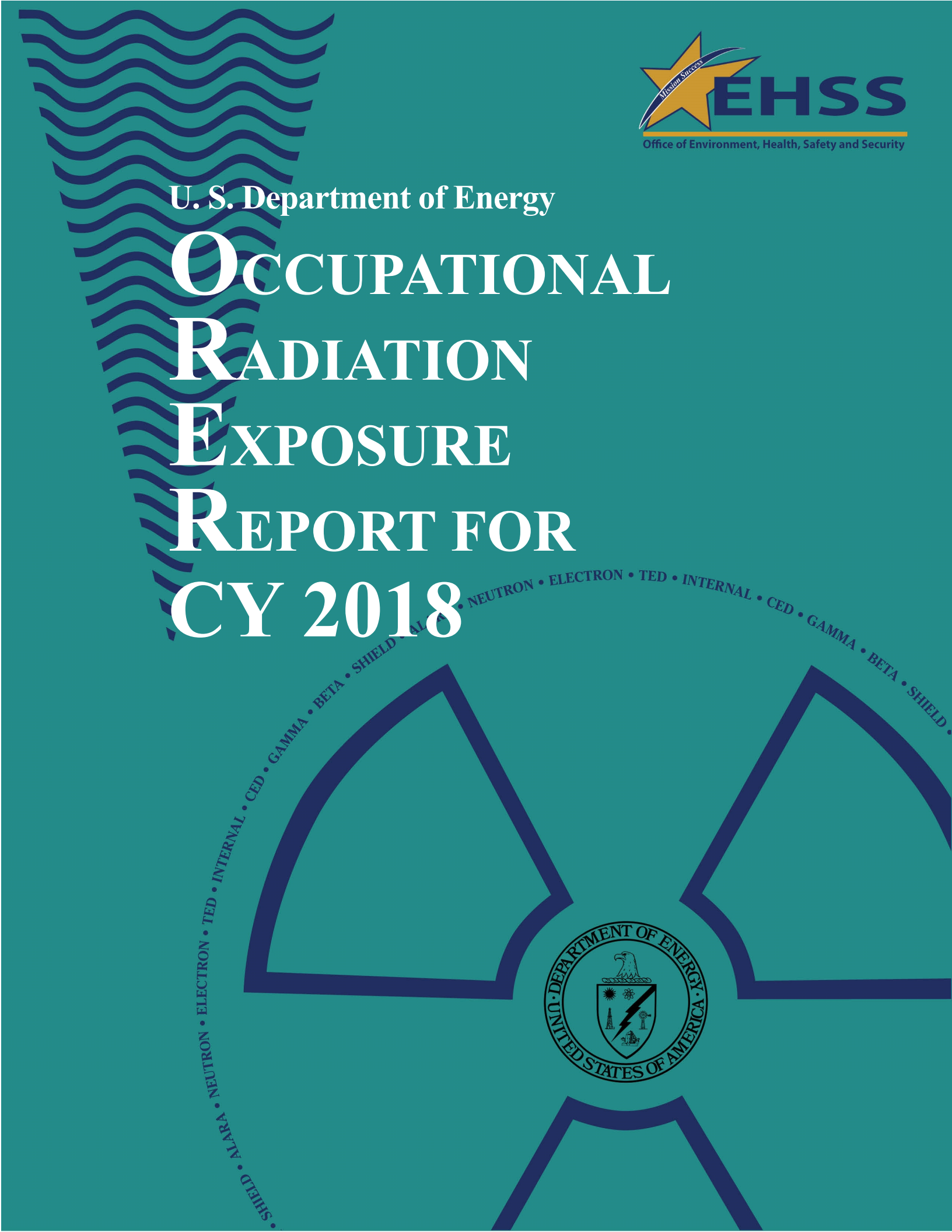
Office of Environment, Health, Safety and Security

U. S. Department of Energy

Occupational Radiation Exposure Report for CY 2018



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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 2018

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Foreword

The *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2018* presents the results of analyses of occupational radiation exposures at DOE (including the National Nuclear Security Administration [NNSA]) operations during calendar year (CY) 2018. The report includes occupational radiation exposure data for over 75,000 DOE employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation.

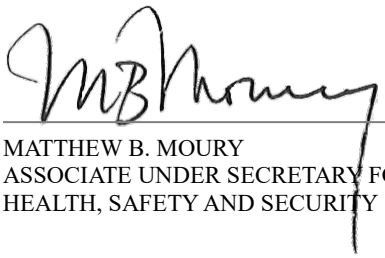
DOE publishes this annual report to provide DOE Management, Program Offices, workers, health physicists and other stakeholders an evaluation of DOE-wide performance regarding compliance with Title 10 of the Code of Federal Regulations (CFR), Part 835, Occupational Radiation Protection (10 CFR 835) radiation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

The report provides a discussion regarding radiation protection and exposure reporting requirements as well as information and analyses regarding aggregate, individual, site, DOE Program, and transient worker exposure data; a 44-year historical review of DOE exposure data; and a DOE occurrence report review.

The analyses provided in this report indicate that Departmental operations were well in compliance with radiation protection requirements as demonstrated by the fact that the average measurable dose received by the 18 percent of monitored individuals exposed to radiation in CY 2018 was only 1 percent of the regulatory limit. The data also indicates that the collective exposure dose amounts decreased by 2 percent although the number of individuals who received a measurable dose increased by 2 percent.

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 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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LIST OF EXHIBITS

LIST OF ABBREVIATIONS AND ACRONYMS

ACL	Administrative Control Level
AEC	U.S. Atomic Energy Commission
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
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DOE	U.S. Department of Energy
ED	Effective Dose
EqD-ME	Equivalent Dose to the Skin of the Maximally Exposed Extremity
EqD-SKWB	Equivalent Dose to the Skin of the Whole Body
EE	Office of Energy Efficiency and Renewable Energy
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
EqD	Equivalent Dose
ERDA	Energy Research and Development Administration
ES&H	Environment, Safety, & Health
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park (Formerly K-25 Site)
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
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, formally known as Nevada Test Site (NTS)
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
ORPS	Occurrence Reporting and Processing System
OST	Office of Secure Transportation
PFP	Plutonium Finishing Plant
PGDP	Paducah Gaseous Diffusion Plant
PNNL	Pacific Northwest National Laboratory
PORTS	Portsmouth Gaseous Diffusion Plant
PPPL	Princeton Plasma Physics Laboratory
Ra-226	Radon-226
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
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

Summary
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 (AU) publishes the annual *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2018* 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 2018* presents the results of analyses of occupational radiation exposures at DOE (including the National Nuclear Security Administration [NNSA]) operations during calendar year (CY) 2018. This report includes occupational radiation exposure information for over 75,000 DOE employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation. The 111 DOE organizations that submitted radiation exposure reports in CY 2018 have been grouped into 35 sites. The information has been analyzed to provide a measure of DOE's performance in protecting its workers from radiation.

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 results of the exposure monitoring 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 (ES&H). 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."

Analysis of the collected radiation dose data for CY 2018 indicate that Departmental 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 2017 to 2018 were:

- the collective TED for all DOE facilities decreased by 2 percent or 12.8 person-rem (128 person-mSv);
- the number of individuals with measurable dose increased by 2 percent;
- the collective CED decreased by 16 percent to 55.2 person-rem (552 person-mSv);
- the collective TED for transient workers (individuals monitored at more than one DOE site) decreased by 6 percent to 18.9 person-rem (189 person-mSv); and
- the sites contributing the majority of the collective TED were (in descending order): Los Alamos National Laboratory (LANL), Oak Ridge, Savannah River, Idaho, and Hanford. These sites accounted for 84 percent of the collective TED in CY 2018. The collective TED increased at LANL and Idaho. The collective TED decreased at Hanford, Oak Ridge, and Savannah River.

During CY 2014 – 2018, a total of 4,927 occurrence reports were submitted to the DOE Occurrence Reporting and Processing System (ORPS). Of these, 8 percent (383) included being tagged with at least one of the 11 Radiological Headquarters (HQ) Keywords. The occurrences were mainly Facility / Equipment / Site

Contamination (68%), Clothing Contamination (19%), and Skin Contamination (15%). External Exposure and Intake each accounted for 2% of the reports.

Over the past 5 years, all monitored individuals received doses below the 2 rem (20 mSv) TED ACL, which is well below the DOE annual limit of 5 rem (50 mSv) TED. The occupational radiation exposure records show that in CY 2018, 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. As DOE has become more involved in the new missions, the collective and average doses have been relatively low. 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

Introduction

The *U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2018* presents the results of analyses of occupational radiation exposures at DOE (including the National Nuclear Security Administration [NNSA]) operations during calendar year (CY) 2018. This report includes occupational radiation exposure information for DOE employees, contractors, and subcontractors, as well as members of the public who have worked or entered controlled areas monitored for exposure to radiation. The 111 DOE organizations that submitted radiation exposure reports for CY 2018 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 the 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 results of the exposure monitoring are used to determine the radiation dose received by the individual, which is reported to DOE in accordance with DOE Order 231.1B. 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 the five sections. Section 1 describes the content and organization of this report. Section 2 discusses the radiation protection and dose reporting requirements. Section 3 presents the CY 2018 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 as low as reasonably achievable (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. Additional supporting technical information on occupational radiation exposure, such as tables of data, report appendices, and additional items are available on the DOE web site at: https://energy.gov/ehss/occupational-radiation-exposure.

1.2 Report Availability

This report is available online and can be downloaded from:

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

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:

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The DOE Radiation Exposure Monitoring System (REMS) web site contains additional information on occupational radiation exposure, such as:

- Annual occupational radiation exposure reports 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.

Standards and Requirements

It is DOE's intent to provide a safe and healthy workplace for all DOE employees, contractors, and subcontractors, as well as members of the public that visit DOE facilities. To meet this intent, 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, contractors and subcontractors are 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 2018.

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 Title 10, *Code of Federal Regulations*, Part 835, Occupational Radiation Protection (10 CFR 835), sections 202, 206, 207, and 208 [4] and are summarized in *Exhibit 2-2*.

2.3 Reporting Requirements

On June 27, 2011, DOE Order (O) 231.1A was updated and reissued as DOE O 231.1B, *Environment, Safety and Health Reporting* [5], which 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 available online at: https://www.energy.gov/ehss/downloads/radiation-exposure-monitoring-systems-data-reporting-guide [6].

Exhibit 2-1:
Laws 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 Order 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 Order 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

Key indicators are analyzed to identify and correlate parameters that impact occupational radiation doses at DOE.

The key indicators for analyzing aggregate data are:

- 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 next year's annual report.

3.2 Analysis of Aggregate Data

3.2.1 Number of Monitored Individuals

As stated in Section 2, DOE requires the reporting of the results of annual individual occupational radiation exposure monitoring to the REMS repository. The results 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 since 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.

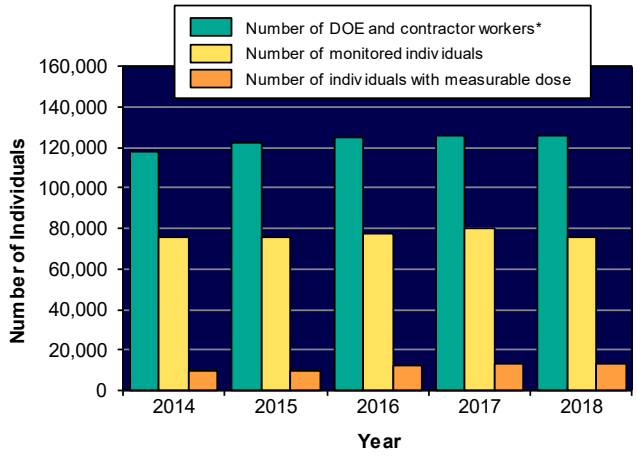
3.2.2 Number of Individuals with Measurable Dose

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 below a TED of 2 rem (20 mSv), the DOE ACL, and hence well below the DOE regulatory limit of 5 rem (50 mSv) TED in a year.

Exhibit 3-1a and *Exhibit 3-1b* show the number of DOE and contractor 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 and contract workers was calculated by converting the total number of hours worked each year into an estimate of the number of workers by dividing the total hours worked 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 and is included here in order to compare it to the number of workers who are monitored.

Exhibit 3-1a:
Monitoring of the DOE Workforce, CY 2014 – 2018.



For CY 2018, 60% of the DOE workforce was monitored for radiation dose, and 18% of monitored individuals received a measurable dose.

Exhibit 3-1b:
Monitoring of the DOE Workforce, CY 2014 – 2018.

Year	DOE & Contractor Workforce*	Number of Monitored Individuals	Percent of Monitored Individuals**	Number of Individuals with Measurable Dose	Percent of Individuals with Measurable Dose**
2014	117,704	75,470	64% ▲	9,508	13% ▼
2015	122,141	75,587	62% ▼	10,033	13%
2016	125,324	77,836	62%	11,987	15% ▲
2017	126,269	79,903	63% ▲	13,024	16% ▲
2018	125,840	75,606	60% ▼	13,320	18% ▲
5-Year Average	**123,456**	**76,880**	**62%**	**11,574**	**15%**

* 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.

3.2.3 Collective Dose

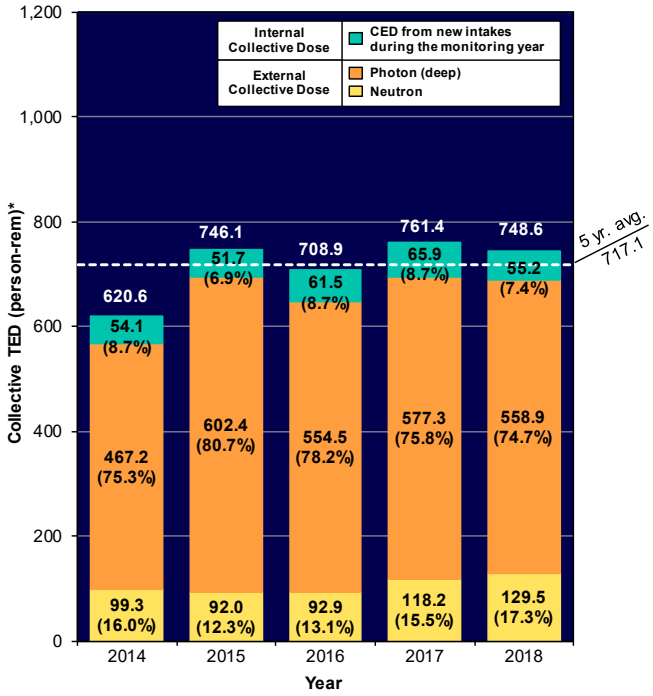
The collective dose is the sum of the dose received by all individuals with a measurable dose and is measured in units of person-rem and person-mSv. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective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

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 2 percent from 761.4 person-rem (7,614 person-mSv) in CY 2017 to 748.6 person-rem (7,486 person-mSv) in CY 2018.

The internal dose is based on the 50-year Committed Effective Dose (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.

Exhibit 3-2:
Components of TED, CY 2014 – 2018.



The collective TED decreased by 2% at DOE from CY 2017 to 2018.

The collective internal dose decreased by 16% from CY 2017 to 2018.

The collective neutron dose increased by 10% from CY 2017 to 2018.

The collective photon dose decreased by 3% from CY 2017 to 2018.

Effective Dose from photons—the component of external dose from gamma or X-ray electromagnetic radiation (also includes energetic betas)

Effective dose from neutrons—the component of external dose from neutrons ejected from the nucleus of an atom during nuclear reactions

Internal dose—radiation dose resulting from radioactive material taken into the body

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

The internal dose component of the collective TED decreased by 16 percent from 65.9 person-rem (659 person-mSv) in CY 2017 to 55.2 person-rem (552 person-mSv) in CY 2018, due to decreases in internal doses across the DOE complex. The collective photon dose decreased by 3 percent from 577.3 person-rem (5,773 person-mSv) in CY 2017 to 558.9 person-rem (5,589 person-mSv) in CY 2018.

The neutron component of the collective TED increased by 10 percent from 118.2 person-rem (1,182 person-mSv) in CY 2017 to 129.5 person-rem (1,295 person-mSv) in CY 2018. The increase resulted primarily from increases in collective neutron dose at LANL (29 percent).

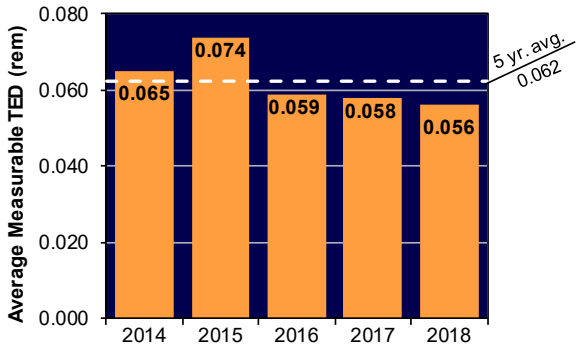
Five DOE sites contributed 84 percent of the collective TED in CY 2018. In descending order of collective TED, these were: LANL, Oak Ridge, Savannah River, Idaho and Hanford. LANL and Idaho had increases in collective TED in CY 2018 while the other three top contributors reported decreases in collective 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 collective dose (in this case, TED) by the number of individuals with measurable dose for TED. This is the average most commonly used when examining trends and comparing doses received by workers, because it reflects the exclusion of those individuals receiving a less than measurable dose.

Exhibit 3-3 illustrates that the average measurable TED decreased by 3 percent from 0.058 rem (0.580 mSv) in CY 2017 to 0.056 rem (0.560 mSv) in CY 2018. For the third year in a row, the average measurable TED has remained below the 5 year average of 0.062 rem (0.620 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.

Exhibit 3-3:
Average Measurable TED, CY 2014 – 2018.



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].

Eighty-six percent of monitored individuals 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 also shows that the dose (TED) distribution for CY 2018 was higher in the 0.750 – 1.000 rem range compared with the CY 2017 data. Ninety-nine percent of all individuals monitored had doses less than 0.250 rem (2.5 mSv).

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

The 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.

Exhibit 3-4:
Distribution of TED by Dose Range, CY 2014 – 2018.

	TED Range (rem)*	2014	2015	2016	2017	2018
Number of Individuals in Each Dose Range	Less than measurable	65,962	65,554	65,849	66,879	62,286
	Measurable to 0.100	7,712	8,029	10,142	11,011	11,405
	0.100 – 0.250	1,259	1,342	1,246	1,396	1,336
	0.250 – 0.500	444	449	451	480	428
	0.500 – 0.750	72	123	90	103	97
	0.750 – 1.000	15	49	38	13	39
	1.0 – 2.0	6	41	20	21	15
	2.0 – 3.0					
	3.0 – 4.0					
	4.0 – 5.0					
	>5.0					
Total number of records for monitored individuals		75,470	75,587	77,836	79,903	75,606
Number with measurable dose		9,508	10,033	11,987	13,024	13,320
Number with dose >0.100 rem		1,796	2,004	1,845	2,013	1,915
Collective TED (person-rem)		620.621	746.088	708.866	761.396	748.595
Average measurable TED (rem)		0.065	0.074	0.059	0.058	0.056

* 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 2014 – 2018.

	TED Range (rem)*	2014	2015	2016	2017	2018
Percentage of Individuals with Measurable TED	Measurable <0.100	81.11%	80.03%	84.61%	84.54%	85.62%
	0.100 – 0.250	13.24%	13.38%	10.39%	10.72%	10.03%
	0.250 – 0.500	4.67%	4.48%	3.76%	3.69%	3.21%
	0.500 – 0.750	0.76%	1.23%	0.75%	0.79%	0.73%
	0.750 – 1.000	0.16%	0.49%	0.32%	0.10%	0.29%
	1.0 – 2.0	0.06%	0.41%	0.17%	0.16%	0.11%
	2.0 – 3.0	0.00%	0.00%	0.00%	0.00%	0.00%
	>3.0	0.00%	0.00%	0.00%	0.00%	0.00%
% of monitored individuals with measurable dose		13%	13%	15%	16%	18%
% of monitored individuals with dose > 0.100 rem		2%	3%	2%	3%	3%

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

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 DOE Limit

No individual was reported to have exceeded the TED regulatory limit (5 rem [50 mSv]) from CY 2014 through 2018.

3.3.2 Doses in Excess of Administrative Control Level

The DOE Standard Radiological Control (DOE-STD-1098-2018) [8] establishes a 2 rem (20 mSv) ACL for TED per year per person for all DOE activities. Approval by the appropriate Secretarial Officer or designee should be required prior to allowing an individual to exceed this value. 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 2 rem (20 mSv) TED from CY 2014 through 2018.

3.3.3 Intakes of Radioactive Material

DOE tracks the number of radionuclide intakes as a performance measure in the report. DOE emphasizes the importance of taking measures to avoid intakes and maintain doses as low as reasonable through the ALARA principle. It should be noted that intakes involving certain radionuclides can take significant time to analyze and determine the final dose. This can result in updates to prior year dose totals if the updates are received after the March 31 annual reporting deadline.

Exhibit 3-6 shows the number of individuals with measurable CED, collective CED, and average measurable CED for CY 2014 through 2018. The number of individuals with measurable CED increased by 4 percent from 1,287 in CY 2017 to 1,333 in CY 2018, while the collective CED decreased by 16 percent. The average measurable CED decreased from 0.051 rem (0.510 mSv) in CY 2017 to 0.041 rem (0.410 mSv) in CY 2018 and was below the 5-year average measurable CED.

Ninety-eight percent of the collective CED in CY 2018 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 2014 through 2018. 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.

Exhibit 3-6:
Number of Individuals with Measurable CED, Collective CED, and Average Measurable CED, CY 2014 – 2018.

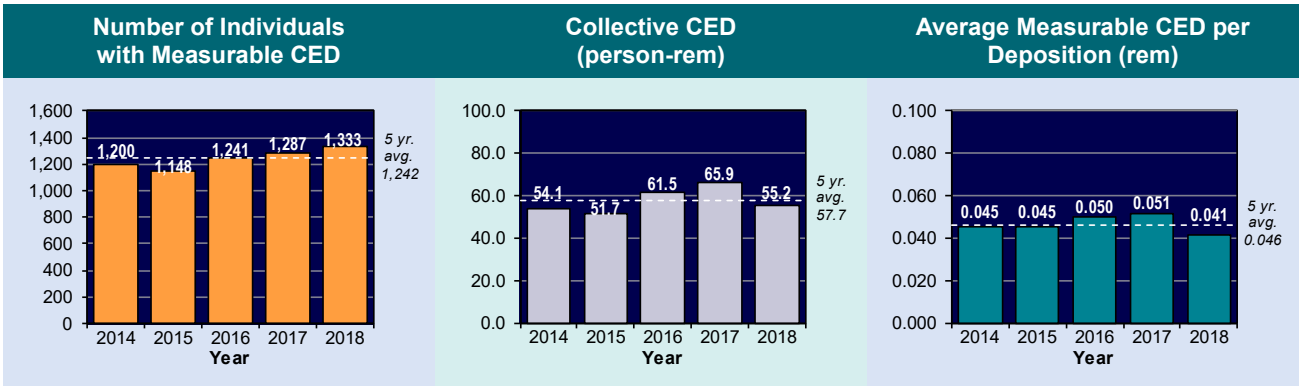


Exhibit 3-7:
Internal Dose Distribution from Intakes, CY 2014 – 2018.

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		
2014	565	479	140	14	2							1,200	54.082
2015	540	467	117	23	1							1,148	51.714
2016	546	522	135	36	2							1,241	61.544
2017	554	544	148	38	3							1,287	65.923
2018	630	546	143	13	1							1,333	55.198

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

The internal dose records indicate that the majority of the intakes resulted in very low doses. In CY 2018, 47 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 11 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

For the monitoring year CY 2018, bioassay and intake summary information was 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. *Exhibit 3-8* shows the breakdown of bioassay measurements by measurement type and number of measurements. LANL had the largest percentage increase (380 percent) in the number of "Urinalysis" measurements in CY 2018. 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 ORNL—accounted for 80 percent of the "In Vivo" measurements.

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. The majority of the measurements reported as "Air Sampling" accounted for 19 percent of the total measurements. Nevada National Security Site (NNSS) had the largest percentage increase in the number of "Air Sampling" measurements, increasing from 75 air sample measurements in CY 2017, to 126 air sample measurements in CY 2018 (see *Exhibit 3-14* for additional information).

Exhibit 3-8:
Bioassay Measurements, CY 2014 – 2018.

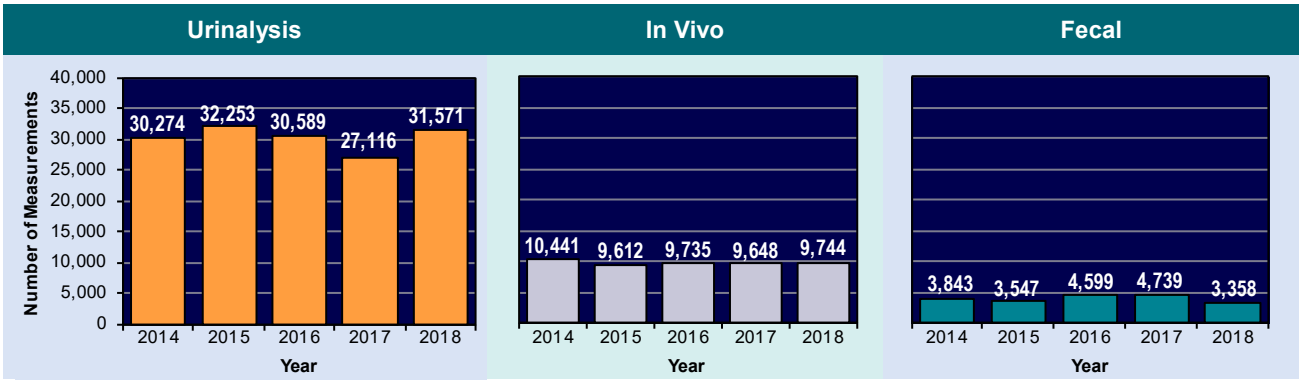


Exhibit 3-9:
Air Sampling Measurements, CY 2014 – 2018.

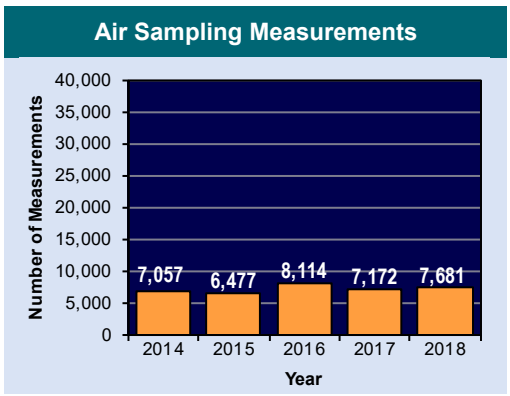
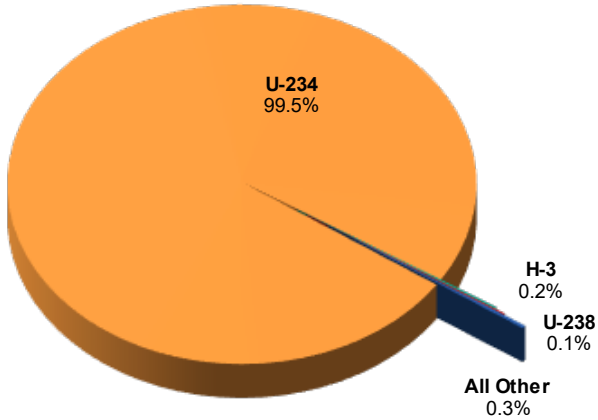


Exhibit 3-10:
Collective CED by Radionuclide from Internal Exposure, CY 2018.



Sixty-four percent of the "Urinalysis" measurements in CY 2018 were performed at four sites: Y-12, LANL, SRS, and Lawrence Livermore National Laboratory (LLNL).

Y-12 performed the largest number of bioassay and air sampling measurements combined, comprising 31 percent of the total measurements taken.

Exhibit 3-10 shows the breakdown of the collective CED by radionuclide for CY 2018. U-234 accounted for the largest percentage of the collective CED, with over 99 percent of this dose accrued at Y-12.

The annual REMS appendices can be found at https://www.energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports, within each annual report.

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 offer more detailed information regarding intake data.

3.4 Analysis of Site Data

3.4.1 Collective TED by Site and Other Facilities

The collective TED values for CY 2016 through 2018 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 2016 – 2018.

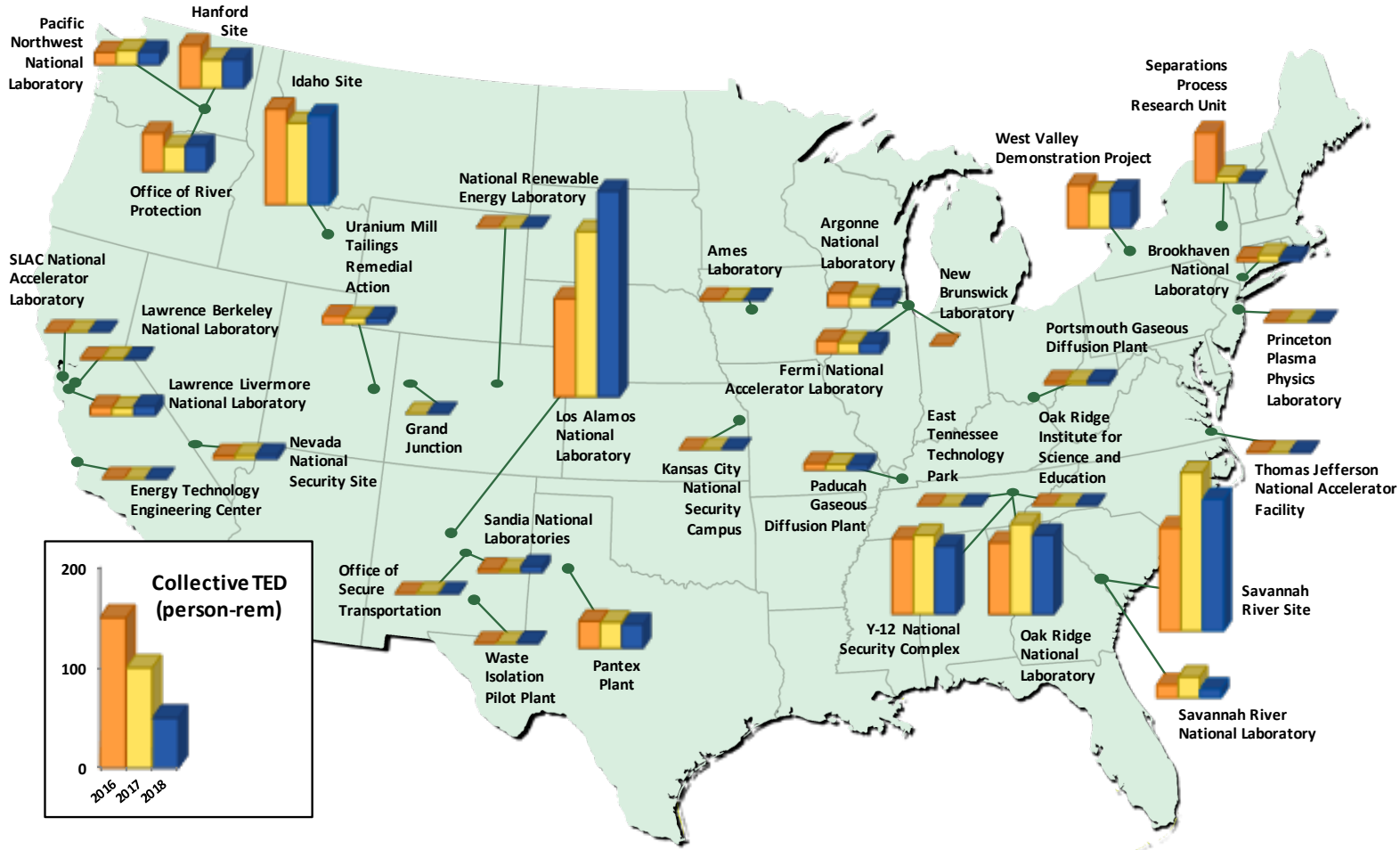


Exhibit 3-12:
Collective TED and Number of Individuals with Measurable TED by DOE Site, CY 2016 – 2018.

Site	2016		2017		2018	
	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	1.240	41	1.053	38	0.935	33
Argonne National Laboratory	13.080	70	9.885	75	7.112	75
Brookhaven National Laboratory	3.217	84	6.076	77	3.924	125
Energy Technology Engineering Center	0.089	2	0.026	2	0.059	3
Fermi National Accelerator Laboratory	11.930	232	10.210	201	9.980	188
Grand Junction Site *			0.010	2	0.336	22
Hanford:						
Hanford Site	41.095	1,217	27.003	717	27.172	566
Office of River Protection	37.102	929	24.387	597	24.926	570
Pacific Northwest National Laboratory	11.599	420	13.555	517	12.225	494
Hanford Totals:	89.796	2,566	64.945	1,831	64.323	1,630
Idaho Site	92.670	1,273	79.008	1,175	86.266	1,368
Kansas City National Security Campus	0.063	24	0.171	44	0.428	58
Lawrence Berkeley National Laboratory	0.823	13	1.257	18	1.014	22
Lawrence Livermore National Laboratory	8.215	98	7.134	115	8.691	145
Los Alamos National Laboratory	95.565	1,106	160.772	1,850	**203.451**	1,953
National Renewable Energy Laboratory	0.034	7	0.020	4	0.006	1
Nevada National Security Site	3.295	84	3.858	94	3.893	74
New Brunswick Laboratory **	0.096	4				
Oak Ridge:						
East Tennessee Technology Park	0.114	3	0.093	6	0.147	18
Oak Ridge Institute for Science and Education	0.171	9	0.243	23	0.317	20
Oak Ridge National Laboratory	69.378	617	87.621	661	76.833	615
Y-12 National Security Complex	72.752	1,459	75.761	1,455	65.234	1,516
Oak Ridge Totals:	**142.415**	2,088	163.718	2,145	142.531	2,169
Office of Secure Transportation	0.072	3	0.311	8	0.288	14
Paducah Gaseous Diffusion Plant	6.201	559	5.159	113	4.580	109
Pantex Plant	25.918	295	24.986	333	22.927	312
Portsmouth Gaseous Diffusion Plant	2.509	40	2.553	41	3.588	69
Princeton Plasma Physics Laboratory	0.311	78	0.361	49	0.239	38
Sandia National Laboratories	2.756	68	2.146	73	5.819	175
Savannah River:						
Savannah River National Laboratory	12.358	361	20.051	576	8.463	314
Savannah River Site	98.980	2,438	152.495	3,835	126.869	4,101
Savannah River Totals:	111.338	**2,799**	**172.546**	**4,411**	135.332	**4,415**
Separations Process Research Unit	47.541	101	5.185	59	0.208	10
SLAC National Accelerator Laboratory	0.170	6	0.057	4	0.047	3
Thomas Jefferson National Accelerator Facility	0.777	30	0.270	20	0.526	26
Uranium Mill Tailings Remedial Action Project	7.044	131	5.656	66	5.485	77
Waste Isolation Pilot Plant	0.311	22	0.279	17	0.909	42
West Valley Demonstration Project	41.122	147	33.653	154	35.549	160
Service Center Personnel ***	0.268	16	0.091	5	0.149	4
Totals	**708.866**	**11,987**	**761.396**	**13,024**	**748.595**	**13,320**

Note: Bold and boxed values indicate the greatest value in each column.
* Grand Junction Site began reporting under the Office of Legacy Management in CY 2017.
** In May 2016, the Office of Science reorganized the New Brunswick Laboratory. Prior operations have ceased and the name is no longer used
*** Includes personnel at National Nuclear Security Administration (NNSA) Albuquerque complex, Oak Ridge, and WIPP in addition to several smaller facilities not associated with a DOE site.

The collective TED decreased 2 percent from 761 person-rem (7,610 person-mSv) in CY 2017 to 749 person-rem (7,490 person-mSv) in CY 2018, with LANL; Oak Ridge (including ETTP, Y-12, ORNL, and ORISE); Savannah River (including SRNL and SRS); Idaho (including INL, ICP, and AMWTP); and Hanford (including the Hanford Site, PNNL, and ORP) contributing 84 percent of the total DOE collective TED.

3.4.2 Changes by Site from CY 2017 to 2018

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. Although Sandia had the highest percent change (171% increase), with a collective TED increase of 3.673 person-rem from CY 2017 to 2018, Los Alamos had a substantial collective TED increase of 42.679 person-rem during that same year. (See section 3.4.3.)

Seventeen of the 35 DOE sites reported increases in the collective TED from the CY 2017 values, and 18 of the 35 DOE sites reported decreases in the collective TED from the CY 2017 values.

Eighteen of the 35 reporting sites experienced increases in the number of workers with a measurable TED from CY 2017 to 2018. The largest increase in total number of workers with a measurable TED occurred at SRS with an increase of 266 workers.

Sixteen of the 35 reporting sites experienced decreases in the number of workers with a measurable TED from CY 2017 to 2018. The largest decrease in the number of workers receiving a measurable TED occurred at SRNL with a decrease of 262 workers. One site (Argonne National Laboratory) 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 2018

In an effort to identify the reasons for changes in the collective dose at DOE, all of the sites provided information on activities that significantly contributed to the collective dose for CY 2018 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 five year average TED. Sites that have reported less than 5 person-rem (50 person-mSv) for CY 2018 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 2018.

Site	2018							
	Collective TED (person-rem)	Percent Change from 2017	Number of Monitored	Percent Change from 2017	Number with Meas. TED	Percent Change from 2017	Avg. Meas. TED (person-rem)	Percent Change from 2017
Ames Laboratory	0.935	◊ ▼	192	◊ ▲	33	◊ ▼	0.028	◊ ▲
Argonne National Laboratory	7.112	-28% ▼	1,791	1% ▲	75	◊	0.095	-28% ▼
Brookhaven National Laboratory	3.924	-35% ▼	4,002	9% ▲	125	62% ▲	0.031	-60% ▼
Energy Technology Engineering Center	0.059	◊ ▲	7	◊ ▼	3	◊ ▲	0.020	◊ ▲
Fermi National Accelerator Laboratory	9.980	-2% ▼	1,454	6% ▲	188	-6% ▼	0.053	5% ▲
Grand Junction Site	0.336	◊ ▲	27	◊ ▼	22	◊ ▲	0.015	◊ ▲
Hanford:								
Hanford Site	27.172	1% ▲	3,669	-8% ▼	566	-21% ▼	0.048	27% ▲
Office of River Protection	24.926	2% ▲	2,799	5% ▲	570	-5% ▼	0.044	7% ▲
Pacific Northwest National Laboratory	12.225	-10% ▼	2,413	-2% ▼	494	-4% ▼	0.025	-6% ▼
Hanford Totals:	*64.323*	*-1%* ▼	*8,881*	-2% ▼	*1,630*	*-11%* ▼	*0.039*	*11%* ▲
Idaho Site	86.266	9% ▲	7,396	3% ▲	1,368	16% ▲	0.063	-6% ▼
Kansas City National Security Campus	0.428	◊ ▲	164	◊ ▲	58	◊ ▲	0.007	◊ ▲
Lawrence Berkeley National Laboratory	1.014	-19% ▼	935	-1% ▼	22	22% ▲	0.046	-34% ▼
Lawrence Livermore National Laboratory	8.691	22% ▲	3,748	-57% ▼	145	26% ▲	0.060	-3% ▼
Los Alamos National Laboratory	**203.451**	27% ▲	**11,836**	9% ▲	1,953	6% ▲	0.104	20% ▲
National Renewable Energy Laboratory	0.006	◊ ▼	11	◊ ▼	1	◊ ▼	0.006	◊ ▲
Nevada National Security Site	3.893	1% ▲	1,415	-8% ▼	74	-21% ▼	0.053	**28%** ▲
Oak Ridge:								
East Tennessee Technology Park	0.147	◊ ▲	360	◊ ▲	18	◊ ▲	0.008	◊ ▼
Oak Ridge Institute for Science and Education	0.317	◊ ▲	89	◊ ▼	20	◊ ▼	0.016	◊ ▲
Oak Ridge National Laboratory	76.833	-12% ▼	4,111	-2% ▼	615	-7% ▼	0.125	-6% ▼
Y-12 National Security Complex	65.234	-14% ▼	5,794	-6% ▼	1,516	4% ▲	0.043	-17% ▼
Oak Ridge Totals:	142.531	-13% ▼	10,354	-4% ▼	2,169	1% ▲	0.066	-14% ▼
Office of Secure Transportation	0.288	◊ ▼	319	◊ ▼	14	◊ ▲	0.021	◊ ▼
Paducah Gaseous Diffusion Plant	4.580	-11% ▼	1,281	-32% ▼	109	-4% ▼	0.042	-8% ▼
Pantex Plant	22.927	-8% ▼	5,039	8% ▲	312	-6% ▼	0.073	-2% ▼
Portsmouth Gaseous Diffusion Plant	3.588	41% ▲	2,504	-4% ▼	69	68% ▲	0.052	-16% ▼
Princeton Plasma Physics Laboratory	0.239	◊ ▼	348	◊ ▼	38	◊ ▼	0.006	◊ ▼
Sandia National Laboratories	5.819	**171%** ▲	1,878	5% ▲	175	**140%** ▲	0.033	13% ▲
Savannah River:								
Savannah River National Laboratory	8.463	-58% ▼	383	-41% ▼	314	-45% ▼	0.027	-23% ▼
Savannah River Site	126.869	-17% ▼	6,211	4% ▲	4,101	7% ▲	0.031	-22% ▼
Savannah River Totals:	135.332	-22% ▼	6,594	-1% ▼	**4,415**	1% ▲	0.031	-22% ▼
Separations Process Research Unit	0.208	◊ ▼	101	◊ ▼	10	◊ ▼	0.021	◊ ▼
SLAC National Accelerator Laboratory	0.047	◊ ▼	2,650	◊ ▲	3	◊ ▼	0.016	◊ ▲
Thomas Jefferson National Accelerator Facility	0.526	◊ ▲	1,257	◊ ▼	26	◊ ▲	0.020	◊ ▲
Uranium Mill Tailings Remedial Action Project	5.485	-3% ▼	125	-1% ▼	77	17% ▲	0.071	-17% ▼
Waste Isolation Pilot Plant	0.909	◊ ▲	594	◊ ▲	42	◊ ▲	0.022	◊ ▲
West Valley Demonstration Project	35.549	6% ▲	415	8% ▲	160	4% ▲	**0.222**	2% ▲
Service Center Personnel*	0.149	◊ ▲	288	◊ ▼	4	◊ ▼	0.037	◊ ▲
Totals	**748.595**	**-2%** ▼	**75,606**	**2%** ▲	**13,320**	**-83%** ▼	**0.056**	**-4%** ▼

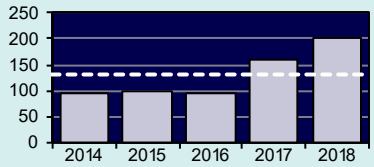
Note: Bold and boxed values indicate the greatest value in each column.
◊ The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv).
* Includes personnel at NNSA Albuquerque complex, Oak Ridge, and WIPP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

Exhibit 3-14:
Activities Significantly Contributing to Collective TED in CY 2018, in Descending Order of Collective Dose.

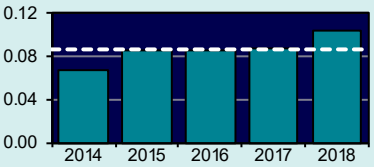
Los Alamos National Laboratory (LANL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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

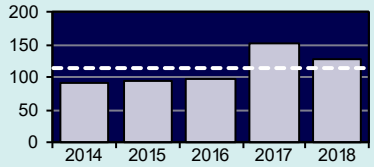
Dose increased in CY 2018 due to:

- Programmatic work at TA-55 was fully resumed and the facility was operating at increased capacity following a stand down in CY 2013; and
- Retrieval, repackaging, and shipping of radioactive solid waste within LANL facilities and at waste facilities TA-50 and TA-54. Beginning May 2018, solid waste handling at TA-54 transitioned to a new contractor, under DOE-EM oversight.

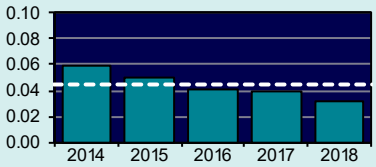
Savannah River Site (SRS)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Tank closures in Savannah River Remediation;
- TRM and HFIR spent fuel campaigns;
- Removal of failed Cell Covers in H Canyon; and
- K Area Complex down-blending.

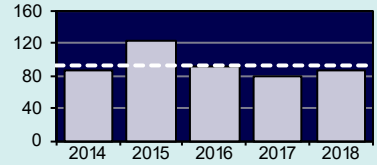
Changes in Dose

- Calendar year 2018 dose was reduced in comparison to 2017 as the result of the reduction in material in the HB-Line for safe layup of the facility.

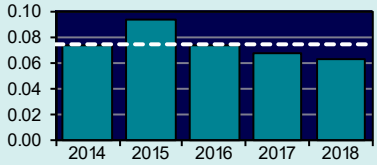
Idaho Site

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

Changes in Dose

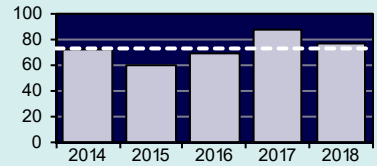
Dose increased in CY 2018 due to:

- Loop experiment sponsor upgrade activities associated with asbestos removal from loop piping in the 1D-N primary cubicle; and
- Emergent work to replace the 1D-N inpile tube involving high radiation work in the subpile room and requiring post-maintenance strainer runs to ensure no debris was resent from maintenance activities.

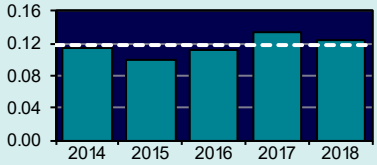
Oak Ridge: Oak Ridge National Laboratory (ORNL)

ORNL 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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

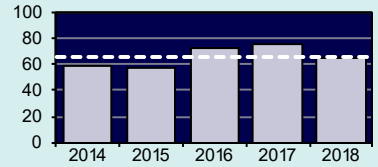
Changes in Dose

- Calendar year 2018 saw an increase in dose for project work at accelerator, radiochemistry, and some hot cell facilities, which was offset by a decrease in dose at the research reactor facility and other hot cell facilities.

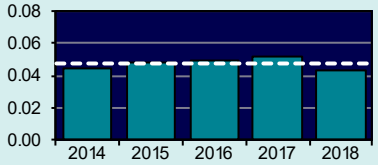
Oak Ridge: Y-12 National Security Complex (Y-12)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Manufacture, processing, and storage of special materials;
- Demolition and cleanup of aging structures; and
- Maintenance of equipment and facilities.

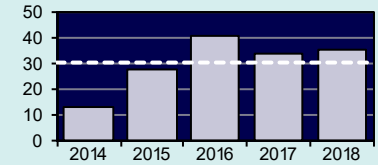
Changes in Dose

- In CY 2018, dose decreases were attributed to the decontamination of work areas, pauses in production, and the cleaning and repair of equipment.

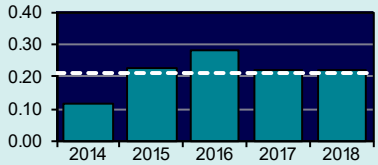
West Valley Demonstration Project (WVDP)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Demolition preparation work in the Main Plant Process Building including the removal of the primary 36" ventilation duct, decontamination of the Ventilation Exhaust Cell, and source reduction in the Ventilation Wash Room;
- Ongoing operations in the Vitrification Facility demolition; and
- Waste operations tasks in lag storage and chemical process cell waste storage area, routine maintenance work on the remote waste handling crane, and Radiological Control Technicians providing support for facility disposition activities.

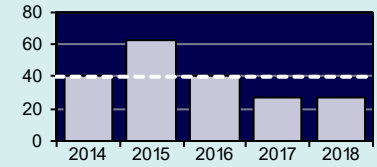
Changes in Dose

- The CY 2018 overall dose increased from the previous year due primarily to increased manned-entries in high dose rate areas in the Main Plant, to open air demolition activities of the Vitrification Facility and the inventorying and removal of high radiation boxes from CPC/outside storage areas into LSA-3.

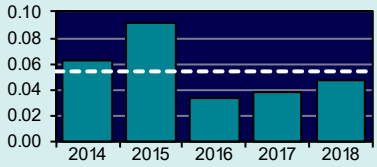
Hanford: Hanford Site

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

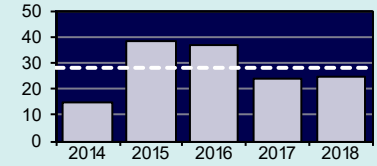
Changes in Dose

- The decrease in collective dose at the Plutonium Finishing Plant (PFP) facility was associated with a transition in work activities from source term removal to facility demolition; and
- Several Hanford projects continued to operate at minimal levels, resulting in a lower dose.

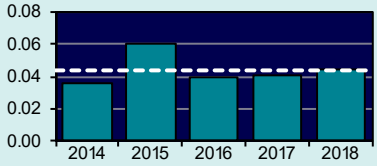
Hanford: Office of River Protection (ORP)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

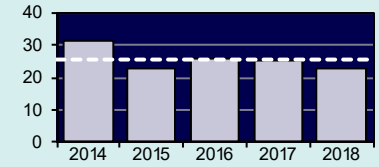
Changes in Dose

- The collective TED increased in CY 2018 due to a combination of factors involving an increasing number of samples and a higher dose rate per sample.

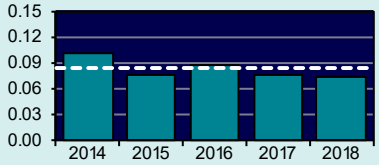
Pantex Plant

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

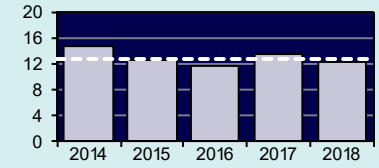
Changes in Dose

- The collective dose did not decrease significantly from CY 2017 to 2018. This small decrease could be attributed to a combination of good ALARA practices and the type of work performed during this reporting period.

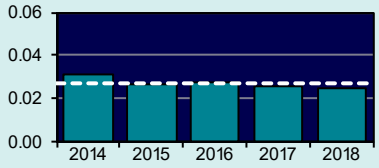
Hanford: Pacific Northwest National Laboratory (PNNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

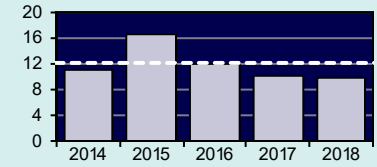
Changes in Dose

- The decrease in collective dose in CY 2018 reflected an overall lower volume of high dose radiological work.

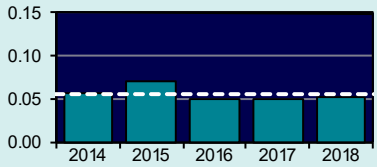
Fermi National Accelerator Laboratory (Fermilab)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Upgrade and repair activities of the Fermilab accelerator complex;
- Centralized radioactive materials storage area (known as the Railhead) activities; and
- Management and disposal of radioactive waste.

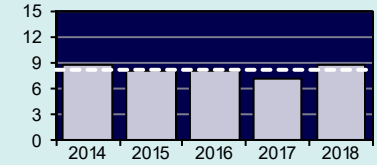
Changes in Dose

- The 2% decrease in collective dose reflects the planned shutdown between July and October, 2018 to upgrade and repair facilities.

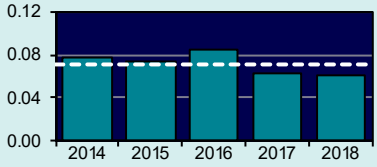
Lawrence Livermore National Laboratory (LLNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

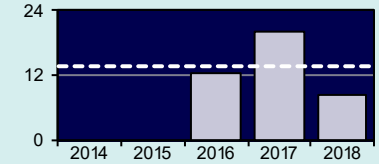
Changes in Dose

- LLNL instituted a change in dosimetry issuance policy which resulted in a significant decrease in the monitored population; and
- The increase in collective dose reflects an increase in work scope.

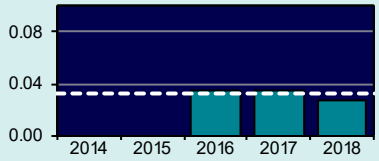
Savannah River National Laboratory (SRNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

Changes in Dose

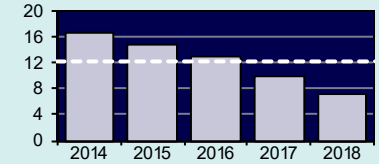
- The decrease in total dose was primarily due to the reduction of radioactive material in the HB Line. The HB Line has most recently been used to produce plutonium oxide. HB Line reduced the inventory of hazardous materials in the facility by flushing vessels used in oxide production. Reducing inventory allows for more stable plant conditions and minimizes associated surveillances.

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

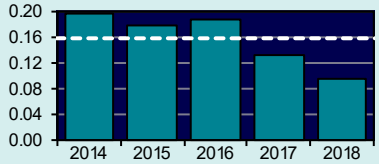
Argonne National Laboratory (ANL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

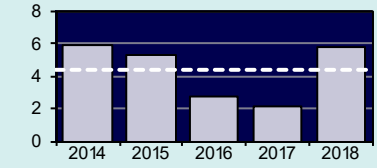
Changes in Dose

- The decreases in collective TED and average measurable TED are attributed to decontamination work at the Alpha Gamma Hot Cell Facility taking less time than anticipated with lower dose rates present than previously observed during the same type of work in CY 2014.

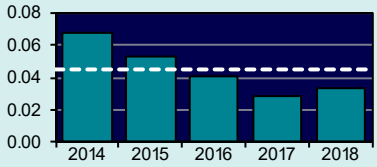
Sandia National Laboratories (SNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

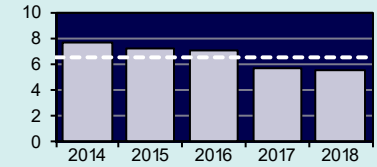
Changes in Dose

- Increases in collective dose were attributed to the completion of the safety review at the Radioactive Mixed Waste Facility allowing processing to resume, as well as a significant increase in the volume of legacy radiological material repackaging at the hot cell facility as compared to CY 2017.

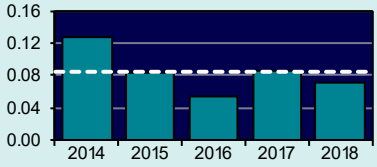
Uranium Mill Tailings Remedial Action Project (UMTRA)

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 two trainloads of tailings each week. The trains have up to 40 railcars, each holding four lidded containers, for a total of 4,600 tons of tailings per shipment. Tailing shipments began in April 2009 and are expected to continue through CY 2034.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Maintenance;
- Erosion control measures;
- Tailings excavation and conditioning;
- Ground water remediation; and
- Health and safety oversight.

Changes in Dose

- UMTRA revised their air immersion DAC to reflect current workplace conditions. Re-evaluating the site DAC value and having workers in the Contaminated Area rotate their operations duties resulted in a reduction of dose.

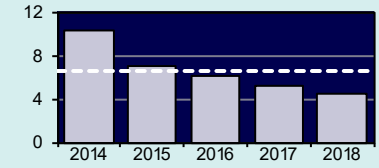
As seen in *Exhibit 3-11*, the majority of the collective TED is received at a few DOE sites. For sites with relatively low collective dose or with fewer monitored individuals, wider variation can occur from year to year. These year-to-year variations are often due to changes in funding or mission priorities that can significantly impact the relatively small amount of work involving radiation exposure. In CY 2018, 18 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 2018, for Sites Reporting Less Than Five Person-Rem, in Descending Order of Collective Dose.

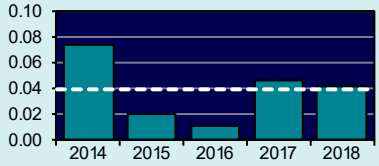
Paducah Gaseous Diffusion Plant (PGDP)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Environmental cleanup;
- Waste disposition; and
- Decontamination and decommissioning (D&D) of inactive facilities.

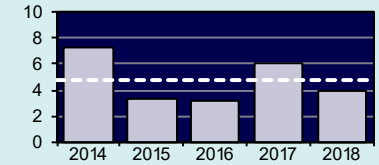
Changes in Dose

- Collective dose decreased when issues were identified and the plant's operational status was changed to shutdown. However, during CY 2018, the plant became operational and began to increase production towards the end of CY 2018.

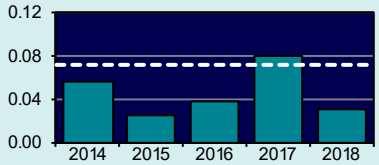
Brookhaven National Laboratory (BNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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

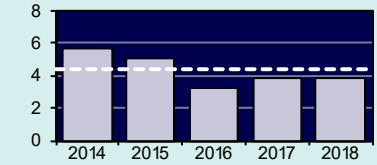
The decrease in total dose was primarily due to:

- Decrease in of handling of high activity sealed radioactive sources; and
- Only normal routine operations taking place at the BNL facilities.

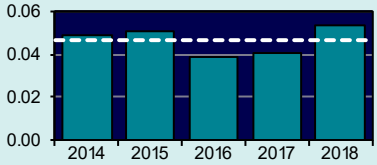
Nevada National Security Site (NNSS)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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 and neutron generators;
- Development, testing, and evaluation of radiation detectors; and
- Surface cleanup and site characterization of contaminated land areas.

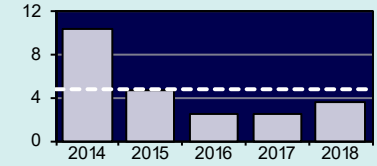
Changes in Dose

- The increase in dose was due to increased activities associated with critical and special National Laboratories experiments.

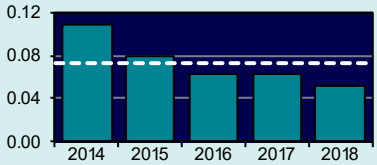
Portsmouth Gaseous Diffusion Plant (PORTS)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Environmental remediation;
- Facility decontamination; and
- Uranium barter transfers.

Changes in Dose

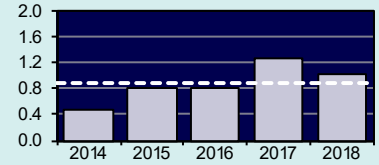
The increase in dose was due to:

- Increase in the number of cylinder transfer operations;
- Better work practices, better cylinder management in the yards, and better worker awareness of the exposure associated with the heel cylinders; and
- Plant production status increased toward years end.

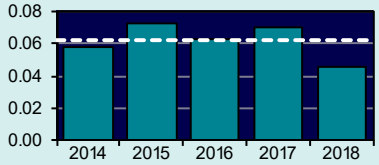
Lawrence Berkeley National Laboratory (LBNL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

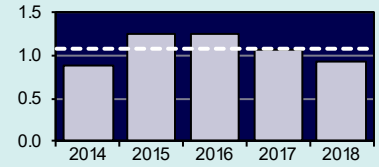
Changes in Dose

- The decrease in dose was primarily due to a reduced level of PET isotope production at the Center for Functional Imaging.

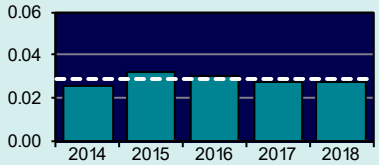
Ames Laboratory

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

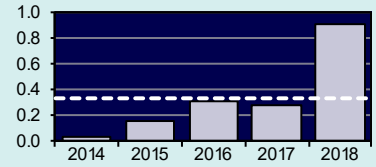
Changes in Dose

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

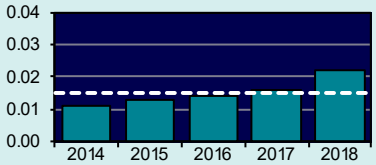
Waste Isolation Pilot Plant (WIPP)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

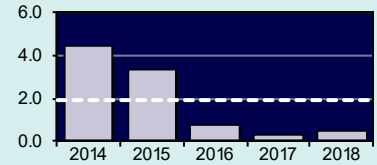
Changes in Dose

- The increase in collective dose was due to decontamination efforts at the WIPP site, as well as an increase in waste handling operations; and
- The site became fully operational resulting in increased volumes of contact handled wastes shipped for disposal.

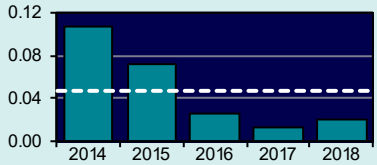
Thomas Jefferson National Accelerator Facility (TJNAF)

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).

Collective TED (person-rem)



Average Measurable TED (rem)



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

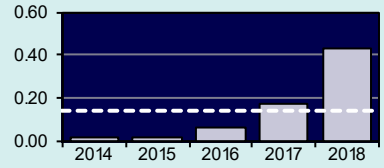
Collective dose at TJNAF remains low as:

- The radiological work associated with the CEBAF 12 GeV upgrade was completed, and the accelerator returned to an operational status in CY 2018; and
- Continued improvement of its procedures and processes for investigating unusual dosimeter results.

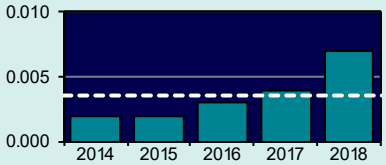
Kansas City National Security Campus (KC-NSC)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Non-destructive testing, telemetry (neutron generators);
- Security operations, depleted uranium operations; and
- Legacy part refurbishment and waste management.

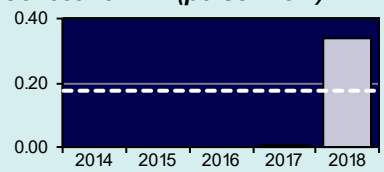
Changes in Dose

- A small increase in collective and average measurable dose was likely due to increased production associated with an on-going weapons Life Extension Program.

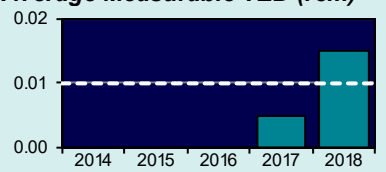
Grand Junction Site

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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; and
- Monitoring well maintenance.

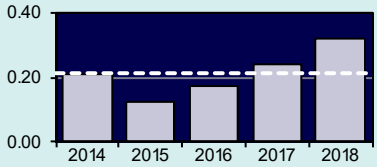
Changes in Dose

- All doses received were from routine field activities performed by Legacy Management personnel and were very low; and
- The number of individuals monitored increased from CY 2017 to 2018.

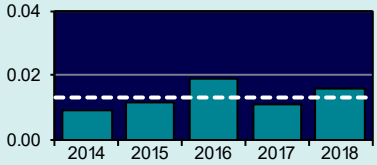
Oak Ridge: Oak Ridge Institute for Science and Education (ORISE)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

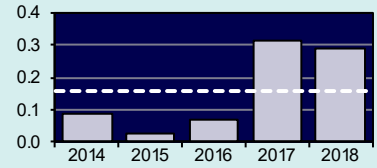
Changes in Dose

- The slight increase was due to more individuals receiving measurable dose at low levels in work areas where the background radiation was slightly higher than normal.

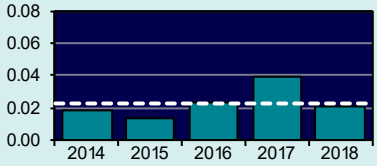
Office of Secure Transportation (OST)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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

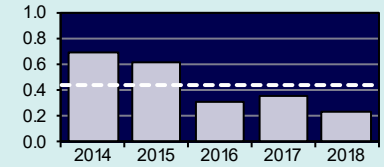
- Differences are insignificant and variations may be attributed to the small number of individuals (less than 10 for each year).

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

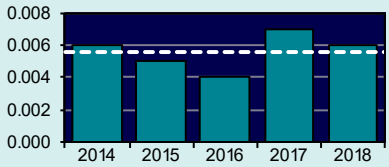
Princeton Plasma Physics Laboratory (PPPL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Experimental and theoretical fusion research; and
- Plasma research and experiments.

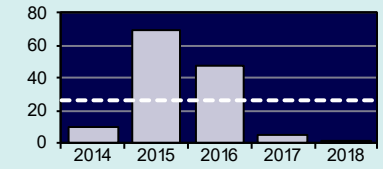
Changes in Dose

- Differences are likely due to a primary experiment undergoing major upgrades as part of a recovery operation, as well as a substantial reduction in work force due to retirements.

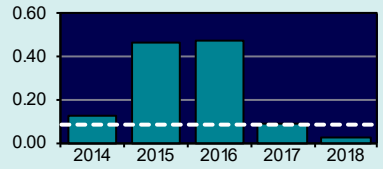
Separations Process Research Unit (SPRU)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

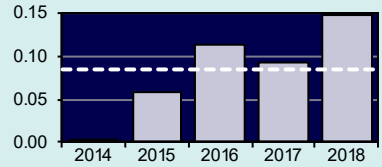
Changes in Dose

- Collective dose decreased due to the completion of the open air demolition of the H2 and G2 Buildings and shipment of the associated waste.

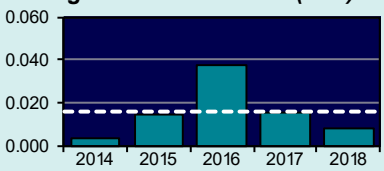
Oak Ridge: East Tennessee Technology Park (ETTP)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Continuation of ongoing cleanup activities.

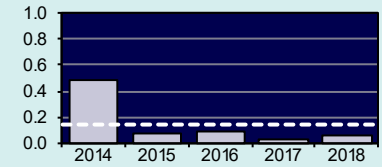
Changes in Dose

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

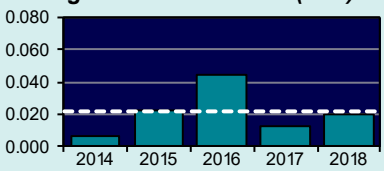
Energy Technology Engineering Center (ETEC)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



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.

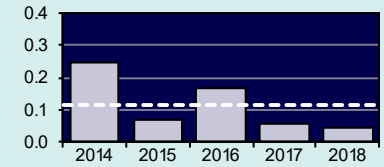
Changes in Dose

- Changes in dose are low and not significant.

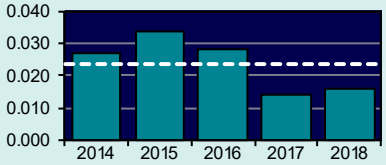
SLAC National Accelerator Laboratory (SLAC)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

- Operation of the LINAC Coherent Light Source - 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.

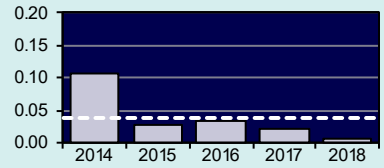
Changes in Dose

- The collective dose decreased slightly in CY 2018 and reflects normal routine operations and normal variations given the limited number of individuals with measurable dose and the very low doses.

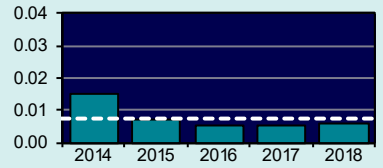
National Renewable Energy Laboratory (NREL)

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.

Collective TED (person-rem)



Average Measurable TED (rem)



Activities Involving Radiation Exposure

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

Changes in Dose

The slight decrease in dose for CY 2018 is not significant, but is likely due to:

- Having only small quantities of low-level radioactive waste in storage; and
- A decrease in work involving radiation exposure and 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 the largest percentages of the collective TED (48 and 35 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. These offices account for 84 percent of the collective TED at DOE.

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 available at https://energy.gov/ehss/occupational-radiation-exposure in the Appendices section of the Annual Report.

Exhibit 3-16:
Program Office Dose Data, CY 2018.

Program Office	Collective TED (person-rem)	Percent Change from 2017	Number with Meas. Dose (TED)	Percent Change from 2017	Avg. Meas. TED (rem)	Percent Change from 2017
Office of Energy Efficiency and Renewable Energy (EE)					**Total Monitored =**	**11***
National Renewable Energy Laboratory	0.006	◊ ▼	1	◊ ▼	0.006	◊ ▲
EE Totals	**0.006**	◊ ▼	**1**	◊ ▼	**0.006**	◊ ▲
Office of Environmental Management (EM)					**Total Monitored =**	**18,895***
East Tennessee Technology Park	0.147	◊ ▲	18	▲	0.008	◊ ▼
Energy Technology Engineering Center	0.059	◊ ▲	3	▲	0.020	◊ ▲
Hanford Site	27.172	1% ▲	566	-21% ▼	0.048	**27%** ▲
Idaho Site (ICP, AMWTP and DOE IOO)	41.855	-14% ▼	673	5% ▲	0.062	-19% ▼
Los Alamos National Laboratory	0.214	◊	10	◊	0.021	◊
Nevada National Security Site	0.022	◊ ▲	1	◊ ▲	0.022	◊ ▲
Oak Ridge National Laboratory	29.353	-16% ▼	201	-9% ▼	0.146	-7% ▼
Office of River Protection	24.926	2% ▲	570	-5% ▼	0.044	7% ▲
Paducah Gaseous Diffusion Plant	4.580	-11% ▼	109	-4% ▼	0.042	-8% ▼
Portsmouth Gaseous Diffusion Plant	3.588	**41%** ▲	69	**68%** ▲	0.052	-16% ▼
Savannah River National Laboratory	8.463	-58% ▼	314	-45% ▼	0.027	-23% ▼
Savannah River Site	**75.996**	-33% ▼	**2,293**	-6% ▼	0.033	-29% ▼
Separations Process Research Unit	0.208	◊ ▲	10	◊ ▼	0.021	◊ ▼
Service Center Personnel*	0.134	◊ ▲	3	◊ ▼	0.045	◊ ▲
Uranium Mill Tailings Remedial Action Project	5.485	-3% ▼	77	17% ▲	0.071	-17% ▼
Waste Isolation Pilot Plant	0.909	◊ ▲	42	◊ ▲	0.022	◊ ▲
West Valley Demonstration Project	35.549	6% ▲	160	4% ▲	**0.222**	2% ▲
EM Totals	**258.660**	**-19%** ▼	**5,119**	**-9%** ▼	**0.051**	**-11%** ▼
Office of Legacy Management (LM)					**Total Monitored =**	**27***
Grand Junction Site	0.336	◊ ▲	22	◊ ▲	0.015	◊ ▲
LM Totals	**0.336**	◊ ▲	**22**	◊ ▲	**0.015**	◊ ▲
National Nuclear Security Administration (NNSA)					**Total Monitored =**	**32,720***
Kansas City National Security Campus	0.428	◊ ▲	58	◊ ▲	0.007	◊ ▲
Lawrence Livermore National Laboratory	8.691	22% ▲	145	26% ▲	0.060	-3% ▼
Los Alamos National Laboratory	**203.237**	26% ▲	**1,943**	5% ▲	**0.105**	20% ▲
Nevada National Security Site	3.871	◊ ▲	73	-22% ▼	0.053	**29%** ▲
Office of Secure Transportation	0.288	◊ ▼	14	▲	0.021	◊ ▼
Pantex Plant	22.927	-8% ▼	312	-6% ▼	0.073	-2% ▼
Sandia National Laboratories	5.819	**171%** ▲	175	**140%** ▲	0.033	13% ▲
Savannah River Site	50.873	29% ▲	1,808	29% ▲	0.028	◊
Y-12 National Security Complex	65.234	-14% ▼	1,516	4% ▲	0.043	-17% ▼
NNSA Totals	**361.368**	**15%** ▲	**6,044**	**12%** ▲	**0.060**	**2%** ▲
Office of Nuclear Energy (NE)					**Total Monitored =**	**5,278***
Idaho National Laboratory	44.411	48% ▲	695	30% ▲	0.064	13% ▲
NE Totals	**44.411**	**48%** ▲	**695**	**30%** ▲	**0.064**	**13%** ▲
Office of Science (SC)					**Total Monitored =**	**18,624***
Ames Laboratory	0.935	◊ ▼	33	◊ ▼	0.028	◊ ▲
Argonne National Laboratory	7.112	-28% ▼	75	◊	0.095	-28% ▼
Brookhaven National Laboratory	3.924	-35% ▼	125	**62%** ▲	0.031	-60% ▼
Fermi National Accelerator Laboratory	9.980	**-2%** ▼	188	-6% ▼	0.053	**5%** ▲
Lawrence Berkeley National Laboratory	1.014	-19% ▼	22	22% ▲	0.046	-34% ▼
Oak Ridge Institute for Science and Education	0.317	◊ ▲	20	◊ ▼	0.016	◊ ▲
Oak Ridge National Laboratory	**47.480**	-10% ▼	414	-6% ▼	**0.115**	-4% ▼
Pacific Northwest National Laboratory	12.225	-10% ▼	**494**	-4% ▼	0.025	-6% ▼
Princeton Plasma Physics Laboratory	0.239	◊ ▼	38	◊ ▼	0.006	◊ ▼
Service Center Personnel*	0.015	◊ ▲	1	◊ ▲	0.015	◊ ▲
SLAC National Accelerator Laboratory	0.047	◊ ▼	3	◊ ▼	0.016	◊ ▲
Thomas Jefferson National Accelerator Facility	0.526	◊ ▲	26	◊ ▲	0.020	◊ ▲
SC Totals	**83.814**	**-12%** ▼	**1,439**	**-2%** ▼	**0.058**	**-11%** ▼

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 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 2014 to 2018. Over the past 5 years, the records of transient individuals have averaged 3 percent of the total records for all monitored individuals. These individuals received, on an average, 3.0 percent of the collective TED. The collective TED for transients decreased from 20.1 person rem (201 person-mSv) in CY 2017 to 18.9 person-rem (189 person-mSv) in CY 2018. The average measurable TED remained static at 0.043 rem (0.430 mSv) in CY 2017 and 2018. The decrease of the average measurable TED was a result of the 6 percent decrease in the number of transient individuals with measurable dose (472 in CY 2017 to 443 in CY 2018) and the 6 percent decrease in the collective TED. 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, as presented in this report. *Exhibit 3-18* and *Exhibit 3-19* show a summary of occupational exposures back to CY 1974, when the Atomic Energy Commission split into the U.S. Nuclear Regulatory Commission and the Energy Research and Development Administration (ERDA), which subsequently became DOE. *Exhibit 3-17* and *Exhibit 3-18* show the collective dose, average measurable dose, and number of workers with a measurable dose from CY 1974 to 2018. As can be seen from the graphs, all three parameters decreased dramatically between CY 1986 and 1993. The main reasons for this large decrease were the shutdown of facilities within the weapons complex and the end of the Cold War era, which shifted the DOE mission from weapons production to shutdown, stabilization, and decontamination and decommissioning, activities.

Exhibit 3-17:
Dose Distribution of Transient Individuals, CY 2014 – 2018.

	Dose Ranges (TED in rem)*	2014	2015	2016	2017	2018
Transients	Less than measurable	2,157	2,151	2,015	2,035	2,290
	Measurable <0.100	380	360	421	432	404
	0.100 – 0.250	41	35	46	24	23
	0.250 – 0.500	12	10	14	12	13
	0.500 – 0.750		3	1	3	1
	0.750 – 1.000	1	2	1	1	2
	1.0 – 2.0					
	>2.0					
	Total number of individuals monitored**	2,591	2,561	2,498	2,507	2,733
	Number with measurable dose	434	410	483	472	443
	% with measurable dose	17%	16%	19%	19%	16%
	Collective TED (person-rem)	21.419	21.636	23.436	20.091	18.934
	Average measurable TED (rem)	0.049	0.053	0.049	0.043	0.043
All DOE	Total number of records for monitored individuals	75,470	75,587	77,836	79,903	75,606
	Number of individuals with measurable dose	9,508	10,033	11,987	13,024	13,320
	% of total monitored individuals who are transient	3.4%	3.4%	3.2%	3.1%	3.6%
	% of the number of individuals with measurable dose who are transient	4.6%	4.1%	4.0%	3.6%	3.3%

*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 – 2018.

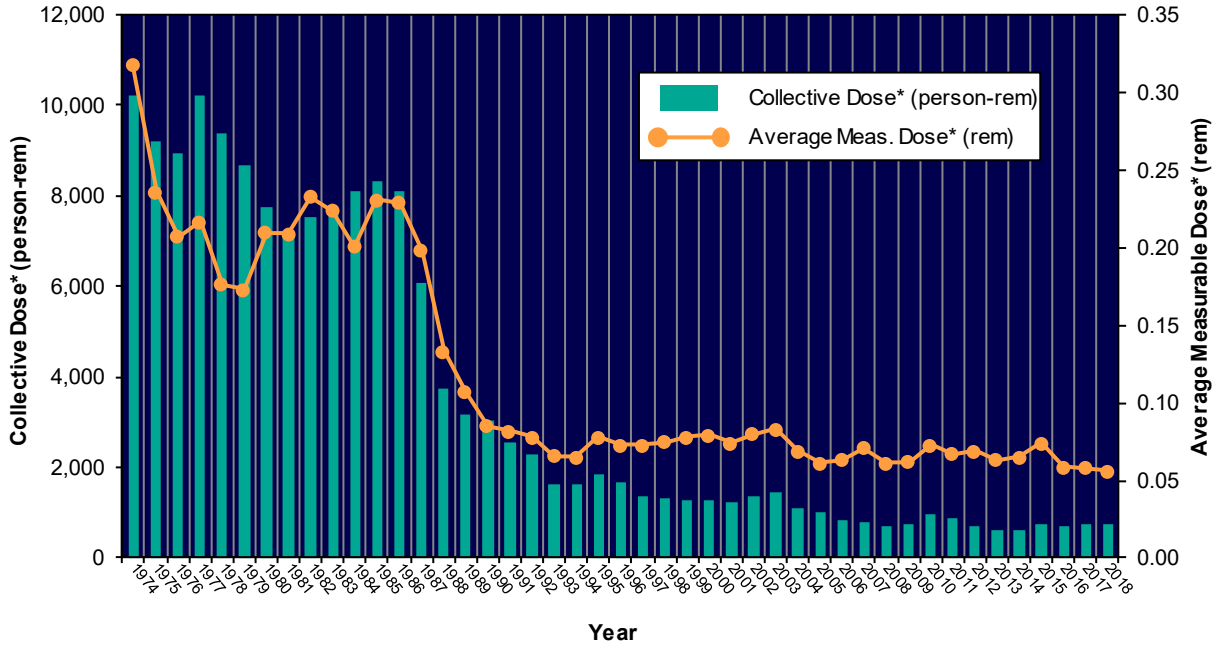
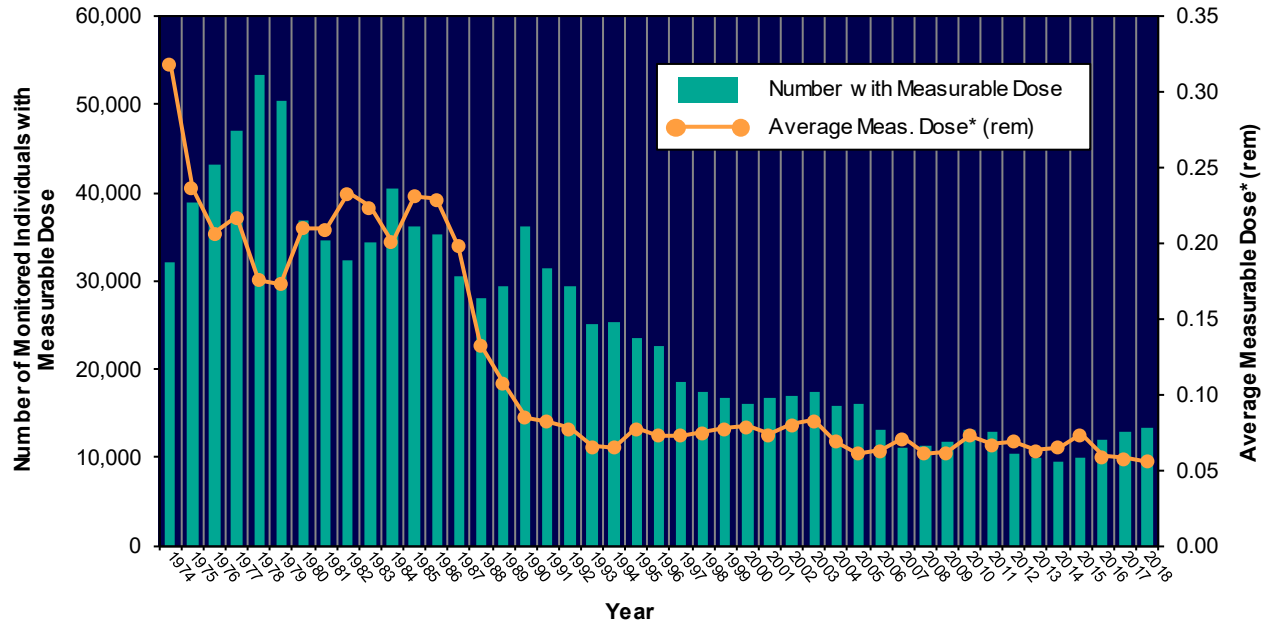


Exhibit 3-19:
Number of Workers with Measurable Dose and Average Measurable Dose, CY 1974 – 2018.



* 1974 – 1989 collective dose = DDE
1990 – 1992 collective dose = DDE + AEDE
1993 – 2009 collective dose = DDE + CEDE
2010 – 2018 collective dose = ED + CED

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

3.7 Radiological Safety Occurrence Reports

DOE's Occurrence Reporting Program provides timely notification to the DOE complex of events that could adversely affect: public or DOE worker health and safety, the environment, national security, DOE's safeguards and security interest, functioning of DOE facilities, or the Department's reputation. Sites are required to report certain unusual or off-normal occurrences involving radiation under DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information* [9]. DOE O 232.2A became effective in January 2017. Additional information regarding DOE O 232.2A or its associated database: Occurrence Reporting and Processing System (ORPS), may be obtained by contacting:

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/policy-guidance-reports/databases/occurrence-reporting-and-processing-system

3.7.1 AU Keyword Analysis

On a daily basis, AU-23 reviews ORPS reports submitted the previous day by DOE sites and assigns keywords to fully capture all aspects of the occurrence. These keywords are referred to as Headquarters (HQ) Keywords and are listed in the *HQ Keywords Binning Guidance and Criteria,* provided in the Reference section of this report. All applicable keywords are assigned to each occurrence, with one exception. The Environment, Safety, and Health (ES&H) Categories, known as the *12-Codes*, are broad categories that identify the primary classification of each *occurrence*. Consequently, only one 12-Code is assigned to each ORPS report.

As shown in the *HQ Keywords Binning Guidance and Criteria*, Subgroup 6 - Radiological includes 11 radiological related HQ Keywords and are identified by the number "6." Three of the HQ Keywords 6 are directly related to occupational radiation exposure and include "6C Skin Contamination," "6F External Exposure," and "6G Intake" occurrences. As clothing contamination can lead to occupational exposure, AU-23 also examined "6A Clothing Contamination." For similar reasons, we also examined "6B Facility / Equipment / Site Contamination" since site contamination can lead to clothing or skin contamination events. The remaining six keywords will not be discussed in this report. For purposes of this report, the terms "occurrence" and "event" are used interchangeably.

The number of reports submitted to ORPS can be an indication of lapses in radiation protection practices particularly when the occurrence results in unanticipated radiation exposures or contamination of personnel or clothing. Significant increases or decreases in the number of reported occurrences may reflect trends in the effectiveness of DOE radiation protection programs, but they may also be due to changes in reporting thresholds or statistical variability rather than any performance trend, so care should be taken when drawing conclusions based solely on the number of reports.

Reports are submitted to ORPS for an occurrence or event. In some cases, one event could result in the contamination or exposure of multiple individuals. In ORPS, this is counted as one occurrence, even though multiple individuals were exposed. In addition, one report may involve the roll up of similar or multiple occurrences. Also, it should be noted that some occurrences are reported based on an initial estimate of exposure, but may be categorized differently upon receipt of the final exposure determination. For the analysis included in this report, occurrence reports with at least one HQ Keyword 6 assigned and with Discovery Dates between CY 2014 – 2018 are considered. The values in this section are reflective of the ORPS database as of July 2019.

During CY 2014 – 2018, 4,927 occurrence reports were submitted to ORPS. Of these, 383 (8%) included at least one of the Radiological HQ Keywords. Multiple Radiological HQ Keywords can be assigned to a single report. Because of the multiple HQ Keyword assignments, the total number of Radiological Safety Occurrence Reports is less than the sum of the combined number of reports containing each HQ Keyword Category. For example, a Radiological Safety Occurrence Report may involve clothing contamination and skin contamination. The occurrence report would therefore include both 6A and 6C HQ Keywords. This report would be included in the number of reports that contain 6A, and it would also be included in the number of reports that contain 6C, while there was actually only one occurrence report.

The distribution of the five Radiological HQ Keywords of interest from CY 2014 – 2018 are summarized in *Exhibit 3-20*. 6A: Clothing Contamination was assigned to 74 of 383 reports (19%), and 6B: Facility / Equipment / Site Contamination was assigned to 259 of 383 reports (68%). 6C: Skin Contamination was assigned to 59 of 383 reports (15%). 6F: External Exposure was assigned to 6 of 383 reports (2%), and 6G: Intake was assigned to 9 of 383 reports (2%).

3.7.2 Change in Significance Classification

DOE O 232.2A contained several changes in the reporting requirements for occurrence reports. For example, reports are now classified with Report Levels which consist of "High," "Low," or "Informational" instead of the previous significance levels of "Operational Emergency" with Significance Categories 1 through 4. Reporting Criterion defined per DOE O 232.2A defines the Report Level. For an occurrence to be submitted as High, the occurrence would impact worker or public safety and health, significant personnel injuries, environmental harm, regulatory compliance, and/or public/business interests Low Level Reports are occurrences that do not meet the criteria for High, but still involve personnel injury, environmental releases, equipment damage, or hazardous circumstances. Informational Level Reports are occurrences that are determined to be a safety, environmental, or mission concern or provides potential learning opportunities for others. Occurrences that were categorized as Report Level High will be discussed in detail for each Radiological HQ Keyword examined.

3.7.3 Clothing Contamination

Clothing Contamination occurrences are reported whenever clothing or personal items are contaminated above threshold levels in 10 CFR Part 835, Appendix D. From CY 2014 – 2018, there were a total of 74 Clothing Contamination occurrences (6A) (*Exhibit 3-20*).

Exhibit 3-21 illustrates the number of clothing contamination reports for the years CY 2014 through 2018 by program office. The Office of Environmental Management (EM) accounted for 38 of 74 (51%), NNSA with 10 of 74 (14%), Nuclear Energy, Science and Technology (NE) accounted for 5 of 74 (7%) and Office of Science (SC) accounted for 21 of 74 (28%) of the Clothing Contamination reports.

When examined by site, Oak Ridge accounted for 16 of 74 (22%), Hanford accounted for 7 of 74 (9%), and Idaho accounted for 8 of 74 (11%) of the Clothing Contamination reports. There were no Clothing Contamination events assigned to the High reporting level that occurred from CY 2014 to 2018.

3.7.4 Facility / Equipment / Site Contamination

Facility / Equipment / Site Contamination occurrences are reported whenever onsite contamination is detected above threshold levels in 10 CFR Part 835, Appendix D. From CY 2014 – 2018, there were a total of 259 Facility / Equipment / Site Contamination (6B) occurrences (*Exhibit 3-20*).

Exhibit 3-20:
Frequency of Selected HQ Category 6 Keywords in Radiological Safety Occurrence Reports, CY 2014 – 2018.

	2014	2015	2016	2017	2018	Total
By HQ Keywords						
6A Clothing Contamination	17	13	14	12	18	**74**
6B Facility/Equipment/Site Contamination	58	57	53	46	45	**259**
6C Skin Contamination	9	11	13	13	13	**59**
6F External Exposure	1	1	1	2	1	**6**
6G Intake	4	4	0	0	1	**9**
Other 6 HQ Keywords	56	37	42	29	36	**200**
Total of All 6 HQ Keywords	**145**	**123**	**123**	**102**	**114**	**607**
By Number of Reports						
Total Number of Reports With Selected Keywords	**95**	**78**	**81**	**67**	**62**	**383**

Exhibit 3-21:
Number of 6A: Clothing Contamination Radiation Safety Occurrence Reports by Program Office, CY 2014 – 2018.

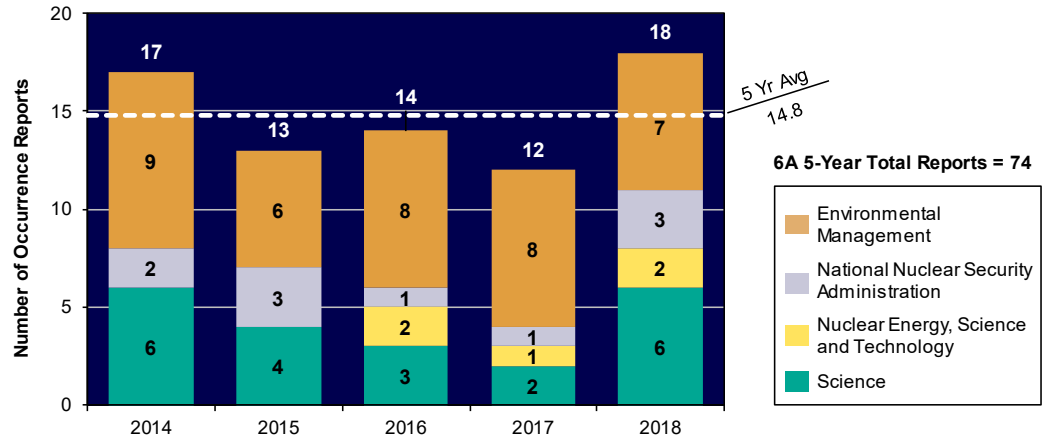
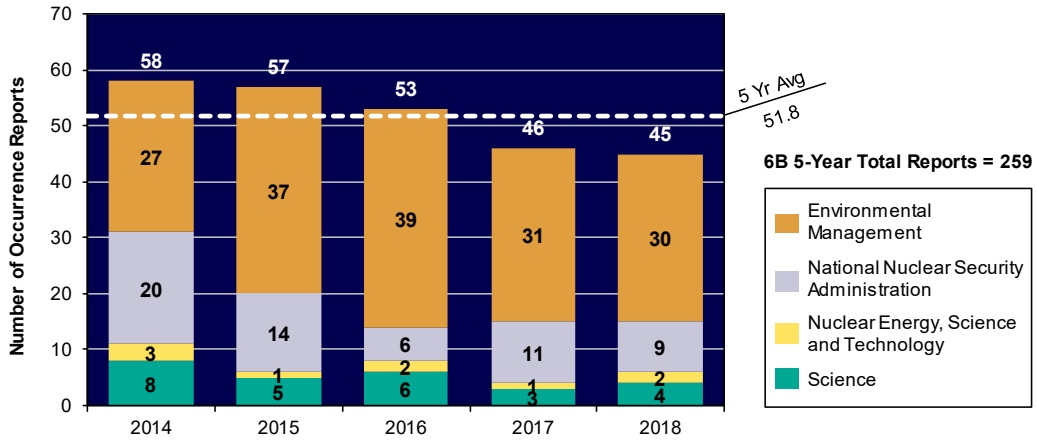


Exhibit 3-22 illustrates the number of Facility / Site / Contamination reports for the years CY 2014 through 2018 by program office. EM accounted for 164 of 259 (63%) of the Facility Contamination reports, followed by NNSA with 60 of 259 (23%), NE accounted for 9 of 259 (3%) and SC accounted for 26 of 259 (10%).

When examined by site, Hanford accounted for 93 of 259 (36%), Oak Ridge accounted for 46 of 259 (18%), and LANL accounted for 23 of 259 (9%) of the Facility / Equipment / Site Contamination reports.

From CY 2014 – 2016, there were no Facility Contamination events classified as Significance Category 1. There were two Facility / Equipment / Site Contamination events assigned to the High reporting level in CY 2017. In the first event (EM-RL--CPRC-PFP-2017-0017), a Radiological Control Technician (RCT) discovered soil contamination outside of the Radioactive Material Area. The location was subsequently posted as a High Contamination Area. In the second event (NA--LASO-LANL-ACCCOMPLEX-2017-0009), a RCT located soil contamination near a cask during routine surveys. The contaminated soil was secured and the area posted as a High Contamination Area. There were three facility contamination events assigned to the High reporting level in CY 2018. In the first event (EM-RL--CPRC-PFP-2018-0006), a contaminated spreader bar was discovered outside of a non-radiologically posted area after it had been removed without project authorization. In another event (EM-RP--WRPS-200LWP-2018-0003), small contaminated particles were located outside of a Radioactive Material Area during routine surveys. The particles were removed and a Radiological Buffer Area established. In a third event (SC-OSO--ORNL-X10EAST-2018-0002), a RCT detected Ra-226 contamination on a lab floor during routine surveillance. The investigation into this event is still ongoing.

Exhibit 3-22:
Number of 6B: Facility/Equipment/Site Contamination Radiation Safety Occurrence Reports by Program Office, CY 2014 – 2018.



3.7.5 Skin Contamination

Skin Contamination occurrences are reported whenever personnel contamination is found on the skin above the contamination values in 10 CFR Part 835, Appendix D. From CY 2014 – 2018, there were 59 Skin Contamination (6C) occurrences (*Exhibit 3-20*).

Exhibit 3-23 illustrates the number of Skin Contaminations for the years CY 2014 through 2018 by program office. EM accounted for 26 of 59 (44%), NNSA with 17 of 59 (29%), NE accounted for 3 of 59 (5%) and SC accounted for 13 of 59 (22%) of the Skin Contamination reports.

When examined by site, LANL accounted for 14 of 59 (24%), Oak Ridge accounted for 10 of 59 (17%), and Hanford accounted for 8 of 59 (14%) of the Skin Contamination reports.

There were two Skin Contamination events that occurred in CY 2018 that were assigned a reporting level of High. One event (EM-ID--FID-RWMC-2018-0001) resulted when a repackaged sludge drum experienced an over-pressurization event, which ejected the drum lid. The Idaho National Laboratory Fire Department responded. Upon doffing protective clothing, the three responding firefighters were found to have low-level alpha contamination on their hands which was successfully removed. In the second event (NA-LASO-LANL-TA55-2018-0013), a technician breached his glove while performing glovebox maintenance. Upon response, a RCT surveyed the worker and detected alpha contamination on two fingers of the worker's left hand. The wound was decontaminated at an offsite medical facility. Radiation protection staff issued the worker a diagnostic bioassay kit which later was found to be positive confirming that an intake occurred.

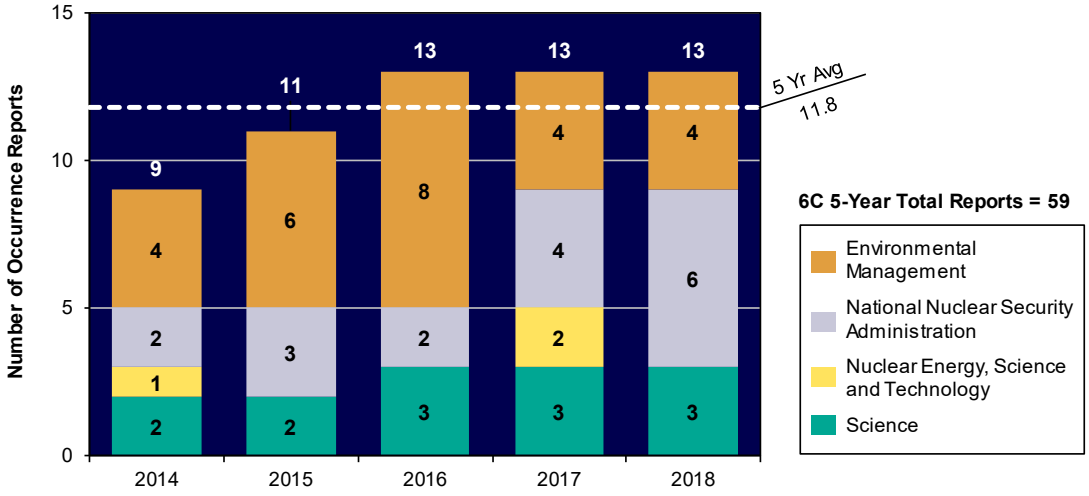
3.7.6 External Exposure

External Exposure occurrences are reported whenever it is determined that a worker receives a dose that exceeds the limits specified in 10 CFR Part 835, "*Occupational Radiation Protection*," Subpart C, "*Standards for Internal and External Exposure.*" External Exposure is also reported when there is a determination of a single occupational dose that exceeds an expected dose by 100-mrem effective dose.

From CY 2014 – 2018, there were six External Exposure (6F) occurrences (*Exhibit 3-20*). The number of External Exposure occurrences reported were low with one reported event in CY 2014, 2015, 2016, and 2018. Two events were reported in CY 2017.

As seen in *Exhibit 3-24*, EM, NNSA, and SC each had two events during the time period of interest. LANL reported an External Exposure event that was classified with a reporting level of High. This event was the glovebox incident described above in section 3.8.5 (NA--LASO-LANL-TA55-2018-0013).

Exhibit 3-23:
Number of 6C: Skin Contamination in Radiation Safety Occurrence Reports by Program Office, CY 2014 – 2018.



3.7.7 Intake

Intake occurrences are reported whenever it is determined that a worker receives an internal dose that exceeds the limits specified in 10 CFR Part 835, "*Occupational Radiation Protection*," Subpart C, "*Standards for Internal and External Exposure"* or when there is an internal dose that exceeds an expected dose by 500-mrem Committed Effective Dose (CED).

As seen in *Exhibit 3-20*, there were four Intakes each in CY 2014 and 2015, and one Intake in CY 2018 for nine Intakes from CY 2014 to 2018. Three Intakes were in EM, three in NNSA, two in SC, and one in NE (*Exhibit 3-25*).

Of the nine events that occurred over the 5-year period, Idaho had two events. LANL, LBNL, NNSS, Oak Ridge, SRS, WIPP, and WVDP each had one event.

No events assigned to the reporting level of High occurred from CY 2014 to 2018.

Exhibit 3-24:
Number of 6F: External Exposure in Radiation Safety Occurrence Reports by Program Office, CY 2014 – 2018.

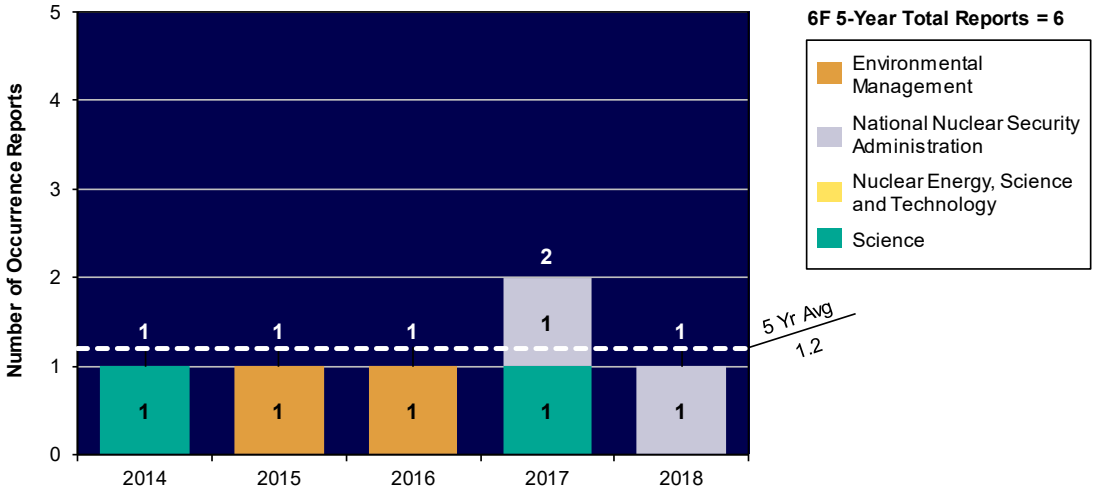
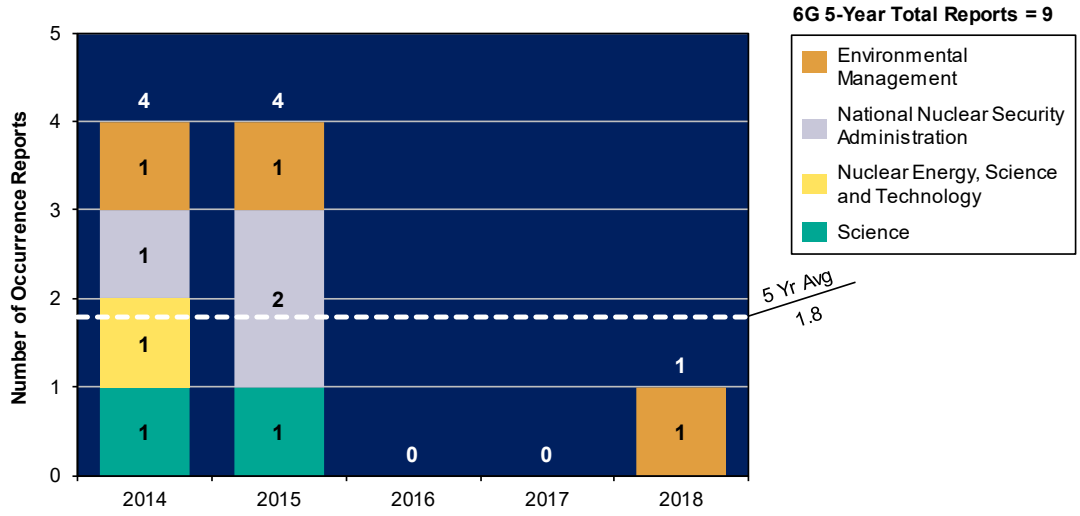


Exhibit 3-25:
Number of 6G: Intake in Radiation Safety Occurrence Reports by Program Office, CY 2014 – 2018.



3.8 HQ Category 12 Keywords

During the initial AU-23 review, a HQ Keyword is assigned which represents the single most important health, safety or environmental aspect of the occurrence, usually identifying the main area of concern and is referred to as the HQ Category 12 Keyword or 12-Code. Two keywords comprised 86% of the radiation-related events under discussion; "12M: Radiological Control" and "12N: Radiological Skin Contamination / Uptakes / Overexposures."

The detailed criteria for the assignment of the HQ Category 12 Keyword can be found in *Exhibit 3-26*. The distribution of the two Radiological HQ Category 12 Keywords of interest from CY 2014 – 2018 are summarized in *Exhibit 3-27*. Radiological Control (12M) issues accounted for 269 of 383 (70%), and Radiological Skin Contamination / Uptakes / Overexposures (12N) accounted for 61 of 383 (16%) of the radiation-related reports under consideration. Other 12 Keywords accounted for 53 of 383 (14%) reports to identify a variety of other issues and concerns and will not be discussed in this section.

3.8.1 12M Keywords

Exhibit 3-28 illustrates the number of Radiological Control reports for the years CY 2014 through 2018 by program office. EM accounted for 168 of 269 (62%) of the Radiological Control reports, followed by NNSA with 59 of 269 (22%), NE accounted for 11 of 269 (4%) and SC accounted for 31 of 269 (12%).

When examined by site, Hanford accounted for 94 of 269 (35%), Oak Ridge accounted for 49 of 269 (18%), and LANL accounted for 21 of 269 (8%) of the Radiological Control reports. The remaining 105 reports occurred at other sites across the DOE complex.

3.8.2 12N Keywords

Exhibit 3-29 illustrates the number of Radiological Skin Contamination / Uptakes / Overexposures reports for the years CY 2014 through 2018 by program office. EM accounted for 24 of 61 (39%) of the Radiological Skin Contamination / Uptakes / Overexposures reports, followed by NNSA with 19 of 61 (31%), NE accounted for 3 of 61 (5%) and SC accounted for 15 of 61 (25%).

When examined by site, LANL accounted for 15 of 61 (25%), Oak Ridge accounted for 15 of 61 (25%), and Hanford accounted for 7 of 61 (11%) of the Radiological Skin Contamination / Uptakes / Overexposures reports. The remaining 24 reports occurred at other sites across the DOE complex.

Exhibit 3-26:
HQ Category 12 Keyword Binning Criteria.

Category 12 Title	Criteria
12M: Radiological Control	Any noncompliance with radiological procedures, clothing/facility/equipment/site/offsite contamination, airborne radiation, inadequate job planning, training deficiencies, or inadequate radiological procedures.
12N: Radiological Skin Contamination / Uptakes / Overexposures	Any reported radiological contamination of the skin or hair, confirmed radionuclide uptakes, or external exposure above expected dose or that results in an overexposure.
All Other	Other criteria may include Authorization Basis, Near Miss, Nuclear Criticality Safety Concern, Injuries Requiring Medical Treatment Other Than First Aid, or Shipping QA.

Exhibit 3-27:
Number of Occurrence Reports by Selected HQ Category 12 Keyword in Radiation Safety Occurrence Reports, CY 2014 – 2018.

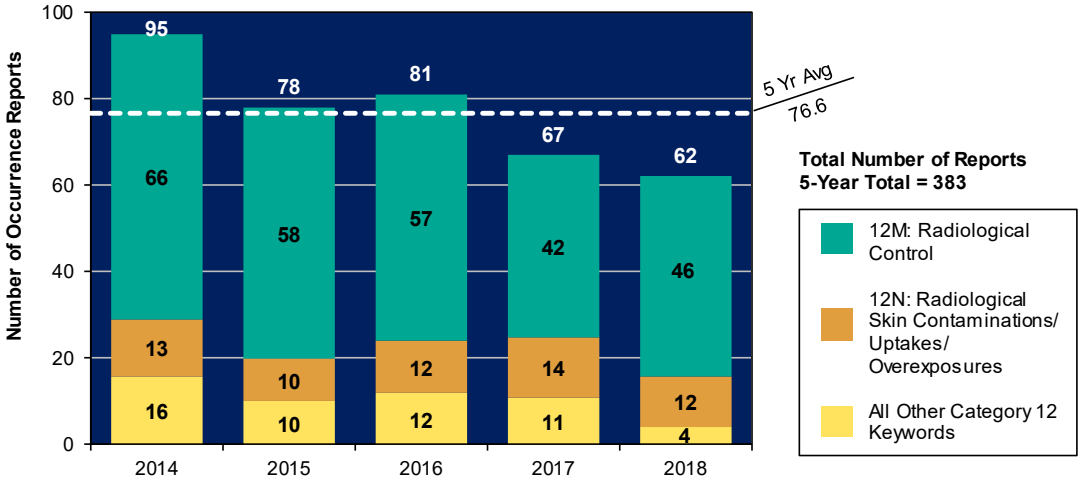


Exhibit 3-28:
Number of 12M: Radiological Control Occurrence Reports by Program Office, CY 2014 – 2018.

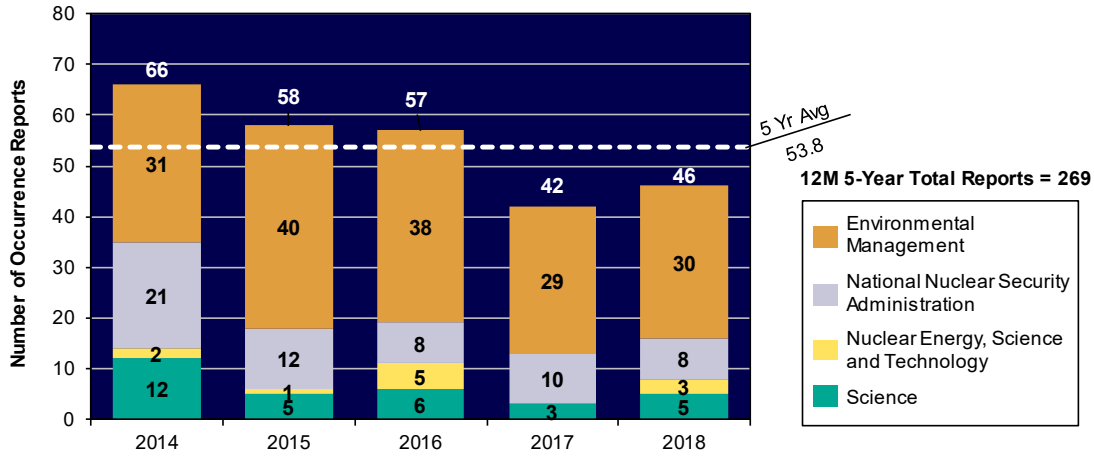
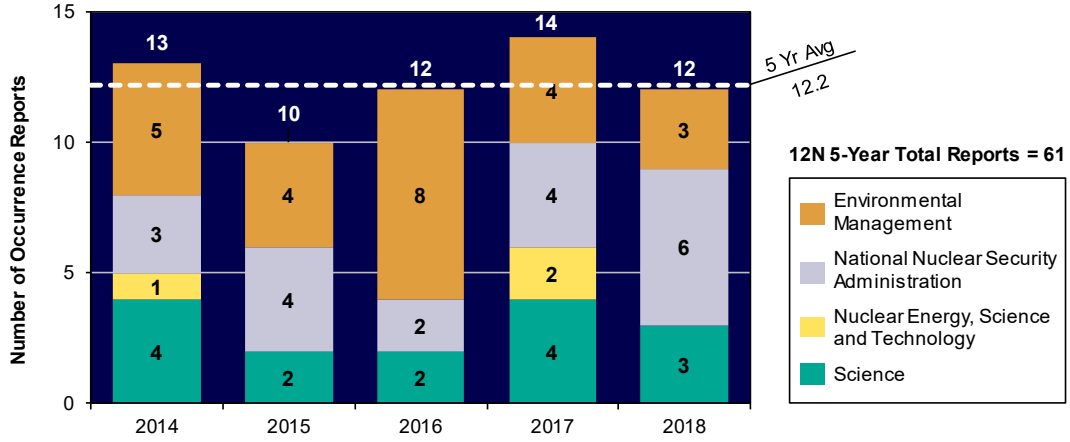


Exhibit 3-29:
Number of 12N: Radiological Skin Contamination / Uptakes / Overexposures by Program Office, CY 2014 – 2018.



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Section Four

4 ALARA Activities at DOE

Descriptions of ALARA activities at DOE are provided on the DOE web site: https://www.energy.gov/ehss/occupational-radiation-exposure-publications 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.

4.1 Submitting ALARA Project Descriptions for Future Reports

Individual project descriptions may be submitted to the DOE Office of ES&H Reporting and Analysis 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://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, which has been enhanced from the lessons learned program that was initially developed in CY 1994. The current DOE Operating Experience Program is described in DOE O 210.2A, *DOE Corporate Operating Experience Program* [10]. The objectives of the Operating Experience Program 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:

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Corporate Operating Experience Program (https://energy.gov/ehss/corporate-operating-experience-program)

Conclusions

Analysis of the collected exposure data for CY 2018 indicate that Departmental operations were in compliance with radiation protection requirements as no exposures were reported to have exceeded the DOE occupational dose limit of 5 rem (50 mSv) TED or the DOE 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 DOE 5 rem TED limit.

The data also indicates that the collective dose decreased by 2 percent although the number of individuals with measurable dose increased by 2 percent. In addition from CY 2017 to 2018 the:

- collective TED for all DOE facilities decreased by 2 percent or 12.8 person-rem (128 person-mSv);
- collective CED (internal exposure to U-234) decreased by 16 percent to 55.2 person-rem (552 person-mSv); and
- collective TED for transient workers (individuals monitored at more than one DOE site) decreased by 6 percent to 18.9 person-rem (189 person-mSv).

During CY 2014 – 2018, a total of 4,927 occurrence reports were submitted to ORPS. Of these, 8 percent (383) included at least one of the 11 Radiological HQ Keywords. The occurrences were mainly Facility / Equipment / Site Contamination (68%), Clothing Contamination (19%), and Skin Contamination (15%). External Exposure and Intake each accounted for 2% of the reports.

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. As DOE has become more involved in the new missions, the collective and average doses have been relatively low. 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) ($H_{E,50}$)
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) ($H_{T,50}$)
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 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 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
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.

References

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

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

3. NCRP (National Council on Radiation Protection and Measurements), 1987. "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP 91; 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.

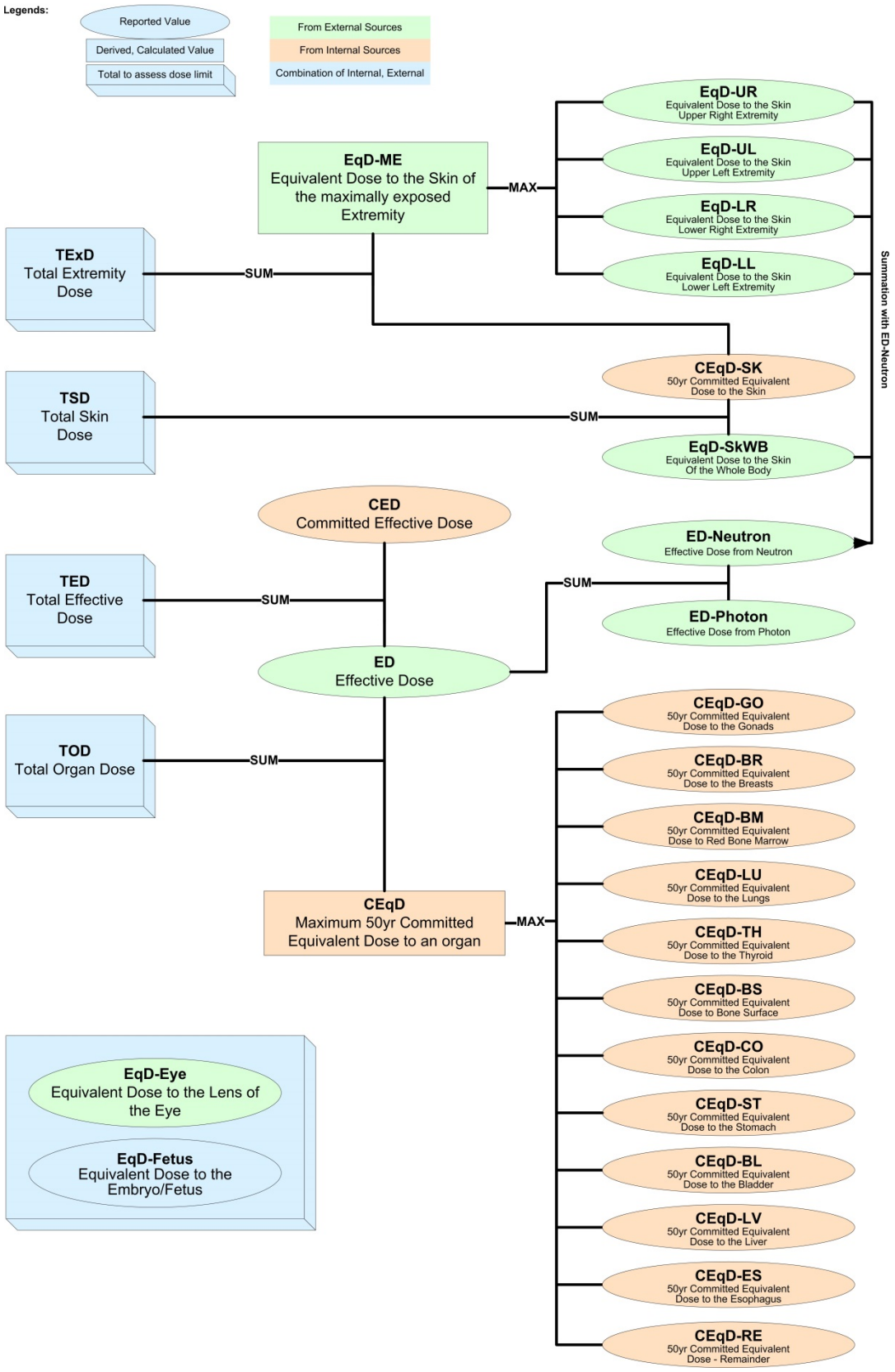
7. Computerized Accident and Incident Reporting System (CAIRS), "DOE and Contractor Injury and Illness Data by Year by Quarter" report. Online at https://www.energy.gov/ehss/policy-guidance-reports/databases/computerized-accident-incident-reporting-system.

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 232.2A, "Occurrence Reporting and Processing of Operations Information," January 2017. Online at https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-A/@@images/file.

10. 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.

DOE Radiation Exposure Monitoring System (REMS)
Dose Abbreviations, Definitions, and Relationships



HQ Keywords Binning Guidance and Criteria (as of 09/17/2018).

1. Work Planning and Control Deficiencies

A. Inadequate Conduct of Ops (Retired)
B. Loss of Configuration Management/Control
C. Violation of AB Elements
D. Missed/Late Surveillance
E. Facility Operations Procedure Noncompliance
F. Training Deficiency
G. Inadequate Procedure
H. Inadequate Safety Analysis/USQ/TSR
I. Safety System Actuation/Evacuation
J. Criticality Procedure Noncompliance
K. LOTO Noncompliance (Elect)
L. LOTO Noncompliance (Other)
M. Inadequate Job Planning (Electrical)
N. Inadequate Job Planning (Other)
O. Inadequate Maintenance
P. Inadequate Oral Communication
Q. Personnel Error
R. Management Issues
S. Incorrect/Inadequate Installation
T. Willful Violation
U. Unplanned Interruption of Operations

2. Environmental

A. Radioactive Release
B. Underground Storage Tank Release
C. Compliance Notification (from regulator with a violation)
D. Compliance Notification (to regulator without a violation)
E. Hazardous Material Release
F. Potable Water Release

3. Fire Protection & Explosives Safety

A. Fire Protection Equip Degradation
B. Fire Suppression Actuation
C. Facility Fire
D. Explosives Safety Issue
E. National Fire Protection Association (NFPA) Code/ Fire Protection Issue
F. Explosion
G. Wildland Fire

4. Instrumentation/Controls

A. I & C Equipment
B. Criticality Equipment
C. Monitor/Analyzer
D. Computer Software
E. Computer Hardware

5. Mechanical/Structural

A. Freeze Protection Failure
B. Seismic Qualification Deficiency
C. Ventilation System/Fan
D. Mechanical Equipment Failure/Damage
E. Structural Deficiency/Failure
F. Corrosion/Material Degradation/End of Life
G. Glovebox Failure
H. HEPA Filter
I. Container/Package Failure

6. Radiological

A. Clothing Contamination
B. Facility/Equip/ Site Contamination
C. Skin Contamination
D. Airborne Radiological Release
E. Radiological Control Procedure Noncompliance
F. External Exposure
G. Intake
H. Inadequate Radiological Control Job Planning
I. Radiological Control Training Deficiency
J. Inadequate Radiological Control Procedure
K. Offsite Spread of Contamination

7. Electrical Systems

A. Emergency or Backup Generator Failure
B. Electrical Distribution
C. Power Outage
D. Electrical Wiring
E. Electrical Equipment Failure
F. Arc Flash

8. OSHA Reportable/Industrial Hygiene

A. Electrical Shock
B. Indoor Air Contamination
C. Industrial Hygiene Exposure
D. Injury
E. Fatality
F. Industrial Operations Issues (Retired)
G. Industrial Equipment
H. Safety Noncompliance
I. Safety Equipment Failure
J. Near miss (Electrical)
K. Near miss (Other)
L. Notice of Violation or Non-Compliance
M. Chemical Safety
N. Laser Safety
O. Construction/Demolition Safety
P. Hoisting/Rigging Incident
Q. Forklift/Hand Truck Incident
R. Excavations/Penetrations
S. Landscaping/Mowing
T. Beryllium Incident

9. Safeguards/Security Issue

A. Fitness for Duty Issue
B. Material Accountability Issue
C. Miscellaneous Security Issue
D. Theft/ Sabotage

10. Transportation

A. Shipping Regulation Noncompliance
B. Vehicle Accident/Incident
C. Industrial Equipment Movement Incident
D. Transportation Notice of Violation or Non-Compliance from Local, State or Federal Agency
E. Shipping Incidents/Accidents

11. Other

A. Chemical Reaction/Pressurized Drum
B. Emergency Management System Failure
C. Nuclear Weapons Safety Issue
D. Natural Phenomena
E. Suspect/Counterfeit Items
F. Inadequate Design
G. Subcontractor
H. Procurement Deficiency/Defective Items
I. Visiting Scientist/Researcher or Student Employee
J. Tenants on DOE Property
K. Excessed Equipment/Material
L. Supplier
M. Outside Agency or Organization/ Site Visitor
N. Nuclear Waste Handling Operations

12. EH Categories (select only one)

A. Authorization Basis
B. Conduct of Operations
C. Electrical Safety
D. Environmental Release/Compliance
E. Equipment Degradation/Failure
F. Fire Protection & Explosive Safety
G. Industrial Operation
H. Injuries Requiring Medical Treatment Other Than First Aid
I. Lockout/Tagout (Electrical & Mechanical)
J. OS/IH
K. Near Miss (Electrical & Mechanical)
L. Nuclear Criticality Safety Concerns
M. Radiological Control
N. Rad. Skin Contaminations/Uptakes/ Overexposures
O. Safeguards & Security
P. Shipping QA
Q. Vehicular Accidents
R. Suspect/Counterfeit Items – Defective Items
Z. Other than Above

13. Management Concerns

A. HQ Significant
B. Accident Investigation - Type A (Retired)
C. Accident Investigation - Type B (Retired)
D. Accident Investigation – Other
E. Facility Call Sheet
F. Operating Experience Summary Article
G. Suspect/Counterfeit Items - Defective Items Data Collection Sheet
H. ARRA - American Recovery and Reinvestment Act (Retired)

14. Quality Assurance

A. Program Deficiency
B. Training & Qualification Deficiency
C. Quality Improvement Deficiency
D. Documents & Records Deficiency
E. Work Process Deficiency
F. Design Deficiency
G. Procurement Deficiency
H. Inspection & Acceptance Testing Deficiency
I. Management Assessment Deficiency
J. Independent Assessment Deficiency
K. Safety Software Deficiency
L. No QA Deficiency

U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2018 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 2018*. **Your feedback is important**. Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to:

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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: _____

   _____

   _____

   _____

2. Distribution:

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

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

(continued on back)

Please circle one.

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

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

Executive Summary	1	2	3	4	5
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
DOE Occupational Dose in Relation to Other Activities	1	2	3	4	5
ALARA Activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

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

Not important				Critical
1	2	3	4	5

Please provide any additional input or comments on the report.

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