EXECUTIVE SUMMARY

Since 1959, the U.S. Department of Energy (DOE) has annually published the Hanford Site Environmental Report in accordance with DOE O 231.1B, *Environment, Safety and Health Reporting,* and DOE O 458.1, *Radiation Protection of the Public and the Environment*. The purpose of the *Hanford Annual Site Environmental Report for Calendar Year 2017* is to inform the public, regulators, employees, and other stakeholders of environmental and operating performance during the year.

Hanford Site operations are affected and, in many cases, regulated by numerous federal and state agencies enforcing legal requirements that address environmental compliance, remediation, planning, preservation, and waste management. For example, the DOE has sole authority to take action on matters under the *Atomic Energy Act*. In some cases, other federal agencies such as the Council on Environmental Quality, U.S. Environmental Protection Agency (EPA), and U. S. Fish and Wildlife Service have authority to regulate activities pursuant to the *National Environmental Policy Act*; *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA); *Endangered Species Act ;* and *Migratory Bird Treaty Act*. The EPA has delegated authority to the State of Washington Departments of Ecology and Health to regulate activities in accordance with the *Resource Conservation and Recovery Act* (RCRA), *Clean Air Act*, and *Clean Water Act*. In still other cases, state laws for licensing and permitting apply to activities and have resulted in the Hanford Site Radioactive Air Emissions License, RCRA Permit, Air Operating Permit, and State Waste Discharge Permits.

In general, the laws, regulations, and other requirements applicable to Hanford Site operations include, but may not be limited to, those that address environmental quality; air quality and noise; water resources; hazardous waste and materials management; radioactive waste and materials management; ecological resources; cultural and paleontological resources; worker safety and health; radiological safety and radiation protection; transportation; emergency planning, pollution prevention, and conservation; and environmental justice. It is DOE's policy to carry out its mission in a sustainable manner to maximize energy and water efficiency; minimize chemical toxicity and harmful environmental releases; promote renewable and other clean energy development; and conserve natural, cultural, and ecological resources while sustaining assigned mission activities.

All previous annual Hanford Site environmental reports are available online through Mission Support Alliance, LLC (MSA) at *http://msa.hanford.gov/page.cfm/enviroreports*. The following sections summarize this year's annual report.

ES.1 Section 1, Introduction

The DOE is responsible for the Hanford Site, one of the largest nuclear cleanup efforts in the world, managing the legacy of five decades of nuclear weapons production. Located in south-central Washington State within the semi-arid Pasco Basin of the Columbia Plateau, the Hanford Site encompasses approximately 581 mi^2 (1,505 km^2) in Benton, Franklin, Adams, and Grant Counties (Figure ES-1). The Hanford Site was established in 1943 to produce plutonium for atomic weapons during World War II and the Cold War. The site has restricted public access and provides a buffer area around facilities formerly used for nuclear materials production, waste storage, and waste disposal.

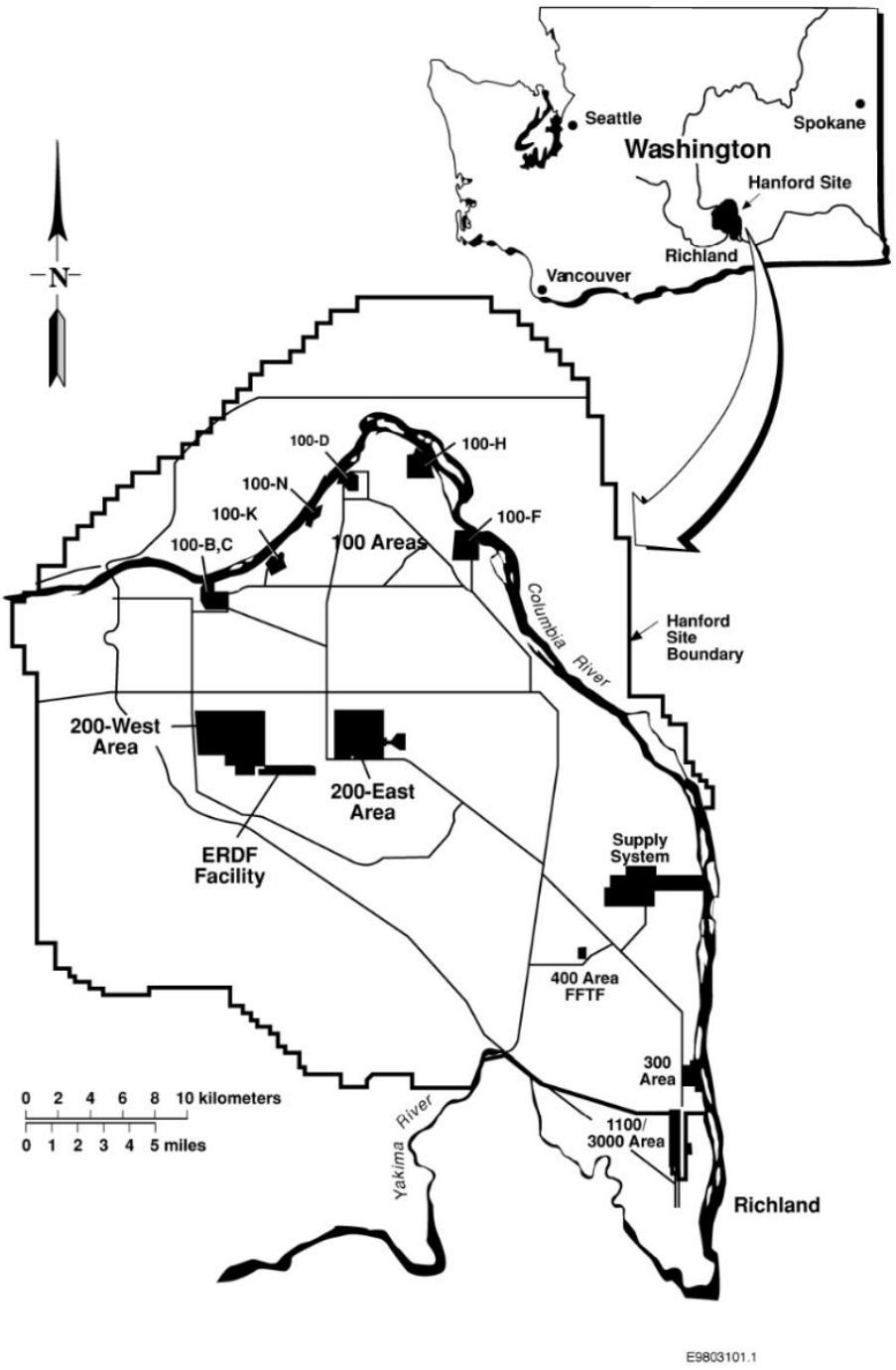

Figure ES-1. Location of the Hanford Site.

With the signing of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [TPA]) in 1989 (Ecology et al. 1989) by the Washington State Department of Ecology (Ecology), EPA, and DOE (collectively, TPA agencies), the primary mission of the Hanford Site shifted from production to cleanup. The Hanford Site's current mission focuses on environmental restoration, which includes remediation of contaminated areas, decontamination and decommissioning of Hanford Site facilities, waste management (i.e., waste storage, treatment, and disposal), and related scientific and environmental research and development of waste management technologies.

Cleanup of the Hanford Site is overseen by the U.S. Department of Energy, Richland Operations Office (DOE-RL) and Office of River Protection (DOE-ORP). The DOE-RL and the DOE-ORP manage the site through several contractors and their subcontractors. The DOE-RL serves as the Hanford Site 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 cleanout, deactivation, and demolition; environmental restoration; plutonium management; and all site support services.

The DOE-ORP was established by Congress in 1998 as a field office to manage the retrieval, treatment, and disposal of approximately 54.1 million gal (204.8 million L) of radioactive tank waste currently stored in 177 underground tanks in the central part of the site. The tank waste is material left over from years of World War II and post-war production of nuclear weapons fuel. In support of this mission, DOE-ORP is responsible for the safe operation of the tank farms and associated 200 Area facilities and construction and operation of the Hanford Tank Waste Treatment Plant and Immobilization Plant (WTP) located in the Central Plateau.

The DOE, U.S. Fish and Wildlife Service, and Washington State Department of Fish and Wildlife each manage portions of the Hanford Reach National Monument. In 2000, President Clinton created the Hanford Reach National Monument (65 FR 37253). Over 300 mi^2 (777 km^2) of riparian habitat and buffer lands surrounding active central Hanford lands were designated for management by the U.S. Fish and Wildlife Service.

The Manhattan Project National Historical Park, created in November 2015, is a partnership between DOE and the National Park Service. DOE continues to own, preserve, and provide public access to the five National Park facilities and areas at Hanford while the National Park Service is responsible for interpretation of the Manhattan Project story, as well as visitor services.

The DOE, Office of Science's Pacific Northwest Site Office manages science and technology facilities, programs, goals, and objectives at the Hanford Site. Its principal laboratory is the Pacific Northwest National Laboratory (PNNL), operated by Battelle Memorial Institute for DOE since 1965.

ES.2 Section 2, Compliance Summary

To ensure the protection of human health and the environment through safe operations, DOE implements compliance programs designed to fulfill requirements of applicable federal, state, and local laws and regulations, as well as DOE orders, directives, policies, and guidelines. In addition, the Hanford Site operates under permits required under specific environmental protection regulations. Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations at the Hanford Site, including the EPA, Ecology, Washington State Department of Health (WDOH), City of Richland, and the Benton Clean Air Agency. The EPA and Ecology are the two main agencies who regulate Hanford Site cleanup as part of the TPA. In addition, the Defense Nuclear Facilities Safety Board (DNFSB) provides oversight of DOE work. Congress created the DNFSB as an independent agency within the Executive Branch to identify the nature and consequences of potential threats to public health and safety at DOE's defense nuclear facilities, to elevate such issues to the highest levels of authority, and to inform the public. During 2016, the DNFSB oversaw projects pertaining to each contractor at the Hanford Site. In addition, the TPA commits DOE to

comply with the remedial-action provisions of the CERCLA and the RCRA treatment, storage, and disposal (TSD) unit regulations and corrective-action provisions.

Tri-Party Agreement

From 1989 through December 31, 2017, a total of 1,314 TPA milestones were completed and 339 target dates were met. During 2017, 34 specific cleanup milestones were scheduled for completion; of those, 10 milestones were deleted, 22 milestones were completed on time, 1 milestone was missed, and 0 were in negotiation. In addition, one target date was met, zero target dates were deleted, and zero target dates were in negotiation.

Federal Facility Compliance Act

DOE provides mixed waste information annually as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to TPA Milestone M-026-01.

Regulatory Inspections

During calendar year (CY) 2017, 79 regulatory agency inspections were conducted at DOE facilities on the Hanford Site: Ecology conducted 45, WDOH 31, EPA (Region 10) 1, and the City of Richland 2. There were five RCRA Permit General Inspections of the 100, 200, 300, and 400 Areas, as well as the banks of the Columbia River by boat. These inspections were conducted by Hanford Site contractors with DOE oversight. Some of the agency inspections were conducted jointly between multiple agencies.

RCRA

The Ecology and EPA inspections focused on TSD unit compliance with the *Hanford Facility Dangerous Waste Permit* (Ecology 2012) and WAC 173-303, "Dangerous Waste Regulations." Generator activities, waste accumulation, and universal waste management areas were also inspected. During 2017, permit modifications were processed to change requirements for TSD units pursuant to WAC 173-303-830, "Permit Changes."

CERCLA

For waste sites where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires a review every 5 years to evaluate the implementation and performance of a remedy to determine if the remedy is or will be protective of human health and the environment. During CY 2017, DOE/RL-2016-01, *Hanford Site Fourth CERCLA Five-Year Review Report*, addressing 2011 through 2015, was completed and received concurrence from EPA (2017).

Hanford Site Air Emission Sources

In 2017, the WDOH inspections focused on compliance of point and non-point emission units with the *Hanford Site Radioactive Air Emissions License #FF-01* (FF-01). Ecology inspections included discharge points (e.g., package boilers, emergency engines/generators, and tank farm ventilation systems) regulated under the Hanford Site Air Operating Permit. During 2017, regulatory agencies conducted 41 *Clean Air Act* inspections on the Hanford Site. There were no compliance actions involving airborne radioactive materials.

Environmental Occurrences

Per DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information*, environmental releases of radioactive and regulated materials from the Hanford Site are reported as legally required under the following categories: Operational Emergency; Recurring; Category 1 (significant impact);

Category 2 (moderate impact); Category 3 (minor impact); and Category 4 (some impact). On October 1, 2017, new Occurrence Reporting Criteria were established and implemented based on DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information* and associated Supplemented Contract Requirements Document. In 2017, there were 31 documented occurrences of legacy contamination.

Emergency Planning and Community Right to Know Act

DOE/RL-2018-07, *2017 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory*, was submitted to Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant counties; and the City of Richland and Hanford Site Fire Department before the annual March 1 deadline. The Hanford Site had 50 hazardous chemicals that exceeded the reporting thresholds.

Pollution Prevention Program

The Hanford Site maintains a pollution prevention and waste minimization program that contributes to the achievement of sustainability goals. In 2017 1,358 metric tons of non-hazardous (i.e., plastic, aluminum, cardboard, paper, wood, and metal) and hazardous (i.e., antifreeze, batteries, bulbs, and oils) wastes were recycled through Hanford Site programs administered through the Mission Support Contract. Greenhouse gas emissions from employee commuting, business travel, offsite wastewater treatment, and contracted solid waste disposal are primarily dependent on work locations and the number of workers employed at the Hanford Site. There was a 23% reduction in Scope 1 and Scope 2 greenhouse gas emissions for the Hanford Site in fiscal year (FY) 2017. Reported greenhouse gas emissions for FY 2017 were 79,342 metric tons of carbon dioxide equivalent compared with 102,645 metric tons carbon dioxide equivalent from the FY 2008 baseline. There was a 31.2% reduction in Scope 3 greenhouse gas emissions for the Hanford Site in FY 2017 from the FY 2008 baseline; emissions in FY 2017 were 28,513 metric tons carbon dioxide equivalent, whereas emissions in FY 2008 were 41,426 metric tons carbon dioxide equivalent.

ES.3 Section 3, Environmental Management System

Environmental management performance measures objectives for 2017 included fleet management, alternative fuel use, potable and non-potable water use, electricity use, facility fuel use, facility energy use, electronic product environmental assessment tool, sanitary waste reduction, and regulated waste reduction. The acquisition target for alternative fuel vehicles was not met in 2017. The alternative fuel use target was surpassed for FY 2017; however, the target for petroleum-based fuel use was missed. The target objectives for potable and non-potable water, renewable electric energy, facility fuel, facility energy, regulated waste reduction, sanitary waste reduction, and Electronic Product Environmental Assessment Tool acquisitions were met in FY 2017.

ES.4 Section 4, Radiological Protection and Doses

Hanford Site radiation protection program staff conduct ongoing monitoring of external radiation sources; perform environmental radiological surveys; and evaluate potential radiological doses to the public. Results of 2017 monitoring efforts are provided below.

External Radiation Monitoring

External radiation fields were monitored in 2017 at 125 environmental dosimeter (thermoluminescent dosimeter) locations near Hanford Site facilities and operations. Quarterly monitoring results were used individually or averaged to determine dose rates in a given area for a specific sampling period. The average dose rate levels measured in the operational areas during 2017 were comparable to the previous years' levels.

Radiological Clearance of Hanford Site Property

No property with anthropogenic (man-made) residual radioactivity above authorized limits was released from the Hanford Site in 2017.

Personal Property. More than 30,000 individual items of personal property were surveyed and verified to be free of residual radioactivity during 2017, allowing them to be released from the Hanford Site for unrestricted use by members of the public. Personal property consists mainly of materials and equipment; formal surveys are conducted on items such as power poles, transformers, miscellaneous electrical equipment, air conditioning units, industrial vehicles, excavation equipment, man lifts, and scaffolding. Verification surveys are also performed on common items such as electronics, pallets, batteries, office items, respiratory protection equipment, compressed gas cylinders, vehicles, tools, and physical security items. Some types of debris may be cleared to go to sanitary waste disposal sites. Scrap metal that has been confirmed to not have been in radiological areas can be verified as free of residual radioactivity and cleared for release from the Hanford Site.

Real Property. No real property (i.e., land and buildings) was cleared during 2017.

Granular Activated Carbon for Offsite Shipment and Regeneration. Approximately 100,100 lb (45,400 kg) of granular-activated carbon was shipped offsite in 2017 for regeneration.

Potential Radiological Doses to the Public and Biota

In 2017, scientists evaluated potential radiological dose to the public and biota resulting from modeled exposure to Hanford Site liquid effluents and airborne emissions to determine compliance with pertinent regulations and limits. The sources of radionuclide releases considered in the dose assessment included gaseous emissions from stacks and ventilation exhausts and contaminated groundwater seeping into the Columbia River. Potential doses were also evaluated based on measured concentrations of radionuclides in samples of Hanford Site drinking water, regional crops from near-by land, and fish from the Columbia River. Potential radiological doses from 2017 Hanford Site operations were evaluated in detail to determine compliance with pertinent regulations and limits. The following radiological doses were assessed:

- Dose to a hypothetical maximally exposed individual (MEI) at an offsite location
- Collective dose to the population residing within 50 mi (80 km) of Hanford Site operation areas
- Dose from recreational activities (e.g., hunting and fishing)
- Dose to a worker consuming drinking water on the Hanford Site
- Dose to a visitor to the Manhattan Project National Historical Park
- Dose from non-DOE industrial sources on and near the Hanford Site

- Absorbed dose received by biota exposed to radionuclide releases to the Columbia River and to radionuclides in onsite surface water bodies.

Additionally, air-pathway doses from stack and fugitive emissions to offsite and non-DOE Hanford Site employees calculated using regulation-specified EPA methods for comparison to the *Clean Air Act* standards in 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," were summarized.

The MEI is a hypothetical person whose location and assumed exposures are modeled in such a protective manner that it is highly unlikely any actual offsite individual would have received a higher Hanford-related dose. The dose to the MEI calculated in 2017 from Hanford Site operations was 0.22 mrem (2.2 µSv), which is 0.22% of the 100 mrem (1,000 µSv) annual public dose limit specified in DOE O 458.1. Many different exposure pathways are included in the dose calculations but inhalation and external exposure to radon isotopes and their radioactive progeny from 300 Area air emissions was the largest contributor. Collective dose was estimated for the entire population living with a 50-mi (80-km) radius of the air emissions sources and also individuals obtaining drinking water from the Columbia River downstream of the Hanford Site. A collective dose of 1.2 person-rem (0.012 person-Sv) was calculated as the sum of doses to all individual members of the exposed population.

Doses to a hypothetical individual were also calculated using measured concentrations of radionuclides in fish tissue and onsite drinking water. For recreational activities, a fish ingestion annual dose of up to 0.15 mrem (1.5 µSv) was estimated based on tissue samples of walleye and whitefish collected from the Hanford Reach of the Columbia River. An annual dose of up to 0.11 mrem (1.1 µSv) was calculated for ingestion of Hanford Site drinking water based on samples from the 400 Area, where water is supplied by groundwater wells. Lastly, annual doses were calculated for workers and visitors at the Hanford Townsite and White Bluffs Bank locations of the Manhattan Project National Historical Park (up to 0.00017 mrem (0.0017 µSv). Like the offsite MEI dose, these doses were far below the public dose limit.

To place this information into perspective, these doses were compared with those received by the U.S. population from other routinely encountered sources of radiation. The 2009 National Council on Radiation Protection and Measurements report *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009) estimated that the overall annual exposure to ionizing radiation for the average American is 620 mrem (6,200 µSv), approximately half of which is related to natural sources and the other half attributable primarily to medical procedures.

ES.5 Section 5, Environmental Restoration and Waste Management

Below is a waste summary for environmental restoration and waste management activities, including Hanford Site River Corridor closure, cleanup and remediation, facility decommissioning, waste management operations, underground waste storage tank status, construction of the Waste Treatment and Immobilization Plant and its associated facilities, and research activities related to waste cleanup. The following describes important 2017 cleanup and remediation activities at the Hanford Site.

River Corridor

The River Corridor includes the Hanford Site 100, 300, and 400 Areas that border the Columbia River. Through 2017, 100 and 300 Area transitions to MSA Long-Term Stewardship are complete with the

exception of a portion of the 100-K Area that is under CH2M Plateau Remediation Contractor (CHPRC) management and a portion of the 300 Area under PNNL management.

100 Area Waste Sites

The 100 Area waste sites vary in complexity and waste type. Typical waste sites include waste burial grounds, liquid effluent waste sites, burn pits, retired septic systems, and piping systems. In 2017, cleanup activities focused on completion of interim remedial actions in the 100-K Area. Waste generated from the cleanup of waste sites was disposed at the Environmental Restoration Disposal Facility (ERDF) in the 200 Areas.

100-K Area

Construction was completed on the Engineered Container Retrieval & Transfer System hardware in both the 105-K West Basin and Annex. Groundwater pump-and-treat operations continued. Remediation of waste sites to protect human health and the environment also continued.

100 Areas Facilities Decommissioning

As of 2017, all deactivation, decommissioning, decontamination, and demolition activities in the 100 Area, with the exception of 100-K Area, have been completed.

200 Area (Central Plateau) Facilities Decommissioning

Central Plateau facilities include buildings and associated waste sites in the 200-East, 200-West, and 200-North Areas and those on the adjoining Rattlesnake Unit. Decommissioning activities for the four main process buildings (234-5Z, 236Z, 242Z, and 291Z) at Plutonium Finishing Plant (PFP) were completed and demolition began in 2017. More than 1,500 roll-on/roll-off containers of rubble were removed from the PFP complex and taken to ERDF for final disposition.

300 Area Facilities Decommissioning

Current activities are focused on the remote excavation of the highly contaminated soil beneath the 324 Building B Cell and a portion of B Cell. Future activities in the 300 Area will address the remainder of the 324 facility, as well as the retained facilities and waste sites.

400 Area Facilities – Fast Flux Test Facility Deactivation

The Fast Flux Test Facility remains in long-term surveillance and maintenance, and routine surveillances are performed annually.

Solid Waste Management

Solid waste management includes the treatment, storage, and disposal of solid waste produced as a result of Hanford Site operations or received from offsite sources authorized to ship waste to the site. Active onsite solid waste facilities as of 2017 are described below.

Central Waste Complex. Located in the 200-West Area, the Central Waste Complex receives waste from Hanford Site sources and any offsite sources authorized by DOE to ship waste to the site for storage. Waste received includes low-level, transuranic, mixed low-level, and radioactive waste contaminated with polychlorinated biphenyls. Currently, the volume of waste stored in the Central Waste Complex Outside Storage Areas is approximately 198,126 ft^3 (5,610 m^3), with the remaining enclosed area storage totaling approximately 446,629 ft^3 (12,647 m^3).

T-Plant. The T-Plant Complex is located in the 200-West Area and provides solid waste treatment, storage, and decontamination services for the Hanford Site and offsite facilities. The T-Plant Complex is preparing to receive K-Basin sludge for storage.

Canister Storage Building. Located in the 200-East Area, this 42,000-ft^2 (3,902-m^2) facility stores about 2,300 tons (2,086 metric tons) of spent nuclear fuel packaged in approximately 400 multi-canister overpacks from the 100-K Basins, 100-N Reactor, and T-Plant.

Low-level Burial Grounds. The low-level burial grounds (LLBG) consist of eight separate burial areas regulated under the *Atomic Energy Act*. Two of the burial grounds are used for disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a dangerous waste component regulated by WAC 173-303). The first operational layer of waste packages in Trenches 31 and 34 has been covered with compacted gravel and soil; waste is currently being placed on the second waste layer. Trench 31 contains approximately 227,132 ft^3 (6,432 m^3) of waste in approximately 3,845 waste packages. Trench 34 contains approximately 186,758 ft^3 (5,288 m^3) of waste in 5,301 waste packages. In 2017, a total of 9,004 ft^3 (255 m^3) of waste was disposed of in Trenches 31 and 34. The LLBG Trench 94 received two defueled U.S. Navy reactor compartments in 2017.

Waste Receiving and Processing Facility. The Waste Receiving and Processing (WRAP) Facility is a treatment, storage, and disposal facility that began operations in 1997 with the mission to analyze, characterize, and prepare drums and boxes of low-level, mixed, and transuranic wastes for disposal. The WRAP complex is composed of the primary 2336W facility, the 2404-WB and 2404-WC storage buildings, and the High Energy Real Time Radiography and High Energy Neutron Counter.

Waste Encapsulation and Storage Facility. Located in the 200-East Area, the Waste Encapsulation and Storage Facility was constructed in 1970 and 1971 on the west end of B-Plant and became active in 1974. The Waste Encapsulation and Storage Facility is operating under interim status standards. Initial RCRA closure of Hot Cells A through F was achieved on April 10, 2017, through grouting these cells to fix any radioactive materials present.

Integrated Disposal Facility. The Integrated Disposal Facility (IDF) is an unused landfill located in the south-central part of the 200-East Area. The IDF is an expandable lined landfill (i.e., a double high-density polyethylene-lined trench with leachate collection and a leak detection system) with a process design capacity of 2.89 million ft^3 (82,000 m^3). The landfill is divided lengthwise into distinct east and west cells, one for disposal of low-level radioactive waste (the east cell) and the other for disposal of mixed waste (the west cell). The west cell is a permitted TSD facility under the Hanford Site RCRA Permit (WA7890008967). The landfill was constructed to accept low-level waste as well as mixed waste, such as vitrified low-activity waste (LAW) from the Waste Treatment Plant (WTP) and Demonstration Bulk Vitrification System (DBVS). Additionally, mixed waste generated by IDF operations will be disposed of in IDF. Work was conducted during CY 2017 to prepare and update a PA for the Integrated Disposal Facility (IDF).

Environmental Restoration Disposal Facility. The Environmental Restoration Disposal Facility (ERDF) began operations in 1996 and serves as the central disposal site for hazardous, low-level radioactive, and mixed low-level waste removed during Hanford Site CERCLA cleanup operations. The largest disposal facility in the DOE complex, DOE and its contractors have disposed 18.2 million tons (16.5 million metric tons) of contaminated material at the ERDF since the facility began operations in 1996.

Liquid Waste Management

The facilities described below are operated on the Hanford Site to store, treat, reduce, and dispose of various types of liquid effluent generated by site cleanup activities. In addition, remediation systems pump-and-treat contaminated groundwater in the 100-D, 100-H, and 200-West Areas.

200 Area Effluent Treatment Facility. Located in the 200-East Area, the Effluent Treatment Facility (ETF) treats liquid to remove toxic metals, radionuclides, and ammonia, in addition to destroying organic compounds. The treated waste is stored in tanks, sampled and analyzed, and discharged to the State-Approved Land Disposal Site (616-A Crib). Approximately 3.34 million gal (12.6 million L) of wastewater in LERF was treated at ETF in 2017.

200 Area Liquid Effluent Retention Facility. Across from the ETF, the Liquid Effluent Retention Facility (LERF) consists of three RCRA-compliant surface basins used to store aqueous waste. The volume of wastewater received for the LERF basin storage in 2017 was approximately 3.03 million gal (11.5 million L). The volume of wastewater being stored in the LERF at the end of 2017 was approximately 18.2 million gal (68.9 million L).

200 Area Treated Effluent Disposal Facility. Located east of the 200-East Area, the Treated Effluent Disposal Facility is a collection and disposal system for non-RCRA waste streams and consists of approximately 11 mi (18 km) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and a 5-ac (2-ha) disposal ponds. The volume of non-radioactive, non-dangerous waste is disposed to this facility in 2017 was approximately 96,212 million gal (803 million L).

242-A Evaporator. The 242-A Evaporator in the 200-East Area concentrates dilute liquid tank waste by evaporation, reducing the volume of liquid waste sent to double-shell tanks for storage and the potential need for other double-shell tanks. In 2017, upgrades to the facility included a stack extension to vessel vent 296-A-22 and an upgrade to the process sampling station.

Underground Waste Storage Tanks

Most Hanford Site waste is stored in 149 large underground single-shell and 28 double-shell tanks grouped into 18 tank farms located on the Central Plateau.

Single-shell Tank System. In 2017, progress continued in retrieving waste from the C Farm tanks and transferring it to newer, safer double-shell tanks (DST) to prepare to feed tank waste to the WTP. At the end of 2017 there were 28.7 million gal (108.6 million L) of waste in the single-shell tanks (SST). Waste volumes are provided in HNF-EP-1082. Table 5-5 summarizes the waste retrieved and stored in the SST system from 2010 through 2017.

Double-shell Tank System. The DST system includes 28 double-shell tanks located in the 200-East and 200-West Areas. The DST system is operating under interim status standards specified in the RCRA Permit (WA7890008967), Double-Shell Tank System Part A Form. At the end of 2017, there were 25.5 million gal (96.6 million L) of waste in the DSTs. Waste volumes are provided in HNF-EP-0182.

Underground Waste Storage Tanks and Associated Facilities Progress on DNFSB.

Throughout 2017, the DOE-ORP and its contractors met with and provided information to the DNFSB and its technical staff to answer questions regarding the following Hanford Site Tank Farm projects:

- Low Activity Waste Pretreatment System

- Maintenance Program
- Wireless Safety Instrumented System.

Single-Shell Tank Closure and Correct Measures Program. The Single-Shell Tank Closure and Corrective Measures Program is responsible for the closure of SST Waste Management Areas (WMAs), conducting performance assessments (PAs), and performing agreed upon interim measures in and around SST WMAs. Closure activities in CY 2017 focused on the development, submittal, and review of closure documents, and in conducting field and engineering activities to support WMA C Closure. Work was conducted during CY 2017 to prepare and update closure documents to meet the requirements of DOE O 435.1, *Radioactive Waste Management*, and the RCRA for WMA C, and prepare and update PAs for WMA C, and WMA A-AX. The WMA C and WMA A-AX PAs support closure of WMA C and WMA A-AX, respectively. In October 2017, construction of two SX Farm interim surface barriers began. The design for a third barrier was developed in CY 2017.

Hanford Tank Waste Treatment and Immobilization Plant

The WTP is being built on 65 ac (26 ha) on the Central Plateau to treat radioactive and hazardous waste currently stored in 177 underground tanks. In 2017, Bechtel National Inc. (BNI) began executing against its new contract modifications, signed in December 2016 with DOE. These modifications prioritize finishing the LAW Facility, BOF, and Analytical Laboratory to feed waste directly from the Hanford Tank Farms to LAW under an approach called Direct Feed Low-Activity Waste.

Pretreatment Facility. In 2017, work continued to resolve the remaining technical decisions that have impacted design and construction at the Pretreatment Facility since 2012. The Pretreatment team completed final testing of the Standard High Solids Test Vessel pulse jet mixers and control systems. Significant progress on the technical decisions was made in 2017 with resolution of the last decisions anticipated in the second quarter CY 2018.

High-level Waste Facility. At this facility, high-level waste (HLW) is combined with materials in high-temperature melters, poured into waste containers to form a solid, immobilized glass form. In 2017, the HLW team completed the Facility Completion Plan and the Design and Operability Report. In September 2017, DOE-ORP approved HLW's Preliminary Design Safety Analysis. It also received three autosamplers for HLW.

Low-Activity Waste Facility. In 2017, WTP workers completed installation of the caustic scrubber, assembly of the two melters in LAW, and installation of the 48-ft (1,463-cm) elevation electrical bulk cable.

Analytical Laboratory. Once operational, the laboratory will process about 10,000 waste samples a year to support glass formulation and waste-form compliance.

Long-term Stewardship

The Hanford Site's Long-Term Stewardship (LTS) Program has responsibilities within the 220 mi^2 (570 km^2) of the Hanford Site's River Corridor and bounded by 46 mi (74 km) of Columbia River shoreline; these responsibilities include managing post-cleanup obligations for 1,636 Waste Information Data System waste sites and 6 Manhattan Project Era production reactors that have been placed in interim safe storage. More than 24,000 cleanup and historic documents have been identified, indexed, and tagged as LTS records. In 2017, housekeeping tasks associated with the six reactors placed in interim safe storage were completed. External inspection of these structures continue to identify any potential

deterioration of the cocooned structure and improve protectiveness of human health and the environment. LTS assessed 229 waste sites with institutional controls.

Scientific and Technical Contributions to Hanford Site Cleanup

The PNNL scientific and technical contributions to cleanup at the Hanford Site are focused on applied science, technology development and maturation, and basic science contributions. These contributions are funded through the DOE-Environmental Management Offices of Soil and Groundwater Remediation and Tank Waste and Waste Processing, DOE-RL, CHPRC, DOE-ORP, Washington River Protection Solutions, and BNI.

ES.6 Section 6, Air Monitoring

Hanford Site contractors monitor airborne emissions from site facilities to determine compliance with federal and state regulatory requirements and assess the effectiveness of emission control equipment. The outdoor ambient air is also monitored on the Hanford Site and offsite in nearby and distant communities.

Air Emissions

Small quantities of radionuclides and industrial air pollutants are emitted to the environment from the Hanford Site due to facility operations. Most facility radioactive air emission sources are sampled or monitored if they have the potential to emit radionuclides. The dose to the MEI calculated in 2017 from Hanford Site operations was 0.22 mrem (1.2 µSv), which is 0.22% of the 100 mrem (1,000 µSv) annual public dose limit specified in DOE O 458.1. Non-radioactive air pollutant emissions are estimated via sampling or chemical and material use. Pollutant emissions from all sources in 2017 were similar to emissions in 2016.

Ambient Air Monitoring

A network of continuously operating samplers at 59 locations across the Hanford Site was used during 2017 to monitor radioactive airborne materials in air near site facilities and operations. Generally, radionuclide levels measured in the 2017 air composite samples were similar to those measured in previous years. Notable exceptions to this were sample results from stations in the 200-West Area in the vicinity of the PFP demolition project. Air monitoring at the 618-10 Burial Ground project north of the 300 Area concluded in December 2017 with the completion of remediation activities.

Hanford Site and Offsite Ambient Air Monitoring

Airborne radionuclide samples were collected in 2017 by 37 continuously operating samplers at or in the vicinity of the Hanford Site. Generally, the 2017 air sample results showed very low radiological concentrations (Appendix C, Table C-3). Two stations showed a sample with radionuclide concentrations above their respective reporting threshold values (i.e., 10% of) of 40 CFR 61, Appendix E, Table 2 concentration values. The EPA concentration values (40 CFR 61, Appendix E, Table 2) are concentrations that would result in an annual dose of 10 mrem (100 µSv)/yr from airborne radiological material if a person stayed in that location for a majority of the year. The values in 40 CFR 61, Appendix E, Table 2 are used as reporting thresholds to the WDOH, pursuant to Section 5.1.5.1, for those stations listed in Table 4-1 of the FF-01 license.

ES.7 Section 7, Water Monitoring

In 2017, water samples were collected and analyzed from different sources including Hanford Site drinking water systems, Columbia River surface water, sediment, and seep water; onsite pond water and sediment; offsite irrigation water; and liquid effluent.

Hanford Site Drinking Water Monitoring

Eight DOE-owned, contractor-operated public water systems supply drinking water to DOE facilities on the Hanford Site. MSA operates five of the public water systems. CHPRC operates two systems, and PNNL operates one system. The City of Richland supplies water to the 300 Area, Richland North Area, and Hazardous Materials Management and Emergency Response facility.

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 for 2017. Contaminant concentrations measured during the year were similar to those observed in recent years.

The 300 Area water system experienced an maximum contaminant level exceedance for disinfection by-products monitoring in the third and fourth quarters of 2017. Transition of the 300 Area operations and responsibilities from MSA to PNNL occurred on October 1, 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.

Columbia River Water Monitoring

Radionuclide concentrations measured in river water samples collected upstream and downstream of the Hanford Site in 2017 were similar to concentrations measured in recent years. Concentrations of radionuclides in samples collected at the City of Richland intake facility were slightly higher than in samples collected upstream at Priest Rapids Dam. Radiological contaminant concentrations were well below the DOE-derived concentration standards.

Radionuclide concentrations measured in cross-river, transect samples were, with one exception, similar to levels measured upstream at Priest Rapids Dam. The tritium concentration measured at the Hanford Townsite transect was higher than at Priest Rapids Dam or at any other transect. Strontium-90 concentrations in Hanford Reach transect samples were comparable to upstream reference concentrations. Strontium-90 concentrations measured in transect samples collected upstream and downstream of the Hanford Site during 2017 were below analytical detection limits. Uranium concentrations in all transect samples were below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]).

Transect samples were also analyzed for inorganic and organic constituents. Copper, uranium, and zinc were detected in most samples at levels below the Washington State Ambient Surface Water Quality criteria for the protection of aquatic life. Organic contaminants trichloroethene and dichloroethene, attributable to past Hanford operations, were well below their respective EPA Drinking Water Standard.

Columbia River Sediment Monitoring.

Samples of Columbia River sediment were from locations upstream and downstream of the Hanford Site as well as at locations along the Hanford Reach. All samples were analyzed for radionuclides, anions, hexavalent chromium, metals, mercury, and total organic carbon. Analytical results for 2017 were comparable to previous years with cesium-137 and uranium isotopes consistently detected at most sediment collection locations.

Columbia River Seep Water

Samples of Columbia River shoreline seep water were collected along the Hanford Reach and analyzed for radiological, inorganic, and organic contaminants. Tritium concentrations were noticeably elevated in samples collected near the Hanford Townsite and at the 300 Area. These results are consistent with concentrations and plume maps reported by the Groundwater Monitoring program.

Pond Water and Sediment

West Lake is the only naturally occurring pond on the Hanford Site. Remotely located, it is most frequented by the indigenous wildlife. Water and sediment samples were analyzed for radiological contaminants and the 2017 concentrations were similar to previous years.

Offsite Irrigation Water

To assess the potential for Hanford Site-associated contaminants to affect food products irrigated with Columbia River downstream of the site, water samples were collected three times during the irrigation season from irrigation systems on each side of the Columbia River. Radionuclide concentrations measured in 2017 were at similar levels measured in Columbia River transect water samples collected upstream of the Hanford Site.

Liquid Effluent Monitoring

Liquid effluent disposal is governed by applicable regulations and permits. In CY 2017 there were no liquid effluent discharges to the Columbia River and two permitted liquid effluent streams discharged to the ground. Sampling and analyses are performed to monitor effluent contaminants of concern. Discharge monitoring reports that contain contaminant data from these analyses are submitted to Ecology.

ES.8 Section 8, Groundwater Monitoring

During Hanford Site operations, chemical and radioactive waste was released into the environment and contaminated soil and groundwater beneath portions of the site, mostly in the 200-East and 200-West Areas in the central part of the site, and the 300 and 100 Areas along the Columbia River. Groundwater monitoring data and information about monitoring wells are available through the DOE Environmental Dashboard Application at https://ehs.hanford.gov/eda. A detailed discussion of groundwater monitoring results is available in DOE/RL-2017-66, *Hanford Site Groundwater Monitoring Report for 2017*, and the interactive online report at https://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

ES.9 Section 9, Soil Monitoring

Surface soil samples are collected on the Hanford Site to evaluate long-term accumulation trends and provide baseline data used to quantify contaminant level changes due to fugitive or accidental releases of Hanford Site radiological materials. Soil samples for this effort have been collected annually for several decades. These samples are typically collected in the late-spring from locations 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. Soil samples from offsite locations are collected every 3 to 5 years and were last collected in 2015. Offsite soil sampling is used for long-term trend analysis and is not used in dose model calculations. The sampling frequency of every 3 to 5 years is consistent with the guidance provided inDOE-HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*.

Analytical results for soil samples collected in 2017 at locations in the 200-East, 200-West, 300, 400, and 600 Areas were consistent with analytical results from previous years. While there are no specific DOE limits for radionuclide concentrations in soil, the 2017 onsite soil sample results were compared to other benchmarks including Hanford Site background concentrations (DOE/RL-96-12), dose-based limits for soil developed for a 1 mrem/yr dose threshold to an offsite member of the public (DOE/RL-91-50), and soil radiological preliminary remediation goals (PRGs) for the 200 Area outdoor worker exposure scenario. Generally, radionuclide concentrations in soil samples collected from the 200, 300, 400, and 600 Areas were near or below the Hanford Site background concentrations and well below the dose-based reporting limits for an offsite member of the public and the PRGs for the outdoor worker exposure scenario. The cesium-137 concentrations in the 200 Areas were slightly above the Hanford Site background level, but they were significantly lower than the PRGs for the 200 Area outdoor worker exposure scenario.

ES.10 Section 10, Biota Monitoring

DOE conducted agricultural monitoring at several locations that vary annually near the Hanford Site to assess potential contaminant concentrations in food and farm products as a result of site activities. Plant and animal species on the site are also monitored to assess abundance, condition, and population distributions. Data collection and analysis are integrated with environmental monitoring of biotic and abiotic media, and analytical results are used to characterize potential risks or impacts.

Agricultural Monitoring

Food and farm products (i.e., alfalfa, cherries, corn, leafy vegetables, melons, milk, potatoes, tomatoes, and wine must) were collected in 2017 at locations near the Hanford Site. Radionuclide concentrations in most food and farm product samples in 2017 were below the analytical laboratory detection levels; however, some potential Hanford Site-produced contaminants (e.g., tritium) were found at low levels in some samples. Data for potassium-40 and beryllium-7 are included to show the natural radioactive elements that exist in food products relative to concentrations of potential Hanford Site-produced contaminants.

Fish and Wildlife Monitoring

The fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants during CY 2016 were walleye (*Sander vitreus*), mountain whitefish (*Prosopium williamsoni*), Canada goose (*Branta Canadensis*) and Nuttall's cottontail rabbit (*Sylvilagus nuttallii*). Most fish and wildlife samples are

collected on and around the Hanford Site and analyzed for human-pathway exposure every 2 to 3 years. Reference samples are obtained at locations determined not to be affected by Hanford Site effluents and emissions at least every 5 years.

Vegetation Monitoring

Native vegetation samples are collected on the Hanford Site to evaluate long-term accumulation trends and provide baseline data used to quantify contaminant level changes due to fugitive or accidental releases of Hanford Site radiological materials. Vegetation samples for this effort have been collected annually for several decades from locations 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. Vegetation samples from offsite locations are collected every 3 to 5 years and were last collected in 2015. Offsite vegetation sampling is used for long-term trend analysis and is not used in dose model calculations. The sampling frequency of every 3 to 5 years is consistent with the guidance provided in DOE-HDBK-1216-2015. Analytical results for vegetation samples collected in 2017 at locations in the 200-East, 200-West, 100-N, 300, 400, and 600 Areas were consistent with previous years.

Radiological Contamination. Investigations of radioactive contamination in vegetation were conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination or to verify radiological conditions at specific project sites. All samples collected during investigations were field-surveyed for alpha- and beta-gamma radiation. Radiological contamination was found in 23 vegetation samples surveyed during the 2017 investigations.

Vegetation Control. Approximately 4,689 ac (1,898 ha) were treated with herbicides in 2017 on radiological waste sites, around operations areas, and along roadways to keep areas free of deep-rooted vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments are included in the total treated acres; several areas received more than one herbicide application.

Waste Site Remediation and Revegetation

In 2017, only 1 ac (0.4 ha) across the Hanford Site was planted with grass seed to stabilize areas where traffic and erosion had damaged the grass cover on waste sites. Waste sites in the 200-East and 200-West Areas were designed and constructed with a cap of perennial grass essential to performance of engineered waste sites.

ES.11 Section 11, Resource Protection

DOE is responsible for managing and protecting biological and cultural resources on the Hanford Site. Ecological and cultural resource monitoring are conducted to collect and track data needed to ensure compliance with applicable laws, regulations, and policies (including management plans) governing DOE activities.

Ecological Protection

Ecological monitoring data provide baseline information about the plants, animals, and habitats under DOE stewardship at Hanford that is required to make cleanup decisions. During 2017, DOE continued to monitor and evaluate species that are protected by federal or state laws and regulations or are of special interest to the public and stakeholders. Fall Chinook salmon redds, steelhead redds, and bald eagle nesting and night roosting activity were assessed because these species have the potential to be

impacted by Hanford Site operations. Additional monitoring efforts included ferruginous hawk nest monitoring, roadside bird surveys, burrowing owls, pollinators, ground squirrels, and bats.

Endangered and Threatened Species

Two endangered and threatened fish species, spring-run Chinook salmon and steelhead, are known to occur regularly on the Hanford Site. One additional threatened fish species (bull trout) has been recorded at the site but scientists believe that the species is transient. Umtanum desert buckwheat and White Bluffs bladderpod, federally listed as threatened plant species, also occur on the site. No other plants or animals known to occur on the Hanford Site are currently federally listed as threatened or endangered, though the Washington ground squirrel is a candidate for federal listing. In addition, 13 plant species and 4 bird species have been listed as either endangered or threatened by Washington State. Numerous additional species of animals and plants are listed as candidate or sensitive species by Washington State. There are 31 state-level sensitive and candidate species of animals and 15 sensitive plant species occurring or potentially occurring on the Hanford Site.

Cultural and Historic Resource Protection

DOE is responsible for managing and protecting the Hanford Site's cultural and historic resources in accordance with applicable federal cultural resources laws and regulations and DOE management plans. In 2017, Hanford Site archaeologists completed 75 *National Historic Preservation Act of 1966* (NHPA) Section 106 cultural resources reviews. Thirty-three undertakings had the potential to affect cultural resources. Thirty-two projects affected historic buildings and were determined exempt by Hanford Site archaeologists after meeting the DOE-approved historic buildings programmatic agreement (DOE/RL-96-77) exemption criteria following an initial review. Eight projects had been reviewed for effects to cultural resources under previous NHPA Section 106 reviews. Two projects were reviewed and completed by Hanford Site archaeologists under an emergency declaration. A total of 2,723.03 ac (1,101.97 ha) of new ground was surveyed for cultural resources from NHPA Section 106 project-specific surveys.

Collection Management and Curation

The Hanford History Project provides professional curatorial and archival services for the management, conservation, and public access of the Hanford Collection, which consists of artifacts and multimedia relating to the Manhattan Project and Cold War Era. In addition to public outreach and education, Washington State University, Tri Cities (WSU-TC) provides a repository for the collection that meets the requirements of 36 CFR 79, "Curation of Federally-Owned and Administered Archaeological Collections," including protecting these resources from theft, fire, breakage, or deterioration. During 2017, 15 artifacts were evaluated for inclusion, picked up from Hanford Site facilities, and delivered to the Hanford History Project repository at WSU-TC, leaving 26 (3.5%) of the 743 tagged artifacts scheduled for collection between 2018 and 2048. Having transitioned the bulk of the Hanford Collection to the WSU-TC facility in 2016, tasks during 2017 consisted mainly of artifact cataloguing and archival processing. Additionally, 191 archival items staged at a secure Mission Support Alliance facility were reviewed for public release prior to being transferred to the Hanford History Project's repository for curation.

ES.12 Section 12, Quality Assurance

Quality assurance (QA) and quality control (QC) programs for the Hanford Site and offsite environmental surveillance were documented through project-specific QA plans and describe applicable QA elements.

Several types of field QC samples are collected to ensure the validity of the sampling procedures and the resulting sample data. The potential cross-contamination between samples during the sampling process is evaluated using trip blanks and equipment blanks. Additionally, field duplicates are collected to evaluate sample matrix heterogeneity and sample collection reproducibility. In 2017, field duplicate samples were collected and analyzed for air, soil, Columbia River water, natural vegetation, milk, wine, cherries, wildlife, irrigation water, sediment, and seep samples. The accepted method of evaluating the precision or reproducibility of duplicate samples is the calculation of the Relative Percent Difference. In 2017, Hanford Site Environmental Surveillance samples were sent to two laboratories (General Engineering Laboratories, LLC [GEL] and TestAmerica Richland Laboratory [TARL]). These laboratories participated in various independent QA and QC programs including the Mixed Analyte Performance Evaluation Program (MAPEP) and DOE Consolidated Audit Program.

GEL's MAPEP program results were nearly all acceptable. GEL received warnings in studies 36 and 37 for results with bias in the range of 20 to 30% for uranium-235, uranium-238, uranium total, and strontium-90, which are still considered acceptable. GEL received unacceptable results for bias greater than 30% for antimony and mercury. Unacceptable results such as these will be mitigated by future results and are not currently considered to be an unrecoverable problem under the MAPEP.

TARL's MAPEP results were nearly all acceptable. TARL received warnings in studies 36 and 37 for results with bias in the range of 20 to 30% for cesium-137, cobalt-60, uranium-238, uranium total, and technetium-99, which are still considered acceptable. TARL received unacceptable results for a false positive on nickel-63 and for a result biased by more than 30% for iron-55. Similar to the GEL results, these issues will be mitigated by future results and are not currently considered to be an unrecoverable problem under the MAPEP program.

ES.13 References

36 CFR 79. "Curation of Federally-Owned and Administered Archaeological Collections." *Code of Federal Regulations*, as amended. Online at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title36/36cfr79_main_02.tpl.

40 CFR 61. "National Emission Standards for Hazardous Air Pollutants." *Code of Federal Regulations*, as amended. Online at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr61_main_02.tpl.

65 FR 37253. 2000. "Establishment of the Hanford Reach National Monument." *Federal Register*, Washington, D.C. Online at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=00-15111-filed.pdf.

Atomic Energy Act of 1954. 42 U.S.C. 2011 et seq. Online at https://www.nrc.gov/docs/ML1327/ML13274A489.pdf.

Clean Air Act of 1963. 42 U.S.C. 7401 et seq., Public Law 88-206, as amended. Online at https://www.gpo.gov/fdsys/pkg/STATUTE-77/pdf/STATUTE-77-Pg392.pdf.

Clean Water Act of 1977. 33 U.S.C. 1251 et seq., Public Law 95-217, as amended. Online at http://uscode.house.gov/view.xhtml?req=(title:33%20section:1251%20edition:prelim).

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 et seq., Public Law 107-377. Online at https://www.epa.gov/enforcement/comprehensive-environmental-response-compensation-and-liability-act-cercla-and-federal.

DOE-HDBK-1216-2015. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*. U.S. Department of Energy, Washington, D.C. Online at http://www.id.doe.gov/ESER/DOC/DOE-HDBK-1216-2015v2.pdf.

DOE O 231.1B. 2011. *Environmental, Safety and Health Reporting*. U.S. Department of Energy, Washington, D.C. June 27. Online at https://www.directives.doe.gov/directives-documents/200-series/0231.1-BOrder-b-admchg1.

DOE M 231.1-2. 2003. *Occurrence Reporting and Processing of Operations Information*. U.S. Department of Energy, Washington, D.C. Online at https://www.directives.doe.gov/directives-documents/200-series/0231.1-DManual-2/@@images/file.

DOE O 232.2A. 2017. *Occurrence Reporting and Processing of Operations Information*. U.S. Department of Energy, Washington, D.C. June 27. Online at https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-A.

DOE O 458.1, Chg. 3. 2013. *Radiation Protection of the Public and the Environment*. U.S. Department of Energy, Washington, D.C. Online at https://www.directives.doe.gov/directives-documents/400-series/0458-1-border-admc3.

DOE/RL-91-50. 2018. *Hanford Site Environmental Monitoring Plan*. Rev. 8. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-12. 1997. *Hanford Site Background: Part 2, Soil Background for Radionuclides*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at https://pdw.hanford.gov/arpir/pdf.cfm?accession=D1808987

DOE/RL-96-77, Rev 0. 1996. *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*. Richland, WA. Online at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=da06717578.

DOE/RL-2016-01. 2017. *Hanford Site Fourth CERCLA Five-Year Review Report.* Rev. 0. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0071636H.

DOE/RL-2017-66, in progress, *Hanford Site Groundwater Monitoring Report for 2017*, CH2M HILL Plateau Remediation Company, Richland, Washington.

DOE/RL-2018-07, *2017 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory*

Ecology, EPA, DOE. 1989. *Hanford Federal Facility Agreement and Consent Order*, as amended. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. Richland, Washington. Online at http://www.hanford.gov/?page=81.

Endangered Species Act of 1973. 16 U.S.C. 1531 et seq., Public Law 93–205, as amended. Online at https://www.fws.gov/laws/lawsdigest/esact.html.

EPA. 2017. "Hanford Site 4th CERCLA Five Year Review." External letter to R. Corey, U.S. Department of Energy, Richland Operations Office, from D. Faulk, U.S. Environmental Protection Agency, Richland, Washington, May 4.

Hanford Site Radioactive Air Emissions License #FF-01, Washington State Department of Health, Olympia, Washington.

Migratory Bird Treaty Act of 1918, as amended. 16 U.S.C. 703. Online at https://www.gpo.gov/fdsys/pkg/USCODE-2010-title16/pdf/USCODE-2010-title16-chap7-subchapII-sec703.pdf.

National Environmental Policy Act of 1969 as amended. 42 U.S.C. 4321 et seq., Public Law 91-190. Online at https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap55-sec4321.pdf.

National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. Online at https://www.nps.gov/history/local-law/nhpa1966.htm.

NCRP. 2009. *Ionizing Radiation Exposure of the Population of the United States*. Report No. 160. National Council on Radiation Protection and Measurements, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq. Online at https://www.epa.gov/laws-regulations/summary-resource-conservation-and-recovery-act.

WAC 173-303. "Dangerous Waste Regulations." *Washington Administrative Code,* Olympia, Washington. Online at http://apps.leg.wa.gov/wac/default.aspx?cite=173-303.

WAC 173-303-830. "Permit Changes." *Washington Administrative Code,* Olympia, Washington. Online at http://apps.leg.wa.gov/wac/default.aspx?cite=173-303-830.