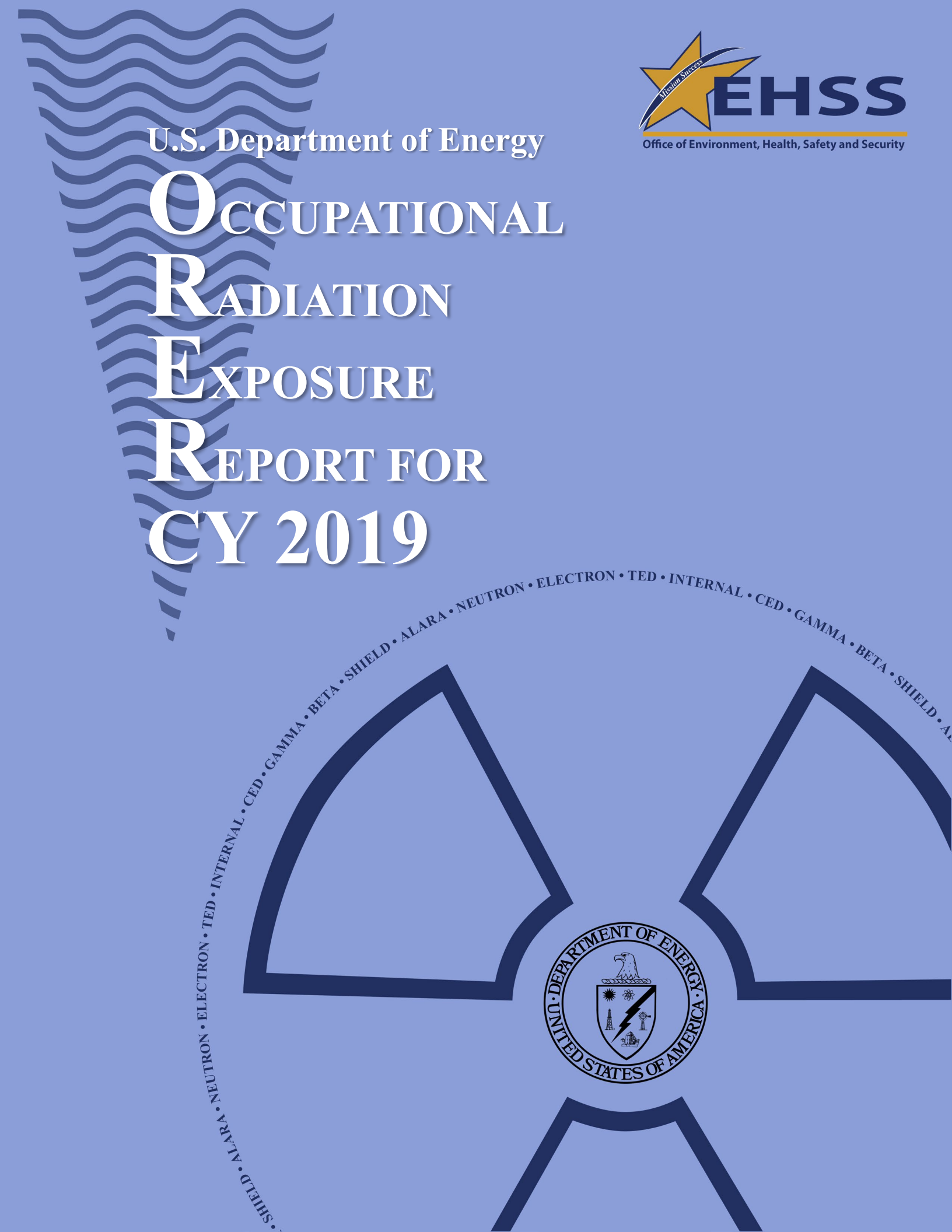
Office of Environment, Health, Safety and Security

U.S. Department of Energy

Occupational Radiation Exposure Report for CY 2019



This document is available on the U.S. Department of Energy
Radiation Exposure Monitoring System Program Web Site at:
https://energy.gov/ehss/occupational-radiation-exposure

U.S. Department of Energy

Occupational Radiation Exposure Report for Calendar Year 2019

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Prepared by:
Nimi Rao
U.S. Department of Energy
Office of Environment, Safety, and Health Reporting and Analysis (AU-23)

D.A. Hagemeyer
D.B. Holcomb
Oak Ridge Institute for Science and Education (ORISE)

Foreword

The *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2019* presents the results of analyses of occupational radiation exposures at the Department of Energy (DOE), including the National Nuclear Security Administration operations, during calendar year 2019. This report includes occupational radiation exposure data for over 75,000 DOE Federal employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation.

DOE publishes this annual report to provide DOE Management, Program Offices, workers, health physicists and other stakeholders an evaluation of DOE-wide performance regarding compliance with Title 10 of the *Code of Federal Regulations* (CFR), Part 835, *Occupational Radiation Protection* (10 CFR 835) radiation exposure limits and adherence to as low as reasonably achievable (ALARA) principles.

This report provides a discussion regarding radiation protection and exposure reporting requirements as well as information and analyses regarding aggregate, individual, site, DOE Program, transient workers, and a 45-year historical review of DOE exposure data. DOE continues to be diligent in protecting its workers and the public from exposure to radiation as proven by the results contained in this report.

As part of our continual improvement process, you, the reader, are encouraged to provide comments and suggestions regarding this report via the User Survey included at the end of this report.

MATTHEW B. MOURY
ASSOCIATE UNDER SECRETARY FOR ENVIRONMENT,
HEALTH, SAFETY AND SECURITY

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* Appendices for this annual report are located at:
https://www.energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports

LIST OF EXHIBITS

LIST OF ABBREVIATIONS AND ACRONYMS

ACL	Administrative Control Level
AEC	U.S. Atomic Energy Commission
AEDE	Annual Effective Dose Equivalent
ALARA	As Low As Reasonably Achievable
AMWTP	Advanced Mixed Waste Treatment Project
ANL	Argonne National Laboratory
ATR	Advanced Test Reactor
AU	Office of the Associate Under Secretary for Environment, Health, Safety and Security
AU-23	Office of Environment, Safety, and Health Reporting and Analysis
BNL	Brookhaven National Laboratory
CEBAF	Continuous Electron Beam Accelerator Facility
CED	Committed Effective Dose
CEDE	Committed Effective Dose Equivalent
CEqD	Committed Equivalent Dose
CEqD-SK	Committed Equivalent Dose to the Skin
CFR	Code of Federal Regulations
CY	Calendar Year
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DOE	U.S. Department of Energy
ED	Effective Dose
EqD	Equivalent Dose
EqD-ME	Equivalent Dose to the Skin of the Maximally Exposed Extremity
EqD-SKWB	Equivalent Dose to the Skin of the Whole Body
EqD-WB	Equivalent Dose to the Whole Body
EE	Office of Energy Efficiency and Renewable Energy
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
ES&H	Environment, Safety, & Health
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park
F-18	Flourine-18
Fermilab	Fermi National Accelerator Laboratory
HQ	Headquarters
ICP	Idaho Cleanup Project
ICRP	International Commission on Radiological Protection
INL	Idaho National Laboratory
KC-NSC	Kansas City National Security Campus
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LINAC	Linear Accelerator
LCLS	LINAC Coherent Light Source
LLD	Lower Limit of Detection

LLNL	Lawrence Livermore National Laboratory
LM	Office of Legacy Management
mSv	Millisievert
NE	Office of Nuclear Energy
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORP	Office of River Protection
OST	Office of Secure Transportation
PGDP	Paducah Gaseous Diffusion Plant
PNNL	Pacific Northwest National Laboratory
PORTS	Portsmouth Gaseous Diffusion Plant
PPPL	Princeton Plasma Physics Laboratory
RCT	Radiological Control Technician
rem	Roentgen equivalent man
REMS	Radiation Exposure Monitoring System
Rh-102	Rhodium-102
Rh-102m	Rhodium-102m
SC	Office of Science
SLAC	SLAC National Accelerator Laboratory
SNM	Special Nuclear Material
SNL	Sandia National Laboratories
SPRU	Separations Process Research Unit
SPEAR3	Stanford Positron-Electron Asymmetric Ring
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
Sv	Sievert
TED	Total Effective Dose
TJNAF	Thomas Jefferson National Accelerator Facility
TOD	Total Organ Dose
TRU	Transuranic
TSS	Transportation Safeguards System
U	Uranium
U-234	Uranium-234
UMTRA	Uranium Mill Tailings Remedial Action Project
USEC	United States Enrichment Corporation
WIPP	Waste Isolation Pilot Plant
WTP	Waste Treatment Plant
WVDP	West Valley Demonstration Project
Y-12	Y-12 National Security Complex

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Executive Summary

The U.S. Department of Energy (DOE) Office of Environment, Safety, and Health (ES&H) Reporting and Analysis within the Office of the Associate Under Secretary for Environment, Health, Safety and Security publishes the annual occupational radiation exposure reports to provide DOE Management, Program Offices, workers, health physicists, and other stakeholders an evaluation of DOE-wide performance regarding compliance with Title 10 of the Code of Federal Regulations (CFR) Part 835, *Occupational Radiation Protection* (10 CFR 835) radiation exposure limits and adherence to as low as reasonably achievable (ALARA) principles.

The *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2019* presents the results of analyses of occupational radiation exposures at DOE operations, including the National Nuclear Security Administration, during calendar year (CY) 2019. This report includes occupational radiation exposure information for over 75,000 DOE Federal employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation. The 97 DOE organizations that submitted radiation exposure reports in CY 2019 have been grouped into 35 sites. The information has been analyzed to provide a measure of DOE's performance in protecting workers and individuals who have entered controlled areas.

Individuals who may be exposed to radiation at a DOE facility are required to be monitored in accordance with 10 CFR 835 Subpart E. The exposure monitoring data are used to determine the radiation dose received by the individual, which is reported to DOE in accordance with DOE Order 231.1B, *Environment, Safety and Health Reporting*. Unless otherwise specified, the term "dose" used in this report refers to the total effective dose (TED) and is measured in units of "rem" (Roentgen equivalent man). The sievert (Sv) is the international unit of effective dose where one Sv is equal to 100 rem and one rem is therefore equal to 10 millisieverts (mSv). The TED is the summation of the effective dose from sources of radiation that are external and internal to the body. The committed effective dose (CED) is the dose resulting from radioactive material taken into the body and is commonly referred to as internal dose. The term "collective dose" is the sum of the individual doses received by a group of individuals and is shown in units of "person-rem."

Analysis of the collected radiation dose data for CY 2019 indicates that DOE operations were in compliance with radiation protection requirements as no doses were reported to have exceeded the DOE occupational dose limit of 5 rem (50 mSv) or the DOE Administrative Control Level (ACL) of 2 rem (20 mSv). Only 18 percent of the monitored workers received a measurable dose, and the average measurable dose received was only 1 percent of the annual DOE TED limit of 5 rem (50 mSv).

Notable changes in radiation exposure data from CY 2018 to CY 2019 were:

- the collective TED for DOE decreased by less than 1 percent or 1.1 person-rem (110 person-mSv);
- the collective CED decreased by 15 percent to 50.5 person-rem (505 person-mSv);
- the sites* contributing 86 percent of the collective TED were (in descending order): Los Alamos National Laboratory (LANL), Savannah River, Oak Ridge, Idaho, and Hanford. The collective TED increased at Savannah River, LANL and Hanford. The collective TED decreased at Oak Ridge and Idaho;

* For the purposes of this report, "Savannah River" includes the Savannah River Site and the Savannah River National Laboratory. "Oak Ridge" includes the East Tennessee Technology Park, the Oak Ridge Institute for Science and Education, the Oak Ridge National Laboratory, and the Y-12 National Security Complex. "Idaho" includes the Idaho National Laboratory, the Idaho Cleanup Project, and the Advanced Mixed Waste Treatment Project. "Hanford" includes the Hanford Site, the Office of River Protection, and the Pacific Northwest National Laboratory.

- the number of individuals that received a measurable dose increased by 487 individuals or 4 percent; and

- the collective TED for transient workers (individuals monitored at more than one DOE site) increased by 17 percent to 22.2 person-rem (222 person-mSv).

Over the past 5 years, only one monitored individual received a dose above the 2 rem (20 mSv) TED ACL. The event leading to the dose occurred on August 18, 2018, however, the final dose information was not received in time to be included in the 2018 annual report. The data for 2018 has been updated in this year's report and the event is discussed in more detail in section 3.3.1. While the total organ dose (TOD) from this accident exceeded the TOD limit and the TED received was in excess of the ACL, 3.6 rem (36 mSv), it was below the DOE annual limit of 5 rem (50 mSv) TED.

The occupational radiation exposure records show that in CY 2019, DOE facilities continued to comply with DOE dose limits and ACLs, and worked to minimize exposure to individuals. Also the collective dose at DOE facilities has decreased by 91 percent since CY 1986. This coincides with the end of the Cold War era, which largely shifted the DOE mission from weapons production to stabilization, waste management, and environmental remediation activities, along with the consolidation and remediation of facilities across the complex to meet the new mission. Also, in alignment with the change in mission, regulations and requirements have been modified (see Section 2) that reinforce DOE's focus on ALARA practices and risk reduction to lowering occupational radiation dose.

This report and other information regarding DOE occupational radiation exposure may be accessed at:

https://energy.gov/ehss/occupational-radiation-exposure

1 Introduction

The *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2019* presents the results of analyses of occupational radiation exposures at Department of Energy (DOE), including the National Nuclear Security Administration (NNSA), operations during calendar year (CY) 2019. This report includes occupational radiation exposure information for DOE Federal employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation. The 97 DOE organizations that submitted radiation exposure reports for CY 2019 have been grouped into 35 sites.* The information has been analyzed and trended to provide a measure of DOE's performance in protecting its workers from radiation.

This report is published by the DOE Office of Environment, Safety, and Health (ES&H) Reporting and Analysis (AU-23) within the Office of the Associate Under Secretary for Environment, Health, Safety and Security (AU). The purpose of this report is to provide DOE Management, Program Offices, workers, health physicists and other stakeholders an evaluation of DOE-wide performance regarding compliance with Title 10 of the *Code of Federal Regulations* (CFR) Part 835, *Occupational Radiation Protection* (10 CFR 835) radiation exposure limits and adherence to as low as reasonably achievable (ALARA) principles.

Individuals who may be exposed to radiation at a DOE facility are required to be monitored in accordance with 10 CFR 835 Subpart E. The exposure monitoring data are used to determine the radiation dose received by the individual, which is reported to DOE in accordance with DOE Order (O) 231.1B, *Environment, Safety and Health Reporting*. Unless otherwise specified, the term "dose" used in this report refers to the total effective dose (TED) and is measured in units of "rem" (Roentgen equivalent man). The TED is the summation of the effective dose from sources of radiation that are external and internal to the body. The committed effective dose (CED) is the dose resulting from radioactive material taken into the body and is commonly referred to as internal dose. The term "collective dose" is the sum of the individual doses received by a group of individuals and is shown in units of "person-rem."

1.1 Report Organization

This report is organized into five sections. Section 1 describes the content and organization of this report. Section 2 discusses radiation protection, radiation dose limits, and reporting requirements. Section 3 presents the CY 2019 occupational dose data along with trends over the past 5 years and includes information and analyses regarding aggregate, individual, site, DOE Program, and transient worker exposure data; a historical review; and a DOE occurrence report review. Section 4 provides instructions to submit successful ALARA projects, and Section 5 discusses conclusions. A user survey form is included at the end of this report and users are encouraged to provide feedback.

1.2 Report Availability

This report, the appendices, and all other associated information are available on the DOE Radiation Exposure Monitoring System (REMS) web site at:

https://www.energy.gov/ehss/corporate-reporting-analysis/databases/occupational-radiation-exposure

* For the purposes of this report, "Savannah River" includes the Savannah River Site and the Savannah River National Laboratory. "Oak Ridge" includes the East Tennessee Technology Park, the Oak Ridge Institute for Science and Education, the Oak Ridge National Laboratory, and the Y-12 National Security Complex. "Idaho" includes the Idaho National Laboratory, the Idaho Cleanup Project, and the Advanced Mixed Waste Treatment Project. "Hanford" includes the Hanford Site, the Office of River Protection, and the Pacific Northwest National Laboratory.

The REMS web site contains additional information on occupational radiation exposure, such as:

- Annual occupational radiation exposure reports and associated Appendices in pdf since CY 1974;
- Guidance on reporting radiation exposure information to the DOE REMS;
- Updated REMS-Online Query Tool;
- Guidance on how to request a dose history for an individual;
- Statistical data since CY 1987 for analysis;
- Applicable DOE orders and manuals for the recordkeeping and reporting of occupational radiation exposure at DOE;
- Occupational Exposure Dashboard—interactive data explorer;
- Ten Year Summary—graphical comprehensive overview of past 10 years of radiation exposure data; and
- ALARA activities at DOE.

Requests for access to the data files, or for individual dose records used to compile this report, as well as suggestions and comments, should be directed to:

Ms. Nirmala Rao
DOE REMS Program Manager
Office of ES&H Reporting and Analysis (AU-23)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-1290
E-mail: nimi.rao@hq.doe.gov

Standards and Requirements

It is DOE's mission is to provide a safe and healthy workplace for all DOE Federal employees, contractors, and subcontractors, as well as members of the public that visit DOE facilities. To meet this mission, AU establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The DOE standards for occupational radiation protection include radiation exposure limits to workers. In addition, DOE is required to maintain radiation exposures as far below the limits as is reasonable through application of the ALARA process which incorporates pre-job planning, engineering controls, and worker training.

This section identifies the radiation protection standards and requirements applicable to DOE operations in CY 2019.

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 CY 1987 [1]. The guidance, initially implemented by DOE in CY 1989, was based on the CY 1977 recommendations of the International Commission on Radiological Protection (ICRP) Publication 26 [2] and the CY 1987 recommendations of the National Council on Radiation Protection and Measurements Publication 91 [3]. EPA recommends that internal dose be added to the external whole-body dose to determine the TED equivalent. The laws and requirements for occupational radiation protection pertaining to the information collected and presented in this report are summarized in *Exhibit 2-1*.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835, Sections 202, 206, 207, and 208 [4] and are summarized in *Exhibit 2-2*.

2.3 Reporting Requirements

DOE O 231.1B, Environment, Safety and Health Reporting [5] contains the requirements for reporting annual individual radiation exposure records to the REMS repository. Exposure records for the monitoring year are required to be reported by March 31 of the following calendar year. Specific instructions for preparing occupational exposure data for submittal to the REMS repository are contained in the REMS Reporting Guide [6] available online at:

https://www.energy.gov/ehss/downloads/radiation-exposure-monitoring-systems-data-reporting-guide

Exhibit 2-1:
Regulations and Requirements Pertaining to the Collection and Reporting of Radiation Exposures.

Title	Date	Description
10 CFR 835, Occupational Radiation Protection [4]	Issued 12/14/93 Amended 11/4/98 Amended 6/8/07 Amended 4/13/11 Amended 8/11/17	Establishes radiation protection standards, exposure limits, and program requirements for protecting individuals from ionizing radiation that results from the conduct of DOE activities.
DOE O 231.1B, Environment, Safety and Health Reporting [5]	Approved 6/27/11 Amended 11/28/12	Requires the annual reporting of occupational radiation exposure records to the DOE REMS repository.
REMS Reporting Guide [6]	Issued 2/23/12	Specifies the current format and content of the reports required by DOE O 231.1B.

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

Personnel Category	Section of 10 CFR 835	Type of Exposure	Acronym	Annual Limit
General employees	835.202	Total effective dose. The sum of the effective dose (for external exposures) and the committed effective dose.	TED	5 rem
		The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye.	EqD-WB + CEqD (TOD)	50 rem
		Equivalent dose to the lens of the eye	EqD-Eye	15 rem
		The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity	EqD-SkWB + CEqD-SK and EqD-ME + CEqD-SK	50 rem
Declared pregnant workers*	835.206	The equivalent dose to the embryo/fetus from the period of conception to birth as a result of occupational exposure of a declared pregnant worker.	EqD-Fetus	0.500 rem from the period of conception to birth
Minors	835.207	Total effective dose	TED	0.100 rem
Members of the public in a controlled area	835.208	Total effective dose	TED	0.100 rem

* Limit applies to the embryo/fetus.

2.4 Amendments to 10 CFR 835

In August 2006, DOE published a proposed amendment to 10 CFR 835 in the *Federal Register*, and in June 2007, the amended rule was published. The amendment:

- Specified new dosimetric terminology and quantities based on ICRP 60/68 in place of ICRP 26/30;
- Specified ICRP 60 *tissue weighting factors* in place of ICRP 26 *weighting factors*;
- Specified ICRP 60 *radiation weighting factors* in place of ICRP 26 *quality factors*;
- Amended other parts of the regulation that changed as a result of adopting ICRP 60 dosimetry system;
- Used the ICRP 68 dose conversion factors to determine values for the derived air concentrations; and
- Adopted other changes intended to enhance radiation protection.

The amended rule became effective on July 9, 2007, and was required to be fully implemented by DOE sites by July 9, 2010. All terminology used in this annual report reflects that of the amendment. In addition, 10 CFR 835 was revised in April 2011 when Appendix C (Derived Air Concentration [DAC] for Workers) was updated. On August 11, 2017, Appendices C and E were amended. The amendment to Appendix C corrected the air immersion DAC for any single radionuclide not listed in the Appendix C table with a decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than two hours, adjusted for an 8-hr work day. The amendment to Appendix E corrected the activity information of two radioisotopes of rhodium (Rh-102 and Rh-102m).

Occupational Radiation Dose at DOE

3.1 Analysis of the Data

The following key indicators are analyzed to identify and correlate parameters that impact occupational radiation doses at DOE:

- number of records for monitored individuals;
- individuals with measurable dose;
- collective dose;
- average measurable dose; and
- dose distribution.

The analysis of key indicators for individual dose data includes:

- doses exceeding the 5 rem (50 millisievert [mSv]) DOE regulatory limit; and
- doses exceeding the 2 rem (20 mSv) DOE administrative control level (ACL).

Additional information is provided in this report concerning activities at sites contributing to the majority of the collective dose. The data for prior years contained in this report are subject to change because sites may submit corrections for previous years. Corrected or updated records received after the annual March 31 deadline are included in the following year's annual report. In this report, the 2018 data has been updated to reflect a glove box incident in which one monitored individual received a dose of 3.6 rem (36 mSv) TED.

3.2 Analysis of Aggregate Data

3.2.1 Number of Monitored Individuals

The data in the REMS repository are reported by each facility in the form of a record for a monitoring period for each individual. An individual may have been monitored more than once at the same facility (e.g., multiple short-term assignments) or may have been monitored at more than one facility during the year. This can result in more than one record for an individual during the year in the REMS repository. However, the impact of multiple records per person on the annual trends and aggregate analysis of the data in this report is not significant as it occurs consistently from year to year. An analysis of the number of individuals who are monitored at more than one location during the year is provided in Section 3.5 which supports this assertion. The term "number of monitored individuals" will be used herein with the understanding that it is determined by the count of records for monitored individuals.

3.2.2 Number of Individuals with Measurable Dose

DOE uses the number of individuals with measurable dose to represent the exposed workforce size. In this context, "with measurable dose" means that a detectable value was reported for the individual.

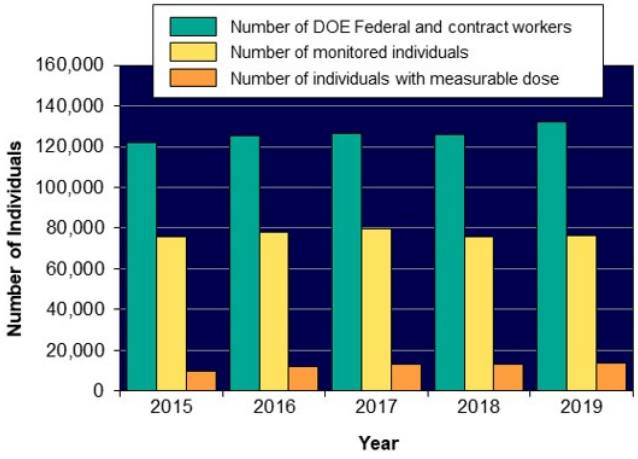
Over the past 5-year period, measurable doses to all monitored individuals were well below the annual DOE regulatory limit of 5 rem (50 mSv) TED; however, one monitored individual received a single dose of 3.6 rem (36 mSv) in 2018, exceeding the 2 rem (20 mSv) DOE ACL.

Exhibit 3-1a and *Exhibit 3-1b* show the number of DOE Federal and contract workers, the total number of individuals monitored for radiation dose, the number of individuals with a measurable dose, and the relative percentages of individuals with measurable dose for the past 5 years. The number of DOE Federal and contract workers was calculated by dividing the total hours worked per year by the average number of work hours per year. It is therefore, not a true count of individuals, but is a representation of the total size of the DOE workforce as full-time equivalents (FTE) and is included here in order to compare it to the number of workers who are monitored.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with a measurable dose and is measured in units of person-rem and person-mSv. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

Exhibit 3-1a:
Monitoring of the DOE Workforce, CY 2015 – 2019.



For CY 2019, 58 percent of the DOE workforce was monitored for radiation dose, and 18 percent of monitored individuals received a measurable dose.

Exhibit 3-1b:
Monitoring of the DOE Workforce, CY 2015 – 2019.

Year	DOE Federal & Contractor Workforce*	Number of Monitored Individuals	Percent of Monitored Individuals**	Number of Individuals with Measurable Dose	Percent of Individuals with Measurable Dose**
2015	122,141	75,593	62% ▲	10,033	13% ▲
2016	125,324	77,848	62%	11,983	15% ▲
2017	126,268	79,906	63% ▲	13,019	16% ▲
2018	125,969	75,633	60% ▼	13,335	18% ▲
2019	132,147	76,120	58% ▼	13,822	18%
5-Year Average	**126,370**	**77,020**	**61%**	**12,438**	**16%**

* The number of DOE and contractor workers was determined from the total annual work hours at DOE [7] converted to full-time equivalents.
** Up arrows indicate an increase from the previous year's value. Down arrows indicate a decrease from the previous year's value.

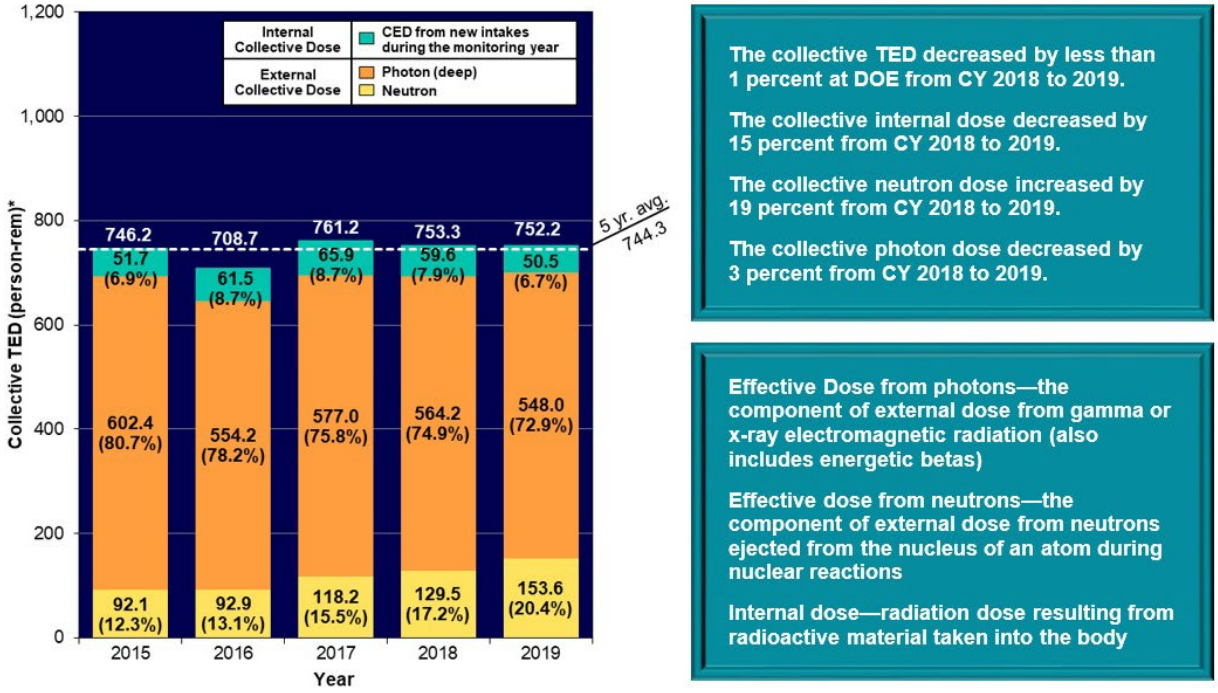
In this report, the term "collective dose" is also applied to various types of radiation dose, such as external or internal, and will be specified in conjunction with the term "collective" to clarify the intended meaning.

As shown in *Exhibit 3-2*, the collective TED decreased at DOE by less than 1 percent from 753.3 person-rem (7,533 person-mSv) in CY 2018 to 752.2 person-rem (7,522 person-mSv) in CY 2019.

The internal dose is based on the 50-year CED methodology. Under this methodology, the cumulative dose received from the intake of radioactive material over the next 50 years is assigned to the individual as a one-time dose in the year of intake. In other words, the CED is the effective dose from radionuclides taken into the body during the reporting year integrated over the next 50 years.

The internal dose component of the collective TED decreased by 15 percent from 59.6 person-rem (596 person-mSv) in CY 2018 to 50.5 person-rem (505 person-mSv) in CY 2019, due to decreases in internal doses across the DOE complex. The collective photon dose decreased by 3 percent from 564.2 person-rem (5,642 person-mSv) in CY 2018 to 548.0 person-rem (5,480 person-mSv) in CY 2019.

Exhibit 3-2:
Components of TED, CY 2015 – 2019.



* The percentages in parentheses represent the percentage of each dose component to the collective TED.

The neutron component of the collective TED increased by 19 percent from 129.5 person-rem (1,295 person-mSv) in CY 2018 to 153.6 person-rem (1,536 person-mSv) in CY 2019. The increase resulted primarily from increases in collective neutron dose at Los Alamos National Laboratory (LANL) (12 percent).

Five DOE sites contributed 86 percent of the collective TED in CY 2019. In descending order of collective TED, these were: LANL, Savannah River, Oak Ridge, Idaho, and Hanford. LANL, Savannah River and Hanford had increases in collective TED in CY 2019 while Idaho and Oak Ridge reported decreases in collective TED. (See section 3.4.3.)

3.2.4 Average Measurable Dose

The average measurable dose to DOE workers, a key radiation dose indicator, is calculated by dividing the TED by the number of individuals with measurable dose. This is the average most commonly used when examining trends and comparing doses received by workers, because it excludes those individuals receiving a less than measurable dose.

Exhibit 3-3 illustrates that the average measurable TED decreased by 4 percent from 0.056 rem (0.560 mSv) in CY 2018 to 0.054 rem (0.540 mSv) in CY 2019. For the fourth year in a row, the average measurable TED has remained below the 5 year average of 0.060 rem (0.600 mSv). While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not depict the distribution of doses among the worker population.

3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the TED distribution among the worker population. *Exhibit 3-4* shows the number of individuals in each of 11 different dose ranges. The number of individuals receiving doses above 0.100 rem (1 mSv) is included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c) [4].

Exhibit 3-3:
Average Measurable TED, CY 2015 – 2019.

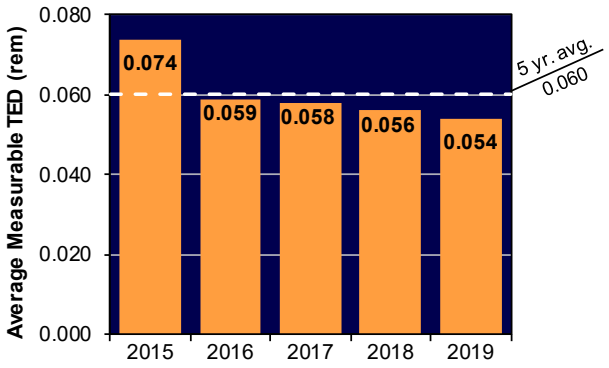


Exhibit 3-4 also shows that the dose (TED) distribution for CY 2019 was lower in the 1.0-2.0 rem range compared with the data for the previous 4 years. Ninety-nine percent of all individuals monitored had doses less than 0.250 rem (2.5 mSv).

Exhibit 3-5 presents the dose distribution of those individuals with measurable doses, in terms of the percentage of individuals with measurable TED in each range. The doses received by the eighty-six percent of monitored individuals who received a measurable dose, were below the required monitoring threshold of 0.100 rem (1 mSv) specified in 10 CFR 835.402 (a) and (c).

These results reflect DOE's conservative practice of monitoring more individuals than are required in order to ensure adequate protection of the worker and that ALARA principles are being effectively implemented at reducing radiation exposure.

3.3 Analysis of Individual Dose Data

The previous section's analysis is based on aggregate data for DOE. From both individual worker and regulatory perspectives, it is important to examine the doses received by individuals in the elevated dose ranges to understand the circumstances that led to these exposures in order to reduce or eliminate these type of exposures in the future.

3.3.1 Doses in Excess of the Regulatory Limit

No individual was reported to have exceeded the TED regulatory limit (5 rem [50 mSv]) from CY 2015 through 2019.

Eighty-six percent of monitored individuals who received a measurable dose, received doses below the required monitoring threshold of 0.100 rem (1 mSv) specified in 10 CFR 835.402 (a) and (c).

Exhibit 3-4:
Distribution of TED by Dose Range, CY 2015 – 2019.

	TED Range (rem)*	2015	2016	2017	2018	2019
Number of Individuals in Each Dose Range	Less than measurable	65,560	65,865	66,887	62,298	62,298
	Measurable to 0.100	8,028	10,138	11,006	11,418	11,945
	0.100 – 0.250	1,343	1,246	1,396	1,336	1,310
	0.250 – 0.500	449	451	480	429	423
	0.500 – 0.750	123	90	103	97	91
	0.750 – 1.000	49	38	13	39	42
	1.0 – 2.0	41	20	21	15	11
	2.0 – 3.0	0	0	0	0	0
	3.0 – 4.0	0	0	0	1	0
	4.0 – 5.0					
	>5.0					
Total number of records for monitored individuals		75,593	77,848	79,906	75,633	76,120
Number with measurable dose		10,033	11,983	13,019	13,335	13,822
Number with dose >0.100 rem		2,005	1,845	2,013	1,917	1,877
Collective TED (person-rem)		746.239	708.656	761.209	753.322	752.184
Average measurable TED (rem)		0.074	0.059	0.058	0.056	0.054

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

Exhibit 3-5:
Percentage of Individuals with Measurable TED by Dose Range, CY 2015 – 2019.

	TED Range (rem)*	2015	2016	2017	2018	2019
Percentage of Individuals with Measurable TED	Measurable <0.100	80.02%	84.60%	84.54%	85.62%	86.42%
	0.100 – 0.250	13.39%	10.40%	10.72%	10.02%	9.48%
	0.250 – 0.500	4.48%	3.76%	3.69%	3.22%	3.06%
	0.500 – 0.750	1.23%	0.75%	0.79%	0.73%	0.66%
	0.750 – 1.000	0.49%	0.32%	0.10%	0.29%	0.30%
	1.0 – 2.0	0.41%	0.17%	0.16%	0.11%	0.08%
	2.0 – 3.0	0.00%	0.00%	0.00%	0.00%	0.00%
	>3.0	0.00%	0.00%	0.00%	0.01%	0.00%
% of monitored individuals with measurable dose		13%	15%	16%	18%	18%
% of monitored individuals with dose > 0.100 rem		3%	2%	3%	3%	2%

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

In CY 2018, one individual was reported to have exceeded the 10 CFR 835.202 total organ dose (TOD) limit of 50 rem. A plutonium-238 intake occurred in August 2018 at the Technical Area (TA) Plutonium Facility located at LANL. The intake occurred when a worker's glovebox glove was punctured by a frayed wire cable. Final bioassay results reported a TOD to the bone surfaces of 118.5 rem and a CED of 3.6 rem. Details of the incident are available in the occurrence report NA--LASO-LANL-TA55-2018-0013.

3.3.2 Doses in Excess of the DOE Administrative Control Level

DOE Standard (STD)-1098-2017, *Radiological Control* [8] establishes a 2 rem (20 mSv) ACL for TED per year per person for all DOE activities. The Standard states that each DOE site should establish an annual facility ACL based on historical and projected exposures and that no individual should be allowed to exceed this value without prior facility management approval.

No individual was reported to have exceeded the TED ACL (2 rem [20 mSv]) in 2019.

However, a corrected dose record for CY 2018 was submitted and one individual was reported to have exceeded 2 rem (20 mSv) TED as discussed in the previous section. The tables and charts in this report have been updated to reflect this corrected record for 2018.

3.3.3 Intakes of Radioactive Material

DOE tracks the number of radionuclide intakes as a performance measure in this report. DOE emphasizes the importance of implementing measures to avoid intakes and maintain doses as low as reasonable through the ALARA principle. Intakes involving certain radionuclides can take significant time to analyze and determine final dose. This can result in changes to prior year dose totals if the updates are received after the March 31 annual reporting deadline. This in fact, occurred for the 2018 internal dose record as identified in the previous section.

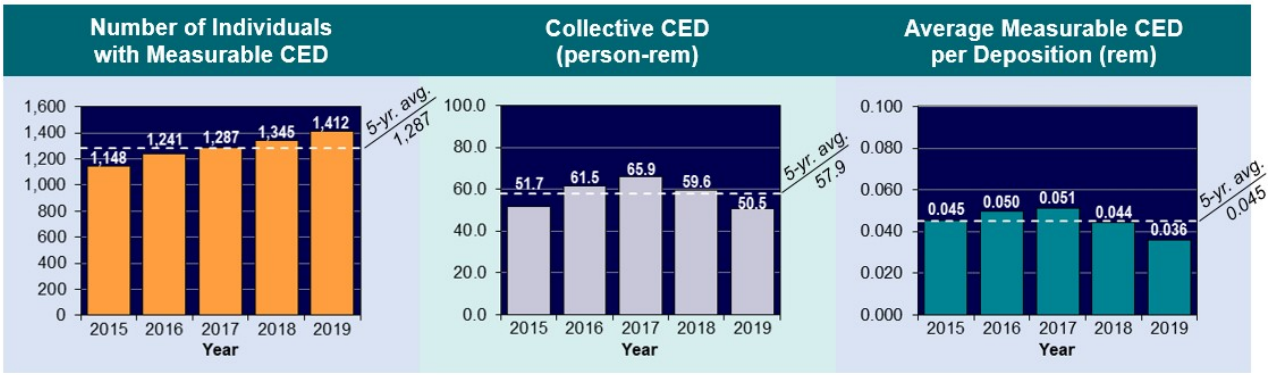
Exhibit 3-6 shows the number of individuals with measurable CED, collective CED, and average measurable CED for CY 2015 through 2019. The number of individuals with measurable CED increased by 5 percent from 1,345 in CY 2018 to 1,412 in CY 2019, while the collective CED decreased by 15 percent. The average measurable CED decreased from 0.044 rem (0.440 mSv) in CY 2018 to 0.036 rem (0.360 mSv) in CY 2019 and was below the 5-year average measurable CED.

Ninety-five percent of the collective CED in CY 2019 was from uranium intakes at Y-12 during the operation and management of Enriched Uranium Operations facilities at the site. Compared with external doses, few individuals at DOE receive measurable internal doses. Larger fluctuations may occur from year to year in the number of workers and the collective CED compared to other components of TED.

Exhibit 3-7 shows the distribution of the CED from CY 2015 through 2019. The total number of individuals with measurable CED in each dose range is the sum of the number of individuals receiving a CED in the dose range. Individuals may have had more than one intake of radioactive material, but the site would report one CED value from these intakes. Doses below 0.020 rem (0.200 mSv) are shown as a separate dose range, to show the large number of individuals in this low dose range.

The internal dose records indicate that the majority of the intakes resulted in very low doses.

Exhibit 3-6:
Number of Individuals with Measurable CED, Collective CED, and Average Measurable CED, CY 2015 – 2019.



Note: The number of internal depositions represents the number of internal dose records with positive results reported for each individual.

Exhibit 3-7:
Internal Dose Distribution from Intakes, CY 2015 – 2019.

Year	Number of Individuals with CED in the Ranges (rem)*											Total No. of Indiv.	Total Collective CED (person-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	4.0–5.0	>5.0		
2015	540	467	117	23	1	0	0	0	0	0	0	1,148	51.714
2016	546	522	135	36	2							1,241	61.544
2017	554	544	148	38	3	0	0	0	0	0	0	1,287	65.923
2018	629	559	141	14	1				1			1,345	59.556
2019	682	613	115	2		0	0	0	0	0	0	1,412	50.541

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

In CY 2019, 48 percent of the internal dose records were for doses below 0.020 rem (0.200 mSv). Over the 5-year period, internal doses accounted for 8 percent of the collective TED; although only 12 percent of the individuals who received internal doses had estimated doses above the monitoring threshold (0.100 rem [1 mSv]) specified in 10 CFR 835.402(c) [4]. It is noted that the CED is a dose received over a 50-year period after the intake that is all credited to the worker in the year of intake so the actual annual dose is lower.

3.3.4 Bioassay and Intake Summary Information

Exhibit 3-8 shows the breakdown of bioassay measurements by measurement type and number of measurements. For the monitoring year CY 2019, bioassay and intake summary information were required to be reported under the REMS Reporting Guide [6].

During the past 5 years, "Urinalysis" has been reported as the most common method of bioassay measurement used to determine internal doses to the individuals. Argonne had the largest percentage increase (68.6 percent) in the number of "Urinalysis" measurements in CY 2019. Sixty-six percent of the "Urinalysis" measurements in CY 2019 were performed at four sites: Y-12, SRS, Hanford Site, and Lawrence Livermore National Laboratory (LLNL).

The measurements reported as "In Vivo" include direct measurements of the radioactive material in the body of the monitored person. Examples of "In Vivo" measurements include whole body counts and lung or thyroid counts. Three sites—Hanford, SRS, and Oak Ridge—accounted for 81 percent of the "In Vivo" measurements.

The value shown for "Fecal" is the number of fecal bioassay measurements taken. Y-12 accounted for 92% of the measurements in CY 2019.

Exhibit 3-9 shows the reported "Air Sampling" measurements which are used to calculate the amount of airborne radioactive material taken into the body and the resultant internal dose. The numbers shown are based on the number of measurements taken and not the number of individuals monitored. Individuals may have measurements taken more than once during the year.

Exhibit 3-8:
Bioassay Measurements, CY 2015 – 2019.

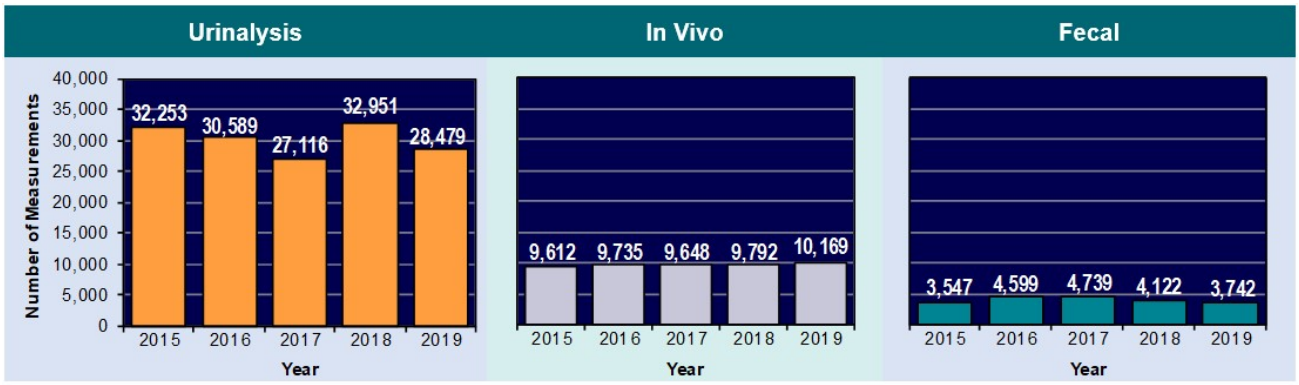


Exhibit 3-9:
Air Sampling Measurements, CY 2015 – 2019.

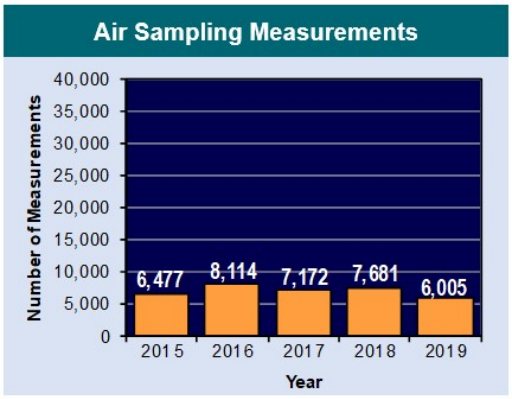
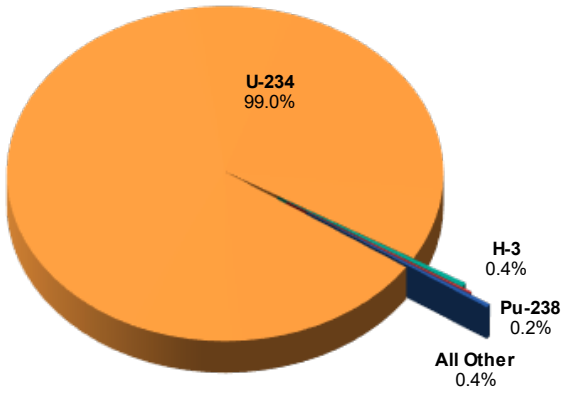


Exhibit 3-10:
Collective CED by Radionuclide from Internal Exposure, CY 2019.



The majority of the measurements reported as "Air Sampling" accounted for 17 percent of the total measurements. SRS had the largest percentage increase in the number of "Air Sampling" measurements, increasing from 5,628 air sample measurements in CY 2018, to 5,908 air sample measurements in CY 2019 (see *Exhibit 3-14* for additional information).

Y-12 performed the largest number of bioassay and air sampling measurements combined, comprising 38 percent of the total measurements taken.

Exhibit 3-10 shows the breakdown of the collective CED by radionuclide for CY 2019. Uranium-234 (U-234) accounted for the largest percentage of the collective CED, with over 99 percent of this dose accrued at Y-12.

Appendices for this annual report can be found at:

https://www.energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports

Appendix B contains additional information on intake data such as: *Exhibits B-4*, Internal Dose by Site; *B-18*, Internal Dose by Facility Type and Nuclide; *B-20*, Internal Dose by Labor Category; and *B-22*, Internal Dose Distribution by Site and Nuclide.

3.4 Analysis of Site Data

3.4.1 Collective TED by Site and Other Facilities

The collective TED values for CY 2017 through 2019 for the major DOE sites and operations/field offices are shown graphically in *Exhibit 3-11*. A list of the collective TED and number of individuals with measurable TED by DOE sites is shown in *Exhibit 3-12*.

Exhibit 3-11:
Collective TED by DOE Site for CY 2017 – 2019.

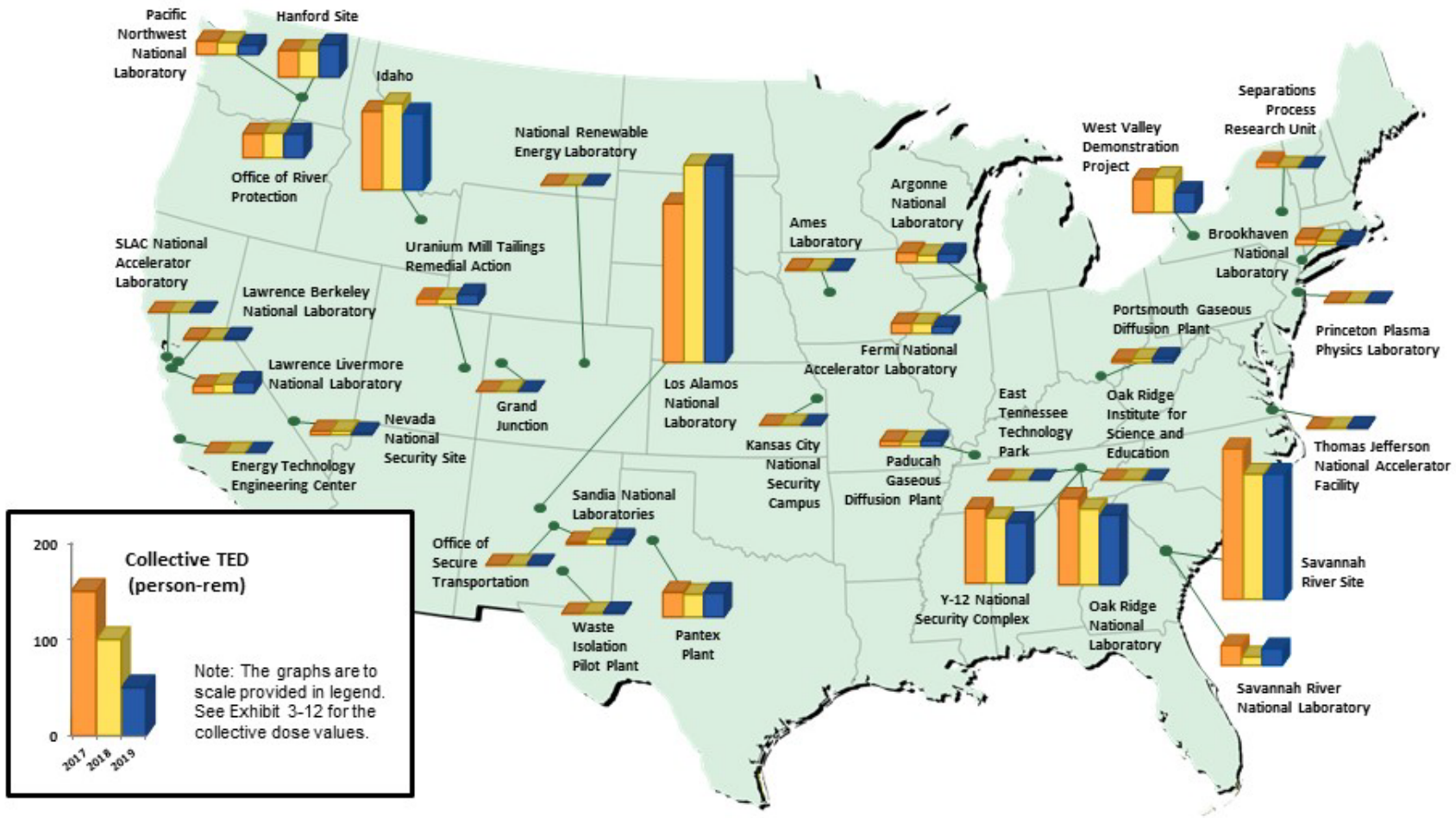


Exhibit 3-12:
Collective TED and Number of Individuals with Measurable TED by DOE Site, CY 2017 – 2019.

Site	2017		2018		2019	
	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED
Ames Laboratory	1.053	38	0.935	33	0.837	31
Argonne National Laboratory	9.885	75	7.174	77	8.650	83
Brookhaven National Laboratory	6.076	77	3.924	125	3.191	137
Energy Technology Engineering Center	0.026	2	0.059	3	0.009	2
Fermi National Accelerator Laboratory	10.210	201	9.980	188	7.060	154
Grand Junction Site	0.010	2	0.336	22	0.041	13
Hanford:						
Hanford Site	27.003	717	27.008	565	32.673	822
Office of River Protection	24.387	597	24.926	570	24.153	671
Pacific Northwest National Laboratory	13.555	517	12.225	494	9.717	446
Hanford Totals:	*64.945*	*1,831*	*64.159*	*1,629*	*66.543*	*1,939*
Idaho	79.008	1,175	86.799	1,373	76.511	1,203
Kansas City National Security Campus	0.171	44	0.428	58	0.364	66
Lawrence Berkeley National Laboratory	1.257	18	1.014	22	1.810	23
Lawrence Livermore National Laboratory	6.947	110	8.691	145	10.648	152
Los Alamos National Laboratory	**160.772**	1,850	**207.051**	1,953	**224.472**	1,983
National Renewable Energy Laboratory	0.020	4	0.006	1	0.001	1
Nevada National Security Site	3.858	94	3.893	74	1.940	50
Oak Ridge:						
East Tennessee Technology Park	0.093	6	0.147	18	0.186	19
Oak Ridge Institute for Science and Education	0.243	23	0.317	20	0.237	22
Oak Ridge National Laboratory	87.621	661	76.833	615	70.689	539
Y-12 National Security Complex	75.761	1,455	65.917	1,524	61.531	1,664
Oak Ridge Totals:	*163.718*	*2,145*	*143.214*	*2,177*	*132.643*	*2,244*
Office of Secure Transportation	0.311	8	0.288	14	0.448	13
Paducah Gaseous Diffusion Plant	5.159	113	4.593	110	5.554	100
Pantex Plant	24.986	333	22.927	312	24.248	758
Portsmouth Gaseous Diffusion Plant	2.553	41	3.588	69	4.289	71
Princeton Plasma Physics Laboratory	0.361	49	0.239	38	0.391	72
Sandia National Laboratories	2.146	73	5.819	175	5.323	154
Savannah River:						
Savannah River National Laboratory	20.051	576	8.463	314	16.631	547
Savannah River Site	152.495	**3,835**	126.869	**4,101**	126.763	**3,651**
Savannah River Totals:	*172.546*	*4,411*	*135.332*	*4,415*	*143.394*	*4,198*
Separations Process Research Unit	5.185	59	0.208	10	0.029	2
SLAC National Accelerator Laboratory	0.057	4	0.047	3	0.206	11
Thomas Jefferson National Accelerator Facility	0.270	20	0.526	26	1.266	52
Uranium Mill Tailings Remedial Action Project	5.656	66	5.485	77	9.748	95
Waste Isolation Pilot Plant	0.279	17	0.909	42	1.113	54
West Valley Demonstration Project	33.653	154	35.549	160	20.459	139
Service Center Personnel *	0.091	5	0.149	4	0.996	22
Totals	**761.209**	**13,019**	**753.322**	**13,335**	**752.184**	**13,822**

Note: Bold and boxed values indicate the greatest value in each column.
* Includes personnel at NNSA Albuquerque complex, Oak Ridge, and Waste Isolation Pilot Plant (WIPP) in addition to several smaller facilities not associated with a DOE site.

The collective TED decreased less than 1 percent from 753 person-rem (7,530 person-mSv) in CY 2018 to 752 person-rem (7,520 person-mSv) in CY 2019, with LANL; Savannah River (including Savannah River National Laboratory [SRNL] and SRS); Oak Ridge (including East Tennessee Technology Park [ETTP], Y-12, Oak Ridge National Laboratory [ORNL], and Oak Ridge Institute for Science and Education [ORISE]); Idaho (including Idaho National Laboratory [INL], Idaho Cleanup Project [ICP], and Advanced Mixed Waste Treatment Project [AMWTP]); and Hanford (including the Hanford Site, Pacific Northwest National Laboratory [PNNL], and Office of River Protection [ORP]) contributing 86 percent of the total DOE collective TED.

3.4.2 Changes by Site from CY 2018 to 2019

Exhibit 3-13 shows the collective TED, the number monitored, the number with a measurable TED, and the average measurable TED, as well as the percentage change in these values from the previous year. Some of the largest percentage changes occurred at relatively small facilities, where conditions may fluctuate from year to year due to changes in workload and tasks conducted.

Changes that have the most impact in the overall values at DOE typically occur at sites with large collective TED. For example, although Thomas Jefferson National Accelerator had the highest percent change (141 percent increase), with a collective TED increase of 0.74 person-rem from CY 2018 to 2019, LANL had the largest collective TED increase of 17.421 person-rem during that time period. (See section 3.4.3.)

Seventeen of the 35 DOE sites reported increases in the collective TED from the CY 2018 values, and 18 of the 35 DOE sites reported decreases in the collective TED from the CY 2018 values.

Twenty of the 35 reporting sites experienced increases in the number of workers with a measurable TED from CY 2018 to 2019. The largest increase in total number of workers with a measurable TED occurred at Pantex with an increase of 446 workers.

Fourteen of the 35 reporting sites experienced decreases in the number of workers with a measurable TED from CY 2018 to 2019. The largest decrease in the number of workers receiving a measurable TED occurred at Nevada National Security Site (NNSS) with a decrease of 24 workers. One site (National Renewable Energy Laboratory [NREL]) experienced no change. A discussion of activities at the highest dose facilities is included in section 3.4.3.

3.4.3 Activities Significantly Contributing to Collective Dose in CY 2019

In an effort to identify the reasons for changes in the collective dose at DOE, the sites provided information on activities that significantly contributed to the collective dose for CY 2019 as instructed in the REMS Reporting Guide, Item 1. In *Exhibit 3-14*, these sites are presented in descending order of collective TED with a dotted line representing the site's 5-year average TED. Sites that have reported less than 5 person-rem (50 person-mSv) for CY 2019 can be found in *Exhibit 3-15*. Due to the low doses and small number of individuals with measurable dose, wider variation can occur from year to year.

Exhibit 3-14 Site Listing > 5 Person-Rem

Exhibit 3-15 Site Listing < 5 Person-Rem

Exhibit 3-13:
Site Dose Data, CY 2019.

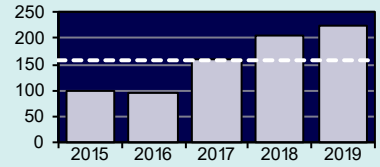
Site	2019							
	Collective TED (person-rem)	Percent Change from 2018	Number of Monitored Individuals	Percent Change from 2018	Number with Meas. TED	Percent Change from 2018	Avg. Meas. TED (person-rem)	Percent Change from 2018
Ames Laboratory	0.837	◊	164	◊	31	◊	0.027	◊
Argonne National Laboratory	8.650	21% ▲	1,852	3% ▲	83	8% ▲	0.104	12% ▲
Brookhaven National Laboratory	3.191	-19% ▼	2,384	-40% ▼	137	10% ▲	0.023	-26% ▼
Energy Technology Engineering Center	0.009	◊	5	◊	2	◊	0.005	◊
Fermi National Accelerator Laboratory	7.060	-29% ▼	1,488	2% ▲	154	-18% ▼	0.046	-14% ▼
Grand Junction Site	0.041	◊	26	◊	13	◊	0.003	◊
Hanford:								
Hanford Site	32.673	21% ▲	3,723	1% ▲	822	45% ▲	0.040	-17% ▼
Office of River Protection	24.153	-3% ▼	2,886	3% ▲	671	18% ▲	0.036	-18% ▼
Pacific Northwest National Laboratory	9.717	-21% ▼	2,735	13% ▲	446	-10% ▼	0.022	-12% ▼
Hanford Totals:	*66.543*	*4% ▲*	*9,344*	5% ▲	*1,939*	*19% ▲*	*0.034*	*-13% ▼*
Idaho	76.511	-12% ▼	7,584	2% ▲	1,203	-12% ▼	0.064	1% ▲
Kansas City National Security Campus	0.364	◊	227	◊	66	◊	0.006	◊
Lawrence Berkeley National Laboratory	1.810	79% ▲	962	3% ▲	23	5% ▲	0.079	**71%** ▲
Lawrence Livermore National Laboratory	10.648	23% ▲	3,846	2% ▲	152	5% ▲	0.070	17% ▲
Los Alamos National Laboratory	**224.472**	8% ▲	**12,059**	2% ▲	1,983	2% ▲	0.113	7% ▲
National Renewable Energy Laboratory	0.001	◊	7	◊	1	◊	0.001	◊
Nevada National Security Site	1.940	-50% ▼	903	-36% ▼	50	-32% ▼	0.039	-26% ▼
Oak Ridge:								
East Tennessee Technology Park	0.186	◊	434	◊	19	◊	0.010	◊
Oak Ridge Institute for Science and Education	0.237	◊	89	◊	22	◊	0.011	◊
Oak Ridge National Laboratory	70.689	-8% ▼	4,329	5% ▲	539	-12% ▼	0.131	5% ▲
Y-12 National Security Complex	61.531	-7% ▼	6,336	9% ▲	1,664	9% ▲	0.037	-15% ▼
Oak Ridge Totals:	*132.643*	*-7% ▼*	*11,188*	*8% ▲*	*2,244*	*3% ▲*	*0.059*	*-10% ▼*
Office of Secure Transportation	0.448	◊	336	◊	13	◊	0.034	◊
Paducah Gaseous Diffusion Plant	5.554	21% ▲	1,340	5% ▲	100	-9% ▼	0.056	33% ▲
Pantex Plant	24.248	6% ▲	5,063	0% ▲	758	**143%** ▲	0.032	-56% ▼
Portsmouth Gaseous Diffusion Plant	4.289	20% ▲	2,477	-1% ▼	71	3% ▲	0.060	16% ▲
Princeton Plasma Physics Laboratory	0.391	◊	345	◊	72	◊	0.005	◊
Sandia National Laboratories	5.323	-9% ▼	2,040	9% ▲	154	-12% ▼	0.035	4% ▲
Savannah River:								
Savannah River National Laboratory	16.631	97% ▲	693	**81%** ▲	547	74% ▲	0.030	13% ▲
Savannah River Site	126.763	◊	6,582	6% ▲	**3,651**	-11% ▼	*0.035*	12% ▲
Savannah River Totals:	*143.394*	*6% ▲*	*7,275*	*10% ▲*	*4,198*	*-5% ▼*	*0.034*	11% ▲
Separations Process Research Unit	0.029	◊	9	◊	2	◊	0.015	-30% ▼
SLAC National Accelerator Laboratory	0.206	◊	2,692	◊	11	◊	0.019	20% ▲
Thomas Jefferson National Accelerator Facility	1.266	**141%** ▲	1,391	11% ▲	52	100% ▲	0.024	20% ▲
Uranium Mill Tailings Remedial Action Project	9.748	78% ▲	138	10% ▲	95	23% ▲	0.103	44% ▲
Waste Isolation Pilot Plant	1.113	22% ▲	428	-28% ▼	54	29% ▲	0.021	-5% ▼
West Valley Demonstration Project	20.459	-42% ▼	378	-9% ▼	139	-13% ▼	**0.147**	-34% ▼
Service Center Personnel*	0.996	◊	169	◊	22	◊	0.045	22% ▲
Totals	**752.184**	**0%**	**76,120**	**1%** ▲	**13,822**	**4%** ▲	**0.054**	**-4%** ▼

Note: Bold and boxed values indicate the greatest value in each column.
◊ The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv).
* Includes personnel at NNSA Albuquerque complex, Oak Ridge, and WIPP in addition to several smaller facilities not associated with a DOE site.

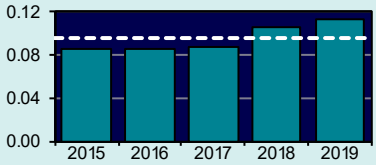
Exhibit 3-14:
Activities Significantly Contributing to Collective TED in CY 2019, in Descending Order of Collective Dose.

Los Alamos National Laboratory (LANL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

LANL conducts radiological operations in active facilities, storage facilities, facilities with legacy radiological concerns, in addition to operations in inactive facilities and areas destined for decommissioning. Radiological activities include programmatic and production work; facility construction, modification, and maintenance; and research, development, and testing.

Activities Involving Radiation Exposure

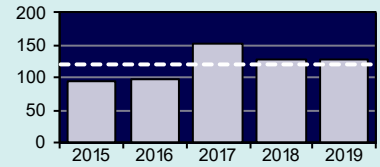
- Weapons manufacturing and related work at the TA-55 plutonium facility;
- Plutonium-238 work;
- Retrieval, repackaging, and shipping of radioactive waste; and
- Infrastructure support for radiological work and facility maintenance.

Changes in Dose

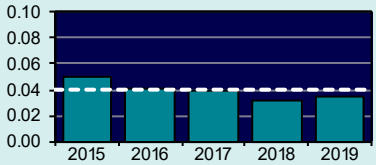
- Dose increased in CY 2019 due to successful startup of radiological work under the N3B contract which included the handling of solid radioactive waste to support transuranic waste shipments; and
- Increased productivity at TA-55 Plutonium Facility decontamination and decommissioning and environmental remediation work associated with legacy operations.

Savannah River Site (SRS)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

SRS was constructed during the early 1950s to produce the basic materials used in the fabrication of nuclear weapons, primarily tritium and plutonium-239, in support of our nation's defense programs. Five reactors were built to produce these materials. Also built were a number of support facilities including two chemical separations plants, a heavy water extraction plant, a nuclear fuel and target fabrication facility, a tritium extraction facility, and waste management facilities.

Activities Involving Radiation Exposure

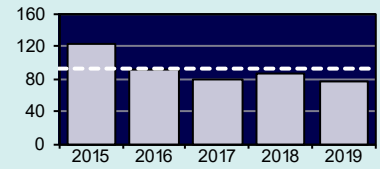
- Replacement of transfer pumps on cesium removal process tanks;
- Preparation and shipment of High Activity Waste Tank trailer;
- Post-closure care at closed reactor facilities; and
- Plutonium down blending.

Changes in Dose

- Calendar year 2019 dose remained the same in comparison with 2018. Innovations such as using drones in post closure areas and optimization process projects in support of K area plutonium down blend help to reduce radiological exposure.

Idaho

Collective TED (person-rem)



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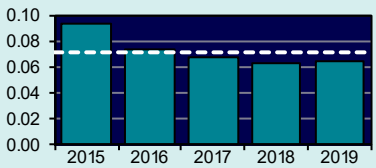


Site Description

The primary focus of activities at INL is nuclear energy research and development. The DOE Idaho office oversees three major contracts to ensure that operations and research activities are carried out safely, and in compliance with laws, regulations and contract provisions. The Idaho Cleanup Project (ICP) focuses on addressing legacy wastes resulting from decades of widely-varied work including conventional weapons testing, government-owned research and power reactor development and testing, spent nuclear fuel reprocessing, laboratory research, and defense missions.

Activities Involving Radiation Exposure

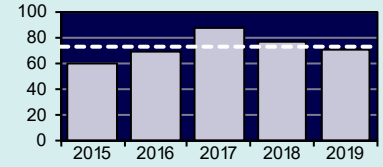
- Work at the Advanced Test Reactor (ATR) Complex, including experiment system operations, plant maintenance and modifications, routine ATR power and outage operations, and Research and Development Operations/Laboratory support;
- Activities at the Materials and Fuel Complex including maintenance and upgrades at the analytical and radiochemistry laboratories, treatment and storage for waste repackaging, benchtop and glovebox operations, decontamination efforts; and
- Waste handling, consolidation and shipment, decontamination work, and radiography operations.

Changes in Dose

- Dose decreased in CY 2019 due to monitored individuals being involved with contractor oversight in areas with minimal potential for occupational radiation exposure. Flux wire monitor analysis and disposal backlog decreased in 2019; and
- Several ALARA initiatives were implemented in CY 2019.

Oak Ridge: Oak Ridge National Laboratory (ORNL)

Collective TED (person-rem)



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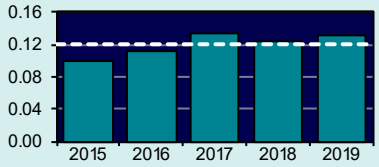


Site Description

ORNL, the largest of the DOE laboratories, is a multiprogramming science and technology laboratory. ORNL's mission is to deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in clean energy and global security, and in doing so create economic opportunity for the nation. ORNL also performs other work for the DOE, including isotope production, information management, and technical program management, and provides research and technical assistance to other organizations.

Activities Involving Radiation Exposure

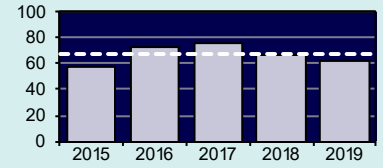
- Work related to the Spallation Neutron Source and the High Flux Isotope Reactor;
- Nuclear reactor research and radioisotope production; and
- Facility maintenance.

Changes in Dose

- CY 2019 saw a decrease in dose for project work at the research reactor and accelerator facilities. The decrease was partially offset by an increase in dose at radiochemistry, and some hot cell facilities.

Oak Ridge: Y-12 National Security Complex (Y-12)

Collective TED (person-rem)



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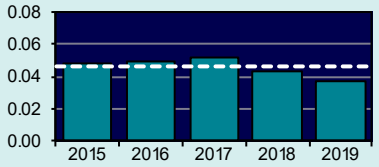


Site Description

Y-12 is one of four production facilities in the NNSA Nuclear Security Enterprise. The facility's emphasis is the processing and storage of uranium and development of technologies associated with those activities. Y-12 maintains the safety, security, and effectiveness of the U.S. nuclear weapons stockpile and processes highly enriched uranium for the Naval Nuclear Propulsion Program.

Activities Involving Radiation Exposure

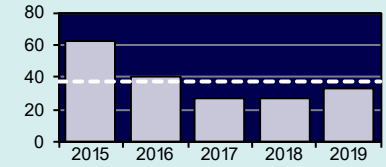
- Manufacture, processing, and storage of special materials;
- Characterization and hazardous waste removal at Y-12 Biology Complex; and
- Maintenance of equipment and facilities.

Changes in Dose

- In CY 2019, dose decreases were attributed to specialized work scope and ALARA techniques utilized to characterize and clean up areas of higher radiological risk.

Hanford: Hanford Site

Collective TED (person-rem)



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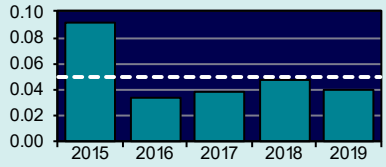


Site Description

DOE's Hanford Site sits on 586 square miles in the desert of southeastern Washington State. The area is home to nine former nuclear reactors and their associated processing facilities that were built beginning in CY 1943. Hanford reactors produced plutonium from CY 1944 until 1987. Today, Hanford workers are involved in an environmental cleanup project and remediation of the site.

Activities Involving Radiation Exposure

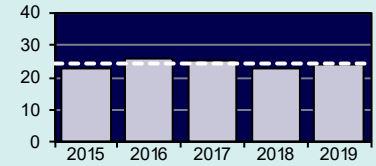
- Work activities at the plutonium finishing plant facility;
- Material handling and waste transfer; and
- Facility demolition and site remediation.

Changes in Dose

- Dose increased in CY 2019 due to work restarted at the plutonium finishing plant in CY 2019 and additional work at the 324 Building. Both of these activities involved planned long work hours and being located in areas with elevated external dose rates.

Pantex Plant

Collective TED (person-rem)



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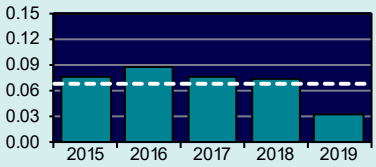


Site Description

The DOE/NNSA Pantex Plant is the nation's primary facility for the final assembly, disassembly, and maintenance of nuclear weapons. The last new nuclear weapon was completed in CY 1991. Since then, Pantex has safely dismantled thousands of weapons retired from the stockpile by the military and placed the resulting plutonium pits in interim storage. Pantex has approximately 650 buildings, including specialized facilities in which maintenance, modification, disassembly, and assembly operations are conducted.

Activities Involving Radiation Exposure

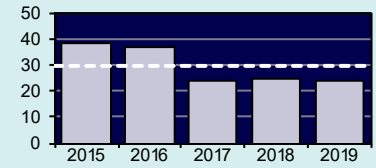
- Operations that expose workers to large numbers of bare weapon pits containing significant quantities of special nuclear material (SNM); and
- Nuclear explosive assembly/disassembly operations, weapon dismantlement programs, life-extension programs, SNM Component Re-qualification, and SNM staging.

Changes in Dose

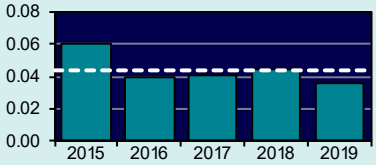
- The collective TED did not increase significantly in CY 2019 as personnel continued working with special nuclear materials.

Hanford: Office of River Protection (ORP)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

The DOE ORP mission is to retrieve and treat Hanford's waste and close the tank farms to protect the Columbia River. Chemical and radioactive waste, resulting from more than four decades of plutonium production, is currently stored in 177 large underground tanks. ORP is responsible for the retrieval, treatment, and disposal of this waste. The cornerstone of the tank waste cleanup project is the Waste Treatment Plant (WTP). The WTP will use a technology called vitrification to immobilize chemical and radioactive waste in an exceptionally sturdy form of glass to isolate it from the environment.

Activities Involving Radiation Exposure

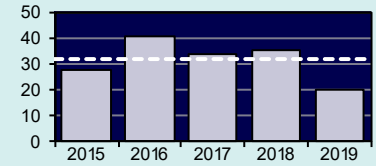
- Removal and transfer of waste from older single-shell tanks to newer double-shell tanks;
- Maintenance and support of the evaporator which reduces the volume of stored liquid waste by concentrating radioactive waste solutions;
- Work at the 222-S laboratory; and
- Well logging activities using an AmBe source.

Changes in Dose

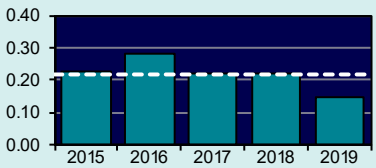
- The collective TED did not decrease significantly in CY 2019 as personnel continued cleanup and maintenance activities.

West Valley Demonstration Project (WVDP)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

WVDP is a unique operation within DOE and came into being through the WVDP Act of 1980. The Act requires DOE to be responsible for solidifying the high-level waste and disposing of waste created by the solidification and decommissioning of the facilities used in the process. The land and facilities are not owned by DOE; rather, the project premises are the property of the New York State Energy Research and Development Authority (NYSERDA) and represent only 200 acres of the larger Western New York Service Center, which is approximately 3,300 acres, also owned by NYSERDA. After DOE's responsibilities under the Act are complete, the Act requires that the premises be returned to New York State.

Activities Involving Radiation Exposure

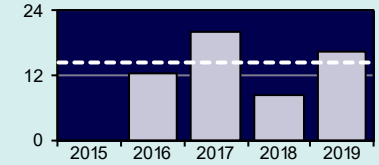
- Demolition preparation work in the Main Plant Process Building;
- Waste operations tasks in lag storage and chemical process cell waste storage area, waste processing in the remote waste handling facility; and
- Radiological Control Technicians providing support for facility disposition activities.

Changes in Dose

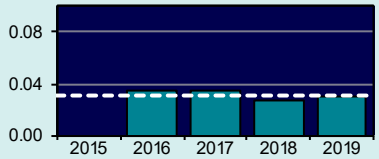
- The CY 2019 overall dose decreased from the previous year due primarily to fewer manned-entries in high dose rate areas in the Main Plant, and the completion of open air demolition activities of the Vitrification Facility.

Savannah River National Laboratory (SRNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

SRNL began reporting separately from SRS effective CY 2016. SRNL supports DOE in its environmental management and nuclear security missions. SRNL applies its expertise in nuclear chemical manufacturing to assist DOE in meeting its objectives in areas such as nuclear waste cleanup and defense nonproliferation.

Activities Involving Radiation Exposure

- Currently, most SRNL programs support the SRS tritium mission. This includes applying hydrogen technologies used in processing tritium; extraction, purification, and storage of tritium;
- Execution of the Mark-1A Pu-244 recovery program

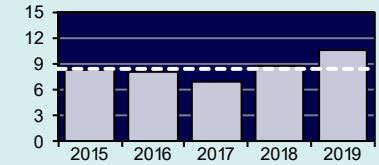
Changes in Dose

- The increase in dose was primarily due to the implementation of system upgrades and lab modifications. The SRNL ream completed set-up of TRU Waste Assay System upgrade which includes features such as increased efficiency in handling TRU waste drums, decreased dose exposure to workers, elimination of the use of liquid nitrogen, and uninterrupted power supply, and compliance with SRNL Documented Safety Analysis (DSA) upgrades.

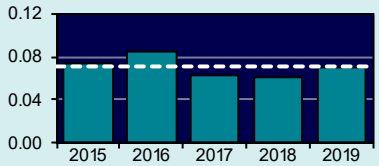
Note: Until CY 2016, SRNL was reported with SRS. Beginning in CY 2016 it was recorded as an independent entity.

Lawrence Livermore National Laboratory (LLNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

LLNL is a DOE facility operated by the Lawrence Livermore National Security, LLC management team, which includes Bechtel, the University of California, BWX Technologies, Washington Group, and Battelle. The site serves as a national resource of scientific, technical, and engineering capability with a special focus on national security. LLNL's mission encompasses such areas as: strategic defense, energy, the environment, biomedicine, technology transfer, education, counter-terrorism, and emergency response. The types of radioactive materials range from tritium to transuranic (TRU); the quantities of each range from nanocuries (i.e., normal environmental background values) to kilocuries.

Activities Involving Radiation Exposure

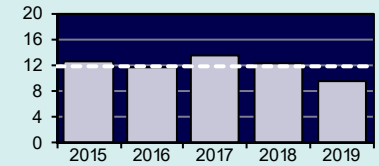
- Radiation producing devices such as x-ray machines, accelerators, and electron-beam welders; and
- Handling a wide range and quantity of radioactive materials.

Changes in Dose

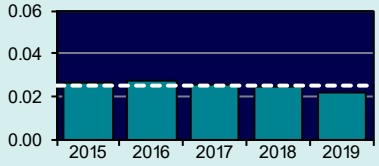
- The increase in collective dose reflects an increase in work scope.

Hanford: Pacific Northwest National Laboratory (PNNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

Located in Richland, Washington, PNNL is 1 of 10 national laboratories managed by DOE's Office of Science (SC). The laboratory provides the facilities, unique scientific equipment, and world-renowned scientists and engineers to strengthen U.S. scientific foundations through fundamental research and innovation. The lab also supports Hanford site cleanup efforts by performing scientific and technical evaluations and reviews, and developing and advancing new technologies to address site cleanup challenges.

Activities Involving Radiation Exposure

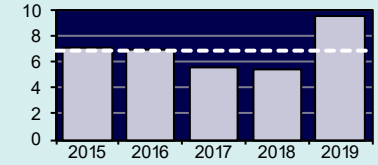
- Work at the Radiochemical Processing Laboratory;
- Radiation detection research; and
- Implementation of security measures for radiological materials of concern.

Changes in Dose

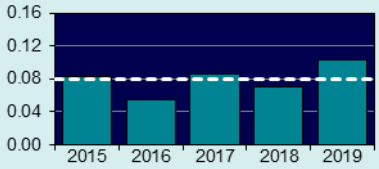
- The decrease in collective dose in CY 2019 reflects an overall lower volume of elevated risk, high dose radiological work.

Uranium Mill Tailings Remedial Action Project (UMTRA)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

The UMTRA site is located approximately 3 miles northwest of Moab in Grand County, Utah, and includes a former uranium-ore processing facility. The site encompasses 480 acres, of which approximately 130 acres are covered by a uranium mill tailings pile. The UMTRA Project ships four trainloads of tailings to the Crescent Junction Disposal Site each week. The trains contain 144 containers of approximately 40 tons each, or a total of 23,040 tons of tailings per week. Tailing shipments began in April 2009 and are expected to continue through CY 2034.

Activities Involving Radiation Exposure

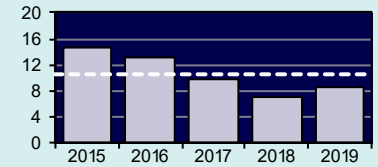
- Maintenance;
- Erosion control measures;
- Tailings excavation and conditioning;
- Loading tailings into containers and transporting to the rail beach;
- Ground water remediation; and
- Health and safety oversight.

Changes in Dose

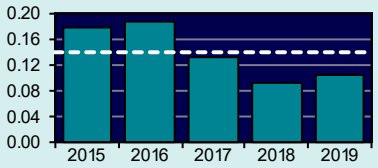
- The project added about 30 additional staff and doubled its production in CY 2019 (increasing from shipping railcars twice a week to four times a week) which attributed to the increase in dose.

Argonne National Laboratory (ANL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

ANL is one of DOE's largest national laboratories for scientific and engineering research. The lab's mission is to apply a unique mix of world-class science, engineering, and user facilities to deliver innovative research and technologies. The principal radiological facilities at Argonne are the Advanced Photon Source, a superconducting heavy-ion linear accelerator (LINAC), a 22-MeV pulsed electron LINAC, and several other charged-particle accelerators.

Activities Involving Radiation Exposure

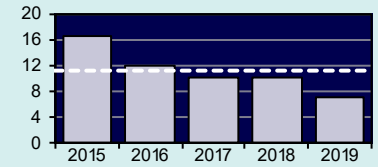
- Work supporting the lab's radiological facilities;
- Programmatic activities resulting primarily from research activities in the Irradiated Materials Laboratory; and
- Material handling, management, storage, and disposition activities associated with the Alpha Gamma Hot Cell Facility, the Waste Management Operations Facility, and the Radioactive Waste Storage Facility.

Changes in Dose

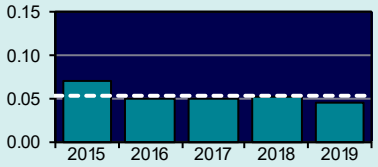
- The increases in collective TED and average measurable TED are attributed to decontamination work and repairs at the Alpha Gamma Hot Cell Facility, taking more time than anticipated specifically related to manipulator repairs; and
- New initiatives on the programmatic side related to research with medical isotopes resulted in increased dose, as well.

Fermi National Accelerator Laboratory (Fermilab)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

Fermilab provides leadership and resources for qualified researchers to conduct basic research at the frontiers of high-energy particle physics and related disciplines. The primary features of the site include the accelerator complex and associated building infrastructure, an interconnected industrial cooling water system, a housing complex for visiting researchers, row crop agriculture, and natural areas in various states of restoration.

Activities Involving Radiation Exposure

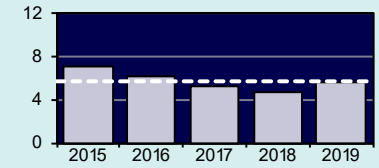
- Upgrade and repair activities of the Fermilab accelerator complex;
- Installation of new NuMi target, upgrade of water piping, replacement of pre- and HEPA filters, ion pump replacement; and
- Management and disposal of radioactive waste.

Changes in Dose

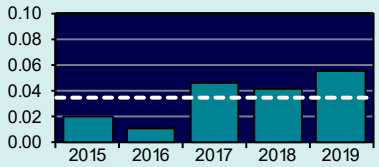
- The 29 percent decrease in collective dose reflects the planned shutdown between July and September 2019, to upgrade and repair facilities. The 138 planned jobs were reviewed and 6 ALARA plans were identified and implemented, resulting in improved accelerator performance, enhanced reliability, and better control of present and future radiation exposures.

Paducah Gaseous Diffusion Plant (PGDP)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

PGDP is located 3 miles south of the Ohio River and is 12 miles west of Paducah, Kentucky. The plant began enriching uranium in CY 1952, first for the nation's nuclear weapons program and then for nuclear fuel for commercial power plants. In CY 1994, the enrichment facilities were leased to United States Enrichment Corporation (USEC). In August 2013, USEC notified DOE that they were discontinuing enrichment operations and planning to de-lease the enrichment facilities.

Activities Involving Radiation Exposure

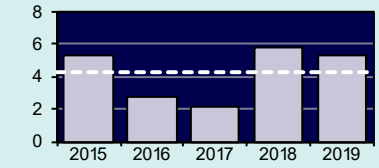
- Continued support of plant operations and maintenance of the Depleted Uranium Hexafluoride project (DUF6) as a nuclear facility;
- Environmental remediation and cleanup activities;
- Waste disposition; and
- Decontamination and decommissioning (D&D) of inactive facilities.

Changes in Dose

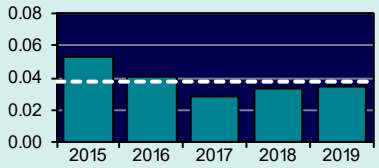
- Increase in the CY 2019 can be attributed to the fact that the plant became operational again after a long-term shutdown and fluctuating production rates and line status prior to CY 2018. The plant became operational and began to increase production towards the end of CY 2018; and
- Some of the increase was offset because the dose for the Swift and Staley Team (infrastructure support and site services) decreased during CY 2019 as a result of the change of the minimum reporting level to 10 mrem for quarterly dosimeter wear periods and to 20 mrem for annual dosimeter wear periods as per a Lower Limit of Detection (LLD) and background study performed in 2018.

Sandia National Laboratories (SNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

SNL's primary mission is ensuring the U.S. nuclear arsenal is safe, secure, and reliable, and can fully support our nation's deterrence policy. Sandia is the engineering arm of the U.S. nuclear weapons enterprise. Sandia's foundation is science-based engineering, in which fundamental science, computer models, and unique experimental facilities come together so researchers can understand, predict, and verify weapon systems performance.

Activities Involving Radiation Exposure

- Operation of a research reactor, gamma irradiation facility, hot cell facility, and several pulsed-power accelerators;
- Conducting light laboratory work involving x-ray machines, tracer radionuclides; and
- Waste operations.

Changes in Dose

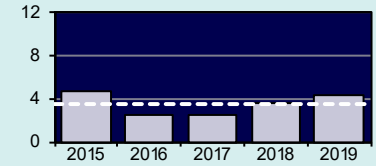
- Decreases in collective dose were attributed to normal statistical fluctuations in the measured doses, with no significant change in radiological work between CY 2018 and CY 2019.

As seen in *Exhibit 3-11*, the majority of the collective TED is received at a few DOE sites. For sites with relatively low collective dose or with fewer monitored individuals, wider variation can occur from year to year. These year-to-year variations are often due to changes in funding or mission priorities that can significantly impact the relatively small amount of work involving radiation exposure. In CY 2019, 17 DOE sites reported less than 5 person-rem (50 person-mSv) collective TED for their respective site. These sites and the activities contributing to collective TED can be found in *Exhibit 3-15*.

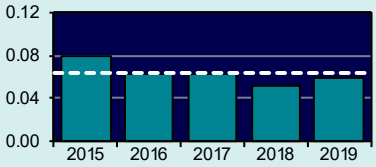
Exhibit 3-15:
Activities Significantly Contributing to Collective TED in CY 2019, for Sites Reporting Less Than 5 Person-Rem, in Descending Order of Collective Dose.

Portsmouth Gaseous Diffusion Plant (PORTS)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

PORTS is located in Pike County, Ohio. PORTS was one of three large gaseous diffusion plants initially constructed to produce enriched uranium to support the nation's nuclear weapons program and later enrich uranium for commercial nuclear reactors. The plant has been shut down and is currently undergoing decontamination and decommissioning.

Activities Involving Radiation Exposure

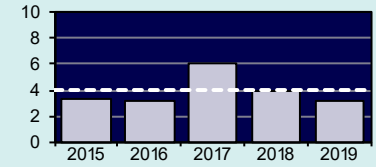
- Site deactivation, decommissioning, and demolition activities;
- Waste handling, processing, and shipment of uranium-bearing materials;
- Processing of uranium (UF6) cylinders;
- Facility decontamination; and
- Uranium barter transfers.

Changes in Dose

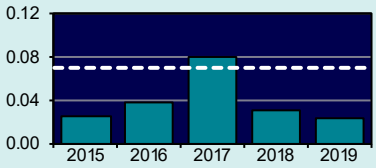
- The increase in dose was due to extensive construction near UF6 cylinder storage yards; and
- Mid-America Conversion Service (G Plant) became operational and production status increased during the year.

Brookhaven National Laboratory (BNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

BNL conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security. BNL also builds and operates major scientific facilities which are available to university, industry, and government researchers.

Activities Involving Radiation Exposure

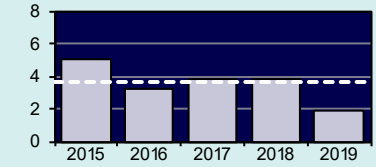
- Research involving nuclear and particle physics, accelerator science, and biological systems research;
- Facility maintenance and source replacement; and
- Support for the National Aeronautics and Space Administration Space Radiation Laboratory.

Changes in Dose

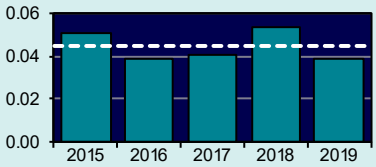
- The decrease in total dose was primarily due to completion of controlled routine operations and activities at the BNL facilities.

Nevada National Security Site (NNSS)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

NNSS is located approximately 65 miles northwest of Las Vegas. It is a remote facility that covers approximately 1,375 square miles of land. The NNSS has been the primary location for testing nuclear experiments in the continental United States since CY 1951.

Activities Involving Radiation Exposure

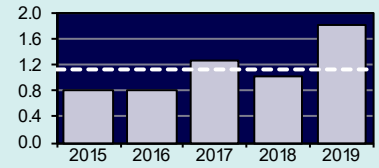
- Operation of low-level radioactive and mixed waste disposal facilities;
- Assembly and execution of subcritical experiments, confined critical experiments;
- Assembly/disassembly of special experiments;
- Operation of pulsed x-ray machines, linear accelerators, and neutron generators;
- Development, testing, and evaluation of radiation detectors;
- Surface cleanup and site characterization of contaminated land areas; and
- Managing environmental activity for the University of Nevada system.

Changes in Dose

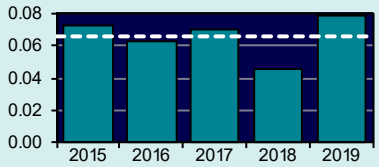
- The decrease in dose was attributed to the decrease in activities associated with critical and special national laboratories experiments.

Lawrence Berkeley National Laboratory (LBNL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

LBNL is a member of the national laboratory system supported by DOE through its Office of Science and is charged with conducting unclassified research across a wide range of scientific disciplines. LBNL employs approximately 4,200 scientists, engineers, support staff, and students.

Activities Involving Radiation Exposure

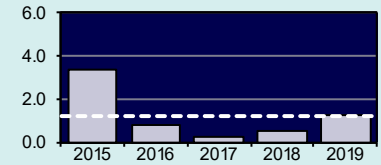
- Fluorine-18 (F-18) research;
- Antineutrino research and experiments; and
- Site inventory of radioactive and nuclear material activities.

Changes in Dose

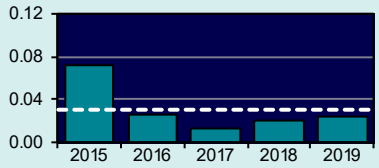
- The increase in dose was primarily due to the increased dose to workers performing maintenance and upgrade work at the 88-inch Cyclotron facility. This facility has been performing increased deuteron and proton beam runs causing an increase in the activation of cyclotron components that require periodic maintenance.

Thomas Jefferson National Accelerator Facility (TJNAF)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

TJNAF is one of 17 national laboratories funded by DOE. TJNAF's primary mission is to conduct basic research of the atom's nucleus using the unique particle accelerator known as the Continuous Electron Beam Accelerator Facility (CEBAF).

Activities Involving Radiation Exposure

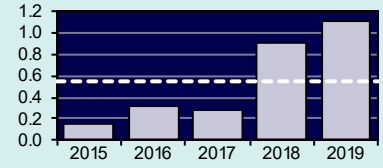
- Maintenance, modification, and repair of activated components associated with the CEBAF and other ancillary activities (e.g., transport, storage, and disposal of radioactive materials).

Changes in Dose

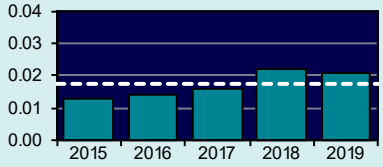
- Collective dose at TJNAF increased slightly during CY 2019 which is consistent with stable periods of accelerator operation with some routine maintenance and repair activities, along with an increase in dose related to radiological surveys that supported experiments with significant residual radioactivity in experimental Hall A.

Waste Isolation Pilot Plant (WIPP)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

WIPP is located in the Chihuahuan Desert near Carlsbad, New Mexico. This DOE facility safely disposes of the nation's defense-related TRU radioactive waste. WIPP began disposal operations in March 1999.

Activities Involving Radiation Exposure

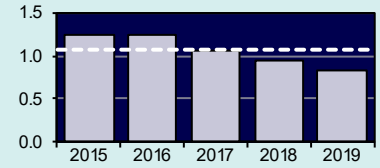
- Handling and processing of transuranic waste for storage; and
- Managing long-term repository operations.

Changes in Dose

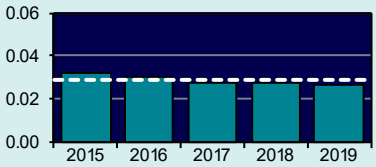
- The increase in collective dose was due to changes in the amount of radioactive material contained in the waste processed at WIPP.

Ames Laboratory

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

Ames Laboratory is a government-owned, contractor-operated research facility of the DOE. For over 65 years, the Ames Laboratory has sought solutions to energy-related problems through the exploration of chemical, engineering, materials, mathematical, and physical sciences.

Activities Involving Radiation Exposure

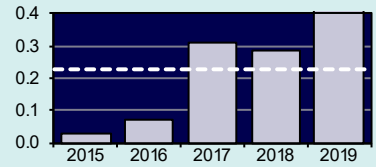
- Remediation of radiological legacy contamination; and
- Operation of 23 x-ray systems and 1 Mossbauer spectroscopy system.

Changes in Dose

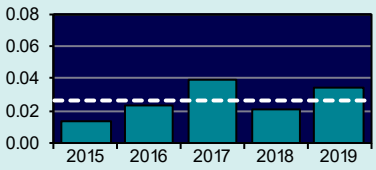
- Dose decreased due to a limited amount of radioactive material research, as well as the use of microgram quantities of radionuclides.

Office of Secure Transportation (OST)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

OST is the NNSA organization tasked to provide secure ground transportation of nuclear weapons, special nuclear material (SNM), nuclear weapon components, and nuclear explosive-like assemblies. OST operates both secure ground transporters and Federal aircraft, which make up the Transportation Safeguards System (TSS). The TSS Federal Agent and vehicle maintenance facilities are located in Oak Ridge, Tennessee, Amarillo, Texas, and Albuquerque, New Mexico. The OST Administrative Headquarters are located at Kirtland Air Force Base in Albuquerque, New Mexico.

Activities Involving Radiation Exposure

- Providing secure ground transportation of nuclear weapons, SNM, nuclear weapon components, and nuclear explosive-like assemblies; and
- Tracking and directing cargo loading revisions to minimize radiation exposure.

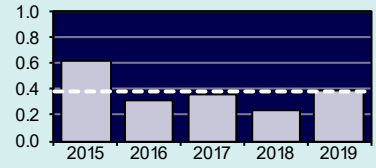
Changes in Dose

- Differences are insignificant and variations may be attributed to the small number of individuals (less than 10 for each year).

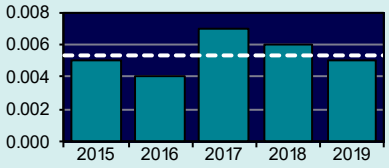
Note: Until CY 2015, OST was counted among other sites. Since CY 2015, it has been recorded as an independent entity.

Princeton Plasma Physics Laboratory (PPPL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

PPPL is a collaborative national center for fusion energy research. The laboratory advances the coupled fields of fusion energy and plasma physics research and enhances the scientific understanding and key innovations needed to realize fusion as an energy source for the world.

Activities Involving Radiation Exposure

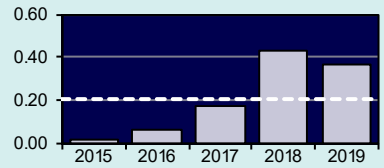
- Experimental and theoretical fusion research; and
- Plasma research and experiments involving radioactive sources and x-ray generating devices.

Changes in Dose

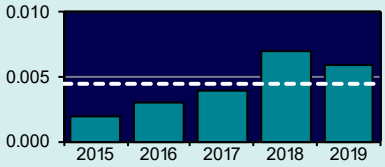
- The increase in dose in CY 2019 is statistically insignificant when considering the low dose historically experienced at the site.

Kansas City National Security Campus (KC-NSC)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

The KC-NSC is responsible for manufacturing and procuring non-nuclear components for nuclear weapons, including electronic, mechanical, and engineered material components. It supports national laboratories, universities, and U.S. industry and is located in Kansas City, Missouri.

Activities Involving Radiation Exposure

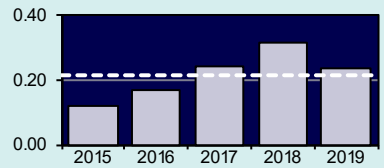
- Non-destructive testing, telemetry (neutron generators);
- Security operations, depleted uranium operations;
- Full production of weapons Life Extension Program; and
- Legacy part refurbishment and waste management.

Changes in Dose

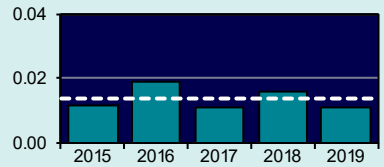
- Collective plant-wide dose reduction of 14.9 percent in CY 2019 while increasing the radiation worker population by 38 percent.

Oak Ridge: Oak Ridge Institute for Science and Education (ORISE)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

ORISE is a DOE institute focusing on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists.

Activities Involving Radiation Exposure

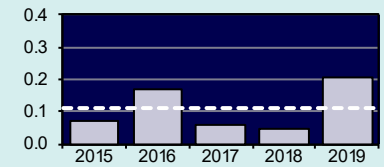
- Independent verification activities involving radiological surveys at sites undergoing decommissioning; and
- Environmental sample processing and radiological protection.

Changes in Dose

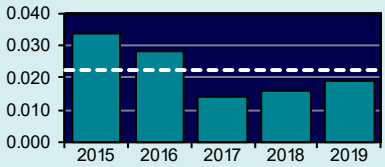
- The decrease in dose was due to less project work that would normally result in doses to workers. The overall number of projects declined during the last quarter of CY 2019.

SLAC National Accelerator Laboratory (SLAC)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

SLAC, which opened in CY 1962, is 1 of 10 DOE Office of Science laboratories and is operated by Stanford University on behalf of DOE. Originally a premier high-energy particle accelerator laboratory, SLAC has grown into a state-of-the-art photon science laboratory. SLAC's scientific mission has diversified from an original focus on particle physics and accelerator science to include cosmology, materials and environmental sciences, biology, chemistry, and alternative energy research.

Activities Involving Radiation Exposure

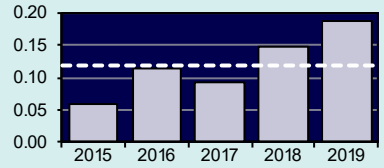
- Operation of the LINAC Coherent Light Source (LCLS) – the world's first hard x-ray free electron laser;
- Operation of the Stanford Synchrotron Radiation Lightsource – a pioneering synchrotron radiation facility; and
- Operation of the Stanford Positron-Electron Asymmetric Ring (SPEAR3), and a separate, shorter linear accelerator (LINAC), and a booster ring for injecting accelerated beams of electrons into SPEAR3.

Changes in Dose

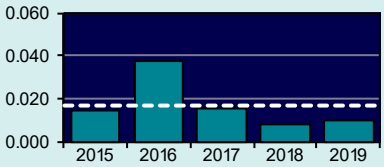
- The collective dose increased slightly in CY 2019 and reflects normal routine operations and normal variations given the limited number of individuals with measurable dose and the very low doses and;
- The LCLS was shut down for beamline upgrades.

Oak Ridge: East Tennessee Technology Park (ETTP)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

ETTP was originally named the Oak Ridge Gaseous Diffusion Plant. As part of the Manhattan Project, the plant was designed to produce enriched uranium for use in atomic weapons operations during World War II. After the war, this Plant was renamed the Oak Ridge K-25 Site and produced enriched uranium for the commercial nuclear power industry from CY 1945 to 1985. In CY 1987, DOE renamed the site ETTP and began a major environmental cleanup project with the long-term goal of converting ETTP into a private industrial park.

Activities Involving Radiation Exposure

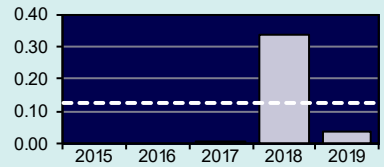
- Continuation of ongoing cleanup activities.

Changes in Dose

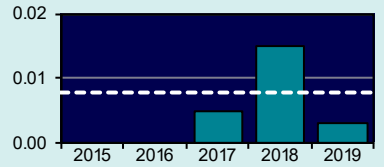
- Small increase of dose reported, but due to the small number of individuals with measurable dose and low dose, these changes were not significant.

Grand Junction Site

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

The Grand Junction disposal site was transferred to the Office of Legacy Management in CY 2003. Legacy Management manages the site according to a site-specific Long-Term Surveillance and Maintenance Plan.

Activities Involving Radiation Exposure

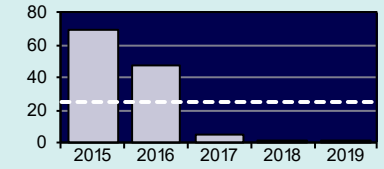
- Conducting annual sampling of groundwater and surface water, validating the analytical data generated from the annual sampling event;
- Conducting an annual site inspection and preparing an inspection report;
- Abandoned mine site inspections; and
- Monitoring well maintenance.

Changes in Dose

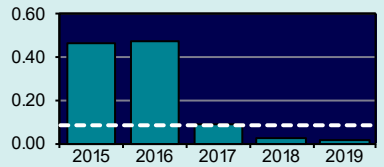
- All doses received were from routine field activities performed by Legacy Management personnel and were very low; and
- The number of individuals monitored decreased from CY 2018 to CY 2019.

Separations Process Research Unit (SPRU)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

SPRU is located at Knolls Atomic Power Laboratory based in upstate New York. Built in the 1940s, the buildings supported the SPRU mission to research the chemical process to extract plutonium from irradiated materials. Although equipment was flushed and drained and bulk waste was removed following the shutdown of the facilities in CY 1953, residual materials are present in the tanks, buildings H2 and G2, and interconnecting pipe tunnels. The site is currently undergoing a variety of cleanup activities, including demolition, decontamination, and remediation.

Activities Involving Radiation Exposure

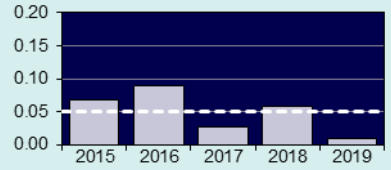
- Repackaging transuranic waste;
- Processing and shipping low activity water and waste; and
- Surveillance and maintenance of site condition activities.

Changes in Dose

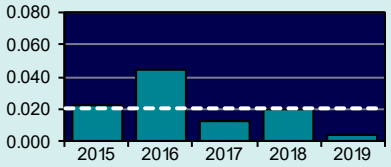
- Collective dose decreased due to maintaining proper ALARA controls during quarterly inspections of the TRU waste storage area.

Energy Technology Engineering Center (ETEC)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

ETEC is located within area IV of the Santa Susana Field Laboratory. The laboratory comprises four discrete operational areas with two adjacent undeveloped properties. In CY 1988, DOE decided to close the remaining ETEC operations. ETEC is currently in a safe shutdown mode, pending the completion of the Environmental Impact Statement.

Activities Involving Radiation Exposure

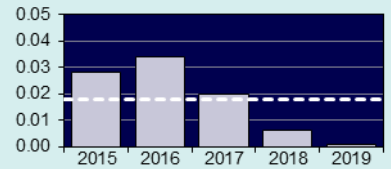
- Disposition of government property;
- Cleanup of facilities, demolition of facilities, and site restoration;
- Area IV is undergoing characterization for cleanup of the area; and
- Investigation and remediation of soil and groundwater.

Changes in Dose

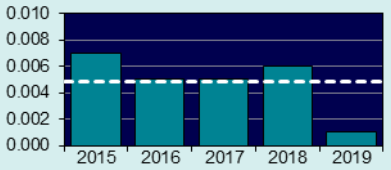
- The lower dose in CY 2019 is due to a decrease in the number of workers; and
- The fact that the ETEC facility is not operational and only monitoring and maintenance and abatement activities are being performed.

National Renewable Energy Laboratory (NREL)

Collective TED (person-rem)



Average Measurable TED (rem)



Site Description

NREL focuses on creative answers to today's energy challenges. From fundamental science and energy analysis to validating new products for the commercial market, NREL researchers are dedicated to transforming the way the world uses energy. With more than 35 years of successful innovation in energy efficiency and renewable energy, NREL discoveries provide sustainable alternatives for powering homes, businesses, and transportation systems.

Activities Involving Radiation Exposure

- Electron microscopy staining; and
- Operation of analytical and process equipment containing sealed sources.

Changes in Dose

- The decrease in dose for CY 2019 is not significant, and is due to a decrease in work involving radiation exposure and the completion of decontamination activities. Due to the small number of individuals with measurable dose, these small differences are within normal variations.

3.4.4 Summary by Program Office

DOE has divided the responsibility of managing its missions among specific program offices. A site may include facilities or project areas that perform work in support of the mission of multiple program offices. In these cases, the dose records are separated by the reporting organization and assigned to the corresponding program office. For this reason, some sites will have portions of the collective dose shown under more than one program office.

Exhibit 3-16 shows the collective TED, number of individuals with measurable TED, and the average measurable TED by DOE program office. The NNSA and the Office of Environmental Management (EM) account for 83 percent of the collective TED (47 and 36 percent, respectively). NNSA is responsible for the management and security of the nation's nuclear weapons, nuclear nonproliferation, and naval reactor programs, as well as responding to radiological emergencies and the transportation of nuclear weapons and SNM. The mission of EM is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research.

The primary sites contributing to the collective TED within EM are SRS and Idaho. For NNSA, the primary contributors are LANL and Y-12.

A more detailed breakdown of the exposure information by site, program office, and contractor is in the Appendices section of the Annual Report available at:

https://www.energy.gov/ehss/corporate-reporting-analysis/databases/occupational-radiation-exposure

Exhibit 3-16:
Program Office Dose Data, CY 2019.

Program Office	Collective TED (person-rem)	Percent Change from 2018	Number with Meas. Dose (TED)	Percent Change from 2018	Avg. Meas. TED (rem)	Percent Change from 2018
Office of Energy Efficiency and Renewable Energy (EE)					**Total Monitored =**	**7***
National Renewable Energy Laboratory	0.001	◊	1	◊	0.001	◊
EE Totals	**0.001**	◊	**1**	**0%**	**0.001**	◊
Office of Environmental Management (EM)					**Total Monitored =**	**19,930***
East Tennessee Technology Park	0.186	◊	19	◊	0.010	◊
Energy Technology Engineering Center	0.009	◊	2	◊	0.005	◊
Hanford Site	32.673	21% ▲	822	45% ▲	0.040	-17% ▼
Idaho (ICP, AMWTP and DOE IOO)	36.669	-13% ▼	598	-12% ▼	0.061	-1% ▼
Los Alamos National Laboratory	1.586	**641%** ▲	29	**190%** ▲	0.055	**156%** ▲
Nevada National Security Site	0.032	◊	2	◊	0.016	◊
Oak Ridge National Laboratory	18.289	-38% ▼	176	-12% ▼	0.104	-29% ▼
Office of River Protection	24.153	-3% ▼	671	18% ▲	0.036	-18% ▼
Paducah Gaseous Diffusion Plant	5.554	21% ▲	100	-9% ▼	0.056	33% ▲
Portsmouth Gaseous Diffusion Plant	4.289	20% ▲	71	3% ▲	0.060	16% ▲
Savannah River National Laboratory	16.631	97% ▲	547	74% ▲	0.030	13% ▲
Savannah River Site	**87.309**	15% ▲	**2,319**	1% ▲	0.038	14% ▲
Separations Process Research Unit	0.029	◊	2	◊	0.015	◊
Service Center Personnel*	0.973	◊	21	◊	0.046	◊
Uranium Mill Tailings Remedial Action Project	9.748	78% ▲	95	23% ▲	0.103	44% ▲
Waste Isolation Pilot Plant	1.113	22% ▲	54	29% ▲	0.021	-5% ▼
West Valley Demonstration Project	20.459	-42% ▼	139	-13% ▼	**0.147**	-34% ▼
EM Totals	**259.702**	**0%**	**5,667**	**11%** ▲	**0.046**	**-9%** ▼
Office of Legacy Management (LM)					**Total Monitored =**	**26***
Grand Junction Site	0.041	◊	13	◊	0.003	◊
LM Totals	**0.041**	◊	**13**	◊	**0.003**	◊
National Nuclear Security Administration (NNSA)					**Total Monitored =**	**33,108***
Kansas City National Security Campus	0.364	◊	66	◊	0.006	◊
Lawrence Livermore National Laboratory	10.648	**23%** ▲	152	5% ▲	0.070	**17%** ▲
Los Alamos National Laboratory	**222.886**	8% ▲	**1,954**	1% ▲	**0.114**	7% ▲
Nevada National Security Site	1.908	-51% ▼	48	-34% ▼	0.040	-25% ▼
Office of Secure Transportation	0.448	◊	13	◊	0.034	◊
Pantex Plant	24.248	6% ▲	758	**143%** ▲	0.032	-56% ▼
Sandia National Laboratories	5.323	-9% ▼	154	-12% ▼	0.035	4% ▲
Savannah River Site	39.454	-22% ▼	1,332	-26% ▼	0.030	5% ▲
Y-12 National Security Complex	61.531	-7% ▼	1,664	9% ▲	0.037	-15% ▼
NNSA Totals	**366.810**	**0%** ▲	**6,141**	**1%** ▲	**0.060**	**-1%** ▼
Office of Nuclear Energy (NE)					**Total Monitored =**	**5,394***
Idaho National Laboratory	39.842	-11% ▼	605	-13% ▼	0.066	2% ▲
NE Totals	**39.842**	**-11%** ▼	**605**	**-13%** ▼	**0.066**	**2%** ▲
Office of Science (SC)					**Total Monitored =**	**17,632***
Ames Laboratory	0.837	◊	31	◊	0.027	◊
Argonne National Laboratory	8.650	21% ▲	83	8% ▲	0.104	12% ▲
Brookhaven National Laboratory	3.191	-19% ▼	137	10% ▲	0.023	-26% ▼
Fermi National Accelerator Laboratory	7.060	-29% ▼	154	-18% ▼	0.046	-14% ▼
Lawrence Berkeley National Laboratory	1.810	79% ▲	23	5% ▲	0.079	**71%** ▲
Oak Ridge Institute for Science and Education	0.237	◊	22	◊	0.011	◊
Oak Ridge National Laboratory	**52.400**	10% ▲	363	-12% ▼	**0.144**	26% ▲
Pacific Northwest National Laboratory	9.717	-21% ▼	**446**	-10% ▼	0.022	-12% ▼
Princeton Plasma Physics Laboratory	0.391	◊	72	◊	0.005	◊
Service Center Personnel*	-	◊	-	◊	-	◊
SLAC National Accelerator Laboratory	0.206	◊	11	◊	0.019	◊
Thomas Jefferson National Accelerator Facility	1.266	**141%** ▲	52	**100%** ▲	0.024	20% ▲
SC Totals	**85.765**	**2%** ▲	**1,394**	**-3%** ▼	**0.062**	**6%** ▲

Note: Bold and boxed values indicate the greatest value in each column.
◊ The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv).
* Individuals who worked at more than one program office are represented within each grouping; therefore, the total monitored values will not match the annual number of workers monitored.

3.5 Transient Individuals

For the purpose of this report, a DOE site is defined as a geographic location. Transient individuals, or transients, are defined as individuals who are monitored at more than one DOE site during the calendar year. During the year, some individuals performed work at multiple sites and, therefore, had more than one monitoring record reported to the REMS repository. In addition, some individuals transferred from one site to another. This section presents information on transient individuals to determine the extent to which individuals traveled from site to site and to examine the doses received by these individuals. *Exhibit 3-17* shows the dose distribution and total number of transient individuals from CY 2015 to 2019. Over the past 5 years, the records of transient individuals have averaged 3.4 percent of the total records for all monitored individuals. These individuals received, on an average, 2.9 percent of the collective TED. The collective TED for transients increased from 18.9 person rem (189 person-mSv) in CY 2018 to 22.2 person-rem (222 person-mSv) in CY 2019. The average measurable TED decreased only slightly from 0.043 rem (0.430 mSv) in CY 2018 to 0.042 in CY 2019. The 17 percent increase in the collective TED in CY 2019 is the result of the increase in the number of transients monitored with measurable dose. Since CY 1993, the percentages have remained relatively constant.

The tracking and analysis of transient workers are important aspects of the AU REMS project. While each site is responsible for monitoring individuals during their work at that site, the REMS project collects dose records from all sites and verifies that individuals do not exceed regulatory limits by accruing doses at multiple facilities. Although the number of transient individuals and average doses have been low, the examination of these records remains an important function of AU in assessing performance of DOE worker health and safety programs.

3.6 Historical Data

In order to provide historical context for radiation exposure data at DOE, it is useful to include information prior to the past 5 years. *Exhibit 3-18* and *Exhibit 3-19* show a summary of occupational exposures starting in CY 1974, when the Atomic Energy Commission (AEC) split into the U.S. Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which subsequently became DOE. *Exhibit 3-18* and *Exhibit 3-19* show the collective dose, average measurable dose, and number of workers with a measurable dose from CY 1974 to 2019. All three parameters decreased dramatically between CY 1986 and 1993due to the shutdown of facilities within the weapons complex and the end of the Cold War era. After this time the DOE mission shifted from weapons production to shutdown, stabilization, and decontamination and decommissioning activities.

Exhibit 3-17:
Dose Distribution of Transient Individuals, CY 2015 – 2019.

	Dose Ranges (TED in rem)*	2015	2016	2017	2018	2019
Transients	Less than measurable	2,152	2,016	2,035	2,291	2,142
	Measurable <0.100	360	420	432	404	475
	0.100 – 0.250	35	46	24	23	31
	0.250 – 0.500	10	14	12	13	12
	0.500 – 0.750	3	1	3	1	2
	0.750 – 1.000	2	1	1	2	2
	1.0 – 2.0					
	>2.0					
	Total number of individuals monitored**	2,562	2,498	2,507	2,734	2,664
	Number with measurable dose	410	482	472	443	522
	% with measurable dose	16%	19%	19%	16%	20%
	Collective TED (person-rem)	21.636	23.363	20.069	18.934	22.169
	Average measurable TED (rem)	0.053	0.048	0.043	0.043	0.042
All DOE	Total number of records for monitored individuals	75,593	77,848	79,906	75,633	76,112
	Number of individuals with measurable dose	10,033	11,983	13,019	13,335	13,816
	% of total monitored individuals who are transient	3.4%	3.2%	3.1%	3.6%	3.5%
	% of the number of individuals with measurable dose who are transient	4.1%	4.0%	3.6%	3.3%	3.8%

*Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
** Total number of individuals represents the number of individuals monitored and not the number of records.

Exhibit 3-18:
Collective Dose and Average Measurable Dose, CY 1974 – 2019.

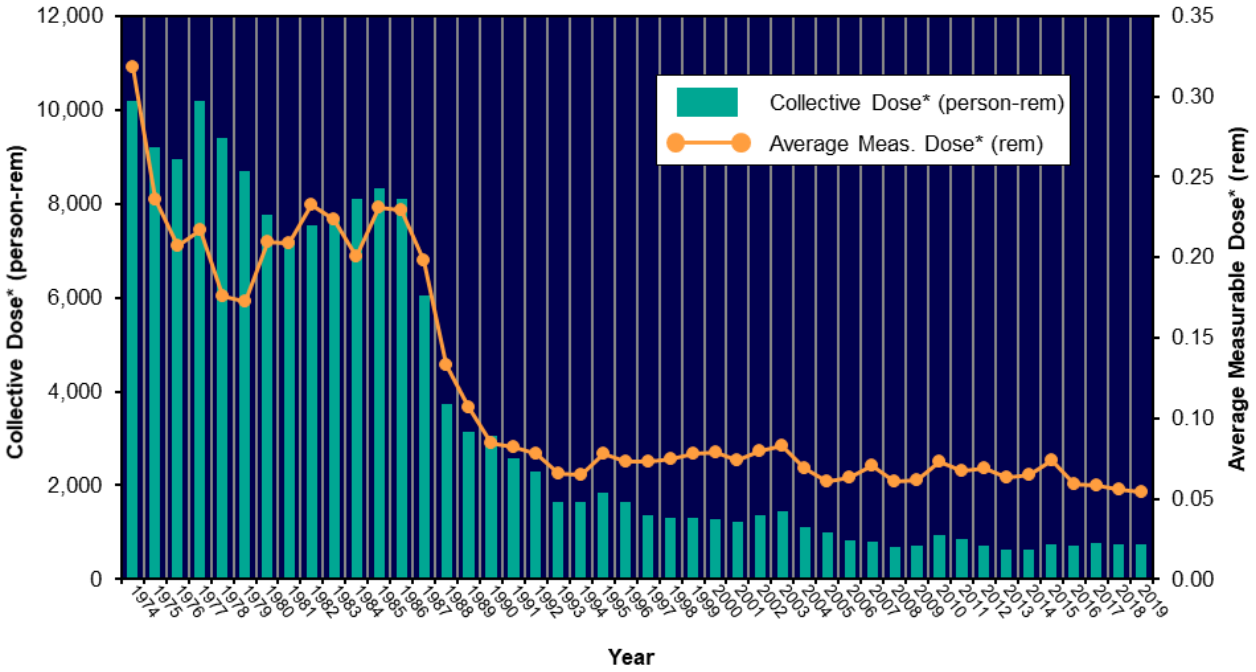
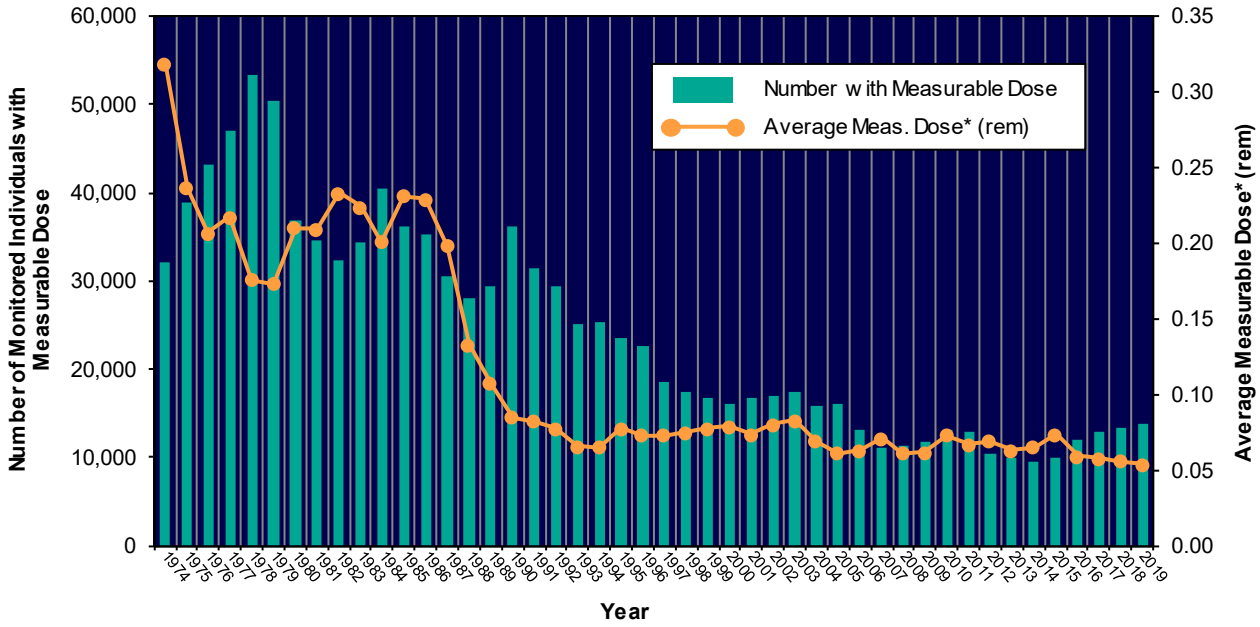


Exhibit 3-19:
Number of Workers with Measurable Dose and Average Measurable Dose, CY 1974 – 2019.



* 1974 – 1989 collective dose = DDE
1990 – 1992 collective dose = DDE + AEDE
1993 – 2009 collective dose = DDE + CEDE
2010 – 2020 collective dose = ED + CED

1946 – 1974 Atomic Energy Commission (AEC)
1974 – 1977 Energy Research and Development Administration (ERDA)
1977 – Present Department of Energy (DOE)

ALARA Activities at DOE

Descriptions of ALARA activities at DOE are collected for the purpose of sharing strategies and techniques that have shown promise in reducing the radiation exposure and to facilitate the dissemination among DOE radiation protection managers and others. Project descriptions are voluntarily submitted from the sites and are not independently verified or endorsed by DOE. Program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of integrated safety management and quality are encouraged to provide input.

Descriptions of ALARA activities at DOE are provided on the DOE web site:

https://www.energy.gov/ehss/occupational-radiation-exposure-publications

4.1 Submitting ALARA Project Descriptions for Future Reports

Individual project descriptions may be submitted to the DOE Office of Environmental Protection and ES&H Reporting (AU-23) through the REMS web site. The submissions 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 web site provides a form to collect the following information about the project:

- Mission statement;
- Project description;
- Radiological concerns;
- Total collective dose for the project;
- Dose rate to exposed workers before and after exposure controls were implemented;
- Information on how the process implemented ALARA techniques in an innovative or unique manner;
- Estimated dose avoided;
- Project staff involved;
- Approximate cost of the ALARA effort;
- Impact on work processes, in person-hours if possible (may be negative or positive);
- Figures and/or photos of the project or equipment (electronic images if available); and
- Point of contact for follow-up by interested professionals.

The REMS web page for submitting ALARA project descriptions can be accessed on the internet at:

https://www.energy.gov/ehss/downloads/line-alara-project-submittal-form-report-alara-project-descriptions-rems

4.2 Operating Experience Program

DOE has a mature Operating Experience Program (OEP), which has been enhanced from the lessons learned program that was initially developed in CY 1994. The OEP is described in DOE O 210.2A, DOE Corporate Operating Experience Program [9]. The objectives of the OEP are to institute a DOE-wide program for the management of operating experience to prevent adverse operating incidents and to expand the sharing of good work practices among DOE sites. The program provides a systematic review, identification, collection, screening, evaluation, and dissemination of operating experience from U.S. and foreign government agencies and industry, professional societies, trade associations, national academies, universities, and DOE and its contractors. DOE Headquarters takes corporate responsibility for identifying, analyzing, and sharing operating experience information. Operating experience/lessons learned provided by DOE field sites optimize the knowledge gained by communicating through various products, including a corporate database.

DOE posts operating experience information and links to other operating experience resources on the internet. DOE uses the internet to disseminate information so that DOE and external entities may improve the health and safety aspects of operations within their facilities, including reducing the number of accidents and injuries.

For further information contact:

Ms. Colette Broussard
Office of ES&H Reporting and Analysis (AU-23)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-1290
E-mail: colette.broussard@hq.doe.gov

https://www.energy.gov/ehss/corporate-operating-experience-program

Conclusions

Analysis of the collected exposure data for CY 2019 indicate that DOE operations were in compliance with regulatory and organizational radiation protection requirements as no exposures were reported to have exceeded the occupational dose limit of 5 rem (50 mSv) TED or the ACL of 2 rem (20 mSv). Only 18 percent of the monitored workers received a measurable dose, and the average measurable dose received was only 1 percent of the 5 rem TED limit.

The data also indicates that the collective dose decreased by less than 1 percent although the number of individuals with measurable dose increased by 4 percent. In addition, from CY 2018 to CY 2019 the:

- collective TED for all DOE facilities decreased by less than 1 percent or 1.1 person-rem (110 person-mSv);
- collective CED (internal exposure to U-234) decreased by 15 percent to 50.5 person-rem (505 person-mSv); and
- collective TED for transient workers increased by 17 percent to 22.2 person-rem (222 person-mSv).

The collective dose at DOE facilities has decreased by 91 percent since CY 1986. This coincides with the end of the Cold War era, which shifted the DOE mission from weapons production to stabilization, waste management, and environmental remediation activities, along with the consolidation and remediation of facilities across the complex to meet the new mission. Also, in alignment with the change in mission, regulations and requirements have been modified (see Section 2) that reinforce DOE's focus on ALARA practices and risk reduction to lowering occupational radiation dose.

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Glossary

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

As Low As Reasonably Achievable (ALARA)
ALARA means "As Low As is Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable. [10 CFR 835.2]

Average Measurable Dose
The 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. In this report, average measurable dose is calculated for total effective dose (TED) and committed effective dose (CED).

Collective Dose
The sum of doses to all individuals in a population for a period of time. The general term "collective dose" is used whenever the dose may refer to more than one type of dose. In cases where the type of dose is specified, the term "collective" is followed by the type of dose such as the TED, CED, or photon. In all cases, the population is the group of DOE workers that were monitored for occupational radiation exposure, and the period of time is the monitoring year. Collective dose is expressed in units of person-rem.

Committed Effective Dose (CED) or (E_{50})
Committed effective dose (E_{50}) means the sum of the committed equivalent doses to various tissues or organs in the body ($H_{T,50}$), each multiplied by the appropriate tissue weighting factor (w_T)—that is, $E_{50} = \Sigma w_T H_{T,50} + w_{Remainder} H_{Remainder,50}$. Where $w_{Remainder}$ is the tissue weighting factor assigned to the remainder organs and tissues and $H_{Remainder,50}$ is the committed equivalent dose to the remainder organs and tissues. Committed effective dose is expressed in units of rem (or Sv). [10 CFR 835.2]

Committed Equivalent Dose (CEqD) or ($H_{T,50}$)
Committed equivalent dose ($H_{T,50}$) means the equivalent dose 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 equivalent dose is expressed in units of rem (or Sv). [10 CFR 835.2]

Dose
Dose is a general term for absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or total effective dose as defined in this part. [10 CFR 835.2]

Effective Dose
Effective dose (E) means the summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (w_T)—that is, $E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with this part, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose is expressed in units of rem (or Sv). [10 CFR 835.2]

Equivalent Dose (EqD)
Equivalent dose (H_T) means the product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (w_R). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rem (or Sv). [10 CFR 835.2]

Measurable Dose
A dose greater than zero rem (not including doses reported as "not detectable").

Member of the Public
Member of the public means an individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives an occupational dose. [10 CFR 835.2] The definition of general employee is specified in 10 CFR 835.

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

Occupational 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.

Person-rem
The unit of measurement used for the collective dose to all DOE Federal employees, contractors, and subcontractors.

Rem
A unit of dose derived from the phrase roentgen equivalent man. The rem is equal to 0.010 Sv, which is the international unit of measurement for radiation exposure.

Total Effective Dose (TED)
Total effective dose (TED) means the sum of the effective dose (for external exposures) and the committed effective dose. [10 CFR 835.2]

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

Total Organ Dose (TOD)
The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye.

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

Urinalysis
The technique of determining the amount of radioactive material in the urine excreted from the body.

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

4. 10 CFR 835, 1998, "Occupational Radiation Protection." Rule; DOE *Federal Register*, November 4, 1998. Amended August 11, 2017.

5. DOE O 231.1B, 2011, "Environment, Safety and Health Reporting," June 27, 2011.

6. REMS Reporting Guide, issued February 23, 2012. Online at https://www.energy.gov/ehss/downloads/radiation-exposure-monitoring-systems-data-reporting-guide.

7. Computerized Accident and Incident Reporting System (CAIRS), "DOE and Contractor Injury and Illness Data by Year by Quarter" report. Online at https://www.energy.gov/ehss/policy-guidance-reports/databases/computerized-accident-incident-reporting-system.

8. DOE Standard, DOE-STD-1098-2017, "Radiological Control," January 2017. Online at https://www.standards.doe.gov/standards-documents/1000/1098-AStd-2017/@@images/file.

9. DOE O 210.2A, "DOE Corporate Operating Experience Program," April 8, 2011. Online at https://www.directives.doe.gov/directives-documents/200-series/0210.2-BOrder-a/@@images/file.

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U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2019 User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2019*. **Your feedback is important**. Constructive feedback will ensure this report can continue to meet user needs. Please fill out the attached survey form and return it to:

Ms. Nirmala Rao
Office of ES&H Reporting and Analysis (AU-23)
DOE REMS Program Manager
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-1290
nimi.rao@hq.doe.gov
Fax: (301) 903-1257

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

1. Identification:

   Name: _____

   Title: _____

   Mailing Address: _____

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

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Please circle one.

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

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

Executive Summary	1	2	3	4	5
Analysis of Aggregate Data	1	2	3	4	5
Collective Dose	1	2	3	4	5
Average Measurable Dose	1	2	3	4	5
Dose Distribution	1	2	3	4	5
Analysis of Individual Dose Data	1	2	3	4	5
Doses in Excess of DOE limit (5 rem)	1	2	3	4	5
Doses in Excess of ACL limit (2 rem)	1	2	3	4	5
Intakes of Radioactive Material	1	2	3	4	5
Bioassay and Intake Summary Information	1	2	3	4	5
Analysis of Site Data	1	2	3	4	5
Collective TED by Site and Other Facilities	1	2	3	4	5
Activities Significantly Contributing to Collective Dose	1	2	3	4	5
Additional Site Descriptions	1	2	3	4	5
Summary by Program Office	1	2	3	4	5
Transient Individuals	1	2	3	4	5
Historical Data	1	2	3	4	5
ALARA Activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

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

Not important				Critical
1	2	3	4	5

Please provide any additional input or comments on this report.

Prepared for the Office of Environment, Health, Safety and Security
by ORISE, P.O. Box 117 • Oak Ridge, TN 37831-0117