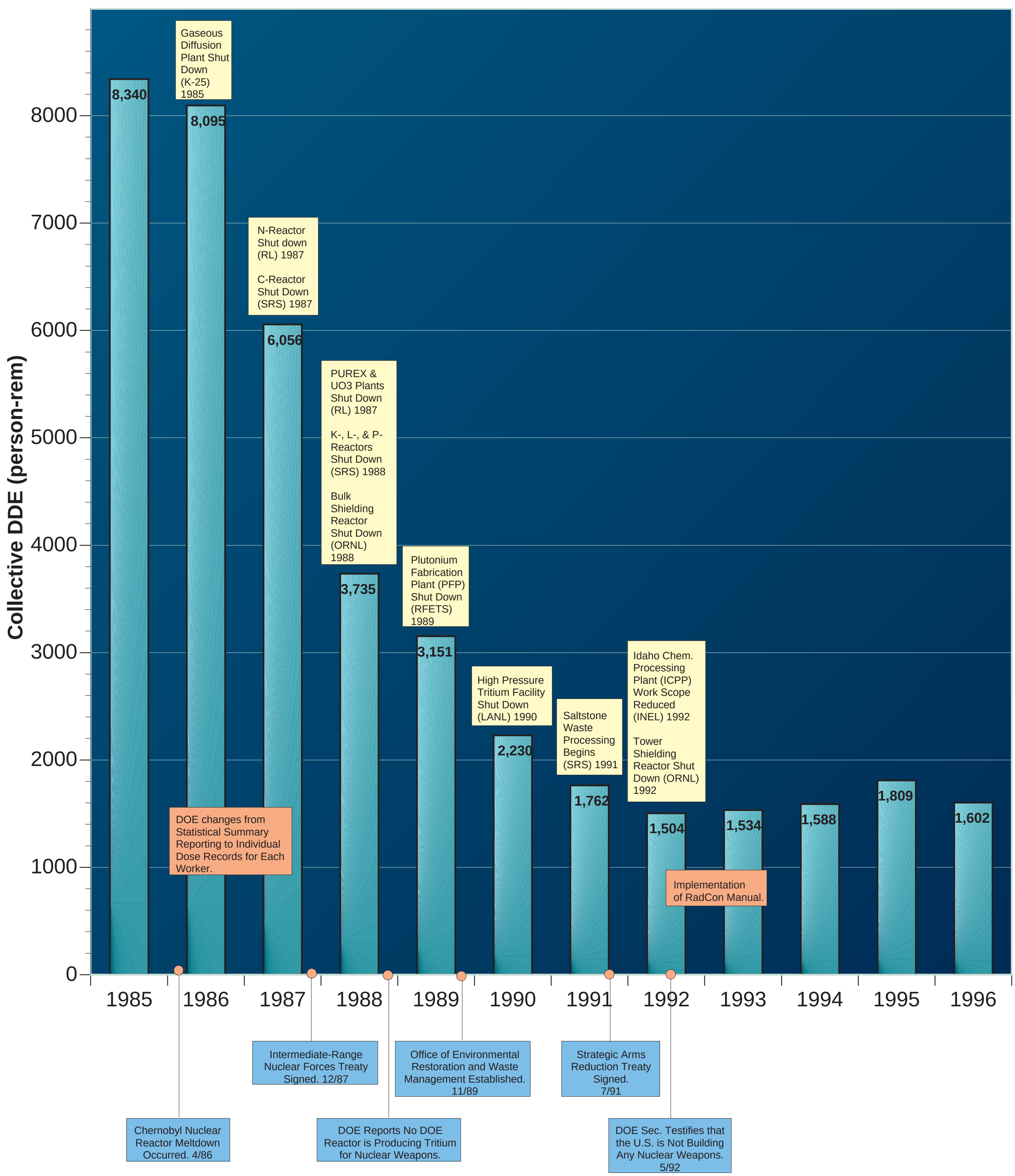
Two of the three largest collective TEDE labor categories were Miscellaneous and Unknown. The highest individual dose (11.5 rem) was received by an individual reported as an Operator at a Production facility. Overall, the production and technician labor categories had the highest average TEDE dose. Miners/drillers had the highest average measurable TEDE dose due to only one individual receiving a dose of 0.192 rem.

B-22: Internal Dose Distribution by Site and Nuclide, 1996

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. -0.020	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			
Albuquerque	Ops. and Other Facilities	Hydrogen-3	7	2									9	0.085	0.009
	Los Alamos Nat'l. Lab (LANL)	Hydrogen-3	46	3									49	0.305	0.006
		Plutonium							1		1		2	4.800	**2.400**
		Uranium	38	1									39	0.182	0.005
	Pantex Plant (PP)	Hydrogen-3	7										7	0.016	0.002
Chicago	Ops. and Other Facilities	Americium	12										12	0.031	0.003
		Hydrogen-3	66	5									71	0.403	0.006
		Other	7										7	0.035	0.005
		Plutonium	1										1	0.005	0.005
	Argonne Nat'l. Lab - East (ANL-E)	Americium	1										1	0.006	0.006
		Hydrogen-3	5										5	0.024	0.005
		Other	1										1	0.005	0.005
		Plutonium	3	2	1								6	0.266	0.044
	Brookhaven Nat'l. Lab (BNL)	Hydrogen-3	38	25	8	1							72	2.962	0.041
Idaho	Idaho Site	Plutonium	2	2	1		5						10	3.625	0.363
		Uranium	6	1									7	0.104	0.015
Oakland	Lawrence Berkeley Lab. (LBL)	Hydrogen-3		2									2	0.112	0.056
	Lawrence Livermore Nat'l. Lab. (LLNL)	Hydrogen-3	6										6	0.013	0.002
Oak Ridge	Ops. and Other Facilities	Thorium	2		3								5	0.393	0.079
		Uranium	2	6	5	4	3	1	1				22	6.409	0.291
	Oak Ridge Site	Hydrogen-3	4										4	0.026	0.007
		Other	11	4									15	0.203	0.014
		Technetium	2										2	0.006	0.003
		Uranium	306	70	2								378	4.426	0.012
	Paducah Gaseous Diff. Plant (PGDP)	Uranium	32	7	1								40	0.651	0.016
	Portsmouth Gaseous Diff. Plant (PORTS)	Thorium	58	37	10	4		2	1				112	8.628	0.077
Ohio	Fernald Environmental Mgmt. Project	Thorium	25	3	3								31	0.612	0.020
		Uranium	28	6									34	0.438	0.013
	Mound Plant	Hydrogen-3	54	1									55	0.206	0.004
		Uranium	16	1									17	0.149	0.009
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	Plutonium	16	4	2	2	1						25	1.715	0.069
		Uranium	2										2	0.021	0.011
Richland	Hanford Site	Other	8										8	0.040	0.005
		Plutonium	8	4		2							14	0.782	0.056
Savannah River	Savannah River Site (SRS)	Americium			3								3	0.535	0.178
		Hydrogen-3	504	13									**517**	2.201	0.004
		Plutonium		3	3			1				1	8	**13.104**	1.638
Totals			**1,324**	**202**	**42**	**13**	**9**	**4**	**3**		**1**	**1**	**1,599**	**53.524**	**0.033**

The highest average internal doses were at LANL as a result of two high doses from intakes of Plutonium. The highest collective doses were at SRS followed by Portsmouth Gaseous Diffusion Plant, LANL, Oak Ridge Site, and Idaho, respectively. The highest individual dose (11.5 rem) occurred at SRS resulting from an intake of Plutonium.

B-23: Correlation of Occupational Radiation Exposure with Nuclear Weapons Production



B-23: Correlation of Occupational Radiation Exposure with Nuclear Weapons Production (Continued)

Site	Facility	Total Collective DDE (person-rem)											
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Idaho Nat'l. Engineering Lab.	Fuel Processing	169	156	141	145	218	146	61	38	65	73	94	78
	Maintenance & Support	0	16	10	8	6	5	2	2	2	8	9	6
	Other	12	214	11	9	28	150	61	14	117	91	148	46
	Reactor	166	144	79	44	40	31	33	28	43	51	19	15
	Research, General	0	4	2	27	19	12	4	4	8	8	7	9
	Waste Processing/Mgmt.	0	4	5	4	5	3	1	1 [14]	2	5 [18]	7	6
	INEL TOTAL	**347**	**537**	**248**	**238**	**315**	**347**	**162**	**87**	**236**	**237**	**284**	**160**
Los Alamos National Lab.	Accelerator	0	0	0	48	72	45	23	18	21	22	24	16
	Maintenance & Support	0	0	2	92	32	16	15	22	24	40	68	56
	Other	31	22	1	46	19	12	9	2	2	5	9	9
	Reactor	0	0	0	2	1	0	0	0	0	0	0	0
	Reseach, Fusion	0	0	0	1	0	0	0	1	0	0	1	0
	Research, General	745	548	376	199	201	146	113	89	93	108	129	95
	Waste Processing/Mgmt.	0	0	0	0	0	5	1	0	1	1	3	2
	Weapons Fab. & Testing	0	0	0	3	0	0	0	0 [13]	0	0 [18]	0	0
	LANL TOTAL	**776**	**570**	**379**	**391**	**325**	**224**	**162**	**132**	**142**	**176**	**234**	**179**
Oak Ridge Site	Fuel Processing	0	0	9	3	3	0	1	0	0	0	0	0
	Fuel/Uranium Enrichment	3	2	5	5	1	1	0	1	2	1	1	1
	Other	2	0	0	1	0	0 [11]	0	0	9	8	16	16
	Research, General	116	137	149	77	43	30	42 [12]	42	45	45	41	60
	Weapons Fab. & Testing	50	181	103	75	71	31	17 [9]	29 [10]	15	12 [16]	7	7
	Oak Ridge Site TOTAL	**171**	**320**	**265**	**162**	**118**	**62**	**59**	**71**	**71**	**66**	**64**	**84**
Rocky Flats	Weapons Fab. & Testing	1,370	1,245	880	654	412	145 [7]	313 [8]	297	250	229 [16]	260	266
	Rocky Flats TOTAL	**1,370**	**1,245**	**880**	**654**	**412**	**145**	**313**	**297**	**250**	**229**	**260**	**266**
Hanford Site	Fuel Fabrication	62	94	14	3	10	1	1	1	0	0	0	0
	Fuel Processing	0	0	14	22	62	11	8	10	5	5	7	6
	Maintenance & Support	0	0	1,098	172 [2]	152	118	103	86	72	77	97	94
	Other	1,105	887	29	7 [1]	16	9	10	13	17	19	32	33
	Reactor	1,183	964	776	152	163	51	19	20	14	13	17	13
	Research, General	183	307	103	56	85	55	42	46	47	44	55	45
	Waste Processing/Mgmt.	0	0	367	239 [3]	131	86	69	64	52	56 [16]	81	74
	Hanford Site TOTAL	**2,533**	**2,251**	**2,402**	**652**	**619**	**330**	**252**	**239**	**207**	**213**	**290**	**265**
Savannah River Site	Fuel Fabrication	70	89	57	49	31	33	0	0	15	19	9	1
	Fuel Processing	405	423	267	215	209	126	117	1	90	87	60	55
	Maintenance & Support	0	0	368 [5]	376	379	372	159	265	12	16	15	15
	Other	716	787	50 [4]	52	45	48	73	27	3	3	4	4
	Reactor	144	129	50	55	37	29	17	15	12	14	12	6
	Research, General	41	57	30	25	24	17	8	9	12	13	15	20
	Waste Processing/Mgmt.	0	0	112	105	76	51	35	0	46	61	59	47
	Weapons Fab & Testing	18	13	11 [6]	10	3	6	3	0	69	97 [17]	77	88
	SRS TOTAL	**1,394**	**1,498**	**945**	**887**	**804**	**683**	**412**	**317**	**258**	**310**	**250**	**236**
Totals	**TOTAL FOR SIX SITES**	**6,592**	**6,422**	**5,119**	**2,983**	**2,593**	**1,791**	**1,360**	**1,144**	**1,163**	**1,231** [15]	**1,382**	**1,194**
	DOE OVERALL TOTAL*	**8,340**	**8,095**	**6,056**	**3,735**	**3,151**	**2,230**	**1,762**	**1,504**	**1,534**	**1,600**	**1,809**	**1,602**
	Percentages of Sites to DOE Overall	79%	79%	85%	80%	82%	80%	77%	76%	76%	77%	76%	75%

* Does not include Schenectady Naval Reactor Office or Pittsburgh Naval Reactor Office.

B-23: Correlation of Occupational Radiation Exposure with Nuclear Weapons Production (Continued)

Events	Impacts
The N-Reactor closed at the Hanford Site in January 1987, followed by the shutdown of both the PUREX and UO3 plants in 1988, and the shutdown of the PFP in 1989.	A large decrease in the collective dose at the Hanford Site for the "Reactor" ① and "Other" ② facility types occurs between 1987 and 1988. The overall decrease in collective dose at the Hanford Site from 1987 to 1988 is dramatic ③.
DOE reported in mid-1988 that no DOE reactor was producing tritium for nuclear weapons. The C-Reactor at the SRS was shut down in 1987. The L-Reactor at SRS was restarted in 1985 and shutdown again in 1988. The P-Reactor and the K-Reactor at SRS were shut down in 1988 and never restarted except for a brief K-Reactor test run in 1992. The production of nuclear weapons materials at SRS ended in 1992.	Collective dose for the "Reactor" ④ and "Other" ⑤ facility types at the SRS decreased between 1986 and 1987. The overall decrease for the SRS indicates that there is a slowdown in activity at the SRS ⑥.
Rocky Flats PFP operations were curtailed in 1989 and many other functions suspended in the subsequent years with a total halt in plutonium operations in 1991. The plant began preparations to resume activities in 1991, but a change in mission to shut down, decontaminate, and decommission occurred in 1993.	The collective dose at the Rocky Flats Site decreased by 88% from 1986 to 1990 ⑦. It increased in 1991 ⑧ as a result of the aborted resumption effort, and has slowly decreased between 1991 and 1994.
The Office of Environmental Restoration and Waste Management (EM) was established in November 1989. The K-25 Plant at Oak Ridge was shut down in 1985 and became an EM site in 1992. The bulk shielding and tower shielding reactors at ORNL were shut down in 1988 and 1992, respectively. The mission of the Y-12 Plant has been changed to the dissassembly of nuclear weapons.	The collective dose at the Oak Ridge Site decreased from 1986 to 1991 ⑨ and increased slightly in 1992 ⑩. In general, the K-25 Plant is reported as a "Fuel/Uranium Enrichment" facility type, ORNL is reported as a "Research, General" facility type, and the Y-12 Plant is reported as a "Weapons, Fab & Testing" facility type. The shutdown of the K-25 Plant occurred before 1985. The shutdown of the experimental reactors at ORNL correlates with a collective dose decrease in the "Research, General" facility type from 1987 to 1990 ⑪. The Y-12 Plant, "Weapon, Fab & Testing" facility type collective dose decreased between 1986 and 1991 ⑫. This correlates with the end of weapons assembly.
The Secretary of Energy testified before Congress in May 1992 that the United States was not building any nuclear weapons for the first time since 1945. The high pressure tritium facility at LANL was shut down in 1990 and the work scope at the Idaho Chemical Processing Plant (ICPP) (INEL) was reduced in 1992.	The basic mission at the LANL has not changed and INEL has many missions with the US Navy. The collective dose shown for these sites shows gradual decrease. LANL collective dose decreases 82% from 1985 to 1992 ⑬. INEL shows a decrease of more than 79% during this period but this decrease is not consistent from year to year ⑭.

During the reporting period 1992-1994, the DOE overall collective DDE increased by 5% ⑮. The collective DDE at the Hanford, Rocky Flats, and Oak Ridge Sites decreased ⑯ and the collective DDE at the SRS has remained about constant ⑰. The collective dose increased at INEL and LANL ⑱ as a result of increased activities at the ICPP, and increased throughput for satellite heat sources at the LANL plutonium facilities.

As can be seen from this analysis, changes in mission and operational status can have a large impact on the occupational dose at DOE.

Facility Type Code Descriptions

DOE Order 5484.1 [10] 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 policy decision of 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.

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.

The differences in accelerator types, sizes, and energies result in differences in the radiation types and dose rates associated with the accelerator facilities. In general, radiation doses to employees at the facilities are attributable to neutrons and X-rays, as well as muons at some larger facilities. Dose rates inside the primary shielding can range up to 0.2 rem/h as a result of X-ray production near some machine components. Outside the shielding, however, X-ray exposure rates are very low, and neutron dose rates are generally less than 0.005 rem/h. Average annual doses at these facilities are slightly higher than the overall average for DOE; however, the collective dose is lower than the collective dose for most other DOE facility categories because of the relatively small number of employees at accelerator facilities. 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 [15]. 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.

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

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 [15]. 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. Both the average and collective external doses at these facilities are among the lowest of any DOE facility category.

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 [15]. 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. Average external doses at fuel fabrication facilities are generally higher than at other types of DOE facilities; however, collective doses are relatively low because the number of employees is low. Internal doses from inhalation of uranium are kept very low.

Fuel Processing

The DOE administers several facilities that reprocess spent reactor fuel. These facilities separate the plutonium produced in reactors for use in defense programs. 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.

The very high radioactivity of fission products in spent nuclear fuel results in employees at fuel processing facilities consistently having among the highest average doses of any DOE facility type. However, the collective dose at these facilities is less significant because of the small total number of employees. Penetrating doses are attributable primarily to gamma photons, although some neutron exposures do occur. Skin and extremity doses from handling samples are also significant, although only a few employees typically receive skin doses greater than 5 rem/year. 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, and annual effective dose equivalents from the depositions are typically less than 0.5 rem.

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.

Because many maintenance and support activities at DOE sites do not involve work near sources of ionizing radiation, the average dose equivalent per monitored employee is typically among the lowest of any facility type. However, those employees who do perform work near radiation sources receive relatively high average annual doses, as is indicated by the relatively high average annual dose per employee who receives a measurable exposure. Also, collective doses are relatively high because there is a large number of these employees relative to the number classified under other facility types. 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.

In 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. The average and collective external doses relative to other facility types are highly dependent on the status of reactor operations. Inhalation of airborne radioactive material is a concern in some plant areas. However, protective measures, such as area ventilation or use of respiratory-protection equipment, result in low internal doses.

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. Relative to other facility types, average annual individual doses are slightly above average at general research facilities. The collective dose equivalent is higher than at most other facility types because of the many individuals employed at general research facilities.

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. Relative to other DOE facility types, average individual doses and collective doses are typically the lowest at fusion research facilities. Regarding internal exposures, airborne tritium is a concern at some fusion research facilities, although the current level of operation results in minimal doses.

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 relatively high, sometimes exceeding 1 rem/ year. Penetrating doses at waste processing facilities are attributable primarily to gamma photons; however, neutron exposures are significant at the large-scale facilities. Skin doses are generally not a significant problem. Overall, average annual doses at waste processing/ management facilities are among the highest of any DOE facility type, which is attributable primarily to the two large-scale facilities and the shift in DOE mission from national defense production to waste management and environmental restoration. The annual collective doses are closer to the average of all facility types, however, because of the relatively small number of employees at this type of facility.

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 the testing facilities, radiation doses received by personnel are generally minimal because of the strict controls over personnel access to testing areas, although extremity doses can be relatively high from handling neutron-activated materials. Radiation doses are a greater concern at facilities where weapons and weapons-grade nuclear material are handled. At these facilities, neutron radiation dose rates can be significant when processing relatively small quantities of ^{238}Pu or larger quantities of mixed plutonium isotopes [16]. Penetrating doses from gamma photons and plutonium x-rays can also be significant in some situations, as can skin and extremity doses from plutonium x-rays. Overall, average individual annual doses at these facilities are slightly higher than the DOE average. The collective doses received by employees at these facilities are generally higher than the collective doses at other facility types because of the large number of individuals employed.

Also of significant concern at these facilities is inhalation of plutonium, where inhalation of very small amounts can result in doses exceeding limits. To prevent plutonium intakes, strict controls are in place including process containment, contamination control procedures, and air monitoring and bioassay programs [16]. As a result, significant internal exposures are very rare at these facilities.

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. In general, employees classified under this facility type receive annual doses significantly less than the annual doses averaged over all DOE facilities. However, the wide variation in the type of work performed by these individuals results in a wide variation in the types and levels of exposures. Although exposures to gamma photons are predominant, some individuals may be exposed to beta particles, x-rays, neutrons, or airborne radioactive material.

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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.

Monitoring Practices

Radiation monitoring practices differ widely 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 on which workers to monitor. While all sites have achieved compliance with the DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurements, there are still differences in the dosimeters used that can contribute to differences in the collective dose from site to site. 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 inflate the number of monitored workers with no dose, it also can add a large 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 add significantly to the site collective dose. In contrast, other sites only monitor workers who exceed the monitoring requirement threshold (10% of the dose limit). This tends to reduce the number of monitored workers and reports only those workers receiving doses in the higher dose ranges. This can decrease the site's collective dose while increasing the average measurable dose.

AEDE vs CEDE

Prior to 1990, the dose resulting from penetrating ionizing radiation (external dose) and the dose resulting from the intake of radionuclides (internal dose), was reported separately. In 1993, the DOE changed the internal dose calculation methodology from annual effective dose equivalent (AEDE) to the 50-year committed effective dose equivalent (CEDE). The total effective dose equivalent (TEDE) then became the sum of the CEDE and the deep dose equivalent (DDE). This report presents TEDE data from 1992 through 1996. Internal AEDE data are reported for 1992 and internal CEDE data are reported for 1993, 1994, 1995, and 1996. Where possible, the legacy component of the AEDE data is highlighted when presenting TEDE data that are trended for the years 1990 to 1992. See Section 2.4 for a discussion of this change in requirements.

Occupation Codes

Each individual's dose record includes the occupation code for the individual while he or she 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 are 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.

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. Two such changes are noteworthy within the past several years. The Fernald Field Office began reporting independently in 1993. Prior to 1993 it reported under the Oak Ridge Field Office. In 1994, Fernald was incorporated into the newly created Ohio Field Office. The Ohio Field Office began reporting in 1994. For this reason, the

Fernald data are shown under the Ohio Field Office. The Mound Plant and West Valley Project also changed Operations Office during the past 3 years and are now shown under the Ohio Field Office. Footnotes indicate the change in Operations Offices.

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".

Updates to the Data

The data in the REMS database are subject to correction and update on a continual basis. Data for prior years are subject to correction as well as the data for the most recent year included in this report. Corrections will be reflected in subsequent annual reports. For the most up-to-date status of radiation exposure information, contact:

Ms. Nirmala Rao
REMS Project Manager
U.S. Department of Energy
Office of Worker Protection Programs and
  Hazards Management (EH-52)
Germantown, MD 20874

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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. Recently the REMS has undergone 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-tiered approach has been developed to allow researchers flexibility in accessing the REMS data.

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 and skill sets needed for each method. Descriptions of the intended research audience and experience level (for computer systems) are also provided. To obtain further information, a contact name and phone number are provided.

A brief summary of the multi-tier access to the REMS information is shown in *Exhibit E-1*.

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 is the health risk associated with worker exposure to radiation. While the health risk from occupational exposure is 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 risk 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. In the past 2 years, the program's holdings have been expanded to include data from both occupational and community health studies, such as those examining the impact of fallout from nuclear weapons testing, community dose reconstructions, data from the decades of follow-up on atomic bomb survivors, and health surveillance reports on current DOE workers.

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 dial-up connections, 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 risks of radiation exposure.

For further information concerning the CEDR system, contact:

Ms. Barbara G. Brooks
Program Manager
Office of Epidemiologic Studies, EH-62
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

E-mail: barbara.brooks@hq.doe.gov
Or access the CEDR internet web page at
http://cedr.lbl.gov

Exhibit E-1: Methods of Accessing REMS Information

REMS Information Access Method	Experience Requirements			Software Requirements[3]	Eligibility Requirements	To Get Access
	Knowledge of REMS Data	Computer Expertise				
		User	System Adminstrator-Setup			
Hardcopy Annual Report	**None.** Data explained in report.	**N/A**	**N/A**	**None.**	**None.**	Contact EH-52[1] to request that you be added to Annual Report mailing list.
Web Page	**Low.** General knowledge/interest in radiation data.	**Minimal** computer skills. Only a knowledge of how to use the Web browser, and an Internet connection.	**Medium.** Supply LAN connection to Internet or Internet Provider. Support Web browser.	Internet access. Web browser client software.	**None.**	Connect to http://rems.eh.doe.gov/
InfoMaker - Pre-defined reports	**Medium.** Need to know the data limitations of the data in REMS, and what the exposure data represent.	**Minimal.** Familiarity with Windows applications. Need to understand difference between Query and Reports.	**Medium.** Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
InfoMaker - Ad Hoc Queries	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**Medium** (to High). Some knowledge of SQL highly recommended. Should be familiar with "Report generation"-type software.	**Medium.** Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Client query tool other than InfoMaker	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**High.** Need to be skilled in SQL and connecting to the system. Need to be skilled in the use of whatever query tool is used.	**Medium.** Support for LAN connection to Internet or Internet Provider. Support user query software.	Internet access (TCP/IP). Oracle SQLNet. ODBC Drivers. Query Tool client. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Running SQL on the REMS Server	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**High.** Need to be skilled in SQL and connecting to the system.	**Medium.** Support for LAN connection to Internet or Internet Provider. Support TELNet software.	Internet access (TCP/IP). TeLNet software.	Category 2 use only. TeLNet authorization required for firewall.	Contact OIM[2] to request access.

① EH-52 contact Ms. Nirmala Rao at — Phone: (301) 903-2297, Fax: (301) 903-7773, E-mail: Nimi.Rao@hq.doe.gov
② OIM contact Mr. Pat Heinig at — Phone: (301) 903-9850, Fax: (301) 903-0118
③ See REMS User Manual for detailed software requirements.
④ Category 1 - All data in the REMS system, including Privacy Act data such as name and social security number of the monitored individual.
Category 2 - Access to non-sensitive radiation monitoring information per monitored individual. See REMS Reference Manual for details.

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Appendix F

User Survey

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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. Nirmala Rao
DOE EH-52 270/cc
19901 Germantown Road
Germantown, MD 20874

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

— —

1. Identification:

Name: ....

Title: ....

Mailing Address: ....

....

....

....

2. Distribution:

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

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

3. Was the presentation/discussion of dose distribution data for:

DOE-wide .... adequate ___ inadequate ___

Sites................................ adequate ___ inadequate ___

Facilities .... adequate ___ inadequate ___

Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

....

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....

....

4. Was the presentation/discussion of dose trends for:

DOE-wide .... adequate ___ inadequate ___
Sites................................ adequate ___ inadequate ___
Facilities .... adequate ___ inadequate ___
Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

....
....
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....

5. Was the discussion of ALARA Projects at specific sites:

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

6. Was the discussion of AEDE vs CEDE helpful?

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

7. Would additional/different breakouts of the data be helpful?

Yes ___ No ___

Comments/areas for improvement:

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....

8. Suggestions for new facility type, occupation, and/or labor codes.

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9. If/when the data become available, would person/rem-hour or person-rem/RWP be useful in this report?

Yes ___ No ___

Comments/areas for improvement:

....

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....

10. To publish this report in the second quarter and to be able to use it as a management tool, we need the data *as soon as possible* after you have processed it. Please indicate when you can provide the data.

Quarterly ___

Semi-Annually ___ *By end of January, February, March

Yearly* ___ *(please circle one)*

11. DOE is considering the addition of a code for indicating the Phase of Operation of the facility type that is currently reported with each dose record (see A-4). The Phase of Operation will allow for expanded analysis of the dose information by considering the operational phase of the facility. Please indicate whether this information is available at your site, and the years the information would cover.

Available___ Years:________to_________

Not available___

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