Summary of Annual Site Environmental Report Radiological Doses and Releases 2015−2018

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Contents

Acknowledgment iv
Executive Summary vi
1.0 Introduction 1.1
1.1 DOE Environmental Monitoring and Surveillance Programs 1.5
1.2 ASER Requirements and Guidance for Radiation Protection of the Public 1.6
1.3 Organization of this Report 1.8
1.4 Comparison with the 1998−2001 ASER Summary Report 1.8
1.5 References 1.13
2.0 Dose Estimates to Members of the Public 2.1
2.1 Background 2.1
2.2 Maximally Exposed Individual Dose Estimates 2.2
2.3 Collective Dose Estimates 2.13
2.4 Comparisons of Dose Estimates in ASERs and Subpart H Reports 2.27
2.5 References 2.33
3.0 Biota Dose Evaluations 3.1
3.1 Background 3.2
3.2 Demonstrating Protection of Biota and Reporting Compliance with DOE Dose Limits and Requirements 3.3
3.3 Results of CY 2015–2018 Biota Dose Evaluation Reporting in ASERs 3.4
3.4 References 3.11
4.0 Releases of Radioactive Material to Air and Water 4.1
4.1 Nonroutine Releases 4.1
4.2 Routine Releases via Air and Liquid Effluent 4.2
4.2.1 Radioactive Materials in Air Effluent 4.3
4.2.2 Radioactive Materials in Liquid Effluent 4.10
4.3 References 4.17
5.0 Liquids Surveillance 5.1
5.1 Groundwater Surveillance 5.4
5.1.1 State Groundwater Standards 5.4
5.1.2 Results of CY 2015−2018 Groundwater Surveillance and Reporting 5.5
5.2 DOE Potable Water Systems Surveillance 5.19
5.2.1 State Drinking Water Standards 5.20
5.2.2 Results of CY 2015−2018 DOE Potable Water System Surveillance 5.20
5.3 Surface Waters and Stormwater Surveillance 5.28
5.3.1 State Standards 5.28
5.3.2 Results of CY 2015−2018 Surface Water Surveillance 5.28
5.3.3 Results of CY 2015−2018 Stormwater Surveillance 5.42
5.4 References 5.51
Appendix A – Glossary, Acronyms & Abbreviations, and Numbers & Units A.1
A.1 Glossary A.1

A.2 Acronyms and Abbreviations A.5
A.3 Numbers, Symbols, and Units A.9
A.3.1 Use of Scientific Notation A.10
A.3.2 Significant Figures A.10
A.3.3 Units of Measurement A.10
A.3.4 Units and Conversions A.10
Appendix B – 2015–2018 ASER References B.1
Appendix C – Site Descriptions and Monitoring Programs C.1
C.1 Introduction C.2
C.2 Office of Energy Efficiency and Renewable Energy C.3
C.2.1 National Renewable Energy Laboratory C.3
C.3 Office of Environmental Management C.4
C.3.1 Hanford Site C.5
C.3.2 Paducah Gaseous Diffusion Plant C.6
C.3.3 Portsmouth Gaseous Diffusion Plant C.7
C.3.4 Santa Susanna Field Laboratory C.8
C.3.5 Savannah River Site C.8
C.3.6 Waste Isolation Pilot Plant C.10
C.3.7 West Valley Demonstration Project C.11
C.4 National Nuclear Security Administration C.13
C.4.1 Lawrence Livermore National Laboratory C.13
C.4.2 Los Alamos National Laboratory C.14
C.4.3 Nevada National Security Site C.16
C.4.4 Pantex Plant C.18
C.4.5 Sandia National Laboratories, Albuquerque, New Mexico C.19
C.4.6 Sandia National Laboratories, Livermore, California C.20
C.4.7 Sandia National Laboratories, Tonoapah Test Range, Tonopah, Nevada C.21
C.4.8 Sandia National Laboratories, Kaua'i, Hawaii C.22
C.5 NNSA Naval Nuclear Propulsion Program C.22
C.5.1 Bettis Atomic Power Laboratory C.23
C.5.2 KAPL-Kesselring Site C.23
C.5.3 KAPL-Knolls Laboratory C.24
C.5.4 Naval Reactors Facility at INL C.26
C.6 Office of Fossil Energy C.27
C.6.1 National Energy Technology Laboratory C.27
C.6.2 Strategic Petroleum Reserve C.28
C.7 Office of Nuclear Energy C.29
C.7.1 Idaho National Laboratory C.29
C.8 Office of Science C.31
C.8.1 Ames Laboratory C.32
C.8.2 Argonne National Laboratory C.32
C.8.3 Brookhaven National Laboratory C.33

C.8.4 Fermi National Laboratory C.34
C.8.5 Lawrence Berkeley National Laboratory C.35
C.8.6 Oak Ridge Reservation C.37
C.8.7 Pacific Northwest National Laboratory C.40
C.8.8 Princeton Plasma Physics Laboratory C.41
C.8.9 Stanford Linear Accelerator Center C.42
C.8.10 Thomas Jefferson National Accelerator Facility C.43
Appendix D – Summary of Radionuclide Air Emissions from DOE Facilities, 2015–2018 .... D.1
D.1 Compliance with the Subpart H Dose Standard D.4
D.1.1 Regulatory Requirements D.4
D.1.2 Radionuclide Emissions to the Atmosphere during Normal Operations D.5
D.1.3 Dosimetry Models and Codes D.16
D.1.4 Environmental Measurements as an Alternative to Dosimetry Models D.18
D.1.5 Status of Compliance with Subpart H Dose Standard D.18
D.1.6 Unplanned Releases to the Atmosphere D.25
D.2 Supplemental Information D.26
D.2.1 Radon Emissions D.26
D.2.2 Collective Dose Estimates from Radionuclide Air Emissions D.29
D.3 References D.36
Appendix E – State Standards for Liquids Surveillance E.1
E.1 State Groundwater Standards E.1
E.2 State Drinking Water Standards E.2
E.3 State Surface Water and Stormwater Standards E.2

FIGURES

Figure 1-1. ASER-Reported Dose to the MEI Receptor for CYs 1998–2001 and 2015–2018............ 1.11
Figure 1-2. ASER-Reported Collective Dose for CYs 1998–2001 and 2015–2018.......................... 1.12
Figure 2-1. Maximum or Representative Public Receptor Doses with Lowest Doses Indicated at 0.01 mrem/yr (2015–2018).. 2.12
Figure 2-2. 2018 Collective Doses with Sites Sorted by Program Office and 50 mi Population Size (high to low).. 2.27

TABLES

Table 1-1. DOE Sites Reviewed for Radiological Release, Monitoring, and Dose for Calendar Years 2015–2018.. 1.3
Table 1-2. DOE (2004) Sites Not Reviewed in this Report.. 1.9
Table 1-3. Clarifications for DOE (2004) Sites Summarized in this Report.................................... 1.9
Table 1-4. Sites New to this Report Not Included in the DOE 2004 Report.................................. 1.10
Table 1-5. Total Radionuclide Releases from DOE Sites to Ambient Air and Via Liquid Effluent (2001 and 2018).. 1.12
Table 2-1. DOE Sites with No MEI Dose Estimates (2015–2018) 2.3
Table 2-2. Public Receptor Dose Estimates in DOE ASERs (2015−2018)...................................... 2.4
Table 2-3. Sites that Report a Public Receptor Dose Greater Than 1 mrem/yr (2015–2018).............. 2.5
Table 2-4. ASER Estimates of Maximum Public Receptor Dose by Pathway (2015−2018)................ 2.7
Table 2-5. DOE Sites with No Collective Dose (2015–2018).. 2.14
Table 2-6. Total Collective Doses Estimates in DOE ASERs (2015−2018)................................... 2.15
Table 2-7. Average Reported Collective Doses by Program Office (2015–2018)............................ 2.16
Table 2-8. ASER Estimates of Collective Dose from DOE Emissions and Collective Background Dose (2015–2018).. 2.17
Table 2-9. Comparison of Dose Estimates from ASER and Subpart H Reports (2015−2018)........... 2.29
Table 3-1. DOE Sites with No Reported Biota Dose (2015–2018).. 3.2
Table 3-2. DOE-STD-1153-2002 Biota Dose Standards.. 3.3
Table 3-3. Summary of ASER Biota Dose (2015–2018)... 3.5
Table 4-1. Total Activity Released via Air and Liquid Effluents for General Radionuclide Types (2015–2018).. 4.3
Table 4-2. Total Activity Released to Ambient Air by DOE Site (2015–2018)................................. 4.4
Table 4-3. Category Descriptions for Emissions to Air Effluent Tables.. 4.5
Table 4-4. Summary of 2015 Emissions to Air Effluent (total Ci and radionuclide counts).................. 4.6
Table 4-5. Summary of 2016 Emissions to Air Effluent (total Ci and radionuclide counts).................. 4.7
Table 4-6. Summary of 2017 Emissions to Air Effluent (total Ci and radionuclide counts).................. 4.8
Table 4-7. Summary of 2018 Emissions to Air Effluent (total Ci and radionuclide counts).................. 4.9
Table 4-8. Total Activity Released via Liquid Effluents by DOE Site (2015–2018)........................... 4.10
Table 4-9. Sites Not Reporting Total Activity of Radioactive Liquid Effluents (2015–2018)............... 4.11
Table 4-10. Radionuclide Activity Released via Liquid Effluent in 2015 (Ci).................................... 4.13
Table 4-11. Radionuclide Activity Released via Liquid Effluent in 2016 (Ci).................................... 4.14

Table 4-12. Radionuclide Activity Released via Liquid Effluent in 2017 (Ci)..................................... 4.15
Table 4-13. Radionuclide Activity Released via Liquid Effluent in 2018 (Ci)..................................... 4.16
Table 5-1. Types of Liquid Effluent Radiological Surveillance at DOE Sites (2015–2018)............ 5.2
Table 5-2. Sites That Report a Liquid Pathway Dose for the Maximally Exposed Receptor (2015–2018).. 5.3
Table 5-3. DOE Sites with No Reported Groundwater Surveillance Results (2015–2018).................. 5.4
Table 5-4. Radioactive Constituents Sampled in Groundwater at DOE Sites (2015–2018)................. 5.5
Table 5-5. Summary of Groundwater Monitoring at DOE Sites (2015–2018)................................... 5.7
Table 5-6. Water Sources for DOE Potable Water Systems (2015−2018)..................................... 5.19
Table 5-7. Radioactive Constituents Sampled in Water from DOE Potable Water Systems (2015–2018).. 5.20
Table 5-8. Summary of DOE Potable Water System Monitoring (2015–2018)................................. 5.21
Table 5-9. DOE Sites with No Reported Surface Water Surveillance (2015–2018)......................... 5.29
Table 5-10. Radioactive Constituents Sampled in Surface Water (2015–2018)................................ 5.30
Table 5-11. Summary of DOE Sites Surface Water Surveillance (2015–2018)................................. 5.31
Table 5-12. DOE Sites with No Reported Stormwater Surveillance (2015–2018)............................. 5.42
Table 5-13. Radioactive Constituents Sampled in Stormwater at DOE Sites (2015−2018)................. 5.43
Table 5-14. Summary of ASER Stormwater Surveillance (2015–2018)... 5.44

Executive Summary

U.S. Department of Energy (DOE) sites that conduct significant environmental protection programs are required to prepare Annual Site Environmental Reports (ASERs) in accordance with DOE Order (O) 231.1B, Chg 1, *Environment, Safety and Health Reporting*. ASERs present environmental data that characterize site environmental management performance; report compliance with environmental standards and requirements; and highlight significant environmental and sustainability programs and efforts. Radiological operations at DOE sites are managed under site-specific environmental protection programs. Radionuclide emissions to the environment may result from these operations. Such releases can be dispersed by site meteorology and hydrology. DOE strives to minimize radionuclide emissions and to protect human and environmental health at both onsite and offsite locations.

This report summarizes radiological emissions and releases to the environment that could contribute to offsite exposures to members of the public and surrounding environment from DOE operations, as reported in the DOE Annual Site Environmental Reports (ASERs) during calendar years 2015–2018. This report includes information regarding DOE site radionuclide releases through air and liquid effluent; reported compliance with the individual receptor dose, biota dose, and liquid effluent (ground-, surface-, storm-, and potable water) standards; and reporting of collective dose (i.e., population dose). This summary report is an update to DOE/EH-0692 (2004) *Summary, Annual Site Environmental Report Radiological Doses and Releases, 1998–2001*.

The dose impacts from DOE emissions reported herein can be compared to the average dose from natural background radiation. Natural sources of radioactive materials (e.g., uranium-238, potassium-40) contribute to every individual's natural background radiation dose. Typical background radiation dose to a member of the public is estimated to be 0.310 rem/yr NCRP Report No. 160 (2009), *Ionizing Radiation Exposure of the Population of the United States*.

The following statements summarize the data presented in DOE site ASER reports for calendar years 2015–2018.

- Individual public receptor doses at all sites were far below the 100 mrem/yr all-pathways dose limit specified in DOE O 458.1, Chg 3, *Radiation Protection of the Public and Environment*—even with typical dose modeling that results in overestimates of dose to any actual receptor. Doses include exposure from site emissions via air and liquid effluents. Routes of exposure include inhalation, ingestion (e.g., food, water, game), and external dose, as applicable to each site's operations.
- Collective dose to the public, for which there is no limit or constraint, is presented for all sites. Collective doses from site operations (about 32 person-rem from all sites) are a small fraction of the natural background exposures to the public population surrounding those sites (e.g., about 26 million person-rem in 2015).
- Biota dose estimates at all sites were below the dose limits for all four representative biota categories that require evaluation. DOE biota dose criteria indicate that dose rates should not exceed 1 rad/d for aquatic animals and for terrestrial plants, and 0.1 rad/d for riparian animals and for terrestrial animals. Biota doses can be estimated with site-specific ambient air, soil, water, or tissue data, using a graded approach to the assessment.
- About 63,000–110,000 Ci/yr of activity was released directly to ambient air from all DOE sites.
- About 2,000 Ci/yr of activity was released to the ambient environment via liquid effluents from all DOE sites.
- Onsite groundwater monitoring indicated radionuclide concentrations above some State groundwater standards at several sites. Remediation actions are ongoing. Exceedances were identified for tritium (hydrogen-3), carbon-14, strontium-89/90, technetium-99, iodine-129, cesium-137, radium-228, uranium radionuclides, as well as gross alpha and gross beta criteria.

- Onsite DOE-operated potable water systems at sites were sampled to determine compliance with State drinking water standards. No site reported potable water measurements above Federal and State applicable drinking water standards.
- Two sites found radionuclide concentrations above their respective State surface water standards. Exceedences were noted for tritium and gross alpha criteria.
- Stormwater sampling results indicated compliance with applicable radiation protection limits for most sites. However, at four DOE sites, there were a few instances where stormwater sampling results were above applicable limits for tritium, strontium-89/90, radium-226, radium-228, uranium-233/234, uranium-238, as well as gross alpha and gross beta criteria.

In addition to current operational releases, some sites continue to address the environmental media (e.g., soil and water) contamination legacy from early DOE operations. DOE sites continue to make progress in remediating this legacy contamination of land, surface water, and groundwater to reduce and eliminate (future) offsite and onsite radiological contamination.

Sites continue their work to accomplish DOE missions. Current DOE site operators conduct radiological laboratory and waste management activities to minimize radionuclide emissions to the ambient environment. They strive to operate such that emissions are far below applicable environmental criteria so that potential impacts to members of the public are minimal. Sampling results found above regulatory limits are subject to remedial actions. The 2015-2018 dose to the maximally exposed member of the public from any site releases are well below dose criteria.

1.0 Introduction

U.S. Department of Energy (DOE) sites that conduct significant environmental protection programs are required to prepare Annual Site Environmental Reports (ASERs), in accordance with DOE Order (O) 231.1B, Chg 1, *Environment, Safety and Health Reporting*. ASERs present environmental data that characterize site environmental management performance; report compliance with environmental standards and requirements; and highlight significant environmental and sustainability programs and efforts. ASERs also document the potential radiological and nonradiological impacts of DOE operations on the public and environment near each site and serve as the primary mechanism for documenting compliance with DOE requirements for radiation protection of the public and environment per DOE O 458.1, Chg 3, *Radiation Protection of the Public and Environment*. Although DOE O 458.1 was updated to Chg 4 in 2020, the 2015-2018 ASERs reviewed in this report were subject to the requirements in DOE O 458.1, Chg 3.

This report also summarizes information about the radiological protection programs at DOE sites that conduct radiological or nuclear research & development, production, or waste disposition operations. It reviews radiological releases to air and water, potential doses to people living near the sites, biota dose evaluations, and monitoring of radionuclides in groundwater, surface water, and stormwater.

This summary report provides an overview of the *radiological* releases, monitoring, and dose estimates reported in DOE ASERs in calendar year (CY) 2015, 2016, 2017, and 2018. In this report, doses are reported only in traditional units (e.g., mrem and rad) rather than in terms of International System of units (SI) (e.g., Sv) and traditional units. Radiological activity is presented in units of curies (conversion factors for International System of units [SI] are available in Section A.3.4 in Appendix A).

A DOE site may include one location or be operationally tied to one or more smaller sub-sites. ASERs from DOE sites managed under the following Program Offices were reviewed (also, see Table 1-1 at the end of this section):

- Office of Environmental Management (EM) – 7 sites, plus Oak Ridge Reservation (ORR) and KAPL-Knolls (KNOL) sub-sites;
- National Nuclear Security Administration (NNSA) – 8 sites, plus Lawrence Livermore National Laboratory (LLNL), Nevada National Security Site (NNSS), and ORR sub-sites;
- NNSA Naval Nuclear Propulsion Program (NNSA-NNPP) – 3 sites, plus an Idaho National Laboratory (INL) sub-site;
- Office of Science (SC) – 10 sites, plus Pacific Northwest National Laboratory (PNNL) and ORR sub-sites;
- Office of Nuclear Energy (NE) – 1 site, with an INL sub-site;
- Office of Fossil Energy (FE) – 2 sites; and
- Office of Energy Efficiency and Renewable Energy (EERE) – 1 site, with a National Renewable Energy Laboratory (NREL) sub-site.

Table 1-1 breaks out sites with operations that are either geographically distinct, or onsite locations managed under different Program Offices (as indicated in the site documentation) as sub-sites. In total, 43 DOE sites and sub-sites[1] are included. ASERs reviewed for this report are listed in Appendix B. Additional details about sub-sites are identified in the site descriptions in Appendix C.

Office of Legacy Management (LM) sites are not reviewed in this report. For information about LM sites, see https://www.energy.gov/lm/office-legacy-management. LM sites are in a stable configuration with no

[1] This count of 43 sites considers the composited ORR as a single site.

DOE radiological operations. Required post-closure activities occur at these locations until DOE relinquishes the site.

Program Offices are assigned to each site based on the office that manages the significant portion of radiological operations. Several sites conduct radiological operations for more than one DOE Program Office. Legacy radiological cleanup activities under EM are conducted concurrent with research under other Program Offices at several sites. Among these are Savannah River Site (SRS) and ORR Y-12 National Security Complex (Y-12) (assigned as NNSA sites); and INL (assigned as an NE site). In addition, the Hanford Site was assigned as an EM site, even though significant SC radiological operations occur onsite.

Throughout this summary report, the terms "DOE site" and "DOE facility" describe the operations at a site or facility that are under DOE jurisdiction and are subject to DOE O 458.1, Chg 3. In a few situations, DOE may not be directly responsible for the entire site or an onsite facility operation involving radioactive material conducted at these locations may not be subject to DOE authority under DOE O 458.1. In such cases, the discussion and information presented herein refers to DOE operations or activities, unless otherwise indicated.

As indicated above, a single organization may manage DOE operations at several locations (e.g., see Table 1-1: INL, Knolls Atomic Power Laboratory-Knolls Laboratory [KNOL], LLNL, ORR, PNNL, and Sandia National Laboratories [SNL]). The activities at each location may or may not be under the same Program Office.

Radiological activities at several DOE sites or sub-sites listed in Table 1-1 that prepare ASERs use only X-ray or sealed sources or have no current (2015−2018) or remediation radiological activities onsite. The ASER information from these locations with no radiological releases are not included in this report, but their operations are described briefly in Appendix C. The sub-site locations whose data is not included in this report include:

- Office of Fossil Energy – National Energy Technology Laboratory (NETL) and Strategic Petroleum Reserve (SPR),
- Office of Energy Efficiency and Renewable Energy – NREL Other,
- National Nuclear Security Administration – SNL−Kaua'i Test Facility (KTF), NNSS North Las Vegas Facility (NLVF),
- Office of Nuclear Energy – INL Research and Education Campus (REC), and
- Office of Science – Ames Laboratory (AMES), ORR Oak Ridge Institute for Science and Education (ORISE).

Table 1-1. DOE Sites Reviewed for Radiological Release, Monitoring, and Dose for Calendar Years 2015–2018

Acronym	Site Name	Location	DOE Program Office[(a)]	Principal Radiological Operations
AMES[(b)]	Ames Laboratory	Ames, IA	SC	Research and development
ANL	Argonne National Laboratory	Argonne, IL	SC	Accelerator operations and applied nuclear science
BETTIS	Bettis Atomic Power Laboratory	West Mifflin, PA	NNSA-NNPP	Naval nuclear propulsion research
BNL	Brookhaven National Laboratory	Upton, NY	SC	Applied nuclear science and particle physics
FERMI	Fermi National Laboratory	Batavia, IL	SC	Accelerator operations and particle physics
HANF	Hanford Site	Richland, WA	EM	Environmental remediation and applied nuclear science research
INL	Idaho National Laboratory	Idaho Falls, ID	NE	Nuclear energy solutions and environmental remediation
INL REC[(b)]	Research and Education Complex of INL	Idaho Falls, ID	NE	Research and education
INL NRF	Naval Reactors Facility at INL	Idaho Falls, ID	NNSA-NNPP	Naval nuclear propulsion research
JLAB	Thomas Jefferson National Accelerator Facility	Newport News, VA	SC	Nuclear physics and accelerator research
KESS	Knolls Atomic Power Laboratory-Kesselring Site	West Milton, NY	NNSA-NNPP	Naval nuclear propulsion testing and training
KNOL	Knolls Atomic Power Laboratory-Knolls Laboratory	Niskayuna, NY	NNSA-NNPP	Naval nuclear propulsion research
KNOL SPRU	Separations Process Research Unit at KNOL	Niskayuna, NY	EM	Environmental remediation
LANL	Los Alamos National Laboratory	Los Alamos, NM	NNSA	Stockpile stewardship and research
LBNL	Lawrence Berkeley National Laboratory	Berkeley, CA	SC	Basic and applied research
LLNL	Lawrence Livermore National Laboratory	Livermore, CA	NNSA	Stockpile management; countering the proliferation of weapons of mass destruction; and research
LLNL Site 300	LLNL Site 300	Tracy, CA	NNSA	Non-nuclear weapons component research and assessment
NETL[(b)]	National Energy Technology Laboratory	Morgantown, WV	FE	Effective and efficient energy source research and development
NNSS	Nevada National Security Site	Mercury, NV	NNSA	Stockpile science and waste management
NNSS NLVF[(b)]	North Las Vegas Facility of NNSS	Las Vegas, NV	NNSA	Legacy H-3 contamination (CY 1995)
NREL Other[(b)]	National Renewable Energy Laboratory	Denver, CO	EERE	Renewable energy and energy efficiency
NREL STM	NREL South Table Mountain	Golden, CO	EERE	Laboratory research
ORR	Oak Ridge Reservation (with all sub-sites)	Oak Ridge, TN	SC	(Composite of sub-site operations)

Acronym	Site Name	Location	DOE Program Office[a]	Principal Radiological Operations
ORR ETTP	East Tennessee Technology Park	Oak Ridge, TN	EM	Environmental remediation
ORR ORISE[b]	Oak Ridge Institute for Science and Education	Oak Ridge, TN	SC	Technical support with laboratory and assessment capabilities
ORR ORNL	Oak Ridge National Laboratory	Oak Ridge, TN	SC	Energy and security research
ORR Y-12	Y-12 National Security Complex	Oak Ridge, TN	NNSA	Nuclear material storage; naval reactor fuels; research; and environmental remediation
PGDP	Paducah Gaseous Diffusion Plant	Paducah, KY	EM	Cleanup and depleted uranium hexafluoride (DUF_6) conversion
PANTEX	Pantex Plant	Amarillo, TX	NNSA	Stockpile stewardship
PNNL MSL	PNNL Marine Sciences Laboratory	Sequim, WA	SC	Marine and environmental research
PNNL Richland	PNNL Richland Campus	Richland, WA	SC	Basic and applied nuclear research
PORTS	Portsmouth Gaseous Diffusion Plant	Piketon, OH	EM	Cleanup and DUF_6 conversion
PPPL	Princeton Plasma Physics Laboratory	Princeton, NJ	SC	Plasma and fusion science
SLAC	Stanford Linear Accelerator Center	Menlo Park, CA	SC	Accelerator operations and particle physics
SNL-CA	Sandia National Laboratories-CA	Livermore, CA	NNSA	Nuclear weapons research and management
SNL-KTF[b]	SNL-Kaua'i Test Facility	Kaua'i, HI	NNSA	Stockpile engineering support and rocket research
SNL-NM	SNL-NM	Albuquerque, NM	NNSA	National security research and technical support
SNL-TTR	SNL-Tonopah Test Range	Tonopah, NV	NNSA	Testing non-nuclear weapons systems and components
SPR[b]	Strategic Petroleum Reserve	New Orleans, LA	FE	Safe storage of petroleum reserves
SRS	Savannah River Site	Aiken, SC	EM	Environmental remediation, nuclear material management, and research
SSFL	Santa Susana Field Laboratory at Energy Technology Engineering Center	Canoga Park, CA	EM	Environmental remediation
WIPP	Waste Isolation Pilot Plant	Carlsbad, NM	EM	Federal transuranic (TRU) and mixed-TRU waste disposal
WVDP	West Valley Demonstration Project	West Valley, NY	EM	Environmental remediation

(a) Program Offices include Energy Efficiency and Renewable Energy (EERE), Environmental Management (EM), Fossil Energy (FE), National Nuclear Security Administration (NNSA), NNSA Naval Nuclear Propulsion Program (NNSA-NNPP), and Office of Science (SC). Coloration visually highlights the different Program Offices in this alphabetic site list.

(b) Legacy and current (2015−2018) radiological work is limited to occupational exposures, if any. Operations at these locations are not discussed further in this report.

1.1 DOE Environmental Monitoring and Surveillance Programs

DOE O 458.1, Chg 3 establishes requirements for the protection of the public and the environment from undue risk from radiation associated with radiological activities managed by DOE. DOE and its site contractors must maintain programs and capabilities, consistent with the types of radiological activities conducted, to monitor routine and nonroutine radiological releases and assess the radiation dose to members of the public and to particular biota groups. These programs aid in determining whether facility operations are functioning as designed to properly control releases of radioactive and nonradioactive materials and assessing compliance with applicable environmental radiation protection standards, including DOE O 458.1. In addition, site radiological processes are implemented to reduce levels of radioactive releases to as low as reasonably achievable (ALARA).

ASERs summarize environmental programs and the estimated environmental impacts of operations, including estimates of the radiation dose to individual members of the public and to the general population that could have resulted from operations at the site during the year. The ASERs also describe nonradioactive effluents released to the environment, and cleanup operations involving radioactive and chemically hazardous materials. This summary report only addresses radiological monitoring programs, radiological releases through air and liquid effluents, and resulting potential doses reported in ASERs.

Sampling of releases from DOE facilities can take place at the point of release to the ambient environment (effluent monitoring) and in the ambient environment (environmental surveillance). Monitoring and surveillance are used to ensure compliance with effluent control requirements and other applicable environmental standards. For most facilities, releases of radioactive material are not measurable in the environment beyond the DOE site boundary. Therefore, doses to the public and biota must be estimated, rather than obtained through direct measurement. The estimates are generally based on monitoring data taken from liquid effluent release points or airborne discharge locations; however, in some cases environmental monitoring data are used to project potential doses.

Software is used to model the dispersion of the radionuclides throughout the environment (air, soil, and water) and produce human and biota dose results reported in ASERs. Spreadsheet calculations and published dose conversion factors are included under the umbrella term *software*. The models estimate the radioactive material concentrations in air, food, soil, and water, then resolve the human and biota exposures and intakes to determine dose impacts. For facilities such as accelerators, whose primary contribution to public dose may be direct external radiation, measurements from onsite and offsite dosimeters may be used as the basis for dose calculations.

ASER-reported estimated dose to the maximally exposed member of the public and dose to biota are compared with applicable DOE and U.S. Environmental Protection Agency (EPA) standards to assess a site's performance (DOE O 458.1, Chg 3; 40 CFR Part 61 Subpart H). The dose calculations rely on conservative assumptions, which vary from site to site, and in some cases from year to year for a given site. The expectation is that any actual or likely dose would be lower than the estimate presented in the ASERs.

Environmental regulations establish criteria to minimize or eliminate impacts on the public and environment. A variety of regulations address releases of radionuclides. DOE site operations for which site missions require the use of unsealed radioactive sources or accelerators result in radionuclides being emitted to the ambient environment. These operations are conducted to comply with environmental regulations. All sites, in calendar year (CY) 2015−2018 ASERs, report data that demonstrate estimated radiological doses to the public are well below DOE protective requirements, as well as EPA- and state-regulated dose and risk standards.

Several sites still manage radionuclide contaminated environmental media (soil and water) from past operations. In addition to providing a safe environment for its workers who are addressing this legacy environmental contamination, DOE is committed to protecting the public and the environment during remediation activites.

Site remediation activities are under way at several sites and are at various stages of implementation. Remediation activities require extensive and thoughtful planning, implementation, and sampling to ensure that contamination and wastes are addressed and remediated appropriately and consistently. Results are demonstrated, for example, by the number of sites being transferred to the DOE-LM, and the volume of radioactive waste disposal in compliant facilities. Remediation activities will continue to reduce the potential exposure of radionuclide releases of past operations to the public and environment. This report summarizes surface water, stormwater, and groundwater surveillance data that may reflect reductions that result from the remedial action activities.

1.2 ASER Requirements and Guidance for Radiation Protection of the Public

ASERs are prepared in accordance with DOE Orders and guidance issued by DOE Office of Environmental Protection and ES&H Reporting (EHSS-20) within DOE Office of Environment, Health, Safety and Security (EHSS). The EHSS guidance provides recommendations for reporting that may be used to supplement the requirements of DOE Orders which were contractually applicable to DOE sites during the calendar year described in the ASER. The EHSS guidance, while not mandatory, promotes consistency and uniformity in the reporting of environmental information in ASERs.

ASERs report on the 2015–2018 radiological activities that may impact the public and the environment, per requirements in the following DOE directives:

- DOE O 231.1B, Admin Chg 1, *Environment, Safety, and Health Reporting*
- DOE O 458.1, Chg 3, *Radiation Protection of the Public and the Environment*
- DOE O 414.1D, Admin Chg 1, *Quality Assurance*
- DOE O 435.1, Chg 1, *Radioactive Waste Management*.

DOE O 231.1B establishes the following basic requirements for ASERs:

- Characterization of site environmental management performance, including effluent releases, environmental monitoring, the types and quantities of radioactive materials emitted or discharged to the environment, the estimated or calculated total effective dose to a Representative Person or maximally exposed member(s) of the public and the calculated collective dose to members of the public from exposure to radiation sources identified under DOE O 458.1, and where it is of concern, releases of radon and its decay products from DOE sources and the resultant individual and collective dose from these radionuclides, which need not be combined with dose estimates from other sources;
- A summary of environmental occurrences and responses reported during the calendar year;
- Confirmation of compliance with environmental standards and requirements;
- Highlights of significant site programs and efforts, including environmental performance indicators and/or performance measures that reflect the size and extent of programs at a particular site; and
- A description of property clearance activities, including a summary of approved Authorized Limits, results of radiological monitoring and surveys of cleared property, types and quantities of property cleared, and independent verification program results in accordance with DOE O 458.1.

Consistent with DOE's commitment to transparency and public involvement regarding its operations, the ASERs should be prepared to present information about areas of likely public concern that includes site environmental management performance and compliance summaries that are informative to the public and other stakeholders. Annual guidance issued by the EHSS[2] supplemented the requirements in DOE Orders for the years 2015 and 2017 (DOE 2016, 2018). Specific requirements and guidance are discussed further in relevant sections of this report.

DOE O 458.1 establishes requirements to protect the public and the environment from undue risk associated with radiological activities conducted under the control of DOE, pursuant to the *Atomic Energy Act* of 1954, as amended. The objectives of this Order are to conduct DOE radiological activities while maintaining exposure to members of the public below the dose limits established by the Order; to control the radiological clearance of DOE real and personal property; and to ensure that potential radiation exposures to members of the public are ALARA. DOE O 458.1 also covers monitoring routine and nonroutine radiological releases and assessing the radiation dose to members of the public, as well as providing guidance for the protection of the environment from the effects of radiation and radioactive material.

ASERs describe the radiological monitoring program at the site, as well as any assessments conducted during the year for doses to the public and releases to the environment. ASER information should also address details on the models and assumptions used in performing the dose calculations and any new monitoring data, as appropriate. Environmental measurements of air, surface water, soil, and foodstuff in ASERs should be reported in appropriate units.

The ASER should provide information about the total effective dose (TED) to the member-of-the-public Representative Person or to the Maximally Exposed Individual (MEI), collective (population) dose to the total regional population (typically within 50 miles), and estimated background dose. The ASER should also present the following radiological data:

- A comparison of the dose to the Representative Person or MEI with DOE, EPA, or other standards, and with the natural background at the site.
- Radionuclides released to air and water during the calendar year in units of curies (Ci) and becquerels (Bq). Totals by radionuclide released, and the half-life of each of the radionuclides reported, should be given.
- Gaseous releases.
- Liquid releases to surface waters and soils.

DOE O 414.1D presents the quality assurance requirements to implement and maintain a consistent and high level of quality requirements and expectations for environmental radiological data. ASERs should include discussions of site data collection and analysis programs; and summarize information from participation in inter-laboratory cross-checking programs, with the inclusion of site results and expected results. Specific details about quality assurance programs at sites are not summarized in this report but are typically summarized in the Quality Assurance section of ASERs.

DOE O 435.1 provides objectives to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. ASER guidance requests that information about the wastes that are managed at the site (e.g., high level, low level, transuranic), and the type of waste management practices the site is performing (e.g., generation, treatment, storage, disposal), be included. For DOE sites authorized to manage a low-level radioactive waste facility, information such as a table or listing of the status of each phase of the low-level radioactive waste management process (e.g., performance assessment/composite analysis [PA/CA], closure plan, PA/CA maintenance program, and disposal authorization statement), and a narrative description of the site's low-level radioactive waste management program, should be included in the ASER. Management of

[2] Current guidance available at https://www.energy.gov/ehss/policy-guidance-reports/environment-policy-guidance-reports/annual-site-environmental-reports (Accessed March 2021).

11e (2) byproduct material, as defined in the *Atomic Energy Act* of 1954 (42 USC 2011 et seq.), and naturally occurring radioactive material (NORM), is conducted under the provisions of DOE O 458.1, except when such material meets the conditions set forth in DOE Manual (M) 435.1, *Radioactive Waste Management Manual*, to allow for its disposal in an authorized low-level radioactive waste disposal site. Specific details regarding radioactive waste management at sites are not summarized in this report. Information is typically summarized in the Compliance Summary section of ASERs.

1.3 Organization of this Report

Information in the ensuing sections is presented as follows:

- Section 2.0 − Reported dose for both the MEI/Representative Person and the population in the vicinity of the DOE site.
- Section 3.0 − Reported biota dose to four aquatic or terrestrial biota categories.
- Section 4.0 − Reported radionuclide activity (curies) released in air and liquid effluents at operating DOE sites.
- Section 5.0 − Reported surveillance of liquid effluents, including groundwater, DOE-owned potable water systems, surface water, and stormwater results.

Appendices provide additional support information, as follows:

- Appendix A is a glossary of terms, acronyms, numeric format, and data units with useful conversion factors.
- Appendix B provides the titles of ASERs or monitoring reports reviewed for the compilation of data in this report. The ASERs provide more detail about all aspects of site operations, including site geography; quantity and identity of the radionuclides and chemicals released; radioactive and chemically hazardous material handling and cleanup; and facility descriptions. A limited amount of content related to ASERs was acquired from site Subpart H reporting (see Appendix D).
- Appendix C provides a brief description of each DOE site addressed in this report, along with an overview of the site's environmental monitoring program.
- Appendix D provides a summary of reports filed by DOE sites as part of their compliance with EPA *Clean Air Act* regulations regarding releases of radionuclides to ambient air (40 CFR Part 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities*). This section was presented as an Annex in the prior report. Data about atmospheric releases and related individual and collective (population) dose estimates are included.

No radiological release of property is summarized in this report. Details regarding ambient air-sampling and environmental dosimetry programs are also not covered in detail, but some information is provided if reported MEI or biota doses are based on dosimeter results in whole or in part.

1.4 Comparison with the 1998−2001 ASER Summary Report

This ASER summary report is intermittently updated. The prior ASER summary report (DOE 2004) included data from ASERs for 1998−2001 DOE operations. Several site name and DOE organizational changes have taken place since that report was published.

Table 1-2 identifies sites that were included in the previous summary report but not included in this summary report because they have since been designated as LM sites. Table 1-3 provides clarification to site name abbreviations used in DOE 2004 versus those used in this report. Table 1-4 lists new sites included in this report that were not summarized in the DOE 2004 report.

Table 1-2. DOE (2004) Sites Not Reviewed in this Report

Abbreviation (DOE 2004)	Site Name, Location	Reason for Discontinuing Site ASER
AEMP	Ashtabula Environmental Management Project, Ashtabula, OH	Now a DOE Office of Legacy Management (LM) site (Ashtabula, Ohio, Site)
BCL	Battelle Columbus Laboratories [West Jefferson Site], Columbus, OH	Now a DOE LM site (Columbus, Ohio, Site)
FEMP	Fernald Environmental Management Project, Fernald, OH	Now a DOE LM site (Fernald Preserve)
GJO	Grand Junction Office, Grand Junction, CO	Now a DOE LM site (Grand Junction, CO, Site)
KAPL-3	Knolls Atomic Power Laboratory-Windsor, Windsor, CT	Now a DOE LM site (Windsor, CT, Site)
LEHR	Laboratory for Energy-Related Health Research, Davis, CA	Now a DOE LM site (Laboratory for Energy-Related Health Research, CA, Site)
MEMP	Miamisburg Environmental Management Project, Miamisburg, OH	Now a DOE LM site (Mound, Ohio, Site)
MMTS	Monticello Mill Tailings Site, Monticello, UT	Now a DOE LM site (Monticello, UT, Disposal and Processing Sites)
WSSRAP	Weldon Spring Site Remedial Action Project, St. Charles County, MO	Now a DOE LM site (Weldon Spring, MO, Site)

Table 1-3. Clarifications for DOE (2004) Sites Summarized in this Report

DOE (2004) Site Abbreviation − Name	Clarification
ANL-E − Argonne National Laboratory-East	ANL-E (DOE 2004) is updated to **ANL** in this report. Previously, there was an ANL-W located at INL. ANL-W operations were consolidated with INL operations at the time of INL's name change from INEEL.
ETEC − Energy Technology Engineering Center	Only remediation activities at a location referred to as **SSFL** remain at ETEC. Site reference updated to SSFL.
INEEL − Idaho National Engineering and Environmental Laboratory	INEEL (DOE 2004) is updated to **INL** in this report.
KAPL-1 − Knolls Atomic Power Laboratory-Knolls	KAPL-1 (DOE 2004) is updated to **KNOL** in this report.
KAPL-2 − Knolls Atomic Power Laboratory-Kesselring	KAPL-2 (DOE 2004) is updated to **KESS** in this report.
NTS − Nevada Test Site	NTS (DOE 2004) is updated to **NNSS** in this report.
SNLA − Sandia National Laboratories, Albuquerque	SNLA (DOE 2004) is referred to as **SNL-NM** in this report.
SNLL − Sandia National Laboratories, Livermore	Sandia National Laboratories, Livermore (DOE 2004) is referred to as **SNL-CA** in this report. This site was mentioned but not summarized in the DOE 2004 report because it had no radioactive emissions that required monitoring (1998–2001). Radiological operations continue to be of a limited nature in 2015–2018.
SNLT − Sandia National Laboratories, Tonopah	SNLT (DOE 2004) is referred to as **SNL-TTR**.
JLAB − Thomas Jefferson National Accelerator Facility	JLAB (DOE 2004) remains the site-preferred acronym and is retained.

Table 1-4. Sites New to this Report Not Included in the DOE 2004 Report

Site (Location)	Comment
PNNL Richland (Richland, WA)	PNNL Richland Campus radiological air emission units licensed to DOE commenced in CY 2010. Prior to that time, PNNL radiological operations occurred on the Hanford Site or were conducted in privately operated laboratories.
PNNL MSL[(a)] (Sequim, WA)	PNNL MSL, Sequim Site, radiological operations transitioned to a DOE license in CY 2012. Prior to that time, MSL operations occurred in privately operated laboratories.
NETL (Morgantown, WV)	NETL is described in Appendix C, but the site has no radiological emissions.
NREL (Colorado locations)	NREL operates in two cities in Colorado. The South Table Mountain (NREL STM) facility in Golden has some radiological emissions; the Other Denver facilities (NREL Other) have no radiological emissions (see Appendix C).
SNL-KTF (Kaua'i, HI)	While this DOE site ASER is published with the SNL-TTR ASER, 2015−2018, radiological operations at SNL-KTF (if any) are limited to occupational exposures. Therefore, no further radiological details are presented in this report.
SPR (project management office in New Orleans, LA)	While this DOE site ASER is reviewed, 2015−2018 radiological operations are limited to occupational exposures (e.g., X-ray and sealed sources). Storage facilities are located in Plaquemine and Hackberry, LA; and Winnie and Freeport, TX.

(a) In CY2020, PNNL MSL changed its identification to PNNL Sequim.

This report's discussion of Dose Estimates to the Public (Section 2.0), Releases of Radioactive Material to the Air and Water (Section 3.0), and the Title 40 of the Code of Federal Regulations Part 61 (40 CFR Part 61), Subpart H, (Appendix D - Summary of Radionuclide Air Emissions from DOE Facilities) parallels information presented in Annex A of the 1998−2001 report (DOE 2004). This current report also includes a new section on stormwater monitoring (Section 5.3.3). The biota dose evaluations are presented in more detail in Section 3.0 of this report, as DOE O 458.1, Chg 3, now requires the demonstration of compliance with DOE-Standard (STD) 1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrrestrial Biota*.

A critical measure of offsite impacts from DOE site radiological operations is the annual dose estimate to the MEI, or an offsite Representative Person. Average annual dose estimates to the individual (MEI or Representative Person) near DOE sites have decreased since the 1998−2001 report (DOE 2004). Figure 1-1 displays average and median MEI dose estimates by year for 1998–2001 (DOE 2004) and 2015–2018. The average doses in the DOE 2004 report were about 1.4–2.4 mrem; those summarized in this report are about 0.6–1.2 mrem (2015–2017), with increase seen in 2018. This critical receptor's dose is, on average, currently about 1 percent of the 100 mrem/yr effective dose equivalent (EDE) that DOE O 458.1 defines as the all-pathways dose limit.

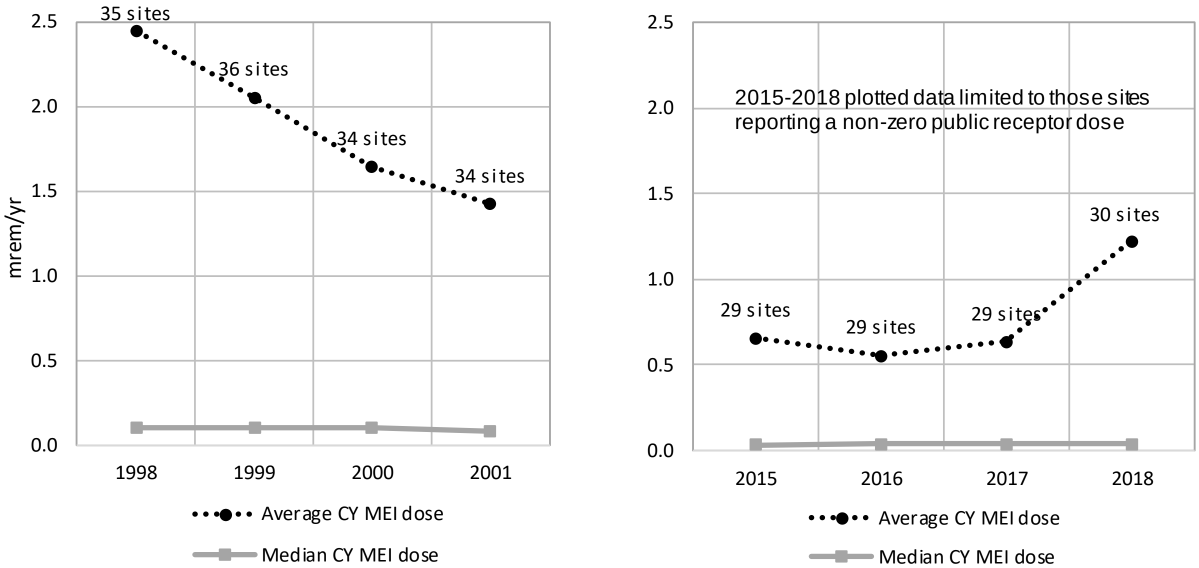

Figure 1-1. ASER-Reported Dose to the MEI Receptor for CYs 1998–2001 and 2015–2018

In the DOE 2004 report, most estimated doses were less than 1.0 mrem resulting in the median MEI dose estimate to be about 0.1 mrem. A few sites reported dose estimates that were large enough to increase the annual averages compared to the median for the year. The decrease in the 2015–2018 average doses can be attributed to smaller operational emissions, cleanup of legacy diffuse and fugitive emission sources, and less conservatism in the modeling, in part due to improved algorithms. In 2015−2018, estimates of average, all-sites dose, ranged from 0.6−1.2 mrem for the MEI, with median doses being about 0.04 mrem.

Figure 1-2 illustrates the collective dose results comparison of 1998–2001 (DOE 2004) and the 2015–2018 results summarized in this report. DOE 2004 used the term “population dose” and this report uses the current vernacular of “collective dose” (e.g., NCPR 2009) for this same data point. Average and median collective doses at DOE sites are much smaller than those reported in DOE 2004, for the same reason that the individual receptor doses are smaller. In addition, computational tools have allowed more precise estimates to be efficiently calculated. The average (and total) populations within 50 mi of DOE sites in 2001 and 2015 grew from an average of 2 million (55 million total) to an average of 3 million (85 million total), respectively, while the average collective dose decreased.

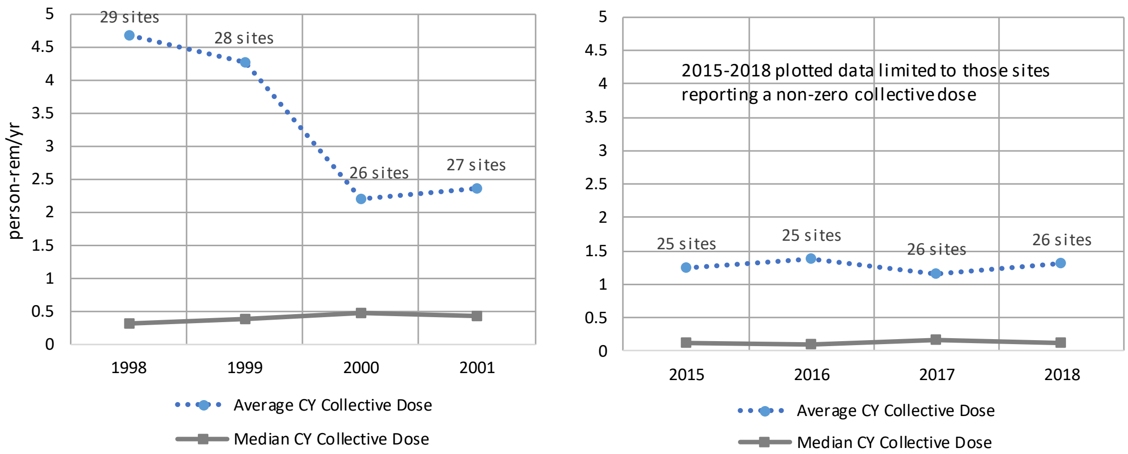

Figure 1-2. ASER-Reported Collective Dose for CYs 1998–2001 and 2015–2018

Table 1-5 is an aggregated summary of the 2001 and 2018 total radionuclide activity reported to be released from DOE facilities through air effluents or water effluents. With limited exceptions, these radionuclide activities do not include previous releases of radionuclides in environmental media (e.g., contamination in groundwater) from prior operations. DOE operations significantly reduced annual radionuclide activity emissions between 2001 and 2018. The remainder of this report describes these emissions in more detail.

Table 1-5. Total Radionuclide Releases from DOE Sites to Ambient Air and Via Liquid Effluent (2001 and 2018)

Releases	2001 (Ci)[(a)]	2018 (Ci)	Reduction by 2018
To Ambient Air	160,000	106,000	approx. 35%
Via Liquid Effluents	4,300	2,200	approx. 50%

(a) Source: DOE 2004

The averaged dose estimates to the individual member of the public impacted by site emissions reported in ASERs through the 1998–2001 time period, were reduced by approximately 50 percent across all DOE sites in 2015–2018. Collective doses and emissions, on a curie basis, over this period were also reduced. Such reductions result from cleanup and stabilization of legacy waste and LM sites. Reported emissions via liquid effluents to the ambient environment are more significantly reduced than those emitted to ambient air.

As reported in DOE 2004, an accelerator is the most common type of facility emitting direct radiation. The radiation is produced by the accelerator beam and is highly penetrating so that a fraction of the radiation may pass through the facility's shielding, thereby creating a potential source of exposure exterior to the accelerator building. In recent years, smaller beam target areas are used in current accelerators. As a result, this direct radiation source to a site MEI is not as significant as was reported in the past (DOE 2004).

Neither historical releases nor ongoing direct radiation are included in the estimates of annual releases to the air (Section 4.2.1). A small portion of historical releases to water may be included in current estimates of annual releases to water (Section 4.2.2) as an effluent stream from a groundwater treatment facility. Tritium is a common example of a radionuclide that may be released in groundwater from DOE operations; tritium is more difficult to remove from liquid effluents than other radionuclides.

1.5 References

40 CFR Part 61, Subpart H, *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H*, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*. U.S. Environmental Protection Agency.

42 USC 2011 et seq. *Atomic Energy Act* (AEA) of 1954.

DOE Order 435.1 Chg 1, *Radioactive Waste Management, 2001.* U.S. Department of Energy. Accessed November 2021, at https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg1-PgChg/@@images/file.

DOE Order 231.1B, Admin Chg 1, *Environment, Safety and Health Reporting, 2012.* U.S. Department of Energy. Accessed November 2021, at https://www.directives.doe.gov/directives-documents/200-series/0231.1-BOrder-b-admchg1/@@images/file.

DOE Order 458.1, Chg 3, *Radiation Protection of the Public and the Environment, 2013a.* U.S. Department of Energy. Accessed November 2021, at https://www.directives.doe.gov/directives-documents/400-series/0458.1-BOrder-chg3-admchg/@@images/file.

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DOE Order 458.1, Chg 4, *Radiation Protection of the Public and the Environment, 2020.* U.S. Department of Energy. Accessed November 2021, at https://www.directives.doe.gov/directives-documents/400-series/0458.1-border-chg4-ltdchg.

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.* Accessed November 2021, at https://www.standards.doe.gov/standards-documents/1100/1153-AStd-2002.

DOE (U.S. Department of Energy). 2004. *Summary, Annual Site Environmental Report Radiological Doses and Releases, 1998–2001*. DOE/EH-0692, Office of Air Water and Radiation Protection Policy and Guidance, Washington, D.C.

DOE (U.S. Department of Energy). 2016. *Guidance for Preparation of the 2015 Department of Energy Annual Site Environmental Reports. DOE Office of Environment, Health, Safety and Security.* Washington, D.C. Accessed November 2021 at https://www.energy.gov/sites/prod/files/2016/06/f32/2015_ASER_Guidance.pdf.

DOE (U.S. Department of Energy). 2018. *Guidance for Preparation of the 2017 Department of Energy Annual Site Environmental Reports. DOE Office of Environment, Health, Safety and Security*. Washington, D.C.

2.0 Dose Estimates to Members of the Public

Emissions to the ambient environment (e.g., air, liquid, soil) can result in radiation dose to members of the public through several environmental pathways. This section provides a summary of dose estimates to members of the public from site emissions to the environment. ASERs provide two estimates of public dose from DOE operations: the estimated dose to the MEI and the estimated collective dose to the population living within 50 mi (80 km) of the DOE site. To be consistent with current U.S. and international terminology, the term “collective dose” is used in lieu of “population dose”, as was used in the prior ASER summary report (DOE 2004).

2.1 Background

MEI and collective dose estimates are based on site-specific operations and may incorporate data from environmental sampling of atmospheric and liquid effluents or groundwater, monitoring of direct radiation, and modeling of potential releases. For each DOE site, dose estimates presented in ASERs are calculated rather than measured, and the calculations rely upon conservative assumptions. Dosimetry measurements are used to estimate external dose from intense X-ray sources, neutron sources, and potential short-lived gamma- and beta-emitters.

The stated purpose of DOE O 458.1, Chg 3, is as follows:

> To establish requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the Department of Energy (DOE) pursuant to the Atomic Energy Act of 1954, as amended (AEA).

The measure of risk to a member of the public is radiation dose. Dose estimates are calculated using appropriate Federal guidance and dose conversion factors approved by DOE and EPA for internal organs impacted by inhalation and ingestion of radioactive materials (EPA 1999), and for external doses (EPA 1993 and EPA 2019). These factors are based on recommendations of the International Commission on Radiological Protection ([ICRP] 1991, 2007, 2015). Existing health physics models are not immediately updated to the most current ICRP recommendations. ICRP updates have been driven by updates in radiological decay parameters, tissue and radiation weighting factors, and improvements in the biological modeling of intakes. Because ICRP methods have stabilized over the years, any differences in dose factors due to recent updates are generally small.

Limits on the dose to individuals and requirements for dose evaluations are contained in DOE O 458.1, Chg 3 (Paragraph 4.b). The DOE public dose limit for an individual in the vicinity of a DOE facility is 100 mrem/yr (1 mSv/yr) TED for all pathways and all sources of exposure. In addition, each DOE site must work to maintain doses ALARA. Paragraph 4.b further states the 100 mrem/yr limit applies to " all sources." Each DOE facility must maintain doses from each exposure pathway at a fraction of the limit to ensure that its contribution to dose to a member of the public does not cause an individual to exceed the limit from all sources. In paragraph 4.b(2), the public dose limit is specifically stated to apply to members of the public…

> “…located off DOE sites and on DOE sites outside of controlled areas, and to those exposed to residual radioactive material subsequent to any remedial action or clearance of property.”

Per DOE O 458.1, DOE assumes that if the DOE all-pathway dose to the MEI is less than one-fourth of the 100 mrem/yr limit, sites are complying with the "all sources" limit. Otherwise, per DOE O 458.1, Chg 3 (Paragraph 4.e.1.c), sites would need to consider doses from other sources in their evaluation to ensure the MEI is not exposed to doses exceeding the 100 mrem limit. In addition, EPA regulations

(40 CFR Part 61, Subpart H) limit the dose to an individual from a single site from only airborne radionuclide emissions to 10 mrem/yr (0.1 mSv/yr).

Temporary dose limits can be authorized in special cases by DOE authorities (DOE O 458.1, Paragraph 4.c). However, no such authorizations were reported in CY 2015–2018 ASERs.

There is no collective dose limit designated by DOE. Collective dose estimates provide an indication of the overall radiological impact of site operations. The collective dose reported in the ASER is one factor used to evaluate the effectiveness of the site's ALARA program (see DOE O 458.1, Paragraph 4.e.1.d). Collective dose estimates are useful in comparing operations over time and, to a limited extent, among similar facilities; and the estimates are an integral part of radiation protection program planning. Annual ASER guidance (e.g., DOE 2018)[1] indicates that DOE has no *de minimis* level for reporting of collective dose.

2.2 Maximally Exposed Individual Dose Estimates

The dose to the MEI is reported annually for each DOE site that has a radiological monitoring program. DOE 2017 ASER guidance (DOE 2018) states that for the MEI:

> Doses should be calculated following the requirements and effective standards cited in DOE O 458.1. Where appropriate, the ASER should state that, because the doses are calculated rather than measured, they represent potential or estimated, rather than actual doses. The all-pathways dose reported should be the total dose to the Representative Person or the MEI, but it should not be the sum of the individual pathway doses unless all the pathway-specific MEI doses are actually to the same receptor. That said, some sites do provide the sum the doses from various pathways to different receptors to bound MEI dose estimate. In such cases, DOE 2018 guidance indicates that the conservative nature (overestimation of dose) should be discussed. In addition, other unrealistic assumptions (e.g., assumed occupancy factors for exposures of 24 hours/day for 365 days) should be explained if they are used in establishing bounding dose estimates. Although reported doses should not underestimate likely doses, DOE prefers dose estimates presented in ASERs to be as realistic as possible. The estimate should be reasonable but not likely to underestimate the MEI dose. Calculation of the dose to a person spending 100% of his time at the fence line is useful for comparison purposes, but it biases comparative analyses.

DOE O 458.1 indicates that the public dose limit includes the TED resulting from exposure to radiation, airborne effluents, and liquid effluents of DOE origin. Compliance can be demonstrated by a dose determination to the MEI or the Representative Person. External radiation sources include direct radiation from sources located onsite, airborne radioactive material (with certain exclusions[2]), offsite surface deposition of DOE radioactive material, and residual radioactive material on, or in, cleared real property. Internal radiation sources include inhaled airborne radioactive material, radioactive material incorporated into food (terrestrial or aquatic foods), and intakes of residual radioactive material on, or in, cleared real property. In addition, dose from any other pathway unique to a DOE site or activity should be considered.

According to DOE O 458.1, the MEI or Representative Person is representative of the persons or group likely to receive the most dose and is based on pathway and exposure parameters that are not likely to underestimate or substantially overestimate the dose. The ASER dose estimate should be based on a

[1] This guidance is representative of the time frame of ASERs summarized in this report. ASER guidance is updated annually.

[2] DOE O 458.1, Chg 3 (Paragraph b.1.a) excludes dose from radon and its decay products in air; patient dose from medical exposures; background radiation dose; and dose from occupational exposure.

scenario and parameters that approximate an actual situation. The estimate should be reasonable but not likely to underestimate the dose. Calculation of the dose to a person spending 100 percent of their time at the fence line is useful for comparison purposes, but it overestimates the dose to the Representative Person or the MEI and introduces bias to the comparative analyses (DOE 2018). The current ASERs should contain estimates based on realistic situations and should clearly describe the location of critical receptors and the scenarios used to calculate the estimated doses. The guidance further states that estimates of dose to individuals should include "multiple exposure pathways and releases from multiple sources (e.g., point and diffuse) if they contribute to the dose to the same individuals," and ASERs should clearly describe the location of critical receptors and the scenarios used to calculate the estimated doses (DOE 2018). That said, some sites still report MEI doses based on maximizing assumptions (e.g., BNL, NNSS, and ORR assume the MEI consumes radionuclide concentrations found in game which can be a significant portion of the MEI dose).

In addition to the sites not further reviewed due to their lack of radioactive material use (see Section 1.0), Table 2-1 indicates the sites where no MEI dose estimate is reported.

Table 2-1. DOE Sites with No MEI Dose Estimates (2015–2018)

DOE Program Office	Site Abbreviation	Comment
EM	SSFL	No radioactive emissions or dose above background reported for CY 2015−2018.
NNSA	SNL-CA	Reports indicate no radioactive emissions during CY 2015–2017. External dose is monitored at the site perimeter and background locations; no MEI dose is declared.

Table 2-2 summarizes the total public receptor dose estimates in DOE ASERs from 2015 through 2018, highlighting doses greater than 1 mrem (bold) and doses less than 0.01 mrem (gray). Sites with public receptor dose estimates less than 0.01 mrem/yr from all pathways are less than 0.01 percent of the dose limit. About a third of the 29 sites reporting a maximum or representative public receptor dose, report doses below 0.01 mrem/yr.

Table 2-3 provides details regarding sites that have a total public receptor dose of more than 1 mrem. Approximately a fifth of the 29 sites report a dose above 1 mrem/yr; in other words, more than 80 percent of the sites report a dose that is less than 1 percent of the 100 mrem/yr all-pathways dose limit.

Further details regarding sites that have dose estimates above 1 mrem/yr in Table 2-3 are described in Table 2-8 (in Section 2.3). These estimates are based on conservative assumptions (in some instances improbable, worst-case scenarios), and sites expect any actual dose to fall well below the estimated dose.

Table 2-2. Public Receptor Dose Estimates in DOE ASERs (2015−2018)

Program Office-Site	2015 (mrem)	2016 (mrem)	2017 (mrem)	2018 (mrem)
EERE				
NREL STM	0.036	0.038	0.045	0.037
EM				
HANF	0.21	0.12	0.22	0.28
PGDP	**5.4**	**4.5**	**4.1**	**5.1**
PORTS	0.96	0.64	0.90	0.92
SRS	0.18	0.19	0.25	0.27
WIPP	8.8E-06	4.7E-06	3.0E-06	2.9E-06
WVDP	0.49	0.50	0.47	0.57
NE				
INL	0.53	0.014	0.054	0.026
NNSA				
LANL	0.13	0.12	0.47	0.35
LLNL	1.7E-03	2.8E-03	1.9E-03	6.7E-03
LLNL Site 300	4.8E-04	2.2E-04	4.8E-05	9.6E-05
NNSS	**2.9**	**1.5**	0.81	**12.9**
PANTEX	1.4E-07	2.7E-05	7.6E-06	1.7E-06
SNL-CA	n/a	n/a	n/a	**4.0**
SNL-NM	3.0E-03	2.5E-03	0.010	0.017
SNL-TTR	0.024	0.024	1.0E-10	7.9E-11
NNSA-NNPP				
BETTIS	**<1.4**	**<1.1**	**<1.2**	**<1.2**
INL NRF	5.4E-04	3.3E-04	2.4E-04	3.4E-04
KESS	1.7E-03	9.2E-04	1.3E-03	2.7E-03
KNOL SPRU	1.1E-03	0.026	0.044	0.030
SC				
ANL	0.029	9.0E-03	0.017	0.017
BNL	**3.2**	**3.2**	**5.6**	**5.0**
FERMI[(a)]	0.028	0.041	0.042	0.073
JLAB	0.057	0.61	0.092	**2.4**
LBNL	0.41	0.41	0.20	0.55
ORR total	**3**	**3**	**3**	**3**
PNNL MSL	1.1E-04	9.6E-05	1.6E-04	4.5E-04
PNNL Richland	2.6E-04	5.8E-04	2.3E-05	1.8E-05
PPPL	2.4E-03	4.9E-03	2.6E-03	3.4E-03
SLAC	0.045	0.052	0.031	0.041

Gray-shaded values are <0.010 mrem; bold values are ≥1 mrem.
(a) This FERMI dose does not include reported muon dose (see Table 2-4).

Table 2-3. Sites that Report a Public Receptor Dose Greater Than 1 mrem/yr (2015–2018)

Program Office/Site	Dose Estimate (mrem/yr)				Comment
	2015	2016	2017	2018	
EM					
PGDP	5.4	4.5	4.1	5.1	Assumed direct radiation exposure from public transit by radioactive materials stored onsite (UF_6 cylinder storage yards) contributed at least 93% of the receptor dose in 2015–2018. The direct radiation dose reported overestimated impacts to an actual receptor.
NNSA					
NNSS	2.9	1.5	(<1)	12.9	Game ingestion assumption accounted for at least 98% of the receptor dose in 2015, 2016, and 2018. Maximum pronghorn antelope consumption from onsite roadkill in 2015, 2018 (elevated Pu and/or Am) and maximum mule deer consumption from onsite monitored mountain lion kills in 2016 (elevated Pu and Am) resulted in elevated game ingestion dose estimates. Onsite game species were conservatively assumed to be available offsite, hunted and consumed by the maximum public receptor.
SNL-CA	-	-	-	4	Direct radiation at the site boundary from dosimetry. Boundary (43 mrem/yr) minus background (39 mrem/yr).
NNSA-NNPP					
BETTIS	<1.4	<1.1	< 1.2	<1.2	Assumed direct radiation exposure from residual radioactive materials in Bull Run streambank sediments with elevated radioactivity attributed to effluent releases in the 1950s and 1960s. This sediment dose contributed at least 71% of the receptor dose reported for 2015 and 2016. This dose was assumed to result from a public receptor taking a 1-hour daily walk along the stream bank. A 2011 radiation survey was used to report 2015 results; and a 2016 radiation survey was used to report 2016 results.
SC					
BNL	3.2	3.2	5.6	5.0	Game (deer) ingestion accounted for at least 77% of the annual receptor doses reported. A large intake (64 pounds) of the onsite deer meat with maximum measured Cs-137 levels was assumed in 2015. 2015 deer were harvested and monitored as part of a deer population reduction measure; NY State established a 10 mrem dose health advisory limit for deer and fish, which was met. In 2016 and 2017, deer in the vicinity of BNL were harvested and monitored. 2017 deer ingestion doses were the largest (4.8 mrem).
JLAB	-	-	-	2.42	Direct radiation at a non-public location was assigned to the MEI.
ORR total	3 [a]	3 [a]	3 [a]	3 [a]	Liquid effluent pathways and game (deer) ingestion accounted for the majority of dose to the ORR in 2015 (29% liquid path, 38% game); 2016 (44%/42%); 2017 (35%/72%), and 2018 (7%/72%). Fish ingestion was considered part of the liquid pathway at ORR, accounting for much of this pathway dose. Deer ingestion overestimated impacts by assuming the largest deer harvested was consumed and contaminated at the highest Cs-137 concentration measured in any onsite released deer.

(a) ORR total (ORNL, Y-12, ETTP) dose estimate rounded up and reported to one significant digit.

Table 2-4 lists pathway details (air, liquid, and other) for the estimated maximum potential doses to individuals from each DOE site ASER. The table also indicates the percentage of the DOE 100 mrem/yr limit that the total individual dose represents. The total MEI all-pathway estimates range from less than 1 mrem/yr (0.01 mSv/yr) to 12.9 mrem/yr (0.129 mSv/yr), or from less than 1 to about 13 percent of the DOE 100 mrem/yr limit. The table also reports how close the air pathway dose is to the EPA's 10 mrem/yr "Subpart H" National Emission Standards for Hazardous Air Pollutants (NESHAP) standard for that radionuclide emission route. The values range from less than 0.001 mrem/yr (0.00001 mSv/yr) to 1.63 mrem/yr (0.0163 mSv/yr), or up to about 16 percent of the EPA 40 CFR Part 61, Subpart H dose standard.[1]

[1] Compliance with the EPA dose standard for atmospheric releases is discussed further in Appendix D of this report.

Table 2-4. ASER Estimates of Maximum Public Receptor Dose by Pathway (2015−2018)

DOE Site	CY	Air Pathway Dose (mrem)	Liquid Pathway Dose (mrem)	Other Pathway Dose (mrem)	Total Receptor Dose (mrem)	Other Pathway Comment	Percent of 100 mrem/y All-Pathway Dose Limit	Percent of 10 mrem/yr Air Pathway Dose Standard
EERE								
NREL	2015	0.036	n/a	n/a	**0.036**	-	<1%	<1%
NREL	2016	0.038	n/a	n/a	**0.038**	-	<1%	<1%
NREL	2017	0.045	n/a	n/a	**0.045**	-	<1%	<1%
NREL	2018	0.037	n/a	n/a	**0.037**	-	<1%	<1%
EM								
HANF	2015	0.15	0.052	n/a	**0.21**	-	<1%	2%
HANF	2016	0.10	0.014	n/a	**0.12**	-	<1%	1%
HANF	2017	0.22	0.0011	n/a	**0.22**	-	<1%	2%
HANF	2018	0.20	0.071	n/a	**0.28**	-	<1%	2%
PGDP	2015	8.7E-05	0.30	5.1	**5.4**	direct radiation	5%	<1%
PGDP	2016	1.3E-04	0.34	4.2	**4.5**	direct radiation	5%	<1%
PGDP	2017	4.4E-04	0.25	3.8	**4.1**	direct radiation	4%	<1%
PGDP	2018	9.0E-02	0	5.1	**5.1**	Direct radiation (5.0), incidental soil ingestion (0.054)	5%	<1%
PORTS	2015	0.0012	0.0017	0.96	**0.96**	direct radiation	1%	<1%
PORTS	2016	0.016	0.0015	0.64	**0.64**	direct radiation	1%	<1%
PORTS	2017	0.12	0.0012	0.778	**0.90**	direct radiation from cylinder yards (0.74 mrem); sediment and soil ingestion (0.038 mrem)	1%	1%
PORTS	2018	0.10	0.0017	0.817	**0.92**	direct radiation (0.78 mrem) from cylinder yards (0.78 mrem); soil, sediment, and biota ing. dose (0.037 mrem)	1%	1%
SRS	2015	0.032	0.15	n/a	**0.18**	-	<1%	<1%
SRS	2016	0.15	0.038	n/a	**0.19**	-	<1%	2%
SRS	2017	0.027	0.22	n/a	**0.25**	-	<1%	<1%
SRS	2018	0.082	0.19	n/a	**0.27**	-	<1%	1%
SSFL	2015	0	n/a	0	**0**	direct radiation	0	<1%
SSFL	2016	0	n/a	0	**0**	direct radiation	0	<1%
SSFL	2017	0	n/a	0	**0**	direct radiation	0	<1%
SSFL	2018	0	n/a	0	**0**	direct radiation	0	<1%
WIPP	2015	8.8E-06	n/a	n/a	**8.8E-06**	-	<1%	<1%
WIPP	2016	4.7E-06	n/a	n/a	**4.7E-06**	-	<1%	<1%

DOE Site	CY	Air Pathway Dose (mrem)	Liquid Pathway Dose (mrem)	Other Pathway Dose (mrem)	Total Receptor Dose (mrem)	Other Pathway Comment	Percent of 100 mrem/y All-Pathway Dose Limit	Percent of 10 mrem/yr Air Pathway Dose Standard
WIPP	2017	3.0E-06	n/a	n/a	**3.0E-06**	-	<1%	<1%
WIPP	2018	2.9E-06	n/a	n/a	**2.9E-06**	-	<1%	<1%
WVDP	2015	0.47	0.021	n/a	**0.49**	-	<1%	5%
WVDP	2016	0.49	0.013	n/a	**0.50**	-	<1%	5%
WVDP	2017	0.46	0.016	n/a	**0.47**	-	<1%	5%
WVDP	2018	0.55	0.02	n/a	**0.57**	-	1%	6%
NE								
INL	2015	0.033	n/a	0.49	**0.53**	Waterfowl ingestion	<1%	<1%
INL	2016	0.014	n/a	0	**0.014**	No waterfowl collected.	<1%	<1%
INL	2017	0.0080	n/a	0.046	**0.054**	Waterfowl ingestion	<1%	<1%
INL	2018	0.01	n/a	0.016	**0.026**	Waterfowl ingestion	<1%	<1%
NNSA								
LANL	2015	0.13	0	0	**0.13**	foodstuffs, soil (<0.1 mrem)	<1%	1%
LANL	2016	0.12	0	0	**0.12**	foodstuffs, soil (<0.1 mrem)	<1%	1%
LANL	2017	0.47	0	0	**0.47**	foodstuffs, soil (<0.1 mrem)	<1%	5%
LANL	2018	0.35	0	0	**0.35**	foodstuffs, soil (<0.1 mrem)	<1%	4%
LLNL	2015	0.0017	n/a	n/a	**0.0017**	-	<1%	<1%
LLNL	2016	0.0028	n/a	n/a	**0.0028**	-	<1%	<1%
LLNL	2017	0.0019	n/a	n/a	**0.0019**	-	<1%	<1%
LLNL	2018	0.0067	n/a	n/a	**0.0067**	-	<1%	<1%
LLNL Site 300	2015	4.8E-04	n/a	n/a	**4.8E-04**	-	<1%	<1%
LLNL Site 300	2016	2.2E-04	n/a	n/a	**2.2E-04**	-	<1%	<1%
LLNL Site 300	2017	4.8E-05	n/a	n/a	**4.8E-05**	-	<1%	<1%
LLNL Site 300	2018	9.6E-05	n/a	n/a	**9.6E-05**	-	<1%	<1%
NNSS	2015	0.040	0	2.87	**2.9**	game ingestion (maximum pronghorn antelope)	3%	<1%
NNSS	2016	0.034	0	1.5	**1.5**	game ingestion (maximum mule deer)	2%	<1%
NNSS	2017	0.070	0	0.74	**0.81**	game ingestion (maximum mule deer)	1%	1%
NNSS	2018	0.07	0	12.87	**12.9**	game ingestion (maximum pronghorn antelope; Pu-239 predominant)	13%	1%
PANTEX	2015	1.4E-07	0	n/a	**1.4E-07**	-	<1%	<1%
PANTEX	2016	2.7E-05	0	n/a	**2.7E-05**	-	<1%	<1%
PANTEX	2017	7.6E-06	0	n/a	**7.6E-06**	-	<1%	<1%
PANTEX	2018	1.7E-06	0	n/a	**1.7E-06**	-	<1%	<1%

DOE Site	CY	Air Pathway Dose (mrem)	Liquid Pathway Dose (mrem)	Other Pathway Dose (mrem)	Total Receptor Dose (mrem)	Other Pathway Comment	Percent of 100 mrem/y All-Pathway Dose Limit	Percent of 10 mrem/yr Air Pathway Dose Standard
SNL-CA	2018	n/a	n/a	4	**4**	External dose from dosimetry.	4%	-
SNL-NM	2015	0.0030	n/a	n/a	**0.0030**	-	<1%	<1%
SNL-NM	2016	0.0025	n/a	n/a	**0.0025**	-	<1%	<1%
SNL-NM	2017	0.010	n/a	n/a	**0.010**	-	<1%	<1%
SNL-NM	2018	0.017	n/a	n/a	**0.017**	-	<1%	<1%
SNL-TTR	2015	0.024	n/a	n/a	**0.024**	-	<1%	<1%
SNL-TTR	2016	0.024	n/a	n/a	**0.024**	-	<1%	<1%
SNL-TTR	2017	1.0E-10	n/a	n/a	**1.0E-10**	-	<1%	<1%
SNL-TTR	2018	7.9E-11	n/a	n/a	**7.9E-11**	-	<1%	<1%
NNSA-NNPP								
BETTIS	2015	0.37	n/a	<1	**<1.4**	direct radiation	1%	4%
BETTIS	2016	0.11	n/a	<1	**<1.1**	direct radiation	1%	1%
BETTIS	2017	0.17	n/a	<1	**<1.2**	direct radiation	1%	2%
BETTIS	2018	0.185	n/a	<1	**<1.2**	direct radiation	1%	2%
INL NRF	2015	5.4E-04	n/a	n/a	**5.4E-04**	-	<1%	-
INL NRF	2016	3.3E-04	n/a	n/a	**3.3E-04**	-	<1%	-
INL NRF	2017	2.4E-04	n/a	n/a	**2.4E-04**	-	<1%	-
INL NRF	2018	3.4E-04	n/a	n/a	**3.4E-04**	-	<1%	-
KESS	2015	0.0017	8.3E-06	n/a	**0.0017**	-	<1%	<1%
KESS	2016	9.2E-04	4.3E-06	n/a	**9.2E-04**	-	<1%	<1%
KESS	2017	0.0013	4.6E-06	n/a	**0.0013**	-	<1%	<1%
KESS	2018	0.0027	4.1E-06	n/a	**0.0027**	-	<1%	<1%
KNOL,SPRU	2015	0.001	3.9E-04	n/a	**0.0011**	-	<1%	<1%
KNOL,SPRU	2016	0.026	3.2E-04	n/a	**0.026**	-	<1%	<1%
KNOL,SPRU	2017	0.044	3.40E-04	n/a	**0.044**	-	<1%	<1%
KNOL,SPRU	2018	0.030	2.60E-04	n/a	**0.030**	-	<1%	<1%
SC								
ANL	2015	0.025	0.004	0	**0.029**	Direct radiation <0.001 mrem	<1%	<1%
ANL	2016	0.005	0.004	0	**0.009**	Direct radiation <0.001 mrem	<1%	<1%
ANL	2017	0.008	0.009	0	**0.017**	Direct radiation <0.001 mrem	<1%	<1%
ANL	2018	0.006	0.01	0	**0.017**	Direct radiation <0.001 mrem	<1%	<1%
BNL	2015	0.28	0.088	2.8	**3.2**	Game (deer) ingestion	<1%	3%
BNL	2016	0.62	0.088	2.45	**3.2**	Game (deer) ingestion	3%	6%

DOE Site	CY	Air Pathway Dose (mrem)	Liquid Pathway Dose (mrem)	Other Pathway Dose (mrem)	Total Receptor Dose (mrem)	Other Pathway Comment	Percent of 100 mrem/y All-Pathway Dose Limit	Percent of 10 mrem/yr Air Pathway Dose Standard
BNL	2017	0.72	0.088	4.8	**5.6**	Game (deer) ingestion	6%	7%
BNL	2018	1.63	0.088	3.32	**5.0**	Game (deer) ingestion	5%	16%
FERMI	2015	0.028	0	0	**0.028**	TLD results <0.094 mrem to receptor at an offsite house	<1%	<1%
FERMI[(a)]	2015	n/a	n/a	0.094	**0.094**	Direct radiation muons	<1%	<1%
FERMI	2016	0.041	0	0	**0.041**	TLD results <0.103 mrem to receptor at an offsite house	<1%	<1%
FERMI[(a)]	2016	n/a	n/a	0.103	**0.10**	Direct radiation muons	<1%	<1%
FERMI	2017	0.042	0	0	**0.042**	TLD results <0.088 mrem to receptor at an offsite house	<1%	<1%
FERMI[(a)]	2017	n/a	n/a	0.088	**0.088**	Direct radiation muons	<1%	<1%
FERMI	2018	0.0725	0	0	**0.0725**	-	0%	1%
FERMI[(a)]	2018	0.0725	0	0.062	**0.13**	direct radiation muons	0%	1%
JLAB	2015	0.0062	0	0.051	**0.057**	Direct radiation	<1%	<1%
JLAB	2016	0.0037	0	0.61	**0.61**	Direct radiation	1%	<1%
JLAB	2017	0.0017	0	0.090	**0.092**	Direct radiation	<1%	<1%
JLAB	2018	0.0389	0	1.38	**2.4**	Direct radiation at non-public boundary location.	2%	0%
LBNL	2015	0.0079	n/a	0.398	**0.41**	Penetrating radiation sources	<1%	<1%
LBNL	2016	0.012	n/a	0.40	**0.41**	Penetrating radiation sources	<1%	<1%
LBNL	2017	0.0097	n/a	0.19	**0.20**	Penetrating radiation sources	<1%	<1%
LBNL	2018	0.004	n/a	0.542	**0.55**	Penetrating radiation sources (gamma, neutron).	1%	0%
ORR total	2015	0.40	0.86	1.1	**3.0**	game ingestion (deer, geese, turkey)	3%	4%
ORR total	2016	0.20	1.3	1.3	**3.0**	game ingestion (deer, geese, turkey)	3%	2%
ORR total	2017	0.30	1.1	2.2	**3**	game ingestion (deer, geese, turkey)	3%	3%
ORR total	2018	0.2	0.21	2.15	**3**	game ingestion (deer, geese, turkey)	3%	2%
PNNL MSL	2015	1.1E-04	n/a	n/a	**1.1E-04**	-	<1%	<1%
PNNL MSL	2016	9.6E-05	n/a	n/a	**9.6E-05**	-	<1%	<1%
PNNL MSL	2017	1.6E-04	n/a	n/a	**1.6E-04**	-	<1%	<1%
PNNL MSL	2018	4.5E-04	n/a	n/a	**4.5E-04**	-	<1%	<1%

DOE Site	CY	Air Pathway Dose (mrem)	Liquid Pathway Dose (mrem)	Other Pathway Dose (mrem)	Total Receptor Dose (mrem)	Other Pathway Comment	Percent of 100 mrem/y All-Pathway Dose Limit	Percent of 10 mrem/yr Air Pathway Dose Standard
PNNL Richland	2015	2.6E-04	n/a	n/a	**2.6E-04**	-	<1%	<1%
PNNL Richland	2016	5.8E-04	n/a	n/a	**5.8E-04**	-	<1%	<1%
PNNL Richland	2017	2.3E-05	n/a	n/a	**2.3E-05**	-	<1%	<1%
PNNL Richland	2018	1.8E-05	n/a	n/a	**1.8E-05**	-	<1%	<1%
PPPL	2015	2.0E-03	4.3E-04	3.00E-11	**2.4E-03**	Direct, scattered radiation (neutron and gamma)	<1%	<1%
PPPL	2016	2.1E-03	2.8E-03	2.90E-06	**4.9E-03**	Direct, scattered radiation (neutron and gamma)	<1%	<1%
PPPL	2017	2.4E-03	2.2E-04	0	**2.6E-03**	Direct, scattered radiation (neutron and gamma)	<1%	<1%
PPPL	2018	3.2E-03	1.7E-04	n/a	**3.4E-03**	No NSTX-U reactor ops in 2018, so no direct radiation source	<1%	<1%
SLAC	2015	3.5E-03	n/a	0.042	**0.045**	direct radiation	<1%	<1%
SLAC	2016	2.4E-03	n/a	0.05	**0.052**	direct radiation	<1%	<1%
SLAC	2017	1.4E-03	n/a	0.03	**0.031**	direct radiation	<1%	<1%
SLAC	2018	1.4E-03	n/a	0.04	**0.041**	direct radiation	<1%	<1%

n/a = not applicable.

(a) FERMI does not declare an MEI or Representative Person dose; indicates receptor dose and separately a muon dose. Muon dose to the MEI was considered a special dose estimate for this summary report.

Figure 2-1 graphically presents the 2015–2018 maximum or representative receptor dose with a y-axis cutoff set at 0.01 mrem (see Table 2-2 for dose values below this cutoff). All doses reported for the CY 2015−2018 emissions result in impacts well below the 100 mrem/yr public dose limit established in DOE O 458.1. The figure also demonstrates that the annual variability of MEI dose does not result in doses that approach the DOE O 458.1 dose limit of 100 mrem/yr.

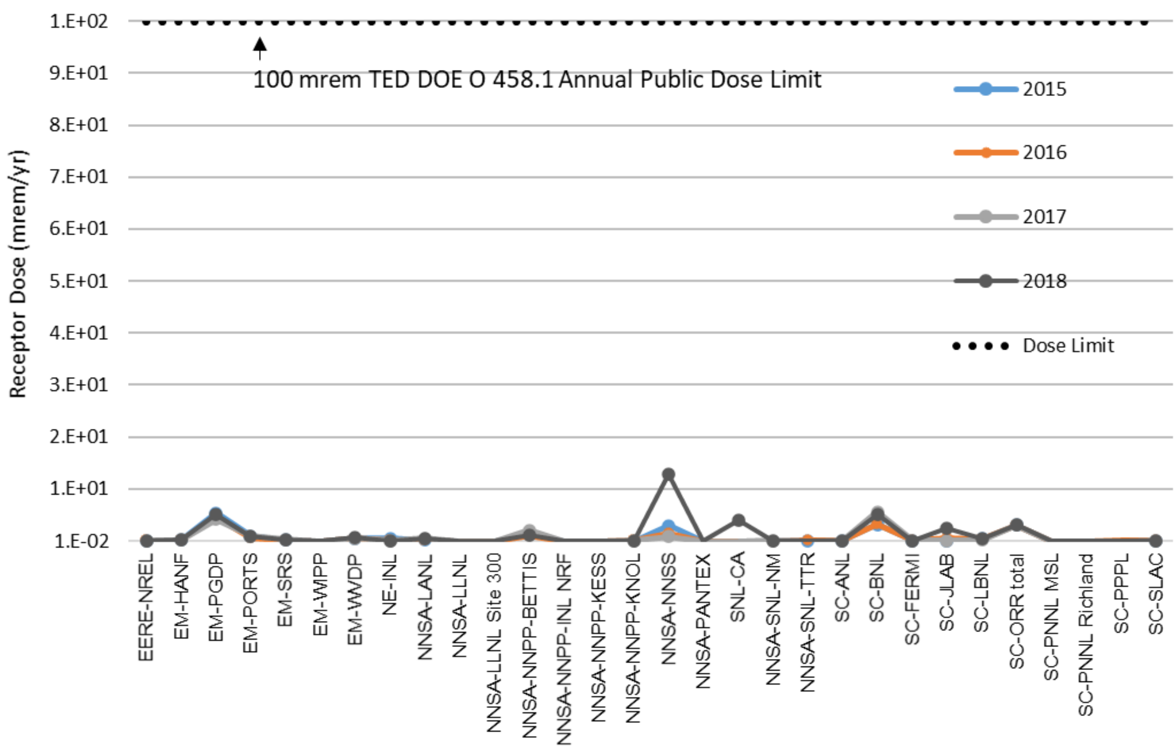

Figure 2-1. Maximum or Representative Public Receptor Doses with Lowest Doses Indicated at 0.01 mrem/yr (2015–2018)

Sites determine the appropriate methods and exposure pathway(s) to use in dose calculations based on the nature of site operations and local conditions, as illustrated in the following examples.

- Some sites are permitted by their regulator to report emissions compliance by an alternative method rather than determining a dose estimate. For example, at SSFL representative air was sampled in lieu of modeling to obtain a dose estimate to compare with the dose standard.

- Several sites include dose from consumption of fish and other wildlife, drinking water, other water uses (swimming, wading, boating), and other sources of direct radiation exposure (gamma, beta, neutron, muon). These pathways may apply to the declared maximum individual dose or are reported for other, non-maximum receptors. As an example, SRS provides maximum onsite sportsman (hunting, fishing), offsite hunter, and swamp fisherman doses reported separately from the Representative Person dose; all but the fisherman dose is greater than the declared Representative Person dose.

- The dominant exposure pathway at several accelerator facilities (e.g., JLAB, PPPL, SLAC) is external radiation.

Each site determines the hypothetical MEI (e.g., where they would reside or travel to receive the largest dose) or Representative Person (e.g., where this receptor would reside or travel to give the reference person criteria established for a site). For some sites, this person resides at the closest offsite residence. Other DOE sites assume that a person remains at the point of highest potential exposure at the site boundary for 24 hours per day throughout the year (a fence line dose estimate). SRS calculates a Representative Person dose using reference person criteria specific to SRS. The SRS Representative Person falls at the 95th percentile of national and regional data, and therefore is not likely to under-report dose impacts. Still, other sites, such as the Paducah Gaseous Diffusion Plant (PGDP), take a "worst-case" approach and assumes the same individual is exposed to the most extreme conditions from each pathway. At PGDP, this person would ingest all drinking water from a downstream source (incidental surface water ingestion) and incidentally consume sediment during every other day of the hunting season; occupy the publicly accessible area with the greatest direct radiation exposure for 80 hr/yr; and live at the location of the nearest offsite neighbor that has the greatest potential for exposure from airborne emissions. FERMI is the only site that reports a muon external dose, which is reported separately from its lower MEI dose. Both of these FERMI receptor doses are listed in Table 2-4 due to the uniqueness of this muon dose reporting.

As discussed above, how dose estimates are calculated vary by site. Software is useful to calculate both environmental dispersion and receptor doses (i.e., in lieu of sample collection for every potential pathway and receptor location). For the air pathway, most sites use the CAP88-PC software to calculate dose. The COMPLY software is used to calculate air pathway doses at some smaller DOE sites. PORTS uses LADTAP XL software to calculate water pathway doses. INL reports an MEI air pathway dose determined from CAP88-PC software but uses a more site-specific model (MDIFFH software for air dispersion in 2015; HYSPLIT/DOSEMM software for 2016–2018) for collective dose determinations. The Hanford Site (HANF) uses GENIIv2 software for estimating doses from both air and water pathways for its ASER dose reporting. Further discussion on the use of atmospheric models for dose calculation is provided in Appendix D.

Based on the data reported in the ASERs, all sites control exposure to the MEI or Representative Person well below applicable dose limits. However, caution is required in interpreting dose estimates for a single site and comparing estimates among sites. The degree of conservatism in assumptions and the methodologies underlying dose estimates vary from site to site, and in some cases, even from year to year for a given site.

2.3 Collective Dose Estimates

To demonstrate compliance per DOE O 458.1 for collective dose, sites estimate collective dose to members of the public. The collective dose reflects the potential collective dose to all persons living within 50 mi (80 km) of the site that results from radiation emitted or radioactive materials released from DOE activities only (excluding dose from radon and its progeny in air; background radiation dose; occupational doses; and medical exposure doses). While the outer population distance is not prescribed, a 50 mi (80 km) distance has historically been used. Representative collective dose estimates for members of the public should be of adequate quality for supported comparisons and trending. Collective dose estimates are generally most precise for sites that have mature radiological operations and monitoring programs. Sites that have smaller radiological operations generally use average meteorological parameters and emission rates that are small but overestimated.

DOE does not prescribe a particular methodology to calculate collective dose. Collective dose can be calculated, for example, by dividing the area around a site into segments. Then, the average dose to an individual living in a segment, multiplied by the total number of people living in that segment, yields the segment's collective dose. The sum of the collective doses for all segments equals the total collective dose. Note that the average dose used in this calculation is not the dose to the MEI, and in fact, is always far less than the MEI dose.

Natural sources of radioactive materials (e.g., uranium-238, potassium-40) contribute to every individual's natural background radiation dose. Typical natural background radiation dose to a member of the public is estimated to be 0.310 rem/yr (NCRP 2009). DOE sources are one of several artificial sources of additional radiation dose to individuals, others include medical and occupational dose. Multiplying the population by the individual background dose provides an estimate of collective background dose. Multiplying 0.310 rem and the 85 million individuals within 50-mi of all DOE sites in 2015 (see Section 1.4) would result in about 26 million person-rem collective background radiation dose. As a point of reference, the 2015 estimate of collective dose from all DOE operations (31 person-rem) is six orders of magnitude less than this natural background.

In addition to the sites not further reviewed due to their lack of radioactive material use or radiological emissions (see footnote (b) sites in Table 1-1), Table 2-5 indicates the sites where no collective dose is reported.

Table 2-5. DOE Sites with No Collective Dose (2015–2018)

DOE Program Office	Site Abbreviation
EERE	NREL STM
EM	SSFL[(a)]
NNSA	SNL-CA[(a)]
NNSA	SNL-TTR
NNSA-NNPP	INL NRF[(b)]

(a) Zero emissions are reported, with a zero MEI dose; collective dose is reported as zero. No population dose information is provided in the report.
(b) Individual dose is reported, but no site emissions collective dose is reported. However, background collective dose is reported.

Table 2-6 summarizes the total collective doses reported at a high level. Table 2-7, also a high-level summary, presents average collective doses by DOE Program Office. EM sites' average collective doses have remained stable over the reporting period. SC sites report higher collective doses, on average, because of short-lived accelerator-produced radionuclides being emitted to the air.

Table 2-6. Total Collective Doses Estimates in DOE ASERs (2015−2018)

Program Office-Site	2015 (person-rem)	2016 (person-rem)	2017 (person-rem)	2018 (person-rem)
EM				
HANF	1.7	1.2	1.2	2.5
PGDP	1.0	0.89	0.81	0.76
PORTS	0.22	0.06	0.47	2.9
SRS	3.7	4.9	4.4	6.0
WIPP	1.1E-07	1.3E-05	9.9E-06	8.8E-06
WVDP	< 5.1	< 5.0	< 5.0	< 1.3
NE				
INL	0.61	0.0041	0.011	0.0075
NNSA				
LANL	0.06	0.1	0.2	0.09
LLNL Main	0.13	0.22	0.13	0.47
LLNL Site 300	2.4E-05	3.0E-05	7.2E-05	2.8E-05
NNSS	n/a	< 0.6	0.25	0.74
PANTEX	2.2E-06	0.00099	1.0E-05	2.4E-06
SNL-NM	0.085	0.097	0.097	0.10
NNSA-NNPP				
BETTIS	3.85	1.69	2.27	2.43
KESS	0.0083	0.0044	0.0060	0.016
KNOL, SPRU	0.0099	0.0069	0.15	0.063
SC				
ANL	0.25	0.18	0.18	0.22
BNL	0.42	0.94	1.2	2.6
FERMI	0.49	0.99	1.2	1.9
JLAB	0.0034	0.0044	0.00089	0.0054
LBNL	0.41	0.21	0.17	0.040
ORR total	13	18	12	12
PNNL MSL	0.00012	0.00064	0.00018	5.0E-06
PNNL Richland	0.00027	0.00062	0.00016	7.6E-05
PPPL	0.077	0.10	0.076	0.13
SLAC	0.033	0.050	0.025	0.020
TOTAL (person-rem)	**31**	**34**	**30**	**34**

Gray cells are the first, second, and third highest estimates reported for each calendar year.

Table 2-7. Average Reported Collective Doses by Program Office (2015–2018)

Program Office	Number of Sites	2015 (person-rem)	2016 (person-rem)	2017 (person-rem)	2018 (person-rem)
EM	6	2.0	2.0	2.0	2.2
NE	1	0.61	0.0041	0.011	0.0075
NNSA	5-6	0.055	0.084	0.11	0.23
NNSA-NNPP[(a)]	3	1.3	0.57	0.81	0.84
SC(b)	10	1.5	2.0	1.5	1.7

(a) The INL NRF-specific value was not included as an NNSA-NNPP site.
(b) The ORR total was counted as one SC site; specifically, ORR sub-sites were not included in the site counts or averages for EM (ORR ETTP), NNSA (ORR Y-12), and SC (ORR ORNL).

Table 2-8 presents details about the collective dose estimates for each DOE site for the 2015–2018 period. The tables are intended to facilitate a review of the data from each site and should not be viewed as a system for ranking sites or comparing estimates among sites. Background collective dose is also presented in this table to provide perspective on the collective dose reported from site radionuclide effluents. A number of sites use National Council on Radiation Protection and Measurements (NCRP) Report 160 (NCRP 2009) as the basis for the annual natural background exposure rate applied.

Caution is advised when comparing collective dose among sites. When a dispersion code, such as CAP88-PC is used to calculate collective dose, sites with only radioactive air emissions report results that are generally able to be compared. Sites that implement other models have a range of overestimating assumptions incorporated into their calculation. With no collective dose standard, sites may implement extremely conservative (overestimating) assumptions in this calculation.

Atmospheric releases typically are the dominant contributor to collective dose. Exceptions include SRS where water pathways doses are predominant, PGDP where hiking frequently near contaminated sediment is the predominant source of dose, and SLAC where potential exposure to direct radiation from accelerator operations is a predominant factor.

Table 2-8. ASER Estimates of Collective Dose from DOE Emissions and Collective Background Dose (2015–2018)

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
EM							
HANF	2015	586000	1.7	1.63E+05	0.0010%	GENIIv2.10. Air and water pathways. Greatest 50 mi population indicated. Air and surface water pathways.	(0.019 terrestrial+0.030 cosmic+0.230 Rn220&222) = 0.279 rem average natural background.
HANF	2016	586000	1.2	1.63E+05	0.0007%	See HANF CY 2015 comment.	See HANF CY 2015.
HANF	2017	586000	1.2	1.63E+05	0.0007%	See HANF CY 2015 comment.	See HANF CY 2015.
HANF	2018	586000	2.5	1.82E+05	0.00138%	See HANF CY 2015 comment.	SER Table 4-8 indicates a natural background dose of 0.310 rem.
ORR ETTP[(a)]	2015	1172530	0.0007	3.52E+05	<1E-4%	2010 census.	0.300 rem/yr.
ORR ETTP[(a)]	2016	1172530	0.0003	3.52E+05	<1E-4%	2010 census. Air emissions only, CAP88v4	0.300 rem/yr.
ORR ETTP[(a)]	2017	1172530	0.0004	3.52E+05	<1E-4%	2010 census. Air emissions only, CAP88v4	0.300 rem/yr.
ORR ETTP[(a)]	2018	1172530	0.0003	3.52E+05	<1E-4%	Collective Dose air only. CAP88 modeled.	About 0.300 rem/yr.
PGDP	2015	534000	1.02	1.66E+05	0.0006%	Air (5E-4), drinking water (DW) (0.25), external onsite hikers (0.77) total dose. Air and water pathways. 2010 census.	0.310 rem/yr U.S. background.
PGDP	2016	534000	0.89	1.66E+05	0.0005%	Air (9.1E-4), DW (0.25) external onsite hikers (0.64).	0.310 rem/yr U.S. background.
PGDP	2017	534000	0.81	1.66E+05	0.0005%	Air (3.8E-3), DW (0.25) external onsite hikers (0.56).	0.310 rem/yr U.S. background.
PGDP	2018	534000	0.76	1.66E+05	0.0005%	Air (6.0E-4), drinking water (0), sediment from incidental ingestion of the 150 WKWMA hikers (8.1E-3 incidental soil, 0.75 external).	0.310 rem/yr U.S. background.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
PORTS	2015	677000	0.22	1.96E+04	0.0011%	-	0.029 rem per person assumed.
PORTS	2016	662000	0.06	1.94E+04	0.0003%	-	0.029 rem from ingestion of natural radionuclides in water and food. Report does mention 0.311 rem average total natural radiation but uses the 0.029 rem value for collective dose comparisons.
PORTS	2017	662000	0.47	1.96E+04	0.0024%	-	0.029 rem/yr individual dose value used for collective dose.
PORTS	2018	662000	2.9	1.96E+04	0.0148%	Based on air emissions.	0.029 rem/yr individual dose value used for collective dose.
SRS	2015	781060	3.7	2.34E+05	0.0016%	Water (2.6 pers-rem) and air (1.1 pers-rem) pathways.	0.300 rem/yr based on natural source collective dose result.
SRS	2016	781060	4.9	2.43E+05	0.0020%	Water (3.5 pers-rem) and air (1.4 pers-rem) pathways.	0.311 rem/yr.
SRS	2017	781060	4.4	2.43E+05	0.0018%	Water (3.4 pers-rem) and air (0.97 pers-rem) pathways.	0.311 rem/yr.
SRS	2018	781060	6.0	2.43E+05	0.0025%	Water (3.4 pers-rem) and air (2.6 pers-rem).	0.311 rem/yr.
WIPP	2015	92599	1.1E-07	2.78E+04	<1E-4%	2010 census. Air pathway.	0.300 rem/yr.
WIPP	2016	92599	1.33E-05	2.78E+04	<1E-4%	Air pathway (water and others = 0).	0.300 rem/yr.
WIPP	2017	92599	9.93E-06	2.78E+04	<1E-4%	Air pathway (water and others = 0).	0.300 rem/yr.
WIPP	2018	92599	8.8E-06	2.78E+04	<1E-4%	Air pathway (water and others = 0).	0.300 rem/yr.
WVDP	2015	1620000	< 5.099	5.03E+05	0.0010%	Air (<0.50), water (0.099), Rn-220 in air (<4.5) pathways. 50 mi population includes 128,000 Canadians.	0.310 rem/yr natural background (cosmic, terrestrial, internal, Rn-222, Rn-220). Man-made (0.310 rem) presented but not used for comparison.
WVDP	2016	1620000	< 4.96	5.02E+05	0.0010%	Air (<0.42), water (0.040), Rn-220 in air (<4.5) pathways. 50 mi population includes 128,000 Canadians.	See WVDP CY 2015 comment.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
WVDP	2017	1620000	< 5.028	5.02E+05	0.0010%	Air (<0.46), water (0.068), Rn-220 in air (<4.5) pathways. 50 mi population includes 128,000 Canadians.	See WVDP CY2015 comment.
WVDP	2018	1620000	< 1.31	5.03E+05	0.0003%	Air (<1.24), water (<0.072). Total is a less than value.	0.310 rem from natural sources.
NE							
INL	2015	323111	0.614	1.25E+05	0.0005%	MDIFFH used for dispersion for the air pathway.	0.388 rem/yr background. NCRP 160 (2009) and site-specific information.
INL	2016	327823	0.00408	1.26E+05	<1E-4%	DOSEMM and HYSPLIT models. 2016 population estimate.	0.383 rem/yr background. NCRP 160 (2009) and site-specific information.
INL	2017	332665	0.0106	1.27E+05	<1E-4%	DOSEMM and HYSPLIT models. 2017 population estimate	0.383 rem/yr background. NCRP 160 (2009) and site-specific information.
INL	2018	337643	0.00746	1.29E+05	<1E-4%	DOSEMM and HYSPLIT models. 2018 population estimate.	0.383 rem/yr background. NCRP 160 and site-specific information.
NNSA							
LANL	2015	343000	0.06	2.68E+05	<1E-4%	CAP88-PC. Air pathway is only significant contributor.	0.780 rem/yr, with higher site-specific cosmic, terrestrial, and radon background dose.
LANL	2016	343000	0.1	2.68E+05	<1E-4%	See LANL CY 2015 comment.	See LANL CY 2015 comment.
LANL	2017	343000	0.2	2.68E+05	<1E-4%	See LANL CY 2015 comment.	See LANL CY 2015 comment.
LANL	2018	353342	0.09	2.83E+05	<1E-4%	2018 population from StatsAmerica.	0.800 rem/yr.
LLNL Main	2015	7770000	0.13	4.87E+06	<1E-4%	Air pathway.	NCRP 160 (2009)-based background from natural and man-made sources.
LLNL Main	2016	7770000	0.22	4.87E+06	<1E-4%	Air pathway.	See LLNL CY 2015 comment.
LLNL Main	2017	7770000	0.13	4.87E+06	<1E-4%	Air pathway.	See LLNL CY 2015 comment.
LLNL Main	2018	7770000	0.47	4.87E+06	<1E-4%	-	See LLNL CY 2015 comment.
LLNL Site 300	2015	7110000	2.4E-05	4.46E+06	<1E-4%	Air pathway.	NCRP 160 (2009)-based background from natural and man-made sources.
LLNL Site 300	2016	7110000	3.0E-05	4.46E+06	<1E-4%	Air pathway.	See Site 300 CY 2015 comment.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
LLNL Site 300	2017	7110000	7.2E-05	4.46E+06	<1E-4%	Air pathway.	See Site 300 CY 2015 comment.
LLNL Site 300	2018	7110000	2.8E-05	4.46E+06	<1E-4%	-	See Site 300 CY 2015 comment.
NNSS	2015	<100,000	n/a	n/a	n/a	Discontinued after 2004 but reviewed annually (population and emissions) for potential renewed reporting. 2015 population approximated from ASER information, assuming central point 50 mi population.	0.620 rem/yr from natural and man-made sources.
NNSS	2016	<100,000	< 0.6	n/a	n/a	Discontinued after 2004 but reviewed annually (population and emissions) for potential renewed reporting. 2016 population approximated from ASER information, assuming a central point 50 mi population. The <value, describes the 1992−2004 results.	0.357 rem/yr background from cosmic and terrestrial; and internal dose.
NNSS	2017	493700	0.25	1.78E+05	0.0001%	CAP88-PC estimate.	0.360 rem/yr (=0.099+0.031+0.230) from cosmic and natural; and internal dose.
NNSS	2018	503300	0.74	1.81E+05	0.0004%	A CAP88 estimate and 50-mi population.	0.360 rem/yr (=0.099+0.031+0.230) from cosmic and natural sources.
ORR Y-12[(a)]	2015	1172530	1.4	3.52E+05	0.0004%	2010 census.	0.300 rem/yr.
ORR Y-12[(a)]	2016	1172530	0.7	3.52E+05	0.0002%	2010 census. Air emissions only, CAP88v4	0.300 rem/yr.
ORR Y-12[(a)]	2017	1172530	2.9	3.52E+05	0.0008%	2010 census. Air emissions only, CAP88v4	0.300 rem/yr.
ORR Y-12[(a)]	2018	1172530	1.8	3.52E+05	0.0005%	Collective Dose air only, CAP88 modeled.	About 0.300 rem/yr.
PANTEX	2015	316132	2.21E-06	3.16E+04	<1E-4%	2010 census. Air pathway. CAP88.	0.100 rem/yr (based on SER Table 4.2 population and background results).

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
PANTEX	2016	316132	9.94E-04	3.16E+04	<1E-4%	2010 census.	0.100 rem/yr (based on SER Table 4.2 population and background results).
PANTEX	2017	316132	1.04E-05	3.16E+04	<1E-4%	2010 census.	0.100 rem/yr (based on SER Table 4.3 population and background results).
PANTEX	2018	296000	2.41E-06	2.96E+04	<1E-4%	2010 census.	0.100 rem/yr (based on SER Table 4.3 population and background results).
SNL-NM	2015	950563	0.0847	2.83E+05	<1E-4%	Population around zip code 87123.	Collective background divided by population = 0.298 rem/yr.
SNL-NM	2016	950563	0.0966	2.83E+05	<1E-4%	50 mi population around zip code. KAFB collective dose.	The local annual radiation dose from natural background sources (indoor radon not included) estimated equivalent is 140 mrem; Collective background divided by population = 0.298 rem/yr. For KAFB, background indicated as 0.311 rem/yr.
SNL-NM	2017	950563	0.0966	2.96E+05	<1E-4%	Population within a 50 mi radius of SNL-NM zip code. Kirtland Air Force Base (KAFB) collective dose also reported (0.00145 pers-rem; population not indicated).	0.311 rem/yr (KAFB).
SNL-NM	2018	975410	0.104	2.83E+05	<1E-4%	For population Searchbug used. Site collective dose indicated. KAFB collective dose (0.0157 pers-rem).	Local background from dosimeter results is 89 mrem (not specific to 2018). SER also indicates a 0.311 rem/yr background.
NNSA-NNPP							
BETTIS	2015	3000000	3.85	9.00E+05	0.0004%	Air and direct radiation.	0.311 rem background per NCRP160 (2009; used for population background). BETTIS background reported as about 79 mrem/yr.
BETTIS	2016	3000000	1.69	9.00E+05	0.0002%	Air and direct radiation.	0.311 rem background per NCRP160 (2009, used for population background). BETTIS background reported as about 79 mrem/yr.
BETTIS	2017	3000000	2.27	9.00E+05	0.0003%	Air and direct radiation	0.311 rem background per NCRP160 (2009, used for

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
							population background). BETTIS background reported as about 79 mrem/yr.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Col lective Dose Comment	Site Individual Background Dose Assumption
BETTIS	2018	3000000	2.43	9.00E+05	0.0003%	Air (2.42) and direct radiation (1E-2).	0.311 rem background (p. 65) per NCRP 160 (2009; used for population background). Bettis background reported as about 79 mrem/yr.
INL NRF	2015	157000	n/a	5.75E+04	n/a	Air pathway only. Environmental Monitoring Report has limited reporting.	0.366 rem background for Idaho residents.
INL NRF	2016	157000	n/a	5.75E+04	n/a	See CY 2015 comment.	See CY 2015 comment.
INL NRF	2017	157000	n/a	5.75E+04	n/a	See CY 2015 comment.	See CY 2015 comment.
INL NRF	2018	157000	n/a	5.75E+04	n/a	See CY 2015 comment.	See CY 2015 comment.
KESS	2015	1230000	0.0083	7.10E+04	<1E-4%	CAP88v3; 2010 census-based population.	TLD results used for background estimate.
KESS	2016	1230000	0.0044	7.50E+04	<1E-4%	CAP88v4 for air; 2010 census-based population.	TLD results used for background estimate.
KESS	2017	1230000	0.0060	6.90E+04	<1E-4%	CAP88v4 for air; 2010 census-based population.	TLD results used for background estimate.
KESS	2018	1230000	0.016	6.90E+04	<1E-4%	CAP88v4 for air; 2010 census-based population.	TLD results used for background estimate.
KNOL	2015	1360000	0.0099	9.80E+04	<1E-4%	CAP88v3; 2010 census-based population. Includes SPRU.	TLD results used for background estimate.
KNOL	2016	1360000	0.0069	9.40E+04	<1E-4%	CAP88v4; 2010 census-based population. Includes SPRU.	TLD results used for background estimate.
KNOL	2017	1360000	0.15	9.70E+04	0.0002%	See KNOL CY2016 comment.	TLD results used for background estimate.
KNOL	2018	1360000	0.063	9.10E+04	<1E-4%	See KNOL CY2016 comment.	TLD results used for background estimate.
SC							
ANL	2015	9301586	0.25	2.89E+06	<1E-4%	CAP88v3; 2010 census-based with 2013 projection. Sawmill Creek water ingestion assumed (100 people) with insignificant contribution compared to air pathway dose.	0.311 rem/yr average U.S. dose from all natural sources.
ANL	2016	9301586	0.18	2.89E+06	<1E-4%	See CY 2015 comment.	See ANL CY 2015 comment.
ANL	2017	9301586	0.18	2.89E+06	<1E-4%	See CY 2015 comment.	See ANL CY 2015 comment.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
ANL	2018	9301586	0.22	5.80E+09	<1E-4%	2010 census-based with 2015 projection. Liquid pathway (Sawmill Creek to Des Plaines water ingestion) = 1E-5 person-rem.	0.624 rem/yr average U.S. background dose from NCRP 160.
BNL	2015	6031539	0.419	1.88E+06	<1E-4%	CAP88v4. Air pathway.	0.311 rem/yr natural background and radon.
BNL	2016	6031539	0.937	1.88E+06	<1E-4%	CAP88v4. Air pathway.	See BNL CY 2015 comment.
BNL	2017	6031539	1.16	1.88E+06	<1E-4%	CAP88v4. Air pathway.	See BNL CY 2015 comment.
BNL	2018	6031539	2.55	1.87E+06	0.0001%	Air pathway dose, only for collective dose. Drinking water dose zero; no fish or deer collective dose calculated.	See BNL CY 2015 comment.
FERMI	2015	8951013	0.49	n/a	n/a	No collective dose in ASER; data from Subpart H compliance report (i.e., air emissions only); CAP88v4.	n/a
FERMI	2016	8951013	0.994	n/a	n/a	See CY 2015 comment.	n/a
FERMI	2017	8951013	1.22	n/a	n/a	See CY 2015 comment.	n/a
FERMI	2018	8951013	1.85	n/a	n/a	See CY 2015 comment.	n/a
JLAB	2015	1849866	0.0034	5.75E+05	<1E-4%	Air (3.4E-3), water, external pathways.	0.311 rem/yr.
JLAB	2016	1849866	0.0044	5.75E+05	<1E-4%	Air (4.4E-3), water, external pathways.	0.311 rem/yr.
JLAB	2017	1849866	0.00089	5.75E+05	<1E-4%	Air (8.9E-4), water, external pathways.	0.311 rem/yr.
JLAB	2018	1849866	0.0054	5.75E+05	<1E-4%	"Plausible scenario." Population from NESHAP report.	0.311 rem/yr.
LBNL	2015	7253000	0.413	2.25E+06	<1E-4%	Daytime population.	0.310 rem/yr U.S. background.
LBNL	2016	7253000	0.214	2.25E+06	<1E-4%	Daytime population.	0.310 rem/yr U.S. background.
LBNL	2017	7253000	0.169	2.25E+06	<1E-4%	Daytime population.	0.310 rem/yr U.S. background.
LBNL	2018	7253000	0.0399	2.25E+06	<1E-4%	Daytime population.	0.310 rem/yr U.S. background.
ORR ORNL[(a)]	2015	1172530	9.4	3.52E+05	0.0027%	2010 census.	0.300 rem/yr.
ORR ORNL[(a)]	2016	1172530	5.7	3.52E+05	0.0016%	2010 census. Air emissions only, CAP88v4.	0.300 rem/yr.
ORR ORNL[(a)]	2017	1172530	7.3	3.52E+05	0.0021%	2010 census, air emissions only, CAP88v4.	0.300 rem/yr.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
ORR ORNL[a]	2018	1172530	5.0	3.52E+05	0.0014%	Collective Dose air only, SER. CAP88 modeled.	About 0.300 rem/yr.
ORR total	2015	1172000	13	3.52E+05	0.0037%	Includes game hunter ingestion and fish ingestion.	0.300 rem/yr.
ORR total	2016	1172530	17.7	3.52E+05	0.0050%	2010 census. Air, water (drinking water, fish, recreation, irrigation), game, external pathways. Drinking water largest contributor in 2016 (8.5 pers-rem).	0.300 rem/yr.
ORR total	2017	1172530	12.3	3.52E+05	0.0035%	2010 census. Air, water (DW, fish, recreation, irrigation), game, external pathways.	0.300 rem/yr.
ORR total	2018	1172530	11.7	3.63E+05	0.0032%	Collective Dose – SER Table 7.7 (air, liquid, other). Total population reflects air pathway total population.	SER Table 7.7.
PNNL MSL	2015	362000	0.00012	1.12E+05	<1E-4%	COMPLY-based calc; includes Canada portion. Air pathway.	0.310 rem/yr.
PNNL MSL	2016	362000	0.00064	1.12E+05	<1E-4%	See CY 2015 comment.	0.310 rem/yr.
PNNL MSL	2017	362000	0.00018	1.12E+05	<1E-4%	See CY 2015 comment.	0.310 rem/yr.
PNNL MSL	2018	362000	0.000005	1.12E+05	<1E-4%	See CY 2015 comment.	0.310 rem/yr.
PNNL Richland	2015	432000	0.00027	1.34E+05	<1E-4%	CAP88v4.	0.310 rem/yr.
PNNL Richland	2016	432000	0.00062	1.34E+05	<1E-4%	CAP88v4.	0.310 rem/yr.
PNNL Richland	2017	432000	0.00016	1.34E+05	<1E-4%	CAP88v4. Air pathway.	0.310 rem/yr.
PNNL Richland	2018	432000	0.000076	1.34E+05	<1E-4%	CAP88v4. Air pathway.	0.310 rem/yr.
PPPL	2015	17700000	0.077	5.49E+06	<1E-4%	2012 American community survey. H-3 air pathway, primarily. Air, water, neutrons (external) pathways.	0.310 rem/yr natural background.
PPPL	2016	17700000	0.104	5.49E+06	<1E-4%	See CY 2015 comment.	0.310 rem/yr natural background.

Site	CY	50 mi (80 km) Population	Collective Dose (person-rem)	Background Collective Dose (person-rem)	Collective Dose as Percent of Background	Collective Dose Comment	Site Individual Background Dose Assumption
PPPL	2017	17700000	0.0763	5.49E+06	<1E-4%	2012−2017 American community survey. H-3 air pathway, primarily. Air and water pathways considered. Neutrons and gamma (external) are n/a in 2017.	0.310 rem/yr natural background.
PPPL	2018	17700000	0.129	5.49E+06	<1E-4%	2012-2017 American community survey. H-3 air pathway, primarily. Air and water pathways considered. Neutrons and gamma (external) are n/a in 2018.	0.310 rem/yr natural background (did not include the 310 man-made indicated for collective background calculation).
SLAC	2015	5300000	0.033	1.67E+06	<1E-4%	Air (5E-3) and external (0.028).	About 0.300 rem/yr.
SLAC	2016	5300000	0.050	1.67E+06	<1E-4%	Air (0.014) and external (0.036).	About 0.300 rem/yr.
SLAC	2017	5300000	0.025	1.67E+06	<1E-4%	Air (2E-3) and external (0.023).	About 0.300 rem/yr.
SLAC	2018	5300000	0.020	1.67E+06	<1E-4%	Air, external.	SER Table 5-6 (0.300 rem/yr) but 0.314 based on collective background (Table 5-6) divided by population.

(a) The ORR Total (SC site) collective dose result includes all sub-site information (ORR ETTP, ORR Y-12, and ORR ORNL).

Figure 2-2 illustrates collective doses by DOE Program Office, with sites sorted according to the estimated 50 mi (80 km) population size. Bars indicate the 2018 population size and are labeled with the 2018 collective dose at each site. Figures for 2015–2017 results would be similar to the 2018 results of Figure 2-2. Collective doses do not necessarily increase with larger surrounding populations. For example, PPPL has the highest 50 mi population (17.7 million), but the collective dose is a relatively low 0.129 person-rem. In contrast, the ORR (ORNL, Y-12, and ETTP) total population of 1.2 million has a relatively high 11.7 person-rem collective dose. The figure also suggests that EM sites are located in generally less densely populated areas whereas SC sites are in generally more populated areas.

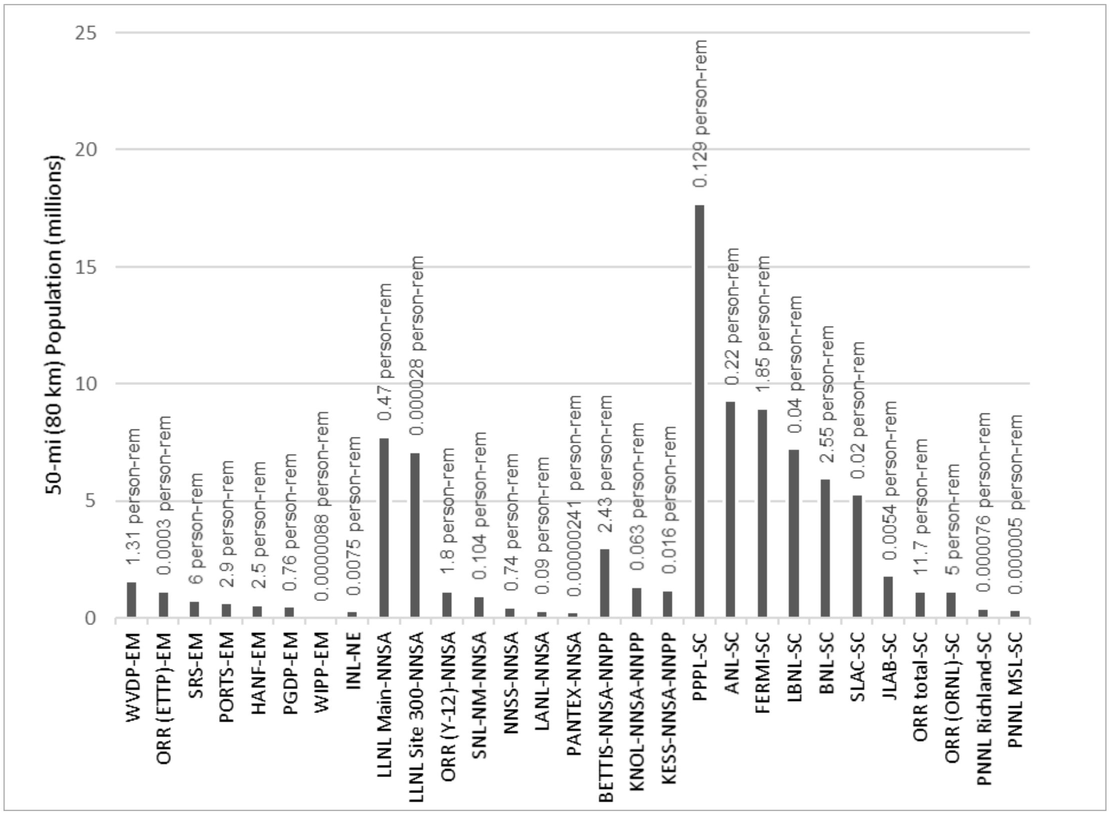

Figure 2-2. 2018 Collective Doses with Sites Sorted by Program Office and 50 mi Population Size (high to low)

2.4 Comparisons of Dose Estimates in ASERs and Subpart H Reports

DOE sites evaluate the impacts of their routine radionuclide emissions to air as part of their compliance with EPA regulations regarding atmospheric releases of radionuclides (40 CFR Part 61, Subpart H). This report includes a summary of those *Subpart H* reports filed by DOE sites for CYs 2015–2018 (see Appendix D). Table 2-9 lists the MEI (or Representative Person) and collective dose estimates contained in the ASER and Subpart H reports.

The ASER doses result from all pathways of radionuclide sources (air, water, direct external, and specific local food ingestion), whereas the Subpart H doses reflect only the air effluent radionuclide emissions pathway contributions. The dose limit of the ASER (100 mrem/yr) considers all site radionuclide sources for reporting dose to a public receptor.

To clarify, the Subpart H dose standard (10 mrem/yr) applies to radionuclide emissions to air during a calendar year. The emissions to air may enter the ambient air from sources such as a DOE facility stack, a DOE facility where the emission point is not as tightly controlled as a stack, facility renovation activities, or resuspension of contaminated soil. Other types of radionuclide emissions to air sources also are possible. One unusual emission source to air is at Argonne National Laboratory (ANL), where H-3 contaminated groundwater is remediated by phytoremediation when the groundwater is taken up by roots and transpired by trees to ambient air. The emissions are modeled so that the maximum public receptor dose from inhalation, ingestion, and external exposure of the radionuclide emission to air can be reported, based on site-specific meteorology, release characteristics, and receptor parameters.

While Subpart H doses include external exposure, the Subpart H external dose generally results from noble gases and other radionuclides resuspended in the air, and the airborne radioactive materials modeled to deposit on ambient surfaces at the receptor location. ASER evaluations consider these same external dose sources, but also include the monitoring results for external dose from sources of activated materials (e.g., accelerator facilities) or large volumes of radioactive waste (e.g., past, storage silos of radioactive waste) that provide a source of ionizing energy at a potential public receptor location.

The dose estimates in these two reports may be the same at some DOE sites when air effluent emissions are the only route of public exposures and the models used in the ASER and Subpart H report are the same. There are a variety of reasons why the critical individual receptor and collective dose results at a DOE site may differ in the ASER and Subpart H reports. The two primary reasons include the use of different computer models, and the different routes of exposure considered. There are two EPA pre-approved modeling codes for use when evaluating dose to the critical receptor from radionuclide emissions to air. Permission can be sought to use a different model, but no site currently uses a non-pre-approved model. Routes of exposure for Subpart H compliance are air pathway routes. ASER evaluates additional pathways beyond the air pathway routes.

Table 2-9. Comparison of Dose Estimates from ASER and Subpart H Reports (2015−2018)

Program Office/ Site	CY	ASER Individual Receptor (mrem/yr)	Percent of DOE O 458.1 Public Dose Limit (100 mrem/yr)	Subpart H MEI (mrem/yr)	Percent of EPA Subpart H Dose Standard (10 mrem/yr)	ASER Collective Dose	Subpart H Collective Dose
EERE							
NREL	2015	3.6E-02	<1% of 100 mrem	3.6E-02	<1% of 10 mrem	n/a	n/a
NREL	2016	3.8E-02	<1% of 100 mrem	3.8E-02	<1% of 10 mrem	n/a	n/a
NREL	2017	4.5E-02	<1% of 100 mrem	4.5E-02	<1% of 10 mrem	n/a	n/a
NREL	2018	3.7E-02	<1% of 100 mrem	3.7E-02	<1% of 10 mrem	n/a	n/a
EM							
HANF	2015	2.1E-01	**2%** of 100 mrem	1.5E-01	**2%** of 10 mrem	1.7E+00	1.1E+00
HANF	2016	1.2E-01	<1% of 100 mrem	4.4E-02	<1% of 10 mrem	1.2E+00	2.9E-01
HANF	2017	2.2E-01	**1%** of 100 mrem	9.3E-02	**1%** of 10 mrem	1.2E+00	3.1E-01
HANF	2018	2.8E-01	<1% of 100 mrem	7.7E-02	**1%** of 10 mrem	2.5E+00	4.2E-01
PGDP	2015	5.4E+00	**5%** of 100 mrem	8.7E-05	<1% of 10 mrem	1.0E+00	5.0E-04
PGDP	2016	4.5E+00	**5%** of 100 mrem	1.3E-04	<1% of 10 mrem	8.9E-01	9.1E-04
PGDP	2017	4.1E+00	**4%** of 100 mrem	4.4E-04	<1% of 10 mrem	8.1E-01	3.8E-03
PGDP	2018	5.1E+00	**5%** of 100 mrem	9.0E-05	<1% of 10 mrem	7.6E-01	6.0E-04
PORTS	2015	9.6E-01	**1%** of 100 mrem	3.7E-02	<1% of 10 mrem	2.2E-01	n/a
PORTS	2016	6.4E-01	**1%** of 100 mrem	1.6E-02	<1% of 10 mrem	6.0E-02	n/a
PORTS	2017	9.0E-01	**1%** of 100 mrem	1.2E-01	**1%** of 10 mrem	4.7E-01	n/a
PORTS	2018	9.2E-01	**1%** of 100 mrem	1.0E-01	**1%** of 10 mrem	2.9E+00	n/a
SRS	2015	1.8E-01	<1% of 100 mrem	2.2E-02	<1% of 10 mrem	3.7E+00	3.2E+00
SRS	2016	1.9E-01	<1% of 100 mrem	2.4E-02	<1% of 10 mrem	4.9E+00	3.5E+00
SRS	2017	2.5E-01	<1% of 100 mrem	2.9E-02	<1% of 10 mrem	4.4E+00	2.7E+00
SRS	2018	2.7E-01	<1% of 100 mrem	8.8E-02	**1%** of 10 mrem	6.0E+00	8.6E+00
SSFL	2015	0.0E+00	0% of 100 mrem	n/a	n/a	0	n/a
SSFL	2016	0.0E+00	0% of 100 mrem	n/a	n/a	0	n/a
SSFL	2017	0.0E+00	0% of 100 mrem	n/a	n/a	0	n/a
SSFL	2018	0.0E+00	0% of 100 mrem	n/a	n/a	0	n/a
WIPP	2015	8.8E-06	<1% of 100 mrem	8.8E-06	<1% of 10 mrem	1.1E-07	2.0E-05
WIPP	2016	4.7E-06	<1% of 100 mrem	4.7E-06	<1% of 10 mrem	1.3E-05	1.3E-05
WIPP	2017	3.0E-06	<1% of 100 mrem	3.0E-06	<1% of 10 mrem	9.9E-06	9.3E-06
WIPP	2018	2.9E-06	<1% of 100 mrem	2.9E-06	<1% of 10 mrem	8.8E-06	8.8E-06

Program Office/ Site	CY	ASER Individual Receptor (mrem/yr)	Percent of DOE O 458.1 Public Dose Limit (100 mrem/yr)	Subpart H MEI (mrem/yr)	Percent of EPA Subpart H Dose Standard (10 mrem/yr)	ASER Collective Dose	Subpart H Collective Dose
WVDP	2015	4.9E-01	<1% of 100 mrem	< 4.7E-01	**5%** of 10 mrem	< 5.1E+00	< 5.0E-01
WVDP	2016	5.0E-01	<1% of 100 mrem	< 4.9E-01	**5%** of 10 mrem	< 5.0E+00	< 4.2E-01
WVDP	2017	4.7E-01	<1% of 100 mrem	< 4.6E-01	**5%** of 10 mrem	< 5.0E+00	< 4.6E-01
WVDP	2018	5.7E-01	1% of 100 mrem	< 5.5E-01	**5%** of 10 mrem	< 1.3E+00	< 1.2E+00
NE							
INL	2015	5.3E-01	**1%** of 100 mrem	3.3E-02	<1% of 10 mrem	6.1E-01	6.1E-01
INL	2016	1.4E-02	<1% of 100 mrem	1.4E-02	<1% of 10 mrem	4.1E-03	4.1E-03
INL	2017	5.4E-02	<1% of 100 mrem	8.0E-03	<1% of 10 mrem	1.1E-02	1.1E-02
INL	2018	2.6E-02	<1% of 100 mrem	1.0E-02	<1% of 10 mrem	7.5E-03	7.5E-03
NNSA							
LANL	2015	1.3E-01	<1% of 100 mrem	1.3E-01	**1%** of 10 mrem	6.0E-02	6.0E-02
LANL	2016	1.2E-01	<1% of 100 mrem	1.2E-01	**1%** of 10 mrem	1.0E-01	1.0E-01
LANL	2017	4.7E-01	<1% of 100 mrem	4.7E-01	**5%** of 10 mrem	2.0E-01	1.9E-01
LANL	2018	3.5E-01	<1% of 100 mrem	3.5E-01	**4%** of 10 mrem	9.0E-02	9.0E-02
LLNL	2015	1.7E-03	<1% of 100 mrem	1.7E-03	<1% of 10 mrem	1.3E-01	1.3E-01
LLNL	2016	2.8E-03	<1% of 100 mrem	2.8E-03	<1% of 10 mrem	2.2E-01	2.2E-01
LLNL	2017	1.9E-03	<1% of 100 mrem	1.9E-03	<1% of 10 mrem	1.3E-01	1.3E-01
LLNL	2018	6.7E-03	<1% of 100 mrem	6.7E-03	<1% of 10 mrem	4.7E-01	4.7E-01
LLNL Site 300	2015	4.8E-04	<1% of 100 mrem	4.8E-04	<1% of 10 mrem	2.4E-05	2.4E-05
LLNL Site 300	2016	2.2E-04	<1% of 100 mrem	2.2E-04	<1% of 10 mrem	3.0E-05	3.0E-05
LLNL Site 300	2017	4.8E-05	<1% of 100 mrem	4.8E-05	<1% of 10 mrem	7.2E-05	7.2E-05
LLNL Site 300	2018	9.6E-05	<1% of 100 mrem	9.6E-05	<1% of 10 mrem	2.8E-05	2.8E-05
NNSS	2015	2.9E+00	**3%** of 100 mrem	6.4E-01	**6%** of 10 mrem	n/a	< 6.0E-01
NNSS	2016	1.5E+00	**2%** of 100 mrem	6.0E-01	**6%** of 10 mrem	< 6.0E-01	< 6.0E-01
NNSS	2017	8.1E-01	**1%** of 100 mrem	5.7E-01	**6%** of 10 mrem	2.5E-01	2.5E-01
NNSS	2018	1.3E+01	**12%** of 100 mrem	5.2E-01	**5%** of 10 mrem	7.4E-01	7.4E-01
PANTEX	2015	1.4E-07	<1% of 100 mrem	1.4E-07	<1% of 10 mrem	2.2E-06	2.2E-06
PANTEX	2016	2.7E-05	<1% of 100 mrem	2.7E-05	<1% of 10 mrem	9.9E-04	9.9E-04
PANTEX	2017	7.6E-06	<1% of 100 mrem	7.6E-06	<1% of 10 mrem	1.0E-05	1.0E-05
PANTEX	2018	1.7E-06	<1% of 100 mrem	1.7E-06	<1% of 10 mrem	2.4E-06	2.4E-06
SNL-NM	2015	3.0E-03	<1% of 100 mrem	3.0E-03	<1% of 10 mrem	8.5E-02	8.6E-02
SNL-NM	2016	2.5E-03	<1% of 100 mrem	1.1E-03	<1% of 10 mrem	9.7E-02	9.8E-02
SNL-NM	2017	1.0E-02	<1% of 100 mrem	1.0E-02	<1% of 10 mrem	9.7E-02	9.1E-02

Program Office/ Site	CY	ASER Individual Receptor (mrem/yr)	Percent of DOE O 458.1 Public Dose Limit (100 mrem/yr)	Subpart H MEI (mrem/yr)	Percent of EPA Subpart H Dose Standard (10 mrem/yr)	ASER Collective Dose	Subpart H Collective Dose
SNL-NM	2018	1.7E-02	<1% of 100 mrem	1.0E-02	<1% of 10 mrem	1.0E-01	1.2E-01
SNL-TTR	2015	2.4E-02	<1% of 100 mrem	2.4E-02	<1% of 10 mrem	n/a	n/a
SNL-TTR	2016	2.4E-02	<1% of 100 mrem	2.4E-02	<1% of 10 mrem	n/a	n/a
SNL-TTR	2017	1.0E-10	<1% of 100 mrem	2.4E-02	<1% of 10 mrem	n/a	n/a
SNL-TTR	2018	7.9E-11	<1% of 100 mrem	7.9E-11	<1% of 10 mrem	n/a	n/a
NNSA-NNPP							
BETTIS	2015	< 1.4E+00	**1%** of 100 mrem	9.5E-05	<1% of 10 mrem	3.9E+00	9.6E-04
BETTIS	2016	< 1.1E+00	**1%** of 100 mrem	5.9E-05	<1% of 10 mrem	1.7E+00	6.9E-04
BETTIS	2017	< 1.2E+00	**1%** of 100 mrem	7.2E-05	<1% of 10 mrem	2.3E+00	7.6E-04
BETTIS	2018	1.2E+00	**1%** of 100 mrem	2.0E-03	<1% of 10 mrem	2.4E+00	9.5E-04
INL NRF	2015	5.4E-04	<1% of 100 mrem	5.4E-04	<1% of 10 mrem	n/a	n/a
INL NRF	2016	3.3E-04	<1% of 100 mrem	3.3E-04	<1% of 10 mrem	n/a	n/a
INL NRF	2017	2.4E-04	<1% of 100 mrem	2.4E-04	<1% of 10 mrem	n/a	n/a
INL NRF	2018	3.4E-04	<1% of 100 mrem	3.4E-04	<1% of 10 mrem	n/a	n/a
KESS	2015	1.7E-03	<1% of 100 mrem	1.7E-03	<1% of 10 mrem	8.3E-03	8.3E-03
KESS	2016	9.2E-04	<1% of 100 mrem	9.2E-04	<1% of 10 mrem	4.4E-03	4.4E-03
KESS	2017	1.3E-03	<1% of 100 mrem	1.3E-03	<1% of 10 mrem	6.0E-03	5.9E-03
KESS	2018	2.7E-03	<1% of 100 mrem	2.7E-03	<1% of 10 mrem	1.6E-02	1.6E-02
KNOL	2015	1.1E-03	<1% of 100 mrem	1.1E-03	<1% of 10 mrem	9.9E-03	2.1E-03
KNOL	2016	2.6E-02	<1% of 100 mrem	2.6E-02	<1% of 10 mrem	6.9E-03	3.0E-03
KNOL	2017	4.4E-02	<1% of 100 mrem	4.4E-02	<1% of 10 mrem	1.5E-01	1.4E-01
KNOL	2018	3.0E-02	<1% of 100 mrem	3.0E-02	<1% of 10 mrem	6.3E-02	6.0E-02
SC							
ANL	2015	2.9E-02	<1% of 100 mrem	2.2E-02	<1% of 10 mrem	2.5E-01	1.1E-01
ANL	2016	9.0E-03	<1% of 100 mrem	2.8E-03	<1% of 10 mrem	1.8E-01	1.8E-01
ANL	2017	1.7E-02	<1% of 100 mrem	5.5E-03	<1% of 10 mrem	1.8E-01	5.2E-02
ANL	2018	1.7E-02	<1% of 100 mrem	4.1E-03	<1% of 10 mrem	2.2E-01	4.8E-02
BNL	2015	3.2E+00	**3%** of 100 mrem	2.8E-01	**3%** of 10 mrem	4.2E-01	4.2E-01
BNL	2016	3.2E+00	**3%** of 100 mrem	6.1E-01	**6%** of 10 mrem	9.4E-01	9.4E-01
BNL	2017	5.6E+00	**6%** of 100 mrem	7.2E-01	**7%** of 10 mrem	1.2E+00	1.2E+00
BNL	2018	5.0E+00	**5%** of 100 mrem	1.6E+00	**16%** of 10 mrem	2.6E+00	2.6E+00
FERMI	2015	2.8E-02	<1% of 100 mrem	2.8E-02	<1% of 10 mrem	4.9E-01	4.9E-01

Program Office/ Site	CY	ASER Individual Receptor (mrem/yr)	Percent of DOE O 458.1 Public Dose Limit (100 mrem/yr)	Subpart H MEI (mrem/yr)	Percent of EPA Subpart H Dose Standard (10 mrem/yr)	ASER Collective Dose	Subpart H Collective Dose
FERMI	2016	4.1E-02	<1% of 100 mrem	4.1E-02	<1% of 10 mrem	9.9E-01	9.9E-01
FERMI	2017	4.2E-02	<1% of 100 mrem	4.2E-02	<1% of 10 mrem	1.2E+00	1.2E+00
FERMI	2018	7.3E-02	<1% of 100 mrem	7.3E-02	**1%** of 10 mrem	1.9E+00	1.9E+00
JLAB	2015	5.7E-02	<1% of 100 mrem	6.2E-03	<1% of 10 mrem	3.4E-03	3.4E-03
JLAB	2016	6.1E-01	**1%** of 100 mrem	3.7E-03	<1% of 10 mrem	4.4E-03	4.4E-03
JLAB	2017	9.2E-02	<1% of 100 mrem	1.7E-03	<1% of 10 mrem	8.9E-04	8.9E-04
JLAB	2018	2.4E+00	**2%** of 100 mrem	3.9E-02	<1% of 10 mrem	5.4E-03	5.4E-03
LBNL	2015	4.1E-01	<1% of 100 mrem	7.9E-03	<1% of 10 mrem	4.1E-01	1.6E-01
LBNL	2016	4.1E-01	<1% of 100 mrem	1.2E-02	<1% of 10 mrem	2.1E-01	2.1E-01
LBNL	2017	2.0E-01	<1% of 100 mrem	9.7E-03	<1% of 10 mrem	1.7E-01	1.7E-01
LBNL	2018	5.5E-01	<1% of 100 mrem	3.7E-03	<1% of 10 mrem	4.0E-02	4.0E-02
ORR total	2015	3E+00	**3%** of 100 mrem	4.0E-01	**4%** of 10 mrem	1.3E+01	1.1E+01
ORR total	2016	3E+00	**3%** of 100 mrem	2.0E-01	**2%** of 10 mrem	1.8E+01	6.4E+00
ORR total	2017	3E+00	**3%** of 100 mrem	3.0E-01	**3%** of 10 mrem	1.2E+01	1.0E+01
ORR total	2018	3E+00	**3%** of 100 mrem	2.0E-01	**2%** of 10 mrem	1.2E+01	6.8E+00
PNNL MSL	2015	1.1E-04	<1% of 100 mrem	1.1E-04	<1% of 10 mrem	1.2E-04	1.2E-04
PNNL MSL	2016	9.6E-05	<1% of 100 mrem	9.6E-05	<1% of 10 mrem	6.4E-04	6.4E-04
PNNL MSL	2017	1.6E-04	<1% of 100 mrem	1.6E-04	<1% of 10 mrem	1.8E-04	1.8E-04
PNNL MSL	2018	4.5E-04	<1% of 100 mrem	4.5E-04	<1% of 10 mrem	5.0E-06	5.0E-04
PNNL Richland	2015	2.6E-04	<1% of 100 mrem	2.6E-04	<1% of 10 mrem	2.7E-04	2.7E-04
PNNL Richland	2016	5.8E-04	<1% of 100 mrem	5.8E-04	<1% of 10 mrem	6.2E-04	6.2E-04
PNNL Richland	2017	2.3E-05	<1% of 100 mrem	2.3E-05	<1% of 10 mrem	1.6E-04	1.6E-04
PNNL Richland	2018	1.8E-05	<1% of 100 mrem	1.6E-05	<1% of 10 mrem	7.6E-05	7.6E-05
PPPL	2015	2.4E-03	<1% of 100 mrem	4.4E-03	<1% of 10 mrem	7.7E-02	7.7E-02
PPPL	2016	4.9E-03	<1% of 100 mrem	5.3E-03	<1% of 10 mrem	1.0E-01	1.0E-01
PPPL	2017	2.6E-03	<1% of 100 mrem	4.3E-03	<1% of 10 mrem	7.6E-02	7.6E-02
PPPL	2018	3.4E-03	<1% of 100 mrem	7.3E-03	<1% of 10 mrem	1.3E-01	1.3E-01
SLAC	2015	4.5E-02	<1% of 100 mrem	2.2E-03	<1% of 10 mrem	3.3E-02	5.2E-03
SLAC	2016	5.2E-02	<1% of 100 mrem	2.4E-03	<1% of 10 mrem	5.0E-02	1.4E-02
SLAC	2017	3.1E-02	<1% of 100 mrem	1.4E-03	<1% of 10 mrem	2.5E-02	2.0E-03
SLAC	2018	4.1E-02	<1% of 100 mrem	1.4E-03	<1% of 10 mrem	2.0E-02	1.7E-03

2.5 References

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3.0 Biota Dose Evaluations

Beyond potential radiological impacts on humans, non-human biota may be impacted by DOE radiological operations. Certain organisms are known to be more sensitive to ionizing radiation than others. DOE O 458.1, Chg 3 requires operations to be conducted while protecting local biota from the adverse effects of radiation and radioactive material releases. The general categories of biota that may be included in a biota dose assessment at a DOE site include aquatic animals, riparian (riverbank) animals, terrestrial plants, and terrestrial animals.

To demonstrate that a site adequately protects biota, one or more of the following evaluations can be implemented:

1. Use the graded approach described in DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.

2. Implement an alternative approach demonstrating that dose rates to representative biota populations do not exceed the dose rate criteria in DOE-STD-1153-2002.

3. Conduct an ecological risk assessment to demonstrate that radiation and radioactive material released from DOE operations will not adversely affect populations within the ecosystem.

The biota dose criterion in DOE-STD-1153-2002 is intended to be a simple, defensible, and straightforward means of demonstrating that the ecosystem is protected from radiation. ICRP 1977 stated: "if man is adequately protected then other living things are likely to be sufficiently protected." This assumption was considered appropriate if humans and biota inhabit the same environment and have common routes of exposure.[6] However since 1977, the ICRP stance has evolved and continues to evolve with this topic most recently addressed in ICRP 2014 and 2017.

Biota dose results were reported in the prior ASER summary report (DOE 2004) which summarized CY 1998–2001 DOE operations. Biota dose guidance was updated in the DOE Technical Standard, DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, the year following the summarized years. The DOE 2002 guidance is summarized here. The 2002 biota guidance was updated in 2019 (DOE-STD-1153-2019, DOE 2019) and is first referenced in CY 2018 ASERs. The 2019 standard did not substantially change the 2002 standard but was more of a simplification of its presentation.[7] Biota dose results from sites for CYs 2015–2018 are presented in Section 3.3.

Table 3-1 indicates the sites at which no biota dose is reported, in addition to the sites not further reviewed due to their lack of radioactive material emissions (see Section 1.0).

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[6] Exceptions to this assumption include the following: contaminated areas where human access is restricted but access by biota is possible; cases in which unique pathways for biota exist; environments where rare, threatened, and endangered species are present; and situations where other stressors on biota may pose a significant threat.

[7] In June 2020, EHSS-22 published an Information Brief titled "DOE-STD-1153-2019 A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (see https://www.energy.gov/ehss/biota for a link to both the information brief and updated Standard). Summary data presented in this report would not have used this more recent guidance.

Table 3-1. DOE Sites with No Reported Biota Dose (2015–2018)

DOE Program Office	Site Abbreviation
EERE	
	NREL STM
NNSA	
	SNL-CA
	SNL-NM
	SNL-TTR
NNSA-NNPP	
	BETTIS
	KESS
	KNOL/SPRU
SC	
	FERMI

3.1 Background

DOE facility operations, site remediation, and stewardship activities may result in releases of radionuclides to ambient air and water, accumulation of radionuclides in soil and sediment, and the potential for plants, animals, and members of the public to be exposed to radiation. In the past, regarding environmental protection, scientific organizations (ICRP 1977) have assumed that if radiological controls and established dose limits for humans were found to be protective, then non-human species (i.e., biota: plants and animals) also would be sufficiently protected. This assumption is considered largely appropriate in cases where humans and other biota inhabit the same environment and contaminated area and are subject to similar pathways of radiological exposure (Barnthouse 1995). This assumption is less applicable when human access is restricted, but populations of plants and animals remain exposed (e.g., to contaminated water, sediment, and soil); and where unique exposure pathways exist for plants and animals that do apply to humans. The standard also indicates that a species-specific assessment, rather than the graded approach to dose estimation, may be required at sites where a threatened or endangered species population requires evaluation.

Maintaining biota radiological impacts below biota dose standards is part of maintaining a sustainable ecosystem. It demonstrates environmental management performance under DOE O 436.1 and conformance with (or certification by) ISO 14001:2015 (ISO 2015). Both aquatic and terrestrial evaluations are required to be conducted as an integral part of a site's environmental monitoring and surveillance program. The results of these evaluations are reported in the ASER. However, some sites do not have aquatic biota or water pathways, so aquatic and riparian reporting requirements are not applicable.

DOE first recommended that ASERs discuss radiation protection of biota for CY 1999 (DOE 2000). This reporting guidance has continued for each subsequent year. Prior to the publication of DOE O 458.1 in 2011, DOE Order 5400.5, Chg 2, provided interim guidance that included an aquatic animal dose limit of 1 rad/d. Dose criteria for other biota categories (riparian animals, terrestrial plants, and terrestrial animals) were not indicated. Now, biota dose requirements are included in DOE O 458.1, Chg 3 (Paragraph 4.j). The Order points to DOE-STD-1153-2002 for site biota dose assessments. As indicated, DOE-STD-1153-2002 was updated in DOE-STD-1153-2019. Biota dose standards (see Table 3-2) are indicated in Table 2.2 of DOE-STD-1153-2002, Module 1, and Table 1-1 of DOE-STD-1153-2019. The graded approach refers to the use of conservative (overestimating) data such as maximum water concentrations and maximizing default parameters; reasonable data, such as average water concentrations, with maximizing default parameters; and site-specific data, such as site biota sampling results or site-specific parameters.

Table 3-2. DOE-STD-1153-2002 Biota Dose Standards

Biota Category	Biota Dose Standard
Aquatic animals	1 rad/d (10 mGy/d)
Terrestrial plants	1 rad/d (10 mGy/d)
Riparian animals	0.1 rad/d (1 mGy/d)
Terrestrial animals	0.1 rad/d (1 mGy/d)

The unit of biota dose is rad (= 0.01 Gy = 10 mGy). A dose of 1 rad indicates that 1 gram of material absorbed 100 ergs of energy as a result of exposure to ionizing radiation. Different materials that receive the same exposure may not absorb the same amount of radiation.

DOE-STD-1153-2002 provides methods, models, and guidance within a graded approach that DOE and its contractors may use to evaluate doses of ionizing radiation to populations of aquatic animals, terrestrial plants, and terrestrial animals, from DOE activities for demonstrating protection; and provides dose evaluation methods that can be used to meet DOE O 458.1, Chg3, requirements. Biota dose is based on modeled or sampled water, sediment, and/or soil concentrations of radionuclides or sampled biota.

The RESRAD BIOTA software (e.g., ISCORS 2004) is a popular choice for sites to use to demonstrate compliance with DOE-STD-1153-2002. The RESRAD BIOTA code provides a complete spectrum of biota dose evaluation capabilities, from methods for general screening to comprehensive receptor-specific dose estimation. The code provides the user with a three-level graded approach. RESRAD Level 1 screening uses maximum measured concentrations and conservative default modeling assumptions; Level 2 screening uses average concentrations or site-specific modeling assumptions; and the most precise Level 3 analysis uses site-specific biota parameters or measured concentrations of a biota sample harvested at the assessed location.

3.2 Demonstrating Protection of Biota and Reporting Compliance with DOE Dose Limits and Requirements

Current guidance for addressing the radiation protection reporting for biota is included in Attachment II of DOE's *Guidance for Preparation of the 2017 Department of Energy Annual Site Environmental Reports* (DOE 2018). The text provides additional details regarding the graded approach. In addition, examples of noteworthy, past ASER biota dose text are provided in DOE 2018.

For ASER reporting of biota dose compliance, the following recommendations were put forth:

- List the dose standard and biota category for each category evaluated.
- Briefly describe the method used to demonstrate compliance.
- Describe the site areas and supporting data used in the evaluation.
- Summarize the results.

The biota criteria indicate an absorbed daily dose rate (rad/d or mGy/d) to various biota categories from exposure to radiation or radioactive material. DOE-STD-1153-2002 and DOE-STD-1153-2019 indicate that the dose rate criteria were set to protect plant and animal populations from adverse effects.

Use of the DOE-STD-1153-2002 and DOE-STD-1153-2019 screening method, which produces the most conservative (overestimating) results, involves the use of radionuclide-specific conversion factors. Both revisions of the standard include BCGs (Biota Concentration Guides), which indicate the limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for aquatic and terrestrial biota to be exceeded. RESRAD BIOTA software implements the DOE-STD-1153-2002 and DOE-STD-1153-2019 methodology.

The screening and analysis methods contained in the DOE-STD-1153-2002 and DOE-STD-1153-2019 provide a means of demonstrating that the dose rate guidelines for aquatic and terrestrial biota are being met. The graded approach consists of a three-step process that guides the user from an initial, prudently conservative set of screening values to, if needed, a more rigorous analysis using site-specific information. This three-phased approach helps to ensure that the evaluation effort is commensurate with the likelihood and severity of potential environmental impacts. In the general screening phase, measured radionuclide concentrations in environmental media are compared with the BCGs. The multi-tiered analysis process provided in the DOE-STD-1153-2002 and DOE-STD-1153-2019 is also appropriate for conducting detailed ecological risk assessments of radiological impact.

Several companion software tools for use with DOE-STD-1153-2002 are provided for DOE and public use. In 2002, the RAD-BCG Calculator was released to provide a set of electronic spreadsheets for conducting the screening and analysis methods in the graded approach. In 2003, DOE released the RESRAD BIOTA code and a supporting User's Guide. The code duplicates the graded approach methodology and includes additional advanced analysis features. The DOE-STD-1153-2002 and the RESRAD BIOTA code that DOE first released in 2003 are the preferred tools for estimating and evaluating doses to biota.

3.3 Results of CY 2015–2018 Biota Dose Evaluation Reporting in ASERs

Sites had fully adopted DOE's approach to biota dose assessment using DOE-STD-1153-2002 for CY 2015–2018 ASER reporting. Most sites were able to comply with the dose criteria for all applicable biota groups using the most conservative (overestimating) method, based on maximum water, soil, or sediment samples. Due to the lack of perennial surface water sources, some DOE sites did not have to evaluate aquatic biota groups. Additional or more detailed assessments based on average sampling results (Level 2), site-specific parameter use (Level 3), or biota samples were used by a small number of sites to meet or confirm that dose criteria were met.

ASER biota dose data are summarized in Table 3-3. The 2015–2018 biota dose estimates at all sites were below the dose criteria limits of for all four representative biota categories that require evaluation. Maximum biota values are reported for sites that provide biota dose information for more than one site location for a biota category. When a more detailed biota dose evaluation is reported (e.g., for a specific biota type at a specific site location), it is reported along with the screening data. Refer to site ASERs for additional details regarding their biota dose reporting. RESRAD Biota Level 3 analyses, the most detailed biota analyses, were implemented at a number of sites in their compliance demonstrations. Riparian and terrestrial animal tissue samples used at some sites for dose assessment included bat, waterfowl, great horned owl, game animals, and rabbits.

Table 3-3. Summary of ASER Biota Dose (2015–2018)

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
EM							
HANF	2015	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Tier 1 (= Level 1). Columbia River sediment and water for aquatic and riparian animals. Soils near facilities for terrestrial biota.
HANF	2015	RESRAD Biota 1.8, Level 3	<1	n/a	<0.1	n/a	Tier 3 (= Level 3). West Lake.
HANF	2016	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Tier 1 (= Level 1). Columbia River sediment and water for aquatic and riparian animals. Soils near facilities for terrestrial biota.
HANF	2016	RESRAD Biota 1.8, Level 3	<1	n/a	<0.1	n/a	Tier 3 (= Level 3). West Lake.
HANF	2017	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Tier 1 (= Level 1). Columbia River sediment and water for aquatic and riparian animals. Fish samples also measured. Soils near facilities for terrestrial biota. Terrestrial plant samples also measured.
HANF	2017	RESRAD Biota 1.8, Level 3	<1	n/a	<0.1	n/a	Tier 3 (= Level 3). West Lake. Site-specific U bioaccumulation values used.
HANF	2018	RESRAD Biota 1.8, Level 1	0.53	0.95	0.053	0.0006	Tier 1 (= Level 1). Columbia River sediment and water. Fish samples also measured. Maximum value (sum of fractions times Limit) is reported and assigned to aquatic animals and riparian animals. For terr. plants and terr. animals doses, 8 radionuclides (maximum concentrations) in soils near facilities. Terrestrial plant dose based on measured plant sample maximum concentrations (so may be more of a Level 3).
HANF	2018	RESRAD Biota 1.8, Level 3	0.11	n/a	0.011	n/a	Tier 3 (= Level 3). West Lake. Site-specific U bioaccumulation values used. Sum-of-fractions value times Limit is reported and assigned to aquatic animals and riparian animals.
PGDP	2015	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Bayou Creek, Little Bayou Creek where aquatic life is likely.
PGDP	2016	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Bayou Creek, Little Bayou Creek where aquatic life is likely.
PGDP	2017	RESRAD Biota 1.8, Level 1	<1	<1	<0.1	<0.1	Bayou Creek, Little Bayou Creek where aquatic life is likely.
PGDP	2018	RESRAD Biota 1.8, Level 1	0.021	8E-08	7E-04	1E-06	Bayou Creek, Little Bayou Creek where aquatic life is likely. Sum-of-fractions value times Limit is indicated.
PORTS	2015	RESRAD Biota	<1	<1	<0.1	<0.1	Maximum sampling results used.
PORTS	2016	RESRAD Biota	<1	<1	<0.1	<0.1	Maximum sampling results used.
PORTS	2017	RESRAD Biota	<1	<1	<0.1	<0.1	Maximum sampling results used.
PORTS	2018	RESRAD Biota	<1	<1	<0.1	<0.1	Maximum sampling results used.
SRS	2015	RESRAD Biota 1.5, Level 1	<1	<1	<0.1	<0.1	Aquatic and riparian animals, onsite water and sediment samples, 13/13 passed at Level 1. Terrestrial systems evaluated from 5 onsite soil sample locations, but new annual samples from only one location. No specific fraction information provided.

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
SRS	2016	RESRAD Biota 1.5, Level 1	n/a	<1	n/a	<0.1	Terrestrial biota, onsite samples, 5/5 onsite locations passed at Level 1 (only sample per site each year).
SRS	2016	RESRAD Biota 1.5, Level 2	<1	n/a	<0.1	n/a	Aquatic biota, onsite water and sediment samples, 13/14 passed at Level 1. Z-Area Basin passed at Level 2.
SRS	2017	RESRAD Biota 1.5, Level 1	<1	<1	<0.1	<0.1	Terrestrial biota, onsite samples, 5/5 onsite locations passed at Level 1. Aquatic biota, onsite water, and sediment samples; 14 sample locations.
SRS	2018	RESRAD Biota 1.5, Level 1	n/a	<1	n/a	<0.1	All land-based locations passed Level 1 screenings.
SRS	2018	RESRAD Biota 1.5, Level 2	<1	n/a	<0.1	n/a	All aquatic system locations passed Level 1 or Level 2 screenings.
SSFL	2015	RESRAD Biota, Level 1	n/a	<1	n/a	<0.1	Aquatic biota not applicable. Soil samples from 2011 and 2012. Cs-137 and Sr-90 most significant contributors of 14 nuclides.
SSFL	2016	RESRAD Biota, Level 1	n/a	<1	n/a	<0.1	See 2015 comment.
SSFL	2017	RESRAD Biota, Level 1	n/a	<1	n/a	<0.1	See 2015 comment.
SSFL	2018	RESRAD Biota, Level 1	n/a	<1	n/a	<0.1	See 2015 comment. Sum of fractions was 0.012
WIPP	2015	spreadsheet	0.037	0.048	n/a	0.0048	Aquatic animal dose assigned by multiplying the sum of fractions by the dose limit. Terrestrial system dose was assigned to terrestrial plants and terrestrial animals by multiplying the sum of fractions by the dose limit. Non-detects were assigned a zero result.
WIPP	2016	spreadsheet	0.06	0.074	n/a	0.0074	See 2015 comment.
WIPP	2017	spreadsheet	<1	<1	<0.1	<0.1	Aquatic system evaluation (sediment and surface water samples) was assigned to aquatic animals and riparian animals; terrestrial system evaluation (soil and surface water samples) was assigned to terrestrial animals and plants.
WIPP	2018	spreadsheet	0.0487	0.055	n/a	0.0055	Vegetation sampled (10 nuclides) and roadkill sampled. Dose indicated is sum-of-fractions times the dose limit.
WVDP	2015	RESRAD Biota (2009), Level 2	0.012	0.0036	0.033	0.045	Samples were 2015 surface water samples; most recent sediment samples (2004−2007, 2012); onsite soil samples (1995−2012 range).
WVDP	2016	RESRAD Biota (2009), Level 2	0.0052	0.0036	0.016	0.045	Dose is virtually all from Cs-137 and Sr-90.
WVDP	2017	RESRAD Biota 1.8, Level 2	0.0057	0.0042	0.017	0.056	Soil and sediment samples were acquired at 5 yr intervals at various sampling locations. Surface waters were sampled annually.
WVDP	2018	RESRAD Biota 1.8, Level 2	0.0054	0.0042	0.018	0.056	Used average soil and water concentrations.
NE							
INL	2015	RESRAD Biota 1.5, Level 1	0.011	0.21	3.1E-04	0.021	Dose was assigned as the sum of fractions times the dose limit. Riparian animal (waterfowl) results from Level 3 evaluation also were presented (0.0021 rad/d); less than the RESRAD Level 1 result tabulated.

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
INL	2016	RESRAD Biota 1.5, Level 1	<1	<1	<0.1	<0.1	Level 1. Based on soil samples from 2005–2015. Aquatic based on the Materials and Fuels Complex (MFC) Industrial Waste Pond.
INL	2017	RESRAD Biota 1.5, Level 1	<1	<1	n/a	n/a	Terrestrial and riparian animals passed at Level 1, but site-specific bat and waterfowl samples were more limiting and more detailed. Soil samples included background. Aquatic based on the Materials and Fuels Complex (MFC) Industrial Waste Pond.
INL	2017	RESRAD Biota 1.5, Level 3	n/a	n/a	4.9E-05	0.002	Measured bat data (terrestrial animal) and waterfowl data (riparian animal).
INL	2018	RESRAD Biota 1.5, Level 1	0.00111	0.00198	3.31E-04	0.0209	Sum of fractions times the dose limit. Assumed same RESRAD Biota version as prior year.
INL	2018	RESRAD Biota 1.5, Level 3	n/a	n/a	n/a	0.00253	Bat dose from 4 nuclides. Assumed same RESRAD Biota version as prior year.
NNSA							
LANL	2015	RESRAD Biota	n/a	6.80E-04	n/a	7.30E-04	LANL DARHT facility. (Greater than Area G and LA Canyon Weir results). Tissue samples also were compared to RESRAD results at some locations; RESRAD results were greater.
LANL	2016	RESRAD Biota	n/a	9.00E-04	n/a	0.001	LANL DARHT facility. (Greater than Area G and LA Canyon Weir results.) Pajarito Canyon Flood-retention Structure (un-impacted location) was also evaluated and found to have levels indistinguishable from background.
LANL	2017	RESRAD Biota 1.8, Level 1	n/a	3.70E-04	n/a	3.90E-04	LANL DARHT facility. (Greater than or equal to Area G and LA Canyon Weir results.) Pajarito Canyon Flood-retention Structure (un-impacted location) was also evaluated and found to have levels indistinguishable from background.
LANL	2017	RESRAD Biota 1.8, Level 3	n/a	n/a	n/a	0.0043	Great horned owl tissue results (terrestrial, animal)
LANL	2018	RESRAD Biota 1.8, Level 1	n/a	0.0036	n/a	0.0033	Sitewide assessment (every 3 yr). Results were also evaluated for roadkill deer, coyote, snake, and owl but were similar to background.
LANL	2018	RESRAD Biota 1.8, Level 1	n/a	0.031	n/a	0.042	Area G. Tritium is predominant dose contributor of 8 nuclides. (DARHT facility also reported but results were less than Area G results.)
LLNL	2015	RESRAD Biota	<1	<1	<0.1	<0.1	LLNL main site and Site 300 were evaluated together (maximum fraction from either site). Used stormwater runoff and onsite soil.
LLNL	2016	RESRAD Biota	<1	<1	<0.1	<0.1	See 2015 comment.
LLNL	2017	RESRAD Biota	<1	<1	n/a	<0.1	See 2015 comment.
LLNL	2018	RESRAD Biota	0.059	0.4	n/a	0.04	10 soil nuclides evaluated and 3 water (stormwater runoff) nuclides evaluated. See 2015 comment.
NNSS	2015	RESRAD Biota 1.5	n/a	0.0047	n/a	0.0021	NNSS samples game animals, ground animals, plants, and soils, in addition to biota dose results. Internal dose from maximum sampling results; Sedan (Area 10) biota for 2015. External dose from maximum TLD results for TLD station nearest biota sampling location. Background is subtracted from results. Maximum terrestrial animal result was indicated.

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
NNSS	2016	RESRAD Biota 1.5	n/a	0.0027	n/a	0.0012	Background was subtracted. Terrestrial plants (3 species) from Area 2. Terrestrial animals max (Area 2 rabbits).
NNSS	2017	RESRAD Biota 1.5, Level 3	n/a	0.0067	n/a	0.0053	Estimated external dose for biota samples from nearest TLD location (background was subtracted) to sample location. Internal dose from RESRAD BIOTA 1.5 results.
NNSS	2018	RESRAD Biota 1.5, Level 3	n/a	0.01214	n/a	0.00398	See 2017 comment. Results indicate the largest RESRAD and TLD result.
PANTEX	2015	RAD-BCG	0.0012	n/a	1.20E-04	9.90E-07	Reported dose to aquatic biota and for terrestrial biota, only. Sum of fractions was multiplied by dose limit to report dose. Terrestrial animal was more limiting than terrestrial plants for nuclides evaluated. Aquatic animal or riparian animal may be limiting for the aquatic biota evaluated, so dose was assigned to each category.
PANTEX	2016	RAD-BCG	0.014	n/a	1.40E-03	5.10E-05	See 2015 comment.
PANTEX	2017	RAD-BCG	1.50E-03	n/a	1.50E-04	4.10E-05	See 2015 comment.
PANTEX	2018	RAD-BCG	8.65E-03	<1	n/a	2.95E-05	Result reported is the sum of fractions times the dose limit. Report indicates all dose criteria were met, but did not specifically mention riparian biota, so marked as n/a.
SNL-CA	2015	RAD-BCG	n/a	4.70E-06	n/a	4.70E-07	H-3 and DU only; no H-3 in the CY was above detection limit so the detection limit value was used. Stormwater samples were used for evaluation. No perennial or natural water bodies exist at SNL-CA, so no doses were assigned to the aquatic or riparian animal category. Multiplied sum of fraction by dose limit to assign dose value.
SNL-CA	2016	RAD-BCG	n/a	5.00E-06	n/a	5.00E-07	See 2015 comment.
SNL-CA	2017	None	n/a	n/a	n/a	n/a	Biota dose evaluation was discontinued for CY 2017 reporting due to lack of operational H-3 emissions (no routine H-3 emissions since 1995).
SNL-CA	2018	None	n/a	n/a	n/a	n/a	SER statement: No operations require biota monitoring.
SC							
ANL	2015	spreadsheet, general screening	1.00E-03	n/a	1.00E-04	n/a	6 nuclides in maximum concentrations, ratio to biota concentration guideline. Aquatic biota sum of fractions were multiplied by the aquatic animal and riparian animal dose limit for reporting.
ANL	2016	spreadsheet, general screening	1.10E-03	n/a	1.10E-04	n/a	7 nuclides, ratio to biota concentration guideline. Sum of ratios for aquatic biota were multiplied by dose limits for aquatic animals and riparian animals for dose reporting.
ANL	2017	spreadsheet, general screening	1.10E-03	n/a	1.10E-04	n/a	See 2015 comment.
ANL	2018	spreadsheet, general screening	1.40E-03	n/a	1.40E-04	n/a	See 2016 comment.
BNL	2015	RESRAD Biota 1.8, Level 2	8.40E-05	1.30E-03	2.90E-04	0.014	Cs-137 and Sr-90.
BNL	2016	RESRAD Biota 1.8, Level 2	8.20E-05	4.00E-04	2.90E-04	0.0042	<no comment>

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
BNL	2017	RESRAD Biota 1.8, Level 2	2.10E-04	4.90E-03	4.90E-04	0.052	Cs-137 in soil and Sr-90 in surface water from 2015 samples. No surface water samples in 2017 because of drought conditions. Estimated Cs-137 sediment concentration from a vegetation sample.
BNL	2018	RESRAD Biota 1.8, Level 2	1.89E-05	6.16E-04	2.87E-04	0.00655	For terrestrial: Cs-137 in soil from the tank pond and Sr-90 in surface water at the HY sampling station (headwaters west of the RHIC ring). For aquatic: the Cs-137 concentration in vegetation was used with the Sr-90 surface water value.
JLAB	2015	dosimeters	n/a	1.40E-04	1.40E-04	1.40E-04	Gamma and neutron external dose at boundary locations. Maximum dose would be for onsite ground-dwelling terrestrial animals. External dose was reported from dosimeter results.
JLAB	2016	dosimeters	n/a	2.00E-04	2.00E-04	2.00E-04	See 2015 comment.
JLAB	2017	dosimeters	n/a	1.90E-04	1.90E-04	1.90E-04	See 2015 comment.
JLAB	2018	dosimeters	n/a	5.80E-04	5.80E-04	5.80E-04	Maximum gamma and neutron external dose at Hall C dome. See 2015 comment re: maximum dose and external dose.
LBNL	2015	RESRAD Biota	<1	<1	<0.1	<0.1	Passed "general screening process" in RESRAD. Evaluated creek water, soil, and sediment.
LBNL	2016	RESRAD Biota	<1	<1	<0.1	<0.1	See 2015 comment.
LBNL	2017	RESRAD Biota	<1	<1	<0.1	<0.1	See 2015 comment.
LBNL	2018	RESRAD Biota	<1	<1	<0.1	<0.1	See 2015 comment.
ORR	2015	RESRAD Biota 1.5	n/a	n/a	n/a	<0.1	Terrestrial evaluated in 2014 with next evaluation within the next 5 years (2019). Dose evaluated from unremediated areas. Cs-137 is the primary dose contributor from soil.
ORR ORNL (SC)	2015	RESRAD Biota 1.8, Level 2	<1	n/a	<0.1	n/a	<no comment>
ORR ETTP (EM)	2015	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	<no comment>
ORR Y-12 (NNSA)	2015	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	<no comment>
ORR	2016	RESRAD Biota 1.5	n/a	n/a	n/a	<0.1	See ORR 2015 comment.
ORR ORNL (SC)	2016	RESRAD Biota 1.8, Level 2	<1	n/a	<0.1	n/a	8 surface water and sediment locations. Six of eight passed at Level 1. Two passed at Level 2.
ORR ETTP (EM)	2016	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	11 surface water and sediment locations. (General screening phase = Level 1).
ORR Y-12 (NNSA)	2016	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	6 surface water and sediment locations. (General screening phase = Level 1).
ORR	2017	RESRAD Biota 1.5	n/a	n/a	n/a	<0.1	See ORR 2015 comment.
ORR ORNL (SC)	2017	RESRAD Biota 1.8, Level 3	<1	n/a	<0.1	n/a	12 surface water locations. Site-specific Cs-137 and Sr-90 bioaccumulation factors were used for aquatic animals.
ORR ETTP (EM)	2017	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	11 surface water and sediment locations. (General screening phase = Level 1).
ORR Y-12 (NNSA)	2017	RESRAD Biota 1.8, Level 1	<1	n/a	<0.1	n/a	Five surface water locations.

DOE Site	CY	Biota Dose Method	Aquatic Animals (rad/d)	Terrestrial Plants (rad/d)	Riparian Animals (rad/d)	Terrestrial Animals (rad/d)	Comment
ORR	2018	RESRAD Biota 1.8	<1	n/a	n/a	n/a	ORNL water samples for aquatic biota evaluations taken at seven surface waters, some waterways had multiple samples. Most passed general criteria but WOC (X14) sample passed at Level 3. Y-12 samples (5 surface waters and sediment) passed general criteria. ETTP (5 surface waters) passed general criteria.
ORR	2018	RESRAD Biota 1.8	n/a	n/a	n/a	<0.1	No updated evaluation from 2014 sampling.
PNNL MSL	2015	spreadsheet	2.70E-06	2.70E-06	2.40E-05	2.40E-05	Gross alpha and gross beta air emissions only.
PNNL MSL	2016	spreadsheet	7.20E-05	7.20E-05	6.60E-04	6.60E-04	Gross alpha and gross beta air emissions only.
PNNL MSL	2017	spreadsheet	6.70E-05	6.70E-05	5.90E-04	5.90E-04	Based on air emissions.
PNNL MSL	2018	spreadsheet	6.70E-05	6.70E-05	5.90E-04	5.90E-04	Based on air emissions.
PNNL Richland	2015	spreadsheet	0.0011	0.0011	0.01	0.01	19 nuclides plus gross alpha and gross beta.
PNNL Richland	2016	spreadsheet	1.10E-03	1.10E-03	9.60E-03	9.60E-03	21 nuclides based on air emissions.
PNNL Richland	2017	spreadsheet	8.60E-04	8.60E-04	7.60E-03	7.60E-03	Based on air emissions.
PNNL Richland	2018	spreadsheet	8.90E-03	8.90E-03	7.80E-02	7.80E-02	Based on air emissions.
PPPL	2015	hand calculation	<1	<1	<0.1	<0.1	PPPL reviewed H-3 concentrations in sump and surface water and compared them to water biota BCGs for aquatic and terrestrial systems. It was a small fraction of BCGs. No soil or sediment was evaluated. Assigned “less than” dose to all categories because H-3 does not bioconcentrate much (if at all).
PPPL	2016	hand calculation	<1	<1	<0.1	<0.1	See 2015 comment.
PPPL	2017	hand calculation	<1	<1	<0.1	<0.1	See 2015 comment.
PPPL	2018	hand calculation	<1	<1	<0.1	<0.1	Used highest H-3 in sump (groundwater) concentrations and surface water. See 2015 comment.
SLAC	2015	hand calculation, data review	<1	<1	n/a	<0.1	SLAC evaluates two sources of biota dose: external dose (onsite TLDs) and dose from activation products above natural background in onsite water. H-3 in wastewater and groundwater for activation products.
SLAC	2016	hand calculation, data review	<1	<1	<0.1	<0.1	SLAC evaluates two biota dose measures: external dose from TLDs and activation products (H-3 in wastewater and groundwater).
SLAC	2017	hand calculation, data review	<1	<1	<0.1	<0.1	See 2016 comment.
SLAC	2018	data review	<1	<1	<0.1	<0.1	SLAC evaluates two biota dose measures: external dose from TLDs and activation products (H3 in wastewater and groundwater). Tritium concentrations were indicated to be below detection or below drinking water standard, then it was stated that there is no potential for plants or animals to exceed the biota dose limits.

To convert to mGy/d, multiply rad/d by 10.
n/a = not available.

3.4 References

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4.0 Releases of Radioactive Material to Air and Water

Each DOE site with radiological activities monitors releases of radioactive material to air and water, as appropriate, relative to site-specific circumstances, and as necessary to demonstrate compliance with applicable Federal, State, and local regulations, including DOE's ALARA policy.

Releases of radioactive material from DOE sites are reported in terms of the number of curies of each radionuclide discharged, or as a concentration (i.e., curies per unit air or water). A total quantity for the year may be reported for an operating facility, where, for example, the total volume of air flowing through an exhaust stack is known and can be combined with monitoring results to estimate total releases. Concentration data most often are reported for diffuse sources, such as contaminants in soil that are dispersed by local wind conditions, where an estimate of air flow or total releases would be more uncertain than an estimate for point sources.

Each site calculates an estimated dose to the MEI and population from these releases and other data (e.g., direct radiation monitoring at accelerator facilities). For CYs 2015–2018, these dose estimates fell well below applicable limits (see Section 2.0 of this report).

Release information in this section is indicated as nuclide activity (Ci) released in air or liquid effluent. When comparing release information to dose estimates, it is important to consider radionuclide behavior in the environment (liquid or air ambient dispersion characteristics), radioactive characteristics of the nuclide (emission type and half-life), assumed exposure or intake rate (e.g., modeled inhalation rate assumptions), and biokinetic behavior of the nuclide in the receptor. A site might release several radionuclides, each having distinct properties. High-activity emissions may result in small contributions to total site dose for some nuclides (e.g., Kr-85), whereas low-activity emissions may result in significant contributions to total site dose for others (e.g., Pu-239).

4.1 Nonroutine Releases

Nonroutine releases (otherwise referred to as unplanned releases) are not a routine occurrence at DOE sites. Such releases are, generally stated, significant releases of radioactive materials to ambient air or to ambient water sources during the calendar year as a result of DOE operations. No sites reported such nonroutine releases to the air in the CY 2015–2017 ASERs.[1] One LLNL release of about 5 Ci H-3 to ambient air is reported in the CY 2018 ASER. As an air emission, it is covered in Subpart H reporting (see Appendix D, Section D.1.6). Both Los Alamos National Laboratory (LANL) and SRS had unplanned radioactive material emissions to air reported in Subpart H reporting in CY 2018, as well, but these are not covered in detail in site ASERs; see Appendix D also for details about these emissions. The LANL releases (Ar-41 and C-11) occurred because of a ventilation fan failure. The SRS releases (Cs-137) occurred during routine maintenance activities. Neither the LLNL, nor the LANL and SRS nonroutine releases, resulted in impacts on offsite receptors that exceeded applicable dose standards. No sites reported unplanned releases of radioactive liquid effluent from site facilities in CYs 2015–2018.

While not considered nonroutine releases during CY 2015–2018, some legacy contamination may be found in onsite vegetation and animals; for example, HANF staff have discovered legacy contamination in tumbleweeds, rodents, and birds (Hanford Site 2016). Tumbleweeds have deep tap roots that may encounter subsurface legacy radioactive contamination. Rodents can eat the vegetation and deposit contaminated feces. Birds occasionally build nests using contaminated vegetation. Procedures are in place for handling such expected events at legacy contamination sites.

[1] Appendix D includes descriptions of unplanned releases to air, as reported in site 40 CFR 61, Subpart H, compliance reporting. This additionally includes a brief summary of the most significant, recent unplanned release that occurred at WIPP in 2014.

Wildland fires also occur at DOE sites, more commonly in the arid western sites. Procedures are in place for handling such events. NNSS had an unusually large fire in 2017 (15,000 ac) and several fires were reported in CY 2018, but no radiologically contaminated areas were impacted.

4.2 Routine Releases via Air and Liquid Effluent

The total reported activity of routine releases to air and to liquid effluent are summarized for the years 2015–2018. The routine emissions are those that may be dispersed through environmental pathways to the offsite environment. For routine releases via air effluent, releases via point and non-point (diffuse or fugitive) sources are indicated when provided in ASERs. When activity details were not indicated in ASERs, the Subpart H reports information was reviewed to acquire details about air effluents. For routine releases via liquid effluent, liquid effluent activity is summed for those sampled liquid effluents that may result in immediate or subsequent mixing with ambient liquids. Such liquid effluent releases include those to sanitary sewers or other permitted release points (e.g., evaporative ponds, onsite treatment plant discharges).

When comparing release (specifically, activity) information to dose estimates, it is important to consider radionuclide-specific dose factors and other aspects of dose calculation. DOE sites might release several radionuclides, each having distinct properties (e.g., half-life, mode of decay, chemical characteristics, radiological toxicity, and physical form). In addition, ambient air dispersion mechanisms (how the material is released to and moves through the environment) and exposure pathways vary. Each of these properties influences the dose attributable to a particular release, and to all releases, over the course of a year.

For example, among the highest reported releases to both air and water were those from SRS. During 2015–2018, a total of 120,000 Ci, mostly tritium (98,000 Ci), was released. Each year, this resulted in an estimated dose of about 0.20 mrem to the maximum public receptor and 4 to 6 person-rem to the population. Similarly, some DOE sites release significant Kr-85 activity to the atmosphere in a year. This might account for a significant percentage of the total curies of radioactive material discharged to the environment yet contribute a very small percentage to the estimated dose. This small contribution to dose occurs because Kr-85 does not concentrate in the body and emits mostly beta particles.

Table 4-1 summarizes the activity released for six very general types of radionuclide emissions and indicates the grand total of activity emitted via air effluent and liquid effluent from 2015–2018. Noble gas and short-lived carbon (C), nitrogen (N), and oxygen (O) emissions result from accelerator operations and can be highly variable from year to year; these are only emitted via air pathways. Noble gases do not remain incorporated in liquid effluents. Transuranic emissions constitute a very small fraction of total activity emissions. Further details about air and liquid effluent emissions are provided in the remainder of this section.

Table 4-1. Total Activity Released via Air and Liquid Effluents for General Radionuclide Types (2015–2018)

General Types of Radionuclides	Emitted via Air Effluent (Ci)				Emitted via Liquid Effluent (Ci)			
	2015	2016	2017	2018	2015	2016	2017	2018
Tritium	21,000	24,000	18,000	42,000	2,170	1,640	1,900	2,190
Short-lived C, N, O, and F[(a)]	33,000	52,000	28,000	33,000	0	0	0	0
Noble gases[(b)]	8,800	8,200	13,000	18,000	0	0	0	0
Transuranics	0.41	0.40	0.40	0.41	0.0010	0.0023	0.0060	0.0003
Other radionuclides[(c)]	290	270	1,600	11,000	16	8.2	4.6	23
Rn-220 and Rn-222	1,700	1,500	2,300	2,300	0	0	0	0
Grand Total	**65,000**	**86,000**	**63,000**	**106,000**	**2,200**	**1,600**	**1,900**	**2,200**

(a) Short-lived activation products (primarily C-11, N-13, N-16, O-15) with Ar-41 included in noble gas activity.
(b) Excludes Rn-220 and Rn-222 emissions.
(c) Radionuclides not included in other general types.

4.2.1 Radioactive Materials in Air Effluent

In 40 CFR Part 61, Subpart H, EPA provides regulations for the emission of radioactive materials to the air. Airborne emissions that have the potential to contain higher levels of radioactive materials are sampled and analyzed for gross alpha, gross beta, and specific radionuclides. Compliance reporting is used as a basis for ASER reporting of activity emissions.

ASER guidance provides for rolling activity emissions into a few radionuclide categories. For this report, the number of categories was expanded to present the information in greater detail. Most sites have a limited number of radionuclides emitted to air. Sites with more extensive research operations have long lists of isotopes emitted to air that include small emissions of most radionuclides, and a limited number of radionuclides emitted at multi-curie levels. The reported site radionuclide emissions in air effluent, by activity, are summarized in Table 4-2. About 63,000–110,000 Ci/yr of activity was released to ambient air from all DOE sites during 2015–2018.

To summarize emissions and provide some indication of the variety of radionuclides emitted via air effluents at DOE sites, radionuclide categories were developed for this report (Table 4-3). The categories were used to develop a high-level summary of emissions among all sites and provide an indication of the types of radiological operations occurring at each site.

Table 4-4 through Table 4-7 summarize radioactive material air emissions from DOE sites derived from the review of ASERs and supplemented by reviews of Subpart H reports (see Appendix D), as needed. The range of radionuclides emitted to air at some sites was extensive, so a variety of categories were developed to help characterize emissions in a summary form. These tables summarize total air emission activity in each category across all sites. Also, the count of radionuclides that result in the greatest activity emitted from each site is summarized. Sites with larger counts have more varied radiological research operations. For these varied-operations sites, TRU radionuclides were not summarized if emissions were less than 9.9E-11 Ci/yr, and all other radionuclides were not listed if emissions were less than 3.7E-10 Ci/yr. Using these somewhat arbitrary cutoff limits, which were established for the sake of data compilation efficiency, the numbers of radionuclides emitted ("nuclide count") are listed in Table 4-4 through Table 4-7.

Table 4-2. Total Activity Released to Ambient Air by DOE Site (2015–2018)

Program Office/Site	2015 (Ci)	2016 (Ci)	2017 (Ci)	2018 (Ci)
EM				
Hanford	**8.1E+02**	**4.4E+02**	**4.7E+03**	**1.8E+03**
KNOL SPRU	9.0E-06	9.6E-04	1.6E-03	5.6E-04
PGDP	1.8E-04	3.2E-04	1.3E-03	2.1E-04
PORTS/DOEonly	3.6E-02	7.1E-03	6.7E-02	7.9E-02
SRS	**2.2E+04**	**2.6E+04**	**2.1E+04**	**5.0E+04**
WIPP	1.2E-05	1.3E-05	1.3E-05	1.1E-05
WVDP	**1.1E+03**	**1.1E+03**	**1.1E+03**	**1.1E+03**
NE				
INL	**1.9E+03**	**1.8E+03**	**1.3E+03**	**1.3E+03**
NNSA				
LANL	**1.3E+02**	**2.2E+02**	**4.0E+02**	**4.0E+02**
LLNL	**4.5E+01**	**7.6E+01**	**4.7E+01**	**1.9E+02**
LLNL300	8.5E-07	1.0E-06	2.7E-06	1.0E-06
NNSS	**9.5E+03**	**5.9E+02**	**3.0E+03**	**1.3E+04**
PANTEX	1.9E-02	9.6E-01	4.7E-04	5.6E-04
SNL/NM	**6.0E+01**	**3.3E+01**	**4.5E+01**	**5.2E+01**
NNSA-NNPP				
BETTIS	**2.1E+02**	**1.9E+02**	**2.7E+02**	**2.9E+02**
INL_NRF	**1.1E+00**	7.9E-01	5.5E-01	**1.0E+00**
KESS	5.3E-01	2.6E-01	8.9E-01	**1.4E+00**
KNOL	5.1E-01	1.8E-01	4.6E-01	3.2E-01
SC				
ANL	**3.1E+02**	**8.8E+01**	**1.3E+02**	**7.6E+01**
BNL	**4.6E+03**	**1.0E+04**	**1.1E+04**	**2.3E+04**
FERMI	**1.1E+02**	**1.9E+02**	**2.1E+02**	**2.7E+02**
JLAB	**1.9E+00**	**1.4E+00**	4.4E-01	**1.1E+01**
LBNL	**2.8E+00**	**1.3E+00**	**3.3E+00**	**9.3E-01**
ORR	**2.5E+04**	**4.5E+04**	**2.1E+04**	**1.5E+04**
PNNL Richland	2.7E-04	2.3E-04	2.4E-04	1.6E-04
PNNL MSL	4.0E-08	1.0E-06	1.0E-06	1.0E-06
SLAC	**1.0E+00**	**3.2E+00**	3.5E-01	2.7E-01
TOTAL (Ci)	65,000	86,000	63,000	106,000

Values in **bold** are greater than 1 Ci.

Table 4-3. Category Descriptions for Emissions to Air Effluent Tables

Nuclide Category Names[(a)]	Description of Categories	Comment
Gross alpha NOS, Gross beta NOS **Fission Product NOS** **Low Z Particulate NOS, Higher Z Particulate NOS** **Iodine NOS** **Radium NOS** **Thorium NOS** **Uranium NOS**	General categories with radionuclides or elements not specifically identified (includes both low and higher Z but excludes NG and TRU categories).	Iodine, radium, thorium, and uranium capture the nuclides that are generally not of specific interest (see low Z specific nuclides and elements). The other listed categories combine numerous nuclides, primarily those used in research.
Carbon SL FAPs (<3 hr half-life) **Nitrogen SL FAPs (<3 hr half-life)** **Oxygen SL FAPs (<3 hr half-life)** **Fluorine SL FAPs (<3 hr half-life)**	General categories for short-lived nuclides (half-life of less than 3 hr).	If emitted at large enough levels, the short-lived C, N, O, and Fl can be a concern for external dose close to an emission point.
H-3, C-14, Cl-39, Co-60, Ni-63, Sr-90, I-129, I-131	"Low Z" specific radionuclides and elements (b).	Specific nuclides of general interest. H_3 includes both gas (H_2) and vapor (H_2O) emissions. While Cl-39 is generally not of specific interest, one site had a multi-curie Cl-39 emission of this short-lived nuclide in 2015.
Cs-137, Pb-212, U-234, U-235, U-238, TRU Pu-238, TRU Pu-239 **TRU Plutonium NOS** **TRU Neptunium** **TRU Americium** **TRU Curium** **TRU Californium**	"Higher Z" specific radionuclides and elements, including all TRU categories.[(b)]	Specific nuclides of general interest. If emitted at high levels, some larger Z (e.g., uranium and TRU) categories can pose alpha-emission concerns.
NG Ar-41 **NG Kr-85, NG Kr-85m, NG Kr-87, NG Kr-88, NG Kr-89** **NG Rn-219, NG Rn-220, NG Rn-222** **NG Xenon NOS** **NG Radon NOS** **NG NOS**	Noble gas (NG) categories, both specific and general.	Noble gases are not metabolized but can be an external dose concern (e.g., Ar-41) or have progeny that can be a concern (e.g., Rn-222). Here, noble gases include Ne, Ar, Kr, Xe, and Rn.

(a) FAP = fission or activation product; FP = fission product; NOS = not otherwise specified; NG = noble gas; TRU = transuranic; Z = atomic number with low Z (considered hydrogen to iodine) to higher Z (considered cesium to fermium).
(b) See noble gas category for low Z and higher Z noble gas categories.

Points of general interest from Table 4-4 through Table 4-7 include the following:

- the relative activity of emissions to air from each site (bottom row);
- the total activity of emissions in each radionuclide category (second column);
- the sites that work with a particular radionuclide category by Program Office operation; and
- the number of radionuclides reported to be emitted from each site. The highly variable nature of each site's operations results in a spectrum of radionuclide emissions. Note that some site ASERs may report more radionuclide emissions, but the tables herein implement a lower activity cutoff.

Table 4-4. Summary of 2015 Emissions to Air Effluent (total Ci and radionuclide counts)

Nuclide Category (see Table 4-3 for descriptions)	Total 2015 (Ci)	Count of EM Hanford	Count of EM KNOL SPRU	Count of EM PGDP/DOE+USEC	Count of EM PORTS (DOE only)	Count of EM SRS	Count of EM WIPP	Count of EM WVDP	Count of NE INL	Count of NNSA LANL	Count of NNSA LLNL	Count of NNSA LLNL300	Count of NNSA NNSS	Count of NNSA PANTEX	Count of NNSA SNL/NM	Count of NNSA-NNPP BETTIS	Count of NNSA-NNPP INL_NRF	Count of NNSA-NNPP KESS	Count of NNSA-NNPP KNOL	Count of SC ANL	Count of SC BNL	Count of SC FERMI	Count of SC JLAB	Count of SC LBNL	Count of SC ORR	Count of SC PNNL Richland	Count of SC PNNL MSL	Count of SC SLAC
Gross alpha NOS	3.6E-05					1		1								1	1										1	
Gross beta NOS	2.2E-03					1		1									1										1	
Low Z Particulate NOS	2.0E+00	3	1	1	1	14		1	3	10			2			1		6	1	5		3	2	12	46	3		
H3	2.1E+04	2				2		1	1	1	2		1	1	1		1	1	1	2	1	1	1	1	1	1		
C14	1.0E+00	1	1			1		1	1				1				1	1								1		
Cl39	2.9E+01												1							1			1	1				
Co60	1.3E-02					1		1	1				1				1	1	1					1	1	1		
Ni63	1.8E-03		1			1																			1			
Sr90	8.7E-02	1	1			1	1	1	1				1		1	1			1	1				1	1	1		
Carbon SL FAPs (<3hr half-life)	2.4E+04									2			1							1	1	1	1	1	1			1
Nitrogen SL FAPs (<3hr half-life)	3.0E+03									2			2		1					1		1	1	1	1			1
Oxygen SL FAPs (<3hr half-life)	6.8E+03									2			2		1					1	1	1	1	1				1
Fluorine SL FAPs (<3hr half-life)	2.8E+00					1																		1				
Higher Z Particulate NOS	2.6E+02	4		1	1	10			1	2			3			1								12	40	1		
I129	2.4E-02	1				1		1	1								1			1				1	1			
I131	1.0E-01								1								1	1		1				1	1	1		
Iodine NOS	2.5E+00																							1	6			
Cs137	8.1E-02	1	1			1	1	1	1				1		1	1	1		1					1	1	1		
Pb212	1.7E+00					1																			1			
Radium NOS	4.8E-04	1				2																		2	5	1		
Thorium NOS	3.4E-03		3	2	5	5				1														5	7	1		
U234	3.9E-02			1	1	1		1				1							1						1	1		
U235	7.7E-03		1	1	1	1		1				1							1					1	1	1		
U238	1.4E-02		1	1	1	1	1	1				1	1						1					1	1	1		
Uranium NOS	3.3E-04	2	1			3	1	1	2	1				1					1						3			
TRU Neptunium	8.9E-04	1		1	1	1																			2	1		
TRU Pu238	4.2E-02	1	1		1	1	1	1	1				1			1			1					1	1	1		
TRU Pu239	2.9E-01	1	1		1	1	1	1	1				1						1					1	1	1		
TRU Plutonium NOS	4.6E-03	1	1			4			2	1									3					2	3			
TRU Americium	6.9E-02	2	1		1	2	1	1	2	1			1						1	1				1	2	2		
TRU Curium	1.7E-05		1			1			1																3	1		
TRU Californium	2.0E-08																								1	1		
NG Ar41	1.8E+03								1	1			1		1			1				1	1	1	1			1
NG Kr85	4.2E+03	1				1			1				1		1		1	1	1	1					1			
NG Kr85m	1.2E+02								1				1					1							1			
NG Kr87	2.9E+01								1									1							1			
NG Kr88	2.0E+02																	1							1			
NG Kr89	2.5E+01																								1			
NG Rn219	6.2E+00	1																							1			
NG Rn220	1.7E+03	1						1								1				1					1			
NG Rn222	2.5E-04																								1	1		
NG NOS	4.0E-04																	1										
NG Xenon NOS	2.5E+03								3				5					4		1					8	3		
Grand Total (Nuclide Count)	**n/a**	**25**	**16**	**8**	**14**	**60**	**7**	**17**	**27**	**24**	**2**	**3**	**28**	**2**	**7**	**7**	**9**	**20**	**16**	**18**	**3**	**8**	**8**	**51**	**150**	**26**	**2**	**4**
Total 2015 (Ci)	**6.5E+04**	8.1E+02	9.0E-06	1.8E-04	3.6E-02	2.2E+04	1.2E-05	1.1E+03	1.9E+03	1.3E+02	4.5E+01	8.5E-07	9.5E+03	1.9E-02	6.0E+01	2.1E+02	1.1E+00	5.3E-01	5.1E-01	3.1E+02	4.6E+03	1.1E+02	1.9E+00	2.8E+00	2.5E+04	5.2E-04	4.0E-08	1.0E+00

Table 4-5. Summary of 2016 Emissions to Air Effluent (total Ci and radionuclide counts)

Nuclide Category (see Table 4-3 for descriptions)	Total 2016 (Ci)	Count of EM Hanford	Count of EM KNOL SPRU	Count of EM PGDP/DOE+USEC	Count of EM PORTS/DOEonly	Count of EM SRS	Count of EM WIPP	Count of EM WVDP	Count of NE INL	Count of NNSA LANL	Count of NNSA LLNL	Count of NNSA LLNL300	Count of NNSA NNSS	Count of NNSA PANTEX	Count of NNSA SNL/NM	Count of NNSA-NNPP BETTIS	Count of NNSA-NNPP INL_NRF	Count of NNSA-NNPP KESS	Count of NNSA-NNPP KNOL	Count of SC ANL	Count of SC BNL	Count of SC FERMI	Count of SC JLAB	Count of SC LBNL	Count of SC ORR	Count of SC PNNL Richland	Count of SC PNNL MSL	Count of SC SLAC
Gross alpha NOS	9.6E-05	1				1		1									1							1			1	
Gross beta NOS	3.3E-03	1				1		1									1							1			1	
Low Z Particulate NOS	3.7E-02	3	1	1	1	23			3	10			6			1		2	2	4		3	2	13	63	1		
H3	2.4E+04	2				2		1	1	1	2		1	1	1		1	1	1	2	1	1	1	1	1	1		
C14	1.1E+00	1	1			1			1				1				1	1						1	1			
Cl39	5.5E-02																			1			1	1				
Co60	1.0E-02					1			1				1				1	1	1					1	1	1		
Ni63	6.6E-03		1			1																			1			
Sr90	8.7E-02	1	1			1	1	1	1				1		1	1			1	1				1	1	1		
Carbon SL FAPs (<3hr half-life)	4.4E+04									2										1	1	1	1	1	1			1
Nitrogen SL FAPs (<3hr half-life)	9.8E+02									2			1		1					2		1	1	1	1			1
Oxygen SL FAPs (<3hr half-life)	7.0E+03									2			1		1					1	1	1	1	1				1
Fluorine SL FAPs (<3hr half-life)	1.4E+00					1																		1				
Higher Z Particulate NOS	2.7E+02	4		1	1	15			1	3			4			1								12	44	1		
I129	2.3E-02	1				1		1	1								1			1					1			
I131	4.4E-02					1			1	1			1				1	1		1				1	1			
Iodine NOS	2.1E+00								1				2											1	7			
Cs137	8.5E-02	1	1			1	1	1	1				1		1	1	1	1	1					1	1	1		
Pb212	2.0E+00					1																			1			
Radium NOS	3.1E-05	1				2																		2	4	1		
Thorium NOS	7.6E-04		3	3	5	5				1														4	5			
U234	2.9E-02			1	1	1		1	1			1							1					1	1	1		
U235	1.4E-03		1	1	1	1		1				1							1					1	1	1		
U238	2.6E-02		1	1	1	1	1	1	1			1	1						1					1	1	1		
Uranium NOS	3.1E-04	2	1			3	1	1	1	1				1					1					3	3			
TRU NOS																												
TRU Neptunium	6.8E-05	1			1	1			1																2	1		
TRU Pu238	4.1E-02	1	1		1	1	1	1	1				1			1			1					1	1	1		
TRU Pu239	2.9E-01	1	1		1	1	1	1	1				1						1					1	1	1		
TRU Plutonium NOS	3.3E-03	1	1			4			3	1									3					2	4	1		
TRU Americium	7.0E-02	2	1		1	2	1	1	2	1			1						1					1	2	2		
TRU Curium	4.4E-05		1			1			2																4	1		
TRU Berkelium	7.0E-11																								1			
TRU Californium	2.7E-06								1																4	3		
NG Ar41	1.3E+03								1	1			1		1			1				1	1	1	1			1
NG Kr85	5.2E+03	1				1			1				1		1		1	1	1	1				1	1			
NG Kr85m	9.0E+01												1					1							1			
NG Kr87	3.9E+01								1									1							1			
NG Kr88	8.8E+01								1									1							1			
NG Kr89	2.9E+01																								1			
NG Rn219	0.0E+00																											
NG Rn220	1.5E+03	1						1								1				1					1			
NG Rn222	0.0E+00																											
NG NOS	1.0E-05																	1							1	1		
NG Xenon NOS	1.4E+03								2				5					4		1					8	4		
Grand Total (Nuclide count)	**n/a**	**26**	**16**	**8**	**14**	**75**	**7**	**14**	**32**	**26**	**2**	**3**	**32**	**2**	**7**	**6**	**9**	**17**	**17**	**17**	**3**	**8**	**8**	**58**	**175**	**25**	**2**	**4**
Total 2016 (Ci)	**8.6E+04**	4.4E+02	9.6E-04	3.2E-04	7.1E-03	2.6E+04	1.3E-05	1.1E+03	1.8E+03	2.2E+02	7.6E+01	1.0E-06	5.9E+02	9.6E-01	3.3E+01	1.9E+02	7.9E-01	2.6E-01	1.8E-01	8.8E+01	1.0E+04	1.9E+02	1.4E+00	1.3E+00	4.5E+04	2.3E-04	1.0E-06	3.2E+00

Table 4-6. Summary of 2017 Emissions to Air Effluent (total Ci and radionuclide counts)

Nuclide Category (see Table 4-3 for descriptions)	Total 2017 (Ci)	Count of EM Hanford	Count of EM KNOL SPRU	Count of EM PGDP/ DOE+USEC	Count of EM PORTS/ DOEonly	Count of EM SRS	Count of EM WIPP	Count of EM WVDP	Count of NE INL	Count of NNSA LANL	Count of NNSA LLNL	Count of NNSA LLNL300	Count of NNSA NNSS	Count of NNSA PANTEX	Count of NNSA SNL/NM	Count of NNSA-NNPP BETTIS	Count of NNSA-NNPP INL_NRF	Count of NNSA-NNPP KESS	Count of NNSA-NNPP KNOL	Count of SC ANL	Count of SC BNL	Count of SC FERMI	Count of SC JLAB	Count of SC LBNL	Count of SC ORR	Count of SC PNNL Richland	Count of SC PNNL MSL	Count of SC SLAC
Gross alpha NOS	5.8E-04	1				1											1							1		1		
Gross beta NOS	1.3E-03	1				1											1							1		1		
Low Z Particulate NOS	1.3E+03	3	5	1	1	22			6	10			5			1		2	1	9	9	4	2	18	75	6	1	
H3	1.8E+04	2				2			1	2	2		1	1	1		1	1	1	2	1	1	1	1	1	1	1	
C14	1.2E+00	1	1			1			1								1	1			1			1	1			
Cl39	4.3E-02																			1			1	1				
Co60	9.9E-03	1	1			1			1				1				1	1	1	1	1			1	1	1		
Ni63	6.6E-03		1			1														1				1	1			
Sr90	7.7E-02	1	1			1	1		1	1			1		1	1			1	1				1	1	1		
Carbon SL FAPs (<3hr half-life)	2.0E+04									2										1	1	1	1	1	1			1
Nitrogen SL FAPs (<3hr half-life)	4.8E+02									2			1		1					2		1	1	1	1			1
Oxygen SL FAPs (<3hr half-life)	7.2E+03									2			1		1					1	1	1	1	1				1
Fluorine SL FAPs (<3hr half-life)	3.4E+00					1																		1				
Higher Z Particulate NOS	2.4E+02	4	1	1	1	13			2	3			7			2		1		12	1			14	56	7	1	
I129	5.8E-03	1				1			1								1			1					1			
I131	1.4E+00					1			1				1				1	1		1	1			1	1	1		
Iodine NOS	7.1E+01								1				2								1			1	6		1	
Cs137	8.7E-02	1	1			1	1		1				1		1	1	1	1	1	1	1			1	1	1		
Pb212	3.9E+00					1																			1			
Radium NOS	2.7E-05	1	1			2																		2	5	1		
Thorium NOS	8.4E-04		4	2	4	5				3										3	2			2	6			
U234	2.7E-02		1	1	1	1	1		1	1		1		1					1						1	1	1	
U235	9.8E-04		1	1		1				1		1		1					1					1	1		1	
U238	1.1E-02		1	1	1	1	1		1	1		1	1	1					1	1				1	1		1	
Uranium NOS	2.5E-04	2	2			3			1										1	1				2	4			
TRU NOS																												
TRU Neptunium	1.5E-05	1	1		1	1			1											1					3			
TRU Pu238	4.0E-02	1	1		1	1	1		1	1			1			1			1	1				1	1	1		
TRU Pu239	2.9E-01	1	1		1	1	1		1	1			1						1	1				1	1	1		
TRU Plutonium NOS	4.3E-04	1	2			4			2										3	3				1	5			
TRU Americium	6.9E-02	2	1		1	2	1		2	1			1						1	3	1			1	4	2		
TRU Curium	3.7E-05		3			2			1											3				2	7	1		
TRU Berkelium	6.2E-10																								1			
TRU Californium	4.9E-08																			1					1			
TRU Einsteinium	9.4E-10																							1				
NG Ar41	1.6E+03								1	1			1		1			1				1	1	1	1			1
NG Kr85	6.8E+03	1				1			1						1		1	1	1						1			
NG Kr85m	2.3E+01								1				1					1							1			
NG Kr87	8.5E+01								1									1							1			
NG Kr88	7.5E+01								1									1							1			
NG Kr89	3.3E+01																								1			
NG Rn219	3.6E+03	1																										
NG Rn220	2.3E+03	1						1								1				1					1			
NG Rn222	8.8E-01	1							1							1									1	1		
NG NOS	3.8E-04																	1							2			
NG Xenon NOS	9.8E+02								2				5					4		1					8	4		
Grand Total (Nuclide count)	**n/a**	**29**	**30**	**7**	**12**	**73**	**7**	**1**	**35**	**32**	**2**	**3**	**32**	**4**	**7**	**8**	**9**	**18**	**16**	**54**	**21**	**9**	**8**	**63**	**207**	**32**	**7**	**4**
Total 2017 Ci	**6.3E+04**	4.7E+03	1.6E-03	1.3E-03	6.7E-02	2.1E+04	1.3E-05	1.1E+03	1.3E+03	4.0E+02	4.7E+01	2.7E-06	3.0E+03	4.7E-04	4.5E+01	2.7E+02	5.5E-01	8.9E-01	4.6E-01	1.3E+02	1.1E+04	2.1E+02	4.4E-01	3.3E+00	2.1E+04	2.4E-04	1.0E-06	3.5E-01

Table 4-7. Summary of 2018 Emissions to Air Effluent (total Ci and radionuclide counts)

Nuclide Category (see Table 4-3 for descriptions)	Total 2018 (Ci)	Count of EM Hanford	Count of EM KNOL SPRU	Count of EM PGDP/ DOE+USEC	Count of EM PORTS/ DOEonly	Count of EM SRS	Count of EM WIPP	Count of EM WVDP	Count of NE INL	Count of NNSA LANL	Count of NNSA LLNL	Count of NNSA LLNL300	Count of NNSA NNSS	Count of NNSA PANTEX	Count of NNSA SNL/NM	Count of NNSA-NNPP BETTIS	Count of NNSA-NNPP INL_NRF	Count of NNSA-NNPP KESS	Count of NNSA-NNPP KNOL	Count of SC ANL	Count of SC BNL	Count of SC FERMI	Count of SC JLAB	Count of SC LBNL	Count of SC ORR	Count of SC PNNL Richland	Count of SC PNNL MSL	Count of SC SLAC
Gross alpha NOS	1.8E-04	1				1										1	1							1		1		
Gross beta NOS	2.0E-03	1				1										1	1							1		1		
Low Z Particulate NOS	9.3E+03	2	5	1	1	19		1	2	10			3					7	1	4	5	5	2	12	76	5	2	
H3	4.2E+04	2				2		1	1	2	1		1	1	2		1	1	1	1	1	1	1	1	1	1		
C14	2.5E+00	1	1			1		1	1								1	1		1	1			1	1			
Cl39	4.5E-02																			1			1	1				
Co60	3.9E-04	1	1			1		1	1				1				1	1	1					1	1	1		
Ni63	1.7E-03		1			1												1							1			
Sr90	1.1E-01	1	1			1	1	1	1				1		1	1			1					1	1			
Carbon SL FAPs (<3hr half-life)	1.7E+04									2										1	1	1	1	1	1			1
Nitrogen SL FAPs (<3hr half-life)	3.3E+02									2			1		1					2		1	1	1	1			1
Oxygen SL FAPs (<3hr half-life)	1.5E+04									2			1		1					2	1	1	1	1				1
Fluorine SL FAPs (<3hr half-life)	9.4E-01					1																		1				
Higher Z Particulate NOS	8.7E+02	5		1	1	13			6	2			7			1		1			2			9	56	4	2	
I129	6.6E-03	1				1		1	1								1	1		1				1	1			
I131	6.4E+00					1			1				1				1	1		1					1	1		
Iodine NOS	4.7E+02								1				2											1	7		1	
Cs137	1.4E-01	1	1			1	1	1	1				1		1	1	1	1	1					1	1	1	1	
Pb212	5.5E+00					1																			1			
Radium NOS	3.1E-05	1	1			2			1															2	5	1		
Thorium NOS	8.2E-04		4	3	5	5								1										2	5		1	
U234	1.7E-02		1	1	1	1	1	1		1		1		1					1						1	1	1	
U235	5.8E-04		1	1	1	1		1		1		1		1					1					1	1	1	1	
U238	7.3E-04		1	1	1	1	1	1	1	1		1		1					1					1	1		1	
Uranium NOS	1.2E-01	3	1			3		1	2										1					1	4			
TRU Neptunium	2.2E-05	1		1	1	1			1																3			
TRU Pu238	4.5E-02	1	1		1	1	1	1	1	1			1			1			1					1	1	1		
TRU Pu239	2.9E-01	1	1	1	1	1	1	1	1	1			1						1	1				1	1	1		
TRU Plutonium NOS	2.5E-04	1	2			4			1										2					1	4	2		
TRU Americium	7.2E-02	2	1		1	2	1	1	2	1			1						1	2	1			2	3	2		
TRU Curium	5.2E-06		3			2														1				1	7	1		
TRU Californium	7.6E-06																			1	1				1			
TRU Einsteinium	1.4E-07																							1				
NG Ar41	2.2E+03								1	1			1		1			1		1		1	1	1	1			1
NG Kr85	1.2E+04	1				1							1		1		1	1	1	1				1	1			
NG Kr85m	1.3E+01																	1							1			
NG Kr87	1.1E+01																	1							1			
NG Kr88	8.0E+01								1									1		1					1			
NG Kr89	3.9E+01																								1			
NG Rn219	5.6E+02	1																										
NG Rn220	2.3E+03	1						1								1									1			
NG Rn222	1.0E-01															1									1	1		
NG NOS	6.6E-01												1					1							3			
NG Xenon NOS	2.7E+03								2				5					4		3					8	2		
Grand Total (Nuclide count)	**n/a**	**29**	**27**	**10**	**14**	**70**	**7**	**15**	**30**	**27**	**1**	**3**	**30**	**5**	**8**	**8**	**9**	**25**	**15**	**25**	**13**	**10**	**8**	**51**	**206**	**28**	**10**	**4**
Total 2018 Ci	**1.1E+05**	**1.8E+03**	**5.6E-04**	**2.1E-04**	**7.9E-02**	**5.0E+04**	**1.1E-05**	**1.1E+03**	**1.3E+03**	**4.0E+02**	**1.9E+02**	**1.0E-06**	**1.3E+04**	**5.6E-04**	**5.2E+01**	**2.9E+02**	**1.0E+00**	**1.4E+00**	**3.2E-01**	**7.6E+01**	**2.3E+04**	**2.7E+02**	**1.1E+01**	**9.3E-01**	**1.5E+04**	**1.6E-04**	**1.0E-06**	**2.7E-01**

Nuclide Categories not listed are n/a (0 Ci released).

4.2.2 Radioactive Materials in Liquid Effluent

With appropriate permitting and controls, DOE sites may release radioactive materials to the immediate or subsequent ambient environment via liquid effluents. Sites report these radionuclide emissions, by activity, in ASERs. Table 4-8 indicates the total activity emitted via liquid effluent, as reported in ASERs for CYs 2015–2018. Sites that do not report total activity or radioactive liquid effluent in their ASERs for CY 2015–2018 emissions reporting are indicated in Table 4-9, with comments. A total of about 2000 Ci/yr of activity was released via liquid effluents from all DOE sites during CY 2015-2018.

Table 4-8. Total Activity Released via Liquid Effluents by DOE Site (2015–2018)

	Releases via Liquid Effluent (Ci)			
Site	**2015**	**2016**	**2017**	**2018**
EM				
Hanford	**1.3E+03**	**8.4E+02**	**1.2E+03**	**1.5E+03**
KNOL_SPRU	0	1.1E-05	1.9E-05	0
PORTS/ DOEonly	n/a	5.5E-02	3.0E-02	6.1E-02
SRS	**7.4E+02**	**6.7E+02**	**4.9E+02**	**5.3E+02**
WVDP	3.0E-02	2.2E-02	3.7E-02	1.8E-01
NNSA				
LLNL	6.6E-02	2.5E-02	1.3E-01	1.6E-01
NNSA-NNPP				
KESS	1.9E-03	9.8E-04	1.1E-03	9.4E-04
KNOL	8.4E-04	1.1E-03	1.0E-03	6.9E-04
SC				
ANL	5.5E-02	7.2E-02	1.4E-01	5.3E-02
BNL	1.4E-02	1.5E-02	1.2E-02	2.1E-03
FERMI	2.4E-01	5.4E-01	5.4E-01	5.7E-01
JLAB	5.8E-03	8.7E-04	2.7E-02	8.3E-02
LBNL	3.1E-02	6.9E-03	5.6E-02	6.3E-02
ORR	**1.3E+02**	**1.4E+02**	**2.0E+02**	**2.0E+02**
PNNL Richland	1.7E-05	0	0	0
SLAC	1.4E-05	6.2E-05	1.1E-04	4.0E-05
TOTAL (Ci)	2.2E+03	1.6E+03	1.9E+03	2.2E+03

Site values in **bold** are greater than 1 Ci.
Listed releases may reach ambient offsite environments and release estimates are reported in SERs.

Table 4-9. Sites Not Reporting Total Activity of Radioactive Liquid Effluents (2015–2018)

Program Office-Site	Comment
EM	
PGDP	Groundwater (GW) plume treatment system and sedimentation basin. No total discharge available for radionuclides.
PORTS (CY2015)	No analytes found above detection limits.
WIPP	No liquid effluent.
NE	
INL	Activity (Ci) emissions not reported; only concentrations reported in liquid effluent. Wastewater applied to land and sent to evaporation ponds. Advanced Test Reactor (ATR) Complex Cold Waste Pond; Central Facilities Area (CFA) Sewage treatment plant; Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds; Materials and Fuels Complex Industrial Waste Ditch and Pond. No CFA releases to the ambient environment in 2017.
NNSA	
LANL	National Pollutant Discharge Elimination System (NPDES) outfalls permitted. Most from cooling water and one from treated sanitary waste discharge; 1.05E+08 gal discharged in total. Discharges to canyons. Total Ci estimate not indicated.
LLNL300	No radionuclides reported as liquid effluent. Liquids discharged to sewage evaporation pond, percolation pits, and septic systems. Site has 32 registered injection wells.
NNSS	No discharges to surface waters. Discharge points include E tunnel wastewater disposal system, sewage lagoons, and septic tanks. No total effluent reported.
PANTEX	Current Pantex Plant policy does not allow the discharge of radioactive material in liquid effluent discharges to groundwater (or to sanitary sewers).
SNL/NM	No totals provided. Surface discharges are releases of water and water-based compounds made to roads, open areas, or impoundments. Surface discharge requests are made when access to a sanitary sewer line is not available, such as in remote locations on KAFB where no sewer lines exist. Typical surface discharges are requested as a result of fire-training activities, dust control, and the cleaning of building exteriors. There are two discharge, evaporation lagoons.
NNSA-NNPP	
BETTIS	None indicated. Radioactive liquid effluent is retained until no radioactivity is detectable, then effluent is sent to municipal treatment plant. Higher levels of contaminated liquid are solidified and sent for radwaste disposal. Less than 7 Ci of radioactivity has been released in water effluents since start of BETTIS operations.
INL NRF	NRF has its own sewage lagoon on the northern perimeter. Radwaste treatment facilities do not release rads to the ambient environment. Sewage Treatment Lagoons are lined.
SC	
PNNL MSL	Effluents discharge after being verified as compliant, directly to Sequim Bay (ocean). No total activity reported.
PNNL Richland (CY2016–2018)	Liquids discharge to the municipal sanitary sewer. Fume hood washdown, only, is potentially radiologically impacted liquid effluent. Washdowns are not performed every year.

Table 4-10 through Table 4-13 list the nuclides and activities reported to be released via liquid effluent from routine DOE site operations during CYs 2015–2018. Compared to air effluents, the range of radionuclides emitted via liquid effluents are more limited, so specific radionuclides are reported in these tables, along with a small number of generic categories. Sites that have more than a curie of a nuclide, or total for all radionuclides in their liquid effluents for the calendar year, are highlighted. Tritium was the most commonly released radionuclide and the highest total radioactivity released. Tritium is virtually impossible to remove from aqueous effluent, so it is not uncommon for this element to remain in liquids after effluent treatment.

The final discharge location where liquid effluent is released is indicated in the tables (with the following associated abbreviations):

- SW = surface water (pond, river, evaporation lagoon, etc.)
- Offsite trtmt = an offsite treatment facility determines disposal or release
- SanSwr = a sanitary treatment plant releases effluent after sanitary water treatment
- StormW = stormwater flow to land or surface water
- GW = groundwater

ORR estimates include radioactivity measured in stormwater. KNOL SPRU liquid effluent is collected and sent offsite for treatment; because some permissible amounts of effluent may be discharged under the treatment facility's discharge permit, KNOL SPRU effluents are included in the tables.

HANF liquid effluent releases (Ci) are greater than all other sites' liquid effluent releases during each year evaluated. The largest HANF release type is tritium from groundwater seepage into the Columbia River, calculated as the difference between upstream and downstream average tritium concentrations. SRS (2016, 2017), HANF (2015–2018), and ORR (2017) emitted the most tritium via liquid effluents.

Transuranic elements are released in liquid effluents at only a few sites; most activity in this category is Pu-238 (2015) or Am-241 (2016, 2017, 2018). No single radionuclide accounted for more than 20 percent of the total activity of other radionuclides in 2015 or 2017.

Other radionuclides, excluding tritium and transuranics, had predominant nuclide-specific liquid effluent activity from U-234 (2016), Tc-99 (2018), and U-238 (2018), but the activity released accounted for much less than half of the total activity in this category during the year.

Table 4-10 through Table 4-13 summarize the nuclides and activities released via liquid effluent from routine DOE site operations during CYs 2015–2018.

Table 4-10. Radionuclide Activity Released via Liquid Effluent in 2015 (Ci)

Release Water	SW	All Liquid Effl.	SW	SanSwr	SW	SanSwr	SW	GW	SanSwr	SW	SanSwr	SW, StormW	SanSwr	SanSwr	
Program Office	EM	EM	EM	NNSA	NNSA-NNPP	NNSA-NNPP	SC	SC	SC	SC	SC	SC	SC	SC	
Radionuclide	**Hanford**	**SRS**	**WVDP**	**LLNL**	**KESS**	**KNOL**	**ANL**	**BNL**	**FERMI**	**JLAB**	**LBNL**	**ORR**	**PNNL Richland**	**SLAC**	**Total**
	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	Ci_2015	(Ci)
H-3	1300	737	1.6E-02	6.0E-02	1.9E-03		5.4E-02	1.2E-02	2.4E-01	5.3E-03	1.4E-02	130		1.4E-05	2167
C-14		4.6E-03									1.2E-02				1.6E-02
Co-60			3.7E-05												3.7E-05
Ni-63															0.0E+00
Sr-90	1.7	2.4E-02	3.2E-03			2.4E-04	2.0E-04					7.5E-01			2.5
Y-90						2.4E-04									2.4E-04
Tc-99		1.3E-02	2.6E-04									8.3E-01			8.4E-01
I-129		1.4E-02	4.6E-05												1.4E-02
Cs-134	0.19														1.9E-01
Cs-137		1.1E-02	9.4E-04			3.6E-04						2.1E-01			2.2E-01
Th-234	2.6														2.6
Pa-234m	2.6														2.6
U-232			1.2E-04												1.2E-04
U-234	2.10	6.8E-02	1.0E-04				3.0E-04					4.8E-03			2.17
U-235		2.5E-03	4.6E-06									3.9E-04			2.9E-03
U-238	2.6	7.6E-02	8.4E-05				3.0E-04					7.0E-02			2.7
Np-237		3.2E-07													3.2E-07
Pu-238		5.1E-04	1.7E-06												5.1E-04
Pu-239		1.1E-04	2.0E-06												1.1E-04
Am-241		1.8E-04	3.3E-06												1.8E-04
Cm-244		1.2E-04													1.2E-04
gr-alpha		8.6E-03	6.2E-04	5.4E-04				1.0E-04				5.6E-02	1.7E-05		6.6E-02
gr-beta		9.5E-02	9.5E-03	5.9E-03				1.5E-03				1.80			1.91
TRU NOS.							<1E-04								1.0E-04
Gamma-emitters										5.0E-04					5.0E-04
All others											4.5E-03				5.4E-03
TOTAL	1300	740	3.0E-02	6.6E-02	1.9E-03	8.4E-04	5.5E-02	1.4E-02	2.4E-01	5.8E-03	3.1E-02	130	1.7E-05	1.4E-05	2200

Gray cell shading indicates larger liquid effluent emissions (Ci) sites and sources. See text for Release Water abbreviation descriptions.

Table 4-11. Radionuclide Activity Released via Liquid Effluent in 2016 (Ci)

Release Water	SW	Offsite Trmt	SW	All Liqu Effl.	SW	SanSwr	SW	SanSwr	SW	GW	SanSwr	SanSwr	SanSwr	SW, StormW	SanSwr	
Program Office	EM	EM	EM	EM	EM	NNSA	NNSA-NNPP	NNSA-NNPP	SC	SC	SC	SC	SC	SC	SC	
Radio-nuclide	**Hanford**	**KNOL SPRU**	**PORTS** [(a)]	**SRS**	**WVDP**	**LLNL**	**KESS**	**KNOL**	**ANL**	**BNL**	**FERMI**	**JLAB**	**LBNL**	**ORR**	**SLAC**	**Total**
	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	Ci_2016	(Ci)
H-3	830			668	1.2E-02	2.0E-02	9.8E-04		7.1E-02	1.3E-02	5.4E-01	7.3E-04	4.5E-03	140	6.2E-05	**1639**
C-14		5.6E-09		5.8E-04	2.4E-04								1.2E-03			**2.0E-03**
Co-60					9.5E-06											**9.5E-06**
Ni-63		2.8E-09														**2.8E-09**
Sr-90		6.4E-06		2.0E-02	2.3E-03			4.7E-04	2.0E-04					4.8E-01		**5.0E-01**
Y-90								4.7E-04								**4.7E-04**
Tc-99		1.8E-09		1.9E-02	2.2E-04									2.1E-01		**2.3E-01**
I-129				1.8E-02	4.5E-05											**1.8E-02**
Cs-137		4.4E-06		1.8E-02	3.4E-04			1.4E-04						2.0E-01		**2.2E-01**
Th-228		2.4E-09														**2.4E-09**
Th-230		1.7E-10														**1.7E-10**
Th-234	8.6E-01															**8.6E-01**
Pa-234m	8.6E-01															**8.6E-01**
U-232					1.1E-04											**1.1E-04**
U-234	3.10	2.1E-08		3.3E-02	8.3E-05				5.0E-04					3.3E-03		**3.14**
U-235		1.3E-09		1.0E-03	4.3E-06									3.4E-05		**1.1E-03**
U-238	8.6E-01	1.3E-08		3.7E-02	6.8E-05				5.0E-04					4.7E-02		**9.4E-01**
Np-237				2.8E-06												**2.8E-06**
Pu-238		7.6E-10		2.6E-04	1.5E-06											**2.6E-04**
Pu-239		6.0E-08		1.4E-05	2.2E-06	2.9E-07										**1.6E-05**
Pu-241		2.9E-08														**2.9E-08**
Am-241		4.3E-08		1.8E-03	1.6E-06											**1.8E-03**
Cm-242		2.5E-10														**2.5E-10**
Cm-244				1.5E-04												**1.5E-04**
gr-alpha				4.3E-03	3.9E-04	6.3E-05				2.0E-04				2.8E-02		**3.3E-02**
gr-beta			5.5E-02	1.1E-01	6.0E-03	4.7E-03				1.7E-03				1.20		**1.38**
TRU n.o.s.									<1E-04							**1.0E-04**
gamma-emitters												1.4E-04				**1.4E-04**
All others													1.2E-03			**1.2E-03**
Total	**836**	**1.1E-05**	**5.5E-02**	**668**	**2.2E-02**	**2.5E-02**	**9.8E-04**	**1.1E-03**	**7.2E-02**	**1.5E-02**	**5.4E-01**	**8.7E-04**	**6.9E-03**	**142**	**6.2E-05**	**1647**

Gray cell shading indicates larger liquid effluent emissions (Ci) sites and sources. See text for Release Water abbreviation descriptions.
(a) PORTS liquid effluents from DOE sources, only.

Table 4-12. Radionuclide Activity Released via Liquid Effluent in 2017 (Ci)

Release Water	GW	see KNOL	SW	All Liquid Effl.	SW	SanSwr	SW	SanSwr	SW	GW	SanSwr	SanSwr	SanSwr	SW, StormW	SanSwr	
Program Office	EM	EM	EM	EM	EM	NNSA	NNSA-NNPP	NNSA-NNPP	SC	SC	SC	SC	SC	SC	SC	
Radio-nuclide	**Hanford**	**KNOL SPRU**	**PORTS[a]**	**SRS**	**WVDP**	**LLNL**	**KESS**	**KNOL**	**ANL**	**BNL**	**FERMI**	**JLAB**	**LBNL**	**ORR**	**SLAC**	**Total**
	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci_2017	Ci
H-3	4.86			494	1.7E-02	1.2E-01	1.1E-03		1.4E-01	1.1E-02	0.54	3.3E-03	2.9E-02	200	1.1E-04	**700**
C-14		9.7E-09		1.1E-02	3.7E-04								2.1E-02			**3.2E-02**
Ni-63		4.8E-09														**4.8E-09**
Sr-90		1.1E-05		2.1E-02	5.3E-03			4.1E-04	2E-04					8.9E-01		**9.2E-01**
Y-90								4.1E-04								**4.1E-04**
Tc-99		3.1E-09		1.5E-02	2.3E-04									2.4E-01		**2.6E-01**
I-129				2.2E-02	5.6E-05											**2.2E-02**
Cs-137		7.5E-06		5.8E-03	8.7E-04			2.0E-04						4.9E-01		**5.0E-01**
Th-228		4.2E-09														**4.2E-09**
Th-230		2.9E-10														**2.9E-10**
U-232					1.5E-04											**1.5E-04**
U-234		3.7E-08		3.5E-02	1.3E-04				4E-04					4.5E-03		**4.0E-02**
U-235		2.2E-09		1.2E-03	6.9E-06									4.4E-04		**1.7E-03**
U-238		2.2E-08		3.6E-02	9.9E-05				4E-04					8.3E-02		**1.2E-01**
Pu-238		1.3E-09		2.3E-04	1.7E-06											**2.3E-04**
Pu-239		1.0E-07		2.0E-05	1.5E-06	3.8E-07										**2.2E-05**
Pu-241		5.0E-10														**5.0E-10**
Am-241		7.3E-08		5.6E-03	1.8E-06											**5.6E-03**
Cm-242		4.3E-10														**4.3E-10**
gr-alpha				2.5E-03	6.6E-04	1.6E-04				1.0E-04				5.6E-02		**5.9E-02**
gr-beta			3.0E-02	5.5E-02	1.2E-02	1.2E-02				1.6E-03				2.5		**2.61**
TRU n.o.s.									< 1E-04							**1.0E-04**
gamma-emitters												2.4E-02				**2.4E-02**
All others													6.3E-03			**6.3E-03**
Total (Ci)	**4.86**	**1.9E-05**	**3.0E-02**	**494**	**3.7E-02**	**1.3E-01**	**1.1E-03**	**1.0E-03**	**1.4E-01**	**1.2E-02**	**5.4E-01**	**2.7E-02**	**5.6E-02**	**204**	**1.1E-04**	**704**

Gray cell shading indicates larger liquid effluent emissions (Ci) sites and sources. See text for Release Water abbreviation descriptions.
(a) PORTS liquid effluents from DOE sources only.

Table 4-13. Radionuclide Activity Released via Liquid Effluent in 2018 (Ci)

Release Water	GW, SW	see KNOL	SW	All Liquid Effl.	SW	SanSwr	SW	SanSwr	SW	GW	SanSwr	SanSwr	SanSwr	SW, StormW	SanSwr	
Program Office	EM	EM	EM	EM	EM	NNSA	NNSA-NNPP	NNSA-NNPP	SC	SC	SC	SC	SC	SC	SC	
Radionuclide	**Hanford**	**KNOL SPRU[(a)]**	**PORTS[(b)]**	**SRS**	**WVDP**	**LLNL**	**KESS**	**KNOL**	**ANL**	**BNL**	**FERMI**	**JLAB**	**LBNL**	**ORR**	**SLAC**	**Total**
	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018	Ci_2018
H-3	1467			531	2.3E-02	1.5E-01	9.4E-04		5.2E-02	7.0E-04	5.7E-01	8.3E-02	2.2E-02	190	4.0E-05	2188
C-14				6.2E-04	2.6E-04								3.5E-02			3.6E-02
Sr-90				3.2E-02	1.1E-02			2.5E-04	2.0E-04					6.7E-01		7.1E-01
Y-90								2.5E-04								2.5E-04
Tc-99			(b)	2.8E-02	3.0E-04									12		12
I-129				1.7E-02	6.7E-05											1.7E-02
Cs-137				8.1E-03	1.6E-03			1.9E-04						4.6E-01		4.7E-01
Ra-226				1.0E-03												1.0E-03
U-232					2.2E-04											2.2E-04
U-234	3.8			3.0E-02	1.9E-04			5.9E-07	4.0E-04					8.4E-03		3.8
U-235				5.7E-04	1.8E-05			3.3E-08						7.2E-04		1.3E-03
U-238	4.4		6.1E-02	3.2E-02	1.4E-04			4.5E-07	3.0E-04					8.9E-02		4.5
Pu-238				5.4E-05	3.1E-06			4.0E-09								5.7E-05
Pu-239				5.5E-06	2.9E-06	2.4E-07		3.6E-09								8.5E-06
Am-241				1.4E-04	3.5E-06											1.4E-04
gr-alpha				3.2E-03	8.2E-04	3.8E-04				2.0E-04				3.9E-02		4.4E-02
gr-beta				4.5E-02	1.4E-01	1.0E-02				1.2E-03				1.6		1.8
TRU n.o.s.									<0.0001							1.0E-04
gamma-emitters												2.4E-04				2.4E-04
All others													5.8E-03			5.8E-03
TOTAL (Ci)	**1475**	**(a)**	6.1E-02	**531**	**1.8E-01**	**1.6E-01**	**9.4E-04**	**6.9E-04**	**5.3E-02**	**2.1E-03**	**5.7E-01**	**8.3E-02**	**6.3E-02**	**205**	**4.0E-05**	**2212**

Gray cell shading indicates larger liquid effluent emissions (Ci) sites and sources. See text for Release Water abbreviation descriptions.
(a) Any SPRU releases would be included with KNOL.
(b) PORTS release is from Tc-99 and total uranium. No radionuclide-specific details provided; assigned to U-238 as a default.

4.3 References

40 CFR Part 61, Subpart H, *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H*, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*. U.S. Environmental Protection Agency.

Hanford Site. 2016. *Environmental Report for Calendar Year 2015*, DOE-RL-2016-33. U.S. Department of Energy-RL, Office of Environmental Managment, Richland, Washington.

5.0 Liquids Surveillance

DOE is responsible for conducting effluent monitoring and environmental surveillance programs to determine whether the public and the environment are adequately protected during DOE operations, and whether the impacts of those operations are in compliance with Federal, State, and local radiation standards and requirements. Liquid effluents or soil-borne material may be present in groundwater, surface water, or stormwater. Site liquid effluents that potentially contain radioactive materials are currently managed to minimize such releases to the ambient environment.

The Federal regulations and DOE requirements established to maintain ambient water quality are summarized here.

- *Clean Water Act* (CWA) of 1972 created the National Pollutant Discharge Elimination System (NPDES) to protect surface waters by limiting releases of effluents into streams, reservoirs, and wetlands. Significant to DOE sites, radionuclides regulated under the *Atomic Energy Act* of 1954 are not subject to CWA requirements. Sites use NPDES (or State Pollutant Discharge Elimination System [SPDES]) permit limits for radionuclides.

- *Safe Drinking Water Act* (SDWA) of 1974 (42 USC §300f et seq.) was established to protect the quality and safety of drinking water in the United States and focuses on all waters actually or potentially designated for drinking use, whether from aboveground or underground sources. This act authorizes EPA to establish minimum standards for protecting tap water and requires all owners or operators of public water systems to comply with these primary, health-related standards. The SDWA requires that DOE, as a Federal agency that operates or maintains a public water system, must comply with all Federal, State, and local requirements regarding safe drinking water.

- DOE O 458.1, *Radiation Protection of the Public and the Environment*, establishes requirements for protecting the public and the environment against undue risk from radiation associated with radiological activities conducted under DOE's control, pursuant to the *Atomic Energy Act* of 1954, and for determining whether the impacts of those operations are in compliance with Federal, State, and local radiation standards and requirements.

- All DOE facilities are required, under DOE O 231.1B, *Environment, Safety and Health Reporting*, to annually report, on a CY basis, environmental management performance, including the following: effluent releases, environmental monitoring, and the types and quantities of radioactive materials emitted or discharged to the environment.

Several liquid effluent categories are included in the radiological surveillance programs of DOE sites. Liquid effluents released to the ambient environment may include radioactive materials from DOE operations. Past practices have resulted in legacy contamination at some DOE sites; current emissions, however, are more stringently managed to ALARA levels. Liquid effluent surveillance typically occurs onsite and involves some surveillance of offsite and background locations. Liquids in the ambient environment monitored for radiological constituents at DOE facilities include the following:

- groundwater (Section 5.1),
- DOE potable water systems (Section 5.2), and
- surface waters and onsite stormwater (Section 5.3).

Table 5-1 provides a summary of DOE sites' liquid effluent monitoring programs for radiological constituents. The listed types of liquid effluents may result in releases to the ambient environment that may potentially lead to exposures by members of the public. The indicated monitoring is performed under permit requirements at DOE sites and is evaluated against State and Federal liquid effluent standards for radiological constituents. Some groundwater analyses may be performed for onsite-only plumes. A number of sites evaluate liquid effluent for compliance with radiological limits prior to its discharge to municipal sanitary sewer systems. These are not indicated in this summary table, but are acknowledged elsewhere in this report (e.g., Section 4.2.2).

Table 5-1. Types of Liquid Effluent Radiological Surveillance at DOE Sites (2015–2018)

DOE Program Office	Site Abbreviation	Groundwater Surveillance	DOE Potable Water System Surveillance	Surface Water Surveillance	Stormwater Surveillance
EERE	NREL STM	-	-	-	-
EM	HANF	X	X	X	-
EM	KNOL SPRU	-	-	-	-
EM	PGDP	X	X	X	-
EM	PORTS	X	X	X	X
EM	SRS	X	X	X	X
EM	SSFL	X	-	-	X
EM	WIPP	X	-	X	-
EM	WVDP	X	X	X	-
NE	INL	X	X	X	-
NNSA	LANL	X	-	X	X
NNSA	LLNL	X	-	X	X
NNSA	LLNL Site 300	-	X	-	-
NNSA	NNSS	X	X	X	Exempted (a)
NNSA	NNSS NLVF	-	-	-	Exempted (a)
NNSA	PANTEX	-	- (b)	X	X
NNSA	SNL-CA	X	-	-	X
NNSA	SNL-NM	X	- (c)	-	X
NNSA	SNL-TTR	-	- (b)	-	-
NNSA-NNPP	BETTIS	X	-	X	X
NNSA-NNPP	INL NRF	Exempted (d)	Exempted (d)	Exempted (d)	Exempted (d)
NNSA-NNPP	KESS	X (e)	-	X	X
NNSA-NNPP	KNOL	X (e)	-	X	X
SC	ANL	X	X (f)	X	X
SC	BNL	X	-	X	X
SC	FERMI	X	-	X	X
SC	JLAB	X	-	X	- (g)
SC	LBNL	X	-	X	-
SC	ORR Total		- (c)		
	ETTP (EM)	X	-	X	X
	ORNL (SC)	X	-	X	X
	Y-12 (NNSA)	X	-	X	X
SC	PNNL MSL	-	- (b)	-	-
SC	PNNL Richland	X	-	-	-
SC	PPPL	X	-	X	-
SC	SLAC	X	-	-	X

"- "= not applicable.

(a) NNSS and NNSS NLVF are exempted under a conditional exemption from the NPDES Storm Water Program and a State of Nevada Stormwater General Permit.

(b) Radiological surveillance is not required at onsite source at PANTEX, SNL-TTR, or PNNL MSL.

(c) Kirtland AFB is responsible for monitoring of SNL-NM potable water source. The City of Oak Ridge is responsible for monitoring of an onsite ORR potable water source.

(d) INL NRF was exempted under an Executive Order; INL NRF publishes a separate environmental monitoring report.

(e) KESS and KNOL perform voluntary groundwater surveillance. No monitoring details are summarized in this section for KESS and KNOL.

DOE Program Office	Site Abbreviation	Groundwater Surveillance	DOE Potable Water System Surveillance	Surface Water Surveillance	Stormwater Surveillance

(f) ANL GW potable water wells active until 2015, only.
(g) JLAB implementation of best management practices eliminates the need to sample stormwater directly.

Not all ASERs indicate a liquid pathway dose to their critical receptor. Sites that include a dose estimate from the liquid pathway for their MEI or Representative Person are indicated in Table 5-2. The significance of the liquid pathway dose to the total dose estimate is also summarized in the table. Some sites may perform liquid pathway dose estimates to a specialized receptor (e.g., several sites indicate a liquid pathway dose from fish consumption by a fisherman). Dose from a liquid pathway may result from surface water or groundwater sources.

Table 5-2. Sites That Report a Liquid Pathway Dose for the Maximally Exposed Receptor (2015–2018)

DOE Program Office	Acronym	Liquid Pathway Dose in MEI Estimate
EERE	NREL STM	-
EM	HANF	x
EM	KNOL SPRU	x [(a)]
EM	PGDP	**X**
EM	PORTS	x
EM	SRS	**X**
EM	SSFL	-
EM	WIPP	-
EM	WVDP	x
NE	INL	- [(b)]
NNSA	LANL	x [(c)]
NNSA	LLNL	-
NNSA	LLNL Site 300	-
NNSA	NNSS	x [(c)]
NNSA	NNSS NLVF	-
NNSA	PANTEX	x [(c)]
NNSA	SNL-CA	-
NNSA	SNL-NM	-
NNSA	SNL-TTR	-
NNSA-NNPP	BETTIS	-
NNSA-NNPP	INL NRF	-
NNSA-NNPP	KESS	x
NNSA-NNPP	KNOL	x [(a)]
SC	ANL	x
SC	BNL	x
SC	FERMI	x [(c)]
SC	JLAB	x [(c)]
SC	LBNL	-
SC	ORR Total	**X**
SC	PNNL MSL	-
SC	PNNL Richland	-
SC	PPPL	x
SC	SLAC	-

DOE Program Office	Acronym	Liquid Pathway Dose in MEI Estimate
"-" = No liquid pathway dose assigned. "**X**" = At least one 2015-2018 liquid pathway MEI dose estimate is greater than or equal to 0.1 mrem/yr. "x" = All 2015-2018 liquid pathway MEI dose estimates <0.1 mrem/yr. (a) Includes both KNOL and SPRU. (b) The INL waterfowl consumption dose from onsite pond habitation is considered an other pathway rather than a liquid pathway. (c) Liquid pathway MEI dose result reported as 0 mrem/yr (2015–2018).		

5.1 Groundwater Surveillance

Groundwater surveillance at DOE sites is conducted to determine the distribution of radiological constituents in groundwater, and their potential impact on the public and the environment in close proximity to DOE sites. At DOE sites where contaminants have migrated beyond the DOE property boundary, the detected levels are typically substantially lower than applicable standards. Remediation of contaminated groundwater is conducted in accordance with agreements between DOE and external agencies. (i.e., EPA, State agencies, and/or tribal organizations). The various State groundwater standards, under which some DOE sites determine compliance, are listed in Section 4.1.1.

In addition to the DOE sites that have no reported radioactive material emissions to the ambient environment (see Section 1.0), the sites listed in Table 5-3 perform no groundwater surveillance, or did not otherwise present groundwater surveillance information, and are not listed in the 2015−2018 table of groundwater surveillance results (Table 5-5 in Section 5.1.2).

Table 5-3. DOE Sites with No Reported Groundwater Surveillance Results (2015–2018)

DOE Program Office	DOE Site	Comment
EERE	NREL STM	NREL STM does not have known groundwater contamination.
EM	KNOL SPRU	Did not provide radiological groundwater surveillance results. (Also see comment for NNSA-NNPP KNOL).
NNSA	PANTEX	Did not provide radiological groundwater surveillance information.
NNSA	SNL-TTR	Site does not have groundwater monitoring wells.
NNSA	LLNL Site 300	Did not provide radiological groundwater surveillance results.
NNSA	NNSS NLVF	Did not provide radiological groundwater surveillance results.
NNSA-NNPP	KESS, KNOL	Reporting indicates the quantities of radioactivity contained in liquid and gaseous effluents during operations in CYs 2015−2018 at KNOL and KESS were too small to have a measurable effect on normal background radioactivity.
SC	AMES	No current AMES activities pose a hazard to groundwater; groundwater monitoring is not required.
SC	MSL	No current MSL activities that pose a hazard to groundwater; groundwater is not monitored because it is not required.

5.1.1 State Groundwater Standards

As required, DOE sites maintain compliance with the State groundwater quality standards based upon the location of the DOE site. State standards for groundwater compliance for each state in which a DOE site is located are provided in Appendix E. State standards are provided for California, Illinois, Kentucky, Nevada, New Jersey, New Mexico, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and Washington.

5.1.2 Results of CY 2015−2018 Groundwater Surveillance and Reporting

A wide range of radioactive constituents are sampled in the groundwater at applicable DOE sites. At locations where groundwater surveillance was conducted from CY 2015−2018, samples were primarily taken at onsite locations. However, groundwater surveillance may also be performed at offsite locations, depending on the extent of the groundwater plume. Results reported in this section only describe onsite groundwater sampling results.

The specific radionuclides included in monitoring programs identified in the CY 2015−2018 ASERs are listed in Table 5-4. Some radioactive constituents are monitored in groundwater at numerous DOE sites, including gross alpha, gross beta, Cs-137, H-3, Sr-90, Tc-99, and U-238. Gross alpha and gross beta are general measures of radioactive constituents, including background. Fission products from nuclear reactor effluents include longer-lived Cs-137 (half-life 30.2 yr), Sr-90 (half-life 28.8 yr), and Tc-99 (half-life 211,100 yr).[1] Both nuclear reactor operations and accelerator operations can generate H-3 (half-life 12.3 yr). U-238 (half-life 4,468 million yr) is a natural radioactive material (part of natural background) that has a long decay chain that includes the noble gas Rn-222. Note that all these nuclides have multiyear half-lives, which make them persistent environmental hazards requiring monitoring.

Table 5-4. Radioactive Constituents Sampled in Groundwater at DOE Sites (2015–2018)

Nuclides that May Include Natural Radioactive Background	Other Radionuclides and Analyses	Transuranic Radionuclides
K-40	H-3	Np-237
Tl-208	C-14	Pu-238
Pb-212	Na-22	Pu-239/240
Pb-214	Mn-54	Pu-241
Bi-214	Co-60	Am-241
Ra-226	Sr-89/90	Cm-243/244
Ra-228	Sr-90	
Th-230	Tc-99	
Th-232	I-129	
U-232	Cs-137	
U-234	Eu-154	
U-233/234		
U-235		
U-235/236		
U-238		
Total uranium		
Isotopic uranium		
Gross alpha		
Gross beta		
Gamma-emitters		

During the reporting period of CY 2015−2018, a total of 26 DOE sites reported monitoring of groundwater for radioactive constituents; 9 DOE sites (ORRs subsites counted as one) reported radionuclide standard exceedances. In general, the radionuclides detected above standards were located in known groundwater plumes. Sites reporting onsite groundwater monitoring results with exceedences included:

- NNSA sites: LANL, NNSS, and ORR Y-12;
- EM sites: HANF, PGDP, ORR ETTP, SRS, and WVDP;
- NE sites: INL; and

[1] Tc-99 should not be confused with the medical diagnostic isotope Tc-99m, whose half-life is much shorter (6 hours).

- SC sites: BNL and ORR ORNL.

Table 5-5 provides a complete summary of groundwater monitoring results at DOE sites during CYs 2015–2018. Sites exceeding relevant requirements are noted. Exceedances were indicated most often for H-3, gross alpha, gross beta, Sr-90, Tc-99, and Cs-137. Remediation efforts are active at sites with exceedances.

Table 5-5. Summary of Groundwater Monitoring at DOE Sites (2015–2018)

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
EM							
HANF	2015	C-14, H-3, I-129, Sr-90, Tc-99, U	DOE O 458.1 and State of Washington Groundwater Standards	Y	C-14, H-3, I-129, Sr-90, Tc-99, U	C-14, H-3, I-129, Sr-90, Tc-99, U	In the Groundwater Interest 300 Area, uranium contamination is above the standard. In the Groundwater Interest 100-N Area, strontium-90 contamination is above the standard. In the Groundwater Interest 100-K Area, carbon-14 is above the standard. In the Groundwater Interest 300 Area, tritium is above the standard. Groundwater remediation efforts are active.
HANF	2016	C-14, H-3, I-129, Sr-90, Tc-99, U	See 2015 Standard	Y	C-14, H-3, I-129, Sr-90, Tc-99, U	C-14, H-3, I-129, Sr-90, Tc-99, U	In the Groundwater Interest 300-FF Area, uranium contamination is above the standard. In the Groundwater Interest 100-NR Area, strontium-90 contamination is above the standard. In the Groundwater Interest 100-KR Area, carbon-14 is above the standard. In the Groundwater Interest 300-FF Area, tritium is above the standard. In the Groundwater Interest 300-FF Area, tritium is above the standard. Groundwater remediation efforts are active.
HANF	2017	C-14, H-3, I-129, Sr-90, Tc-99, U	See 2015 Standard	Y	C-14, H-3, I-129, Sr-90, Tc-99, U	C-14, H-3, I-129, Sr-90, Tc-99, U	In the Groundwater Interest 100-KR Area, strontium-90 contamination is above the standard. In the Groundwater Interest 100-NR Area, strontium-90 contamination is above the standard. In the Groundwater Interest 300-FF Area, uranium contamination is above the standard. Groundwater remediation efforts are active.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
HANF	2018	C-14, H-3, I-129, Sr-90, Tc-99, U	See 2015 Standard	Y	C-14, H-3, I-129, Sr-90, Tc-99, U	C-14, H-3, I-129, Sr-90, Tc-99, U	In the Groundwater Interest 100-KR Area, tritium contamination is above the standard. In the Groundwater Interest 100-KR Area, carbon-14 contamination is above the standard. In the Groundwater Interest 100-KR Area, strontium-90 contamination is above the standard.
PGDP	2015	gross alpha, gross beta, Ra-226, Ra-228, Tc-99, Th-230, Th-232, U-234, U-238	DOE O 458.1 and Kentucky Groundwater Standards	Y	Tc-99	Tc-99	Tc-99 exceedances were reported, and Remedial Action efforts are active. Historically, groundwater was the primary source of drinking water for residents and businesses in the vicinity of the plant area. In areas where the groundwater either is known to be contaminated or has the potential to become contaminated in the future, DOE has provided water hookups to the West McCracken County Water District and pays water bills for affected residences and businesses. Residential wells have been capped and locked except for those that are used by DOE for monitoring (per license agreement between DOE and each resident; renewed every five years). An educational mailer is planned to be developed and distributed to residents on an annual basis beginning in CY 2016 in an effort to ensure public awareness of the groundwater contamination.
PGDP	2016	gross alpha, gross beta, Ra-226, Ra-228, Tc-99, Th-230, U-234, U-235, U-238	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 PGDP comment.
PGDP	2017	gross alpha, gross beta, Ra-226, Ra-228, Tc-99, Th-230, Th-232, U-234, U-238	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 PGDP comment.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
PGDP	2018	gross alpha, gross beta, Ra-226, Tc-99, Th-230, U-234, U-235, U-238	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 PGDP comment.
PORTS	2015	Tc-99, U-233/234, U-235/236, U-238	DOE O 458.1 and Ohio Groundwater Standards	Y	Tc-99, U-233/234, U-235/236, U-238	Tc-99	Concentrations of radionuclides present in groundwater in the X-701B area can be affected by the oxidant used in the X-701B Interim Remedial Measure and the oxidant injections conducted in 2006–2008 that were part of the X-701B groundwater remedy.
PORTS	2016	Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	Y	Tc-99, U-233/234, U-235/236, U-238	Tc-99	See 2015 PORTS comment.
PORTS	2017	Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	Y	Tc-99, U-233/234, U-235/236, U-238	Tc-99	See 2015 PORTS comment.
PORTS	2018	Tc-99, U-233/234, U-235/236, U-238, Am-241, Np-237, Pu-238, Pu-239/240,	See 2015 Standard	Y	Tc-99, U-233/234, U-235/236, U-238	Tc-99	See 2015 PORTS comment.
SRS	2015	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	DOE O 458.1 and South Carolina Groundwater Standards	Y	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	In C-Area, tritium is above the standard. In D-Area, tritium is above the standard. In the E-Area Mixed Waste Management Facility (MWMF), tritium is above the standard. Remediation efforts are active.
SRS	2016	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	See 2015 Standard	Y	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	In the F-Area Hazardous Waste Management Facility (HWMF), H 3 is above the standard. In the H Area HWMF, tritium is above the standard. In P-Area, tritium is above the standard. Remediation efforts are active.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
SRS	2017	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	See 2015 Standard	Y	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	In the E-Area MWMF, tritium is above the standard. In C-Area, tritium is above the standard. In D-Area, tritium is above the standard. Remediation efforts are active.
SRS	2018	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	See 2015 Standard	Y	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	gross alpha, nonvolatile beta, H-3, Sr-90, Tc-99	In R-Area, strontium-90 is above the standard. In C-Area, tritium is above the standard. In D-Area, tritium is above the standard. Remediation efforts are active.
SSFL	2015-2017	gross alpha, gross beta, gamma-emitters, Ra-226, Ra-228, Sr-90, H-3, isotopic uranium	DOE O 458.1 and California State Water Resources Control Board Groundwater Standard	N	-	-	The report states groundwater was monitored for radionuclides and the report does not provide radiological groundwater results.
SSFL	2018	gross alpha, gross beta, gamma-emitters, Ra-226, Ra-228, Sr-90, H-3, Na-22, U-233/234, U-235/236, U-238.Co-57, Eu-152, Eu-154, Eu-155, Cs-134, Cs-137, Ac-228, Sb-125, Am-241, K-40, Mn-54	See 2015-2017 Standard	Y	H-3	H-3	A separate groundwater report was published for CY 2018.
WIPP	2015	U-233/234, U-235, U 238, Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90	DOE O 458.1 and New Mexico Groundwater Standards	N	-	U-233/234, U-235, U-238, and K-40	-
WIPP	2016	U-233/234, U-235, U 238, Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90	See 2015 Standard	N	-	U-233/234, U-235, U-238, and K-40	-
WIPP	2017	U-233/234, U-235, U 238, Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90	See 2015 Standard	N	-	U-233/234, U-235, U-238, and K-40	-

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
WIPP	2018	U-233/234, U-235, U 238, Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90	See 2015 Standard	N	-	U-233/234, U-235, U-238, and K-40	
WVDP	2015	gross alpha, gross beta, H-3, C-14, K-40, Co-60, Eu-154, Np-237, Pu-238, Pu-239/240, Pu-241, Am-241, Cm-243/244, Sr-90, Tc-99, I-129, Cs-137, Ra-226, Ra-228, U-232, U-233/234, U-235/236, U-238, total uranium	DOE O 458.1 and New York Groundwater Standards	Y	gross alpha, gross beta, H-3, Sr-90, Tc-99, I-129, U-233/234, U-235/236, U-238, total uranium	Sr-90	A permeable treatment wall for Sr-90 plume remediation was installed in 2010 and remediation efforts are active.
WVDP	2016	gross alpha, gross beta, H-3, C-14, K-40, Co-60, Eu-154, Np-237, Pu-238, Pu-239/240, Pu-241, Am-241, Cm-243/244, Sr-90, Tc-99, I-129, Cs-137, Ra-226, Ra-228, U-232, U-233/234, U-235/236, U-238, total uranium	See 2015 Standard	Y	gross alpha, gross beta, H-3, Sr-90, Tc-99, I-129, Ra-226, Ra-228, U-233/234, U-235/236, U-238, total uranium	Sr-90	See 2015 WVDP comment.
WVDP	2017	gross alpha, gross beta, H-3, C-14, K-40, Co-60, Eu-154, Np-237, Pu-238, Pu-239/240, Pu-241, Am-241, Cm-243/244, Sr-90, Tc-99, I-129, Cs-137, Ra-226, Ra-228, U-232, U-233/234, U-235/236, U-238, total uranium	See 2015 Standard	Y	gross alpha, gross beta, H-3, Sr-90, Tc-99, I-129, Ra-226, Ra-228, U-233/234, U-235/236, U-238, total uranium	Sr-90	See 2015 WVDP comment.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
WVDP	2018	gross alpha, gross beta, H-3, C-14, K-40, Co-60, Eu-154, Np-237, Pu-238, Pu-239/240, Pu-241, Am-241, Cm-243/244, Sr-90, Tc-99, I-129, Cs-137, Ra-226, Ra-228, U-232, U-233/234, U-235/236, U-238, total uranium	See 2015 Standard	Y	gross alpha, gross beta, H-3, Sr-90, Tc-99, I-129, Ra-226, Ra-228, U-233/234, U-235/236, U-238, total uranium	Sr-90	See 2015 WVDP comment.
NE							
INL	2015	gross alpha, gross beta, Cs-137, Co-60, H-3, I-129, Pu-238, Pu-239/240, Sr-90, Tc-99, U-233/234, U-235, U-238	DOE O 458.1 and Idaho Groundwater Standard	Y	Cs-137, Sr-90, Tc-99	gross alpha, gross beta, Cs-137, H-3, Sr-90, U-233/234, U-235, U-238	Remediation plan to reduce Sr-90 and Cs-137 below MCL before 2095; Tc-99 showed stable or declining trends from the previous reporting period.
INL	2016	gross alpha, gross beta, C-14, Cs-137, Co-60, H-3, I-129, Pu-238, Pu-239/240, Sr-90, Tc-99, U-233/234, U-235, U-238	See 2015 Standard	Y	Cs-137, Sr-90, Tc-99	gross aplha, gross beta, C-14, Cs-137, H-3, I-129, Sr-90, Tc-99, U-233/234, U-235, U-238	See 2015 INL Comment
INL	2017	gross alpha, gross beta, Cs-137, Co-60, H-3, I-129, Pu-238, Pu-239/240, Sr-90, Tc-99, U-233/234, U-235, U-238	See 2015 Standard	Y	Cs-137, Sr-90, Tc-99	gross alpha, gross beta, CS-137, H-3, Sr-90, Tc-99, U-233/234, U-235, U-238	Remediation plan is to reduce Sr-90 and Cs-137 below MCL before 2095; Tc-99 showed stable or declining trends from the previous reporting period.
INL	2018	gross alpha, gross beta, gamma-emitters, Cs-137, Co-60, H-3, I-129, Pu-238, Pu-239/240, Sr-90, Tc-99, U-233/234, U-235, U-238, Am-241,	See 2015 Standard	Y	Cs-137, Sr-90	gross alpha, gross beta, CS-137, H-3, Sr-90, Tc-99, U-233/234, U-235, U-238	Remediation plan is to reduce Sr-90 and Cs-137 below MCL before 2095.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
NNSA							
LANL	2015	gross alpha, H-3, Sr-90	DOE O 458.1 and New Mexico Groundwater Standards	Y	Sr-90	gross alpha, H-3, Sr-90	Sr-90 has exceedances; remediation efforts do not appear to be active.
LANL	2016	gross alpha, H-3, Sr-90	See 2015 Standard	Y	gross alpha, Sr-90	gross alpha, H-3, Sr-90	Gross alpha and Sr-90 have exceedances; remediation efforts do not appear to be active.
LANL	2017	H-3, Sr-90	See 2015 Standard	Y	Sr-90	H-3, Sr-90	Sr-90 has exceedances; remediation efforts do not appear to be active.
LANL	2018	H-3, Sr-90	See 2015 Standard	Y	Sr-90	H-3, Sr-90	Sr-90 has exceedances; remediation efforts do not appear to be active.
LLNL	2015	gross alpha, gross beta, H-3	DOE O 458.1 and California State Water Resources Control Board Groundwater Standard	N	-	gross alpha, gross beta, H-3	-
LLNL	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	gross alpha, gross beta, H-3	-
LLNL	2017	gross alpha, gross beta, H-3	See 2015 Standard	N	-	gross alpha, gross beta, H-3	-
LLNL	2018	gross alpha, gross beta, H-3	See 2015 Standard	N	-	gross alpha, gross beta, H-3	-
NNSS	2015	gross alpha, gross beta, H-3	DOE O 458.1, National Pollution Discharge Elimination System Permit, and Nevada Groundwater Standards	Y	H-3	gross alpha, gross beta, H-3	H-3 was reported as an exceedance; remediation efforts are being planned.
NNSS	2016	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	gross alpha, gross beta, H-3	H-3 was reported as an exceedance; remediation efforts are being planned.
NNSS	2017	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	gross alpha, gross beta, H-3	H-3 was reported as an exceedance; remediation efforts are being planned.
NNSS	2018	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	gross alpha, gross beta, H-3	H-3 was reported as an exceedance; remediation efforts are being planned.
SNL-CA	2015	H-3	DOE O 458.1 and California State Water Resources Control Board Groundwater Standard	N	-	H-3	-

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
SNL-CA	2016	H-3	See 2015 Standard	N	-	H-3	-
SNL-CA	2017	H-3	See 2015 Standard	N	-	NULL	Analytical H-3 results were not reported.
SNL-CA	2018	-	See 2015 Standard	N	-	NULL	Tritium analyses were discontinued because SNL/CA has not had active tritium emissions since 1995.
SNL-NM	2015	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	DOE O 458.1 and New Mexico Groundwater Standards	N	-	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	-
SNL-NM	2016	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	-
SNL-NM	2017	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	-
SNL-NM	2018	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	gross alpha, Am-241, gross beta, Cs-137, Co-60, K-40, Ra-226, Ra-228, U-233/234, U-235/236, U-238	
NNSA-NNPP							
BETTIS	2015	gross alpha, gross beta, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	DOE O 458.1 and Pennsylvania Groundwater Standards	N	-	-	-
BETTIS	2016	gross alpha, gross beta, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	See 2015 Standard	N	-	-	-

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
BETTIS	2017	gross alpha, gross beta, Co-60, Cs-137, Sr-90	See 2015 Standard	N	-	-	-
BETTIS	2018	gross alpha, gross beta, Co-60, Cs-137, Sr-90	See 2015 Standard	N	-	-	-
INL NRF	2015	H-3, Sr-90, Cs-137	DOE O 458.1 and Idaho Groundwater Standard	N	-	-	Under Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 436.1, 458.1 and 441.1.D. Therefore, the NRF is not included in an ASER. The NRF did prepare an environmental monitoring report for CY 2015.
INL NRF	2016	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	-	See 2015 comment. An environmental monitoring report was provided for CY 2016.
INL NRF	2017	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	-	See 2015 comment. An environmental monitoring report was provided for CY 2017.
INL NRF	2018	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	-	See 2015 comment. An environmental monitoring report was provided for CY 2018.
SC							
ANL	2015	H-3, Cs-137, and Sr-90	DOE O 458.1 and Illinois Groundwater Standards	N	-	H-3, Cs-137, and Sr-90	-
ANL	2016	H-3, Cs-137, and Sr-90	See 2015 Standard	N	-	H-3	-
ANL	2017	H-3, Cs-137, and Sr-90	See 2015 Standard	N	-	H-3, Cs-137, and Sr-90	-
ANL	2018	H-3, Cs-137, and Sr-90	See 2015 Standard	N	-	H-3, Cs-137, and Sr-90	-
BNL	2015	H-3, Sr-90	DOE O 458.1 and New York Groundwater Standards	Y	H-3, Sr-90	H-3, Sr-90	Achieve Sr-90 MCL at the Chemical Holes by 2040 and at the Brookhaven Graphite Research Reactor by 2070.
BNL	2016	H-3, Sr-90	See 2015 Standard	Y	H-3	H-3	See 2015 BNL comment.
BNL	2017	H-3, Sr-90	See 2015 Standard	Y	H-3	H-3	See 2015 BNL comment.
BNL	2018	H-3, Sr-90	See 2015 Standard	Y	H-3, Sr-90	H-3, Sr-90	See 2015 BNL comment.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
FERMI	2015	H-3	DOE O 458.1 and Illinois Groundwater Standards	N	-	-	Tritium and accelerator-produced radionuclides were not detected in any Illinois Class One groundwater samples.
FERMI	2016	H-3	See 2015 Standard	N	-	-	See 2015 FERMI comment.
FERMI	2017	H-3	See 2015 Standard	N	-	-	See 2015 FERMI comment.
FERMI	2018	H-3	See 2015 Standard	N	-	-	See 2015 FERMI comment.
JLAB	2015	H-3, Be-7, Mn-54, and Na-22	DOE O 458.1, Virginia Pollution Discharge Elimination System Permit, and Virginia Groundwater Standards	N	-	-	-
JLAB	2016	H-3, Be-7, Mn-54, and Na-22	See 2015 Standard	N	-	-	-
JLAB	2017	H-3, Be-7, Mn-54, and Na-22	See 2015 Standard	N	-	-	-
JLAB	2018	H-3, Be-7, Mn-54, Na-22	See 2015 Standard	N	-	-	-
LBNL	2015	H-3	DOE O 458.1 and California State Water Resources Control Board Groundwater Standard	N	-	H-3	The Bevatron Site was demolished in 2010.
LBNL	2016	H-3	See 2015 Standard	N	-	H-3	See 2015 LBNL comment.
LBNL	2017	H-3	See 2015 Standard	N	-	H-3	See 2015 LBNL comment.
LBNL	2018	H-3, gross alpha, gross beta	See 2015 Standard	N	-	H-3	See 2015 LBNL comment.
ORR ETTP (EM)	2015	gross alpha, gross beta, Tc-99	DOE O 458.1 and Tennessee Groundwater Standards	Y	Tc-99	gross alpha, gross beta, Tc-99	Remediation plans are active.
ORR ETTP (EM)	2016	Tc-99	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 ORR ETTP comment.
ORR ETTP (EM)	2017	Tc-99	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 ORR ETTP comment.
ORR ETTP (EM)	2018	gross alpha, gross beta, Tc-99	See 2015 Standard	Y	Tc-99	Tc-99	See 2015 ORR ETTP comment.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
ORR ORNL (SC)	2015	gross alpha, gross beta, Bi-214, H-3,K-40, Pb-212, Pb-214, Sr-89/90, Sr-90,Tc-99, Tl-208	DOE O 458.1 and Tennessee Groundwater Standards	Y	gross beta, H-3, Sr-89/90	gross alpha, gross beta, Bi-214, H-3, K-40, Pb-212, Pb-214, Sr-89/90, Sr-90, Tc-99, Tl-208	Remediation plans are active.
ORR ORNL (SC)	2016	gross alpha, gross beta, Cs-137, H-3, K-40, Sr-89/90	See 2015 Standard	Y	gross beta, H-3, Sr-89/90	gross alpha, gross beta, Cs-137, H-3, K-40, Sr-89/90	See 2015 ORR ORNL comment.
ORR ORNL (SC)	2017	gross alpha, gross beta, Bi-214, H-3, K-40, Pb-212, Pb-214, Sr-89/90	See 2015 Standard	Y	gross beta, H-3	gross alpha, gross beta, Bi-214, H-3, K-40, Pb-212, Pb-214, Sr-89/90	See 2015 ORR ORNL comment.
ORR ORNL (SC)	2018	gross alpha, gross beta, Bi-214, Pb-214, H-3, K-40, Sr-89/90, Ti-208	See 2015 Standard	Y	H-3, gross beta, Sr-89/90	gross alpha, gross beta, Bi-214, H-3, K-40, Pb-212, Pb-214, Sr-89/90	See 2015 ORR ORNL comment.
ORR Y-12 (NNSA)	2015	gross alpha, gross beta, Tc-99	DOE O 458.1 and Tennessee Groundwater Standards	Y	gross alpha, gross beta, Tc-99	gross alpha, gross beta, Tc-99	Remediation plans are active.
ORR Y-12 (NNSA)	2016	gross alpha, gross beta, Tc-99	See 2015 Standard	Y	gross alpha, gross beta, Tc-99	gross alpha, gross beta, Tc-99	See 2015 ORR Y-12 comment.
ORR Y-12 (NNSA)	2017	gross alpha, gross beta, Tc-99	See 2015 Standard	Y	gross alpha, gross beta, Tc-99	gross alpha, gross beta, and Tc-99	See 2015 ORR Y-12 comment.
ORR Y-12 (NNSA)	2018	gross alpha, gross beta, Tc-99	See 2015 Standard	Y	gross alpha, gross beta, Tc-99	gross alpha, gross beta, and Tc-99	See 2015 ORR Y-12 comment.
PNNL Richland	2015	H-3	DOE O 458.1 and Washington Groundwater Standards	N	-	-	Legacy radiological uranium contamination from Hanford 300 Area was not reported.
PNNL Richland	2016	H-3	See 2015 Standard	N	-	-	Legacy radiological uranium contamination from Hanford 300 Area was not reported.
PNNL Richland	2017	H-3	See 2015 Standard	N	-	-	Legacy radiological uranium contamination from Hanford 300 Area was not reported.
PNNL Richland	2018	H-3	See 2015 Standard	N	-	-	Legacy radiological uranium contamination from Hanford 300 Area was not reported.

DOE Site	CY	Constituents Monitored in Groundwater (GW)	GW Surveillance Standard	Was a GW Radionuclide Standard Exceeded?	Nuclide Exceeded	Known Onsite GW Plume Constituents of Concern	Comment
PPPL	2015	H-3	DOE O 458.1 and New Jersey Groundwater Standards	N	-	H-3	-
PPPL	2016	H-3	See 2015 Standard	N	-	H-3	-
PPPL	2017	H-3	See 2015 Standard	N	-	H-3	-
PPPL	2018	H-3	See 2015 Standard	N	-	H-3	-
SLAC	2015	H-3	DOE O 458.1 and California State Water Resources Control Board Groundwater Standard	N	-	-	-
SLAC	2016	H-3	See 2015 Standard	N	-	-	-
SLAC	2017	H-3	See 2015 Standard	N	-	-	-
SLAC	2018	H-3	See 2015 Standard	N	-	-	-

5.2 DOE Potable Water Systems Surveillance

While municipalities in the vicinity of many DOE sites provide potable water to the site, some sites maintain their own potable/drinking water supply. These DOE-operated treatment and/or supply systems provide water to site staff, therefore, sanitary sewer releases of the liquid effluent waste would, potentially, be a source of liquid effluents from the DOE site to the offsite environment.

The Federal SDWA (*Safe Drinking Water Act* of 1974) was established to protect the safety and quality of drinking water in the United States and this law focuses on all water sources actually or potentially designed for drinking use, whether from aboveground or underground sources. The Federal SDWA authorizes the EPA to establish minimum standards to protect drinking water at the tap, and this law requires all owners or operators of public water systems to comply with primary, health-related standards. The EPA sets standards for drinking water and oversees the states, localities, and water suppliers who implement those standards. The Federal SDWA was amended in 1986 and 1996 and requires to the protection of drinking water and its sources—rivers, lakes, reservoirs, springs, and groundwater wells.

The Federal SDWA requires that each Federal agency operating or maintaining a public water system to comply with all Federal, State, and local requirements regarding safe drinking water. At a minimum, State drinking water standards must meet Federal standards, though State standards may be more stringent. Potable water systems surveillance at DOE sites is conducted to comply with State and, thereby, Federal requirements.

This section summarizes radiological sampling of potable water supply systems operated by DOE contractors for DOE site use. About 13 sites operate DOE water supply systems (Table 5-6) supplying onsite potable water for onsite use. ANL ended their well-supplied systems by sealing the wells in 2015. ORR, not listed in the table, has an onsite water supply system north of Y-12 that is operated by a municipality, so it is not considered a DOE potable water system.

Table 5-6. Water Sources for DOE Potable Water Systems (2015−2018)

Water Source	EM	NE	NNSA(a)	SC(b)
GW	PORTS WVDP	INL	LLNL Site 300 NNSS PANTEX SNL-TTR	ANL (c) BNL PNNL MSL
GW and SW	HANF SRS	-	-	ANL (c)
SW	PGDP(d)	-	-	-

GW = groundwater; SW = surface water.
(a) SNL-NM receives potable water from a Kirtland AFB-operated supply (GW).
(b) ORR has an onsite water treatment plant, north of the Y-12 Complex. ORR site potable water is supplied by the City of Oak Ridge.
(c) ANL GW supply wells were sealed in 2015 and formally taken out of service in 2016. Beginning in 2016, Lake Michigan water, the only source of domestic water, was purchased from the DuPage Water Commission.
(d) Remote facilities at PGDP used bottled water during CY 2015 – CY 2017.

5.2.1 State Drinking Water Standards

As required, DOE sites maintain compliance with the State drinking water standards, based on the location of the DOE site. State standards for potable water quality for each state in which a DOE site is located are provided in Appendix E. State standards are provided for California, Idaho, Illinois, Kentucky, Nevada, New Jersey, New Mexico, New York, Ohio, South Carolina, Tennessee, Texas, and Washington.

5.2.2 Results of CY 2015−2018 DOE Potable Water System Surveillance

DOE sites acquire potable water supplies for staff and facility use from offsite public water system suppliers or may operate their own public water supply system. This section summarizes radiological surveillance results for potable water systems that DOE contractors operate to supply potable water for onsite staff.

The full suite of radionuclides monitored in potable water at any DOE site are listed in Table 5-7. Gross alpha and gross beta are most commonly analyzed.

Table 5-7. Radioactive Constituents Sampled in Water from DOE Potable Water Systems (2015–2018)

Nuclides and Analyses that May Include Natural Radioactive Background	Other Radionuclides	Transuranic Radionuclides
Ra-228	H-3	Pu-238
U-235	Co-60	Pu-239
Total uranium	Sr-89/90	Am-241
Gross alpha	Sr-90	Cm-244
Gross beta	I-129	
Gamma-emitters	Cs-137	

Table 5-8 provides a summary of reported monitoring results for DOE-operated systems for potable water supplies. Sites not listed do not report such systems in their ASERs.

SRS monitors for the largest number of constituents in potable water supplies. No site reported potable water measurements above the site's applicable standard(s) for CY 2015−2018 sampling.

Table 5-8. Summary of DOE Potable Water System Monitoring (2015–2018)

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
EM						
HANF	2015	GW and SW	gross alpha, gross beta, H-3, Sr-90	DOE O 458.1 and Washington Drinking Water Standards	N	Routine chemical, physical, and microbiological monitoring of Hanford Site drinking water is performed regularly as mandated by EPA's Community Water System requirements. All DOE-owned Hanford Site systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels.
HANF	2016	GW and SW	gross alpha, gross beta, H-3, Sr-90	See 2015 Standard	N	See 2015 HANF comment.
HANF	2017	GW and SW	gross alpha, gross beta, H-3, Sr-90	See 2015 Standard	N	Routine radiological, chemical, physical, and microbiological monitoring of Hanford Site drinking water is performed regularly as mandated by EPA's Community Water System requirements. With the exception of the 300 Area water system, all of the DOE-owned Hanford Site systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels in 2017. The 300 Area water system experienced a maximum contaminant level exceedance for disinfection by-products monitoring in 2017. Transition of the 300 Area operations and responsibilities from the Mission Support Alliance (MSA) to PNNL occurred in October 2017. MSA assisted the PNNL Water Purveyor with the exceedance response, operational updates, and public notifications. MSA Water & Sewer Utilities continued to operate the water system under an inter-contractor work order agreement with PNNL for the remainder of CY 2017.
HANF	2018	GW and SW	gross alpha, gross beta, H-3, Sr-90	See 2015 Standard	N	See 2015 HANF comment.

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
PGDP	2015	SW	gross alpha, gross beta	DOE O 458.1 and Kentucky Drinking Water Standards	N	The PGDP site supplies onsite drinking water from the Ohio River to its facilities. The drinking water system was operated and managed by the Fluor Federal Services, Inc. (FFSI), Paducah Deactivation Project, maintaining compliance with all drinking water requirements. The FFSI Paducah Deactivation Project maintains a water withdrawal permit from the Kentucky Division of Water for up to 30 MGD. Water is pumped from the Ohio River and treated for onsite distribution. Remote facilities use bottled water.
PGDP	2016	SW	gross alpha, gross beta	See 2015 Standard	N	See 2015 PGDP comment.
PGDP	2017	SW	gross alpha, gross beta	See 2015 Standard	N	The PGDP site supplies onsite drinking water from the Ohio River to its facilities. In CY 2017, the drinking water system was operated and managed by the Four Rivers Nuclear Partnership, LLC (FRNP). FRNP maintains a water withdrawal permit from the Kentucky Division of Water for up to 30 MGD. Water is pumped from the Ohio River and treated for onsite distribution. Remote facilities use bottled water.
PGDP	2018	SW	gross alpha, gross beta	See 2015 Standard	N	The PGDP site supplies onsite drinking water from the Ohio River to its facilities. The drinking water system was operated and managed by FRNP. FRNP maintains a water withdrawal permit from the Kentucky Division of Water for up to 30 MGD. Water is pumped from the Ohio River and treated for onsite distribution.
PORTS	2015	GW	-	DOE O 458.1 and Ohio Drinking Water Standards	N	PORTS obtains its drinking water from two water supply well fields, located west of PORTS in the Scioto River Valley buried aquifer near the Scioto River. The Ohio EPA provides the parameters and schedule for sampling. The ASER did not appear to provide drinking water test results.
PORTS	2016	GW	-	See 2015 Standard	N	See 2015 PORTS comment.
PORTS	2017	GW	-	See 2015 Standard	N	See 2015 PORTS comment.
PORTS	2018	GW	-	See 2015 Standard	N	See 2015 PORTS comment.

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
SRS	2015	GW and SW	gross alpha, gross beta, Co-60, Cs-137, Sr-89/90, U-235, Pu-238, Pu-239, Cm-244, H-3, Am-241	DOE O 458.1 and South Carolina Drinking Water Standards	N	SRS DOE potable water supply is from a GW source. Samples were collected at10 SRS locations and 2 South Carolina public water treatment facilities (one upstream and one downstream). Samples were from the onsite water treatment plant in A-Area, four wells, and five small systems. SRS performed gross alpha and gross beta screening on all onsite and offsite drinking water samples. No results exceeded EPA's 15 pCi/L alpha concentration limit or 50 pCi/L beta concentration limit. In addition, no onsite or offsite drinking water samples exceeded the 20,000 pCi/L EPA standard for tritium or the 8 pCi/L strontium-89/90 Maximum Contaminant Limit (MCL).
SRS	2016	GW and SW	gross alpha, gross beta, Co-60, Cs-137, Sr-89/90, U-235, Pu-238, Pu-239, Cm-244, H-3, Am-241	See 2015 Standard	N	See 2015 SRS comment.
SRS	2017	GW and SW	gross alpha, gross beta, Co-60, Cs-137, Sr-89/90, U-235, Pu-238, Pu-239, Cm-244, H-3, Am-241	See 2015 Standard	N	See 2015 SRS comment.
SRS	2018	GW and SW	gross alpha, gross beta, Co-60, Cs-137, Sr-89/90, U-235, Pu-238, Pu-239, Cm-244, H-3, Am-241, U-234, U-238	See 2015 Standard	N	See 2015 SRS comment.

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
WVDP	2015	GW	gross alpha, gross beta, H-3	DOE O 458.1, New York Drinking Water Standards, and Cattaraugus County Drinking Water Standards	N	Onsite potable (drinking) water is supplied by seven groundwater wells. All drinking water results were in compliance with State and Federal standards.
WVDP	2016	GW	gross alpha, gross beta, H-3	See 2015 Standard	N	See 2015 WVDP comment.
WVDP	2017	GW	gross alpha, gross beta, H-3	See 2015 Standard	N	See 2015 WVDP comment.
WVDP	2018	GW	gross alpha, gross beta, H-3	See 2015 Standard	N	See 2015 WVDP comment. A new potable water treatment system went online in early 2018.
NE						
INL	2015	GW	gross alpha, gross beta, H-3, I-129	DOE O 458.1 and Idaho Drinking Water Standards	N	A water production well is located in Building WMF-603 and is the source of drinking water for the Radioactive Waste Management Complex and the Advanced Mixed Waste Treatment Project.
INL	2016	GW	gross alpha, gross beta, H-3, and I-129	See 2015 Standard	N	See 2015 INL comment.
INL	2017	GW	gross alpha, gross beta, H-3, and I-129	See 2015 Standard	N	See 2015 INL comment.
INL	2018	GW	gross alpha, gross beta, H-3, and I-129	See 2015 Standard	N	See 2015 INL comment.
NNSA						
LLNL Site 300	2015	GW	gross alpha, gross beta, H-3,	DOE O 458.1 and California State Water Resources Control Board Drinking Water Standards	N	Water supply well 20, located in the southeastern part of Site 300, is a deep, high-production well. The well is screened in the Neroly lower sandstone aquifer and can produce up to 1,500 L/min (396 gal/min) of potable water.
LLNL Site 300	2016	GW	gross alpha, gross beta, H-3,	See 2015 Standard	N	See 2015 LLNL Site 300 comment.
LLNL Site 300	2017	GW	gross alpha, gross beta, H-3,	See 2015 Standard	N	See 2015 LLNL Site 300 comment.

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
LLNL Site 300	2018	GW	gross alpha, gross beta, H-3,	See 2015 Standard	N	See 2015 LLNL Site 300 comment.
NNSS	2015	GW	H-3, gross alpha, gross beta	DOE O 458.1 and Nevada Drinking Water Quality Standards found in Nevada Revised Statute, Chapter 445A, Water Controls	N	The NNSS supplies drinking water from onsite wells that comply with all drinking water requirements.
NNSS	2016	GW	H-3, gross alpha, gross beta	See 2015 Standard	N	See 2015 NNSS comment.
NNSS	2017	GW	H-3, gross alpha, gross beta	See 2015 Standard	N	See 2015 NNSS comment.
NNSS	2018	GW	H-3, gross alpha, gross beta	See 2015 Standard	N	See 2015 NNSS comment.
PANTEX	2015	GW	NULL	DOE O 458.1 and Texas Drinking Water Standards	N	Radiological monitoring is not required for the non-transient, non-community public water supply at Pantex. During 2015, radiological monitoring was not conducted.
PANTEX	2016	GW	NULL	See 2015 Standard	N	Radiological monitoring is not required for the non-transient, non-community public water supply at Pantex. During 2016, radiological monitoring was not conducted.
PANTEX	2017	GW	NULL	See 2015 Standard	N	Radiological monitoring is not required for the non-transient, non-community public water supply at Pantex. During 2017, radiological monitoring was not conducted.
PANTEX	2018	GW	NULL	See 2015 Standard	N	Radiological monitoring is not required for the non-transient, non-community public water supply at Pantex. During 2018, radiological monitoring was not conducted.
SNL-NM	2015	GW	NULL	DOE O 458.1 and New Mexico Drinking Water Standards	N	At SNL-NM, potable water is provided by the Kirtland Air Force Base Public Water System, and Kirtland Air Force Base is responsible for maintaining compliance with drinking water requirements.
SNL-NM	2016	GW	NULL	See 2015 Standard	N	See 2015 SNL-NM comment.
SNL-NM	2017	GW	NULL	See 2015 Standard	N	See 2015 SNL-NM comment.

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
SNL-NM	2018	GW	NULL	See 2015 Standard	N	See 2015 SNL-NM comment.
SNL-TTR	2015	GW	NULL	DOE O 458.1 and Nevada Drinking Water Standards	N	The public water system at SNL-TTR is permitted by the Nevada Division of Environmental Protection as a non-transient, non-community water system; this public water system is not required to sample or test for radiological contaminants. The USAF (DOD site Nevada Test and Training Range [NTTR]) public water system and the SNL/TTR public water system are designed such that they can, on an as-needed basis, provide backup drinking water to each other.
SNL-TTR	2016	GW	NULL	See 2015 Standard	N	See 2015 SNL-TTR comment.
SNL-TTR	2017	GW	NULL	See 2015 Standard	N	See 2015 SNL-TTR comment.
SNL-TTR	2018	GW	NULL	See 2015 Standard	N	See 2015 SNL-TTR comment.
SC						
ANL	2015	GW	H-3, Sr-90	DOE O 458.1 and Illinois Drinking Water Standards	N	Former Potable Water Supply Wells were sealed in 2015 and ANL's source of potable water is Lake Michigan via a municipal water supply system.
ANL	2016	SW	n/a	See 2015 Standard	n/a	In late 2015, all former potable groundwater wells at ANL were formally taken out of service and sealed in accordance with Illinois Department of Public Health and DuPage County Health Department requirements. Accordingly, in 2016 ANL discontinued the informational monitoring program of site potable groundwater. Potable water is purchased from the DuPage Water Commission, which obtains Lake Michigan water from the City of Chicago water system.
ANL	2017	SW	n/a	See 2015 Standard	n/a	See ANL 2016 comment.
ANL	2018	SW	n/a	See 2015 Standard	n/a	See ANL 2016 comment.
BNL	2015	GW	gross alpha, gross beta, Ra-228, Sr-90, H-3	DOE O 458.1 and New York Drinking Water Standards	N	-
BNL	2016	GW	gross alpha, gross beta, Ra-228, Sr-90, H-3	See 2015 Standard	N	-
BNL	2017	GW	gross alpha, gross beta, Ra-228, Sr-90, H-3	See 2015 Standard	N	-

DOE Site	CY	Potable Water (PW) Source	Constituents Monitored in PW	PW Surveillance Standard	Was a PW Radionuclide Standard Exceeded?	Comment
BNL	2018	GW	gross alpha, gross beta, Ra-228, Sr-90, H-3	See 2015 Standard	N	-
ORR	2015	NULL	NULL	DOE O 458.1 and Tennessee Drinking Water Standards	N	The water treatment plant, located on ORR, north of the Y-12 Complex, is owned and operated by the City of Oak Ridge. The City of Oak Ridge supplies potable water to the facilities on the ORR and is responsible for meeting all regulatory requirements for drinking water.
ORR	2016	NULL	NULL	See 2015 Standard	N	See 2015 ORR comment.
ORR	2017	NULL	NULL	See 2015 Standard	N	See 2015 ORR comment.
ORR	2018	NULL	NULL	See 2015 Standard	N	See 2015 ORR comment.
PNNL MSL	2015	GW	NULL	DOE O 458.1 and Washington Drinking Water Standards	N	Drinking Water for PNNL MSL facilities is provided exclusively from Battelle Land–Sequim onsite wells. PNNL is considered the water purveyor, and PNNL is responsible for all monitoring and sampling of the drinking water distribution system.
PNNL MSL	2016	GW	NULL	See 2015 Standard	N	See 2015 MSL comment.
PNNL MSL	2017	GW	NULL	See 2015 Standard	N	See 2015 MSL comment.
PNNL MSL	2018	GW	NULL	See 2015 Standard	N	See 2015 PNNL MSL comment.
PPPL	2015	offsite	gamma-emitters, H-3	DOE O 458.1 and New Jersey Drinking Water Standards	N	Potable water is supplied by the public utility, New Jersey American Water Company, formerly Elizabethtown Water Company. In April 1984, a sampling point at the input to PPPL (E1 location) was established to provide baseline data for water coming onto the site.
PPPL	2016	offsite	gamma-emitters, H-3	See 2015 Standard	N	See 2015 PPPL comment.
PPPL	2017	offsite	gamma-emitters, H-3	See 2015 Standard	N	See 2015 PPPL comment.
PPPL	2018	offsite	gamma-emitters, H-3	See 2015 Standard	N	See 2015 PPPL comment.

GW = groundwater; SW = surface water.

5.3 Surface Waters and Stormwater Surveillance

Surface water and stormwater surveillance are conducted at DOE sites to ensure compliance with State and Federal water quality standards and NPDES requirements under the Water Quality Standards Regulation (40 CFR Part 131), which interprets part of the *Clean Water Act*. The *Energy Independence and Security Act* of 2007 requires Federal agencies to reduce stormwater runoff from development and redevelopment projects to protect water resources. Stormwater pollution prevention plans are implemented at DOE sites to achieve compliance with State and Federal stormwater discharge requirements.

Stormwater is considered a specific category of surface water in this report (see Section 5.3.3). Stormwater is regulated because it may provide a route for ambient surface water or groundwater contamination.

> Stormwater is the water associated with a rain or snow storm that can be measured in a downstream river, stream, ditch, gutter, or pipe shortly after the precipitation has reached the ground. Stormwater that passes through some sort of engineered conveyance, be it a gutter, a pipe, or a concrete canal, is regulated under the *Clean Water Act* (CWA). Three permit programs under the CWA are used to regulate discharges of stormwater to receiving waters -- one for municipalities, one for construction sites, and one for industrial facilities. Of these, industrial stormwater is particularly challenging to manage because of the wide range of industrial sectors that must be accounted for, each of which produces a unique suite of contaminants in stormwater.[1]

Section 5.3.2 summarizes the surveillance results for the traditionally considered surface water systems (e.g., streams, rivers, etc.). Section 5.3.3 summarizes surveillance results for stormwater sampling.

5.3.1 State Standards

State standards for surface water and stormwater compliance for the state in which a DOE site is located are provided in Appendix E, including California, Idaho, Illinois, Kentucky, Nevada, New Jersey, New Mexico, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, and Washington. Stormwater compliance is regulated mainly through National (or State) Pollutant Discharge Elimination System (NPDES) permits.

5.3.2 Results of CY 2015−2018 Surface Water Surveillance

Ambient surface water systems (e.g., streams, rivers, etc.) are sampled at DOE sites, but this section also summarizes sampling performed at all liquid effluent release points that may discharge directly or indirectly into surface water systems via onsite retention/detention ponds or offsite water treatment plants.

Stormwater surveillance can be regulated by specific stormwater criteria. This is covered in Section 5.3.3.

Table 5-9 lists sites that have no reported surface water surveillance. Surface water surveillance is not commonly reported at some DOE sites because the levels measured are at or below historical background levels.

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[1] NAS (National Academies of Sciences, Engineering, Medicine). 2019. *Improving the Next-Generation EPA Multi-Sector General Permit for Industrial Stormwater Discharges*. From http://dels.nas.edu/Study-In-Progress/Review-Multi-Sector/DELS-WSTB-16-03; accessed 7/23/19.

A wide range of radioactive constituents are sampled in DOE surface water. The specific nuclides mentioned in 2015−2018 ASER sampling are listed in Table 5-10. Details of surface water monitoring at DOE sites are presented in Table 5-11 for all sites reporting such monitoring. Two sites reported exceedences of State surface water standards. During the 2015–2018 period, under EM, SRS reported exceedences for H-3 and under NNSA, LANL reported gross alpha exceedences in ephemeral surface waters.

Table 5-9. DOE Sites with No Reported Surface Water Surveillance (2015–2018)

Program Office-Site	Comment
EERE	
NREL STM	No surface water sampling reported for radionuclides.
EM	
SSFL	The report does not provide information about radiological surface water sampling results.
KNOL SPRU	No surface water sampling reported for radionuclides.
NNSA	
SNL-CA	No surface water sampling reported for radionuclides.
SNL-NM	No surface water sampling reported for radionuclides.
SNL-TTR	No surface water sampling reported for radionuclides.
LLNL Site 300	No surface water sampling reported for radionuclides.
NNSS NLVF	No surface water sampling reported for radionuclides.
SC	
JLAB	No surface water sampling reported for radionuclides.
ORR's ETTP and Y12 (2015–2017)	No surface water sampling reported for radionuclides in the Site Environmental Report.
PNNL MSL	No surface water sampling reported for radionuclides.
PNNL Richland	PNNL prohibits the discharge of liquid waste streams that contain radiological material to sanitary sewer systems, the ground, or surface water.
SLAC	The report does not state that radiological monitoring occurred. The site surface waters include the San Francisquito Creek and the Los Trancos Creek.

Table 5-10. Radioactive Constituents Sampled in Surface Water (2015–2018)

Nuclides and Analyses That May Include Natural Radioactive Background	Other Radionuclides and Analyses	Transuranic Radionuclides
K-40	H-3	Np-237
Tl-208	C-14	Pu-238
Pb-214	Fe-59	Pu-239
Bi-214	Co-60	Pu-239/240
Ac-228	Sr-89/90	Am-241
Ra-226	Sr-90	Cm-242 and/or Cf-252
U-232	Tc-99	Cm-244 and/or Cf-249
U-234	I-129	
U-233/234	Cs-134	
U-235	Cs-137	
U-235/236	Eu-152	
U-238		
Total Uranium		
Gross alpha		
Gross beta		
Gamma-emitters		

Table 5-11. Summary of DOE Sites Surface Water Surveillance (2015–2018)

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
EM						
HANF	2015	Sr-90, H-3, Tc-99, U-234, U-235, U-238, Cs-137, Pu-238, Pu-239/240	DOE O 231.1B, DOE O 458.1, and Washington Surface Water Quality Standards	N	-	H-3, U-234, U-235, and U-238 were detected below the Water Quality Standard. The Columbia River is a receiving surface water.
HANF	2016	Sr-90, H-3, Tc-99, U-234, U-235, U-238, Cs-137, Pu-238, Pu-239/240	See 2015 Standard	N	-	See 2015 HANF comment.
HANF	2017	Sr-90, H-3, Tc-99, U-234, U-235, U-238, Cs-137, Pu-238, Pu-239/240	See 2015 Standard	N	-	See 2015 HANF comment.
HANF	2018	Sr-90, H-3, Tc-99, U-234, U-235, U-238, Cs-137, Pu-238, Pu-239/240	See 2015 Standard	N	-	See 2015 HANF comment.
PGDP	2015	Tc-99, U-234, U-235, U-238	DOE O 231.1B, DOE O 458.1, and Kentucky Surface Water Quality Standards	N	-	The PGDP site is situated in the western part of the Ohio River Basin. The confluence of the Ohio River with the Tennessee River is about 15 mi upstream of the site, and the confluence of the Ohio River with the Mississippi River is about 35 mi downstream. The PGDP site is located on a local drainage divide. Surface water from the east side of the plant flows east-northeast toward Little Bayou Creek, and surface water from the west side of the plant flows west-northwest toward Bayou Creek. Bayou Creek is a perennial stream that flows toward the Ohio River along a 9-mi course. Little Bayou Creek is an intermittent stream that flows north toward the Ohio River along a 7 mi course. The two creeks converge 3 mi north of the plant before emptying into the Ohio River.
PGDP	2016	Tc-99, U-234, U-235, U-238	See 2015 Standard	N	-	See 2015 PGDP comment.
PGDP	2017	Tc-99, U-234, U-235, U-238	See 2015 Standard	N	-	See 2015 PGDP comment.
PGDP	2018	gross alpha, gross beta, Tc-99, U-234, U-235, U-238	See 2015 Standard	N	-	See 2015 PGDP comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
PORTS	2015	Am-241, Np-237, Pu-238, Pu-239/240, Tc-99, U-233/234, U-235/236, U-238	DOE O 231.1B, DOE O 458.1, and Ohio Surface Water Quality Standards	N	-	The receiving waters are Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek.
PORTS	2016	Am-241, Np-237, Pu-238, Pu-239/240, Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PORTS comment.
PORTS	2017	Am-241, Np-237, Pu-238, Pu-239/240, Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PORTS comment.
PORTS	2018	Am-241, Np-237, Pu-238, Pu-239/240, Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PORTS comment.
SRS	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and South Carolina Surface Water Quality Standards	Y	H-3	The H-3 standard was exceeded at Pen Branch and Fourmile Branch. Tritium levels are higher in Fourmile Branch than in the other streams because of shallow groundwater migration from the historical seepage basins and the Solid Waste Disposal Facility. SRS has taken active measures to reduce this migration. To reduce the tritium flux to Fourmile Branch, SRS has taken active measures to reduce this migration by conducting phytoremediation.
SRS	2016	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	The H-3 standard was exceeded at Fourmile Branch. Tritium levels are higher in Fourmile Branch than in the other streams because of shallow groundwater migration from the historical seepage basins and the Solid Waste Disposal Facility. SRS has taken active measures to reduce this migration. To reduce the tritium flux to Fourmile Branch, SRS has taken active measures to reduce this migration.
SRS	2017	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	See 2016 SRS comment.
SRS	2018	gross alpha, gross beta, H-3	See 2015 Standard	Y	H-3	See 2016 SRS comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
WIPP	2015	Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	DOE O 231.1B, DOE O 458.1, and New Mexico Surface Water Quality Standards	N	-	The Pecos River is a receiving water.
WIPP	2016	Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	See 2015 Standard	N	-	See 2015 WIPP comment.
WIPP	2017	Pu-238, Pu-239-240, Am-241, K-40, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	See 2015 Standard	N	-	See 2015 WIPP comment.
WIPP	2018	Pu-238, Pu-239/240, Am-241, K-40, Co-60, Cs-137, Sr-90, U-233/234, U-235, U-238	See 2015 Standard	N	-	See 2015 WIPP comment.
WVDP	2015	gross alpha, gross beta, C-14, Cs-137, Sr-90, Tc-99, I-129, U-232, U-233/234, U-235/236, U-238, total U, Pu-238, Pu-239/240, Am-241	DOE O 231.1B, DOE O 458.1, and New York Surface Water Quality Standards	N	-	The receiving waters are North Swamp, Northeast Swamp, Franks Creek, Cattaraugus Creek, and Buttermilk Creek.
WVDP	2016	gross alpha, gross beta, C-14, Cs-137, Sr-90, Tc-99, I-129, U-232, U-233/234, U-235/236, U-238, total U, Pu-238, Pu-239/240, Am-241	See 2015 Standard	N	-	See 2015 WVDP comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
WVDP	2017	gross alpha, gross beta, C-14, Cs-137, Sr-90, Tc-99, I-129, U-232, U-233/234, U-235/236, U-238, total U, Pu-238, Pu-239/240, Am-241	See 2015 Standard	N	-	See 2015 WVDP comment.
WVDP	2018	gross alpha, gross beta, H-3, C-14, Sr-90, I-129, Cs-137, U-232, U-233/234, U-235/236, U-238, Pu-238, Pu-239/240, Am-241, Tc-99	See 2015 Standard	N	-	See 2015 WVDP comment.
NE						
INL	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and Idaho Surface Water Quality Standards	N	-	Gross alpha, gross beta, and H-3 were detected; these contaminants did not exceed the standard. Most of the site is in the closed Mud Lake-Lost River drainage basin, which has been informally named the Pioneer Basin. Surface waters within the Pioneer Basin include the Big Lost River, the Little Lost River, and Birch Creek drainages, which drain mountain watersheds located to the north and northwest of the site. All three drainages may flow onto the site during high flow years but are otherwise ephemeral.
INL	2016	gross alpha, gross beta, H-3, Am-241, Pu-238, Pu-239/240, Sr-90	See 2015 Standard	N	-	Am-241, Pu-239/240, and Sr-90 were detected; these contaminants did not exceed the standard. Most of the site is in the closed Mud Lake-Lost River drainage basin, which has been informally named the Pioneer Basin. Surface waters within the Pioneer Basin include the Big Lost River, the Little Lost River, and Birch Creek drainages, which drain mountain watersheds located to the north and northwest of the site. All three drainages may flow onto the site during high flow years but are otherwise ephemeral.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
INL	2017	gross alpha, gross beta, H-3, Am-241, Pu-238, Pu-239/240, Sr-90	See 2015 Standard	N	-	Am-241, Pu-238, Pu-239/240, and Sr-90 were detected; these contaminants did not exceed the standard. Most of the site is in the closed Mud Lake-Lost River drainage basin, which has been informally named the Pioneer Basin. Surface waters within the Pioneer Basin include the Big Lost River, the Little Lost River, and Birch Creek drainages, which drain mountain watersheds located to the north and northwest of the site. All three drainages may flow onto the site during high flow years but are otherwise ephemeral.
INL	2018	gross alpha, gross beta, H-3, Am-241, Pu-238, Pu-239/240, Sr-90	See 2015 Standard	N	-	Gross alpha activity was detected in one sample. Gross beta activity was detected in all surface water samples. Tritium was detected in two of the six surface water samples.
NNSA						
LANL	2015	gross alpha	DOE O 231.1B, DOE O 458.1, and New Mexico Surface Water Quality Standards	Y	gross alpha	Surface water in the Los Alamos region occurs primarily as ephemeral or intermittent flow. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flow across the Laboratory property before the water is lost to evaporation, transpiration, and infiltration.
LANL	2016	gross alpha	See 2015 Standard	Y	gross alpha	See 2015 LANL comment.
LANL	2017	gross alpha	See 2015 Standard	Y	gross alpha	See 2015 LANL comment.
LANL	2018	gross alpha	See 2015 Standard	Y	gross alpha	See 2015 LANL comment.
LLNL	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and California State Water Resources Control Board Surface Water Quality Standards	N	-	Gross alpha, H-3, and gross beta were detected below the MCL. Corral Hollow Creek is an ephemeral receiving water.
LLNL	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 LLNL comment.
LLNL	2017	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 LLNL comment.
LLNL	2018	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 LLNL comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
NNSS	2015	gross alpha, gross beta, H-3	DOE Order 458.1 and Nevada Surface Water Quality Standards	N	-	UE-5 PW-1, -2, and -3 are a compliance wells/surface water. NNSS operations do not require NPDES permitting. Jackass Flats is topographically open, and surface water from this basin flows off the NNSS via the Fortymile Wash.
NNSS	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 NNSS comment.
NNSS	2017	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 NNSS comment.
NNSS	2018	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 NNSS comment.
PANTEX	2015	Pu-238, Pu-239/240, H-3, U-233/234, U-235/236, U-238	DOE O 231.1B, DOE O 458.1, and Texas Surface Water Quality Standards	N	-	The report says surface water was sampled but results were not displayed.
PANTEX	2016	H-3, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PANTEX comment.
PANTEX	2017	H-3, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PANTEX comment.
PANTEX	2018	H-3, U-235/236, U-238	See 2015 Standard	N	-	See 2015 PANTEX comment.
NNSA-NNPP						
BETTIS	2015	gross alpha, gross beta, gamma-emitters, Sr-90, U-234, U-235, U-238	DOE O 231.1B, DOE O 458.1, and Pennsylvania Surface Water Quality Standards	N	-	Bull Run Stream is a receiving water.
BETTIS	2016	gross alpha, gross beta, Sr-90, U-234, U-235, U-238	See 2015 Standard	N	-	Bull Run Stream is a receiving water.
BETTIS	2017	gross alpha, gross beta, Sr-90, U-234, U-235, U-238	See 2015 Standard	N	-	Bull Run Stream is a receiving water.
BETTIS	2018	gross alpha, gross beta, Sr-90, U-234, U-235, U-238, gamma-emitters, Co-60, Cs-137	See 2015 Standard	N	-	Site-generated radioactivity was not released to the Site's effluent streams or sanitary sewers.
KESS	2015	H-3, Co-60	DOE O 231.1B, DOE O 458.1, and New York Surface Water Quality Standards	N	-	The Kesselring Site is located in the transition zone between the Adirondack Mountains and the Hudson-Mohawk Valley lowland. Kayaderosseras Creek forms the main drainage system in the vicinity of KESS.
KESS	2016	H-3, Co-60	See 2015 Standard	N	-	See 2015 KESS comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
KESS	2017	H-3, Co-60	See 2015 Standard	N	-	See 2015 KESS comment.
KESS	2018	H-3, Co-60	See 2015 Standard	N	-	See 2015 KESS comment.
KNOL	2015	gross alpha, gross beta, Sr-90, Cs-137, H-3	DOE O 231.1B, DOE O 458.1, and New York Surface Water Quality Standards	N	-	The Knolls Laboratory is located in the Mohawk River Valley. The Mohawk River is the main receiving surface water.
KNOL	2016	gross alpha, gross beta, Sr-90, Cs-137, H-3	See 2015 Standard	N		See 2015 KNOL comment.
KNOL	2017	gross alpha, gross beta, Sr-90, Cs-137, H-3	See 2015 Standard	N		See 2015 KNOL comment.
KNOL	2018	gross alpha, gross beta, Sr-90, Cs-137, H-3	See 2015 Standard	N		See 2015 KNOL comment.
SC						
ANL	2015	gross alpha, gross beta, H-3, Sr-90, Cs-137, U-234, U-238, Np-237, Pu-238, Pu-239, Am-241, Cm-242 and/or Cf-252, Cm-244 and/or Cf-249	DOE O 231.1B, DOE O 458.1, and Illinois Surface Water Quality Standards	N	-	Gross alpha, gross beta, H-3, Sr-90, Cs-137, U-234, U-238, Np-237, Pu-238, Pu-239, Am-241, Cm-242 and/or Cf-252, and Cm-244 and/or Cf-249 were detected and did not exceed the standard. Sawmill Creek runs through the ANL site, drains surface water from a substantial amount of the site, and flows into the Des Plaines River.
ANL	2016	gross alpha, gross beta, H-3, Sr-90, Cs-137, U-234, U-238, Np-237, Pu-238, Pu-239, Am-241, Cm-242 and/or Cf-252, Cm-244 and/or Cf-249	See 2015 Standard	N	-	See 2015 ANL comment.
ANL	2017	gross alpha, gross beta, H-3, Sr-90, Cs-137, U-234, U-238, Np-237, Pu-238, Pu-239, Am-241, Cm-242 and/or Cf-252, Cm-244 and/or Cf-249	See 2015 Standard	N	-	See 2015 ANL comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
ANL	2018	gross alpha, gross beta, H-3, Sr-90, Cs-137, U-234, U-238, Np-237, Pu-238, Pu-239, Am-241, Cm-242 and/or Cf-252, Cm-244 and/or Cf-249	See 2015 Standard	N	-	See 2015 ANL comment.
BNL	2015	gross alpha, gross beta, H-3, Sr-90	DOE O 231.1B, DOE O 458.1, and New York Surface Water Quality Standards	N	-	Gross alpha, gross beta, H-3, and Sr-90 were detected and did not exceed the standard. The Peconic River and the Carmans River are receiving waters.
BNL	2016	gross alpha, gross beta, H-3, Sr-90	See 2015 Standard	N	-	See 2015 BNL comment.
BNL	2017	gross alpha, gross beta, H-3, Sr-90	See 2015 Standard	N	-	See 2015 BNL comment.
BNL	2018	gross alpha, gross beta, H-3, Sr-90, gamma-emitters	See 2015 Standard	N	-	See 2015 BNL comment.
FERMI	2015	H-3	DOE O 231.1B, DOE O 458.1, and Illinois Surface Water Quality Standards	N	-	H-3 was detected but did not exceed the standard. The site surface waters include Kress Creek, Indian Creek, and Ferry Creek.
FERMI	2016	H-3	See 2015 Standard	N	-	See 2015 FERMI comment.
FERMI	2017	H-3	See 2015 Standard	N	-	See 2015 FERMI comment.
FERMI	2018	H-3	See 2015 Standard	N	-	See 2015 FERMI comment.
JLAB	2015	n/a	DOE O 231.1B, DOE O 458.1, and Virginia Surface Water Quality Standards	N	-	Potential radiological wastewater is discharged to the Hampton Roads Sanitation District. Brick Kiln Creek and the James River are receiving waters. The ASER states the following: "No accelerator-produced radioactivity was detected in any of the samples from the End Station Sump or in surface water." The ASER does not appear to report surface water sampling results.
JLAB	2016	n/a	See 2015 Standard	N	-	See 2015 JLAB comment.
JLAB	2017	n/a	See 2015 Standard	N	-	See 2015 JLAB comment.
JLAB	2018	n/a	See 2015 Standard	N	-	See 2015 JLAB comment.
LBNL	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and California State Water Resources Control Board Surface Water Quality Standards	N	-	Gross alpha and gross beta were detected below the MCL. LBNL lies within the Strawberry Creek watershed. The two main creeks in this watershed receiving stormwater discharges from LBNL are the South Fork of Strawberry Creek (in Strawberry Canyon) and the North Fork of Strawberry Creek (in Blackberry Canyon).

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
LBNL	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 LBNL comment.
LBNL	2017	gross alpha, gross beta, H-3, Ac-228, Bi-214, Cs-134, Cs-137, Eu-152, Fe-59, Pb-214, Ra-226, Tl-208, U-238	See 2015 Standard	N	-	See 2015 LBNL comment.
LBNL	2018	gross alpha, gross beta, H-3, Ac-228, Am-241, Sb-124, Bi-214, Cs-137, Eu-152, Pb-214, K-40, Ra-226, Th-234, U-235, U-238, gamma-emitters	See 2015 Standard	N	-	See 2015 LBNL comment.
ORR ETTP (EM)	2015	n/a	DOE O 231.1B, DOE O 458.1, and Tennessee Surface Water Quality Standards	N	-	In 2015, the monitoring results yielded sums of fractions less than 2 percent of the allowable derived concentration standards at all surface water surveillance locations at ORR ETTP. The ORR lies within the Valley and Ridge Physiographic Province, which is composed of a series of drainage basins or troughs containing many small streams feeding the Clinch River. Surface water on the ORR drains into a tributary or series of tributaries, streams, or creeks within different watersheds. Each of these watersheds drains into the Clinch River which, in turn, flows into the Tennessee River.
ORR Y-12 (NNSA)	2015	n/a	DOE O 231.1B, DOE O 458.1, and Tennessee Surface Water Quality Standards	N	-	In 2015, the monitoring results yielded sums of fractions that were 8.2 percent of the allowable derived concentration standards at Outfall S24.
ORR ORNL (SC)	2015	gross alpha, gross beta, Sr-89/90, gamma-emitters, and H-3	DOE O 231.1B, DOE O 458.1, and Tennessee Surface Water Quality Standards	N	-	In 2015, radionuclides were not reported above 4% of the derived concentration standards at the Fifth Creek (FFK 0.1) location.
ORR ETTP (EM)	2016	n/a	See 2015 Standard	N	-	In 2016, the monitoring results yielded sums of fractions less than 1 percent of the allowable derived concentration standards at all surface water surveillance locations at ORR ETTP.
ORR Y-12 (NNSA)	2016	n/a	See 2015 Standard	N	-	In 2016, the monitoring results yielded sums of fractions that were 9.5 percent of the allowable derived concentration standards at Outfall S24.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
ORR ORNL (SC)	2016	gross alpha, gross beta, Sr-89/90, gamma-emitters, and H-3	See 2015 Standard	N	-	In 2016, radionuclides were not reported above 4% of the derived concentration standards at the Fifth Creek (FFK 0.1) location.
ORR ETTP (EM)	2017	n/a	See 2015 Standard	N	-	In 2017, the monitoring results yielded sums of fractions less than 1 percent of the allowable derived concentration standards at all surface water surveillance locations at ORR ETTP.
ORR Y-12 (NNSA)	2017	n/a	See 2015 Standard	N	-	In 2017, the monitoring results yielded sums of fractions that were 6.4 percent of the allowable derived concentration standards at Outfall S24.
ORR ORNL (SC)	2017	gross alpha, gross beta, Sr-89/90, gamma-emitters, and H-3	See 2015 Standard	N	-	In 2017, radionuclides were not reported above 4% of the derived concentration standards at the Fifth Creek (FFK 0.1) location.
ORR ETTP (EM)	2018	Tc-99	See 2015 Standard	N	-	In 2018, the monitoring results yielded sums of fractions that were 2.2 percent of the allowable derived concentration standards at all surface water surveillance locations.
ORR Y-12 (NNSA)	2018	gross alpha, gross beta, U-238, U-235, U-234, Sr-90, Tc-99, Cs-137, Am-241, Np-237, Pu-238, Pu-239/240, Th-232, Th-230, Th-228, Ra-226, Ra-228, H-3	See 2015 Standard	N	-	In 2018, the monitoring results yielded sums of fractions that were 7.4 percent of the allowable derived concentration standards at Outfall S24.
ORR ORNL (SC)	2018	gross alpha, gross beta, Sr-89/90, gamma-emitters, H-3	See 2015 Standard	N	-	In 2018, radionuclides were not reported above 4% of the derived concentration standards at the Fifth Creek (FFK 0.1) location.
PNNL MSL	2015	n/a	DOE O 231.1B, DOE O 458.1, and Washington Surface Water Quality Standards	N	-	Process wastewater from MSL facilities is discharged directly to Sequim Bay under the authorization of an NPDES permit issued by the Washington State Department of Ecology, after treatment by an onsite wastewater treatment system. All waste streams regulated by this permit are reviewed by PNNL staff and evaluated for compliance prior to discharge. Radiological sampling does not appear to be reported.
PNNL MSL	2016	n/a	See 2015 Standard	N	-	See 2015 PNNL MSL comment.

DOE Site	CY	Surface Water (SW) Surveillance Constituent	SW Surveillance Standard	Was SW Standard Exceeded?	SW Constituent Exceeded	Comment
PNNL MSL	2017	n/a	See 2015 Standard	N	-	See 2015 PNNL MSL comment.
PNNL MSL	2018	n/a	See 2015 Standard	N	-	See 2015 PNNL MSL comment.
PNNL Richland	2015	n/a	DOE O 231.1B, DOE O 458.1, and Washington Surface Water Quality Standards	N	-	On the PNNL Richland Campus, the discharge of process wastewater to the City of Richland sanitary sewer system, which discharges to the Columbia River, is governed by City of Richland industrial wastewater discharge permits. All waste streams regulated by these permits are reviewed by PNNL staff and evaluated for compliance with the applicable permit prior to discharge. Radiological sampling does not appear to be reported. PNNL prohibits the discharge of radiological liquid waste streams to sanitary sewers (unless approved and compliant), groundwater, or surface water.
PNNL Richland	2016	n/a	See 2015 Standard	N	-	See 2015 PNNL comment.
PNNL Richland	2017	n/a	See 2015 Standard	N	-	See 2015 PNNL comment.
PNNL Richland	2018	n/a	See 2015 Standard	N	-	See 2015 PNNL comment.
PPPL	2015	H-3	DOE O 231.1B, DOE O 458.1, and New Jersey Surface Water Quality Standards	N	-	Bee Brook and Devil's Brook are receiving waters.
PPPL	2016	H-3	See 2015 Standard	N	-	See 2015 PPPL comment.
PPPL	2017	H-3	See 2015 Standard	N	-	See 2015 PPPL comment.
PPPL	2018	H-3	See 2015 Standard	N	-	See 2015 PPPL comment.

5.3.3 Results of CY 2015−2018 Stormwater Surveillance

Stormwater is the water produced by the interaction of precipitation events and the physical environment, such as buildings, pavement, and the ground surface. Stormwater runoff can move directly into fresh or marine waters, or it may flow into a storm drain system until it discharges into the environment. Stormwater management activities include implementing best management practices and stormwater pollution prevention plans to ensure stormwater runoff meets required standards.

DOE sites that either did not report whether stormwater was sampled or were not required to perform such surveillance are identified in Table 5-12. These sites are not discussed further in this section.

Table 5-12. DOE Sites with No Reported Stormwater Surveillance (2015–2018)

Program Office-Site	Comment
EERE	
NREL STM	Stormwater sampling is not reported for radionuclides.
EM	
WIPP	The report does not state that stormwater radiological monitoring occurred.
KNOL SPRU	Stormwater sampling is not reported for radionuclides.
HANF	Stormwater sampling is not reported for radionuclides.
PGDP	Stormwater sampling is not reported for radionuclides.
NE	
INL	Stormwater sampling is not sampled for radionuclides.
NNSA	
SNL-TTR	Stormwater sampling is not required.
LLNL Site 300	Stormwater sampling is not reported for radionuclides.
NNSS	NNSS has a conditional exemption from the NPDES Storm Water Program and a State of Nevada Stormwater General Permit.
NNSS NLVF	NNSS NLVF has a conditional exemption from the NPDES Storm Water Program and a State of Nevada Stormwater General Permit.
PANTEX (2018)	Stormwater sampling is not reported for radionuclides.
SNL-CA (2017, 2018)	Stormwater sampling is not reported for radionuclides.
NNSA-NNPP	
INL NRF	INL NRF was exempted under an Executive Order; INL NRF publishes a separate environmental monitoring report.
KESS	Stormwater drains to sampled surface water locations. See section 5.3.2.
KNOL	Stormwater drains to sampled surface water locations. See section 5.3.2.
SC	
JLAB	Stormwater sampling is not required because of Best Management Practices implemented.
LBNL	The stormwater permit does not require radiological monitoring.
PNNL MSL	Stormwater sampling is not reported for radionuclides.
PNNL Richland	Stormwater sampling is not reported for radionuclides.
PPPL	The report does not state stormwater is monitored for radiological contaminants.

Table 5-13 indicates the DOE sites that perform stormwater surveillance. A wide range of radioactive constituents are sampled in DOE onsite stormwater. The specific radionuclides mentioned in 2015−2018

ASER sampling are listed in Table 5-13. The list is similar to that for surface water sampling but includes a longer list of natural background materials.

Table 5-13. Radioactive Constituents Sampled in Stormwater at DOE Sites (2015−2018)

Nuclides That May Include Natural Radioactive Background	Other Radiobnuclides and Analyses	Transuranic Radionuclides
Be-7	H-3	Np-237
K-40	C-14	Pu-238
Pb-212	Na-22	Pu-239/240
Pb-214	Co-60	Am-241
Bi-212	Sr-89/90	
Ac-228	Sr-90	
Ra-223	Tc-99	
Ra-224	Cs-137	
Ra-226		
Ra-228		
Th-227		
Th-231		
Th-234		
U-233/234		
U-235		
U-235/236		
U-238		
Uranium isotopes		
Gross alpha		
Gross beta		
Gamma-emitters		

Details of stormwater monitoring at DOE sites from 2015–2018 are presented in Table 5-14.

Four DOE sites had stormwater sampling results above applicable limits during at least one year from 2015–2018. Exceedences were reported for locations under EM oversight, SRS for H-3; under NNSA oversight, LANL for Ra-226, Ra-228, and gross alpha and SNL-NM for gross alpha; and under SC oversight, ORR for Sr-89/90, U-233/234, U-238, gross alpha, and gross beta.

Table 5-14. Summary of ASER Stormwater Surveillance (2015–2018)

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
EM						
PORTS	2015	U-233/234, U-235/236, U-238, Tc-99, Am-241, Np-237, Pu-238, Pu-239/240	DOE O 231.1B, DOE O 458.1, and State of Ohio NPDES permit	N	-	-
PORTS	2016	U-233/234, U-235/236, U-238, Tc-99, Am-241, Np-237, Pu-238, Pu-239/240	See 2015 Standard	N	-	-
PORTS	2017	U-233/234, U-235/236, U-238, Tc-99, Am-241, Np-237, Pu-238, Pu-239/240	See 2015 Standard	N	-	-
PORTS	2018	U-233/234, U-235/236, U-238, Tc-99, Am-241, Np-237, Pu-238, Pu-239/240	See 2015 Standard	N	-	-
SRS	2015	gross alpha, gross beta, Sr-90, H-3	DOE O 231.1B, DOE O 458.1, and NPDES permit	Y	H-3	The H-3 maximum reported exceedance value was 32,200 pCi/L.
SRS	2016	gross alpha, gross beta, Sr-90, Tc-99, C-14, H-3	See 2015 Standard	Y	H-3	The H-3 maximum reported exceedance value was 21,400 pCi/L.
SRS	2017	gross alpha, gross beta, Sr-90, Tc-99, C-14, H-3	See 2015 Standard	Y	H-3	The H-3 maximum reported exceedance value was 18,400 pCi/L.
SRS	2018	gross alpha, gross beta, Sr-90, Tc-99, C-14, H-3, gamma-emitters	See 2015 Standard	Y	H-3	The H-3 maximum reported exceedance value was 59,500 pCi/L.

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
SSFL	2015	gross alpha, gross beta, H-3, Sr-90, Ra-226, Ra-228, K-40, Cs-137, Uranium isotopes	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	The report states radiological stormwater is monitored and the report does not provide detailed information about radiological sampling results.
SSFL	2016	gross alpha, gross beta, H-3, Sr-90, Ra-226, Ra-228, K-40, Cs-137, Uranium isotopes	See 2015 Standard	N	-	See 2015 SSFL comment.
SSFL	2017	gross alpha, gross beta, H-3, Sr-90, Ra-226, Ra-228, K-40, Cs-137, Uranium isotopes	See 2015 Standard	N	-	See 2015 SSFL comment.
SSFL	2018	gross alpha, gross beta, H-3, Sr-90, Ra-226, Ra-228, K-40, Cs-137, Uranium isotopes	See 2015 Standard	N	-	See 2015 SSFL comment.
NE						
INL	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	-	-	INL monitors storm water runoff primarily for nonradioactive constituents, to comply with applicable laws and regulations, DOE orders, and other requirements.
INL	2016	-	See 2015 Standard	-	-	See 2015 INL comment.
INL	2017	-	See 2015 Standard	-	-	See 2015 INL comment.
INL	2018	-	See 2015 Standard	-	-	See 2015 INL comment.
NNSA						
LANL	2015	gross alpha, Ra-226, Ra-228	DOE O 231.1B, DOE O 458.1, and NPDES permit	Y	Ra-226, Ra-228	2 sampling locations reported a total of 9 exceedances of Ra-228 and 2 exceedances of Ra-226.
LANL	2016	gross alpha	See 2015 Standard	Y	gross alpha	15 sampling locations reported a total of 27 exceedances of gross alpha.
LANL	2017	gross alpha	See 2015 Standard	Y	gross alpha	18 sampling locations reported a total of 38 exceedances of gross alpha.
LANL	2018	gross alpha	See 2015 Standard	Y	gross alpha	30 exceedances were reported from a total of 47 analyses.

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
LLNL	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	Gross alpha, gross beta, and H-3 were detected and did not exceed the standard.
LLNL	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	Gross alpha, gross beta, and H-3 were detected and did not exceed the standard.
LLNL	2017	gross alpha, gross beta, H-3	See 2015 Standard	N	-	Gross alpha, gross beta, and H-3 were detected and did not exceed the standard.
LLNL	2018	gross alpha, gross beta, H-3	See 2015 Standard	N	-	Gross alpha, gross beta, and H-3 were detected and the standards were not exceeded.
NNSS	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	Storm Water No Exposure Waiver ISW-40565 was approved on July 16, 2015 and it provides a conditional exemption from the NPDES Storm Water Program and the State of Nevada Stormwater General Permit. The conditions specify that stormwater discharges from the NLVF will not be exposed to industrial activities or materials. No stormwater exposures to such activities or materials occurred.
NNSS	2016	-	See 2015 Standard	N	-	See NNSS 2015 comment.
NNSS	2017	-	See 2015 Standard	N	-	See NNSS 2015 comment.
NNSS	2018	-	See 2015 Standard	N	-	See NNSS 2015 comment.
PANTEX	2015	Pu-238, Pu-239/240, H-3, U-233/234, U-235/236, U-238	DOE O 231.1B, DOE O 458.1, and Texas Pollutant Discharge Elimination System permit	N	-	The report indicates that stormwater was sampled without displaying results.
PANTEX	2016	H-3, U-235/236, U-238	See 2015 Standard	N	-	The report indicates that stormwater was sampled without displaying results.
PANTEX	2017	H-3, U-235/236, U-238	See 2015 Standard	N	-	The report indicates that stormwater was sampled without displaying results.
PANTEX	2018	-	See 2015 Standard	N	-	-
SNL-CA	2015	H-3	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	-
SNL-CA	2016	H-3	See 2015 Standard	N	-	-
SNL-CA	2017	-	See 2015 Standard	N	-	The report does not state stormwater is monitored for radiological contaminants in CY 2017.
SNL-CA	2018	-	See 2015 Standard	N	-	The report does not state stormwater is monitored for radiological contaminants in CY 2018.

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
SNL-NM	2015	gross alpha, gross beta, Ac-228, Am-241, Be-7, Bi-212, Cs-137, Co-60, Pb-212, Pb-214, Np-237, K-40, Ra-223, Ra-224, Ra-226, Ra-228, Na-22, Th-227, Th-231, Th-234, U-235, U-238	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	Arroyo del Coyote surface water location (SWSP-07).
SNL-NM	2016	-	See 2015 Standard	N	-	Appendix D information for 2016 indicates no radiological constituents were sampled in stormwater.
SNL-NM	2017	gross alpha	See 2015 Standard	N	-	-
SNL-NM	2018	gross alpha	See 2015 Standard	Y	gross alpha	-
NNSA-NNPP						
BETTIS	2015	gross alpha, gross beta, Sr-90, Cs-137, Co-60, U-235, U-238	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	-
BETTIS	2016	Sr-90, Cs-137, Co-60	See 2015 Standard	N	-	-
BETTIS	2017	gross alpha, gross beta, gamma-emitters, Sr-90, U-235, U-238	See 2015 Standard	N	-	-
BETTIS	2018	gross alpha, gross beta, gamma-emitters, Sr-90, U-235, U-238	See 2015 Standard	N	-	-
SC						
ANL	2015	H-3, Sr-90, Cs-137	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	H-3, Sr-90, and Cs-137 were detected and did not exceed the standard.
ANL	2016	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	See 2015 ANL comment.
ANL	2017	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	See 2015 ANL comment.

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
ANL	2018	H-3, Sr-90, Cs-137	See 2015 Standard	N	-	See 2015 ANL comment.
BNL	2015	gross alpha, gross beta, H-3	DOE O 231.1B, DOE O 458.1, and New York State Pollution Discharge Elimination System permit	N	-	Gross alpha, gross beta, and H-3 were detected and did not exceed the standard.
BNL	2016	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 BNL comment.
BNL	2017	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 BNL comment.
BNL	2018	gross alpha, gross beta, H-3	See 2015 Standard	N	-	See 2015 BNL comment.
FERMI	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	The CY 2015 Environment Report notes stormwater was tested; the report does not provide stormwater test results.
FERMI	2016	-	See 2015 Standard	N	-	The CY 2016 Environment Report notes stormwater was tested; the report does not provide stormwater test results.
FERMI	2017	-	See 2015 Standard	N	-	The CY 2017 Environment Report notes stormwater was tested; the report does not provide stormwater test results.
FERMI	2018	-	See 2015 Standard	N	-	The CY 2018 Environment Report notes stormwater was tested; the report does not provide stormwater test results.
ORR ETTP (EM)	2015	gross alpha, gross beta, Tc-99, U-233/234, U-235/236, and U-238	DOE O 231.1B, DOE O 458.1, and NPDES permit	Y	gross alpha, gross beta, U-233/234, U-238	The gross alpha maximum exceedance value was 92.9 pCi/L. The gross beta maximum exceedance value was 40.5 pCi/L. The U-233/234 maximum exceedance value was 102 pCi/L. The U-238 maximum exceedance value was 69.8 pCi/L.
ORR Y-12 (NNSA)	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	In 2015, the monitoring results yielded sums of fractions that were 3.1 percent of the allowable derived concentration standards at Outfall 135.
ORR ORNL (SC)	2015	gross alpha, gross beta, Tc-99, U-233/234, U-235/236, U-238	DOE O 231.1B, DOE O 458.1, and NPDES permit	Y	Sr-89/90	The Sr-89/90 concentration at outfall 004 was 17% of the derived concentration standard (DCS).
ORR ETTP (EM)	2016	gross alpha, gross beta, Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	N	-	In 2016, radiological stormwater monitoring did not exceed 4 percent of the DCS.

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
ORR Y-12 (NNSA)	2016	-	See 2015 Standard	N	-	In 2016, the monitoring results yielded sums of fractions that were 3.1 percent of the allowable DCSs at Outfall 135.
ORR ORNL (SC)	2016	gross alpha, gross beta, Sr-89/90, gamma-emitters, and H-3	See 2015 Standard	N	-	In 2016, none of the stormwater outfalls had a radionuclide concentration in stormwater that was greater than 4 percent of the DCS.
ORR ETTP (EM)	2017	gross alpha, gross beta, Tc-99, U-233/234, U-235/236, U-238	See 2015 Standard	Y	gross alpha and U-233/234	The gross alpha exceedance value was 47.6 pCi/L. The U-233/234 exceedance value was 34.3 pCi/L.
ORR Y-12 (NNSA)	2017	-	See 2015 Standard	N	-	In 2017, the monitoring results yielded sums of fractions that were 0.99 percent of the allowable DCSs at Outfall 135.
ORR ORNL (SC)	2017	gross alpha, gross beta, Sr-89/90, gamma-emitters, H-3	See 2015 Standard	N	-	-
ORR ETTP (EM)	2018	gross alpha, gross beta, Tc-99, U-233/234, U 235/236, U-238	See 2015 Standard	Y	gross alpha	The gross alpha exceedance value was 22.5 pCi/L.
ORR Y-12 (NNSA)	2018	U-238, U-235, U-234, Sr-90, Tc-99, Cs-137, Am-241, Np-237, Pu-238, Pu-239/240, Th-232, Th-230, Th-228, Ra-226, Ra-228	See 2015 Standard	N	-	In 2018, the monitoring results yielded sums of fractions that were 0.77 percent of the allowable DCSs at Outfall 135.
ORR ORNL (SC)	2018	gross alpha, gross beta, Sr-89/90, gamma-emitters, H-3	See 2015 Standard	N	-	-

DOE Site	CY	Stormwater (StormW) Surveillance Constituent	StormW Surveillance Standard	Was StormW Standard Exceeded?	StormW Constituent Exceeded	Comment
PNNL MSL	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	Stormwater discharges from PNNL MSL are not subject to Federal or State NPDES stormwater regulations. Stormwater at PNNL MSL is managed via a stormwater drain system that includes grated drain boxes for paved areas and a trench that drains to an infiltration pond. The infiltration pond is an engineered stormwater collection basin with an overflow trench.
PNNL MSL	2016	-	See 2015 Standard	N	-	See 2015 PNNL MSL comment.
PNNL MSL	2017	-	See 2015 Standard	N	-	See 2015 PNNL MSL comment.
PNNL MSL	2018	-	See 2015 Standard	N	-	See 2015 PNNL MSL comment.
PNNL Richland	2015	-	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	Stormwater discharges from the PNNL Campus comply with Federal and State NPDES stormwater regulations. PNNL's registrations of underground injection wells for stormwater and injection of ground-source heat pump return flow water have been completed as required.
PNNL Richland	2016	-	See 2015 Standard	N	-	See 2015 PNNL Richland comment.
PNNL Richland	2017	-	See 2015 Standard	N	-	See 2015 PNNL Richland comment.
PNNL Richland	2018	-	See 2015 Standard	N	-	See 2015 PNNL Richland comment.
SLAC	2015	Specific constituent sampling not indicated.	DOE O 231.1B, DOE O 458.1, and NPDES permit	N	-	The report states the following: "In CY 2015 (and in all previous years), no radioactivity above natural background was found in any stormwater or storm drain sediment samples." Stormwater was sampled for radioactivity; the constituents tested are not listed.
SLAC	2016	Specific constituent sampling not indicated.	See 2015 Standard	N	-	The report states the following: "In CY 2016 (and in all previous years), no radioactivity above natural background was found in any stormwater or storm drain sediment samples." Stormwater was sampled for radioactivity; the constituents tested are not listed.
SLAC	2017	Specific constituent sampling not indicated.	See 2015 Standard	N	-	The report states the following: "As in all previous years, in CY 2017, no radioactivity above natural background was found in any stormwater or storm drain sediment samples."
SLAC	2018	Specific constituent sampling not indicated.	See 2015 Standard	N	-	The report states the following: "As in all previous years, in CY 2018, no radioactivity above natural background was found in any stormwater or storm drain sediment samples."

5.4 References

33 U.S.C. 1251 et seq., *Clean Water Act* of 1972.

42 U.S.C. 300f et seq., *Safe Drinking Water Act* of 1974.

42 U.S.C. 1801 et seq., *Atomic Energy Act* of 1954.

42 U.S.C. 17001 et seq., *Energy Independence and Security Act* of 2007.

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DOE O 231.1B Admin Chg 1, *Environment, Safety and Health Reporting, 2012.* U.S. Department of Energy. Accessed November 2021, at https://www.directives.doe.gov/directives-documents/200-series/0231.1-BOrder-b-admchg1/@@images/file.

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Appendix A – Glossary, Acronyms & Abbreviations, and Numbers & Units

A.1 Glossary

The following terms and definitions were copied from Appendix F of the SRS 2017 ASER.

A

actinide − Group of radioactive metallic elements of atomic number 89 through 103. Laboratory analysis of actinides by alpha spectrometry generally refers to the elements plutonium, americium, uranium, and curium but may also include neptunium and thorium.

ambient − Existing in the surrounding area. Completely enveloping.

analyte − Constituent or parameter that is being analyzed.

aquifer − Saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

B

background radiation − Naturally occurring radiation, fallout, and cosmic radiation. Generally, the lowest level of radiation obtainable within the scope of an analytical measurement, i.e., a blank sample.

best management practices − Sound engineering practices that are not required by regulation or by law.

beta particle − Negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biota − Plant and animal life.

C

calibration − Process of applying correction factors to equate a measurement to a known standard. Generally, a documented measurement control program of charts, graphs, and data that demonstrate that an instrument is properly calibrated.

compliance − Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

composite − A blend of more than one portion to be used as a sample for analysis.

***Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA)** − This Act addresses the cleanup of hazardous substances and establishes a National Priority List of sites targeted for assessment and, if necessary, restoration.

concentration − Amount of a substance contained in a unit volume or mass of a sample.

conductivity − Measure of water's capacity to convey an electric current.

contamination − State of being made impure or unsuitable by contact or mixture with something unclean, bad, etc.

curie − Unit of radioactivity. One curie is defined as 3.7 x 1010 (37 billion) disintegrations per second.

D

decay (radioactive) − Spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

deactivation − The process of placing a facility in a stable and known condition, including the removal of hazardous and radioactive materials to ensure adequate protection of the worker, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance.

decommissioning − The process that takes place after deactivation and includes surveillance and maintenance, decontamination, and dismantlement.

decontamination − The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

derived concentration standard (DCS) − Concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 0.1 rem (1 mSv). The guides for radionuclides in air and water are given in U.S. Department of Energy Derived Concentration Technical Standard (DOE-STD-1196-2011).

detector − Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

disposal − Permanent or temporary transfer of U.S. Department of Energy (DOE) control and custody of real property to a third party, which thereby acquires rights to control, use, or relinquish the property.

disposition − The activities that follow completion of a program mission including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

dose − Energy imparted to matter by ionizing radiation.

- **collective dose −** Sum of the effective dose of all individuals in an exposed population within a 50 mi (80 km) radius, and expressed in units of person-rem (or person-sievert). The 50 mi distance is measured from a point located centrally with respect to major facilities or DOE program activities.
- **effective dose −** Sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate tissue weighting factor.

dosimeter − Portable detection device for measuring the total accumulated exposure to ionizing radiation.

drinking water standards − Federal primary drinking water standards, both proposed and final, as set forth by the U.S. Environmental Protection Agency.

E

effluent − A release of treated or untreated water or air from a pipe or a stack to the environment. Liquid effluent flows into a body of water such as a stream or lake. Airborne effluent (also called emission) discharges into the atmosphere.

effluent monitoring − Collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.

emission − A release of a gas.

exposure (radiation) − Incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

exposure pathway − The way that a person could be impacted by releases of radionuclides into the water and air.

G

grab sample − Sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

gross alpha and beta releases − The total alpha-emitting and beta-emitting activity determined at each effluent location.

groundwater − Water found underground in cracks and spaces in soil, sand, and rocks.

H

half-life (radiological) − Time required for half of a given number of atoms of a specific radionuclide to decay. Each radionuclide has a unique half-life.

I

isotope − Each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element.

L

legacy − Anything handed down from the past; inheritance, as of nuclear waste.

low-level waste − Waste that includes protective clothing, tools, and equipment that have become contaminated with small amounts of radioactive material.

M

maximally exposed individual − Hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

monitoring − Process whereby the quantity and quality of factors that can affect the environment and or human health are measured periodically to regulate and control potential impacts.

N

nuclide − Atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

O

outfall − Place where treated or untreated water flows out of a pipe to mix with water from a water body, such as a stream or lake.

P

parameter − Analytical constituent; chemical compound(s) or property for which an analytical request may be submitted.

person-rem − Collective dose to a population group. For example, a dose of one rem to 10 individuals results in a collective dose of 10 person-rem.

pH − Measure of the hydrogen ion concentration in an aqueous solution, i.e., power of Hydrogen, (acidic solutions, pH <7; basic solutions, pH >7; and neutral solutions, pH 7).

picocurie (pCi) − 10−12 Ci, one-trillionth of a curie; 0.037 disintegrations per second.

plume − Volume of contaminated water originating at a waste source (e.g., a hazardous waste disposal site). It extends downward and outward from the waste source.

point source − Any defined source of emission to air or water such as a stack, air vent, pipe, channel, or passage to a water body.

population dose − See collective dose equivalent under dose.

potable water − Water that is safe to drink.

R

rad − Unit of absorbed dose deposited in a volume of material.

radioactivity − Spontaneous emission of radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

radioisotopes − Radioactive isotopes.

radionuclide − Unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

release − Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem − Unit of dose equivalent (absorbed dose in rads times the radiation quality factor). Dose equivalent frequently is reported in units of millirem (mrem), which is one thousandth of a rem.

remediation − Assessment and cleanup of sites contaminated with waste due to historical activities.

S

sievert − The International System of Units (SI) derived unit of dose equivalent. It attempts to reflect the biological effects of radiation as opposed to the physical aspects, which are characterized by the absorbed dose, measured in gray. One sievert is equal to 100 rem.

source − Point or object from which radiation or contamination emanates.

stable − Not radioactive or not easily decomposed or otherwise modified chemically.

stack − Vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

stormwater runoff − Surface streams that appear after precipitation.

surface water − Water that has not penetrated below the surface of the ground.

T

temperature − Thermal state of a body, considered with its ability to communicate heat to other bodies.

terrestrial − Living on or growing from the land.

thermoluminescent dosimeter (TLD) − A passive device that measures the exposure from ionizing radiation.

tritium − Elemental form of the radioactive isotope of hydrogen and occurs as a gas.

W

waste management − DOE uses this term to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated at DOE facilities.

waste stream − Waste material generated from a single process or from an activity that is similar in material, physical form, isotopic makeup, and hazardous constituents.

weighting factor − Value used to calculate dose equivalents. It is tissue-specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be attributed to that particular tissue.

A.2 Acronyms and Abbreviations

AEA	*Atomic Energy Act of 1954, as amended*
AGL	Above Ground Level
ALARA	As Low As Reasonably Achievable
AMES	Ames Laboratory
ANL	Argonne National Laboratory
ANLE	Argonne National Laboratory-East
ASER	Annual Site Environmental Report
ATR	Advanced Test Reactor
BCG	Biota Concentration Guide
BDAC	Biota Dose Assessment Committee
BLIP	Brookhaven Linac Isotope Producer
BLM	Bureau of Land Management
BNL	Brookhaven National Laboratory
CA	Composite Analysis
CCUS	Carbon Capture, Utilization, and Storage
CEBAF	Continuous Electron Beam Accelerator Facility
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFA	Central Facilities Area
COC	Contaminant of Concern
CWA	Clean Water Act
CT	Connecticut
CY	Calendar Year
DAF	Device Assembly Facility
DATS	Differential Atmospheric Tritium Sampler
DCS	Derived Concentration Standard
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DU	Depleted Uranium
DW	Drinking Water
DWPF	Defense Waste Processing Facility
ECF	Expended Core Facility
ED	Effective Dose

EDE	Effective Dose Equivalent
EERE	(DOE Office of) Energy Efficiency and Renewable Energy
EHSS	Environment, Health, Safety and Security
EM	(DOE Office of) Environmental Management
EPA	U.S. Environmental Protection Agency
ESER	Environmental Surveillance, Education, and Research
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park
FACET	Facilities for Accelerator Science and Experimental Test
FE	(DOE Office of) Fossil Energy
FERMI	Fermi National Accelerator Laboratory
FFSI	Fluor Federal Services, Inc.
FP	Fernald Closure Project
FY	Fiscal Year
GeV	Giga-electron Volt(s)
GJO	Grand Junction Office
GW	Groundwater
HANF	Hanford Site
HEPA	High-efficiency Particulate Air
HFBR	High Flux Beam Reactor
HFIR	High Flux Isotope Reactor
HT	Tritium
HTO	Tritiated Water
HWMF	Hazardous Waste Management Facility
ICP	Idaho Cleanup Project
ICRP	International Commission on Radiological Protection
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IRC	INL Research Center
ISU	Iowa State University
IWD	Industrial Waste Ditch
JLAB	Thomas Jefferson National Accelerator Facility
JNAF	Thomas Jefferson National Accelerator Facility
KAFB	Kirtland Air Force Base
KAPL	Knolls Atomic Power Laboratory-Windsor

KESS	Knolls Atomic Power Laboratory-Kesselring
KNOL	Knolls Atomic Power Laboratory
KTF	Kaua'i Test Facility
LA	Louisiana
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LBNL	Lawrence Berkeley National Laboratory
LCLS	Linac Coherent Light Source
LERF	Low Energy Recirculator Facility
LLNL	Lawrence Livermore National Laboratory
LM	Legacy Management
LRRI	Lovelace Respiratory Research Institute
LWA	Land Withdrawal Area
MCL	Maximum Contaminant Level
MEI	Maximally Exposed Individual
MEOSI	Maximally Exposed Off-site Individual
MFC	Materials and Fuels Complex
MOU	Memorandum of Understanding
MSA	Mission Support Alliance
MSL	Marine Sciences Laboratory
MTRU	Mixed Transuranic (waste)
MWMF	Mixed Waste Management Facility
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection and Measurements
NE	(DOE Office of) Nuclear Energy
NESHAP	National Emission Standards for Hazardous Air Pollutants
NETL	National Energy Technology Laboratory
NFO	Nevada Field Office
NIF	National Ignition Facility
NLCTA	Next Linear Collider Test Accelerator
NLVF	North Las Vegas Facility
NM	New Mexico
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NNPP	Naval Nuclear Propulsion Program
NORM	Naturally Occurring Radioactive Material
NOS	Not Otherwise Specified
NPDES	National Pollutant Discharge Elimination System

NPP	Nuclear Propulsion Program
NREL	National Renewable Energy Laboratory
NRF	Naval Reactors Facility
NTTR	Nevada Test and Training Range
NuMI	Neutrinos at the Main Injector
NV	Nevada
NWS	National Weather Service
NWTC	National Wind Technology Center
OREM	Oak Ridge Office of Environmental Management
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORP	DOE Office of River Protection
PA	Performance Assessment
PGDP	Paducah Gaseous Diffusion Plant
PANTEX	Pantex Plant
PC	Personal Computer
PCB	Polychlorinated Biphenyl
PMRF	Pacific Missile Range Facility
PORTS	Portsmouth Gaseous Diffusion Plant
PNNL	Pacific Northwest National Laboratory
PPPL	Princeton Plasma Physics Laboratory
PPPO	Portsmouth/Paducah Project Office
PVU	Portable Ventilation Unit
PW	Potable Water
R&D	Research and Development
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
RESRAD	RESidual RADioactivity Computer Code
RHIC	Relativistic Heavy Ion Collider (at BNL)
ROD	Record of Decision
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
SC	DOE Office of Science
SDWA	Safe Drinking Water Act
SER	(Annual) Site Environmental Report
SI	International System of Units

SLAC	Stanford Linear Accelerator Center
SMS	Sewer Monitoring Station
SNL-CA	Sandia National Laboratories, Livermore, CA
SNL- NM	Sandia National Laboratories, Albuquerque, NM
SNS	Spallation Neutron Source
SWPA	Southwestern Power Administration
SPDES	State Pollutant Discharge Elimination System
SRS	Savannah River Site
SPR	Strategic Petroleum Reserve
SPRU	Separations Process Research Unit
SRF	Superconducting Radiofrequency
SSFL	Santa Susanna Field Laboratory
SSRL	Stanford Synchrotron Radiation Lightsource
STM	South Table Mountain
SW	Surface Water
TAN	Test Area North
TED	Total Effective Dose
TLD	Thermoluminescent Dosimeters
TPL	Target Processing Laboratory
TRU	Transuranic
TTR	Tonopah Test Range
UC	University of California
UMTRCA	Uranium Mill Tailings Radiation Control Act
USAF	U.S. Air Force
VOCs	Volatile Organic Compounds
WA	Washington
WIPP	Waste Isolation Pilot Plant
WNYNSC	Western New York Nuclear Service Center
WQPP	Water-Quality Protection Plan
WSSRAP	Weldon Spring Site Remedial Action Project
WVDP	West Valley Demonstration Project

A.3 Numbers, Symbols, and Units

The following information is provided as a quick reference to assist the reader in interpreting the presentation of quantitative data, units of measurement, and abbreviations and symbols used throughout this report. The definitions of many terms mentioned below and used elsewhere in this report are contained in the glossary.

A.3.1 Use of Scientific Notation

Numbers are presented in a form of scientific notation commonly referred to as *E notation*. The letter E in the number is used to mean "times 10 to the power of." For example, the number 1,000,000 (= 1.0 x 10^6) is written as 1.0E+06; and 1/10,000 (= 0.0001 = 1.0 x 10^{-4}) is written as 1.0E-04. Stated another way, translating from E notation requires moving the decimal point either left or right. If the notation after the E is positive (+), the decimal point is moved to the right. Thus, to convert 4.5E+05, move the decimal point in 4.5 to the right five places to get 450,000. Move the decimal point to the left if the symbol after the E is negative (-), so that 3.2E−03 becomes 0.0032.

A.3.2 Significant Figures

Most values presented in this report have been rounded to no more than two significant figures. For example, the number 213.3 appearing in an ASER would be rounded in this report to 210. In some cases, where two or more values are summed to obtain a total, the rounded total may not exactly equal the sum of its component values.

A.3.3 Units of Measurement

Values for radioactivity and radiation dose are presented in this report in conventional units (non-*System International*). This practice was done to accommodate a more general, American readership, improve readability, save space, and avoid conversion errors. Conversions to the metric equivalents (SI units) are provided in the following section of this Appendix.

A.3.4 Units and Conversions

The following units and conversions tables were copied from Appendix H of the SRS 2017 ASER.

Symbol	Name	Symbol	Name
Temperature		***Concentration***	
°C	degrees Celsius	ppb	parts per billion
°F	degrees Fahrenheit	ppm	parts per million
Time		***Rate***	
d	day	cfs	cubic feet per second
h	hour	gpm	gallons per minute
y	year	***Conductivity***	
Length		µmho	micromho
cm	centimeter	***Radioactivity***	
ft	foot	Ci	curie
in	inch	cpm	counts per minute
km	kilometer	mCi	millicurie
m	meter	µCi	microcurie
mm	millimeter	pCi	picocurie
µm	micrometer	Bq	becquerel
Mass		***Radiation Dose***	
g	gram	mrad	millirad
kg	kilogram	mrem	millirem
mg	milligram	Sv	sievert
µg	microgram	mSv	millisievert
Area		µSv	microsievert
mi^2	square mile	R	roentgen
ft^2	square foot	mR	milliroentgen
Volume		µR	microroentgen
gal	gallon	Gy	gray
L	liter		
mL	milliliter		

Fractions and Multiples of Units				
Multiple	**Decimal Equivalent**	**Prefix**	**Symbol**	**Report Format**
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E-01
10^{-2}	0.01	centi-	c	E-02
10^{-3}	0.001	milli-	m	E-03
10^{-6}	0.000001	micro-	µ	E-06
10^{-9}	0.000000001	nano-	n	E-09
10^{-12}	0.000000000001	pico-	p	E-12
10^{-15}	0.000000000000001	femto-	f	E-15
10^{-18}	0.000000000000000001	atto-	a	E-18

Conversion Table (Units of Radiation Measure)		
Current System	***Systeme International***	**Conversion**
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Conversion Table					
Multiply	**By**	**To Obtain**	**Multiply**	**By**	**To Obtain**
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq qt-US	0.945	L	L	1.057	liq qt-US
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
d/m	0.450	pCi	pCi	2.22	d/m
pCi	10^{-6}	µCi	µCi	10^6	pCi
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/mL (air)	µCi/mL (air)	10^{12}	pCi/m^3 (air)

Appendix B – 2015–2018 ASER References

The title and publication date of sources of ASERs reviewed for this report are listed in Table B-1.

Table B-1. Annual Site Environmental Reports Reviewed for this Report

Site	ASER (or otherwise) Title (Published year)
AMES	Ames Laboratory, Annual Site Environmental Report Calendar Year 2018 (2019) Ames Laboratory, Annual Site Environmental Report Calendar Year 2017 (2018) Ames Laboratory, Annual Site Environmental Report Calendar Year 2016 (2017) Ames Laboratory, Annual Site Environmental Report Calendar Year 2015 (2016)
ANL	Site Environmental Report for Calendar Year 2018 (Argonne National Laboratory 2019) Site Environmental Report for Calendar Year 2017 (Argonne National Laboratory 2018) Site Environmental Report for Calendar Year 2016 (Argonne National Laboratory 2017) Site Environmental Report for Calendar Year 2015 (Argonne National Laboratory 2016)
BETTIS	Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 2018 (2019) Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 2017 (2018) Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 2016 (2017) Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 2015 (2016)
BNL	Brookhaven National Laboratory Site Environmental Report 2018, Volume 1 (2019) Brookhaven National Laboratory Site Environmental Report 2017, Volume 1 (2018) Brookhaven National Laboratory Site Environmental Report 2016, Volume 1 (2017) Brookhaven National Laboratory Site Environmental Report 2015, Volume 1 (2016)
FERMI	Report to the Director on the Fermilab Environment Calendar Year 2018 (2019) Report to the Director on the Fermilab Environment Calendar Year 2017 (2018) Report to the Director on the Fermilab Environment Calendar Year 2016 (2017) Report to the Director on the Fermilab Environment Calendar Year 2015 (2016)
HANF	Hanford Annual Site Environmental Report for Calendar Year 2018 (2019) Hanford Annual Site Environmental Report for Calendar Year 2017 (2018) Hanford Annual Site Environmental Report for Calendar Year 2016 (2017) Hanford Annual Site Environmental Report for Calendar Year 2015 (2016)
INL	Idaho National Laboratory Site Environmental Report Calendar Year 2018 (2019) Idaho National Laboratory Site Environmental Report Calendar Year 2017 (2018) Idaho National Laboratory Site Environmental Report Calendar Year 2016 (2017) Idaho National Laboratory Site Environmental Report Calendar Year 2015 (2016)
INL NRF	Naval Reactors Facility, Environmental Monitoring Report, Calendar Year 2018 (2019) Naval Reactors Facility, Environmental Monitoring Report, Calendar Year 2017 (2018) Naval Reactors Facility, Environmental Monitoring Report, Calendar Year 2016 (2017) Naval Reactors Facility, Environmental Monitoring Report, Calendar Year 2015 (2016)
JLAB	2018 Annual Site Environmental Report for Thomas Jefferson National Accelerator Facility (2019) 2017 Annual Site Environmental Report for Thomas Jefferson National Accelerator Facility (2018) 2016 Annual Site Environmental Report (Jefferson Lab 2017) 2015 Site Environmental Report (Jefferson Lab 2016)
KESS[(a)]	Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2018 (2019) Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2017 (2018) Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2016 (2017) Knolls Atomic Power Laboratory, Environmental Monitoring Report Calendar Year 2015 (2016)
KNOL[(a)]	Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2018 (2019) Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2017 (2018)

Site	ASER (or otherwise) Title (Published year)
	Knolls Laboratory and Kesselring Site, Environmental Monitoring Report Calendar Year 2016 (2017)
	Knolls Atomic Power Laboratory, Environmental Monitoring Report Calendar Year 2015 (2016)
LANL	2018 Annual Site Environmental Report (Los Alamos National Laboratory 2019)
	2017 Annual Site Environmental Report (Los Alamos National Laboratory 2018)
	Los Alamos National Laboratory 2016 Annual Site Environmental Report (2017)
	Los Alamos National Laboratory 2015 Annual Site Environmental Report (2016)
LBNL	Site Environmental Report for 2018 (Lawrence Berkeley National Laboratory 2019)
	Site Environmental Report for 2017 (Lawrence Berkeley National Laboratory 2018)
	Site Environmental Report for 2016 (Lawrence Berkeley National Laboratory 2017)
	Site Environmental Report for 2015 (Lawrence Berkeley National Laboratory 2016)
LLNL	2018 Site Annual Environmental Report (Lawrence Livermore National Laboratory 2019)
	2017 Site Annual Environmental Report (Lawrence Livermore National Laboratory 2018)
	2016 Site Annual Environmental Report (Lawrence Livermore National Laboratory 2017)
	2015 Site Annual Environmental Report (Lawrence Livermore National Laboratory 2016)
NETL	2018 Annual Site Environmental Report (National Energy Technology Laboratory 2019)
	2017 Annual Site Environmental Report (National Energy Technology Laboratory 2018)
	2016 Annual Site Environmental Report (National Energy Technology Laboratory 2017)
	2015 Annual Site Environmental Report (National Energy Technology Laboratory 2016)
NNSS	Nevada National Security Site 2018 Environmental Report (2019)
	Nevada National Security Site Environmental Report 2017 (2018)
	Nevada National Security Site Environmental Report 2016 (2017)
	Nevada National Security Site Environmental Report 2015 (2016)
NREL	Environmental Performance Report, 2018 (National Renewable Energy Laboratory 2019)
	Environmental Performance Report, 2017 (National Renewable Energy Laboratory 2018)
	Environmental Performance Report, 2016 (National Renewable Energy Laboratory 2017)
	Environmental Performance Report, 2015 (National Renewable Energy Laboratory 2016)
ORR	Oak Ridge Reservation Annual Site Environmental Report 2018 (2019)
	Oak Ridge Reservation, Annual Site Environmental Report, 2017 (2018)
	2016 Oak Ridge Reservation Annual Site Environmental Report (2017)
	Oak Ridge Reservation Annual Site Environmental Report 2015 (2016)
PGDP	Paducah Site Annual Site Environmental Report for Calendar Year 2018 (2019)
	Paducah Site Annual Site Environmental Report for Calendar Year 2017 (2018)
	Paducah Site Annual Site Environmental Report for Calendar Year 2016 (2017)
	Paducah Site Annual Site Environmental Report for Calendar Year 2015 (2016)
PANTEX	Annual Site Environmental Report, Pantex Plant, for Calendar Year 2018 (2019)
	Annual Site Environmental Report, Pantex Plant, for Calendar Year 2017 (2018)
	Annual Site Environmental Report, Pantex Plant, for Calendar Year 2016 (2017)
	Annual Site Environmental Report, Pantex Plant, for Calendar Year 2015 (2016)
PNNL	Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2018 (2019)
	Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2017 (2018)
	Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2016 (2017)
	Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2015 (2016)
PORTS	Portsmouth Gaseous Diffusion Plant, Annual Site Environmental Report, 2018 (2020)
	Portsmouth Gaseous Diffusion Plant, Annual Site Environmental Report, 2017 (2019)
	Portsmouth Gaseous Diffusion Plant, Annual Site Environmental Report, 2016 (2018)
	Portsmouth Gaseous Diffusion Plant, Annual Site Environmental Report - 2015 (2017)
PPPL	Annual Site Environmental Report, 2018, Princeton Plasma Physics Laboratory (2019)

Site	ASER (or otherwise) Title (Published year)
	Princeton Plasma Physics Laboratory Annual Site Environmental Report for Calendar Year 2017 (2018)
	Princeton Plasma Physics Laboratory Annual Site Environmental Report for Calendar Year 2016 (2017)
	Princeton Plasma Physics Laboratory Annual Site Environmental Report for Calendar Year 2015 (2016)
SLAC	Annual Site Environmental Report: 2018 (SLAC National Accelerator Laboratory 2019)
	Annual Site Environmental Report: 2017 (SLAC National Accelerator Laboratory 2018)
	Annual Site Environmental Report: 2016 (SLAC National Accelerator Laboratory 2017)
	Annual Site Environmental Report: 2015 (SLAC National Accelerator Laboratory 2016)
SNL-CA	Site Environmental Report for 2018, Sandia National Laboratories, California (2019)
	Site Environmental Report for 2017, Sandia National Laboratories, California (2018)
	Site Environmental Report for 2016, Sandia National Laboratories, California (2017)
	Site Environmental Report for 2015, Sandia National Laboratories, California (2016)
SNL-KTF[(a)]	2018 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2019)
	2017 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2018)
	2016 Annual Site Environmental Report, Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2017)
	2015 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2016)
SNL-NM	2018 Annual Site Environmental Report for Sandia National Laboratories, New Mexico (2019)
	2017 Annual Site Environmental Report for Sandia National Laboratories, New Mexico (2018)
	2016 Annual Site Environmental Report for Sandia National Laboratories, New Mexico (2017)
	2015 Annual Site Environmental Report for Sandia National Laboratories, New Mexico (2016)
SNL-TTR[(a)]	2018 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2019)
	2017 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2018)
	2016 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2017)
	2015 Annual Site Environmental Report for Sandia National Laboratories, Tonopah Test Range, Nevada, and Kaua'i Test Facility, Hawai'i (2016)
SPR	Strategic Petroleum Reserve, Site Environmental Report for Calendar Year 2018 (2019)
	Strategic Petroleum Reserve, Site Environmental Report for Calendar Year 2017 (2018)
	Strategic Petroleum Reserve Site Environmental Report for Calendar Year 2016 (2017)
	Strategic Petroleum Reserve Site Environmental Report for Calendar Year 2015 (2016)
SRS	Savannah River Site, Environmental Report 2018 (2019)
	Savannah River Site Environmental Report for 2017 (2018)
	Savannah River Site Environmental Report for 2016 (2017)
	Savannah River Site Environmental Report for 2015 (2016)
SSFL	2018 Annual Site Environmental Report, Department of Energy Operations at the Energy Technology Engineering Center – Area IV, Santa Susana Field Laboratory (2019)
	2017 Annual Site Environmental Report, Department of Energy Operations at the Energy Technology Engineering Center – Area IV, Santa Susana Field Laboratory (2018)
	2016 Annual Site Environmental Report, Department of Energy Operations at the Energy Technology Engineering Center – Area IV, Santa Susana Field Laboratory (2017)
	2015 Annual Site Environmental Report, Department of Energy Operations at the Energy Technology Engineering Center – Area IV, Santa Susana Field Laboratory (2016)
WIPP	Waste Isolation Pilot Plant Annual Site Environmental Report for 2018 (2019)
	Waste Isolation Pilot Plant Annual Site Environmental Report for 2017 (2018)
	Waste Isolation Pilot Plant Annual Site Environmental Report for 2016 (2017)

Site	ASER (or otherwise) Title (Published year)
	Waste Isolation Pilot Plant Annual Site Environmental Report for 2015 (2016)
WVDP	West Valley Demonstration Project Annual Site Environmental Report for Calendar Year 2018 (2019)
	West Valley Demonstration Project Annual Site Environmental Report Calendar Year 2017 (2018)
	West Valley Demonstration Project Annual Site Environmental Report Calendar Year 2016 (2017)
	West Valley Demonstration Project Annual Site Environmental Report Calendar Year 2015 (2016)

(a) Sites combine reporting in a single SER for KNOL and KESS; and SNL-TTR and SNL-KTF.

Appendix C – Site Descriptions and Monitoring Programs

This appendix contains descriptions of the U.S. Department of Energy (DOE) sites covered by this summary report. Table C.1 lists the sites, alphabetically by name, along with their assigned DOE Program Office for this report. A number of DOE sites have operations under several Program Offices. Given the focus of this report on radioactive material monitoring and impact, this report's Program Office assignment was designated as the Office with oversight over the most radioactive material operations (generally, based on activity). Sites with the majority (greater than about 75 percent) of radionuclide operations under one Program Office are listed with that Program Office. The DOE Office of Legacy Management sites (e.g., Fernald Preserve, Weldon Spring) are not summarized in this report.

Sites with distinct sub-sites are listed separately. Sub-site locations may be distinct geographically, by subcontractor operations, or by mission. The site descriptions in the remainder of this Appendix provide details for each DOE site in this report.

Table C-1. Site and Sub-Site Names and Program Office Assignment for this Report

Site[(a)]	Sub-Site[(a)]	Program Office Assigned for this Report
Ames Laboratory	n/a	SC
Argonne National Laboratory	n/a	SC
Bettis Atomic Power Laboratory	n/a	NNSA-NNPP
Brookhaven National Laboratory	n/a	SC
Fermi National Laboratory	n/a	SC
Hanford Site	n/a	EM
Idaho National Laboratory	Main Site	NE
Idaho National Laboratory	Naval Reactors Facility	NNSA-NNPP
Idaho National Laboratory	Research and Education Complex [Idaho Falls]	NE
Kesselring (KAPL-Kesselring)	n/a	NNSA-NNPP
Knolls (KAPL-Knolls)	Knolls	NNSA-NNPP
Knolls (KAPL-Knolls)	Separations Process Research Unit (SPRU)	EM
Lawrence Berkeley National Laboratory	n/a	SC
Lawrence Livermore National Laboratory	Livermore Site	NNSA
Lawrence Livermore National Laboratory	Site 300	NNSA
Los Alamos National Laboratory	n/a	NNSA
National Energy Technology Laboratory	n/a	FE
National Renewable Energy Laboratory	South Table Mountain	EERE
National Renewable Energy Laboratory	[Other Denver Locations]	EERE
Nevada National Security Site	Main Site	NNSA
Nevada National Security Site	North Las Vegas Facility	NNSA
Oak Ridge Reservation	Entire site (ORNL, Y-12 Complex, ETTP, and ORISE)	SC
Oak Ridge Reservation	ORNL	SC
Oak Ridge Reservation	Y-12 National Security Complex	NNSA
Oak Ridge Reservation	ETTP	EM
Oak Ridge Reservation	ORISE	SC
Pacific Northwest National Laboratory	Richland Campus	SC

Site[(a)]	Sub-Site[(a)]	Program Office Assigned for this Report
Pacific Northwest National Laboratory	Marine Sciences Lab (MSL)	SC
Paducah Gaseous Diffusion Plant	n/a	EM
Pantex Plant	n/a	NNSA
Portsmouth Gaseous Diffusion Plant	n/a	EM
Princeton Plasma Physics Laboratory	n/a	SC
Sandia National Laboratories, (Albuquerque) NM	n/a	NNSA
Sandia National Laboratories, (Livermore) CA	n/a	NNSA
Sandia National Laboratories, Tonopah (NV)	n/a	NNSA
Sandia National Laboratories, Kaua'i	n/a	NNSA
Santa Susanna Field Laboratory	n/a	EM
Savannah River Site	n/a	EM
Stanford Linear Accelerator Center	n/a	SC
Strategic Petroleum Reserve	n/a	FE
Thomas Jefferson National Accelerator Facility	n/a	SC
Waste Isolation Pilot Plant	n/a	EM
West Valley Demonstration Project	n/a	EM

EERE = Office of Energy Efficiency and Renewable Energy; EM = Office of Environmental Management; FE = Office of Fossil Energy; n/a = not applicable; NE = Office of Nuclear Energy; NNSA = National Nuclear Security Administration; NNSA-NNPP = NNSA Naval Nuclear Propulsion Program; SC = Office of Science.
Gray-shaded, (light or dark) consecutive sites are at managed together.
(a) For site acronyms, see Table 1-1.

C.1 Introduction

The following site descriptions are based on information presented in the Annual Site Environmental Reports (ASERs), supplemented by Subpart H compliance reports and online information, as needed. While efforts were made to provide consistency among sites with regard to the level of detail, the information provided in each ASER is often based on different reporting approaches and scopes. Site descriptions are organized by DOE Program Office.

Information provided for each site is separated into two sections: Site Description and Site Monitoring. Site Description conveys the basic characteristics of the site, including its location, size, and mission. It addresses features regarding the local geography (e.g., waterways that may be influenced or could contribute to the transport of possible contaminants from a site) and meteorology (weather conditions that could affect the passage of any contaminants released to the atmosphere). Also described are regional land uses, local population, and other aspects important to understanding the potential for individuals to be exposed to possible releases from a site. Major radiological operations facilities and their common acronyms are also included to familiarize the reader with their associations.

Site monitoring at DOE sites is implemented through environmental management programs, which include effluent monitoring and environmental surveillance.

The site descriptions and monitoring results presented in the following sections reflect conditions as they existed from 2015 through 2018. Organizational, operational, or other changes that occurred after 2018 are not included.

C.2 Office of Energy Efficiency and Renewable Energy

The DOE Office of Energy Efficiency and Renewable Energy (EERE) provides oversight for the National Energy Renewable Laboratory (NREL).

C.2.1 National Renewable Energy Laboratory

NREL is the only DOE National Laboratory solely dedicated to advancing renewable energy and energy-efficiency technologies from concept to commercial application. NREL supports research and development (R&D) programs in basic science, bioenergy and biomass fuels, building energy efficiency, computational sciences, distributed power, electricity technologies, energy analysis, renewable hydrogen production technologies, energy measurements and testing, photovoltaic and solar power, materials science, renewable energy resources, renewable thermal technologies, transportation (fuels and advanced vehicles), and wind energy.

NREL's five facilities occupy four separate locations in Jefferson County, Colorado (CO), and one location in the City and County of Denver, CO. The facilities include the National Wind Technology Center (NWTC); South Table Mountain (STM); the Denver West Office Park; the Joyce Street Facility; and the Renewable Fuels and Lubricants Research Laboratory.

NREL is described in this report as NREL Other (all NREL locations except STM) and NREL STM. The NREL STM location is NREL's main campus; it has about 374 laboratories and offices and is the only facility at which radioactive material is used during laboratory operations. STM and NWTC are the primary locations for NREL research operations. The Denver West Office Park is leased space used primarily for administrative functions and limited research activities. The leased Joyce Street Facility space is primarily used for storage. The Renewable Fuels and Lubricants Research Laboratory facility is a leased research space that consists of a single-vehicle high bay and a small office area housed within the Regional Transportation District Shops and Operations Center facility in Denver.

Site Description. The climate for the geographic region of NREL operations is classified as semiarid, typified by limited precipitation (less than 20 in. [50 cm] annually), low relative humidity, abundant sunshine, and large daily and seasonal temperature variations.

The STM site is a roughly triangular parcel of land occupying portions of the top, sides, and lower south-facing slopes of South Table Mountain, a mesa that stands approximately 492 ft (150 m) above the adjacent lowlands. South Table Mountain is composed of sedimentary rocks below a basalt lava cap. The STM site (327 ac [132 ha]) is predominantly bordered by open grassland zoned for recreation and light commercial activity. Portions of the community of Pleasant View are located immediately to the south and west. Open space wraps around the northern and eastern edges of the site. Offsite offices and residences lie to the east. More than half of the STM site (177 ac [72 ha]) is preserved in a conservation easement. No development is allowed on that land, with the exception of some existing utility easements and recreational trails to be established by Jefferson County Open Space.

The NWTC is the main facility for NREL's wind turbine technology research. It is located on the Jefferson-Boulder County border near the intersection of Highways 93 and 128, just east of the foothills of the Rocky Mountains and has abundant wind resources. The NWTC is between Boulder and Golden, approximately 15 mi (24.2 km) north of the STM site. The NWTC occupies a 305 ac (124 ha) area surrounded by open space, grazing, and industrial land uses, with a wildlife refuge bordering it to the south and east.

The Denver West Office Park (Lakewood, CO) is about 2 mi (3.2 km) east of Golden and 12 mi (19.3 km) west of central Denver. The facility is an office complex in an area that has a number of four-story buildings, parking lots, and common areas. In addition to office spaces, activities at the Denver West

Office Park include low-risk research related to fuel and battery characterization, vehicle research, and photo-electrochemical hydrogen production.

The Joyce Street Facility is located in a commercial area surrounded by agricultural land, residential neighborhoods, and small businesses and is currently used by NREL primarily as warehouse space and has no staff offices. The Joyce Street Facility is about 5.5 mi (8.9 km) north of Denver West Office Park and the STM site.

The Renewable Fuels and Lubricants Research Laboratory is used for research, testing, and support activities related to advanced fuels, engines, and vehicles to objectively evaluate performance, emissions, and energy-efficiency impacts, including heavy-duty hybrid vehicles research. The laboratory consists of a single-vehicle high bay and a small office area housed within the Regional Transportation District Shops and Operations Center located in Denver, approximately 12 mi (20 km) east of the STM site. The general area is highly developed with concentrated industrial and commercial activities. Very little natural vegetated habitat exists onsite or in the immediate vicinity, but some trees and shrubs line the South Platte River adjacent to the site's southern, eastern, and northeastern borders.

2020 Site Description Updates. NREL has undergone several facility changes since 2018. The Golden Warehouse, located 6.1 miles (9.8 km) north of the STM in Golden, CO, is primarily used as a secure warehouse space and replaces the previous Joyce Street Facility warehouse that was vacated in December 2018. In 2019, the NWTC's name changed to the Flatirons Campus. Also, as of 2020, NREL occupies an additional facility, the Research and Testing Facility, located in Fairbanks, AK. This facility provides office and lab space to research and product-test cold-climate, energy-efficient building technologies.

Site Monitoring. NREL STM operations involve the use of small amounts of low-level radioisotopes used as biological tracers and microscopy stains in select experiments. NREL facilities do not have legacy radiological or other contamination issues associated with past nuclear weapons production or research activities; therefore, continuous radiation or radiological contamination monitoring is not conducted. No radioactive air emission monitoring is conducted at NREL because of the extremely low use of radioactive material.

C.3 Office of Environmental Management

The chief mission of the DOE Office of Environmental Management (EM) is to complete the safe cleanup of environmental legacy resulting from five decades of nuclear weapons development and government-sponsored nuclear energy research. EM manages and directs the cleanup, including safe disposition of large volumes of nuclear waste, and deactivation and decommissioning of radiologically and chemically contaminated facilities no longer needed to support the DOE mission. Included in this mission is remediation of extensive surface water and groundwater contamination. From 2015 to 2018, EM was assigned as the primary DOE Program Office for a number of sites in this report. EM had responsibility for all or major portions of operations at these sites described in the following sections.

- Hanford Site (HANF)
- Paducah Gaseous Diffusion Plant (PGDP)
- Portsmouth Gaseous Diffusion Plant (PORTS)
- Santa Susanna Field Laboratory (SSFL)
- Savannah River Site (SRS)
- Waste Isolation Pilot Plant (WIPP)
- West Valley Demonstration Project (WVDP)

C.3.1 Hanford Site

HANF's current mission focuses on environmental restoration, which includes remediation of contaminated lands and facilities, waste management (i.e., waste storage, treatment, and disposal), and related scientific and environmental R&D. For more than 40 years, HANF operations produced plutonium for national defense using nuclear reactors and chemical processing facilities. Early development of reactor operations and chemical processing at the site left a legacy of environmental contamination, requiring remediation activities.

Onsite, non-DOE radiological operations include a commercial low-level waste disposal site and a commercial nuclear power reactor. In addition, the recently established Manhattan Project National Historical Park, of which the B Reactor and other HANF structures are a part, focuses on historical preservation and public education.

With oversight from EM, cleanup of HANF is managed by two Hanford-specific DOE offices, the Richland Operations Office (DOE-RL) and the Office of River Protection (DOE-ORP). DOE-RL and DOE-ORP jointly manage the site. The DOE-RL serves as the HANF property owner and oversees cleanup along the Columbia River and in Hanford's Central Plateau, including groundwater and waste site cleanup; management of solid waste, spent nuclear fuel, and sludge; facility remediation; environmental restoration; plutonium management; and all site support services. DOE-ORP manages the approximately 56 million gal (204 million L) of radioactive tank waste currently stored in 177 underground tanks in the central part of the site. In addition, radiological operations at an R&D facility, with oversight by the Office of Science, is located in the southeast portion of the site.

Site Description. HANF is located in the semiarid region of south-central Washington State. HANF stretches approximately 30 mi (50 km) north to south and about 24 mi (40 km) east to west, immediately north-northwest of the confluence of the Yakima and Columbia Rivers. The Columbia River flows eastward through the northern part of the Hanford Site and then turns south, forming part of the eastern site boundary. State Highway 240 traverses an onsite buffer area of the former nuclear materials production and current waste storage and waste disposal areas. Most of HANF consists of shrub-steppe habitats, but valuable riparian, wetland, and aquatic habitats are associated with the Hanford Reach of the Columbia River. HANF also contains riverine islands, bluffs/cliffs, basalt outcrops, swales, and sand dunes.

The size and topography require an extensive meteorological monitoring network. Regional temperatures, precipitation, and winds are affected by the Cascade Range to the west. The area is semiarid, and has a relatively low annual average rainfall (6.3 in. [16 cm]).

Site Monitoring. Large volumes and activities of radioactive material (waste or operational material) are located onsite. Ambient monitoring is conducted for potential radioactive material emissions to the air, water, and soil; for external radiation fields; and for biota. External radiation fields are monitored near HANF facilities and operations. Radiological surveys are performed at active and inactive waste disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination. The types of areas surveyed include underground radioactive material areas, contamination areas, soil contamination areas, high-contamination areas, roads, and fence lines. Routine radiological survey locations include former waste disposal sites, retention basin perimeters, ditch banks, solid waste disposal sites, unplanned release sites, tank farm perimeters, roads, and firebreaks in and around the Hanford Site operational areas.

Air quality is monitored using stack sampling at the sources and a sizable network of ambient air-monitoring locations, both onsite and offsite. Airborne emissions that have the potential to contain higher levels of radioactive materials are sampled and analyzed for gross alpha, gross beta, and specific radionuclides.

Site (100-K, 200-West, and 400 Areas) drinking water treatment facilities collect monthly samples that are analyzed quarterly or annually. Samples of Columbia River surface water are collected upstream and downstream of HANF, as well as at Hanford Reach locations. Sampling is also conducted at the City of Richland raw water intake facility on the Columbia River. Samples of the surface layer of Columbia River sediment are collected from 13 river locations. Selected Columbia River seeps are routinely monitored. Sediment samples are also collected from riverbank seep locations. Water samples at West Lake, a naturally occurring pond on the Hanford Site, are analyzed. Sediment samples are collected from upper-layer material near the pond shoreline. Samples of irrigation water are analyzed. DOE operates an extensive groundwater monitoring program onsite at HANF. Tritium, iodine-129, and nitrate compose the largest contaminant plumes in HANF groundwater.

Environmental surveillance of soil for legacy radioactive material is conducted onsite, both near and farther away from Hanford facilities and operations. Soil sampling is also performed offsite at perimeter and distant locations, and in nearby communities. Surface soil samples are collected on or adjacent to waste disposal sites, as well as from locations downwind, near, or within the boundaries of operating facilities and remedial action sites.

C.3.2 Paducah Gaseous Diffusion Plant

DOE established the Portsmouth/Paducah Project Office (PPPO) in 2003 to provide focused leadership to the EM missions at both the Paducah, Kentucky and Portsmouth, Ohio (see Section C.3.3) gaseous diffusion plants. In addition to gaseous diffusion plant stabilization, deactivation, and infrastructure optimization, the PPPO mission is to accomplish environmental remediation, waste management, depleted uranium hexafluoride conversion, and decontamination and decommissioning.

Radioactive materials present at the Paducah Gaseous Diffusion Plant (PGDP) are the result of processing raw and recycled uranium into nuclear materials.

Site Description. The PGDP site is located in a generally rural area of McCracken County, Kentucky, 10 mi west of Paducah, Kentucky, and 3.5 mi south of the Ohio River. Until 2013, PGDP was an active uranium enrichment facility with extensive support facilities. The plant is on a 3,556 acre (1,439 ha) DOE site comprising about 628 acres (254 ha) within a fenced security area, about 809 acres (327 ha) located outside the security fence, 133 acres (53.8 ha) in acquired easements, and 1,986 acres (803.7 ha) licensed to the Commonwealth of Kentucky as part of a wildlife management area.

PGDP is located in the humid continental zone where summers are warm (79°F) and winters are moderately cold (35°F). Yearly precipitation averages about 49 in. The prevailing wind is from the south-southwest.

The population of McCracken County is approximately 65,000; the major city, Paducah, has a population of approximately 25,000. Three small communities (Heath, Grahamville, and Kevil) are located within 3 mi of the DOE property boundary at the Paducah site. The population within a 50 mi radius of PGDP is about 534,000, according to the 2010 census.

Site Monitoring. Routine EM operations at PGDP may result in releases of radioactive materials to the environment by air and liquid effluent. Surveillance includes analyses of surface water, groundwater, sediment, direct radiation, and ambient air. Radionuclide sources at the site evaluated in 2017 included groundwater plume treatment systems and units, a depleted uranium conversion facility, laboratory hoods, and grouped and building exhaust systems.

Specific activities that could generate fugitive emissions include transport and disposal of waste, decontamination of contaminated equipment, and most environmental remediation activities. Ambient air monitoring, which monitors fugitive emissions from all PGDP operations, including Depleted Uranium Hexafluoride Conversion Facility operations, is conducted using continuous air monitors surrounding the Paducah site reservation. One of these air monitors samples at a background location.

Surface water and two background locations are sampled annually. Samples are also taken near 15 Kentucky Pollutant Discharge Elimination System (KPDES)-permitted outfalls throughout the year. As with other environmental surveillance locations, isotopic analyses are not performed if the alpha and beta activity levels are below established thresholds.

Effluent sampling in surface water at the C-746-S&T and C-746-U Landfills is permit-driven and analyzed for gross alpha and beta activity. Similarly, Northeast Plume effluent (Tc-99) is monitored according to the Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action. Leachate from the C-746-U and C-746-S Landfills is sampled routinely.

Sediment sampling at the PGDP includes radiological and nonradiological constituents. Because both measured concentrations and bioconcentration factors associated with radionuclides of concern at the PGDP in animals and fish are low, routine site-specific pathway assessments, including biota sampling, are not performed.

Sources of external radiation exposure at PGDP include the cylinder storage yards, the operations inside the cascade building, and small items such as instrument calibration sources. Cylinder storage yards have the largest potential for a dose to the public because of their proximity to the PGDP security fence.

C.3.3 Portsmouth Gaseous Diffusion Plant

DOE established the PPPO in 2003 to provide focused leadership to the environmental management missions at both the Portsmouth, Ohio and Paducah, Kentucky (see Section C.3.2) gaseous diffusion plants. In addition to gaseous diffusion plant stabilization, deactivation, and infrastructure optimization, the PPPO mission is to accomplish environmental remediation, waste management, depleted uranium hexafluoride conversion, and decontamination and decommissioning.

Decontamination and decommissioning of the Portsmouth Gaseous Diffusion Plant (PORTS), which includes the three gaseous diffusion process buildings and other associated facilities, is ongoing. Onsite is a leased (non-DOE) operation associated with the Depleted Uranium Hexafluoride Conversion Facility through 2016.

Site Description. PORTS is located in a rural area of Pike County, Ohio, on a 5.9 mi^2 (15.3 km^2 = 3,780 ac) site. The site is 2 mi (3.2 km) east of the Scioto River in a small valley running parallel to and above the Scioto River floodplain. Pike County has approximately 28,160 residents. Scattered rural development is characteristic of the area, which includes small villages such as Piketon and Beaver within a few miles of the plant. The total population within 50 mi of the plant is approximately 662,000 persons.

Site Monitoring. Radionuclides in ambient air are monitored at 15 monitoring stations located onsite, at the perimeter, offsite, and at a background location. Samples are analyzed monthly or quarterly for radionuclides that can be associated with PORTS operations. These radionuclides are transuranic (TRU) elements (americium-241, neptunium-237, plutonium-238, plutonium-239/240), a fission product (technetium-99), and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). External radiation is measured continuously with thermoluminescent dosimeters (TLDs) at locations near the cylinder storage yards and at onsite and offsite locations.

Water from PORTS could be discharged to offsite surface water at 11 outfall locations. Outfalls are monitored for radionuclides and chemicals. Samples of surface water are collected semiannually from locations upstream and downstream of PORTS on the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek, and from background locations. Samples are analyzed for radionuclides.

Samples of sediment are collected at Scioto River, Little Beaver Creek, Big Beaver Creek, Big Run Creek, and background locations on local streams, and at three onsite outfalls. Samples are analyzed for radionuclides and polychlorinated biphenyls (PCBs).

Soil and vegetation samples are collected annually at ambient air-monitoring locations for radionuclides. Deer samples are collected or may be taken from deer killed onsite in vehicle collision events. Fish are collected from onsite and offsite streams (Little Beaver Creek, Big Beaver Creek, and the Scioto River, as available). Crops, milk, and eggs are collected (as available) from the local community. All samples are analyzed for radionuclides.

Groundwater contamination at PORTS is contained onsite. More than 300 wells are sampled to monitor corrective actions, movement of groundwater contaminants, and groundwater quality. Samples are analyzed for radionuclides, as well as other chemicals and other parameters specific to the contaminants present at the monitoring area.

C.3.4 Santa Susanna Field Laboratory

The SSFL has been used for various research, development, and test projects funded by commercial work and several government agencies, including DOE, the Department of Defense, and the National Aeronautics and Space Administration (NASA). Since 1956, various R&D projects had been conducted in Area IV of the site, including small tests and demonstrations of reactors and critical assemblies, fabrication of reactor fuel elements, and disassembly and de-cladding of irradiated fuel elements. All nuclear R&D operations in Area IV, where legacy radioactive material exists, ceased in 1988.

Site Description. The SSFL site occupies 2,850 ac (1,153 ha) located in the Simi Hills of Ventura County, California, approximately 30 mi northwest of downtown Los Angeles. The SSFL is situated on rugged terrain of varying elevations—1,640–2,250 ft (500–700 m)—above sea level. No significant agricultural land use exists within 19 mi (30 km) of the SSFL site. Undeveloped land surrounds most of the SSFL site.

SSFL is divided into four administrative areas and undeveloped land. Area IV consists of approximately 290 ac (117.4 ha), of which DOE leases 90 ac (36.4 ha). The land immediately surrounding Area IV is undeveloped. A university is adjacent to the site to the north. Except for the Pacific Ocean, which is approximately 12 mi south, no sizable recreational body of water is located in the surrounding area. The closest major reservoir, which provides domestic water to the greater Los Angeles area, is more than 6 mi from Area IV.

Originally, 27 radiological facilities operated in Area IV. As of the end of 2014, DOE has released 20 facilities for unrestricted use and four have been declared suitable for unrestricted release. In addition to radiological facilities, two inactive sodium and related liquid metal test facilities remain in Area IV, as well as various support facilities.

Site Monitoring. There are four air emissions monitors which established the background conditions of the site that sample for a range of chemical and radiological constituents from DOE facilities in Area IV, as well as the exhaust stack at the Radioactive Materials Handling Facility. The exhaust stack was placed in safe shutdown mode in 2007; therefore, no effluents are released through the stack. In addition, there are onsite and offsite ambient radiation dosimeter locations.

Wells are sampled to monitor groundwater conditions in Area IV due to radioactivity released by historical DOE operations. The last radiological soil sampling in Area IV was conducted by the U.S. Environmental Protection Agency (EPA) in 2012.

C.3.5 Savannah River Site

Oversight to the missions and operations of SRS are provided by both DOE's Office of Environmental Management (DOE-EM) and the National Nuclear Security Administration (NNSA). To be consistent with previous reports, EM is the assigned Program Office, despite the presence of significant NNSA operations at SRS. Site operations support the nation's nuclear deterrent programs through environmental stewardship, national security, and clean-energy technologies.

Site Description. SRS comprises about 310 square mi (803 square km) in Aiken, Allendale, and Barnwell counties in South Carolina (SC). The site is about 12 mi (19 km) south of Aiken, SC and 15 mi (24 km) southeast of Augusta, Georgia (GA). The Savannah River flows along the site's southwestern border. About 10% of SRS land is industrial, and the remaining 90% consists of natural and managed forests that the U.S. Forest Service-Savannah River plants, maintains, and harvests. Based on 2010 census data, the population within a 50 mi (80 km) radius of the center of SRS is about 781,060, and the largest concentration is in the Augusta, GA metropolitan area.

SRS was constructed in the early 1950s to produce the basic materials used to fabricate nuclear weapons (primarily tritium and plutonium-239). Five nuclear reactors, chemical processing, and support facilities were built onsite. An offsite commercial nuclear power plant, Vogtle Electric Generating Plant, is located in Georgia, on the other side of the Savannah River from the site.

Site Monitoring. SRS conducts environmental monitoring of various media at numerous locations onsite, offsite, and at the site's perimeter. The site monitors rainwater, vegetation, soil, surface water (stream, river, and stormwater basins), drinking water, stream and river sediment, aquatic food products, wildlife, and food products (milk, meat, fruit, nuts, and green vegetables). Offsite monitoring involves collecting samples of air, river water, soil, sediment, vegetation, food products, fish, and other media from many locations and analyzing these samples for radioactive contaminants.

SRS performs effluent monitoring of airborne radionuclides at the point of discharge (e.g., stacks) from operating facilities. SRS conducts additional air sampling at onsite, perimeter, and offsite locations. Beyond the operational facilities, SRS maintains a network of air-sampling stations in and around SRS to monitor tritium and radioactive particulate matter in the air and rainwater.

An extensive TLD network onsite, and around SRS, monitors external ambient gamma exposure rates. The SRS ambient gamma radiation monitoring program evaluates conditions at the site perimeter, population centers, air surveillance stations, and onsite perimeter stations co-located with the Vogtle Electric Generating Plant's stations. SRS conducts most external dose monitoring onsite and at the SRS perimeter. SRS monitors offsite at population centers located near the site boundary; limited monitoring occurs beyond this distance.

Soil samples are collected from onsite, perimeter, and offsite locations. SRS also analyzes grassy vegetation samples (preferably Bermuda grass due to its importance as pasture grass for dairy cows) at locations onsite and offsite. SRS personnel collect terrestrial food products grown and consumed in the communities surrounding the site, as well as fish and shellfish caught from the Savannah River. Food product samples come from each of the four quadrants surrounding SRS and extending up to 10 miles (16 kilometers) from the SRS boundary. Also, SRS collects a control sample 10-25 miles (16-40 kilometers) to the southeast.

SRS routinely collects samples for radionuclide analysis at each liquid effluent discharge point that releases, or has the potential to release, radioactive materials. SRS samples the accumulated stormwater in the site's stormwater basins. SRS has no active processes discharging to SRS's stormwater basins.

SRS continuously samples SRS streams downstream of several process areas to monitor radioactivity that discharged effluents and shallow groundwater migration might transport to the Savannah River. The primary streams that deposit into the Savannah River are Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs. SRS also monitors and quantifies radioactivity migration from SRS seepage basins and the Solid Waste Disposal Facility as part of its stream surveillance program.

SRS conducts continuous sampling along the Savannah River at locations above and below SRS streams, including a location where liquid discharges from Vogtle Electric Generating Plant enter the river. SRS evaluates settleable solids—solids that are heavy enough to sink to the bottom of the collection container—in water to determine, in conjunction with routine sediment monitoring, whether a long-term buildup of radioactive materials occurs in stream systems. SRS collects sediment samples from the Savannah River, basin or pond locations, and from onsite streams or swamp discharge locations.

SRS collects drinking water samples at onsite locations and at two water treatment facilities that use water from the Savannah River as a source of drinking water. Onsite drinking water sampling consists of taking samples from the large treatment plant in A Area, and samples from wells and small systems.

SRS collects aquatic food from the Savannah River. Freshwater fish collectedfrom locations on the Savannah River. Onsite, SRS collects freshwater fish at the mouth of the streams that traverse the site. Saltwater fish come from the Savannah River mouth near Savannah, GA. Shellfish are collected from the Savannah River mouth near Savannah, or SRS purchases them from vendors in the Savannah area that harvest from local saltwater that is potentially influenced by waters of the Savannah River. Beginning in 2017, SRS discontinued tritium analysis in all edible samples.

Annual game animal hunts for deer, coyote, and feral hogs are open to the public. SRS monitors the cesium-137 concentration detected in the flesh of animals.

C.3.6 Waste Isolation Pilot Plant

The WIPP is the nation’s first deep geological repository permitted to dispose of defense-related transuranic (TRU) waste and mixed-TRU (MTRU) waste. Transuranic waste includes radionuclides with an atomic number higher than 92, the atomic number of uranium, whereas MTRU waste contains chemically hazardous constituents, in addition to the radiological components. Waste sent to WIPP for disposal must be in a form that meets content and packaging criteria. Waste is disposed of 2,150 ft (655 m) below the surface in disposal rooms excavated in the Salado Formation, a thick sequence of Permian evaporite salt.

Site Description. The WIPP site is located in the Chihuahuan Desert, of southeast New Mexico (NM), in Eddy County 26 mi east of Carlsbad. This area is relatively flat, sparsely inhabited, and has little surface water. The majority of the lands near the WIPP site are managed by the U.S. Department of the Interior Bureau of Land Management. Surrounding land uses include livestock grazing, potash mining, oil/gas exploration and production, and public recreational activities.

The WIPP site comprises a 16 mi^2 (41.4 km^2 [10,240 ac]) Land Withdrawal Area (LWA), which was signed into law on October 30, 1992. The LWA transferred the administration of Federal land from the U.S. Department of the Interior to the Department of Energy. The WIPP site boundary delineates the perimeter of the LWA, and encompasses four areas, a Property Protection Area, an Exclusive Use Area, an Off-limits Area, and a Multiple Land Use Area. The Property Protection Area (0.14 km^2 [35 ac]) is surrounded by a chain-link fence and security is provided 24 hours a day. The Exclusive Use Area (1.17 km^2 [290 ac]) is surrounded by a barbed-wire fence and use is restricted to the DOE. The Off-Limits Area (5.88 km^2 [1,454 ac]) is a posted buffer area with prohibitions against unauthorized entry, weapons, and/or dangerous materials. Grazing will continue in this off-limits area unless these activities present a threat to the security, safety, or environmental quality of the WIPP site; this area is patrolled by security personnel to prevent unauthorized activities or use. Land outside of the WIPP-controlled areas make up the remainder of the 16 mi^2 and is known as the Multiple Land Use Area (MLUA). The MLUA is open to recreational use by the public for activities such as camping, hiking, and hunting.

The majority of the local population (88,952) within 50 mi of WIPP is concentrated in and around the communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia, NM. Nineteen permanent residents live within 10 mi (16 km) of WIPP. The nearest community is Loving (estimated population 1,413), 18 mi west-southwest of the site. The nearest major populated area is Carlsbad, 26 mi west.

Precipitation at the WIPP site has been recorded at the meteorological tower since 1970; while the annual average rate is 14.0 in. (355.6 mm), 31.6 in. (802.6 mm) were recorded in 2016. The annual average temperature at the 10-m elevation in 2017 was 65.43°F (18.57°C). The average monthly temperature at the WIPP site ranges from 81.52°F (27.51°C) in July to 45.84°F (7.69°C) in December. Winds in the area are predominantly from the southeast.

Site Monitoring. Environmental media, including ambient and exhaust air, groundwater, surface water, soils, sediments, and biota are sampled to monitor the radiological environment around the facility. Air monitoring systems were upgraded after the 2014 unplanned release event. Aerosol samples are analyzed for radionuclides, including natural uranium (uranium-233/234, uranium-235, uranium-238), natural potassium (potassium-40), and radioisotopes known to be in the inventory including plutonium-238, plutonium-239/240, americium-241, cesium-137, strontium-90, and cobalt-60.

Exhaust air from the repository is monitored at two effluent monitoring stations, Stations A and B, using fixed air samplers. Station A samples unfiltered exhaust air, whereas Station B samples exhaust air that has been filtered by HEPA filters. A third station, Station C, samples exhaust air from the Waste Handling Building.

Weekly airborne particulate samples are collected from locations on or near the WIPP site using low-volume air samplers. Event Evaluation samplers are also installed and used if a radiation release event occurs, or there are detections on any of the seven primary samplers. Airborne particulate sampling is performed at 17 locations using 24 samplers.

Of the more than 80 monitoring wells at and around the WIPP site, six wells are used to collect groundwater samples for compliance monitoring under the hazardous water facility permit and EPA certification requirements. Samples are collected at depths ranging from 591–886 ft (180–270 m). Regional and local surface water and sediment sampling extends as far north as Artesia, NM, on the upper Pecos River, and as far south as Pierce Canyon on the lower Pecos River. Sediment and surface-water samples are collected from additional locations around the WIPP site.

Soil samples are collected from the same six locations where the primary seven low-volume air particulate samplers are stationed. Soil samples are collected in three incremental depth profiles: surface soil, intermediate soil, and deep soil. Rangeland vegetation samples are collected from near the locations of the soil samples. Fauna samples are also collected, when available (most samples are from incidental road kill). All biota samples are analyzed for radionuclides.

C.3.7 West Valley Demonstration Project

The WVDP is on the site of a former commercial nuclear fuel reprocessing plant, which shut down in 1976. DOE began work at the site in 1982 in accordance with the WVDP Act (Public Law 96-368) to solidify liquid high-level radioactive waste that had been generated from prior fuel reprocessing operations. High-level waste solidification operations were completed in 2002 and the site is currently being decommissioned. A number of facilities have been removed; the largest remaining structure on the site is the Main Plant Process Building. The site is being decommissioned in two phases. Phase 1 includes above and below-ground facility removal and subsurface soil remediation, including the source area of a strontium-90 groundwater plume. Phase 2 will address four underground, former high-level waste storage tanks in the waste tank farm, the waste disposal areas, and the nonsource area of a strontium-90 groundwater plume. The DOE plans to determine the optimum final remediation alternatives with its Phase 2 decision as part of a Supplemental Environmental Impact Statement (SEIS) expected to be published in 2023.

Site Description. The WVDP is located in western New York, about 30 mi south of Buffalo. The WVDP facilities currently occupy a security-fenced area of about 152 ac (61 ha) within the 3,338 ac (1,351 ha) New York State-Western New York Nuclear Service Center (WNYNSC), located primarily in the town of Ashford in northern Cattaraugus County.

Although extremes of 99°F and -20°F have been recorded in western New York, the climate is moderate with an average annual temperature of approximately 48°F. Precipitation is markedly influenced by Lake Erie to the west and, to a lesser extent, by Lake Ontario to the north. Based on data collected at the onsite meteorological tower, the 10-year average annual precipitation in 2018 at the WVDP was 41 in. Regional winds are generally from the west and averaged 7.65 mph (3.4 m/s) in 2018. WNYNSC lies within the northern deciduous forest biome, and the diversity of its vegetation is typical of the region, being primarily forest and open lands.

Although several roads and a railway approach or pass through the WNYNSC, the public is prohibited from accessing the WNYNSC. Land near the WNYNSC is used primarily for agriculture and arboriculture. Downgradient of the WNYNSC, Cattaraugus Creek is used locally for swimming, canoeing, and fishing. Although some water is taken from the Cattaraugus to irrigate nearby golf course greens and tree farms, no public drinking water is drawn from the creek before it drains to Lake Erie. Water from Lake Erie is used as a public drinking water supply. The communities of West Valley, Riceville, Ashford Hollow, and the village of Springville are located within approximately 5 mi (8 km) of WVDP. Population around the site is sparse (about 61 persons/mi^2). No major industries are located near the site.

Site Monitoring. The environmental monitoring program primarily focuses on surface water and air, because they are the principal means by which contaminants can be transported offsite. Onsite and offsite air, surface water, drinking water, sediment, soil, venison, fish, milk, and food crops are collected and measured for radiological and chemical constituents. Samples are also collected at remote locations to provide background data.

Exhaust from each of four stacks and up to 15 portable ventilation units on the WVDP is continuously filtered and the permanent systems are monitored as air is released to the atmosphere.

Ambient air samplers surround the WNYNSC within approximately 1 mi (0.6 km) of the WVDP property boundary. The background ambient air sampler is located 18 mi (29 km) south of the site. Continuous onsite air sampling is also performed close to the work area during demolition of all radiologically contaminated facilities. Samples from local samplers are collected on a daily basis during demolition activities.

In calendar year (CY) 2018, groundwater samples were collected from 69 onsite, routine groundwater monitoring locations, including 63 monitoring wells and well points, 5 groundwater seepage points, and 1 trench sump. The primary sources of radionuclide releases from the site to surface waters occur at the Lagoon 3 weir, which discharges at outfall 001; and natural drainage from the northeast swamp drainage ditch, and north swamp drainage ditch. Surface water samples are also collected at onsite and offsite downstream background locations. Wastewater discharge outfalls (only one of which [outfall 001] is an active discharge point) and stormwater discharge outfalls are monitored. Stormwater samples are analyzed for the parameters defined in the WVDP State Pollutant Discharge Elimination System permits.

Routine soil and sediment sampling (onsite and offsite) is performed every 5 years at locations on the north plateau where drainage has the potential to be contaminated. Additional offsite sediment samples are collected at a background location on Buttermilk Creek and at downstream locations—one on Buttermilk Creek and two on Cattaraugus Creek.

Food samples are collected from locations near the site and from remote locations. Milk, venison, fish, apples, beans, and corn samples are collected. Venison samples are typically collected during the fall when deer are most active; and fish may be collected at any time of the year. The crops and edible portions of the deer and fish are sampled and analyzed for radionuclides.

C.4 National Nuclear Security Administration

The major missions of the National Nuclear Security Administration (NNSA) are maintaining the U.S. nuclear stockpile, nonproliferation, counterterrorism and counterproliferation, and powering the nuclear propulsion plants of the U.S. Navy. For this report, the NNSA Naval Nuclear Propulsion Program facilities are broken out separately in the NNSA-NNPP section (Section C.5).

From 2015 to 2018, the following NNSA facilities are included in this report:

- Lawrence Livermore National Laboratory (LLNL)
- Los Alamos National Laboratory (LANL)
- Nevada National Security Site (formerly, named the Nevada Test Site) (NNSS)
- Pantex Plant (PANTEX)
- Sandia National Laboratories, Albuquerque (SNL-NM)
- Sandia National Laboratories, Livermore (SNL-CA)
- Sandia National Laboratories, Tonopah (SNL-TTR)
- Sandia National Laboratories, Kaua'i (SNL-KTF)

The following sections describe these sites and their monitoring programs.

C.4.1 Lawrence Livermore National Laboratory

LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable; and for addressing pressing national security needs, including countering the proliferation of weapons of mass destruction, strengthening homeland security, and conducting major research in atmospheric, earth, and energy sciences, bioscience and biotechnology, engineering, basic science, and advanced technology. LLNL consists of two sites: the Livermore site and Site 300, respectively identified for the purposes of this ASER summary report as LLNL and LLNL Site 300.

Site Description. The Livermore site, LLNL's general research site, is within the eastern limits of Livermore, a city with a population of about 90,000 in Alameda County, California. The site occupies 1.3 mi^2 (3.4 km^2 = 840 ac), including the land that serves as a buffer zone along its north and west perimeters. Within a 50 mi (80 km) radius of LLNL are cities such as Tracy and Pleasanton, and the more distant (and more densely populated) cities of Oakland, San Jose, and San Francisco. Of the 7.7 million people within 50 mi of the Laboratory, only about 10% are within 20 mi (32 km).

Site 300, LLNL's experimental test site, is located in the Altamont Hills of the Diablo Range in Central California and straddles the San Joaquin and Alameda county line. The site is 12 mi (19 km) east of the main LLNL site and occupies 10.9 mi^2 (28.2 km^2 = 6,970 ac). The City of Tracy (population of about 91,000) is approximately 6 mi (9.7 km) northeast of the site. Of the 7.1 million people who live within 50 mi of Site 300, 95% are more than 20 mi (32 km) away in large metropolitan areas, which include Oakland, San Jose, and Stockton.

The climate at both sites is characterized by mild, rainy winters and warm-to-hot, dry summers, with strong seasonal wind and rainfall patterns. Wind patterns at both sites tend to be dominated by the thermal draw of the warm San Joaquin Valley that results in wind blowing from the cool ocean toward the warm valley during the warm season, increasing in intensity as the valley heats up. During the winter, the wind blows from the northeast more frequently as cold, dense air spills out of the San Joaquin Valley. The meteorological conditions at Site 300 are also strongly influenced by higher elevation and more pronounced topological relief. Approximately 55% of the rain at both sites falls in January, February, and March and approximately 80% falls in the five months from November through March; very little rain falls during the warmer months. Meteorological towers are located at both the LLNL main site and Site 300.

Site Monitoring. Air effluent monitoring of atmospheric discharge points is used to determine the actual radionuclide releases from individual facilities during routine and nonroutine operations and to confirm the operation of facility emission control systems. Annually from 2015-2018, releases of radioactivity from air exhausts were measured at five LLNL main site facilities and at one LLNL Site 300 facility.

LLNL conducts ambient air monitoring at onsite and offsite locations to determine whether airborne radionuclides are being released to the environs in measurable quantities by LLNL operations. Ambient air samplers, particularly those on the site perimeters, have been placed to monitor locations where elevated air concentrations due to LLNL operations may occur. Ambient air samples are analyzed for tritium, gross alpha and gross beta, and gamma-emitting radionuclides.

LLNL monitors water systems including wastewaters, stormwater, and groundwater, as well as rainfall and local surface water. The Livermore site is serviced by publicly-owned treatment works, but Site 300 is not, so the methods of treating and disposing of sanitary wastewater at the two sites are different. Samplers at the Sewer Monitoring Station (SMS) collect flow proportional composite samples and instantaneous grab samples that are analyzed for radioactivity, nonradioactive constituents, and other water-quality parameters. LLNL determines the total radioactivity contributed by tritium, gross alpha emitters, and gross beta-emitters from the measured radioactivity in the monthly effluent samples.

LLNL conducts surveillance monitoring of groundwater in the Livermore Valley and at Site 300 through networks of wells and springs that include offsite private wells and onsite DOE *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) wells. LLNL has monitored tritium in water hydrologically downgradient of the Livermore site since 1988. The perimeter portion of the surveillance groundwater monitoring network uses three upgradient (background) monitoring wells near the eastern boundary of the site and seven downgradient monitoring wells located near the western boundary.

For surveillance and compliance groundwater monitoring at Site 300, LLNL uses DOE CERCLA wells and springs onsite, and private wells and springs offsite. Representative groundwater samples are obtained at least once per year at every monitoring location and are routinely measured for nonradioactive constituents, general radioactivity (gross alpha and gross beta), uranium activity, and tritium activity. LLNL samples and analyzes groundwater from areas of known or suspected contamination for both the Livermore site and Site 300.

Collected rainwater is analyzed for tritium activity. Surface and drinking water near the Livermore site and in the Livermore Valley are sampled for tritium, gross alpha, and gross beta.

C.4.2 Los Alamos National Laboratory

The current mission of LANL is to solve national security challenges through scientific excellence. The current goals of the Laboratory are to deliver national nuclear security and broader global security mission solutions, and to foster excellence in science and engineering disciplines essential for national security missions by attracting, inspiring, and developing world-class talent to ensure a vital future workplace, and by enabling mission delivery through next-generation facilities, infrastructure, and operational excellence.

Site Description. LANL is located in Los Alamos County, in north-central New Mexico, approximately 60 mi (97 km) north-northeast of Albuquerque and 25 mi (40 km) northwest of Santa Fe. LANL encompasses about 40 mi^2 (104 km^2 = 25,600 ac) and is situated on the Pajarito Plateau, a series of fingerlike mesas and canyons at the eastern edge of the Jemez Mountains, bordered on the east by White Rock Canyon and the Rio Grande. Mesa tops range in elevation from approximately 7,800 ft (2,380 m) on the flanks of the Jemez Mountains to about 6,200 ft (1,890 m) at the edge of White Rock Canyon.

The 2016 population estimated to reside within a 50 mi (80 km) radius of LANL's zip code is approximately 348,863 residents, of which approximately 29,625 (12%) are of Native American descent.

The land surrounding the Laboratory is largely undeveloped, and large tracts of land north, west, and south of LANL are held by the Santa Fe National Forest, the U.S. Bureau of Land Management, Bandelier National Monument, and Los Alamos County. The Pueblo de San Ildefonso borders the Laboratory to the east. Santa Clara Pueblo is north of the Laboratory but does not share a border.

Los Alamos County has a semiarid climate—more water is lost through evaporation and transpiration than is received as annual precipitation. Annual temperatures and amounts of precipitation vary across the site because of the 1,000 ft (305 km) elevation change and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional snow storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. Daily temperatures are highly variable. On average, winter temperatures range from 30–50°F (-1.1–10°C) during the daytime and from 15–25°F (-9.4– -3.9°C) during the nighttime. The Sangre de Cristo Mountains to the east of the Rio Grande act as a barrier to wintertime arctic air masses, making the occurrence of subzero temperatures rare. On average, summer temperatures range from 70–88°F during the day and from 50–59°F (10–15°C) during the night. From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of snow, hail, or any other frozen precipitation) was 19 in. (48 cm). The average annual snowfall was 59 in. (150 cm). Summer afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico lifts over the Jemez Mountains, yielding short, heavy downpours and an abundance of lightning. Local annual lightning density, among the highest in the United States, is estimated at 15 strikes per square mile. Daytime winds in the LANL area are predominately from the south. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and are typically from the west.

Site Monitoring. During 2017, LANL operated 38 environmental air-monitoring stations to sample radionuclides in airborne particulate matter. Sampling locations are categorized as regional, perimeter, onsite, or waste site. These stations are operated continuously; filters are replaced every 2 weeks.

LANL's stack monitoring team monitors emission points that could cause a public dose greater than 0.1 millirem in a year. Radioactive stack emissions can be one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, or (4) gaseous mixed activation products.

LANL monitors direct-penetrating radiation from photons and neutrons at 80 locations in and around the site. TLDs are deployed at every environmental air-monitoring station. Additional dosimeters are located at Technical Areas (TAs) 53 and 54. Neighborhood environmental watch network stations supplement monitoring and are situated near these areas.

Groundwater monitoring is conducted at alluvial, perched-intermediate, and regional aquifer well locations, and at springs that discharge perched-intermediate and regional aquifer groundwater. Monitoring is primarily organized into area-specific monitoring groups. Numerous springs along the Rio Grande are also monitored because they represent natural discharge from perched-intermediate and regional aquifer groundwater that flows beneath the Laboratory. Samples are also collected from 12 Los Alamos County water supply wells, from wells located on Pueblo de San Ildefonso lands, and from the Buckman well field operated by the City of Santa Fe.

Surface water is sampled, when present, in all major canyons and tributaries on current or former LANL lands. This includes an emphasis on monitoring close to and downstream of potential sources of LANL-released substances, including monitoring at the downstream site boundaries and east of New Mexico State Road 4. A total of 39 stream gauging stations are maintained on and near the LANL site, all of which are equipped with samplers that activate at the start of stormwater runoff events. Stormwater samples are also collected at seven additional stream channel locations that do not have active gauging stations. The number and locations of samples are adjusted in response to events such as major floods, forest fires, and changes in stream impairments. Samplers have also been installed in 250 site monitoring areas to directly sample stormwater runoff from 405 solid waste management units and areas of concern. These samplers are not kept on during months that feature freezing temperatures. Because rainstorms on the Pajarito Plateau are frequently very localized and not all rainfall events produce stormwater runoff, not all active sampling locations collect samples each year.

Sediment samples are collected at a depth of between 0–12 in. (0–30 cm), depending on the thickness of the uppermost sediment layer. Samples were collected from stream channels and floodplains where new sediment was deposited during 2017. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water.

During 2017, soil and vegetation samples were collected around the perimeter of Material Disposal Area G at TA 54. Soil, wild bird eggs that did not hatch, and nestlings that died of natural causes were collected at TA 15. Mice and vegetation were collected upstream of sediment control structures within Los Alamos and Pajarito Canyons. Deceased animals (primarily from vehicle strikes) including mule deer, rocky mountain elk, black bear, coyote, gray fox, great horned owl, western screech owl, red-tailed hawk, and bull snake were collected from various onsite areas and were analyzed. The solid, foodstuffs, and biota monitoring program conducts two specific types of monitoring: institutional and facility-specific. Institutional monitoring occurs sitewide and is conducted on LANL property, around the perimeter, and at regional background locations. Institutional monitoring is used to measure the levels of radionuclides and chemicals in areas outside of designated solid waste management units and to compare predictions of chemical and radionuclide transport models with actual results. Facility-specific monitoring is used to measure the nature and extent of radionuclides and chemicals associated with specific facilities, operations, and structures at the Laboratory. Predator fish and bottom-feeding fish are collected and analyzed for radionuclides. In October 2017, benthic macroinvertebrates were collected from the Rio Grande upstream and downstream of its confluence with Los Alamos Canyon. Benthic macroinvertebrates and sediments were collected from seven locations upstream, extending from Los Alamos Canyon to Black Mesa, and from eight locations downstream, extending from Los Alamos Canyon to Ancho Canyon.

C.4.3 Nevada National Security Site

NNSS is a large site, encompassing 1,360 mi^2 (3,522 km^2), larger than the State of Rhode Island. Several NNSS facilities or centers support the NNSS National Security/Defense missions, including the U1a Complex, Big Explosives Experimental Facility, Device Assembly Facility (DAF), Dense Plasma Focus Facility (located within the Los Alamos Technical Facility), Joint Actinide Shock Physics Experimental Research Facility, Nonproliferation Test and Evaluation Complex, the National Criticality Experiments Research Center (located within the DAF), the Radiological/Nuclear Countermeasures Test and Evaluation Complex, and the Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site). NNSS facilities that support EM missions include the currently active Area 5 Radioactive Waste Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS), which is in cold standby. NNSS operations also include support operations conducted at the North Las Vegas Facility (NLVF).

Site Description. The NNSS, formerly named the Nevada Test Site, is located in Nye County in south-central Nevada. The southeast corner of the NNSS is about 55 mi (88 km) northwest of the center of Las Vegas in Clark County. It varies from 28–35 mi (46–56 km) wide from west to east and from 40–55 mi (64–88 km) wide from north to south. The NNSS is surrounded on all sides by Federal lands. It is bordered on the west and north by the Nevada Test and Training Range (NTTR), on the east by an area used by both the NTTR and the Desert National Wildlife Refuge, and on the south and southwest by Bureau of Land Management lands. The combination of the NTTR and the NNSS represents one of the largest unpopulated land areas in the United States, comprising some 5,470 mi^2 (14,200 km^2 = 3.5 million ac).

The population of the area surrounding the NNSS is predominantly rural. The most recent population estimate (2017) for Nye County is 46,390, and the largest Nye County community is Pahrump (39,023), located approximately 50 mi (80 km) south of the NNSS Control Point facility (near the center of the NNSS). Other Nye County communities with populations ranging from about 100–2,000) include Tonopah, Amargosa, Beatty, Round Mountain, Gabbs, and Manhattan. Lincoln County to the east of the NNSS includes a few small communities including Caliente, Pioche, Panaca, and Alamo. Clark County, southeast of the NNSS, is the major population center of Nevada and has an estimated population of 2.2

million, including the City of Las Vegas. The Mojave Desert of California, which includes Death Valley National Park, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swells the population to more than 5,000 on any particular day during holiday periods when the weather is mild. Southern Utah's largest community is St. George, located 137 mi (220 km) east of the NNSS. The northwestern region of Arizona is mostly rangeland, except for the portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest town in closest proximity is Bullhead City, 103 mi (165 km) south-southeast of the NNSS.

Site Monitoring. The sources of radioactive air emissions on the NNSS include the following: (1) tritiated water evaporated from containment ponds; (2) tritiated water vapor diffusion from soil at the Area 3 RWMS, the Area 5 RWMC, and historical surface or near-surface nuclear device test locations (particularly Sedan and Schooner craters); (3) resuspension of contaminated soil at historical surface or near-surface nuclear device test locations; and (4) radionuclides from current operations. The NNSS air-monitoring network consists of samplers near sites of soil contamination, at facilities that may produce radioactive air emissions, and along the NNSS boundaries. Analytes monitored in air include americium-241, gamma-emitters (e.g., cesium-137), tritium, plutonium-238, plutonium-239/240, uranium-233/234, uranium-235/236, uranium-238, gross alpha, and gross beta. A total of 18 environmental sampling locations operated on the NNSS in 2017; 15 had both air particulate and tritium (atmospheric moisture) samplers, one had only an air particulate sampler, and two had only tritium samplers. Air samplers are positioned in predominant downwind directions from sources of radionuclide air emissions and/or are positioned between NNSS contaminated locations and potential offsite receptors.

Radionuclides have been detected in the groundwater in some areas of the NNSS and are a result of historical underground nuclear tests. The radiological water sampling network includes 84 sample locations, categorized into seven different well types. NNSS public water system wells are sampled quarterly.

Direct radiation monitoring is conducted to assess the external radiation environment, detect changes in that environment, respond to releases from NNSA Nevada Field Office (NNSA/NFO) activities, and to measure gamma radiation levels near potential exposure sites. An offsite monitoring program implemented by NNSA/NFO monitors direct radiation in communities adjacent to the NNSS. A surveillance network of TLD sample locations monitors NNSS areas that have elevated radiation levels from historical nuclear weapons testing, current and past radioactive waste management activities, and/or current operations involving radioactive material or radiation-generating devices. In 2017, there were 103 active environmental TLD locations on the NNSS and six control locations.

Two community-based radiological monitoring programs conducted offsite of the NNSS provide independent results for the presence of man-made radionuclides in air and groundwater samples from communities surrounding the NNSS.

Plants and game animals from contaminated NNSS sites are sampled annually. The species selected for vegetation sampling represent the most dominant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is sampled because it is reported to have deeper penetrating roots and potentially higher concentrations of tritium; and is a major source of grazing for game animals that might potentially migrate offsite. Small mammals selected for sampling meet three criteria: (1) they are fossorial (i.e., they burrow and live predominantly underground), (2) they have a home range small enough to ensure that they reside a majority of the time on the waste disposal site, and (3) they are sufficiently abundant at a site to acquire an adequate tissue sample for laboratory analysis. Larger game species are opportunistically collected (killed by a predator or vehicle). Soils excavated by ants or small mammals are also selected for sampling on the basis of size, with preference for larger ant mounds and animal burrow sites under the assumption that these burrows are deeper and have a higher potential for penetrating waste.

All wastewater discharges at NNSS, NLVF, and Remote Sensing Laboratory-Nellis (RSL-Nellis) are under specific State permit requirements, including those of a National Pollutant Discharge Elimination System

(NPDES) permit issued for groundwater pumping activities at the NLVF. Small amounts of tritium continue to be emitted via basement ventilation air from legacy contamination at NLVF.

C.4.4 Pantex Plant

PANTEX is a government-owned, contractor-operated facility. It is the primary assembly, disassembly, maintenance, and evaluation facility supporting the nuclear weapons arsenal. The plant is composed of several functional areas, commonly referred to as numbered zones. Included within the zones are a weapons assembly/disassembly area, a weapons staging area, an area for experimental explosives development, a drinking water treatment plant, a sanitary wastewater treatment facility, a vehicle maintenance facility, and administrative areas. Other functional areas include a utilities area for steam and compressed air, an explosives test-firing facility, a Burning Ground for thermally processing (i.e., burning or flashing) explosive materials, pump and treat groundwater remediation facilities, several agricultural tracts which are irrigated via a subsurface fluid distribution system, and landfills.

Site Description. The PANTEX site, consisting of 17,503 ac (7,001 ha), is located 17 mi (27 km) northeast of Amarillo, Texas (TX), in Carson County. The site is located on the Llano Estacado (staked plains) portion of the Great Plains at an elevation of approximately 3,500 ft (1,067 m). Site topography is relatively flat, characterized by rolling grassy plains and numerous natural playa basins (shallow lakes, mostly less than 0.6 mi [1 km] in diameter). The region is a semiarid farming and ranching area, but several industrial facilities are located nearby. The land around the PANTEX site is used mainly for winter wheat and grain sorghum farming, ranching, and mining (oil and gas). Although dryland farming is dominant, some fields are irrigated using water from the Ogallala Aquifer or, less commonly, from local playas. The economy of the rural panhandle region depends mainly on agriculture, but the more populated counties of the region also have manufacturing, distribution, food processing operations, and medical services. Most of the population is located west-southwest of PANTEX in the Amarillo metropolitan area. Population data from the 2010 census indicate 316,132 people reside within 50 mi (80 km) of the site.

The area's semiarid climate is characterized by hot summers and relatively cold winters, with large variations in daily temperatures, low relative humidity, and irregularly spaced rainfall of moderate amounts. Three-fourths of the average precipitation (20.4 in. [51.7 cm]) falls from April through September, and generally occurs with thunderstorm activity. The average annual snowfall is 17.8 in. (45 cm). Heavier snowfalls of l0 in. (25 cm) or more, usually with near blizzard conditions, occur on average, once every 5 years and last 2–3 days. The Amarillo area is subject to extreme and rapid temperature changes, especially during the fall and winter months when cold fronts from the northern Rocky Mountain and Plains states sweep across the area. Temperature drops of 50–60°F (10–16°C) within a 12-hour period are not uncommon. Humidity averages are moderately low, occasionally dropping below 20% in the spring. The Pantex Plant is located in an area that has a relatively high frequency of tornadoes, convective wind events, and hail. An average of 17 tornadoes occurred each year in the 20 counties of the Texas Panhandle and the adjacent three counties of the Oklahoma Panhandle during the period between 1950 and 2015. The mean temperature at the official National Weather Service (NWS) Forecast Office for Amarillo location is 57.3°F (14.1°C). During 2017, the official NWS rain gauge recorded 25.9 in. (65.8 cm) of precipitation, 5.5 in. (14.0 cm) above normal.

Site Monitoring. The environmental dosimetry program uses TLDs to measure gamma radiation on and around PANTEX, and they are analyzed and replaced at the end of each calendar quarter. Other monitoring and sampling that detect possible airborne emissions of radiological material at PANTEX are conducted at onsite and offsite locations. A total of 18 air-monitoring stations were used to monitor for radionuclides in the air in 2017. Each monitoring station was equipped with a high-volume air sampler and a low-volume air sampler.

Historical operations at PANTEX resulted in contamination of the perched groundwater area, and the contaminant plume has migrated past the site boundaries and beneath the adjacent property to the south and east. The primary contaminants of concern (COCs) in the perched aquifer are hazardous chemicals (explosives RDX and TNT and related breakdown products; perchlorate; hexavalent chromium; and trichloroethene). Groundwater was monitored at 30 wells in 2017. Remedial actions are under way to clean up regions of the perched aquifer.

Radiological monitoring is not required for the non-transient, non-community public drinking water supply at PANTEX. Surface water represented by rivers or streams does not exist around the facility site and all surface water drains to isolated playa lakes. Surface water sampling occurs as a result of precipitation or discharge events. PANTEX conducted stormwater monitoring at all eight stormwater outfalls and all four playas during 2017 at designated sampling locations. Environmental surveillance monitoring was also conducted at the playas as a best management practice.

Animals at the PANTEX site were sampled to determine whether site activities had an impact on them. Black-tailed prairie dogs and cottontail rabbits were the species selected for sampling because they interact with both the primary (air, water) and secondary (vegetation) environmental media which are also being analyzed. Radionuclide surveillance of fauna at Pantex was scheduled semiannually at nine onsite locations and one control location.

Radionuclide analyses were performed on both native vegetation and crops. Native vegetation species on the southern High Plains consist primarily of prairie grasses and forbs. Crops are defined as any agricultural product harvested or gathered for animal or human food, including garden produce, forage, or fiber. Native vegetation samples, primarily consisting of stem and leaves from grasses and forbs, were collected from 1 control, 11 onsite, and 9 offsite locations. During the growing season, samples were collected no more frequently than once per month in 2017. Samples consisting of stems and leaves of dryland and irrigated winter wheat and irrigated grain sorghum were collected onsite, and at the Bushland, TX, control locations.

C.4.5 Sandia National Laboratories, Albuquerque, New Mexico

The core mission at SNL-NM is to provide science and engineering support for the nation’s nuclear weapons stockpile. In addition, SNL-NM personnel collaborate with government agencies, the industrial sector, and universities to develop and commercialize new technologies.

Site Description. SNL-NM operations are conducted on DOE-owned property assigned for operational use, non-DOE-owned property contracted from other Federal agencies, and privately owned leased property. SNL-NM sites located on DOE-owned property comprise 2,938 ac (1,189 ha) and include five technical areas. At non-DOE-owned property, SNL-NM personnel conduct operations on 5,637 ac (2,281 ha) of land permitted by the U.S. Air Force, a portion of which are on land withdrawn by the U.S. Forest Service. DOE leases approximately 2,750 ac (1,113 ha) from the New Mexico State Land Office (La Semilla Buffer Zone) west of the Kirtland Air Force Base (KAFB) boundary. This area serves as a margin of safety and a sound buffer for testing operations. In addition, Sandia personnel conduct operations at offsite leased facilities. The estimated population within a 50 mi radius of the SNL-NM is approximately 965,711 residents. Nine counties are contained or partially included in that radius.

SNL-NM is set in the high desert region of central New Mexico. The habitats of the SNL-NM ecosystem include grasslands, woodland, arroyo shrub, scattered piñon-juniper, and closed canopy piñon-juniper. The mountains on the east and the plateaus on the west create a diverse range of geological, hydrological, ecological, and climatic settings. Large diurnal temperature ranges, summer monsoons, and frequent drying winds are characteristic of the regional climate in the Albuquerque Basin and the Sandia, Manzanito, and Manzano Mountains.

Temperatures are typical of mid-latitude, dry continental climates; summer temperatures in the basin are around 60°–90°F (16°–32°C) and winter temperatures are around 20°–50°F (-6.7°–10°C). The dry continental climate also produces low average humidity in the late spring and early summer, prior to the onset of the monsoon season. Daytime average relative humidity is near 30–50 percent. Precipitation varies across the region; many locations in the higher elevations of the mountains receive twice the annual rainfall of locations in the Albuquerque Basin. The winter season in the Albuquerque Basin and around SNL-NM is generally dry, featuring an average of less than 1.5 in. (3.8 cm) of precipitation falling between December and February. Most precipitation falls between July and October, mainly in the form of brief, heavy rain showers. According to the National Climatic Data Center, the average annual precipitation is approximately 9.45 in. (24 cm) for the Albuquerque area. Winds tend to blow toward the mountains or up the Rio Grande Valley during the day, and nocturnal winds tend to blow down the mountain toward the Rio Grande Valley. These topographically induced wind flows can be enhanced or negated by weather systems that move across the southwestern United States.

Site Monitoring. The items at SNL-NM that are monitored or sampled for radiological parameters include groundwater, wastewater, emissions, environmental media and ambient external gamma radiation.

The groundwater monitoring network at SNL-NM consists of 76 monitoring wells. Depending on the specific well, samples may be analyzed for the following parameters: Target Analyte List metals (plus uranium), inorganics (including nitrate plus nitrite, major anions, total cyanide, perchlorate), total phenols, total alkalinity, volatile organic compounds, diesel and gasoline range organics, total halogenated organics, tritium, gross alpha, gross beta, selected radionuclides, and high explosive compounds.

Wastewater that is discharged to the public sewer system is divided into two categories: sanitary discharges and industrial discharges. Samples may be analyzed for inorganics, tritium, gross alpha, gross beta, and select radionuclides to ensure that radiological levels meet regulatory standards before the water is released to the public sewer system.

Radiological emissions are monitored via point sources that could potentially discharge material to the atmosphere through a facility's exhaust stack or rooftop vent. Monitoring methods include periodic, calculation, and continuous. The emissions are modeled to estimate the annual radiological dose to each of the identified public receptors.

Environmental media (soil, sediment, and vegetation) samples are collected and may be analyzed for inorganics, perchlorate, high explosive compounds, tritium, gross alpha, gross beta, selected radiological constituents. Ambient external gamma radiation levels are measured using environmental dosimeters with results reported as an annual average dose rate.

C.4.6 Sandia National Laboratories, Livermore, California

SNL-CA is a multiprogram engineering and science laboratory that supports the nuclear weapons stockpile program, energy and environment research, homeland security, micro- and nanotechnologies, and basic science and engineering research.

Site Description. SNL-CA is located approximately 40 mi (64 km) east of San Francisco, within the City of Livermore in eastern Alameda County. The site lies at the western base of the Altamont Hills on relatively flat terrain. SNL-CA comprises 410 ac (166 ha). The main campus (134 ac [54 ha]) is surrounded by the remaining undeveloped land (276 ac [112 ha]) on the east, south, and west. To the north of SNL-CA are East Avenue and the DOE LLNL Site (see Section C.4.1). Land use to the east and south of the site is agricultural and low-density residential. A residential development is located along the western boundary of the site.

SNL-CA is located in a seismically active region. The major fault systems in the area are the San Andreas fault system, and the much older Coast Range thrust fault system.

The climate at SNL-CA is typical of the Mediterranean conditions in the San Francisco Bay region where cool, wet winters and hot, dry summers are normal. In the summer, inland valleys, such as the Livermore Valley, generally experience more sunshine and higher temperatures than the coastal areas. In the winter, temperatures in the valley are usually cooler than at the coast. SNL-CA uses a nearby meteorological tower located at LLNL. The annual rainfall for 2017 was 18.67 in. (47.4 cm). Temperatures in 2017 ranged from 26.8 to107.3ºF (-2.9 to 41.8ºC). Average annual rainfall in the Livermore area over the last 5 years was 11.98 in. (30.4 cm). The windiest months in the area occur in the spring and summer and are dominated by westerly sea breezes. The winds during the fall and winter are typically lighter and more varied in direction.

The SNL-CA area is typical of the surrounding region, consisting primarily of grassland and localized areas of coyote brush scrub, willow riparian woodland, and wetland habitat.

Site Monitoring. Personnel at SNL-CA monitor stormwater, wastewater, groundwater, and gamma radiation. There are no radionuclide emission sources that require routine monitoring. SNL-CA personnel maintain an inventory of radioactive isotopes (small quantity sealed and unsealed sources) and operate several radiation-generating devices. Emissions monitoring is not required for these materials and devices. Because there are no radionuclide emission sources and no monitoring data for site operations, calculations for maximum individual dose or collective dose are not possible.

SNL-CA personnel monitor gamma radiation at the site perimeter to ensure that site operations are not significantly contributing to the ambient radiation dose in the surrounding environment. Twelve monitoring stations are equipped with TLDs that are evaluated quarterly.

C.4.7 Sandia National Laboratories, Tonoapah Test Range, Tonopah, Nevada

SNL-TTR personnel conduct operations in support of the DOE Weapons Ordnance Program. SNL-TTR also offers a unique test environment for use by other government agencies and their contractors.

Site Description. SNL-TTR is located on approximately 280 mi^2 (725 km^2 = 179,200 ac) of withdrawn land, which is permitted by the U.S. Air Force (USAF) within the boundaries of the NTTR (Nevada Test and Training Range). Sandia personnel use the land to support DOE and USAF activities and missions. The area north of the SNL-TTR boundary comprises sparsely populated public lands jointly administered by the U.S. Bureau of Land Management and the U.S. Forest Service. Cattle graze this land in winter and spring. A substantial irrigated farming operation is also north of the range. SNL-TTR lies within a portion of the Nevada Wild Horse Range herd area, which is administered by the U.S. Bureau of Land Management. The site has never been used for detonation of nuclear weapons.

The nearest residents are located in the towns of Goldfield, NV, population 268, and Tonopah, NV, population 2,478. Goldfield and Tonopah are located approximately 22 mi (35 km) west, and 32 mi (51 km) northwest of the site boundary, respectively. Las Vegas, population 583,756, the largest municipality by population, is located approximately 140 mi (225 km) southeast of the site boundary.

The topography at SNL-TTR is characterized by a broad, flat valley bordered by two north and south-trending mountain ranges: the Cactus Range to the west (occurring mostly within the boundaries of SNL-TTR) and the Kawich Range to the east. Cactus Flat is the valley floor, where the main operational area of SNL-TTR is located. An area of low hills outcrops in the south. Elevations range from 5,347 ft (1,630 km) at the valley floor to 7,482 ft (2,280 m) at Cactus Peak. The elevation of the town of Tonopah is 6,047 ft (1,843 m).

The climate at SNL-TTR is typical of high desert, mid-latitude locations, with large diurnal and seasonal changes in temperature and little total rainfall. Temperature extremes at the test range vary from highs near 104°F in summer to lows approaching -22°F (-30°C) in winter. July and August are the hottest months, with highs generally in the 90s°F (30s°C) during the day and dropping to the 50s°F (10–15°C) at night. January conditions vary from highs in the 40s°F (single digits °C) to lows in the 10s°F (about -9°C). Average annual precipitation at the Tonopah Airport (the closest station with 30 or more years of data), elevation 5,426 ft (1,654 m), is 5.08 in. (12.9 cm). Typically, the months of May and July have the highest averages of about 0.5 in. (1.4 cm) for both months, and December has the lowest with 0.27 in. (0.69 cm). Winds are generally from the northwest in winter and early spring, switching to southerly directions during summer. The mountain-and-valley system channels the wind such that the wind seldom blows from eastern or southwestern directions. Dust storms are common in the spring, when monthly average wind speeds reach 15 mph (6.7 m/sec). During the spring and fall, there may be a diurnal wind cycle, bringing northwest winds in the early hours and shifting to southerly winds by afternoon.

Site Monitoring. Currently, operations at SNL-TTR do not involve activities that release radioactive emissions from either point sources (stacks and vents) or new diffuse sources. However, diffuse radiological emissions are produced from the resuspension of americium and plutonium, which are present at the Clean Slate environmental restoration sites. There are five air monitoring stations onsite consisting of two primary components: an air sampler for particulate matter and an auxiliary meteorological tower. Particulate matter collected from the air filters are analyzed for gross alpha, gross beta, and radionuclides.

Environmental media (soil) samples are collected and may be analyzed for inorganics and selected radiological constituents.

Ambient external gamma radiation levels are measured using environmental dosimeters. Results are reported as an annual average dose rate.

Wastewater is sampled at the point where wastewater leaves SNL-TTR property and enters the USAF system. Composite wastewater samples are collected for analysis of inorganics, organics, tritium, gross alpha, gross beta, select radionuclides.

C.4.8 Sandia National Laboratories, Kaua'i, Hawaii

The SNL Kaua'i Test Facility (SNL-KTF) has been an active rocket-launching facility since 1962. The facilities and personnel support a variety of missions, including R&D, operational training, and testing and evaluation.

Site Description. SNL-KTF is located on the western coast of Kaua'i. SNL-KTF is a tenant of the Department of Defense Pacific Missile Range Facility (PMRF) and is located within the boundaries of PMRF. The facility is bounded on the north and east by agricultural fields, on the northwest and southwest by the Pacific Ocean, and on the south by PMRF.

Site Monitoring. Operations do not (currently or in the past) involve radioactive materials. No monitoring for radiological parameters is conducted.

C.5 NNSA Naval Nuclear Propulsion Program

The major missions of the National Nuclear Security Administration (NNSA) are maintaining the U.S. nuclear stockpile, nonproliferation, counterterrorism and counterproliferation, and powering the nuclear propulsion plants of the U.S. Navy Naval Nuclear Propulsion Program, (NNPP). Section C.4 of this report covered NNSA sites that were not associated with the Nuclear Navy mission. This section consolidates the site descriptions of the NNSA-NNPP sites.

From 2015 to 2018, the NNSA-NNPP was assigned to the following facilities included in this report:

- Bettis Atomic Power Laboratory (BETTIS)
- Knolls Atomic Power Laboratory-Kesselring Site (KESS)
- Knolls Atomic Power Laboratory-Knolls Laboratory (KNOL)
- Naval Reactors Facility (NRF) located at Idaho National Laboratory (INL)

NRF is described here, separately from the INL Site in Section C.7, because NNSA-NNPP ASER requirements differ from those of INL.

C.5.1 Bettis Atomic Power Laboratory

The primary mission of BETTIS has always been directed toward the design, development, testing, and operations of nuclear reactor propulsion plants for naval surface and submarine vessels.

Site Description. The BETTIS site is located in the Borough of West Mifflin, Allegheny County, Pennsylvania, approximately 8 mi (12.9 km) southeast of central Pittsburgh, and comprises approximately 208 ac (84 ha) of land. The site is located approximately 6,000 ft (1.8 km) west of the Monongahela River. The elevation at the site ranges from approximately 975 ft (297 m) to 1,200 ft (366 m) above mean sea level.

The land use of the region surrounding the site is largely industrial and residential. The section of the borough in which BETTIS is located is zoned as heavy industrial. The total population within a 50 mi (80 km) radius of the site is approximately three million. A heavily wooded area borders the site on the east, and most of this property is owned by the Borough of West Mifflin. Some of this borough-owned property has been developed into the West Mifflin Community Park. A fence has been erected to prevent inadvertent access to the site property from the park area. An industrial district is located along the northern boundary of the site. Commercial and residential developments border the site on the south and west. Two public roadways run along the length of the southern perimeter of the property and a railroad runs along the northern end. Extensive mining of the Pittsburgh Coal seam has occurred to the west and south, as well as under the site. The Pittsburgh Coal seam lies about 200 ft (61 m) below the active portion of the site. Most of the Pittsburgh Coal that can be mined has been removed. There are no current coal mining activities in this area. The seismic risks for the region in which BETTIS is located are judged to be minimal.

Site Monitoring. All radiological, forced-air exhaust systems are continuously monitored for particulate radioactivity. Systems servicing major radiological facilities are provided with continuous monitoring equipment that will alarm if the exhaust air contains levels of radioactivity that are greater than normal, but still much less than the allowable Federal environmental standards at the site boundary. Monitoring of exhaust air has been accomplished through the collection and analysis of samples of the effluent. The sampling technique used depended on the physical and chemical nature of the radioactivity and included filter paper and carbon filter sampling.

The groundwater radiological monitoring program has been maintained since the mid-1980s and includes groundwater samples from seeps, springs, and monitoring wells. Samples are collected regularly and analyzed for gross alpha, gross beta, and specific radionuclides associated with past or current BETTIS operations, such as cobalt-60, cesium-137, and strontium-90. Samples are also taken at remote sites for comparison of the levels of radioactivity naturally occurring in the environment in southwestern Pennsylvania with those of the BETTIS site results.

BETTIS has never maintained a radioactive waste burial ground. However, small amounts of radioactivity from early laboratory work can be found in localized areas of soil and sediment onsite. Most of this radioactivity is located under facilities where it is inaccessible; however, BETTIS routinely monitors these areas where it is possible. BETTIS is engaged in a program of clean-up or removal of the facilities and adjacent soil where the radioactivity exists.

C.5.2 KAPL-Kesselring Site

The Knolls Atomic Power Laboratory (KAPL) has two locations in New York (NY) State (see Section C.5.3 for the other KAPL location, KAPL-Knolls [KNOL], which is 15.8 mi (25.4 km) south-south east of the Kesselring Site [KESS]). By 2018, this DOE site was referred to as the Kenneth A Kesselring Site. The Knolls Atomic Power Laboratory-Kesselring Site (KESS) has two operating, pressurized-water naval nuclear propulsion plants and support facilities, including administrative offices, machine shops, waste storage facilities, oil storage facilities, training facilities, equipment service buildings, chemistry laboratories, a boiler house, cooling towers, and wastewater treatment facilities. KESS is dedicated primarily to the training of personnel in the operation of naval nuclear propulsion plants.

Site Description. KESS (3,900 ac [1,578 ha]) is located near West Milton, NY, approximately 17 mi (27.4 km) north of the City of Schenectady, 9 mi (14.5 km) southwest of Saratoga Springs, and 13 mi (21 km) northeast of Amsterdam. The surrounding area is a rural, sparsely populated region of wooded lands, through which flow the Glowegee Creek and several small streams that empty into the Kayaderosseras Creek.

The climate in the region of KESS is primarily continental in character, but is subjected to some modification from the maritime climate, which prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during the colder winter months often are below freezing and nighttime low temperatures frequently drop to 10°F or lower. Subzero temperatures occur rather infrequently, about a dozen times a year. Annual snowfall in the area is quite variable, averaging approximately 65 in. (165 cm). Over some of the higher elevation areas nearby, snowfall ranges up to 75 in. (190 cm) or more for a season. The mean annual precipitation for the area is approximately 36 in. (91.4 cm). The prevailing winds are from the west. The population within 50 mi (80 km) of KESS is approximately 1,230,000 people.

Site Monitoring. The radiological environmental monitoring program at KESS includes (1) the collection of fish upstream and downstream of discharge locations to the Glowegee Creek, (2) the collection of quarterly samples of Glowegee Creek water and sediment at five locations, and (3) the operation of continuous air samplers at stations located in the primary upwind and downwind directions from the site. Three samples of sediment and one composite water sample are collected quarterly for radioanalysis across the creek at the five locations

Small quantities of particulate radioactivity, principally cobalt-60, are processed through controlled exhaust systems during reactor coolant sampling, draining, and venting operations. The air exhausted from the reactor plants is continuously monitored for particulate radioactivity with monitors that are equipped with alarm functions to provide an alert if an out-of-specification release occurs. The air exhausted from all radiological work facilities is continuously sampled for particulate radioactivity. Reactor plant air emissions are also continuously sampled for radioiodine with activated charcoal cartridges. Sampling is performed for hydrogen-3 (tritium) and carbon-14 using appropriate absorbers. Environmental air samplers measure normal background airborne radioactivity and confirm that site effluents have no measurable effect on normal background levels.

Liquid discharges that might contain tritium are either sampled and analyzed individually or sampled and combined into a monthly composite that is then analyzed for tritium. Monthly grab samples are also taken at Outfalls 001 and 002 (lagoon wastewater treatment system).

Environmental radiation levels are monitored at the perimeter of KESS with a network of TLDs evaluated quarterly. Control TLDs are posted at four remote offsite locations to measure the natural background levels.

KESS performs voluntary radiological monitoring of groundwater at 40 locations on site including the site developed area, closed landfill, and former disposal areas. The drinking water system is sampled and monitored for radionuclides.

C.5.3 KAPL-Knolls Laboratory

The Knolls Atomic Power Laboratory (KAPL) has two locations in New York State (see Section C.5.2 for the other KAPL location [KESS] 15.8 mi (25.4 km) north-northwest of the Knolls site [KNOL]). The principal function at the KAPL- Knolls Laboratory (KNOL) is R&D in the design and operation of naval nuclear propulsion plants. Facilities at the NNSA-NNPP Knolls Laboratory include administrative offices, machine shops, a sewage pumping station, a boiler house, oil storage facilities, cooling towers, waste storage facilities, and chemistry, physics, and metallurgical laboratories.

In addition to the KNOL main site, there is a region overseen by DOE-EM, the Separations Process Research Unit (SPRU). The information about SPRU is presented in the KNOL Environmental Monitoring Report. Therefore, SPRU is also discussed in this section. A Cold War era facility—the SPRU—operated between 1950–1953 at KNOL as a pilot plant to research chemical processes to extract uranium and plutonium from irradiated uranium. The work was done on a limited scale; SPRU was never a production plant. The SPRU processes were developed for use at the Atomic Energy Commission's Hanford Site in Washington State and the Savannah River Plant in South Carolina.

KNOL and SPRU Site Description. KNOL in Niskayuna, NY, is approximately 2 mi (3.2 km) east of Schenectady, NY. It is situated on 170 ac (68.8 ha) along the south bank of the Mohawk River. The surrounding area is a mixture of open land, other light industry, small farms, a closed municipal landfill, a small municipal park, and suburban residential areas. The population within 50 mi (80 km) of the Knolls site is approximately 1,360,000 people.

The climate in the region of the KNOL is primarily continental in character but is subject to some modification by the maritime climate that prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally severe. Maximum temperatures during the colder winter months often are below freezing. Subzero temperatures occur rather infrequently, about a dozen times a year. Annual snowfall in the area is quite variable, averaging approximately 59 in. (150 cm). The mean annual precipitation for the region is approximately 39 in. (99 cm). Westerly winds (W to NW) predominate, and a secondary maximum occurs from the south-southeast direction.

Following cessation of SPRU operations in 1953, partial cleaning of equipment and systems was performed, and the facility was placed in a stable long-term storage condition by the Atomic Energy Commission. KNOL maintained an environmental monitoring program to confirm that the inactivated SPRU facility posed no threat to the health of Laboratory workers, the public, or the environment. SPRU areas are undergoing dismantlement and remediation [and completed in 2020, prior to this publication's date]. The remediation resulted in the removal of hazardous equipment, building materials, and affected soil, and the restoration of the land for KNOL use. KNOL turned over the SPRU facilities (Buildings G2 and H2) and land areas to DOE-EM as necessary to support the objectives of the cleanup work. DOE-EM was responsible for the remediation of the SPRU areas.

The nature of the work performed from 2015 through 2018 in the Building G2/H2 area consisted of the operation of radioactive water collection systems, maintenance of the facility, removal of legacy radioactive materials, remediation of hazardous materials, and decontamination and demolition of Buildings G2 and H2. The work scope also included maintenance of contamination controls and shipments of waste.

KNOL and SPRU Site Monitoring. Airborne effluents from the main radiological emission points are continuously sampled for particulate radioactivity using particulate filter samplers and activated charcoal cartridge samplers where iodine or antimony may be present. Exhaust systems servicing major facilities are also continuously monitored for particulate, iodine, and noble gas radioactivity in effluents. Other minor radiological emission points are evaluated for the potential for release and are monitored on a periodic basis, as necessary, to confirm the low emissions.

The KNOL radiological environmental monitoring program includes (1) the routine collection and analysis of samples of Mohawk River water, sediment, and fish; surface water streams; groundwater; and local municipal waters; and (2) the continuous sampling of air at stations located in the predominant upwind and downwind directions from the site. Mohawk River water and bottom sediment samples are collected for radioactivity analyses at locations upstream and downstream from the main KNOL outfall. Samples are collected during each of three calendar quarters; ice coverage and/or winter weather prevents sampling during the first calendar quarter. In addition, bottom-feeding fish and recreational sport fish are collected from the Mohawk River upstream and downstream from the main KNOL outfall for gamma spectrometry and radiochemical analyses.

Surface water is also sampled monthly for radioactivity at the Midline Stream near the point of entry to the Mohawk River, the West Boundary Stream Ditch, and the East Boundary Stream upstream and downstream of the closed landfill, and the West Landfill Stream. Groundwater wells are sampled annually for radioactivity. Perimeter radiation levels are continuously monitored with TLDs.

Environmental air samplers are operated in the predominant upwind and 10 downwind locations around the entire KNOL perimeter to measure normal background airborne radioactivity, and to confirm that KNOL effluents have no measurable effect on normal background airborne radioactivity levels.

The main SPRU sources of radiological liquid effluents were water collected around the foundation of Building H2, and water collected from the open excavation of the Building G2 and Building H2 demolition footprints. The excavation water included that used for dust suppression during demolition and precipitation that falls on the footprint.

The SPRU operations capable of generating airborne radioactivity included operation of water collection systems, decontamination and demolition activities associated with portable ventilation units (PVUs) and Buildings G2 and H2, and soil excavation. PVUs were used at SPRU to monitor decontamination activities. PVU use is intermittent when heavy equipment is being cleaned. Building demolition, water collection, and soil excavation were sources of fugitive emissions. The Building H2 ventilation system was operational until September 2017 and airborne effluents continuously sampled for particulate activity. Particulate filter papers from ventilation systems were analyzed using a sensitive low-background counting system. Follow-on analyses for specific radionuclides were performed quarterly.

C.5.4 Naval Reactors Facility at INL

The primary mission of the NNPP's NRF at INL is the design, development, and operational testing for nuclear reactor propulsion plants for naval surface and submarine vessels. The major facilities at NRF include three former naval reactor prototypes and the Expended Core Facility (ECF). NRF information is consolidated under this NNSA-NNPP section. INL information is found in Section C.7, under the Office of Nuclear Energy.

Site Description. NRF is located on the INL site, 6.7 mi (11 km) from the nearest INL boundary, in the State of Idaho (ID). The developed portion of the facility within the security fence, the NRF Industrial Complex, covers approximately 89 of the 4,400 ac (6.88 mi^2 = 1,782 ha) under the cognizance of NRF. The remaining 4,311 ac (6.74 mi^2 = 1,745 ha) compose the NRF Administration Area. Most of the INL site, including NRF, is a secure facility that is not accessible to the general public. Located in a semiarid, sagebrush steppe environment, NRF has an average daily summer temperature of 64.8°F (18.2°C) and an average daily winter temperature of 20.8°F (-6.2°C). Precipitation at NRF averages less than 9 in. (22.9 cm) annually, and prevailing winds are out of the southwest.

The INL site comprises 894 mi^2 (2,315 km^2 = 231,545 ha) extending across the northeast portion of the Snake River Plain, which covers parts of Butte, Jefferson, Bingham, Clark, and Bonneville Counties in Idaho. The Snake River Plain is a U-shaped plateau approximately 300 mi (482 km) long and 50–70 mi (80.5–113 km) wide. Within its land area of 12,000 mi^2 (3.1 million ha), the Snake River Plain descends from an elevation of 6,000 ft (1,830 m) in the east, near Ashton, ID, to 2,300 ft (700 m) in the west, near Boise, ID. The plain is bordered on all sides by mountains, some exceeding 12,000 ft (3,658 m) in elevation.

The largest urban areas surrounding the INL include Pocatello to the southeast and Idaho Falls to the east, both in Idaho. Both cities are approximately 50 mi (80 km) by air from NRF. Several small farming communities are located on the western, northwestern, and southeastern boundaries of the INL site. Approximately 157,000 people live within a 50 mi radius of NRF, according to 2010 census data.

Site Monitoring. The NRF liquid effluent monitoring program includes sampling discharges to both the Industrial Waste Ditch (IWD) and the sewage lagoon. Samples of liquid effluent and sediment are collected at the IWD. These samples are analyzed for both chemical constituents and radioactivity. At the sanitary sewage lagoon, samples of liquid effluent are collected and analyzed for radioactivity.

The drinking water monitoring program involves the collection of water samples at the wellheads. The groundwater monitoring program is designed to ascertain whether NRF operations have had an impact on groundwater quality. Samples are collected on an established schedule from 11 groundwater monitoring wells surrounding NRF. These samples are analyzed for chemical constituents and radioactivity.

NRF airborne radioactivity emissions are monitored and/or calculated in accordance with established standards and guidelines. Continuous direct measurement of radiation levels at the NRF site is accomplished by dosimeters located along the security fence. The INL conducts additional onsite monitoring independently at other locations along the NRF perimeter. In addition, measurements of offsite background are monitored with dosimeters.

NRF performs soil and vegetation monitoring at the NRF site to ensure that NRF operations do not adversely impact the surrounding environment. Data collected from soil sampling are also used to estimate the amount of radioactivity that leaves the NRF property in windblown dust.

C.6 Office of Fossil Energy

The DOE Office of Fossil Energy (FE) is responsible for Federal research, development, and demonstration efforts related to advanced power generation; power plant efficiency; water management; and carbon capture, utilization, and storage (CCUS) technologies; as well as the development of technological solutions for the prudent and sustainable development of our unconventional oil and gas domestic resources. It also manages the nation's Strategic Petroleum Reserve and Northeast Home Heating Oil Reserve, both key emergency response tools available to the President to protect Americans from energy supply disruptions. From 2015 to 2018, FE had responsibility for the following DOE facilities included in this report:

- National Energy Technology Laboratory (NETL)
- Strategic Petroleum Reserve. (SPR)

The following sections describe these sites and their monitoring programs.

C.6.1 National Energy Technology Laboratory

The NETL mission is to discover, integrate, and mature technology solutions to enhance the nation’s energy foundation and protect the environment for future generations. Mission elements include effective resource development, efficient energy conversion, and environmental sustainability.

NETL implements a broad spectrum of energy and environmental R&D programs. These include enabling domestic coal, natural gas, and oil to economically power our nation’s homes, industries, businesses, and transportation; and protecting our environment while enhancing our energy independence. NETL has expertise in coal, natural gas, and oil technologies; contract and project management; analysis of energy systems; and international energy issues

Site Description. NETL has laboratory sites in Albany, Oregon (about 42 ac [17 ha]); Morgantown, West Virginia (about 132 ac [53 ha]); Pittsburgh, Pennsylvania (about 237 ac [96 ha]); and a Program Office site in Anchorage, Alaska (leased office space). The Albany site in Linn County is relatively flat and located on a higher section of town and away from floodplains. The Calapooia River is located 0.5 mi west of the laboratory. The Morgantown site in Monongalia County sits within the rolling hills of the

Appalachian Plateau, about 1,000 ft (305 m) east of the Monongahela River and about 10 mi (16 km) west of Chestnut Ridge, the westernmost ridge of the Allegheny Mountains. The Pittsburgh site in Allegheny County has facilities that sit within rolling hills and steeply incised stream valleys that are tributaries of the Monongahela River. The Pittsburgh site is a partially wooded tract, divided into two sub-sites containing scattered industrial and office buildings. The immediate vicinity was completely rural when the Pittsburgh site was first developed, but the nearby population and housing densities have increased dramatically in recent years.

The radiation protection program at NETL focuses on radiation-generating devices, sealed radioactive sources, naturally occurring radioactive materials/technologically, enhanced naturally occurring radioactive materials (NORM/TE-NORM), and legacy radioactive materials.

Site Monitoring. No radiological monitoring is performed at NETL.

C.6.2 Strategic Petroleum Reserve

The SPR consists of four Gulf Coast underground salt dome oil storage facilities (Bayou Choctaw, Big Hill, Bryan Mound, and West Hackberry), a project management facility in New Orleans (administration), a warehouse facility in Mississippi for storage of equipment and piping, and a DOE-leased facility (St. James Terminal).

Site Description. The Bayou Choctaw site is located in Iberville Parish, Louisiana (LA), and occupies 356 ac (144 ha) above the Bayou Choctaw salt dome, including offsite satellite brine disposal wells and associated brine piping. The area surrounding the site is a freshwater swamp, which includes substantial stands of bottomland hardwoods with interconnecting waterways. Small canals and bayous flow through the site area and join larger bodies of water offsite. The site proper is normally dry and protected from spring flooding by the site's flood control levees and pumps.

Jefferson County, TX, is the location of the Big Hill site, which covers approximately 270 ac (109 ha) above the Big Hill salt dome. Offsite facilities include an intake structure that provides raw (brackish) water for cavern development and fluid movements, a brine line for brine disposal, and a crude oil pipeline for receiving and distributing oil in commerce. Most of the site is upland habitat, consisting of tall grass and a few 150-year-old live oak trees.

The Bryan Mound site is in Brazoria County, TX, and occupies 500 ac (202 ha) above the Bryan Mound salt dome. Offsite facilities include an intake structure that provides raw water for cavern development and fluid movements, a brine pipeline for brine disposal, and crude oil pipelines for receiving and distributing oil in commerce. Marsh and prairie areas surround the region, and brackish marshland dominates the low-lying portions of the site.

West Hackberry, located in Cameron Parish, LA, occupies 565 ac (229 ha) over the West Hackberry salt dome. Offsite facilities include an intake structure that provides raw (brackish) water for cavern development and fluid movements, brine disposal wells with associated brine piping, and crude oil pipelines for receiving and distributing oil in commerce. Numerous canals and natural waterways bisect the area. The surrounding area consists of marshland with natural ridges that support grass and trees, and affect water flow through the marshes.

Site Monitoring. Radioactive sources at the SPR consist of electrically generated X-rays that are used in laboratory and security scanning equipment, or other sealed sources brought onsite for performing radiography and cavern wire-line type logging operations. Sealed sources of radiation are used at the SPR for monitoring activities related to the physical properties of crude oil and brine caverns and pipeline integrity. During routine operations no emissions of radioactive materials are expected. No radioactive materials other than NORM would be expected at SPR.

C.7 Office of Nuclear Energy

The Office of Nuclear Energy (NE) mission is to advance nuclear power to meet the nation's energy, environmental, and national security needs. From 2015 to 2018, DOE-NE provided oversight for the INL site, which is included in this report.

C.7.1 Idaho National Laboratory

INL includes three major areas: the main site, the Research and Education Campus (REC), located in Idaho Falls, ID, and the NRF (Naval Reactors Facility). See Section C.5.4 for detailed information about the NNSA-NNPP NRF. The INL mission is to discover, demonstrate, and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure; to operate a multiprogram national R&D laboratory; and to complete environmental cleanup activities stemming from past operations. DOE direction and guidance are provided by DOE-NE for operations and by DOE-EM for cleanup. The REC, operated by the INL contractor, is the collective name for INL's administrative, technical support, and computer facilities in Idaho Falls, and the in-town laboratories (Radiological and Environmental Sciences Laboratory [RESL] and INL Research Center [IRC]), where researchers work on a wide variety of advanced scientific R&D projects. NRF operations on the INL site report to the Pittsburgh Naval Reactors Office.

Site Description. The INL site encompasses about 890 mi^2 (2,305 km^2 = 570,000 ac) of the upper Snake River Plain in southeastern Idaho. Over 50% of the INL site is located in Butte County and the rest is distributed across Bingham, Bonneville, Clark, and Jefferson Counties. The INL site extends 39 mi (63 km) from north to south and is approximately 38 mi (61 km) wide at its broadest east-west portion. By highway, the southeast boundary is approximately 25 mi (40 km) west of Idaho Falls. Other towns surrounding the INL site include Arco, Atomic City, Blackfoot, Rigby, Rexburg, Terreton, and Howe. Pocatello is 53 mi (85 km) to the southeast.

The REC includes operations at the IRC and the DOE-ID RESL. The IRC and RESL are contiguously located on 35.5 ac (14.3 ha) on the north side of Idaho Falls. The REC is about 22 mi east of the INL main site. A limited number of radiological operations occur at the REC. The IRC is principally an experimental research facility dedicated to a wide range of research areas, including microbiology, geochemistry, materials characterization, welding, ceramics, thermal fluids behavior, materials testing, nondestructive evaluation of materials using standard industrial X-ray processes, X-ray diffraction and X-ray fluorescence, analytical and environmental chemistry, and biotechnology. Non-research activities include analytical chemistry and preparation of reference radioactive and nonradioactive standards for evaluation programs. Radiological emissions from the IRC could arise from uncontrolled laboratory fume hoods within the facility. The RESL is a Federally owned laboratory operated by DOE. The laboratory's focus is primarily in analytical chemistry, radiation protection, and as a reference laboratory for numerous performance evaluation programs. RESL emissions are from low-level radiological performance testing sample preparation and verification. Air emissions modeling is conducted for REC emissions; dosimeters measure external dose at IRC; no environmental media sampling is conducted for radiological constituents at REC.

The INL site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94% of the land on the INL site is open and undeveloped. The site has an average elevation of 4,900 ft (1,500 m) above mean sea level and is bordered on the north and west by mountain ranges, and on the south by volcanic buttes and open plain. Lands immediately adjacent to the INL site are open sagebrush steppe, foothills, or agricultural fields. Agriculture is concentrated in areas northeast of the site.

The climate of the high desert environment in which the INL site is located is characterized by sparse precipitation (annually, about 8.45 in. [21.5 cm]), warm summers (average daily temperature of 65.1°F [18.4°C]), and cold winters (average daily temperature of 18.7°F [-7.4°C]), based on observations at the Central Facilities Area from 1950–2017. The altitude, intermountain setting, and latitude at the INL site combine to produce a semiarid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain. Air masses, which gather moisture over the Pacific Ocean, traverse several hundred miles of mountainous terrain before reaching southeastern Idaho. Frequently, the result is dry air and little cloud cover. Solar heating can be intense, with extreme fluctuations in day-to-night temperature.

The population within 50 mi (80 km) of the site is estimated, based on the 2010 census and projected growth, to be 332,665. Over half of this estimated population (178,193) resides in the census divisions of Idaho Falls (109,744) and northern Pocatello (69,159). Another 30,159 are projected to live in the Rexburg census division. Approximately 20,926 are estimated to reside in the Rigby census division and 15,808 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

Site Monitoring. Samples of airborne particulates, atmospheric moisture, and precipitation are analyzed for radioactivity from locations on the INL site, at site boundary locations, and at distant communities. The Environmental Surveillance, Education, and Research Program (ESER) contractor collects air samples primarily around the INL site, encompassing a region of 9,000 mi^2 (23,390 km^2) that extends to locations near Jackson, Wyoming. The Idaho Cleanup Project (ICP) Core contractor monitors air around waste management facilities. Particulate samples are collected using a network of air samplers and samples are analyzed for gross alpha, gross beta, and specific radionuclides (primarily strontium-90, cesium-137, plutonium-239/240, and americium-241). Airborne particulates are also collected biweekly around the perimeters of the Subsurface Disposal Area of the Radioactive Waste Management Complex (RWMC) and the Idaho CERCLA Disposal Facility at the Idaho Nuclear Technology and Engineering Center (INTEC). Charcoal cartridges are collected and analyzed weekly for iodine-131.

Ambient air monitoring is conducted on and off the INL site to identify regional and historical trends, to detect accidental and unplanned releases, and to determine if air concentrations are below 10 percent of derived concentration standards. The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL site at the Experimental Field Station and Van Buren Boulevard, and off the INL site at Atomic City, Howe, Craters of the Moon, and Idaho Falls. Precipitation samples are collected at Atomic City, EFS, Howe, and Idaho Falls and analyzed for tritium.

Liquid effluent is monitored through wastewater, liquid effluent, and surface water runoff sampling and surveillance programs. Facilities are sampled for parameters required by their facility-specific permits. Groundwater sampling related to wastewater and direct discharges is also conducted as part of these programs.

In 2017, the U.S. Geological Survey sampled 26 groundwater monitoring wells and one perched water well at the INL site for analysis of 61 purgeable (volatile) organic compounds. Groundwater surveillance monitoring required in area-specific Records of Decision under the CERCLA was performed at Waste Area Groups (WAGs) 1–4, WAG 7, and WAG 9 in 2017. The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9) and Advanced Test Reactor (ATR) Complex, and drinking water at nine INL site facilities: ATR Complex, Central Facilities Area (CFA), Critical Infrastructure Test Range Complex, Experimental Breeder Reactor-I (EBR-I), the Gun Range, Main Gate, MFC, Test Area North (TAN) Contained Test Facility, and TAN/Technical Support Facility.

INL has 12 drinking water systems that are monitored. Samples are analyzed for gross alpha and gross beta, tritium, and iodine-129 (at the Central Facilities Area system), and annual strontium-90 analysis occurs at some facilities. As part of the offsite monitoring program, offsite drinking water samples were analyzed for radiological constituents (gross alpha, gross beta, and tritium) in 2017. Two locations, Shoshone and Minidoka, which are downgradient of INL, were co-sampled with the State of Idaho in 2017. One upgradient location, Mud Lake, was also co-sampled with the State of Idaho. Samples are also collected at Atomic City, Craters of the Moon, Howe, Idaho Falls, and a Highway 20/26 rest area.

Surface water was co-sampled with Idaho State in 2017 at three springs located downgradient of INL: Alpheus Springs near Twin Falls, Clear Springs near Buhl, and a trout farm near Hagerman. Samples were analyzed for gross alpha, gross beta, and tritium. Big Lost River was sampled during four months in 2017 and analyzed for gross alpha, gross beta, tritium, and gamma-emitting radionuclides. The riverbed is generally dry (the last event was in 2012), but conditions in 2017 allowed the river to flow into the INL site.

Agricultural products and game animals are sampled. Agricultural products focus on milk, lettuces, alfalfa, potatoes, and grains. Milk samples are analyzed for gamma-emitting radionuclides, including iodine-131 and cesium-137. Twice a year, samples from each of seven locations (including the control) are analyzed for strontium-90 and tritium, with the exception of Blackfoot during one quarter. Lettuce samples are collected every year from areas on and adjacent to the INL site. Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2017, grain samples were collected at nine locations around INL, and an additional duplicate sample was collected from Arco. A control sample was purchased from outside the State of Idaho. The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations can change as growers rotate their crops. Potatoes were collected in 2017 at eight locations in the vicinity of INL and were obtained from one location outside eastern Idaho. Data collection began in 2010 for alfalfa consumed by milk cows. A sample of alfalfa is collected from an agricultural location where the highest potential offsite air concentration was calculated by the National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division. Muscle, thyroid, and liver samples are collected from game animals (e.g., pronghorn antelope, mule deer, and elk). Waterfowl species are collected each year at ponds on and off the INL site. They were collected from wastewater ponds located at the ATR Complex and controls were collected from American Falls Reservoir; they were analyzed for gamma-emitting radionuclides, strontium-90, and actinides (americium-241, plutonium-238, and plutonium-239/240).

Bat carcasses have been collected on the site since the summer of 2015. The samples collected in 2015–2016 were analyzed in 2017 for gamma-emitting radionuclides, for specific alpha-emitting radionuclides (plutonium isotopes and americium-241), and for strontium-90 (a beta-emitting radionuclide).

The INL contractor currently completes soil sampling on a 5-year rotation at the site to evaluate long-term accumulation trends and to estimate environmental radionuclide inventories. The ESER contractor collects soil samples in offsite locations first established by RESL every 2 years (in even-numbered years).

Beginning with the May 2010 distribution of dosimeters, the INL contractor began collocating optically stimulated luminescent dosimeters with TLDs. Dosimeters on the site are placed at facility perimeters and are concentrated in areas likely to detect the highest gamma radiation readings. Other dosimeters on the site are located near radioactive materials storage areas and along roads.

C.8 Office of Science

The DOE Office of Science (SC) leads the country in science and technology. It is the nation's largest supporter of basic research in the physical sciences, the steward of numerous National Laboratories, and the lead Federal agency supporting fundamental research for energy production and security. From 2015 to 2018, DOE-SC has been the assigned Program Office for the following facilities included in this report:

- Ames Laboratory (AMES)
- Argonne National Laboratory (ANL)
- Brookhaven National Laboratory (BNL)
- Fermi National Laboratory (FERMI)
- Lawrence Berkeley National Laboratory (LBNL)
- Oak Ridge Reservation (ORR, comprising ETTP, ORNL, and Y-12)
- Pacific Northwest National Laboratory (PNNL Richland and MSL)
- Princeton Plasma Physics Laboratory (PPPL)

- Stanford Linear Accelerator Center (SLAC)
- Thomas Jefferson National Accelerator Facility (JLAB)

C.8.1 Ames Laboratory

AMES is a government-owned, contractor-operated facility, managed by Iowa State University. Ames Laboratory's mission is to create materials, inspire minds to solve problems, and address global challenges. The Laboratory conducts fundamental research in the physical, chemical, materials, and mathematical sciences, and physics, which underlie energy generating conversion, transmission and storage technologies, environmental improvement, and other technical areas essential to national needs.

Site Description. Ames Laboratory is located on the campus of Iowa State University (ISU) in Ames, Iowa, and occupies 13 buildings owned by DOE. The City of Ames surrounds the ISU campus, and is in Story County (county population 97,502). In 2017, the population of Ames was approximately 66,498, which includes the ISU student population of approximately 36,300.

Site Monitoring. As with earlier recent years, AMES has maintained very small inventories and activities of radioactive materials from 2015–2018. It performed no stormwater, groundwater, sanitary sewer water, or environmental air sampling during thie period, because no activities warranted monitoring.

C.8.2 Argonne National Laboratory

ANL is a DOE R&D laboratory. The principal radiological facilities at ANL are the Advanced Photon Source (APS), a superconducting heavy-ion linear accelerator (ATLAS), a 22 MeV pulsed electron linear accelerator, and several other charged-particle accelerators. The principal remaining nuclear facilities at Argonne are the Alpha Gamma Hot Cell Facility, the Waste Management Operations Facility, and the Radioactive Waste Storage Facility. These nuclear facilities are non-reactor facilities that involve material handling, management, storage, and disposition.

Site Description. ANL occupies the central 1,500 ac (607 ha) of a 3,740 ac (1,514 ha) tract in DuPage County, Illinois. The site is 27 mi (43 km) southwest of downtown Chicago and 24 mi (39 km) west of Lake Michigan. The ANL terrain is gently rolling, partially wooded, former prairie and farmland. The grounds have several small ponds and streams.

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. The average wind direction usually varies from the west to the south, but with a significant northeast component. The historical average precipitation for ANL is 38.7 in. (98.4 cm) per year; the historical average yearly temperature is 49.8ºF (9.9ºC).

Site Monitoring. The radioactivity in the environment around ANL is determined by measuring the radionuclide concentrations in the air, surface water, groundwater, and sediment, as well as by measuring the external photon penetrating radiation exposure. Sample collections and measurements are made onsite, at the site perimeter, and offsite for comparative purposes. Historical wind data are used to select air-sampling locations.

ANL uses continuously operating air samplers to collect samples for the measurement of concentrations of airborne particles contaminated by radionuclides. Airborne particle samples for measurement of total alpha, total beta, and gamma-ray emitters are collected continuously at 11 perimeter locations and at four offsite locations on glass-fiber filter media.

Phytoremediation is used to clean up the groundwater in the 317/319 Area. Quarterly monitoring is conducted at the 13 wells that are within the phytoremediation plantation.

Treated ANL wastewater is discharged into Sawmill Creek, which runs through ANL grounds, drains surface water from much of the site, and flows into the Des Plaines River about 1,600 ft (500 m) downstream from the ANL wastewater outfall. Sawmill Creek is sampled upstream from ANL and downstream from the wastewater discharge point to determine whether radioactivity is added to the stream by ANL wastewater or surface drainage. Samples are collected several times per day by an automatic sampler below the wastewater outfall with a composite sample analyzed to obtain an average weekly concentration. Grab samples are collected upstream of the site monthly and analyzed for the same radionuclides measured in the below-outfall samples.

Wastewater from buildings or facilities that use or process radioactive materials is collected in retention tanks. When a tank is full, it is sampled and analyzed for alpha and beta radioactivity. If the radioactivity exceeds the release limits, the tank is processed as radioactive waste.

Two perimeter surface water locations found to contain measurable levels of radionuclides are located south of the 319 Area and south of the 800 Area Landfill. Samples are collected quarterly and analyzed for tritium, strontium-90, and gamma-ray emitters (319 Area south) and tritium (800 Area Landfill south).

One ANL waste management location within the fenced 398A radioactive waste storage area is sampled for surface water drainage at the south (downhill) end of the 398A Area. To evaluate whether any radionuclides are being transported by stormwater flow through the 398A Area, quarterly sampling is conducted from the 398A Area pond and analyzed for tritium and gamma-ray emitting radionuclides.

Because Sawmill Creek empties into the Des Plaines River, data about the radioactivity in this river are important in assessing the contribution of ANL wastewater to environmental radioactivity. The Des Plaines River is sampled downstream and upstream of the mouth of Sawmill Creek to determine whether the radioactivity in the creek has any effect on the radioactivity in the river.

The radioactive content of bottom sediment is measured in Sawmill Creek, above the outfall point where ANL discharges its treated wastewater, at the outfall, and at several locations below the outfall. In addition, a sediment sample was collected at location 16K, upgradient of the entire site.

Levels of external penetrating gamma radiation at and near ANL were measured with optically stimulated luminescence dosimeters provided and read by a commercial vendor. Dosimeters are placed at 17 locations at the site boundary and at several interior locations. Readings are also taken at five offsite locations for comparative purposes.

C.8.3 Brookhaven National Laboratory

BNL advances fundamental research in nuclear and particle physics to gain a deeper understanding of matter, energy, space, and time; applies photon sciences and nanomaterials research to solve energy challenges of critical importance to the nation; provides capabilities in computational science and data management for large-scale research and experimental endeavors; and performs cross-disciplinary research on computation, sustainable energy, national security, and Earth’s climate and ecosystems.

Site Description. BNL is located near the geographical center of Suffolk County, Long Island, NY. BNL’s 5,320 ac (2,153 ha) site is located approximately 65 mi (105 km) east of midtown Manhattan. Approximately 6,031,539 people reside within a 50 mi radius of BNL.

BNL is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from those two directions during the spring and fall. The average yearly temperature for this area of Long Island is 50.5°F (10.3°C). The coolest month of the year is January (average 30.1°F) and the warmest is

July (average 75.1°F). The total annual precipitation in 2017 was 50.35 in. (128 cm). The average yearly snowfall is 33.0 in. (83.8 cm) for this area of Long Island.

Site Monitoring. Emissions are monitored for radioactivity at the High Flux Beam Reactor (HFBR), Brookhaven Linac Isotope Producer (BLIP), and the Target Processing Laboratory (TPL). The samplers in the exhaust stack for BLIP and the TPL exhaust duct are equipped with glass-fiber filters that sample airborne particulate matter generated at these facilities. The filters are collected and analyzed weekly for gross alpha and gross beta. Air-monitoring stations are in place around the perimeter of BNL. Four block-house stations are equipped for collecting samples of particulate matter on a glass-fiber filter. Particulate filters are collected weekly and are analyzed for gross alpha and beta activity. Also, water vapor for tritium analysis is collected on silica-gel adsorbent material and collected every two weeks from the block houses, weekly from BLIP, and monthly from HFBR.

Environmental airborne tritium in the form of HTO (tritiated water) is monitored throughout BNL; samples are collected every two weeks from each sampling station.

BNL routinely monitors surface water quality (including radionuclides) as part of the site surveillance program. BNL continues to monitor surface water at several locations along the Peconic River to assess the impact that previous site operations may have on surface water quality. Onsite monitoring station, HY, is located upstream of all BNL operations and provides information about the background water quality of the Peconic River. The nearby Carmans River, which is not impacted by BNL operations, is monitored as a background control location. Samples from the Carmans River are also analyzed for gross alpha and beta, tritium, and strontium-90.

Real-time monitoring of the BNL sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192, is approximately 1.1 mi (1.8 km) upstream of the sewage treatment plant and provides a minimum of 30 minutes to warn the plant operators that wastewater exceeding State Pollutant Discharge Elimination System limits or BNL administrative effluent release criteria is enroute. The second monitoring site is at the point where the sewage treatment plant influent enters the treatment process. Samples are analyzed weekly for gross alpha and gross beta activity and for tritium. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90. Discharges to the recharge basins are sampled semiannually and analyzed for gross alpha, gross beta, gamma-emitting radionuclides, and tritium.

C.8.4 Fermi National Laboratory

FERMI, also known as Fermilab, is a particle physics and accelerator laboratory. Facilities are used to conduct basic research in high-energy physics and related disciplines.

Site Description. The FERMI site consists of 6,800 ac (2,752 ha) of mixed-use land in Batavia, IL. The site is in Kane and DuPage Counties in the greater Chicago area. The primary FERMI features include the accelerator complex and associated building infrastructure, an interconnected industrial cooling water system, a housing complex for visiting researchers (the Village), row crop agriculture, and natural areas in various states of restoration. The natural areas consist primarily of tall grass prairie, forest, and wetlands. The terrain is generally flat. The climate is continental, with typical rainfall of about 35 in. (90 cm) annually.

Site Monitoring. Environmental surveillance is typically conducted at locations to intercept the pathway of potential pollutants to receptors such as plants, animals, or members of the public. Ground and surface waters are sampled at locations near operating areas, potential contamination sources, and along potential transport pathways. In addition to air and water surveillance, samples of soil are collected and analyzed for radioactivity to ascertain whether there is buildup of radioactive materials in the environment due to long-term operations. Surface water, air, groundwater, soil, and sediment samples are routinely analyzed for radionuclide concentrations. Surface waters are also monitored for potential chemical constituents. While levels of penetrating radiation are, in some places, measurable near operational areas on the site, the levels decrease rapidly with distance from the sources. External penetrating radiation and airborne emissions are commonly below instrument detection levels at the site boundary and must be estimated to provide information about the maximum potential radiation doses to offsite populations. The radiation doses potentially received by the offsite public due to site operations are calculated from data gathered through environmental surveillance of the onsite sources. Selected vent stacks are monitored directly with stack monitors, and indirectly by taking soil samples near the stacks.

Operation of the FERMI accelerator and associated beamlines produces ionizing radiation such as neutrons and muons. Beamlines and experiments are designed so that most of the radiation is absorbed before reaching the ground surface and outdoor areas. The neutrons are absorbed by shielding.

FERMI releases minor amounts of contaminants to bodies of surface water. In addition to monitoring for the physical and chemical parameters required by NPDES permits, samples of surface water are taken monthly from selected water bodies and analyzed for radionuclides. These surface waters are sampled for radionuclides based upon their potential for contamination.

Numerous sumps collect and drain water from building footings and from under beamline tunnels in the Main Injector, and the experimental areas. Water collected by these sumps often contains detectable concentrations of radionuclides (primarily tritium) that have been leached by rainwater from radioactive soil near beam targets and absorbers, or released accidentally to sumps because of losses from beamline cooling water systems. These sumps discharge to ditches and ponds onsite. Water is also collected from the Neutrinos at the Main Injector (NuMI) tunnel system. NuMI tunnel water contains measurable concentrations of tritium; the primary source of the tritium is water contact with components within the tunnel.

Monitoring for radioactivity in surface water continues to be a primary component of FERMI's routine environmental surveillance program because FERMI discharges measurable concentrations of tritium to some surface waters offsite.

FERMI maintains an onsite piping system for the conveyance of sanitary effluent. Monitoring stations, located at the site boundary, sample sewer discharges to the municipalities of Batavia and Warrenville. Low levels of tritium have been detected in effluent discharged to the Batavia treatment works since August 2005.

Groundwater samples are collected from 10 locations for radionuclide analysis. Tritium and accelerator-produced radionuclides were not detected in any Class I groundwater samples. Six "sump" wells at the Booster Neutrino Berm are routinely sampled for tritium. They are not true groundwater wells, but rather drain the north and south ends of the interior interstitial space and exterior of the dual-liner system around the decay pipe via lateral pipes and are not within the Class I groundwater zone.

C.8.5 Lawrence Berkeley National Laboratory

LBNL research is focused on the physical, biological, environmental, and computational sciences with the objective of delivering scientific knowledge and discoveries pertinent to DOE's mission.

Site Description. The LBNL main site and nearby satellite facilities are located in the eastern region of California's San Francisco Bay Area, commonly known as the East Bay. The main site is situated on the ridges and in the draws of Blackberry and Strawberry Canyons in the East Bay Hills about 3 mi (4.8 km) east of San Francisco Bay. The site occupies approximately 200 ac (80.9 ha) of land immediately east of the University of California (UC)-Berkeley campus and straddles the border of the cities of Berkeley and Oakland in Alameda County. LBNL, and the majority of the land bordering it, is owned by UC. Most of the land to the south and east of the site is maintained in its natural state and adjoins wilderness and recreation areas. The general population in the region extending 50 mi (80 km) from the site is approximately 7,253,000 people during the day.

The temperate climate at the main site—cool, dry summers and relatively warm, wet winters—is heavily influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west, and the East Bay Hills to the east. Temperatures typically range between 40–70°F (4.4–21°C), with an average annual temperature of 55°F (13°C). The temperature seldom exceeds 90°F (32°C) or drops below 32°F (0°C). The precipitation total for a "water year" averages 29.11 in. (73.9 cm) of rain with no record of measurable snow. The term water year represents rainfall occurring between October 1 of one year, and September 30 of the next year, to characterize California's seasonal rainfall cycle better than a calendar year. The precipitation total for the 2016–2017 water year (46.3 in. [118 cm]) was the fourth wettest of the 55 seasons of measurements, and it ended five consecutive dry seasons. Wind patterns recorded at the onsite meteorological station change little from year to year. The most common wind pattern is westerly winds blowing off the bay and ocean. The other predominant wind pattern is associated with stormy weather when south-to-southeast winds precede a storm system, then shift to the west or northwest after passing.

Site Monitoring. Radiation-producing machines (e.g., accelerators, X-ray machines, and irradiators) and various radionuclides are used at LBNL for high-energy particle studies and biomedical research. Accelerator operations are the primary contributors of penetrating radiation, and when operating, accelerators may produce gamma and neutron radiation. Real-time monitors, which continuously detect and record gamma radiation, and neutron dose and passive dosimeters (optically stimulated luminescent dosimeters), which provide an integrated dose over time from gamma radiation, are used to determine the environmental radiological impact from accelerator operations.

LBNL's air-monitoring program is designed to measure the impacts of radiological air emissions. The program consists of emissions sampling and monitoring to measure contaminants in building exhaust systems. In 2017, sampling was performed on a total of 17 stacks, and real-time monitoring was performed on four others. Stack exhaust samples were analyzed for five radiological parameters: gross alpha, gross beta, carbon-14, iodine-125, and tritium. Real-time stack air-monitoring systems measured alpha emitters and positron emitters.

Surface water quality is evaluated at and around LBNL by sampling creek water and stormwater. The sampled creeks either flow through or originate on the site. The following creeks are sampled within the Strawberry Creek watershed: North Fork of Strawberry Creek, Cafeteria Creek, Ravine Creek, Ten-Inch Creek, Chicken Creek, No Name Creek, Winter Creek, which is sampled at two locations (inflow and outflow points to the site), and Upper Botanical Garden Creek. Background water-quality samples are also collected semiannually from Wildcat Creek, which flows in a northwest direction away from LBNL. Samples from Chicken Creek, the North Fork of Strawberry Creek, Wildcat Creek, and Winter Creek (inflow and outflow points) were collected semiannually and analyzed for gross alpha, gross beta, and for tritium. Samples from these locations were also analyzed for actinium-228, bismuth-214, cesium-134, cesium-137, europium-152, iron-59, lead-214, potassium-40, radium-226, thallium-208, and uranium-238 using gamma emission spectroscopy.

For wastewater radiological monitoring, time-interval (every hour) composite samples are collected every month at the Hearst and Strawberry outfalls and are analyzed by a state-certified laboratory for gross alpha, gross beta, iodine-125, tritium, and carbon-14.

The groundwater monitoring network consists of more than 175 wells, including 17 that are used to monitor for potential migration of groundwater contaminated by volatile organic compounds beyond the developed areas of the site. A tritium plume is also monitored.

Soil samples obtained from the top 2 in. (5 cm) of surface soil were collected from three locations within the LBNL Site and from one offsite environmental monitoring station. One sample was split for quality control purposes. Samples were analyzed for gross alpha, gross beta, gamma-emitters, tritium, moisture content, pH, and 15 metals.

Sediment samples were collected at Chicken Creek and the North Fork of Strawberry Creek within the LBNL Site and at Wildcat Creek in Tilden Regional Park. Because of limited sediment availability, several grab samples from the general sampling area of each location were composited and analyzed for gross alpha, gross beta, gamma-emitters, tritium, 15 metals, moisture content, pH, petroleum hydrocarbons (diesel and oil/grease), and PCBs.

C.8.6 Oak Ridge Reservation

ORR comprises four sub-sites—Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex (Y-12), the East Tennessee Technology Park (ETTP), and the Oak Ridge Institute for Science and Education (ORISE), as well as government-operated and -owned offices. ORR is assigned as a DOE-SC site, but major operations for numerous DOE Program Offices occur among the four distinct ORR locations. In general, ETTP has EM oversight, Y-12 has NNSA oversight, and both ORNL and ORISE have SC oversight. Despite the range of DOE Program Office activities across ORR, the ORR is assigned as an SC site in this report.

ORR information in this report is generally provided for the entire reservation. Detailed information about ORNL, Y-12, and ETTP is included in the ASERs. Radiological operations at ORISE are minimal.

Site Description. ORR covers about 33,866 ac (13,705 ha) and is located in Roane and Anderson Counties in eastern Tennessee about 25 mi (40 km) from Knoxville. ORR lies within the Great Valley of East Tennessee between the Cumberland (10 mi [16 km]) to the northwest and Great Smoky Mountains (31.6 mi [51 km]) to the southeast, and is bordered by the Clinch River. The largest site drainage basin is Poplar Creek, which drains into the Clinch River. The site also includes the White Oak Creek drainage basin, which also drains into the Clinch River. About 600 ac (243 ha) of wetlands have been identified on the ORR; most are classified as forested palustrine, scrub/shrub, and emergent wetlands. Wetlands occur across the ORR at low elevations. Wetlands identified to date range in size from several square meters at small seeps and springs, to about 25 ac (10 ha) at White Oak Lake.

The population of the 10-county region surrounding the ORR is about 1,096,961. The 2017 U.S. Census population estimate for the official nine-county Knoxville metropolitan statistical area is 883,309. Other municipalities within about 18.6 mi (30 km) of the reservation include Oliver Springs, Clinton, Rocky Top, Lenoir City, Farragut, Kingston, and Harriman.

The climate of the Oak Ridge region may be broadly classified as humid subtropical and is characterized by significant temperature changes between summer and winter. The mean temperature for 1986–2010 was 58.5°F (14.7°C). The coldest month is usually January, when temperatures average about 37.5°F (3.1°C). During 2018, December temperatures were the coldest, averaging 32.8°F (0.4°C). July was the warmest month, with an average temperature of 76.5°F (24.7°C). Average annual precipitation in the Oak Ridge area from 1986–2010 was 52.64 in. (133.8 cm), including about 8.4 in. (21.3 cm) of snowfall annually. In 2018, wind speeds measured at 49 ft (15 m) above ground level (AGL) averaged 2.2 mph (0.94 m/sec). This value remained unchanged for winds at 198 ft (60 m) AGL. The local ridge-and-valley terrain reduces average wind speeds at valley bottoms, resulting in frequent periods of calm or near calm conditions, particularly during clear early morning hours in weak synoptic weather environments.

ETTP was previously known as the K-25 site when operations involved uranium enrichment during the 1940s. ETTP, comprising approximately 2,200 ac (890 ha), is located on the west side of ORR. The current primary mission of ETTP is to perform EM activities, including site remediation, decontamination and decommissioning, and wastewater treatment operations, as well as to establish private sector mixed-use businesses as part of DOE's Reindustrialization Program.

ORNL lies in the southwest corner of ORR and includes facilities in two valleys (Bethel and Melton) and on Chestnut Ridge. The ORNL science programs focus on materials, neutron science, energy, high-performance computing, systems biology, and national security. ORNL has several supercomputers and is a leading neutron science and nuclear research facility. Facilities at ORNL include an operating nuclear reactor (High Flux Isotope Reactor), an accelerator-based neutron source facility (Spallation

Neutron Source), chemical pilot plants, research laboratories, radioisotope production laboratories, fusion test devices, and support facilities.

The **Y-12 Complex (Y-12)** is located in a valley immediately adjacent to the City of Oak Ridge but separated from it by a 300 ft (90 m) high ridge. Y-12 covers more than 810 ac (328 ha) in the Bear Creek Valley, stretching 2.5 mi (4.0 km) in length down the valley and nearly 1.5 mi (2.4 km) across it. Additional NNSA-related facilities located off the Y-12 site, but in Oak Ridge, include the Central Training Facility, Uranium Processing Facility project offices, a records storage facility, Y-12 Shipping and Receiving, and an analytical laboratory. Y-12 Complex activities related to radioactive material handling include receipt, storage, and protection of Special Nuclear Material; nuclear stockpile evaluation and surveillance; radioactive material storage; and provision of fuel for the NNSA-NNPP.

Radiological operations at **ORISE** facilities involve very small inventories and activities; they are used for research and training purposes.

Site Monitoring. DOE operations on ORR have the potential to release a variety of constituents via atmospheric, surface water, and groundwater pathways. Radionuclides potentially released are unique to specialized research and production activities. Each year extensive monitoring is conducted across ORR at ORNL, Y-12, and ETTP. ORR-wide surveillance programs, which include locations and media both on and off ORR, are carried out to enhance and supplement the site-specific efforts. Air, water, direct radiation, vegetation, fish, and wildlife are sampled and analyzed. Annual samples number in the thousands. Sample media, locations, frequencies, and parameters were selected based on environmental regulations and standards, public and environmental pathways, public concerns, and measurement capabilities.

Monitoring at ORNL. Radioactive airborne discharges at ORNL consist primarily of ventilation air from contaminated or potentially contaminated areas, vents from tanks and processes, and hot cell and reactor facility ventilation. Radioactive airborne emissions are treated, then filtered before being discharged. The major radiological emission point sources for ORNL consist of seven stacks; six in Bethel and Melton Valleys and one on Chestnut Ridge. Five of the major sources are equipped with charcoal cartridges, particulate filters, and silica-gel traps that are collected weekly to biweekly. In addition to major sources, ORNL has several minor sources that have the potential to emit radionuclides. Various methods, which comply with EPA criteria, are used to determine the emissions from minor sources.

The ORNL Site has a NPDES permit, which includes requirements for discharging wastewaters from the two onsite ORNL wastewater treatment facilities and from more than 150 category outfalls, as well as the implementation of a water-quality protection plan (WQPP). The NPDES permit and associated WQPP include requirements for monitoring liquid effluents and selected instream locations for both radiological and nonradiological parameters. Samples from two treatment facility outfalls, three instream monitoring locations, and 20 category outfalls were monitored in 2018. Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate; dry-weather grab samples are analyzed. Wet-weather discharges from selected category outfalls are also monitored by collection and analysis of composite samples. In addition to monitoring performed to meet NPDES/WQPP requirements, several other locations on the ORNL site are monitored for radiological and nonradiological parameters and for general water quality as a best management practice.

Mercury and PCBs are legacy contaminants at ORNL. Groundwater, surface water stormwater runoff, and fish are monitored.

Creeks are monitored for benthic macroinvertebrate communities in White Oak Creek, First Creek, Fifth Creek, and lower Melton Branch. A continuous long-term record going back to 1986 demonstrates trends in the invertebrate community that shows the effectiveness of pollution abatement and remedial actions. Fish communities are also monitored.

Groundwater monitoring was conducted in 2018 by the Oak Ridge Office of Environmental Management (OREM) monitoring and by DOE-SC. OREM monitoring includes routine sampling and analysis of groundwater in Bethel and Melton Valleys to measure remedial action performance, and to continue contaminant and groundwater quality trend monitoring. DOE-SC monitoring was performed to evaluate groundwater exit pathways and UT-Battelle facilities (active sites) that potentially pose a risk to groundwater.

Monitoring at Y-12. The Y-12 Complex operates under a Title V Permit containing requirements generally applicable to industrial sites, including asbestos controls, control of ozone–depleting chemicals, and control of fugitive emissions. Y-12 also has requirements associated with radiological hazardous air pollutants, criteria pollutants, and nonradiological hazardous air pollutants. High-efficiency particulate air filters and scrubbers are used at Y-12, and monitoring tasks are conducted.

The release of radiological contaminants, primarily uranium, to the atmosphere at the Y-12 Complex is a result of plant production, maintenance, and waste management activities. In 2017, 32 process exhaust stacks were continuously monitored (25 major and seven minor sources). Unmonitored uranium emissions at Y-12 occurred from 38 emission points associated with onsite, unmonitored processes, and laboratories. Ambient air monitoring for uranium was also conducted.

Onsite ambient air monitoring for mercury and radionuclides is conducted at Y-12 as a best management practice. Ambient air monitoring is conducted at multiple locations near the ORR via the ORR Environmental Surveillance Program.

The Y-12 Complex NPDES permit requires sampling, analysis, and reporting for 56 outfalls located in the following water drainage areas: Bear Creek, East Fork Poplar Creek, and several tributaries on the south side of Chestnut Ridge, all of which eventually drain into the Clinch River.

The water quality of surface streams in the vicinity of the Y-12 Complex is affected by current and legacy operations. Regular monitoring and stormwater characterization are required by the NPDES permit. A radiological monitoring plan was developed for the Y-12 Complex to address compliance with the NPDES permit and DOE Orders. Under the plan, effluent monitoring is conducted at treatment facilities, point-source and area-source discharges, and instream locations. Monitoring is also conducted during stormwater events.

To monitor ambient surface water quality, a network of real-time monitors was set up at three instream locations along the East Fork Poplar Creek. Additional sampling of springs and tributaries is conducted in accordance with the Y-12 Complex Groundwater Protection Program.

Biomonitoring of outfalls is conducted using fathead minnow larvae and water fleas to evaluate for toxicity. In addition, a biological monitoring and abatement program is required as part of the NPDES permit. This program includes bioaccumulation monitoring, benthic macroinvertebrate community monitoring, and fish community monitoring. Monitoring is currently being conducted at five East Fork Poplar Creek sites.

Groundwater monitoring at the Y-12 Complex is performed to comply with Federal, State, and local requirements and DOE Orders. Groundwater data collection is generally performed using permanent monitoring wells. In 2017, 193 wells and 52 surface water locations and springs were monitored.

Monitoring at the ETTP. Quarterly composited samples at all ETTP ambient air-sampling stations indicate the presence of any radiological emissions. In 2017, continuous samples were collected for radiological and selected metals analyses. Inorganic analytical techniques were used to test samples for chromium, lead, and technetium-99. Radiological analyses of samples test for uranium isotopes (uranium-234, -235, and -238).

A total of 27 representative outfalls are monitored for nonradioactive measures as part of the NPDES permit. Additional monitoring efforts are conducted to support CERCLA actions related to the stormwater pollution prevention program and biological monitoring and abatement program activities.

Stormwater discharges are monitored for radionuclides. In addition, monitoring is performed at outfall locations that drain areas before and after decontamination and decommissioning activities. Several monitoring programs sampled for mercury at various ETTP locations during 2017. Chromium is monitored at chromium collection system wells to monitor for chromium and hexavalent chromium concentrations in Mitchell Branch. During 2017, environmental surveillance activities were conducted at 12 surface water locations to monitor groundwater and stormwater runoff at watershed exit pathway locations, ambient stream locations (quarterly), and a slough (semiannually).

Bioaccumulation studies for mercury and PCBs at ETTP involve monitoring caged clams and the collection and analysis of fish from both onsite and offsite locations, including ponds, streams, and sloughs.

C.8.7 Pacific Northwest National Laboratory

PNNL has two primary DOE Campuses at separate locations in Washington State. The PNNL Richland Campus (PNNL Richland) is located north of the City of Richland, in south-central Washington. The PNNL Marine Sciences Laboratory (MSL) is located 214 mi (344 km) northwest of the Richland Campus, east of the City of Sequim on a northeastern coast of the Olympic Peninsula. The transition of the name of the Campus in Sequim from MSL to PNNL Sequim was initiated in 2019; concurrently the property is in process to be purchased by DOE.

PNNL — Richland. Scientists and engineers at the PNNL Richland Campus provide innovative science and technology solutions in energy and environment, fundamental and computational science, and national security disciplines. Research areas include national and homeland security, energy and energy storage technologies, materials science, high-performance computational sciences, climate science, radiation detection, and biological sciences.

Site Description. The PNNL Richland Campus covers approximately 664 ac (269 ha) in Benton County and the Columbia River is part of its eastern border. A DOE meteorological tower providing monitoring for the southeastern Hanford Site is located adjacent to the PNNL Richland Campus. The rain-shadow effect of the Cascade Range and nearby Rattlesnake Mountain influences the climate at the PNNL Richland Campus. Temperature, precipitation, and wind across the Columbia River Basin are affected by these mountain barriers. Winds from the northwestern quadrant are the most common during winter and summer, but summertime drainage winds are generally northwesterly. Normal monthly average temperatures range from a low of 31.1°F (-0.5°C) in December to a high of 77.1°F (25.1°C) in July. The average annual temperature, 30-year average (1981–2010), is 53.6°F (12°C). The normal annual relative humidity is 55.3%.

The PNNL Richland Campus is adjacent to and south of the DOE Hanford Site (see Section C.3.1), in an area that is primarily flat and semiarid. Residents north and east of the PNNL Campus and the Hanford Site generally live on farms or in farming communities. Residents south, southwest, and west of the PNNL Richland Campus live in the urban communities of Richland, Kennewick, Pasco, and West Richland. In 2017, an estimated 198,200 people lived in Benton County and 92,100 people lived in adjacent Franklin County. The population within a 50 mi (80 km) radius of the PNNL Richland Campus is estimated to be about 432,000.

Site Monitoring. PNNL Richland monitors air and water quality to assure compliance with all Federal, State, and local regulatory requirements. Airborne emissions from PNNL facilities are monitored to assess the effectiveness of emission treatment and control systems as well as pollution management practices. Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at PNNL Richland and a background location in Benton City to the west. Liquid effluent discharges from PNNL Richland Campus operations are monitored under permits issued by the City of Richland.

PNNL – MSL. MSL staff provide innovative science and technology solutions critical to the nation's energy, environmental, and security future. Capabilities are based on expertise in environmental chemistry, water and ecosystem modeling, remote sensing, remediation technology research, environmental sensors, ecotoxicology, biotechnology, and national and homeland security. MSL's unique location also places it within one of the cleanest airsheds in the world, providing the ultratrace background for research in measurement and signature sciences.

Site Description. The PNNL MSL operations are in western Washington, east of the City of Sequim in Clallam County, and at the mouth of Sequim Bay on a northeastern coast of the Olympic Peninsula. MSL operations are encompassed in an area of about 7.5 ac (3.0 ha) within property consisting of 150 ac (60.7 ha) of privately held and DOE property. An estimated 75,500 people lived in Clallam County in 2017; Sequim, the nearest population center to MSL, had a population of 7,108 people in 2017. An estimated 2,349,100 people live within a 50 mi (80km) radius of MSL; 1,986,300 in the United States (85%) and 362,800 in Canada (15%). The region is positioned in the rain shadow of the Olympic Mountains and receives less than 15 in. (38 cm) of rainfall annually.

Site Monitoring. MSL handles laboratory-scale levels of radioactive materials. Process wastewater from MSL is treated at an onsite wastewater treatment plant prior to being discharged to Sequim Bay under a permit issued by the Washington State Department of Ecology.

C.8.8 Princeton Plasma Physics Laboratory

PPPL is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop scientific understandings and key innovations leading to an attractive fusion energy source. Related missions include conducting world-class research along the broad frontier of plasma science, providing the highest quality of scientific education and experimentation, and participating in technology transfer and science education projects/programs in the local community and nationwide.

Site Description. The PPPL site is in the center of a highly urbanized northeastern region of New Jersey. The closest urban centers are New Brunswick, 14 mi (22.5 km) to the northeast, and Trenton, 12 mi (19 km) to the southwest. Within a 50 mi (80 km) radius are the major urban centers of New York City, Philadelphia, and Newark. Surrounding the site are preserved and undisturbed areas of land, including upland forest, wetlands, open grassy areas, and a minor stream, which flows along PPPL's eastern boundary.

The climate of central New Jersey is classified as mid-latitude, rainy climate with mild winters, hot summers, and no dry season. In 2017, temperatures ranged from 6–95°F (-14.4–35°C); the average departure from normal temperature (1981−2010) was 2.3°F (16.5°C). Extreme temperatures typically occur once every five years. The typical regional climate is moderately humid and has a total average precipitation of about 55.4 in. (141 cm), evenly distributed throughout the year.

PPPL is the DOE site that has the largest reported 50 mi population. There are an estimated 17.7 million people living within a 50 mi radius of the laboratory, totaling 2,258 people per square mile. The 2017 U.S. Census Bureau estimates that Middlesex County has a population of 842,798. Adjacent counties have populations of 374,733 (Mercer), 626,351 (Monmouth), 335,432 (Somerset), and 563,892 (Union).

Site Monitoring. The PPPL Environmental Radiological program includes information about site tritium releases to the environment, and as measured by dose to employees and to the public. This annual dose is calculated using air and water measurements. No foodstuffs, soil, or vegetation samples were gathered for analysis in 2017.

PPPL uses a differential atmospheric tritium sampler (DATS) to measure elemental (HT) and oxide tritium (HTO) at the D Site stack. DATSs are similarly used at four environmental sampling stations located on D Site facility boundary trailers (T1 to T4); all monitoring is performed on a continuous basis.

Surface water samples from nine locations, two onsite locations and seven offsite locations have been analyzed for tritium. Groundwater samples are taken from two D Site building foundation sumps, which are sampled monthly.

C.8.9 Stanford Linear Accelerator Center

SLAC is a multipurpose National Laboratory that supports the DOE mission, which is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through science and technology solutions. SLAC leverages the laboratory's historical strength in particle physics and accelerator research to power discoveries across an even greater range of scientific disciplines. SLAC operates the world's first hard X-ray free-electron laser, which generates light of unprecedented brilliance that enables the capture of atomic-scale snapshots. SLAC also helps companies use synchrotron radiation to design better pharmaceuticals, stronger materials, and more efficient sources of energy, and it continues to build on a solid foundation in particle physics to peer into the farthest reaches of the universe, using ever more sophisticated tools and techniques.

Site Description. SLAC is located in a belt of low, rolling foothills between the alluvial plain bordering San Francisco Bay to the east and the Santa Cruz Mountains to the west. The site occupies 426 ac (172 ha) on an elongated parcel roughly 2.75 mi (4.4 km) long, oriented in an east-west direction. The parcel widens to about 0.6 mi (0.97 km) at the target (east) end to allow space for buildings and experimental facilities.

The SLAC area climate is Mediterranean. Winters are cool and moist, and summers are mostly warm and dry. Daily mean temperatures are seldom below 32°F (0°C) or above 86°F (30°C). Annual rainfall typically averages about 22 in. (55.9 cm). The distribution of precipitation is highly seasonal. Approximately 75% of the precipitation, including most of the major storms, occurs during the 4-month period from December through March of each year.

The populated area around SLAC is a mix of offices, schools, single-family housing, apartments, condominiums, and Stanford University. SLAC is surrounded by five communities: the City of Menlo Park; the towns of Atherton, Portola Valley, and Woodside; and the unincorporated community of Stanford University, which is located in Santa Clara County. Nearby unincorporated communities in San Mateo County, include Ladera and two neighborhoods located in western Menlo Park.

The main instrument of research at the site is a linear accelerator that can generate high-power beams of electrons and positrons up to 50 GeV. Experimental facilities include, in part, the Linac Coherent Light Source (LCLS), the Stanford Synchrotron Radiation Lightsource (SSRL), Facilities for Accelerator Science and Experimental Test Beams (FACET), the Stanford Positron-Electron Asymmetric Ring (SPEAR III), and the Next Linear Collider Test Accelerator (NLCTA).

The 2 mi (3.2 km) Linac at SLAC is located inside a concrete tunnel 25 ft (7.6 m) beneath the ground surface. Through this underground tunnel, electron beam particles are accelerated to nearly the speed of light up to giga-electron volt levels. Some beam particles strike accelerator components during the acceleration process; the decelerating particles may emit secondary radiation in the form of high-energy photons and neutrons. This secondary radiation is present whenever beam particles are accelerated then lost, but it ceases as soon as power to the accelerator is terminated.

Site Monitoring. SLAC assesses, measures, and reports on radioactivity potentially released to the environment as required by site policies and by State or Federal regulations. Direct radiation is measured at 43 locations around the SLAC site boundary to determine the potential radiation dose to a member of the public.

In CY 2017, SLAC monitored radiation dose and dose rate at approximately 600 onsite locations (most are outside accelerator shielding housing and the rest are inside shielding housing) using passive radiation dosimeters posted for 6-month periods.

Industrial wastewater, stormwater, and groundwater are monitored for radioactivity at SLAC. SLAC will also monitor soil samples when soil could potentially be activated from SLAC operations, as with construction projects in the area.

SLAC implements a groundwater self-monitoring program that includes a groundwater sampling and analysis plan outlining the frequency at which wells are sampled, the constituents for which the samples are analyzed, and a schedule for collecting groundwater samples from extraction and monitoring wells, and surface water. Of the 183 wells used by the Restoration Program at SLAC, 112 wells are used for monitoring groundwater quality, chemicals of potential concern, or water level measurements; 66 wells are extraction wells at a total of five groundwater remediation systems; three wells are inactive soil vapor extraction wells; and two wells at the Former Solvent Underground Storage Tank Area are infiltration wells. Thirteen wells are used for general sitewide surveillance.

C.8.10 Thomas Jefferson National Accelerator Facility

Jefferson Lab (JLAB), a forefront DOE nuclear physics research facility, provides unique research capabilities and innovative technologies of world-class stature. Staff and visiting scientists use the unique particle accelerator, known as the Continuous Electron Beam Accelerator Facility (CEBAF), to conduct discovery class nuclear physics experiments; the Center for Advanced Studies of Accelerators; the Institute for Superconducting Radiofrequency (SRF) Science and Technology; and the Lattice Quantum Chromodynamics Computing Project to perform R&D programs to lead the world in science.

Site Description. JLAB is located in a business park in Newport News, Virginia. The total DOE-owned parcel, upon which JLAB is built, is 169 ac (68.4 ha). The primary electron accelerator at JLAB (the Continuous Electron Beam Accelerator Facility [CEBAF]) incorporates an accelerator ring and four experiment halls that house the physics program experiments. The CEBAF accelerator provides continuous wave electron beams with energies of 0.5 to 12 GeV. The Low Energy Recirculator Facility (LERF) is a recirculating electron linear accelerator (about 150 MeV) that is used for smaller scope and energy research than that conducted at CEBAF.

Site Monitoring. JLAB currently has no process, or associated emissions, that exceed the threshold levels that require air permitting. Internal calculations are routinely conducted to confirm this status. Essentially all airborne radionuclide emissions from JLAB are the result of the release of air from accelerator enclosure vaults containing activation products resulting from beam interactions with the air. The interaction of the beam with air produces short-lived radionuclides such as oxygen-15, nitrogen-13, and carbon-11, and smaller amounts of the longer-lived hydrogen-3 (tritium). Measurable quantities of airborne radionuclide production (and emission) occur almost exclusively in the accelerator area.

JLAB has an extensive radiation-monitoring network in and around the accelerator. Approximately 50 active, real-time radiation monitors and a series of passive integrating detectors are deployed around the accelerator site. Of these, eight monitors collected direct radiation data around the site boundary in 2017. These monitoring stations are equipped with specialized detection devices, optimized for measuring radiation at close to background levels.

JLAB complies with all water-quality protection requirements and performs monitoring in compliance with applicable water-quality permits. Groundwater monitoring wells are sampled routinely to ensure that site operations do not degrade groundwater quality. Groundwater samples are analyzed for tritium, beryllium-7, manganese-54, and sodium-22. The Virginia Pollutant Discharge Elimination System permit specifies limits for radioactivity in the wells, based on their location with respect to the accelerators.

All stormwater discharges are managed through structural and nonstructural best management practices in compliance with regulations and permits and no sampling is conducted. However, sediments from storm drainage channels and soils in areas that could potentially be affected (by contaminated runoff or storage and handling of radioactive materials) are sampled at a variety of locations on a location-specific frequency.

Appendix D – Summary of Radionuclide Air Emissions from DOE Facilities, 2015–2018

This appendix provides a summary of reports filed by U.S. Department of Energy sites as part of their compliance with U.S. Environmental Protection Agency Clean Air Act regulations regarding atmospheric releases of radionuclides (40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities). Subpart H requirements are separate and distinct from Annual Site Environmental Report (ASER) requirements.

This appendix was presented as an Annex in the prior ASER summary report (DOE 2004). It includes data about atmospheric releases of radionuclides and related individual and collective (population) dose estimates.

Facilities[1] owned or operated by the U.S. Department of Energy (DOE) handle and process radioactive materials in conjunction with their research, accelerator operations, nuclear materials handling, remediation, and waste disposal activities. During normal operations, some of these facilities have the potential to release small quantities of radionuclides to the environment.

Radionuclide emissions to the atmosphere from DOE facilities are regulated by the U.S. Environmental Protection Agency (EPA) under the authority of Section 12 of the *Clean Air Act*.[2] Three applicable subparts of the National Emission Standards for Hazardous Air Pollutants (NESHAPs; 40 CFR Part 61) set standards to limit public exposure to these releases:

- **40 CFR Part 61, Subpart H** − National Emissions Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities (hereafter Subpart H)
- **40 CFR Part 61, Subpart Q** − National Emission Standards for Radon Emissions from Department of Energy Facilities
- **40 CFR Part 61, Subpart T** − National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings

None of the facilities discussed in this appendix have emissions applicable under Subparts Q and T. DOE sites at which such air emissions would apply are Office of Legacy Management (LM) sites, which are not summarized in this ASER summary report.

Subpart H requires that DOE facilities submit annual reports by June 30 each year to their respective EPA regional offices and to EPA headquarters describing site activities that occurred during the previous calendar year, including estimates of atmospheric radionuclide emissions and the resulting dose to the maximally exposed individual (MEI) (see 40 CFR 61.94). In all cases, emissions from DOE facilities emissions resulted in impacts that were below the regulatory standard and, at most facilities, well below the standard.

DOE prepared this summary of the reports for calendar years (CYs) 2015–2018 to provide EPA and other interested parties with an overview of the information reported in the individual site Subpart H compliance

[1] A DOE facility, in this appendix, is synonymous with DOE site, discussed in the main part of this report.
[2] Airborne radionuclide emissions also are regulated by DOE under the authority provided by the *Atomic Energy Act of 1954*, as amended, and the *Department of Energy Organization Act of 1977*, as amended. DOE Order (O) 458.1, *Radiation Protection of the Public and the Environment*, replaced DOE 5400.5, Chg 2, *Radiation Protection of the Public and the Environment,* in March 2011, and directive requirements for radioactive air emissions remained unchanged.

reports. A prior report (DOE 2004) summarized similar information for the years 1998 through 2001. This summary is not required by regulation; it is provided to consolidate information and data reported by the individual DOE sites.

An overview of DOE compliance with the Subpart H dose standard is provided in Section D.1.5. In addition to the required compliance information, supplemental information about air emissions is discussed in Section D.2, including radon-220 and radon-222 emissions and collective dose.

Several sites that were included in the prior 1998−2001-year report (DOE 2004) are not included in this report because of site closure or cessation of radiological operations (see Table D-1). Table D-2 lists the DOE sites covered by this appendix, including the associated acronyms used in the figures, tables, and text. Sites in this appendix are listed alphabetically, rather than by DOE Program Office.

Table D-1. Sites Included in the Annex of DOE 2004 Report but Not Included in this Report

Abbreviation	Site Name and Location	Comment
FEMP/FCP/FP	Fernald Environmental Management Project, Ohio/Fernald Closure Project, Ohio	In June 2009, EPA made the determination that a NESHAP report would no longer be required.
MEMP/MOUND	Miamisburg Environmental Management Project/ Mound Closure Project, Mound Site, Ohio	DOE ownership of the project ended in September 2011.
KCP	Kansas City Plant, Missouri	Radiological operations terminated in CY 2010.
LEHR	Laboratory for Energy-Related Health Research, Davis, California	CY 2009 emissions report is the final NESHAP report based on ROD and cleanup under CERCLA.
RFETS	Rocky Flats Environmental Technology Site, Colorado	The CY 2007 emissions report was the final NESHAP report.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; NESHAP = National Emission Standards for Hazardous Air Pollutants; ROD = Record of Decision.

Several other DOE site operations no longer require compliance with Subpart H. The Knolls Atomic Power Laboratory, Windsor Site (KAPL-3) in Connecticut was also remediated to the point that it is no longer subject to Subpart H. The Lovelace Respiratory Research Institute (LRRI) in New Mexico continues to operate, but no longer conducts DOE radiological inhalation research. The Weldon Spring Site Remedial Action Project (WSSRAP) was transferred to the LM Program Office in 2003, under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA; 42 USC 9601), and is no longer subject to Subpart H. The Grand Junction Office (GJO) had uranium tailings; only remediation activities are ongoing under the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) and the site no longer submits a Subpart H report.

Several locations continue to operate but are known by different names since the DOE 2004 publication. Argonne National Laboratory-East (ANLE) is currently referred to as Argonne National Laboratory (ANL). Knolls Atomic Power Laboratory 1 (KAPL-1) is currently referred to as Knolls Atomic Power Laboratory-Kesselring Site (KESS). KAPL-2 is currently referred to as Knolls Atomic Power Laboratory-Knolls Laboratory (KNOL). The Energy Technology Engineering Center (ETEC) is currently referred to as the Santa Susana Field Laboratory at ETEC (SSFL).

Sites that were not previously reported in the DOE 2004 report include the PNNL Richland Campus (PNNL), PNNL's Marine Sciences Laboratory (MSL), and the Waste Isolation Pilot Plant (WIPP). The PNNL Richland Campus had previously been reported with the Hanford Site. WIPP Subpart H reports were included in multi-site summaries starting in 2005.

Table D-2. Subpart H Summary Sites and Acronyms

Site Abbreviation[(a,b)]	Site Name, State	Notes
AMES	Ames Laboratory, Iowa	a
ANL	Argonne National Laboratory, Illinois	
BETTIS	Bettis Atomic Power Laboratory, Pennsylvania	
BNL	Brookhaven National Laboratory, New York	
FERMI	Fermi National Accelerator Laboratory, Illinois	
HANF	Hanford Site, Washington	
INL	Idaho National Laboratory, Idaho	
JNAF	Thomas Jefferson National Accelerator Facility, Virginia	b
KESS	Knolls Atomic Power Laboratory-Kesselring Site, New York	
KNOL/SPRU	Knolls Atomic Power Laboratory-Knolls Site and SPRU, New York	c
LANL	Los Alamos National Laboratory, New Mexico	
LBNL	Lawrence Berkeley National Laboratory, California	
LLNL	Lawrence Livermore National Laboratory, California	
LLNL Site 300	Lawrence Livermore National Laboratory, Site 300, California	
MSL	Marine Sciences Laboratory, Washington	d
NNSS	Nevada National Security Site, Nevada	e
NREL STM	National Renewable Energy Laboratory, South Table Mountain, Colorado	
ORR	Oak Ridge Reservation, Tennessee	f
PANX	Pantex Plant, Texas	
PGDP	Paducah Gaseous Diffusion Plant-DOE, Kentucky	
PNNL	Pacific Northwest National Laboratory Richland Campus, Washington	
PORTS-DOE	Portsmouth Gaseous Diffusion Plant, Ohio	
PPPL	Princeton Plasma Physics Laboratory, New Jersey	
SLAC	Stanford Linear Accelerator Center, California	
SNL/CA	Sandia National Laboratories, (Livermore) California	
SNL/NM	Sandia National Laboratories, (Albuquerque) New Mexico	
SNL/TTR	Sandia National Laboratories, (Tonopah) Nevada	
SRS	Savannah River Site, South Carolina	
SSFL	Santa Susana Field Laboratory, California	
WIPP	Waste Isolation Pilot Plant, New Mexico	
WVDP	West Valley Demonstration Project, New York	

(a) AMES submits reports annually but has no emissions (below 40 CFR Part 61, Appendix E possession limits) from 2015–2018.
(b) The NESHAP acronym (JNAF) differs from the site's preferred JLAB acronym, but represents the same facility.
(c) The Separations Process Research Unit (SPRU) is a DOE Office of Environmental Management location at KNOL.
(d) In 2019, renamed PNNL Sequim Campus
(e) Formerly the Nevada Test Site.
(f) Includes the Y-12 National Security Complex (Y-12), Oak Ridge National Laboratory (ORNL), East Tennessee Technology Park (ETTP), and Oak Ridge Institute for Science and Education (ORISE).

Subpart H compliance reports from 31 DOE research or operations sites for CYs 2015–2018 were summarized. In the Subpart H reports, most site airborne emissions result from routine emissions from point sources. Emissions from non-point (diffuse, fugitive, or area) sources were generally several orders of magnitude lower than emissions resulting from routine point-source operations at sites where production and research operations continue. Other potential sources such as unplanned releases are described for each site, as applicable.

Several measures are reported in Subpart H reports that are not required explicitly by the subpart. A Memorandum of Understanding (MOU) between the EPA and DOE (EPA and DOE 1995), in part, requests information about radon (Rn-222 and Rn-220) emissions from sites. DOE O 458.1, Chg 3 requires the supplementary calculation of collective dose to support DOE oversight of its activities and the application of its as low as reasonably achievable (ALARA) policy. The collective dose to members of the public is representative of the total dose and of adequate quality for supported comparisons, trending, or decisions. Therefore, collective dose estimates for each site are provided in this report for informational purposes and to support trending and assessment of ALARA policy effectiveness. There is no regulatory standard for, nor EPA regulatory requirement to report, collective dose.

For CYs 2015–2018, all DOE facilities demonstrated compliance with the 10 mrem/yr (0.1 mSv/yr) effective dose equivalent (EDE) dose standard for an individual specified by Subpart H. Point-source assessments are conducted in accordance with the EPA-approved methods and procedures specified in Subpart H. Methods used to assess non-point-source dose can vary; the methods used are described in annual reporting.

D.1 Compliance with the Subpart H Dose Standard

This section summarizes the radiological impacts on the public resulting from 2015–2018 operations at DOE facilities. Regulatory compliance reporting by DOE facilities is discussed, as are the models used to calculate dose estimates. The quantities (Ci) of radionuclides released into the atmosphere from DOE facilities and the estimated doses to the MEI are presented.

D.1.1 Regulatory Requirements

On December 15, 1989, EPA promulgated radionuclide emission standards, which became effective during CY 1990. Radionuclide emissions (other than radon) from DOE operations are regulated under 40 CFR Part 61, Subpart H. Radon emissions from DOE storage and disposal facilities are regulated under 40 CFR Part 61, Subpart Q, and those from uranium mill tailings disposal sites are regulated under 40 CFR Part 61, Subpart T.

Dose is determined for Subpart H compliance. Subpart H stipulates the use of the EDE for evaluation of public exposure, as recommended by the International Commission on Radiological Protection in Publication 26 (ICRP 1977). The EDE is the sum of the annual dose resulting from external exposure to radionuclides and the 50-year committed dose from internal exposure to radionuclides inhaled or ingested during the year. Internal dose is calculated by combining doses to specific organs, and each dose is weighted by a factor related to the risk of radiation-induced health effects in that organ. The standard requires that annual MEI doses from radioactive air emissions at DOE facilities (excluding radon) not exceed 10 mrem EDE.

Updated dose factors were recommended in ICRP Publication 60 (ICRP 1991) and Federal Guidance Report 13 (Eckerman et al. 1999). Implementation of these updated dose factors is acceptable to EPA. ICRP Publication 72 (ICRP 1996) dose factors, which incorporate the recommendations of ICRP Publication 60, were implemented in the latest versions of software approved by EPA for use in emissions calculations, namely CAP88-PC, revisions 3 and 4.0. The use of updated dose factors results in a dose reported in units of effective dose (ED) rather that EDE. These units are considered interchangeable for the purposes of radiological dose reporting here. CAP88-PC revision 4.1 was approved for use in 2020

(FR 2020). This software update incorporates an updated dose factor data set, DCFPAK 3.02 (Eckerman and Leggett 2013).

DOE facilities are required to provide EPA with an annual report describing radionuclide emissions and a calculated dose to an individual member of the public (40 CFR 61.94). Each report must include a description of the physical site, the types of radionuclides handled there, and any process involving radionuclides that is conducted at the facility. The report also must include a list of all stacks or vents that have a potential to release airborne radionuclide emissions, the type and efficiency of effluent control systems used at each release point, and the distance to the nearest offsite receptors. DOE has agreed to identify its "non-point" (diffuse, fugitive, or area) sources, and to include the results of their emission and dose estimates as part of this annual report.

To demonstrate compliance with the protective requirements of 40 CFR Part 61, each site estimates the total quantity (Ci) of radionuclides released (for both point and non-point sources) from its facilities during the calendar year, and evaluates the impact of those emissions on the dose to the MEI. In general, the point-source emissions are reported separately and are used to document compliance with the standard. EPA does not specify acceptable methods or procedures for assessing the diffuse or non-point-source emissions in the regulations. Some regional regulatory authorities have established accepted procedures that a site, under its jurisdiction, must follow for reporting diffuse or other non-point-source emissions. In other cases, DOE sites use their own established methods and approaches to evaluate these emissions, as appropriate, for each source and location. These methods are described in the site-specific Subpart H reports. The non-point-source results are commonly reported separately from the point-source results when a site has both sources. The radionuclide emissions from point and non-point sources, as applicable under normal site operations, are used to determine the dose to compare to the 10 mrem/yr (0.1 mSv/yr) dose standard.

D.1.2 Radionuclide Emissions to the Atmosphere during Normal Operations

Emissions that result from normal operations are typically from facility stacks and vents, except for sites under, or pending to be put under, LM oversight. Certain releases from non-point sources were the result of routine activities at some sites and are included in the routine dose estimates for those sites. In some cases, emissions from non-point sources exceeded the site emission from stacks.

D.1.2.1 Emissions from Point Sources (Other than Radon)

Radionuclide point-source emissions to the atmosphere from normal operations during CYs 2015–2018 are detailed in Table D-3 through Table D-5, and are divided into four categories: tritium, noble gases, transuranic elements, and all other radionuclides. More detailed radionuclide-specific information is contained in the NESHAPs air emission reports for each individual site and in Section 4.2.1 of the main text of this report.

Figure D-1 (in Section D.1.2.3) summarizes the total activity emitted in each of four radionuclide categories for all DOE sites combined (CY 2015−2018), presenting information about both point and non-point (i.e., diffuse and fugitive) source emissions. The 2015–2018 releases (point and non-point, excluding radons) to the atmosphere from normal operations at DOE facilities ranged from about 61,000 to 104,000 Ci. Larger year-to-year variations are typically attributable to changes in noble gas and short-lived accelerator releases, although tritium emissions can vary widely depending on operational activities. For example, longer accelerator beam operation times during the year result in larger annual emissions of short-lived gases. Tritium is the single nuclide that remains a prominent component of airborne emissions—many of the DOE sites report some level of tritium release.

Table D-3. Summary of Airborne Point-Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2015 (Ci)

Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
ANL	3.70E-06	1.00E-01	3.80E-09	2.77E+02	**2.78E+02**	(a)
BETTIS	-	-	2.71E-07	1.25E-06	**1.52E-06**	
BNL	4.80E-01	-	-	4.55E+03	**4.55E+03**	
FERMI	3.89E+01	1.53E+01	-	5.49E+01	**1.09E+02**	
HANF	4.15E+02	6.20E+00	1.24E-04	7.67E-04	**4.21E+02**	(b)
INL	5.32E+02	1.34E+03	8.56E-03	1.19E+00	**1.87E+03**	(c)
JNAF	1.07E-02	7.88E-03	-	1.85E+00	**1.87E+00**	(d)
KESS	8.74E-02	4.20E-01	-	2.25E-02	**5.30E-01**	
KNOL/SPRU	3.69E-07	5.10E-01	3.27E-07	1.34E-05	**5.10E-01**	
LANL	3.83E+01	6.91E+00	4.73E-06	8.12E+01	**1.26E+02**	
LBNL	1.23E-03	5.00E-07	9.87E-07	2.76E+00	**2.76E+00**	(e)
LLNL	4.51E+01	-	-	-	**4.51E+01**	
LLNL Site 300	-	-	-	8.50E-07	**8.50E-07**	
MSL	n/a	n/a	n/a	n/a	-	
NNSS	-	2.21E+03	-	1.20E+01	**2.22E+03**	
NREL STM	2.60E-05	-	-	3.85E-03	**3.88E-03**	(f)
ORR	4.50E+02	1.62E+03	1.81E-03	2.26E+04	**2.47E+04**	
PANX	n/a	n/a	n/a	n/a	-	
PGDP	-	-	2.89E-08	1.84E-04	**1.84E-04**	
PNNL	1.20E-04	1.31E-06	9.91E-09	1.42E-04	**2.63E-04**	(c)
PORTS-DOE	-	-	1.45E-05	3.62E-02	**3.62E-02**	(g)
PPPL	3.50E+00	-	-	-	**3.50E+00**	
SLAC	-	4.60E-02		9.76E-01	**1.02E+00**	(d)
SNL/CA	n/a	n/a	n/a	n/a	-	
SNL/NM	5.05E+01	9.76E+00	-	5.05E-04	**6.03E+01**	
SNL/TTR	n/a	n/a	n/a	n/a	-	
SRS	1.91E+04	2.78E+03	2.30E-05	1.63E-02	**2.19E+04**	
SSFL	n/a	n/a	n/a	n/a	-	
WIPP	-	-	3.57E-06	8.13E-06	**1.17E-05**	
WVDP	n/s	n/s	n/s	n/s	-	(h)
Total Ci	**20644**	**7982**	**0.011**	**27613**	**56238**	

To convert values in this table to SI units, use the conversion factor 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category.

n/a = not applicable, no point source releases at this site for this calendar year.

n/s = information is not summarized for this site.

(a) Noble gas estimate does not include 30. Ci Rn releases.

(b) Noble Gas Ci includes Rn-219, but excludes Rn-220 and Rn-222.

(c) Includes diffuse and fugitive sources, also. For INL, source is: INL, Site Environmental Report, DOE/ID-12082(15), September 2016, Chapter 4.

(d) Diffuse releases treated as point releases.

(e) Main Lab Site emissions.

(f) Conservatively assumed emission of entire inventory for use in COMPLY.

(g) Emissions for DOE operations only. Centrus enrichment plant emissions not included.

(h) WVDP emissions were not reported. EPA approved compliance determination based on environmental surveillance.

Table D-4. Summary of Airborne Point-Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2016 (Ci)

Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
ANL	2.10E-03	1.00E-01	1.70E-11	5.77E+01	**5.78E+01**	(a)
BETTIS	-	-	2.41E-07	1.68E-06	**1.92E-06**	
BNL	6.91E-01	-	-	1.04E+04	**1.04E+04**	
FERMI	8.58E+01	2.86E+01	-	7.89E+01	**1.93E+02**	
HANF	2.66E+02	2.80E-07	6.55E-05	1.22E-03	**2.66E+02**	
INL	4.72E+02	1.38E+03	4.25E-03	1.13E+00	**1.85E+03**	(b)
JNAF	1.56E-03	1.44E-01	-	1.28E+00	**1.43E+00**	(c)
KESS	2.06E-01	2.14E-02	-	3.29E-02	**2.60E-01**	
KNOL/SPRU	1.33E-07	1.84E-01	1.50E-07	8.19E-06	**1.84E-01**	(d)
LANL	6.34E+01	1.15E+01	3.58E-06	1.47E+02	**2.21E+02**	
LBNL	8.44E-04	1.05E-05	1.11E-06	1.33E+00	**1.33E+00**	(b,e)
LLNL	7.64E+01	-	-	-	**7.64E+01**	
LLNL Site 300	-	-	-	1.02E-06	**1.02E-06**	
MSL	n/a	n/a	n/a	n/a	-	
NNSS	-	-	-	-	**0.00E+00**	
NREL STM	2.60E-05	-	-	7.38E-03	**7.41E-03**	(f)
ORR	1.09E+03	2.42E+03	2.32E-05	4.11E+04	**4.47E+04**	
PANX	-	-	-	-	0.00E+00	
PGDP	-	-	0.00E+00	3.16E-04	**3.16E-04**	
PNNL	1.20E-04	1.82E-06	2.02E-07	1.03E-04	**2.25E-04**	(b)
PORTS-DOE	-	-	1.51E-06	5.20E-03	**5.20E-03**	(g)
PPPL	4.58E+00	-	-	-	**4.58E+00**	
SLAC	-	4.40E-02	-	3.21E+00	**3.25E+00**	(c)
SNL/CA	n/a	n/a	n/a	n/a	-	
SNL/NM	1.60E+01	1.75E+01	-	6.07E-04	**3.35E+01**	
SNL/TTR	n/a	n/a	n/a	n/a	-	
SRS	1.95E+04	3.96E+03	1.07E-04	2.75E-02	**2.35E+04**	
SSFL	n/a	n/a	n/a	n/a	-	
WIPP	-	-	7.50E-07	1.20E-05	**1.27E-05**	
WVDP	7.79E-04	-	1.16E-06	2.53E-05	8.05E-04	(h)
Total Ci	**21615**	**7811**	**0.004**	**51867**	**81293**	

To convert values in this table to SI units, use the conversion factor 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category.

n/a = information is not applicable for this site for this calendar year.

(a) Noble gas estimate does not include 30. Ci Rn releases.

(b) Includes diffuse and fugitive sources, also. For INL, source is: INL, Site Environmental Report, DOE/ID-12082(16), September 2017, Chapter 4.

(c) Diffuse releases treated as point releases.

(d) KNOL releases are 100% H3 and Nobles; 73.4% TRU; 92.4% Other. SPRU releases make up balance of each category.

(e) Main Lab Site emissions.

(f) Conservatively assumed emission of entire inventory for use in COMPLY.

(g) Emissions for DOE operations only. Centrus enrichment plant emissions not included.

(h) WVDP emissions were not used for dose calculations. EPA approved compliance determination based on environmental surveillance.

Table D-5. Summary of Airborne Point-Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2017 (curies)

Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
ANL	8.70E-07	1.00E-01	0.00E+00	9.68E+01	**9.69E+01**	(a)
BETTIS	-	-	2.70E-07	1.64E-06	**1.91E-06**	
BNL	4.04E-01	-	5.00E-08	1.07E+04	**1.07E+04**	
FERMI	1.17E+02	2.84E+01	-	6.40E+01	**2.09E+02**	
HANF	1.76E+02	3.60E+03	7.18E-05	1.12E-03	**3.78E+03**	
INL	3.95E+02	9.24E+02	5.39E-04	7.57E-01	**1.32E+03**	(b)
JNAF	7.51E-03	8.24E-03	-	4.21E-01	**4.37E-01**	(c)
KESS	1.28E-01	7.46E-01	-	1.76E-02	**8.92E-01**	
KNOL/SPRU	1.73E-07	4.59E-01	1.55E-07	7.66E-06	**4.59E-01**	(d)
LANL	1.06E+02	9.52E+00	6.94E-07	1.38E+02	**2.53E+02**	
LBNL	3.80E-05	5.00E-07	1.23E-08	3.35E+00	**3.35E+00**	(b,e)
LLNL	4.50E+01	-	-	-	**4.50E+01**	(f)
LLNL Site 300	-	-	-	2.65E-06	**2.65E-06**	
MSL	n/a	n/a	n/a	n/a	-	
NNSS	-	-	-	-		(g)
NREL STM	2.60E-05	-	-	3.86E-03	**3.88E-03**	(h)
ORR	8.97E+02	2.81E+03	2.89E-04	1.69E+04	**2.06E+04**	
PANX	-	-	-	-	0.00E+00	
PGDP	-	-	0.00E+00	1.32E-03	**1.32E-03**	
PNNL	1.20E-04	1.01E-04	3.94E-07	1.26E-05	**2.34E-04**	(b)
PORTS-DOE	-	-	5.73E-05	7.67E-02	**7.68E-02**	(i)
PPPL	3.45E+00	-	-	-	**3.45E+00**	
SLAC	-	2.60E-02	-	3.28E-01	**3.54E-01**	(c)
SNL/CA	n/a	n/a	n/a	n/a		
SNL/NM	3.71E+01	7.40E+00	-	6.07E-04	**4.45E+01**	
SNL/TTR	n/a	n/a	n/a	n/a	-	
SRS	1.26E+04	5.45E+03	7.73E-04	3.39E-02	**1.81E+04**	
WIPP	-	-	3.29E-07	1.24E-05	1.27E-05	
WVDP	2.19E-04	-	1.25E-05	1.06E-04	**3.38E-04**	(j)
Total Ci	**14399**	**12827**	**0.0017**	**27834**	**55060**	

To convert values in this table to SI units, use the conversion factor 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category.

n/a = information is not applicable for this site for this calendar year.

(a) Noble gas estimate does not include 30. Ci Rn releases.

(b) Includes diffuse and fugitive sources, also. For INL, source is: INL, Site Environmental Report, Calendar Year 2017, DOE/ID-12082 (17), September 2018, Table 4-2.

(c) Diffuse releases treated as point releases.

(d) KNOL releases are 100% H3 and Nobles; 94% TRU; 97% Other.

(e) Main Lab Site emissions.

(f) LLNL H3 emissions includes estimate for non-monitored daily emissions.

(g) NNSS and NLVF emissions assigned as diffuse emissions. Most are diffuse rather than point emissions.

(h) Conservatively assumed emission of entire inventory for use in COMPLY.

(i) Emissions for DOE operations only. Centrus enrichment plant emissions (however, 0 Ci in 2017) not included.

(j) WVDP emissions (Ci) reported, but not used for dose calculations. EPA approved compliance determination based on environmental surveillance.

Table D-6. Summary of Airborne Point-Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2018 (Ci)

Site	Tritium	Noble Gas	Transuranic	All Other	Total	Notes
ANL	6.0E-07	5.0E-01	-	7.6E+01	**7.6E+01**	(a)
BETTIS	-	-	3.5E-07	1.4E-06	**1.7E-06**	
BNL	4.4E-01	-	3.7E-06	2.3E+04	**2.3E+04**	
FERMI	1.3E+02	4.3E+01	-	9.4E+01	**2.7E+02**	
HANF	3.3E+02	5.6E+02	7.7E-05	1.5E-03	**8.9E+02**	
INL	3.4E+02	9.4E+02	1.0E-04	6.1E+00	**1.3E+03**	(b)
JNAF	1.3E-01	6.5E-01	-	9.9E+00	**1.1E+01**	(c)
KESS	3.1E-01	9.9E-01	-	5.9E-02	**1.4E+00**	
KNOL/SPRU	1.6E-07	3.2E-01	1.1E-07	7.9E-06	**3.2E-01**	
LANL	4.9E+01	1.4E+01	7.1E-07	2.2E+02	**2.8E+02**	
LBNL	1.7E-04	7.2E-05	2.3E-07	1.0E+00	**1.0E+00**	(b)
LLNL	1.9E+02	-	-	-	**1.9E+02**	
LLNL-300	-	-	-	1.0E-06	**1.0E-06**	
MSL	n/a	n/a	n/a	n/a		
NNSS	1.2E+03	2.0E+03	-	9.8E+03	**1.3E+04**	(d)
NREL STM	2.6E-05	-	-	3.9E-03	**3.9E-03**	(e)
ORR	8.1E+02	3.7E+03	1.3E-05	1.0E+04	**1.5E+04**	
PANX	n/a	n/a	n/a	n/a		
PGDP	-	-	1.7E-08	2.1E-04	**2.1E-04**	
PNNL	1.2E-04	3.1E-05	2.3E-07	1.4E-05	**1.6E-04**	(b)
PORTS-DOE	-	-	6.0E-05	7.8E-02	**7.9E-02**	(f)
PPPL	5.8E+00	-	-	-	**5.8E+00**	
SLAC	-	2.5E-02	-	2.5E-01	**2.7E-01**	(c)
SNL/CA	n/a	n/a	n/a	n/a		
SNL/NM	5.0E+01	1.6E+00	-	7.9E-04	**5.2E+01**	
SNL/TTR	n/a	n/a	n/a	n/a		
SRS	2.5E+04	1.0E+04	1.4E-04	6.3E-02	**3.5E+04**	
WIPP	-	-	2.5E-07	1.0E-05	**1.1E-05**	
WVDP	-	-	-	-	-	(g)
Total Ci	**28239**	**17614**	**4.0E-04**	**43402**	**89256**	

To convert values in this table to SI units, use the conversion factor 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category.

n/a = information is not applicable for this site for this calendar year.

(a) Noble gas estimate does not include 30 Ci Rn-220 releases.

(b) Includes diffuse and fugitive sources, also. Only emissions with >0.1% MEI dose. For INL, source is: INL, Site Environmental Report, Calendar Year 2018, DOE/ID-12082 (18), September 2019, Table 7-2.

(c) Diffuse releases treated as point releases.

(d) NNSS and its associated operations in North Las Vegas reported emissions with a more detailed breakout by point/non-point in the CY2018 report.

(e) Conservatively assumed emission of entire inventory for use in COMPLY.

(f) Emissions for DOE operations only. Centrus enrichment plant emissions (however, 0 Ci in 2018) not included.

(g) No WVDP emissions (Ci) point source emissions reported. EPA approved compliance determination based on environmental surveillance.

D.1.2.2 Emissions from Non-point Sources (Other than Radon)

As indicated earlier, the radionuclide emission requirements in Subpart H specifically address point-source emissions. As modeling tools and emissions characterization methods have developed over the years with MOU implementation, non-point emissions from diffuse, fugitive, and some area sources are considered in a more routine manner and are also included in MEI dose estimations. Non-point emissions may also be characterized separately to track releases from such DOE sources at each site. Non-point-source emissions include emissions from resuspension of radionuclides from contaminated surfaces, atmospheric emissions of radionuclides from contaminated ponds and lagoons, and low unmonitored facility emissions that are not vented through a sole release point. Because the primary sources of potentially larger impact emissions for operating DOE facilities are those from stacks and vents, the regulations and associated guidance emphasize point sources.

The non-point-source emission rates (Ci/yr) and radionuclide category are indicated in Table D-7 to Table D-10. In 2015, about 16 sites reported non-point-source emissions. Non-point-source emissions may be combined with point sources for dose determination, or they may indicate compliance based on environmental measurement results with no dose reported from non-point-source emissions modeling. Combined radionuclide emissions to the atmosphere from all reported non-point-source emissions for 2015–2018 range from a low of about 2,800 Ci in 2016 to about 14,000 Ci in 2018. Among the four categories, Tritium and All Others account for most non-point-source releases. For sites that provide emission estimates specifically for non-point sources, SRS is the predominant source of tritium emissions to the air, and during some years, the NNSS is the site that emits the largest amount of All Other-category emissions in a remote site location. The overwhelming majority of transuranic (TRU) non-point emissions are estimates from NNSS from past testing activities.

Annual non-point-source emissions during 2015-2018 were above a curie occur for tritium (LLNL, NNSS, and SRS); noble gases (LANL and NNSS); and All Other (LANL, NNSS, and SRS). The greatest TRU emissions from non-point sources occur at NNSS and are the result of soil resuspension modeling across the site. All Other non-point-source emissions (activation products) occur at high levels in a remote area of NNSS (2015–2017) only during years when certain equipment is operated or at SRS (2018) due to tritium releases. Relative to the Tritium, Noble Gas, and All Other categories, low levels of TRUs are emitted from DOE sites (see Figure D-1, which illustrates emissions of both point and non-point sources). Most TRUs are potent inhalation hazards due to their alpha-particle emissions. The expense of their creation and isolation, high potential health impacts, and ease of particulate filtration capture all enter into the resulting lower release values.

D.1.2.3 Emissions from Both Point and Non-point Sources (Other than Radon)

Figure D-1 indicates the activity emitted to air from DOE Complex radiological operations. The activities of point emissions are generally greater than those of non-point emissions. The exception is for TRU emissions, which are *measured* at very low levels from point sources and are *estimated* at greater levels from non-point sources.

Non-point-source and point-source Subpart H dose estimates can be carried out independently using different methods (i.e., CAP88 code, COMPLY code, or environmental measurements). See Section D.1.5 for details. Both software codes provide a conservative estimate (i.e., overestimate) of the actual dose that the adult receptor would incur. However, non-point-source dose results are, in general, more greatly overestimated than the dose from point sources.

Figure D-1. Point and Non-point Totals of Activity Emitted to Air from DOE Sites in CYs 2015–2018 Subpart H Reporting

Table D-7. Summary of Airborne Non-point (Diffuse or Fugitive) Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2015 (Ci)

Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
ANL	3.00E-03	-	-	-	**3.00E-03**	(b)
BETTIS	n/a	-	n/a	n/a	n/a	(c)
HANF	-	-	5.20E-03	3.80E-01	**3.85E-01**	(d)
INL	-	-	-	-	n/a	(e)
KESS	-	-	-	-	**0.00E+00**	
KNOL/SPRU	-	-	1.29E-07	1.08E-05	**1.09E-05**	(f)
LANL	-	1.31E+01	-	4.08E+01	**5.39E+01**	(g)
LBNL	-	-	-	-	n/a	(h)
LLNL	2.23E+00	-	(i)	-	**2.23E+00**	
LLNL-300	-	-	-		n/a	(j)
MSL	1.37E-09	-	1.27E-12	3.84E-08	**3.97E-08**	
NNSS	3.61E+02	8.50E+02	3.97E-01	6.10E+03	**7.31E+03**	(k)
ORR	-	-	-	-	n/a	(l)
PANX	1.87E-02	-	-	2.63E-10	**1.87E-02**	
PGDP	-	-	-	-	n/a	(m)
PORTS-DOE	-	-	-	-	n/a	(l)
SNL/TTR	-	-	-	-	n/a	(l)
SRS	2.08E+03	-	3.20E-04	4.29E-02	**2.08E+03**	(n)
WVDP	3.37E-03	-	1.51E-09	8.40E-05	**3.45E-03**	(o)
Total Ci	**2443**	**863**	**0.40**	**6137**	**9444**	

To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7×10^{10} Bq.

"-" = no releases for this category; n/a =not available.

(a) Diffuse source emissions do not include radon-220 and radon-222.

(b) Area source of tritium transpired by trees, based on average water concentration.

(c) Diffuse release estimated for building demolition. Dose results in the E-5 mrem range; no emissions estimates listed in report.

(d) Releases reported are a calculational result from monitoring results; releases not associated with any known specific diffuse source(s).

(e) Diffuse and stack curies not clearly broken out in INL Site Environmental Report where release values indicated. (diffuse sources account for 47% of the MEI dose)

(f) Includes both KNOL and SPRU emissions.

(g) Gaseous area sources only. Other diffuse emissions captured from environmental measurements.

(h) Diffuse Ci not clearly broken out in total emissions table.

(i) Resuspension of surface soil Pu-239, not quantified. One 2015 ambient air sample had a Pu239/240 detection.

(j) No diffuse U emissions estimate provided for LLNL Site 300.

(k) NLVF diffuse tritium emissions at downtown facility were 0.0024 Ci H-3.

(l) Diffuse source emissions were not specifically quantified; dose based on environmental measurements.

(m) PGDP - environmental measurements used for diffuse evaluation. All measurements below 40CFR61 AppE Table 2 values, so no further diffuse evaluation done.

(n) Contains significant contributions from unidentified alphas (TRU) and unidentified betas (All Other) (assigned as Pu-239 and Sr-90, respectively)

(o) WVDP emissions (Ci) reported, but EPA approved compliance determination based on environmental surveillance.

Table D-8. Summary of Airborne Non-point (Diffuse or Fugitive) Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2016 (Ci)

Site	Tritium	Noble Gas	Trans-uranic	All Other	Total	Notes
ANL	2.0E-08	-	-	-	2.0E-08	(b)
BETTIS	n/a	-	n/a	n/a	n/a	(c)
HANF	-	-	3.6E-03	4.1E-01	4.1E-01	(d)
INL	-	-	-	-	n/a	(e)
KESS	-	-	-	3.3E-09	3.3E-09	
KNOL/SPRU	-	-	3.6E-05	9.2E-04	9.6E-04	(f)
LANL	-	2.3E+01	-	1.0E+01	3.3E+01	(g)
LBNL	-	-	-	-	n/a	(h)
LLNL	1.8E+00	-		-	1.8E+00	(i)
LLNL-300	-	-	-		n/a	(j)
MSL	-	-	1.3E-12	1.0E-06	1.0E-06	
NNSS	2.1E+02	3.1E+02	4.0E-01	2.1E+00	5.2E+02	(k)
ORR	-	-	-	-	n/a	(l)
PANX	9.65E-01	-	-	1.9E-12	9.6E-01	
PGDP	-	-	-	-	n/a	(m)
PORTS-DOE	-	-	-	-	n/a	(l)
SNL/TTR	-	-	-	-	n/a	(l)
SRS	2.2E+03	-	3.4E-04	4.4E-02	2.2E+03	(n)
WVDP	3.5E-03	-	1.6E-09	9.8E-05	3.6E-03	(o)
Total	**2452**	**329**	**0.40**	**13**	**2794**	

To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category; n/a =not available.

(a) Diffuse source emissions do not include radon-220 and radon-222.

(b) Area source of tritium transpired by trees, based on average water concentration.

(c) Diffuse release estimated for building demolition. Dose results in the E-5 mrem range; no emissions estimates listed in report.

(d) Releases reported are a methematical estimate from monitoring results; releases not associated with any known specific diffuse source(s).

(e) Diffuse and stack curies not clearly broken out in INL Site Environmental Report where release values indicated.

(f) KNOL releases are 0.03% Others; SPRU releases are essentially all the TRU.

(g) Gaseous area sources only. Other diffuse emissions captured from environmental measurements.

(h) Diffuse release values not broken out in release table.

(i) Resuspension of surface soil Pu-239, not quantified. One 2016 ambient air sample had a Pu239/240 detection.

(j) No diffuse U emissions estimate provided for LLNL Site 300. Dose based on env.monitoring; 2 samples.

(k) NLVF diffuse tritium emissions at downtown facility were 0.0021 Ci H-3.

(l) Diffuse source emissions were not specifically quantified; dose based on environmental measurements.

(m) PGDP - environmental measurements used for diffuse evaluation. All measurements below 40CFR61 AppE Table 2 values, so no further diffuse evaluation done.

(n) Contains significant contributions from unidentified alphas (TRU) and unidentified betas (All Other) (assigned as Pu-239 and Sr-90, respectively)

(o) WVDP emissions (Ci) reported from lagoon calculations, but EPA approved compliance determination based on environmental surveillance.

Table D-9. Summary of Airborne Non-point (Diffuse or Fugitive) Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2017 (Ci)

Site	Tritium	Noble Gas	Transuranic	All Other	Total	Notes
ANL	3.0E-03	-	-	-	3.0E-03	(a)
BETTIS	-	-	-	-	0.0E+00	
HANF	-	-	-	8.6E-01	8.6E-01	(b)
INL	-	-	-	-	n/a	(c)
KESS	-	-	-	1.0E-12	1.0E-12	
KNOL/SPRU	-	-	3.1E-05	1.5E-03	1.6E-03	(d)
LANL	-	1.0E+02	-	4.2E+01	1.4E+02	(e)
LBNL	-	-	-	-		(f)
LLNL	2.2E+00	-	-	-	2.2E+00	(g)
LLNL-300	-	-	-	-	n/a	(h)
MSL	7.0E-11	-	1.3E-12	1.0E-06	1.0E-06	
NNSS	1.3E+03	3.0E+02	4.0E-01	1.4E+03	3.0E+03	(i)
ORR	-	-	-	-	n/a	(j)
PANX	4.66E-04	-	-	5.3E-06	4.7E-04	
PGDP	-	-	-	-	n/a	(k)
PORTS-DOE	-	-	-	-	n/a	(j)
SNL/TTR	-	-	1.8E-10	-	n/a	(l)
SRS	2.6E+03	-	3.2E-04	4.2E-02	2.6E+03	(m)
WVDP	2.6E-03	-	7.5E-10	8.4E-05	2.7E-03	(n)
Total	**3872**	**407**	**0.40**	**1438**	**5717**	

To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category; n/a =not available.

(a) Area source of tritium transpired by 800 trees, based on average water concentration.

(b) Releases reported are a methematical estimate from monitoring results; releases not associated with any known specific diffuse source(s).

(c) Diffuse and stack curies not clearly broken out in INL Site Environmental Report where release values indicated.

(d) KNOL releases are 0.008% TRU and 0.05% Others.

(e) Gaseous area sources only. Other diffuse emissions captured from environmental measurements.

(f) Diffuse release values not broken out in release table.

(g) Based on estimates from air sampling modeling.

(h) No diffuse U emissions estimate provided for LLNL Site 300. No open air tests in 2017; ambient monitoring done.

(i) Includes some point emissions; most are diffuse emissions. NLVF diffuse tritium emissions at downtown facility were 0.0020 Ci H-3.

(j) Diffuse source emissions were not specifically quantified; dose based on environmental measurements.

(k) PGDP - environmental measurements used for diffuse evaluation. All measurements below 40CFR61 AppE Table 2 values, so no further diffuse evaluation done.

(l) Estimate of release from 2017 soil remediation activity; emissions for MEI dose result are not quantified.

(m) Contains significant contributions from unidentified alphas (TRU) and unidentified betas (All Other) (assigned as Pu-239 and Sr-90, respectively)

(n) WVDP emissions (Ci) reported from lagoon evaporation calculations; not used for dose assessment. EPA approved compliance determination based on environmental surveillance.

Table D-10. Summary of Airborne Non-point (Diffuse or Fugitive) Source Radionuclide Releases from Normal Operations at DOE Facilities during CY 2018 (Ci)

Site	Tritium	Noble Gas	Transuranic	All Other	Total	Notes
ANL	2.5E-03	-	-	-	2.5E-03	(a)
BETTIS	-	-	-	-		(b)
HANF	-	-	8.6E-03	6.9E-01	7.0E-01	(c)
INL	-	-	-	5.9E-05	5.9E-05	(d)
KESS	-	-	-	4.6E-09	4.6E-09	
KNOL/SPRU	-	-	6.6E-06	5.6E-04	5.6E-04	
LANL	-	3.4E+01	-	8.2E+01	1.2E+02	(e)
LBNL	-	-	-	-		(f)
LLNL	1.9E+00	-		-	1.9E+00	(g)
LLNL-300	-	-	-			(h)
MSL	7.0E-11	-	1.3E-12	1.0E-06	1.0E-06	
NNSS	2.7E+01	1.3E+00	4.0E-01	1.1E-01	2.9E+01	
ORR	-	-	-	-		(i)
PANX	5.31E-04	-	-	1.2E-06	5.3E-04	
PGDP	-	-	-	-		(j)
PORTS-DOE	-	-	-	-		(i)
SNL/TTR	-	-	1.2E-10	-	1.2E-10	(k,i)
SRS	1.4E+04	-	4.7E-04	2.9E-02	1.4E+04	(l)
WVDP	2.7E-03	-	1.2E-09	7.7E-05	2.8E-03	(m)
Total Ci	**14229**	**35**	**0.41**	**83**	**14347**	

To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7 x 10^{10} Bq.

"-" = no releases for this category; n/a =not available.

(a) Area source of tritium transpired by 800 trees, based on average water concentration.

(b) Building demolition dose indicated, but nuclide constituents not specified in NESHAP report.

(c) Releases reported are a mathematical estimate from monitoring results; releases not associated with a specific diffuse source(s).

(d) Diffuse and stack curies not clearly broken out in INL Site Environmental Report where release values indicated; indicated releases from Naval Reactor Facility on INL Site.

(e) Gaseous area sources only. Other diffuse emissions measured by ambient air measurements.

(f) Diffuse release values not broken out in release table.

(g) Based on estimates from air sampling modeling.

(h) No diffuse U emissions estimate provided for LLNL Site 300.No open air tests in 2018; ambient monitoring done.

(i) Diffuse source emissions were not specifically quantified; dose based on environmental measurements.

(j) PGDP - environmental measurements used to confirm low emissions. All measurements below 40CFR61 AppE Table 2 values.

(k) Estimate of release from 2018 soil remediation activity using maximum sample results.

(l) Contains significant contributions from gross alpha (TRU category) and unidentified betas (All Other category) (assigned as Pu-239 and Sr-90, respectively). Diffuse emissions include grouped small-point-source emissions.

(m) WVDP emissions (Ci) estimated from lagoon evaporation calculations; not used for compliance determination. EPA approved compliance determination based on environmental surveillance.

D.1.3 Dosimetry Models and Codes

Computer codes are used to calculate dose estimates to an adult receptor for compliance determination. The dosimetry models approved by EPA are specified by the regulations. These codes are used by DOE sites to demonstrate compliance with the dose standard. The EPA-approved code packages include CAP88, CAP88-PC, COMPLY, and AIRDOS-PC. Current (i.e., 2020), typical computer operating systems are capable of processing only CAP88-PC and COMPLY. Approval of alternative methods for demonstrating compliance with the dose standard may be requested from EPA on a case-by-case basis. These approvals include exclusive use of environmental surveillance results (ambient air-sampling results indicate radioactive material concentrations in air) for demonstrating compliance. A few sites do not demonstrate compliance with the dose standard using the environmental surveillance results, but use the results to confirm low emissions. The models used by individual DOE sites to demonstrate compliance with the standard for CYs 2015–2018 are indicated in Table D-11. Section D.1.5 (Figure D-2; and Table D-12 through Table D-15) provides MEI dose estimated results from the modeling and other methods.

The CAP88 code package (Beres 1990), updated over the years to its current form “CAP88-PC,” implements a steady-state gaussian plume atmospheric dispersion model and comes with a set of radionuclide-specific data that correspond to the data used in the internal dosimetry models described in ICRP Publications (e.g., ICRP 1979−1982) for the early version of the code. CAP88 required what was known as a mainframe computer system to operate, and no site uses this version because more recent CAP88-PC software operates more efficiently.

The MS-DOS-based personal computer (PC) version of CAP88 (CAP88-PC) is currently used by the large majority of the sites (see Table D-11). CAP88-PC was used by 70% of the reporting DOE sites to demonstrate compliance with the NESHAPs standard during the CY 2015−2018 period. The CAP88-PC code (Parks 1992), developed by EPA with DOE funding, was released in March 1992. A windows-compatible version was developed in 2000, called CAP88-PC V2.0 (Chaki and Parks 2000). CAP88-PC V2.0 was approved for demonstrating compliance with 40 CFR 61.93 in October 1999. CAP88-PC V3.0 (Rosnick 2007; updated by Rosnick 2013) was approved by EPA in 2006 for use by DOE facilities. Version 3 is the first version to calculate ED for internal dose calculations, an update from the EDE calculated by the earlier code versions. Such a unit change incorporates more recent ICRP biokinetics models and tissue weighting factors. Output reports continue to indicate dose results as EDE. The total dose reported in CAP88-PC V3.0 and V4.0 (Rosnick and TEA 2014) output files is also reported in the compliance reporting to be consistent (total effective dose equivalent).

The COMPLY V1.6 code (EPA 1989c), with an update (V1.7) to run on current Windows-based operating systems (EPA 2018), is a screening model consisting of four levels, each of which requires increasingly detailed site-specific data to produce a more realistic (and less conservative) dose estimate. COMPLY is used for comparatively small sites with “small” releases because it does not require extensive site-specific data. It has a large radionuclide library comparable to that of CAP88 and may be used for situations where the receptor is located closer to the site than is appropriate for other codes. However, the lower screening levels of COMPLY will provide more conservative (i.e., overestimating) results. Three DOE sites (MSL, NREL STM, and PPPL) used COMPLY solely to estimate doses for their air emissions reports (2015–2018). LBNL used COMPLY, along with CAP88-PC, for the evaluation of potential receptors located less than 100 mi away.

The models used to demonstrate compliance with Subpart H contain varying degrees of conservatism,[1] which vary with the site-specific procedures and operations, the code used, and site setting. In general, the more simplistic models use fewer site-specific parameters as input and produce more conservative results. Because doses from radionuclide emissions to air at many DOE facilities are very low, the degree of conservatism in the resulting dose estimates does not significantly impact the ability of sites to demonstrate compliance with the dose standard. However, because of this varied conservatism among

[1] Conservative, as used in this appendix, refers to over-estimation. In other words, the reported dose is higher than it would actually be expected to be.

the approved models, direct comparison of results from different sites does not necessarily reflect absolute differences in MEI doses at DOE sites. However, because most DOE sites used CAP88-PC V4.0 for CY 2015–2018 emissions, some comparability is established among results reported by different sites.

Table D-11. Codes or Methods Used to Demonstrate Compliance with the Subpart H Dose Standard

Site	2015 Compliance Code	2016 Compliance Code	2017 Compliance Code	2018 Compliance Code
AMES	n/a	n/a	n/a	n/a
ANL	CAP88-PC v 4.0	NC	NC	NC
BETTIS	CAP88-PC v 3	CAP88-PC v 4.0	NC	NC
BNL	CAP88-PC v 4.0	NC	NC	NC
FERMI	CAP88-PC v 4.0	NC	NC	NC
HANF	CAP88-PC v 4.0, environmental measurements	NC	NC	NC
INL	CAP88-PC v 3	CAP88-PC v 4.0	NC	NC
JNAF	CAP88-PC v 4.0	NC	NC	NC
KESS	CAP88-PC v 3	CAP88-PC v 4.0	NC	NC
KNOL/SPRU	CAP88-PC v 3	CAP88-PC v 4.0	NC	NC
LANL	CAP88-PC v4; environmental measurements	NC	NC	NC
LBNL	CAP88-PC v 4.0; COMPLY	NC	NC	NC
LLNL	CAP88-PC v 4.0; environmental measurements.	NC	NC	NC
LLNL Site 300	CAP88-PC v 4.0; environmental measurements	NC	NC	NC
MSL	COMPLY v1.6 (Level 4)	NC	COMPLY v1.7 (Level 4)	NC
NNSS	Environmental measurements	NC	NC	NC
NREL STM	COMPLY v1.6 (Level 1 and 4)	NC	COMPLY v1.7 (Level 4)	NC
ORR	CAP88-PC v 4.0, environmental measurements	NC	NC	NC
PANX	CAP88-PC v 3	NC	CAP88-PC v 4.0	NC
PGDP	CAP88-PC v 4.0	NC	NC	NC
PNNL	CAP88-PC v 4.0	NC	NC	NC
PORTS-DOE	CAP88-PC v 4.0; environmental measurements for low emissions confirmation	NC	NC	NC
PPPL	COMPLY v1.6 (Level 4)	NC	NC	COMPLY v1.7 (Level 4)
SLAC	CAP88-PC v 2.1	NC	NC	NC
SNL/CA	n/a	n/a	n/a	n/a
SNL/NM	CAP88-PC v 4.0	NC	NC	NC
SNL/TTR	1990s environmental measurements	NC	NC	2018 env. measurements
SRS	CAP88-PC v 4.0	NC	NC	NC
SSFL	n/a	n/a	n/a	n/a
WIPP	CAP88-PC v 4.0	NC	NC	NC
WVDP	Environmental measurements	NC	NC	NC

NC = No Change from prior year compliance code.

D.1.4 Environmental Measurements as an Alternative to Dosimetry Models

Subpart H explicitly applies to point-source releases of radioactive materials. Since 1990, development of software tools and procedures, and the signing of the MOU between EPA and DOE (EPA and DOE 1995), resulted in the routine inclusion of diffuse release emissions estimation and impact assessment under the umbrella of Subpart H. Diffuse sources do not allow for ideal release sampling conditions to precisely characterize radioactive material emissions (e.g., windblown soil contamination at legacy sites). Remediation activities, facility upgrades, and application of site ALARA programs have reduced diffuse sources emissions to low levels. Sites with only low levels of emissions may demonstrate compliance with the emission standard by the using environmental measurements rather than dose modeling (EPA and DOE 1995).

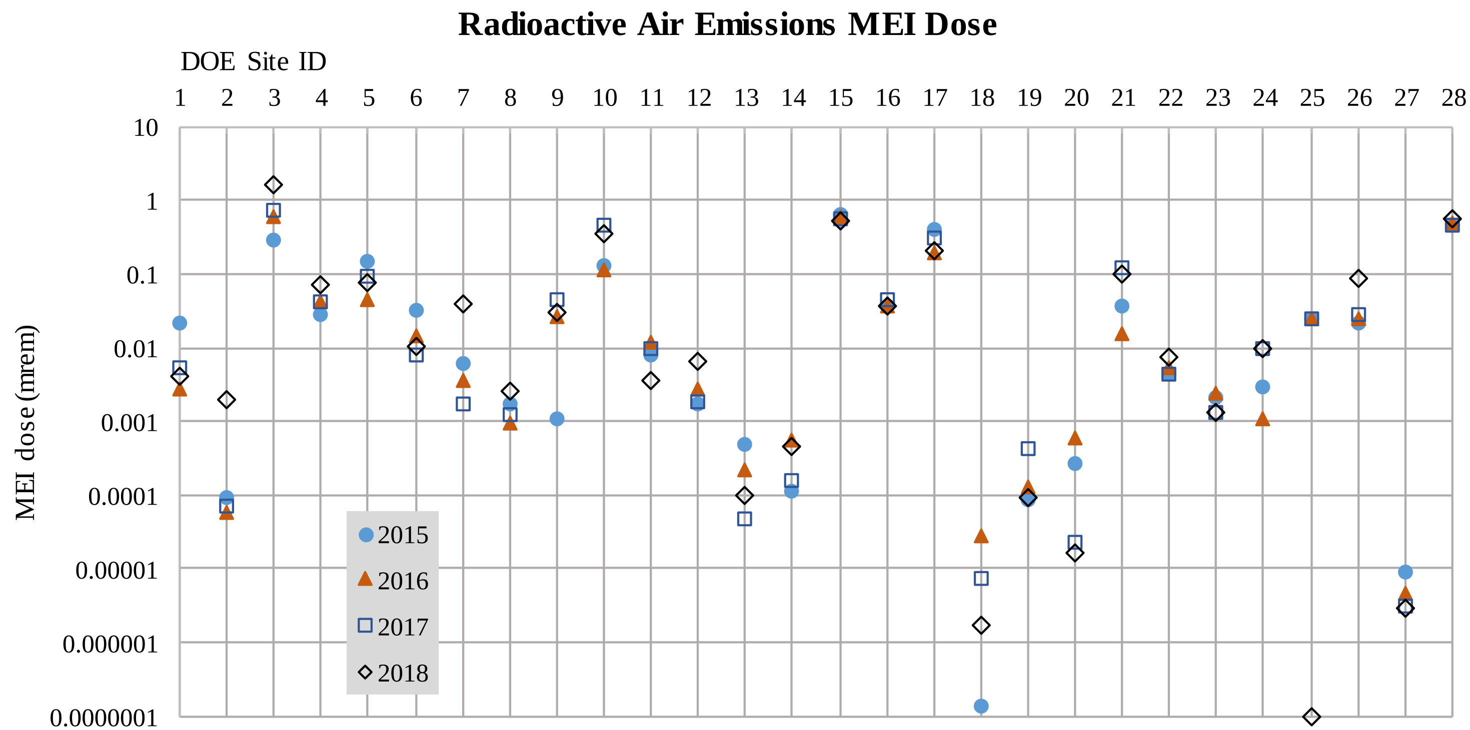
Ambient air-sampling stations are located at an appropriate proximity to the potential release locations. Sampling results based on acceptable detection, capture, and laboratory analysis criteria (e.g., acceptable minimum detectable air concentration) may be used to demonstrate compliance. In other words, if the sampling program is capable of detecting air concentrations that could indicate a hazard and actual sample results are below a critical air concentration, the environmental measurements would indicate a compliant facility under the *Clean Air Act*. For radioactive materials, the EPA-listed critical air concentrations found in 40 CFR Part 61, Appendix E, Table 2, are considered the limiting standard for the environmental measurements. Only three of the DOE sites summarized used environmental measurements for their entire Subpart H compliance reporting during 2015−2018: NNSS, WVDP, and SNL/TTR. Some sites with both point and diffuse sites (e.g., LANL and HANF) use environmental measurements to support compliance reporting for non-point-source emissions. The NNSS is particularly unusual in that its environmental measurements are acquired well inside the border of NNSS, near a crater of a former test.

D.1.5 Status of Compliance with Subpart H Dose Standard

MEI doses from emissions of radionuclides to air during routine CY 2015−2018 site operations are reported annually. The EPA regulates with a 10 mrem/yr dose standard for radionuclide emissions to air. Figure D-2 summarizes Subpart H-reported MEI doses and ranges of doses for 2015–2018 reported by the DOE sites. Table D-12 through Table D-15 provide additional details. All dose estimates were less than the 10 mrem/yr dose standard. The dose estimates were produced using EPA-approved models for emissions estimates, or in a few cases where approved to do so, environmental measurements. Over the 4-year period reviewed, the estimated MEI dose ranged from 8E-11 to 1.6 mrem/yr.

Of the approximately 30 operational DOE sites subject to Subpart H, 80% or more of the sites reported doses below 0.1 mrem/yr or 1% of the standard from 2015–2018 operations. The site with the highest estimated doses from CY 2015–2018 normal operations was BNL in 2017 at 1.6 mrem/yr TEDE (1,160 m MEI). At BNL, increased accelerator operating time, beam energy, and beam current results in more short-lived radionuclide emissions that, in turn, result in higher dose estimates. Accelerator operations were briefer in CY 2015 and the BNL MEI dose reflected this (3% of dose standard). At least five sites reported doses between 0.1 and 10 mrem/yr each calendar year. MEI distances from the dominant release point range from 120 mi to 16 km. A dominant release point could be an actual stack, or a central site location, depending on the model assumption used.

Compliance reporting demonstrates that radionuclide emissions from DOE facilities result in doses at least an order of magnitude below the 40 CFR Part 61, Subpart H, dose standard, and the inclusion of non-point-source emissions in dose estimates does not negatively impact DOE facility compliance with the 10 mrem/yr standard. Diffuse sources of radionuclide emissions (other than radon) generally result from secondary processes such as the resuspension of contaminated soil, but they may also be from stacks that contribute only a small fraction to the potential MEI dose.



1 ANL	6 INL	11 LBNL	16 NREL	21 PORTS-DOE	26 SRS
2 BETTIS	7 JNAF	12 LLNL	17 ORR	22 PPPL	27 WIPP
3 BNL	8 KESS	13 LLNL-300	18 PANX	23 SLAC	28 WVDP (a)
4 FERMI	9 KNOL/SPRU	14 PNNL MSL	19 PGDP	24 SNL/NM	
5 HANF	10 LANL	15 NNSS (a)	20 PNNL Richland	25 SNL/TTR (b)	

(a) NNSS (15) and WVDP (28) are conservative approximations, converted to dose from environmental measurements.

(b) The 2018 SNL/TTR (25) MEI dose is 7.9E-11 mrem, plotted as <1E-7 mrem.

Figure D-2. MEI Doses from Radioactive Air Emissions from CYs 2015–2018

Table D-12. Subpart H MEI Dose from Point and Non-point Emissions to Air (2015)

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2015 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes
AMES	n/a	n/a	n/a	**n/a**	
ANL	2.2E-02	2.0E-08	**0.022**	1200	(b)
BETTIS	9.5E-05	2.1E-05	**0.000095**	305	(c)
BNL	2.8E-01	n/a	**0.28**	1159	
FERMI	2.8E-02	n/a	**0.028**	800	
HANF	6.7E-02	2.2E-02**	**0.15**	1600	(d,e)
INL	1.8E-02	1.6E-02	**0.033**	7976	(e,f)
JNAF	6.2E-03	-	**0.0062**	250	(e)
KESS	1.7E-03	-	**0.0017**	1650	
KNOL/SPRU	6.5E-04	4.4E-04	**0.0011**	470	(e,g)
LANL	6.4E-02	6.4E-02**	**0.13**	774	(e,h)
LBNL	4.6E-03	3.3E-03	**0.0079**	460	(e,i)
LLNL	1.4E-03	3.3E-04	**0.00173**	974	(j,k)
LLNL Site 300	1.3E-07	4.8E-04	**0.00048**	3200	
MSL	-	1.1E-04	**0.00011**	190	(e)
NNSS	-	6.4E-01**	**0.641**	onsite	(e,l,m)
NREL STM	3.6E-02	-	**0.036**	119	(n)
ORR	3.9E-01	1.0E-02**	**0.40**	4220	(o)
PANX	n/a	1.4E-07	**0.00000014**	5200	(e)
PGDP	8.7E-05	(p)	**0.000087**	1080	(j)
PNNL	2.6E-04	-	**0.00026**	150	(e)
PORTS-DOE	3.7E-02	1.2E-03** (p)	**0.037**	2540	(q,r)
PPPL	4.4E-03	-	**0.0044**	351	
SLAC	2.2E-03	-	**0.0022**	1395	(e,s)
SNL/CA	n/a	n/a	n/a	**n/a**	
SNL/NM	3.0E-03	n/a	**0.0030**	fence line	
SNL/TTR	n/a	2.4E-02**	**0.024**	onsite	(e)
SRS	1.9E-02	3.5E-03	**0.022**	15706	(e)
SSFL	n/a	n/a	n/a	n/a	
WIPP	8.8E-06	n/a	**0.0000088**	8900	
WVDP	-	-	**< 0.47****	2400	(t)

n/a = not available; n/s = not summarized.

(a) Receptor distance represents distance from MEI to the facility that is the major contributor to dose, or to a central reference point.
(b) MEI dose of 0.032 mrem/yr would include dose from Rn-220. Diffuse dose assignment from average area source.
(c) "Urban" agriculture data were used. Business is the nearest receptor. All releases assumed from single central emission point. Diffuse dose is a conservative estimate from demolition activities; not used for the declared MEI dose.
(d) Total includes radon dose.
(e) MEI dose includes, or is entirely based on, emissions from diffuse sources: HANF, INL, JNAF, KNOLS/SPRU, LANL, LBNL, MSL, NNSS, PANX, PNNL, SLAC, SNL/TTR, SRS.
(f) IRC and RESL doses are not included in the INL estimate. NRF dose is included in the INL estimate. IRC/RSEL is 22 mi from the INL Site north of Idaho Falls. The IRC/RESL MEI is 0.0127 mrem and is @ 100 m south of IRC/RESL.
(g) KAPL MEI 3.8E-4 mrem @ 470 m; SPRU MEI 7.1E-4 mrem @ 470 m. Includes both point and diffuse emissions.
(h) LANL diffuse dose is 0.022 mrem from environmental monitoring and 0.042 mrem from CAP88 gas area emissions modeling. LANL MEI dose = 50% point source; 20% environmental measurements; and 30% diffuse gases.
(i) COMPLY was used for the MEI location <100 m from the emission point.
(j) All environmental measurements are below 40 CFR 61Appendix E, Table 2 values. Quarterly (not annual) results are provided in the compliance report.
(k) The LLNL MEI distance is the distance to highest dose contributor.
(l) The MEI is located onsite. Offsite doses would be lower.
(m) Dose was calculated from scaling of environmental measurements and 10 mrem standard of 40 CFR 61 Appendix E air concentrations. The fence line (Gate 510) scaled dose is 0.036 mrem (most representative of actual public dose).
(n) COMPLY Level 1 was used to demonstrate compliance with the standard, but Level 4 was used to produce the dose estimate. Dose was estimated at the fence line.

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2015 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes

(o) The point-source receptor offsite closest to ORNL. The point-source dose was assumed to be the declared MEI dose minus the diffuse dose. The diffuse source receptor was at fence line location (Station 39 minus background). The maximum diffuse dose is 0.040 mrem.
(p) PGDP, PORTS environmental measurements were used to confirm low onsite and offsite air concentrations are low compared to 40 CFR 61 Appendix E, Table 2, but were not used to report dose from site emissions.
(q) The dose for PORTS is from DOE and Centrus (onsite non-DOE operations, separately managed) sources. The Centrus-only dose to the DOE MEI is 2.8E-6 mrem. The Centrus' MEI location dose is 0.016 mrem from the DOE and Centrus sources.
(r) The PORTS report indicates the diffuse dose from environmental measurements is not included in the reported NESHAP MEI dose. Only confirmation of low emissions, not for compliance.
(s) Conservative emissions, release assumptions, and use of CAP88-PC V2 overestimate actual impacts. Diffuse emissions were modeled as point emissions.
(t) "Critical receptor" rather than MEI, because of the environmental measurements approach.
Point sources are generally a stack(s). Non-point sources are diffuse and fugitive sources.

** Environmental surveillance data (air concentration) converted to a dose.

Table D-13. Subpart H MEI Dose from Point and Non-point Emissions to Air (2016)

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2016 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes
AMES	n/a	n/a	n/a	**n/a**	
ANL	2.8E-03	2.0E-08	**0.0028**	1200	(b)
BETTIS	5.9E-05	2.1E-05	**0.000059**	305	(c)
BNL	6.1E-01	n/a	**0.61**	1159	
FERMI	4.1E-02	n/a	**0.041**	304	(d)
HANF	3.8E-02	6.0E-03**	**0.044**	1600	(e)
INL	1.0E-02	4.2E-03	**0.014**	7976	(e,f)
JNAF	3.7E-03	-	**0.0037**	275	(e)
KESS	9.2E-04	1.7E-08	**0.0009**	1650	
KNOL/SPRU	1.8E-04	2.6E-02	**0.0259**	470	(e,g)
LANL	9.0E-02	2.7E-02**	**0.12**	774	(e,h)
LBNL	9.6E-03	1.9E-03	**0.0115**	460	(e,i)
LLNL	2.6E-03	2.3E-04**	**0.0028**	~ fence line	(e,j)
LLNL-300	9.3E-08	2.2E-04**	**0.00022**	3200	
MSL	n/a	5.7E-04	**0.00057**	190	(e)
NNSS	-	6.0E-01**	**0.6**	onsite	(e,k,l)
NREL	3.8E-02	-	**0.038**	119 @ fence line	(m)
ORR	2.0E-01	6.2E-02**	**0.20**	5240	(n)
PANX	n/a	2.7E-05	**0.000027**	5200	(e)
PGDP	1.3E-04	(t)	**0.00013**	1080	(o)
PNNL	5.8E-04	1.9E-06	**0.00058**	150	(e)
PORTS-DOE	1.6E-02	1.3E-3** (t)	**0.016**	2540	(p,q)
PPPL	5.3E-03	-	**0.0053**	351	
SLAC	2.4E-03	-	**0.0024**	560	(e,r)
SNL/CA	n/a	n/a	**n/a**	n/a	
SNL/NM	1.1E-03	n/a	**0.0011**	fence line	
SNL/TTR	n/a	2.4E-02**	**0.024**	onsite	(e)
SRS	2.0E-02	3.8E-03	**0.024**	15706	(e)
SSFL	n/a	n/a	n/a	n/a	
WIPP	4.7E-06	n/a	**0.0000047**	8850	
WVDP	-	-	**< 0.49****	2400	(s)

n/a = not available; n/s = not summarized.
(a) Receptor distance typically represents the distance from the MEI to the facility that is the major contributor to dose, or to a central reference point.

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2016 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes

(b) An MEI dose of 0.0051 mrem/yr would include dose from Rn-220. Diffuse dose assignment resulted from average area H-3 transpiration source.
(c) An "Urban" agriculture datum was used. Business is the nearest receptor. All releases were assumed to be from single central emission point. Diffuse dose is from demolition activities and was not used for the declared MEI dose.
(d) The nearest receptor is assumed to be the MEI distance.
(e) The MEI dose includes, or is entirely based on, emissions from diffuse sources: HANF, INL, JNAF, KNOLS/SPRU, LANL, LLNL, LBNL, MSL, NNSS, PANX, PNNL, SLAC, SNL/TTR, SRS.
(f) IRC and RESL doses are not included in the INL estimate. The NRF dose is included in the INL estimate. IRC/RSEL is 22 mi from the INL Site north of Idaho Falls. The IRC/RESL MEI is 0.0161 mrem and is @ 100 m south of IRC/RESL.
(g) The KAPL MEI 1.4E-4 mrem @ 470 m; SPRU MEI 2.6E-2 mrem @ 470 m. Includes both point and diffuse.
(h) The LANL diffuse dose is 0.011 mrem from environmental monitoring and 0.016 mrem from CAP88 gas diffuse emissions modeling. The LANL MEI dose = 75% point source; 9% environmental measurements; and 16% diffuse gases.
(i) COMPLY was used for the MEI location <100 m from emission point, but the 2016 MEI was based on CAP88 results.
(j) The LLNL MEI distance is distance from the facility with highest dose contribution.
(k) The MEI is located onsite. Offsite doses would be significantly lower.
(l) Dose calculated from scaling of environmental measurements and 10 mrem standard of Appendix E air concentrations. The fence line (Gate 510) scaled dose is 0.003 mrem (most representative of actual public dose).
(m) COMPLY Level 1 was used to demonstrate compliance with standard, but Level 4 was used to produce the dose estimate. The dose was estimated at fence line.
(n) The point-source MEI is the offsite receptor closest to ORNL. The point-source dose is the CAP88 result. Diffuse source receptor (offsite ETTP, Station K12, onsite business).
(o) All environmental measurements are below 40CFR61 Appendix E, Table 2 values.
(p) The dose for PORTS is from DOE and Centrus sources. The Centrus-only dose to the DOE MEI is 2.0E-6 mrem.
(q) The PORTS report indicates diffuse dose from environmental measurements is not included in the reported NESHAP MEI dose. Only confirmatory purposes.
(r) Conservative emissions, release assumptions, and use of CAP88-PC V2 overestimate actual impacts. Diffuse emissions are modeled as point emissions.
(s) "Critical receptor" at AF05_E rather than MEI, because of the environmental measurements approach.
(t) PGDP, PORTS environmental measurements were used to confirm low onsite and offsite air concentrations are low compared to 40CFR61 Appendix E, Table 2, but were not used to report dose from site emissions.

The point source is generally a stack(s). Non-point sources are diffuse and fugitive sources.

** Environmental surveillance data (air concentration) converted to a dose.

Table D-14. Subpart H MEI Dose from Point and Non-point Emissions to Air (2017)

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2017 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes
AMES	n/a	n/a	n/a		
ANL	5.5E-03	2.0E-08	**0.0055**	1200	(b)
BETTIS	7.2E-05	n/a	**0.000072**	305	(c)
BNL	7.2E-01	n/a	**0.72**	1050	
FERMI	4.2E-02	n/a	**0.042**	800	
HANF	7.2E-02	2.1E-02**	**0.093**	1600	(d)
INL	4.3E-03	3.8E-03	**0.0080**	7976	(d,e)
JNAF	1.7E-03	-	**0.0017**	275	(d)
KESS	1.3E-03	7.9E-12	**0.0013**	1650	
KNOL/SPRU	2.0E-04	4.4E-02	**0.044**	470	(d,f)
LANL	2.6E-01	2.1E-01**	**0.47**	774	(d)
LBNL	9.4E-03	2.0E-04	**0.0097**	460	(d,g)
LLNL	1.5E-03	3.6E-04**	**0.0019**	~ fence line, 434 m	(d)
LLNL-300	2.8E-07	4.8E-05	**0.000048**	1717	
MSL	-	1.6E-04	**0.00016**	190	(d)
NNSS	-	5.7E-01**	**0.57**	onsite	(d,h,i)
NREL	4.5E-02	-	**0.045**	119 @fence line	(j)
ORR	3.0E-01	2.0E-02 (r)	**0.30**	2270	(k)
PANX	-	7.6E-06	**0.0000076**	1156	(d)
PGDP	4.4E-04	(l,n)	**0.00044**	1080	(l)
PNNL	2.3E-05	-	**0.000023**	700	(d)
PORTS-DOE	1.2E-01	4.6E-04** (n)	**0.12**	3170	(m,o)
PPPL	4.3E-03	-	**0.0043**	351	
SLAC	1.4E-03	-	**0.0014**	1713 (onsite)	(d,p)
SNL/CA	-	-	**n/a**		
SNL/NM	1.0E-02	n/a	**0.010**	fence line	
SNL/TTR	Na	2.4E-02	**0.024**	onsite (Nellis AFR)	(d)
SRS	2.3E-02	6.2E-03	**0.029**	9397	(d)
SSFL			**n/a**		
WIPP	3.0E-06	n/a	**0.0000030**	8850	
WVDP	-	-	**< 0.46****	2800	(q)

n/a = not available.

(a) Receptor distance typically represents the distance from the MEI to the facility that is the major contributor to dose, or to a central reference point.

(b) An MEI dose of 0.027 mrem/yr would include dose from Rn-220. Diffuse dose assignment is from average area H-3 transpiration source.

(c) An "Urban" agriculture datum was used. Business is the nearest receptor. All releases were assumed to be from single central emission point.

(d) MEI dose includes, or is entirely based on, emissions from diffuse sources: HANF, INL, JNAF, KNOLS/SPRU, LANL, LLNL, LBNL, MSL, NNSS, PANX, PNNL, SLAC, SNL/TTR, and SRS.

(e) IRC and RESL doses are not included in the INL estimate. The NRF dose is included in the INL estimate. The IRC/RSEL is 22 mi from INL Site, north of Idaho Falls. The IRC/RESL MEI is 0.0100 mrem and is @ 100m south of IRC/RESL.

(f) The KNOL MEI 1.9E-4 mrem @ 470 m; SPRU MEI 4.4E-2 mrem @ 470 m. Includes both point and diffuse.

(g) COMPLY was used for the MEI location <100 m from the emission point, but the 2016 MEI was based on the CAP88 results. Two other MEIs, evaluated for Berkeley West Biocenter and for Joint BioEnergy Institute, both had smaller MEI and collective doses.

(h) The environmental measurements compliance location is onsite. Offsite doses are lower.

(i) Dose was calculated from scaling of environmental measurements and 10 mrem standard of 40CFR61 Appendix E, Table 2, air concentrations. Offsite receptor dose is 0.074 mrem (Nevada Test and Training Range) (representative of actual offsite).

Site	Point-Source Dose (mrem)	Non-Point-Source Dose (mrem)	CY 2017 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes

(j) COMPLY Level 4 was used to produce the dose estimate.
(k) Point-source MEI offsite, closest to Y-12. Point-source dose reflects the CAP88 result. Diffuse source receptor (site 40, closest to point-source MEI). Y-12 (76.6%; ORNL 23.4%; ETTP 0.002%).
(l) All environmental measurements below 40CFR61 Appendix E, Table 2 values.
(m) Dose for PORTS is from DOE and Centrus sources. Centrus-only dose to DOE MEI is 0 mrem. MEI distance not reported (email from Lawson Feb 8, 2019).
(n) PGDP, PORTS environmental measurements were used to confirm low onsite and offsite air concentrations are low compared to 40CFR61 Appendix E Table 2, but were not used to report dose from site emissions.
(o) PORTS report indicates diffuse dose from environmental measurements at a sampling location. Only confirmatory purposes.
(p) Conservative emissions, release assumptions, 0.33 occupancy factor for onsite receptor, and use of CAP88-PC V2 overestimate actual impacts. Diffuse emissions modeled as point emissions.
(q) "Critical receptor" (at AF10_SSW) rather than MEI, because of the environmental measurements approach.
(r) Dose for the station closest to the ORR MEI location.

** Environmental surveillance data (air concentration) converted to a dose.

Table D-15. Subpart H MEI Dose from Point and Non-point Emissions to Air (2018)

Site	Point-Source Dose (mrem)	Non-point-Source Dose (mrem)	CY 2018 MEI Dose (mrem)	Receptor Distance (m)[(a)]	Notes
AMES	n/a	n/a	n/a		
ANL	4.1E-03	2.0E-08	**0.0041**	1200	(b)
BETTIS	8.6E-05	1.9E-03	**0.0020**	305	(c)
BNL	1.6E+00	n/a	**1.6**	1159	
FERMI	7.3E-02	n/a	**0.073**	800	
HANF	5.8E-02	1.9E-02	**0.077**	1600	(d)
INL	6.0E-03	4.1E-03	**0.010**	7976	(d,e)
JNAF	3.9E-02	-	**0.039**	200	(d)
KESS	2.7E-03	1.5E-08	**0.0027**	1650	
KNOL	3.5E-04	2.3E-05	**0.00038**	470	(d)
KNOL/SPRU	4.9E-07	3.0E-02	**0.030**	470	(d)
LANL	2.9E-01	6.1E-02	**0.35**	957	(d,f)
LBNL	3.6E-03	9.5E-05	**0.0037**	460	(d)
LLNL	6.5E-03	2.5E-04	**0.0067**	35 m beyond fenceline	(d)
LLNL-300	9.9E-08	9.6E-05	**0.00010**	3806 @ boundary	
MSL	-	4.5E-04	**0.00045**	234	(d)
NNSS	-	5.2E-01	**0.52**	onsite	(d,g,h)
NREL STM	3.7E-02	-	**0.037**	119 @ fenceline	
ORR	2.0E-01	2.0E-03	**0.20**	2270	(i)
PANX	Na	1.7E-06	**0.0000017**	1150	(d)
PGDP	9.0E-05	-	**0.0000902**	1149	(j)
PNNL	1.6E-05	-	**0.000016**	640	(d)
PORTS	1.0E-01	5.9E-02	**0.10**	3284	(k,l)
PPPL	7.3E-03	-	**0.0073**	351	
SLAC	1.4E-03	-	**0.0014**	1713 (onsite)	(d,m)
SNL/CA	n/a	n/a	**n/a**		
SNL/NM	1.7E-02	n/a	**0.010**	fenceline	
SNL/TTR	Na	7.9E-11	**7.9E-11**	8600 (Nellis AFB)	(d)
SRS	5.4E-02	3.4E-02	**0.088**	12378	(d)
SSFL	n/a	n/a	**-**		
WIPP	2.9E-06	n/a	**0.0000029**	8850	
WVDP	-	-	**< 0.55**	1400	(n)

n/a = not available
(a) Receptor distance typically represents the distance from the MEI to the facility that is the major contributor to dose, or to a central reference point.
(b) MEI dose of 0.0063 mrem/y would include dose from Rn-220. Diffuse dose assignment from average area H3 transpiration source.

Site	Point-Source Dose (mrem)	Non-point-Source Dose (mrem)	CY 2018 MEI Dose (mrem)	Receptor Distance (m)[a]	Notes

(c) An "Urban" agriculture data set was used. Business is nearest receptor. All releases were assumed to be from a single central emission point; diffuse dose from demolition emissions estimate.

(d) MEI dose includes, or is entirely based on, emissions from diffuse sources. HANF, INL, JNAF, KNOLS, SPRU, LANL, LLNL, LLNL Site 300, LBNL, MSL, NNSS, NREL STM, PANX, PNNL, SLAC, SNL/TTR, and SRS. NNSA-NNPP's Naval Reactor Facility emissions impact is included in INL estimate.

(e) LANL point-source dose includes dose from unplanned emission (0.033 mrem); diffuse dose includes environmental measurements dose and Los Alamos Neutron Science Center diffuse sources dose. NNSS environmental measurements compliance location is onsite. Offsite doses are lower.

(f) NNSS dose calculated from summing environmental measurements fractions and 10mrem-based standard of 40CFR61, Appendix E, Table 2 air concentrations. Offsite receptor dose is 0.071 mrem (Armagosa Valley (N end)) (representative of an offsite maximum receptor).

(g) ORR point-source MEI who is offsite, closest to Y-12. Point-source dose reflects CAP88 result. Diffuse source receptor (station 40, closest to point-source MEI). Dose contributors: Y-12 81%; ORNL 19%; ETTP 0.004%. PGDP diffuse: all quarterly environmental measurements below 40CFR61, Appendix E, Table 2 values. Dose for PORTS is from DOE and Centrus sources (Centrus-only dose to DOE MEI is 0 mrem in CY2018).

(h) PORTS report indicates diffuse dose from environmental measurements at a sampling location. Only confirmatory purposes.

(i) SLAC uses conservative emissions, release assumptions, 0.33 occupancy factor for onsite receptor, and use of CAP88-PC v2 to overestimate actual impacts. Diffuse emissions modeled as point source.

(j) WVDP "critical receptor" (at AF10_SSW) rather than MEI or MEOSI, because of environmental measurements approach.

D.1.6 Unplanned Releases to the Atmosphere

Among all DOE sites reporting under Subpart H during the decade from 2009–2018, an average of one site reports an unplanned release of radioactive materials to air, annually. No DOE facilities reported dose impacts on offsite members of the public for unplanned radioactive material releases to air during CY 2015–2017. During CY 2018, however, three sites (LANL, LLNL, and SRS) reported unplanned radioactive material emissions to ambient air. Appropriate management of facility radioactive materials, staff training, and the administration and maintenance of facilities and equipment has resulted in the low frequency of unplanned releases in recent years.

- LANL (2018) – The Los Alamos Neutron Science Center (LANSCE) facility operates experimental stations along different accelerator beam lines of this proton accelerator. Beam operations can result in the buildup of radioactive air in facility tunnels, which are normally held stagnant or exhausted out monitored stacks. A ventilation fan failed in one experimental area, resulting in pressurization of an adjacent beam tunnel that forced radioactive-material-laden air that had built up in the tunnel to exit through an unmonitored pathway. The issue was discovered immediately by routine detection systems. Emissions of Ar-41 (1.28 Ci) and C-11 (30.7 Ci) were estimated to have resulted in an MEI impact of 0.033 mrem.
- LLNL (2018) – LLNL reported two unplanned release events. The Tritium Facility (B331) had a 0.081 Ci release of tritium when a vacuum pump component failed during cleanup activities. The release exited via a monitored stack. The second unplanned release occurred at the National Ignition Facility (NIF, B581). NIF houses a precise, reproducible energetic laser facility that can focus lasers onto a small fusion target. A tritium target shot was executed, but a valve line-up error resulted in tritium being routed out a stack rather than through the tritium abatement system. About 5 Ci of tritium gas was released from this second event. Impacts from both LLNL tritium releases resulted in a total estimated dose of 4E-4 mrem.
- SRS (2018) – SRS reported two unplanned release events at their Defense Waste Processing Facility (DWPF). Radioactive material emissions were both released via a monitored stack. The first event resulted in a 0.00021 Ci release of Cs-137 as a result of maintenance activities. The second event, later in the year, released about 0.0011 Ci of Cs-137. Impacts from both SRS cesium releases resulted in a total estimated dose of 1.8E-4 mrem.

Prior to CY 2018, the last year unplanned emissions were reported was in 2014 when three sites (LANL, LLNL, and WIPP) reported unplanned emissions during that year. These emissions are described below, so that the nature of the most recent unplanned radioactive material emissions to air with offsite impacts can be acknowledged. The WIPP unplanned release was covered widely in the media, but still had MEI dose impacts well below the dose standard for routine emissions. Residual contamination outside of containers remained in underground areas, which prompted ventilation system upgrades.

- **LANL (2014)** – Two diffuse emissions events from the LANSCE accelerator facility were identified. The radioactive gas emissions resulted from the migration of beam tunnel air through drains and cable penetrations into a high bay area. Emissions resulted in an estimated 0.083 mrem to an offsite MEI. The second diffuse LANSCE unplanned release resulted from a cracked vacuum discharge line, resulting in gas emissions with an estimated offsite impact of 0.0003 mrem.
- **LLNL (2014)** – Two unplanned emissions occurred, both with minor dose consequences. A vacuum system failure at the LLNL NIF resulted in the unplanned release of 0.782 Ci of H-3 (93 percent water vapor tritium). Later in the year, an unplanned noble gas release from the NIF occurred because of a failure to follow procedures for vacuum pump isolation. A release of 5E-5 Ci of an assumed Xe-138 release was assumed for a conservative impact assessment. Both releases resulted in a total estimated impact on a member of the public of 3.3E-5 mrem.
- **WIPP (2014)** – On February 14, 2014, an air-monitoring system for the underground storage area ventilation alarmed. No employees were underground at the time. The HEPA (high-efficiency particulate air) filtration mode for underground air was successfully switched on, a small amount of air leaked around the ventilation system dampers. Radioactive material (Pu-239/240 and Am-241) was released to the ambient environment. Disposal operations ceased and an accident investigation was implemented. The release resulted from an exothermic reaction of incompatible materials in a waste drum. The heat generated from the reaction caused a waste drum over-pressurization and a drum locking ring failure with a subsequent release of radioactive materials to the underground air. About 1.7E-3 Ci of material were estimated to have been released. No contamination was detected offsite or in surrounding communities. The initial dose impact was estimated to be 0.24 mrem onsite at the WIPP Exclusive Use Area Fenceline. Final dose estimates to an offsite MEI were 0.0059 mrem. Disposal operations ceased for a time (February 15, 2014–January 3, 2017); major ventilation system upgrades occurred to address concerns related to residual contamination; and waste packaging practices were improved.

D.2 Supplemental Information

Supplemental information is provided in DOE site compliance reporting that is not covered explicitly under Subpart H. Radon emissions, which are covered by other sections of the NESHAPs and are subject to environmental protection limits other than the 10 mrem/yr (0.1 mSv/yr) standard of Subpart H, is one such topic. The radon emissions from DOE sites are discussed in Section D.2.1.

Other supplemental information includes the reported collective (population) dose from radionuclide emissions to air for each DOE site. No regulatory dose standard exists under EPA or DOE for collective dose. Under DOE Order 5400.5, Chg 2, the collective dose was used as a tool in the ALARA process at DOE sites, for trending purposes. DOE O 458.1 replaced DOE O 5400.5, Chg 2, in 2011. Under DOE O 458.1, Chg 3, the collective dose is to be used to support comparison, trending, or decisions. As such, collective doses are estimated in site reporting. The collective dose is the sum of the per capita dose for the individuals exposed within a stated distance (usually 50 mi) from the DOE site. Collective dose is reported in person-rem. The collective doses for DOE sites are discussed in Section D.2.2.

D.2.1 Radon Emissions

Emissions of radon-222 (the decay product of radium-226 and uranium-238 that has a 3.8-day half-life) from DOE storage and disposal sites are regulated under Subpart Q of 40 CFR Part 61. Sites containing uranium mill tailings are regulated under Subpart T. The standards for radon emissions under Subparts Q and T are expressed in terms of radon flux and are averaged over the area of the radon source. The radon source is considered to be an isolated pile, impoundment, or structure containing radium. Unlike Subpart H, Subpart Q contains no reporting requirements but identifies the Federal Facilities Agreement under CERCLA as a means of demonstrating compliance with its requirements. Subpart T requires pre-closure radon flux measurements at uranium mill tailings disposal sites, which must be reported to EPA during various stages of the final disposal process. DOE sites subject to only Subpart T are exempt from Subpart H for radionuclide particulate emissions.

The regulations under NESHAPs Subpart H for DOE sites do not address sources of radon-220 (a decay product of radium-224, thorium-232, and uranium-232 that has a 55 sec half-life). DOE has collected radon-220 emission data and associated dose estimates from its sites as part of the MOU concerning the *Clean Air Act* emission standards for radionuclides (EPA and DOE 1995). This effort has included flux measurements at storage or disposal facilities that handle wastes containing significant concentrations of thorium-232 and uranium-232. In addition to investigating waste management operations, DOE has investigated the contribution of radon-220 to doses associated with its normal operations.

Doses from radon-222 and radon-220 result primarily from exposure to their decay products. The radon-220 and radon-222 emissions from DOE sites during the years 2015–2018 are summarized in Table D-16 and resulting dose estimates are listed in Table D-17. WVDP, BETTIS, and HANF were the dominant emitters of radon-220 during the evaluation period. BETTIS is the predominant radon-222 emitter.

The majority of all radon-220 emitted from DOE sites during CYs 2015–2018 was released from WVDP. These releases amounted to an average of 3.0 Ci/day based on 2013 “THOREX” waste estimates. The 2013 estimates were reported for years 2015–2018. WVDP reporting indicates that some source material has been removed from the site since 2013, so the release and dose estimates are conservative.

BETTIS routinely released primarily radon-220 and is the greatest radon-222 emitter during the years summarized. Although the BETTIS radon total release is smaller than that of WVDP, the estimated impacts on their site MEI are greater than those of other sites for the latest years summarized. The estimated radon dose to the BETTIS MEI in 2017 was about twice that of the WVDP MEI.

Table D-16. Summary of Airborne Radon Releases from DOE Sites (CYs 2015–2018)[a]

Year	Site	Rn-220 (Ci)	Rn-222 (Ci)	Total (Ci)	Notes
2015	ANL	30	-	30	(b)
	BETTIS	207	0.71	208	
	FERMI	-	-	-	(c)
	HANF	385	-	385	
	LANL	-	-	-	(d)
	ORR	1.7	3E-11	1.7	(e)
	PNNL	-	2.5E-04	2.5E-04	
	WVDP	1095	-	1095	(f)

Year	Site	Rn-220 (Ci)	Rn-222 (Ci)	Total (Ci)	Notes
2016	ANL	30	-	30	(b)
	BETTIS	194	0.66	195	
	FERMI	-	-	-	(c)
	HANF	178	-	178	
	LANL	-	-	-	(d)
	ORR	2.0	4E-12	2.0	(e)
	PNNL	-	5.9E-08	5.9E-08	
	WVDP	1095	-	1095	(f)
2017	ANL	30	-	30	(b)
	BETTIS	267	0.83	268	
	FERMI	-	-	-	(c)
	HANF	885	3.6E-05	885	
	LANL	-	-	-	(d)
	ORR	3.9	0.048	4.0	(e)
	PNNL	-	1.0E-06	1.0E-06	
	WVDP	1095	-	1095	(f)
2018	ANL	30	-	30	(b)
	BETTIS	289	0.10	289	
	FERMI	-	-	-	(c)
	HANF	220	-	220	
	LANL	-	-	-	(d)
	ORR	-	-	-	(e)
	PNNL	-	1.7E-08	1.7E-08	
	WVDP	<1095	-	<1095	(f)

(a) To convert values in this table to SI units, use the conversion factor: 1 Ci = 3.7 x 10^{10} Bq.
(b) ANL Rn-220 released from Building 200.
(c) FERMI has some Rn-222 created from U-238 decay in sealed cryogenic vessels with no airborne emissions.
(d) LANL Rn-222: Very low releases from material in storage (0.14 pCi/m^2/s from a 1993-1994 study).
(e) ORR reported and modeled as first progeny release (Pb-212 for Rn-220 and Pb-210 for Rn-222) and is included in the stack release estimates (assumed same modeling in 2016; not explicitly stated).
(f) From waste emissions, averaging 3 Ci/day (year 2013); releases from main plant stack. The THOREX waste source was removed in 2016; emissions were reported to be unchanged in 2016 and 2017.
"-" = no emission

Table D-17. Summary of MEI Dose from Radon-220 and Radon-222 Emissions (CYs 2015−2018)

Site	2015 Radon (mrem)	2016 Radon (mrem)	2017 Radon (mrem)	2018 Radon (mrem)
ANL	0.010[(a)]	0.010[(a)]	0.0025[(a)]	0.0022[(a)]
BETTIS	0.40	0.12	0.18	0.19
FERMI	n/a	n/a	n/a	n/a
HANF	0.064(a)	0.026(a)	0.14	0.14
LANL	[(b)]	[(b)]	[(b)]	[(b)]
ORR	[(b)]	[(b)]	[(b)]	[(b)]
PNNL	2.6E-04	5.9E-08	3.9E-10	5.6E-10
WVDP	Approx.0.094[(a,c)]	<0.094[(a,c)]	<0.094[(a,c)]	<0.094[(a,c)]

(a) Rn-220 only.
(b) Radon-only dose not quantified.
(c) Radon dose reported as similar to a prior (2013) dose estimate.

Site	2015 Radon (mrem)	2016 Radon (mrem)	2017 Radon (mrem)	2018 Radon (mrem)
n/a = not applicable.				

D.2.2 Collective Dose Estimates from Radionuclide Air Emissions

In addition to the dose to the MEI for each DOE site, sites provide supplemental information to DOE for the collective dose to populations within a stated distance (typically 50 mi). A DOE O 458.1, Chg 3 (Paragraph 4.e.1.d) graded approach allows no collective dose reporting for sites involving an MEI dose of less than 10 microrem/yr (1.0E-02 mrem/yr). Although collective dose information is not required in the radionuclide air emissions reports that are submitted to EPA under Subpart H, most facilities provide this information. Some sites refer readers to the ASERs for collective dose information, which includes both air effluent and liquid effluent impacts, but each component is presented separately. As with MEI dose from radon, collective dose from radon emissions may be reported separately.

The collective dose for radionuclide air emissions may be obtained from several of the EPA-approved computer codes, such as CAP88 and CAP88-PC, as well as from a number of other models used by DOE sites. The collective dose is typically obtained by computing the average dose for a central point in a given geographical sector, multiplying that dose by the number of persons residing in that sector, and summing the doses from all sectors. The collective dose is expressed in person-rem and is a quantity that may be used as a basis for assessing collective risk and to support comparisons, trending, or decisions. Table D-18 through Table D-21 (at the end of this section) present CY 2015–2018 results from the sites reporting collective doses. The reported results indicate that the reported collective dose from all DOE operations was variable over the summary period.

Average DOE site collective doses reported from 2015–2018 range from 0.56 to 0.93 person-rem. The collective dose values reported recently at some sites are significantly less than those reported from 2014 and earlier years. This reduction is largely due to improved modeling in CAP88-PC V4 where radioactive decay of the emissions of short-lived nuclides is realistically modeled. For example, in 2014 ORR reported a 69 person-rem collective dose and the more recent ORR collective doses average of 9.1 person-rem.

Total DOE site collective doses range from a low of 14 person-rem in the year 2016 to 23 person-rem in 2018. Each year, the largest two reported collective doses accounted for at least 70% of the total collective dose from all sites. The largest collective dose estimates were from ORR (2015–2017) and SRS (2018). ORR reporting includes emissions from several Oak Ridge operations: ORNL, Y-12, and ETTP. ORR and SRS have large ongoing radiological operations.

Coarsely summarized, collective dose estimates result from the product of emissions and population. Although the process at each site varies, many sites do not update the census data used in collective dose estimations more than once every 10 years when the U.S. Census Bureau provides results. Options for more frequent updates are available and implemented by a small number of sites. LBNL is unique in that daytime population estimates are used. Both WVDP and MSL collective doses include a small portion of Canadians within the 50 mi radius.

For ALARA assessments, carcinogenic risk factors can be used to estimate the number of cancers (incidences) and number of fatal cancers expected from total radiation exposure of exposed populations. As indicated above, the collective dose estimates include varying degrees of conservative (overestimating) assumptions, which result in an overestimated number of cancers. Annual collective dose is evaluated for its contribution to cancer incidence and cancer fatality risk. The EPA cancer risk rates (EPA 2011) were determined, and are primarily based on Biological Effects of Ionizing Radiation (BEIR) VII (NAS 2006). The EPA (2011) annual cancer incidence and mortality risk coefficient (approximately 1.16E-3 per person-rem and 5.8E-4 per person-rem, respectively) were applied to the maximum annual collective dose reported from CY 2015–2018 estimates. A 23.1 person-rem dose would produce an estimated 0.03 cancers (90% confidence interval of 0.01-0.05). Therefore, no cancers, and subsequently, no cancer deaths, would be anticipated from the radiological air emissions of DOE facilities.

For comparison purposes, two metrics are presented: 2019 U.S. cancer incidence and natural background radiation levels with their estimated cancer incidence levels for 2019:

- An estimated 1,700,000 new U.S. cancer cases were anticipated (ACS 2019) in 2019 based on incidence rates of all cancers and the 2019 population. This estimate excluded basal cell and squamous cell skin cancers because they are not required to be reported to cancer registries. This estimate also excluded noninvasive cancers except for those of the urinary bladder.
- Annual average dose to an individual from natural background radiation is 0.31 rem (NCRP 2009) and the 2010 U.S. population was about 308.8 million (USCB 2011) during the year of the last U.S. Census. Application of the EPA cancer incidence risk coefficient to this 95.73 million person-rem average impact results in an estimated 11,000 cancers from natural background radiation.

Table D-18. Collective Dose to the 80 km Population from Radionuclide Emissions to Air (CY 2015)

Site	Collective Dose (person-rem)	Population within 80 km	Comment
ANL	1.1E-01	9.3E+06	
BETTIS	9.6E-04	3.0E+06	(a)
BNL	4.2E-01	6.0E+06	
FERMI	4.9E-01	9.0E+06	
HANF	1.1E+00	5.9E+05	(b)
INL	6.1E-01	3.2E+05	(c)
JNAF	3.4E-03	1.8E+06	(d)
KESS	8.3E-03	1.2E+06	
KNOL/SPRU	2.1E-03	1.4E+06	(e)
LANL	6.0E-02	3.4E+05	(f)
LBNL	1.6E-01	7.3E+06	
LLNL	1.3E-01	7.8E+06	
LLNL-300	2.4E-05	7.1E+06	
MSL	1.2E-04	2.4E+06	(g)
NNSS	< 6.0E-01	4.4E+05	
NREL	n/a	n/a	
ORR	1.1E+01	1.2E+06	(h)
PANX	2.2E-06	3.2E+05	
PGDP	5.0E-04	5.3E+05	
PNNL	2.7E-04	4.3E+05	
PORTS-DOE	n/a	n/a	
PPPL	7.7E-02	1.8E+07	
SLAC	5.2E-03	~5.3E+06	
SNL/NM	8.6E-02	9.1E+05	(i)
SNL/TTR	n/a	n/a	
SRS	3.2E+00	7.8E+05	
WIPP	2.0E-05	9.3E+04	
WVDP	< 5.0E-01	1.6E+06	(j)
Total	**18.3**	**8.68E+07**	

n/a = not available; ~ = uncertain estimate.
(a) BETTIS: Excludes dose from Rn-220 and Rn-222.
(b) From HANF Site Environmental Report for air pathways only. GENIIv2 used.
(c) From INL, Site Environmental Report. MDIFFH dispersion modeling used.
(d) From JNAF, Site Environmental Report.
(e) KNOL 7.77E-4 person-rem; SPRU 1.28E-3 person-rem.
(f) LANL collective dose from point sources and diffuse gases, no diffuse particulate dose included.
(g) MSL total collective dose is based on the MEI dose estimate.
(h) Y-12 Complex (NNSA) 1.4 person-rem; ORNL (SC) 9.4 person-rem; ETTP (EM) 0.0007 person-rem.
(i) SNL/NM: Sum of offsite KAFB 50-mi population and Kirtland Air Force Base population (KAFB population not indicated).
(j) WVDP collective dose calculated based on environmental measurements. A new approach to the calculation was used in the 2015 emissions report. Includes some Canadians.

Table D-19. Collective Dose to the 80 km Population from Radionuclide Emissions to Air (CY 2016)

Site	Collective Dose (person-rem)	Population within 80 km	Comment
ANL	1.8E-01	9.3E+06	(a)
BETTIS	6.9E-04	3.0E+06	(b)
BNL	9.4E-01	6.0E+06	
FERMI	9.9E-01	9.0E+06	
HANF	2.9E-01	5.9E+05	(c)
INL	4.1E-03	3.3E+05	(d)
JNAF	4.4E-03	1.8E+06	(e)
KESS	4.4E-03	1.2E+06	
KNOL/SPRU	3.0E-03	1.4E+06	(f)
LANL	1.0E-01	3.4E+05	(g)
LBNL	2.1E-01	7.3E+06	
LLNL	2.2E-01	7.8E+06	
LLNL-300	3.0E-05	7.1E+06	
MSL	6.4E-04	2.4E+06	
NNSS	< 6.0E-01	4.4E+05	(h)
NREL	n/a	n/a	
ORR	6.4E+00	1.2E+06	(i)
PANX	9.9E-04	3.2E+05	
PGDP	9.1E-04	5.3E+05	
PNNL	6.2E-04	4.3E+05	
PORTS-DOE	n/a	n/a	
PPPL	1.0E-01	1.8E+07	
SLAC	1.4E-02	~5.3E+06	
SNL/NM	9.8E-02	9.1E+05	(j)
SNL/TTR	n/a	n/a	
SRS	3.5E+00	7.8E+05	
WIPP	1.3E-05	9.3E+04	
WVDP	< 4.2E-01	1.6E+06	(k)
Total	**14.1**	**8.68E+07**	

n/a = not available. ~ = uncertain estimate
(a) ANL collective dose from ASER (ANL-17/02, Sept 2017) indicated because it is greater than the collective dose reported in NESHAP report (0.038 person-rem).
(b) BETTIS: Excludes dose from Rn-220 and Rn-222.
(c) Sum of HANF 50 mi collective doses from each of four operational areas. Excludes Rn-220 dose.
(d) INL collective dose from ASER. DOSEMM model used.
(e) JLAB collective dose from ASER.
(f) KNOL 4.14E-4 person-rem; SPRU 2.6E-3 person-rem.
(g) LANL collective dose from point sources and diffuse gases, no diffuse particulate dose included.
(h) NNSS value repeated since 2004; no updates because no reported change in operations or population.
(i) Y-12 Complex (NNSA) 0.7 person-rem; ORNL (SC) 5.7 person-rem; ETTP (EM) 0.0003 person-rem.
(j) SNL/NM: Sum of offsite KAFB 50 mi population and Kirtland Air Force Base population (KAFB population not indicated) collective dose.
(k) WVDP collective dose calculated based on environmental measurements. Includes some Canadians.

Table D-20. Collective Dose to the 80 km Population from Radionuclide Emissions to Air (CY 2017)

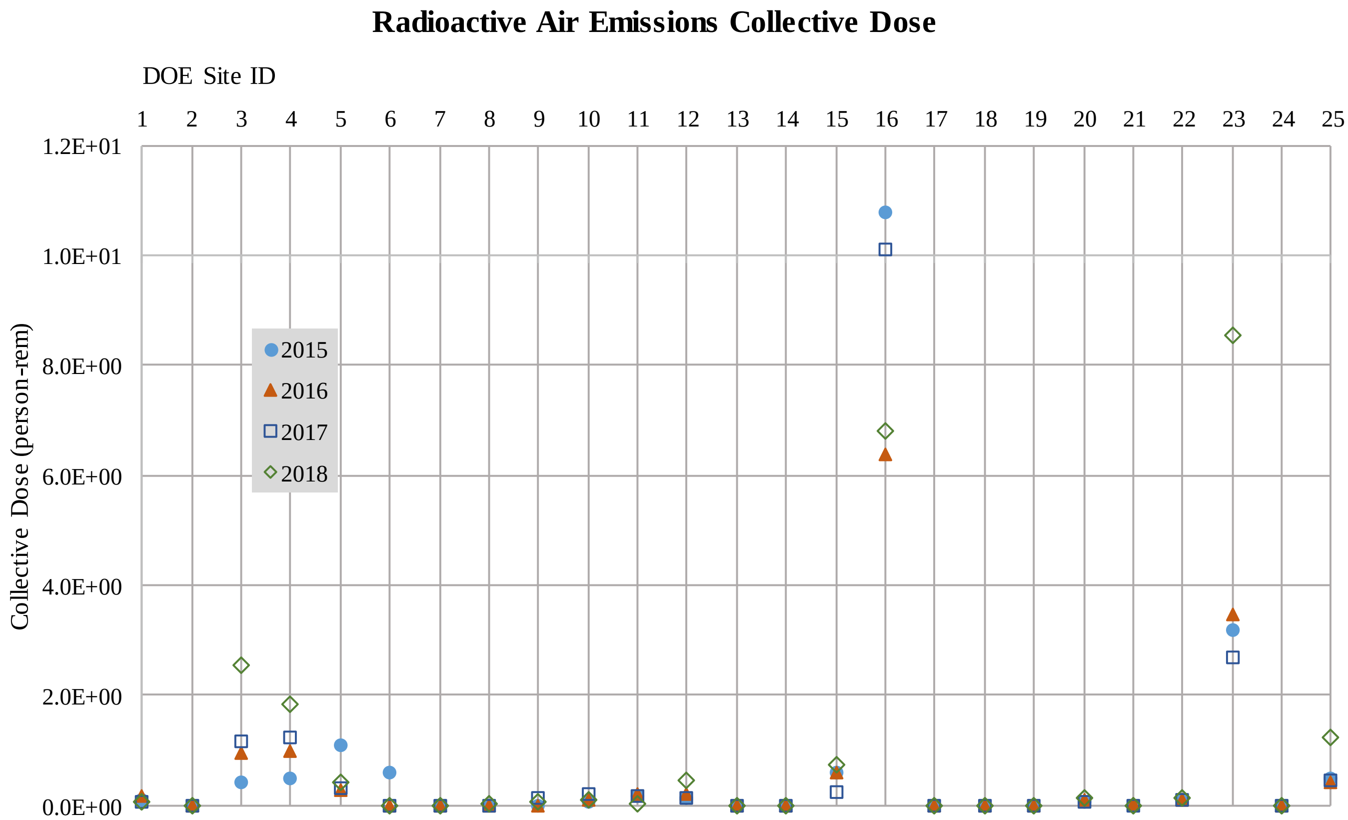
Site	Collective Dose (person-rem)	Population within 80 km	Comment
ANL	5.2E-02	9.3E+06	(a)
BETTIS	7.6E-04	3.0E+06	(b)
BNL	1.16E+00	6.0E+06	
FERMI	1.2E+00	9.0E+06	
HANF	3.1E-01	5.9E+05	(c)
INL	1.1E-02	3.3E+05	(d)
JLAB	8.9E-04	1.8E+06	(e)
KESS	6.0E-03	1.2E+06	
KNOL/SPRU	1.4E-01	1.4E+06	(f)
LANL	1.9E-01	3.4E+05	(g)
LBNL	1.7E-01	7.3E+06	(h)
LLNL	1.3E-01	7.8E+06	
LLNL-300	7.2E-05	7.1E+06	
MSL	1.8E-04	2.4E+06	
NNSS	0.25	4.9E+05	(i)
NREL	n/a	n/a	
ORR	1.01E+01	1.2E+06	(j)
PANX	1.0E-05	3.2E+05	
PGDP	3.8E-03	5.3E+05	
PNNL	1.6E-04	4.3E+05	
PORTS-DOE	n/a	n/a	
PPPL	7.6E-02	1.8E+07	
SLAC	2.0E-03	~5.3E+06	
SNL/NM	9.1E-02	9.1E+05	(k)
SNL/TTR	n/a	n/a	
SRS	2.7E+00	7.8E+05	
WIPP	9.3E-06	9.3E+04	
WVDP	< 4.6E-01	1.6E+06	(l)
Total	**17.1**	**8.68E+07**	

n/a = not available. ~ = uncertain estimate
(a) ANL collective dose from ANL ASER.
(b) BETTIS: Dose excludes contribution from Rn-220 and Rn-222 emissions.
(c) HANF: Sum of 50mi collective dose from each of four operational areas. Excludes Rn-220 emission dose.
(d) INL collective dose from INL ASER. DOSEMM model used.
(e) JLAB collective dose from JLAB ASER.
(f) KNOL 5.14E-4 person-rem; SPRU 1.42E-1 person-rem.
(g) LANL collective dose from monitored stacks and diffuse LANSCE sources.
(h) Collective dose from LBNL main site, Berkeley West Biocenter, and Joint BioEnergy Institute.
(i) Estimated as NNSS receptor dose at population centers multiplied by population. Dose to those within 50 mi of emission sources.
(j) Y-12 Complex (NNSA) 2.9 person-rem; ORNL (SC) 7.3 person-rem; and ETTP (EM) 0.0004 person-rem.
(k) Sum of offsite KAFB 50 mi population and Kirtland Air Force Base population (KAFB population not indicated) collective dose.
(l) Collective dose calculated based on environmental measurements. Includes some Canadians.

Table D-21. Collective Dose to the 80 km Population from Radionuclide Emissions to Air (CY 2018)

Site	Collective Dose (person-rem)	Population within 80 km	Comment
ANL	4.8E-02	9.3E+06	(a)
BETTIS	9.5E-04	3.0E+06	(b)
BNL	2.6E+00	6.0E+06	
FERMI	1.9E+00	9.0E+06	
HANF	4.2E-01	5.9E+05	(c)
INL	7.5E-03	3.4E+05	(d)
JNAF	5.4E-03	1.8E+06	(e)
KESS	1.6E-02	1.2E+06	
KNOL/SPRU	5.9E-02	1.4E+06	
LANL	9.0E-02	3.4E+05	(f)
LBNL	4.0E-02	7.3E+06	
LLNL	4.7E-01	7.8E+06	
LLNL-300	2.8E-05	7.1E+06	
MSL	5.0E-04	2.4E+06	
NNSS	7.4E-01	5.0E+05	(g)
NREL STM	n/a	n/a	
ORR	6.8E+00	1.2E+06	(h)
PANX	2.4E-06	3.2E+05	
PGDP	6.0E-04	5.3E+05	
PNNL	7.6E-05	4.3E+05	
PORTS-DOE	n/a	n/a	
PPPL	1.3E-01	1.8E+07	
SLAC	1.7E-03	~5.3E+06	
SNL/NM	1.2E-01	9.1E+05	(i)
SNL/TTR	n/a	n/a	
SRS	8.6E+00	8.0E+05	(j)
WIPP	8.8E-06	9.3E+04	
WVDP	< 1.2E+00	1.6E+06	(k)
Total	**23.1**	**8.69E+07**	

n/a = not available. ~ = uncertain estimate.
(a) ANL collective dose including Rn-220 is 0.17 person-rem (source: ANL ASER, ANL-19-02, Sept 2019).
BETTIS value excludes dose from Rn-220 and Rn-222.
(d) HANF sum of collective doses 50-mi from each of four operational areas. Rn-220 collective dose would add 1.30 person-rem more.
(e) INL ASER (DOE/ID-12082(18), September 2019); DOSEMM model used. JNAF ASER information used.
(f) LANL collective dose from monitored stacks and diffuse LANSCE sources.
(g) Estimated as NNSS receptor dose at population centers multiplied by population. Dose to those within 50 mi of emission sources.
(h) Y-12 Complex (NNSA) 1.8 person-rem; ORNL (SC) 5.0 person-rem; ETTP (EM) 0.0003 person-rem.
(i) Sum of KAFB offsite 50-mi population and Kirtland Air Force Base population (KAFB population not indicated) collective dose.
(j) SRS population grid updated significantly for CY2018, to reflect H-Area central release. Collective dose significantly greater than CY17.
(k) WVDP collective dose calculated based on environmental measurements. Includes some Canadians.



1 ANL	6 INL	11 LBNL	16 ORR	21 SLAC
2 BETTIS	7 JLAB	12 LLNL	17 PANX	22 SNL/NM
3 BNL	8 KESS	13 LLNL-300	18 PGDP	23 SRS
4 FERMI	9 KNOL/SPRU	14 MSL	19 PNNL	24 WIPP
5 HANF	10 LANL	15 NNSS	20 PPPL	25 WVDP

(a) NNSS (15) for 2015, 2016; and WVDP (25) for all years are less-than results.

Figure D-3. Collective Doses from Radioactive Air Emissions from CYs 2015–2018

D.3 References

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Appendix E – State Standards for Liquids Surveillance

U.S. Department of Energy (DOE) sites with radiological operations that could provide a route to ambient liquids are regulated under both Federal and State standards. This Appendix lists State standards for the DOE sites reviewed in Section 5.0. States implement separate surveillance criteria for groundwater (Section E.1), drinking water (Section E.2), and surface waters, which also include stormwater (Section E.3).

E.1 State Groundwater Standards

As required, DOE sites maintain compliance with the State groundwater quality standards, based on the location of the DOE site. The following are the groundwater quality standards for each state in which a DOE site is located:

- California State Water Resources Control Board Groundwater Quality Standards. Accessed in November 2021 at: https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/
- Idaho Groundwater Quality Standards. Accessed in November 2021, at: https://adminrules.idaho.gov/rules/2011/58/0111.pdf
- Illinois Groundwater Quality Standards. Accessed in November 2021, at: https://www2.illinois.gov/epa/about-us/rules-regs/Pages/water.aspx#groundwater
- Kentucky Groundwater Quality Standards. Accessed in November 2021, at: https://water.ca.uky.edu/kdowregs
- Nevada Groundwater Quality Standards. Accessed in November 2021, at: https://ndep.nv.gov/water/water-pollution-control/resources/statutes-regulations
- New Jersey Ground Water Quality Standards. Accessed in November 2021, at: https://www.nj.gov/dep/rules/rules/njac7_9c.pdf
- New Mexico Ground Water Quality Standards. Accessed in November 2021, at: https://www.env.nm.gov/gwqb/
- New York Groundwater Quality Standards. Accessed in November 2021, at: https://www.dec.ny.gov/chemical/23853.html
- Ohio Groundwater Quality Standards. Accessed in November 2021, at: https://epa.ohio.gov/ddagw/
- Pennsylvania Groundwater Quality Standards. Accessed in November 2021, at: http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/groundwaterprotection/links.htm
- South Carolina Groundwater Quality Standards. Accessed in November 2021, at: https://scdhec.gov/environment/water-quality/water-quality-standards/water-quality-standards-south-carolina
- Tennessee Groundwater Quality Standards. Accessed in November 2021, at: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality.html
- Virginia Groundwater Quality Standards. Accessed in November 2021, at: https://law.lis.virginia.gov/admincode/title9/agency25/chapter280/section20/
- Washington Groundwater Quality Standards. Accessed in November 2021, at: https://ecology.wa.gov/Water-Shorelines/Water-quality/Groundwater/Groundwater-quality-standards.

E.2 State Drinking Water Standards

Each DOE site must maintain compliance with the State drinking water quality standards, based on the location of the DOE site. The following are the drinking water quality standards for each state where a DOE site is located:

- California State Water Resources Control Board Drinking Water Quality Standards. Accessed in November 2021, at: https://www.waterboards.ca.gov/drinking_water/programs/
- Idaho Drinking Water Quality Standards. Accessed in November 2021, at: http://www.deq.idaho.gov/water-quality/drinking-water/
- Illinois Drinking Water Quality Standards. Accessed in November 2021, at: https://www2.illinois.gov/epa/topics/drinking-water/Pages/default.aspx
- Kentucky Drinking Water Quality Standards. Accessed in November 2021, at: https://eec.ky.gov/Environmental-Protection/Water/Drinking/Pages/Drinking%20Water.aspx
- Nevada Drinking Water Quality Standards. Accessed in November 2021, at: https://ndep.nv.gov/water/drinking-water
- New Jersey Drinking Water Quality Standards. Accessed in November 2021, at: https://www.state.nj.us/dep/watersupply/dwc_quality.html
- New Mexico Drinking Water Quality Standards. Accessed in November 2021, at: https://www.env.nm.gov/drinking_water/
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- Ohio Drinking Water Quality Standards. Accessed in November 2021, at https://epa.ohio.gov/ddagw/
- South Carolina Drinking Water Quality Standards. Accessed in November 2021, at: https://www.scdhec.gov/environment/your-home/drinking-water-concerns/drinking-water-quality
- Tennessee Drinking Water Quality Standards. Accessed in November 2021, at: https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/drinking-water-redirect.html
- Texas Drinking Water Quality Standards. Accessed in November 2021, at: https://www.tceq.texas.gov/drinkingwater
- Washington Drinking Water Quality Standards. Accessed in November 2021, at: https://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater

E.3 State Surface Water and Stormwater Standards

Each DOE site must maintain compliance with the State surface water quality and stormwater standards, based on the location of the DOE site. The following are the water quality standards for each state in which a DOE site is located:

- California State Water Resources Control Board Surface Water Quality Standards. Accessed in November 2021 at: https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/
- Idaho Surface Water Quality Standards. Accessed in November 2021, at: https://www.deq.idaho.gov/water-quality/surface-water/water-quality-standards/
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- Kentucky Surface Water Quality Standards. Accessed in November 2021, at: https://eec.ky.gov/Environmental-Protection/Water/Regs/Pages/default.aspx
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- New Mexico Surface Water Quality Standards. Accessed in November 2021, at: https://www.env.nm.gov/surface-water-quality/wqs/
- New York Surface Water Quality Standards. Accessed in November 2021, at: https://www.dec.ny.gov/regs/2485.html
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