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Idaho National Laboratory
Site Environmental Report

Calendar Year 2016

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Environmental Surveillance, Education, and Research Program

U.S. Department of Energy, Idaho Operations Office

September 2017

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Environmental Surveillance, Education, and Research Program
120 Technology Drive
Idaho Falls, ID 83401

Water Sampling with Idaho DEQ on the Snake River.

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Dry Big Lost River riverbed.

To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2016 is an overview of environmental activities conducted on and in the vicinity of the Idaho National Laboratory (INL) Site from January 1 through December 31, 2016. This report includes:

- Effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products for radioactivity. The results are compared with historical data, background measurements, and/or applicable standards and requirements in order to verify that the INL Site does not adversely impact the environment or the health of humans or biota.
- A summary of environmental management systems in place to protect air, water, land, and other natural and cultural resources potentially impacted by INL Site operations.
- Ecological and other scientific research conducted on the INL Site that may be of interest to the reader.

The report addresses three general levels of reader interest:

- The first is a brief summary with a take-home conclusion. This is presented in the chapter highlights text box at the beginning of each chapter. There are no tables, figures, or graphs in the highlights. This section is intended to highlight general findings for an audience with limited scientific background.
- The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs. A person with some scientific background can read and understand this report after reading the section entitled “Helpful Information.”
- The third level includes links to supplemental and technical reports and websites that support the annual report. This level is directed toward scientists who would like to see original data and more in-depth discussions of the methods used and results. The links to these reports may be found in the Quick Links section of the annual report webpage (http://www.idahoeser.com/Annuals/2016/index.htm).

The Environmental Surveillance, Education, and Research Program is responsible for contributing to and producing the annual Idaho National Laboratory Site Environmental Report. In April 2016, DOE-ID awarded a five-year contract to Wastren Advantage, Inc., to manage the Environmental Surveillance, Education, and Research Program. The program was previously managed by Gonzales-Stoller Surveillance, LLC, whose contract ended in March 2016.

Other major contributors to the annual Idaho National Laboratory Site Environmental Report include the INL contractor (Battelle Energy Alliance, LLC); Idaho Cleanup Project Core contractor (Fluor Idaho, LLC); U.S. Department of Energy, Idaho Operations Office; National Oceanic and Atmospheric Administration; and U.S. Geological Survey (USGS). Links to their websites and the ESER website are:

- Idaho National Laboratory (https://www.inl.gov/)
- Idaho Cleanup Project (https://fluor-idaho.com/About/Idaho-Cleanup-Project-Core/)
- U.S. Department of Energy, Idaho Operations Office (http://www.id.doe.gov/)
- Field Research Division of National Oceanic and Atmospheric Administration’s Air Resources Laboratory (www.noaa.inel.gov/)
- U.S. Geological Survey (http://id.water.usgs.gov/)
- Environmental Surveillance, Education, and Research Program (http://www.idahoeser.com/)

Included in the chapter headings of this report are photographs, as well as common and scientific names of rare and sensitive plants and animals native to the INL Site. Photo credits: ESER Program, National Park Service, Idaho Fish and Game, and Fish and Wildlife Service.

Executive Summary

INTRODUCTION

In operation since 1949, the Idaho National Laboratory (INL) Site is a U.S. Department of Energy (DOE) reservation located in the southeastern Idaho desert, approximately 25 miles west of Idaho Falls (Figure ES-1). At 890 square miles (569,135 acres), the INL Site is roughly 85 percent the size of Rhode Island. It was established in 1949 as the National Reactor Testing Station, and for many years was the site of the largest concentration of nuclear reactors in the world. Fifty-two nuclear reactors were built, including the Experimental Breeder Reactor-I which, in 1951, produced the first usable amounts of electricity generated by nuclear power. Researchers pioneered many of the world's first nuclear reactor prototypes and advanced safety systems at the INL Site. During the 1970s, the laboratory's mission broadened into other areas, such as biotechnology, energy and materials research, and conservation and renewable energy.

Today the INL is a science-based, applied engineering national laboratory dedicated to supporting the DOE's missions in nuclear and energy research, science, and national defense.

The INL mission is to discover, demonstrate and secure innovative nuclear energy solutions and other clean energy option and critical infrastructure with a vision to change the world's energy future and secure the nation's critical infrastructure.

In order to clear the way for the facilities required for the new nuclear energy research mission, the Idaho Cleanup Project (ICP) Core has been charged with the environmental cleanup of the legacy wastes generated from World War II-era conventional weapons testing, government-owned reactors, and spent fuel reprocessing. The overarching aim of the project is to reduce risks to workers and production facilities, the public, and the environment and to protect the Snake River Plain aquifer. A great deal of this cleanup has occurred since the project began. Significantly, an ICP Decontamination and Decommissioning Project was officially closed out in 2012 with the safe decontamination and decommissioning of 223 buildings and structures for a total footprint reduction of over 1.6 million square feet.

Figure ES-1. Regional Location of the Idaho National Laboratory Site.

PURPOSE OF THE INL SITE ENVIRONMENTAL REPORT

The INL Site's operations, as well as the ongoing cleanup, necessarily involve a commitment to environmental stewardship and full compliance with environmental protection laws. As part of this commitment, the INL Site Environmental Report is prepared annually to inform the public, regulators, stakeholders, and other interested parties of the INL Site's environmental performance during the year. This report is published for the U.S. Department of Energy, Idaho Operations Office (DOE-ID) in compliance with DOE Order 231.1B, "Environment, Safety and Health Reporting." Its purpose is to:

- Present the INL Site, mission, and programs
- Report compliance status with applicable federal, state, and local regulations
- Describe the INL Site environmental programs and activities
- Summarize results of environmental monitoring
- Discuss potential radiation doses to the public residing in the vicinity of the INL Site
- Report on ecological monitoring and research conducted at the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data.
- Provide supplemental technical data and reports which support the INL Site Environmental Report (http://www.idahoeser.com/Annuals/2016/Data.htm).

MAJOR INL SITE PROGRAMS AND FACILITIES

There are two primary programs at the INL Site: the INL and the ICP Core. The prime contractors at the INL Site in 2016 were: Battelle Energy Alliance, the management and operations contractor for the INL; and Fluor Idaho, which managed ongoing cleanup operations under the ICP and operated the Advanced Mixed Waste Treatment Project.

The INL Site consists of several primary facilities situated on an expanse of otherwise undeveloped terrain. Buildings and structures at the INL Site are clustered within these facilities, which are typically less than a few square miles in size and separated from each other by miles of undeveloped land. In addition, DOE-ID owns or leases laboratories and administrative offices in the city of Idaho Falls, some 25 miles east of the INL Site border. About 30 percent of employees work in administrative, scientific support, and non-nuclear laboratory programs and have offices in Idaho Falls.

The major facilities at the INL Site are the Advanced Test Reactor (ATR) Complex; Central Facilities Area (CFA); Critical Infrastructure Test Range Complex (CITRC); Idaho Nuclear Technology and Engineering Center (INTEC); Materials and Fuels Complex (MFC); Naval Reactors Facility; Radioactive Waste Management Complex (RWMC); and Test Area North (TAN), which includes the Specific Manufacturing Capability (Figure ES-2). The Research and Education Campus is located in Idaho Falls. The major facilities and their missions are outlined in Table ES-1.

ENVIRONMENTAL PROTECTION PROGRAMS

Directives, orders, guides, and manuals are DOE's primary means of establishing policies, requirements, responsibilities, and procedures for DOE offices and contractors. Among these are a series of Orders directing each DOE site to implement sound stewardship practices that are protective of the public and the environment. These orders require the implementation of an environmental management system (EMS), a Site Sustainability Plan, radioactive waste management, and radiation protection of the public and biota. Battelle Energy Alliance and Fluor Idaho have each established and implemented an EMS and contribute to the INL Site Sustainability Plan, as required by DOE and executive orders. Each EMS integrates environmental protection, environmental compliance, pollution prevention, and waste minimization into work planning and execution throughout all work areas. The INL Sustainability Plan contains strategies and activities that will lead to continual greenhouse gas reductions as well as energy, water, and transportation fuels efficiency at the INL Site. Plan requirements are integrated into each INL Site contractor's Integrated Safety Management System and EMS.

The INL Site was far below all DOE public and biota dose limits for radiation protection in 2016.

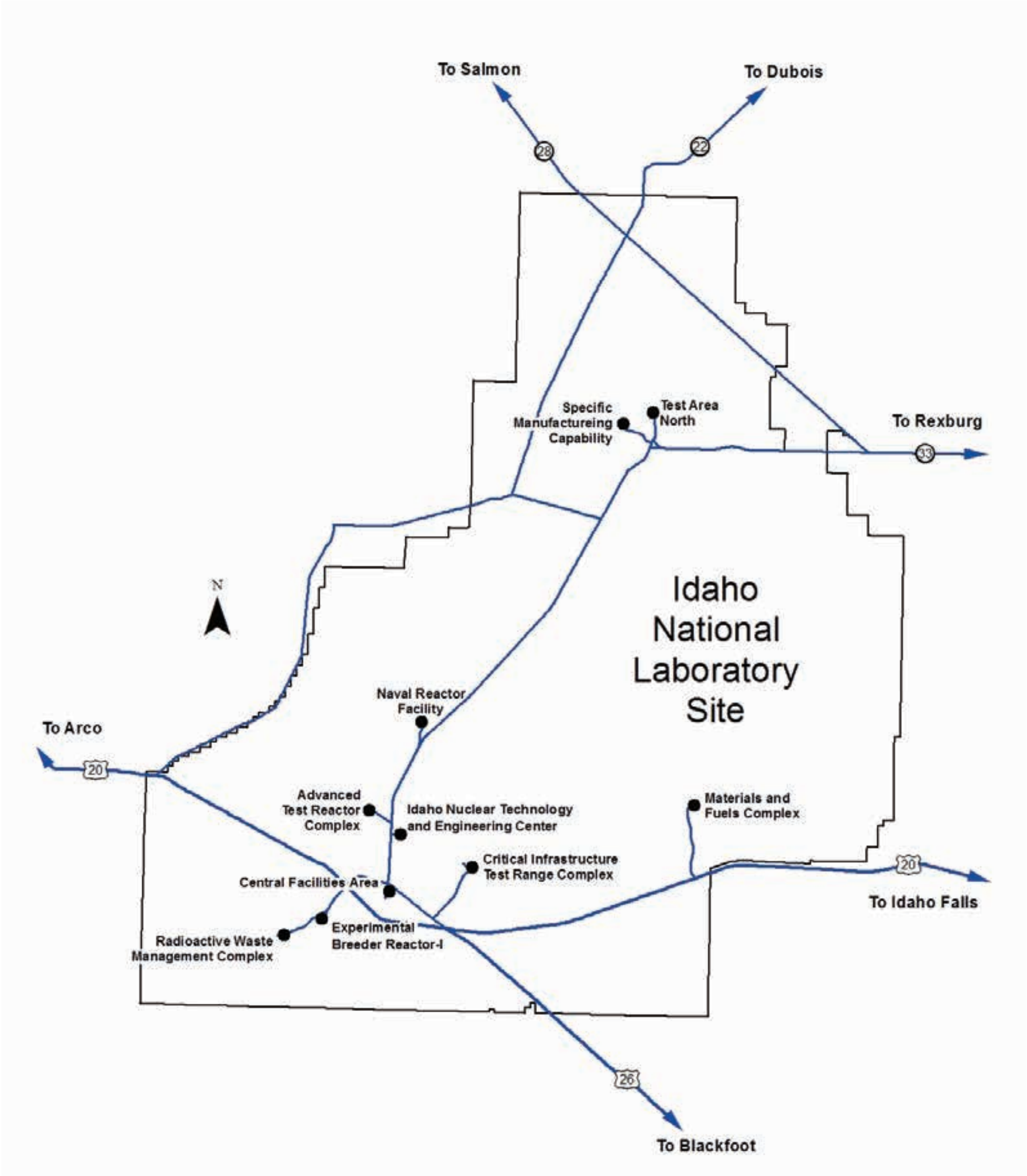


Figure ES-2. Idaho National Laboratory Site Facilities.

ENVIRONMENTAL RESTORATION

Environmental restoration at the INL Site is conducted under the Federal Facility Agreement and Consent Order (FFA/CO) among DOE, the state of Idaho, and U.S. Environmental Protection Agency (EPA). The FFA/CO governs the INL Site's environmental remediation. It specifies actions that must be completed to safely clean up release sites at the INL Site in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act and with the corrective action requirements of the Resource Conservation and Recovery Act. The INL Site is divided into ten Waste Area Groups (WAGs) as a result of the FFA/CO, and each WAG is divided into smaller cleanup areas called operable units. Since the FFA/CO was signed in 1991, the INL Site has cleaned up release sites containing asbestos, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials.

Comprehensive remedial investigation/feasibility studies have been conducted at all WAGs and closeout activities have been completed at six WAGs. In 2016, all institutional controls and operational and maintenance

Table ES-1. Major INL Site Areas and Missions.

Major INL Site Area[a]	Operated By	Mission
Advanced Test Reactor Complex	INL	Research and development of nuclear reactor technologies. Home of the ATR, a DOE Nuclear Science User Facility and the world's most advanced nuclear test reactor.
Central Facilities Area	INL	INL Support for the operation of other INL Site facilities.
Critical Infrastructure Test Range Complex	INL	Supports National and Homeland Security missions of the laboratory, including program and project testing (i.e., critical infrastructure resilience and nonproliferation testing and demonstration).
Idaho Nuclear Technology and Engineering Center	ICP	Dry and wet storage of spent nuclear fuel, management of high-level waste calcine and sodium-bearing liquid waste, and operation of the Idaho Comprehensive Environmental Response, Compensation and Liability Act Disposal Facility including a landfill, evaporation ponds, and a staging and treatment facility.
Materials and Fuels Complex	INL	Focuses on research and development of nuclear fuels. Pyroprocessing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Nuclear batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex	ICP	Environmental remediation; and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. Advanced Mixed Waste Treatment Project (AMWTP) characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities.
Research and Education Campus	INL	Located in Idaho Falls, is home to INL administration, the INL Research Center, the Center for Advanced Energy Studies (CAES), and other energy and security research programs. Research is conducted at IRC in robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. CAES is a research and education partnership between Boise State University, INL, Idaho State University, and University of Idaho to conduct energy research and address the looming nuclear energy work-force shortage.
Test Area North/Specific Manufacturing Capability (SMC)	INL	Several historic nuclear research and development projects were conducted at TAN. Major cleanup and demolition of the facility was completed in 2008 and the current mission is manufacture of tank armor for the U.S. Army's battle tanks at the SMC for the U.S. Department of Defense.

a. The Naval Reactors Facility is also located on the INL Site. It is operated for Naval Reactors by Bechtel Marine Propulsion Corporation. The Naval Nuclear Propulsion Program is exempt from DOE requirements and is therefore not addressed in this report.

requirements were maintained and active remediation continued on WAGs 1, 3, 7, and 10.

RADIATION DOSE TO THE PUBLIC AND BIOTA FROM INL SITE RELEASES

Humans, plants, and animals potentially receive radiation doses from various INL Site operations. The DOE sets dose limits for the public and biota to ensure that exposure to radiation from site operations are not a health concern. Potential radiological doses to the public from INL Site operations were calculated to determine compliance with pertinent regulations and limits (Table ES-2). The calculated dose to the maximally exposed individual in 2016 from the air pathway was 0.0143 mrem (0.143 µSv), well below the 10-mrem standard established by the Clean Air Act. The maximally exposed individual is a hypothetical member of the public who could receive the maximum possible dose from INL Site releases. This person was assumed to live just south of the INL Site boundary. For comparison, the dose from natural background radiation was estimated in 2016 to be 383 mrem (3,830 µSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 327,823 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.00408 person-rem (0.0000408 person-Sv), below that expected from exposure to background radiation (125,556 person-rem or 1,256 person-Sv). The 50-mi population dose calculated for 2016 is approximately 150 times lower than that calculated for 2015 (0.614 person-rem or 0.00614 person-Sv). This is due primarily to a more realistic approach used to assess the dose in 2016, as described in Chapter 8.

The maximum potential individual dose from consuming waterfowl contaminated at the INL Site was not calculated because no samples were collected in 2016 due to the fact that the ATR waste pond lining was being replaced and the area could not be accessed. There were no gamma-emitting radionuclides detected in big game animals sampled in 2016, hence there was no dose associated with consuming big game. The representative person off the INL Site could thus potentially receive a total dose of 0.0143 mrem (0.143 µSv) from air pathways only in 2016. This is 0.0143 percent of the DOE health-based dose limit of 100 mrem/yr (1 mSv/yr) from all pathways for the INL Site.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located along the southern INL Site boundary. A hypothetical

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2016).

	Dose to Maximally Exposed Individual		Percent of DOE 100-mrem/yr Dose Limit[a]	Estimated Population Dose		Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Pathway	**(mrem)**	**(µSv)**		**(person-rem)**	**(person-Sv)**		
Air	0.0143	0.0143	0.143	0.004	0.00004	327,823	125,556
Waterfowl[c]	NA[d]	NA	NA	NA	NA	NA	NA
Big game animals	0	0	NA	0	0	NA	NA
Total pathways	**0.0143**	**0.0143**	**0.0143**	**0.004**	**0.00004**	**NA**	**NA**

a. The DOE limit for all pathways is 100 mrem/yr (1mSv/yr) total effective dose equivalent. For this analysis, it was assumed that the hunter who eats contaminated game animals lives at the same location (Frenchman's Cabin) as the maximally exposed individual

b. The individual dose from background was estimated to be 383 mrem (3.8 mSv) in 2016 (Table 7-5).

c. Waterfowl not collected in 2016.

d. NA = Not applicable

individual drinking water from these wells would receive a dose of less than 0.2 mrem (0.002 mSv) in one year. This is an unrealistic pathway to humans because there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for tritium corresponds to a dose of approximately 4 mrem (0.04 mSv).

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Based on the conservative screening calculations, there is no evidence that INL Site-related radioactivity in soil or water is harming populations of plants or animals.

ENVIRONMENTAL COMPLIANCE

One measure of the achievement of the environmental programs at the INL Site is compliance with applicable environmental regulations, which have been established to protect human health and the environment. INL Site compliance with major federal regulations established for the protection of human health and the environment is presented in Table ES-3.

ENVIRONMENTAL MONITORING OF AIR

Airborne releases of radionuclides from INL Site operations are reported annually in a document prepared in accordance with the Code of Federal Regulations, Title 40, "Protection of the 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." An estimated total of 1,856 curies (6.87×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2016. These airborne releases of radionuclides are reported to comply with regulatory requirements and are considered in the design and conduct of INL Site environmental surveillance activities.

The INL Site environmental surveillance programs, conducted by the INL, ICP Core, and the Environmental Surveillance, Education, and Research (ESER) contractors, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2016, the INL contractor monitored ambient air at 16 locations on INL Site and at five locations off the INL Site. The ICP Core contractor focused on ambient air monitoring of waste management facilities, namely INTEC and the RWMC. The ESER contractor sampled ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at five locations distant from the INL Site.

Air particulate samples were collected weekly by the ESER and INL contractors and biweekly by the ICP Core contractor. These samples were initially analyzed for gross alpha and gross beta activity. The particulate samples were then combined into monthly (ICP Core contractor), or quarterly (ESER and INL contractors) composite samples and were analyzed for gamma-emitting radionuclides, such as cesium-137. Particulate filters were also composited quarterly by the ICP Core and ESER contractors and analyzed for specific alpha- and beta-emitting radionuclides, specifically strontium-90, plutonium-238, plutonium-239/240, and americium-241. Charcoal cartridges were also collected weekly by ESER and INL contractors and analyzed for radioiodine.

All radionuclide concentrations in ambient air samples were below DOE radiation protection standards for air and were within historical measurements. In addition, gross alpha and gross beta concentrations were analyzed statistically, and there were no differences between samples collected on the INL Site, at the INL Site boundary, and off the INL Site. Trends in the data appear to be seasonal in nature and do not demonstrate any INL Site influence. This indicates that INL Site airborne effluents were not measureable in environmental air samples.

The INL contractor collected atmospheric moisture samples at three stations on and two stations off the INL Site. The ESER contractor also collected atmospheric moisture at four offsite locations. In addition, the ESER contractor sampled precipitation at two stations on the INL Site and one location off the INL Site. These samples were all analyzed for tritium. The results were within measurements made historically by the EPA and were below DOE standards. Tritium measured in these samples is most likely the result of natural production in the atmosphere and not the result of INL Site effluent releases.

Table ES-3. Major Federal Regulations Established for Protection of Human Health and the Environment.

Regulator/ Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA/40 CFR 61, Subpart H	The Clean Air Act (CAA) is the basis for national air pollution control. Emissions of radioactive hazardous air pollutants are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutant (NESHAPs), (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in National Emission *Standards for Hazardous Air Pollutants – Calendar Year 2016.*	2.2.1 4.2 8.2.1
DOE/Order 458.1, Change 2	The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires the preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment.	The INL Site maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions does not present risk to the public, workers, or environment. Environmental monitoring plans are well documented and the results are published in the annual INL Site Environmental Report.	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/40 CFR 300	The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites.	Nuclear research and other operations at the INL Site left behind contaminates that pose a potential risk to human health and the environment. In 1991, the DOE-ID entered into a tri-party agreement, the Federal Facility Agreement and Consent Order, with EPA, and the state of Idaho. INL Site remediation is conducted by the Idaho Cleanup Project Core (ICP).	3.2
EPA/40 CFR 109-140	The Clean Water Act (CWA) establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two CWA permits – the National Pollution Discharge Elimination System (NPDES) permits and Storm Water Discharge Permits for construction activity.	2.3.1
EPA/40 CFR 141-143	The Safe Drinking Water Act (SDWA) establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site has 12 active drinking water systems which area routinely sampled and analyzed as required by the state of Idaho and EPA.	6.6 2.3.2
EPA/40CFR 270.13	The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste.	The Idaho Department of Environmental Quality conducted an annual RCRA inspection of the INL Site in 2016 and issued a Warning letter to DOE May17, 2016. There were two apparent violations.	2.1.2

ENVIRONMENTAL MONITORING OF GROUNDWATER, DRINKING, AND SURFACE WATER FOR COMPLIANCE PURPOSES

The INL and ICP contractors monitor liquid effluents, drinking water, groundwater, and storm water runoff at the INL Site, primarily for nonradioactive constituents, to comply with applicable laws and regulations, DOE orders, and other requirements. Wastewater is typically discharged from INL Site facilities to infiltration ponds or to evaporation ponds. Wastewater discharges occur at percolation ponds southwest of INTEC, a cold waste pond at the ATR Complex, and a sewage treatment facility at CFA. DOE-ID complies with the state of Idaho groundwater quality and wastewater rules for these effluents through wastewater reuse permits, which provide for monitoring of the wastewater and, in some instances, groundwater in the area. During 2016, liquid effluent and groundwater monitoring were conducted in support of wastewater reuse permit requirements. An annual report for each permitted facility was prepared and submitted to the Idaho Department of Environmental Quality. No permit limits were exceeded.

Additional liquid effluent monitoring was performed at ATR Complex, CFA, INTEC, and MFC to comply with environmental protection objectives of DOE Orders. Most results were within historical measurements. All radioactive parameters were below health-based contaminant levels.

Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Drinking water was sampled in twelve drinking water systems at the INL Site in 2016. Results were below limits for all relevant drinking water standards. The CFA distribution system serves 500 workers daily and is downgradient from a historic radioactive groundwater plume resulting from past wastewater injection directly into the aquifer. Because of this, a dose was calculated to a worker who might obtain all their drinking water from the CFA drinking water system during 2016. The dose, 0.149 mrem (1.49 µSv), is below the EPA standard of 4 mrem/yr (40 µSv/yr) for public drinking water systems.

Surface water flows off the Subsurface Disposal Area (SDA) following periods of heavy precipitation or rapid snowmelt. During these times, water may be pumped out of the SDA retention basin into a drainage canal, potentially carrying radionuclides originating from radioactive waste or contaminated surface soil off the SDA. Surface water is collected when it is available. Americium-241, plutonium-239/240, and strontium-90 were detected in 2016 samples within historical levels. The detected concentrations are well below standards established by DOE for radiation protection of the public and the environment.

ENVIRONMENTAL MONITORING OF THE EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain aquifer beneath the eastern Snake River Plain is perhaps the single-most important aquifer in Idaho. Composed of layered basalt lava flows and some sediment, it covers an area of approximately 10,800 square miles. The highly productive aquifer has been declared a sole source aquifer by the EPA due to the nearly complete reliance on the aquifer for drinking water supplies in the area.

The USGS began to monitor the groundwater below the INL Site in 1949. Currently, the USGS performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain aquifer under and adjacent to the INL Site. These activities utilize an extensive network of strategically placed monitoring wells on and around the INL Site. In 2016, the USGS continued to monitor localized areas of chemical and radiochemical contamination beneath the INL Site produced by past waste disposal practices, in particular the direct injection of wastewater into the aquifer at INTEC and the ATR Complex. Results for monitoring wells sampled within the plumes show nearly all wells had decreasing trends of tritium and strontium-90 concentrations over time.

Several purgeable (volatile) organic compounds (VOCs) were detected by USGS in 28 groundwater monitoring wells and one perched well sampled at the INL Site in 2016. Most concentrations of the 61 compounds analyzed were either below the laboratory reporting levels or their respective primary contaminant standards. Trend test results for carbon tetrachloride concentrations in water from the RWMC production well indicate a statistically significant increase in concentrations has occurred for the period 1987-2015; however, trend analyses for the data collected from 2005-2015 show a decreasing trend in the RWMC production well. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect. Trichloroethene (TCE) was measured in another well at

TAN within the plume, which was expected as there is a known groundwater plume at this location.

Groundwater surveillance monitoring continued for the Comprehensive Environmental Response, Compensation, and Liability Act WAGs on the INL Site in 2016. At TAN (WAG 1), groundwater monitoring continues to monitor the progress of remediation of the plume of TCE. Remedial action consists of three components: in situ bioremediation; pump and treat; and monitored natural attenuation.

Data from groundwater in the vicinity of the ATR Complex (WAG 2) show no concentrations of chromium, strontium-90, and tritium above their respective maximum drinking water contaminant levels established by the EPA.

Groundwater samples were collected from 18 aquifer monitoring wells at and near INTEC (WAG 3) during 2016. Stronium-90, technetium-99, total dissolved solids, and nitrate exceeded their respective drinking water maximum contaminant levels in one or more aquifer monitoring wells at or near INTEC, with strontium-90 exceeding its minimum contaminant level by the greatest margin but at levels similar or slightly lower than those reported in previous samples.

Monitoring of groundwater at WAG 4 consists of CFA landfill monitoring and monitoring of a nitrate plume south of the CFA. Wells at the landfills were monitored in 2016 for metals (filtered), volatile organic compounds, and anions (nitrate, chloride, fluoride, and sulfate). These contaminants were either not detected or below their respective primary drinking water standards except that nitrate continued to exceed the EPA maximum contaminant level in one well in the plume south of the CFA in 2016, and overall the data show a downward trend since 2006.

Groundwater monitoring has not been conducted at WAG 5 since 2006. Independent groundwater monitoring in the vicinity of WAG 6 is not performed.

At the RWMC (WAG 7), carbon tetrachloride, carbon-14, TCE and inorganic analytes were detected at several locations. Only carbon tetrachloride exceeded the EPA maximum contaminant level in one aquifer well northeast of the facility. In general, constituents of concern in the aquifer at RWMC are relatively stable or trending slightly downward.

Wells at the MFC (WAG 9) were sampled for radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters. Overall, the results show no evidence of impacts from MFC activities.

Drinking water and surface water samples were sampled downgradient of the INL Site and analyzed for gross alpha and beta activity, and tritium. Tritium was detected in some samples at levels within historical measurements and below the EPA maximum contaminant level for tritium. Gross alpha and beta results were within historical measurements and the gross beta activity was well below the EPA's screening level. The data appear to show no discernible impacts from activities at the INL Site.

MONITORING OF AGRICULTURAL PRODUCTS, WILDLIFE, AND DIRECT RADIATION MEASUREMENTS

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, grain, and potatoes) and wildlife were sampled and analyzed for radionuclides in 2016. The agricultural products were collected on, around and distant from the INL Site by the ESER contractor.

Wildlife sampling included collection of big game animals killed by vehicles on roads within the INL Site. No waterfowl were sampled from INL Site wastewater ponds in 2016. In addition, direct radiation was measured on and off the INL Site in 2016. Some human-made radionuclides were detected in agricultural products. However, measurements were consistent with those made historically.

Strontium-90, a radionuclide measured in fallout, was detected at low levels in most lettuce samples collected locally. No gamma-emitting radionuclides were detected in the five big game animals sampled in 2016.

Direct radiation measurements made at offsite, boundary, and onsite locations were consistent with historical and/or natural background levels.

MONITORING OF WILDLIFE POPULATIONS

Field data are routinely collected on several key groups of wildlife at the INL Site for information that can be used to prepare National Environmental Policy Act documents and to enable DOE to make informed decisions for planning projects and compliance with environmental policies and executive orders related to protection of wildlife. Surveys are routinely conducted on bird, big game, and bat populations on the INL Site. Monitoring in 2016 included the midwinter eagle survey, sage-grouse lek surveys, and a breeding bird survey. During 2016, permanent bat monitoring stations continued to be monitored at the INL Site.

Notable results from the 2016 surveys were discovery of three new sage-grouse leks, the reclassification of two known sage-grouse leks as inactive, the highest mid-winter count of golden eagles since 2006, a continuing upward trend in the number of ravens and raven nests, and that passive acoustic monitoring at long-term stations operating at caves and facilities is revealing patterns of bat activity across the INL Site.

ENVIRONMENTAL RESEARCH AT THE INL SITE

In 1975, the mostly pristine land within the INL Site's borders became DOE's second National Environmental Research Park. All lands within the Park serve as an ecological field laboratory where scientists from government agencies, universities, and private foundations may set up long-term research. This research has covered a broad range of topics and issues from studies on the basic ecology of native sagebrush steppe organisms to the potential natural pathways of radiological materials through the environment, and even to highly applied research on the design of landfill covers that prevent water from reaching buried waste. The research topics have included native plants and wildlife as well as attempts to understand and control non-native, invasive species. The Park also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The Idaho National Environmental Research Park maintains several regionally and nationally important long-term ecological data sets. It is home to one of the largest data sets on sagebrush steppe vegetation anywhere. In 1950, 100 long-term vegetation plots were established on the INL Site and were originally designed to look for the potential effects of nuclear energy research on native vegetation. Since then, the plots have been surveyed about every five to seven years.

In 2016 ecological research and monitoring projects included the collection of data at 89 active long-term vegetation plots for the thirteenth time; sagebrush habitat monitoring and restoration; studies of ants and ant guests at the INL Site; and studies of ecosystem responses of sagebrush steppe to altered precipitation, vegetation, and soil properties.

USGS RESEARCH

The USGS INL Project Office drills and maintains research wells which provide information about subsurface water, rock and sediment, and contaminant movement in the eastern Snake River Plain aquifer at and near the INL Site. In 2016, the USGS published six research reports.

QUALITY ASSURANCE

Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to help provide confidence in the data and ensure data completeness. Programs involved in environmental monitoring developed quality assurance programs and documentation which follow requirements and criteria established by DOE. Environmental monitoring programs implemented quality assurance program elements through quality assurance project plans developed for each contractor.

Adherence to procedures and quality assurance project plans was maintained during 2016. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To ensure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP Core, and ESER contractors during 2016 were addressed with the laboratories and have been or are being resolved.

Helpful Information

Much of the Annual Site Environmental Report deals with radioactivity levels measured in environmental media, such as air, water, soil, and plants. The following information is intended for individuals with little or no familiarity with radiological data or radiation dose. It presents terminology and concepts used in the Annual Site Environmental Report to aid the reader.

WHAT IS RADIATION?

Matter is composed of atoms. Some atoms are energetically unstable and change to become more stable. During this transformation, unstable or radioactive atoms give off energy called “radiation” in the form of particles or electromagnetic waves. Generally, we refer to the various radioactive atoms as radionuclides. The radiation released by radionuclides has enough energy to eject electrons from other atoms it encounters. The resulting charged atoms or molecules are called ions, and the energetic radiation that produced the ions is called ionizing radiation. Ionizing radiation is referred to simply as “radiation” in the rest of this report. The most common types of radiation are alpha particles, beta particles, X-rays, and gamma-rays. X-rays and gamma-rays, just like visible light and radiowaves, are packets of electromagnetic radiation. Collectively, packets of electromagnetic radiation are called photons. One may, for instance, speak of X-ray photons or gamma-ray photons.

Alpha Particles. An alpha particle is a helium nucleus without orbital electrons. It is composed of two protons and two neutrons and has a positive charge of plus two. Because alpha particles are relatively heavy and have a double charge, they cause intense tracks of ionization, but have little penetrating ability (Figure HI-1). Alpha particles can be stopped by thin layers of materials, such as a sheet of paper or piece of aluminum foil. Alpha particles can be detected in samples containing radioactive atoms of radon, uranium, plutonium, and americium.

Beta Particles. Beta particles are electrons that are ejected from unstable atoms during the transformation or decay process. Beta particles penetrate more than alpha particles but are less penetrating than X-rays or gamma-rays of equivalent energies. A piece of wood or a thin block of plastic can stop beta particles (Figure HI-1). The ability of beta particles to penetrate matter increases with energy. Examples of beta-emitting radionuclides include tritium (^{3}H) and radioactive strontium.

X-Rays and Gamma-Rays. X-rays and gamma-rays are photons that have very short wavelengths compared to other electromagnetic waves, such as visible light, heat rays, and radio waves. Gamma-rays and X-rays have identical properties, behavior, and effects, but differ only in their origin. Gamma-rays originate from an atomic nucleus, and X-rays originate from

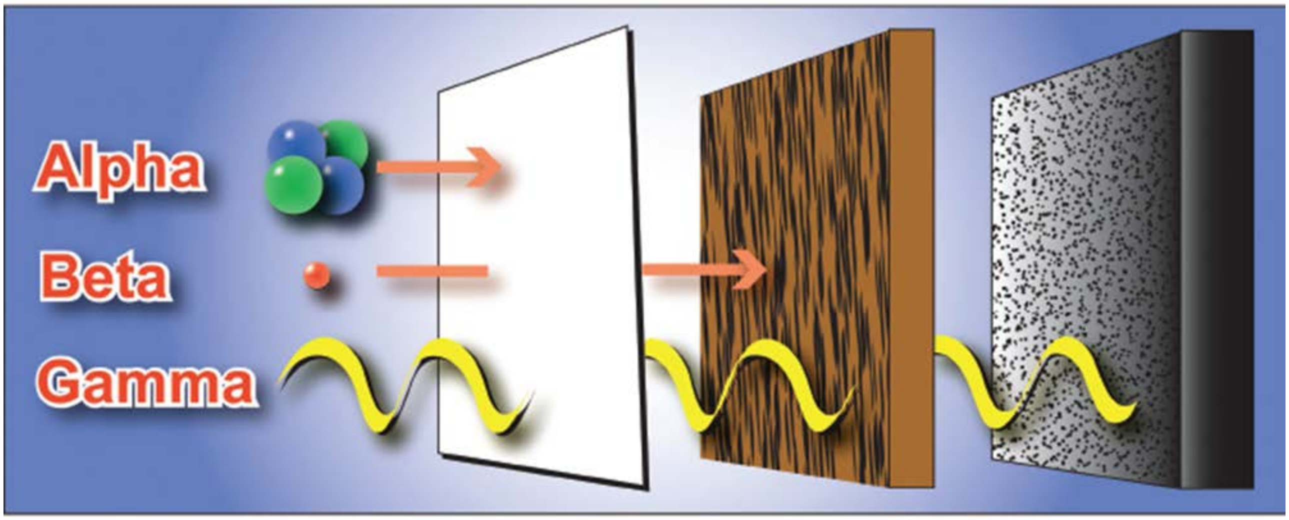


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

interactions with the electrons orbiting around atoms. All photons travel at the speed of light. Their energies, however, vary over a large range. The penetration of X-ray or gamma-ray photons depends on the energy of the photons, as well as the thickness, density, and composition of the shielding material. Concrete is a common material used to shield people from gamma-rays and X-rays (Figure HI-1).

Examples of gamma-emitting radionuclides include radioactive atoms of iodine and cesium. X-rays may be produced by medical X-ray machines in a doctor's office.

HOW ARE RADIONUCLIDES DESIGNATED?

Radionuclides are frequently expressed with a one or two letter abbreviation for the element and a superscript to the left of the symbol that identifies the atomic weight of the isotope. The atomic weight is the number of protons and neutrons in the nucleus of the atom. Most radionuclide symbols used in this report are shown in Table HI-1. The table also shows the half-life of each radionuclide. Half-life refers to the time in which one-half of the atoms of a radioactive sample transforms or decays in the quest to achieve a more energetically stable nucleus. Most radionuclides do not decay directly to a stable element, but rather undergo a series of decays until a stable element is reached. This series of decays is called a decay chain.

HOW ARE RADIOACTIVITY AND RADIONUCLIDES DETECTED?

Environmental samples of air, water, soil, and plants are collected in the field and then prepared and analyzed for radioactivity in a laboratory. A prepared sample is placed in a radiation counting system with a detector that converts the ionization produced by the radiation into electrical signals or pulses. The number of electrical pulses recorded over a unit of time is called a count rate. The count rate is proportional to the amount of radioactivity in the sample.

Air and water samples are often analyzed to determine the total amount of alpha and beta-emitting radioactivity present. This is referred to as a gross measurement because the radiation from all alpha-emitting and beta-emitting radionuclides in the sample is quantified. Such sample analyses measure both human-generated and naturally occurring radioactive material. Gross alpha and beta analyses are generally considered screening measurements, since specific radionuclides are not identified. The amount of gross alpha and beta-emitting radioactivity in air samples is frequently measured to screen for the potential presence of manmade radionuclides. If the results are higher than normal, sources other than background radionuclides may be suspected, and other laboratory techniques may be used to identify the specific radionuclides in the sample. Gross alpha and beta activity also can be examined over time and between locations to detect trends.

The low penetration ability of alpha-emitting particles makes detection by any instrument difficult. Identifying specific alpha-emitting radionuclides typically involves chemical separations in the laboratory to purify the sample prior to analysis with an alpha detection instrument. Radiochemical analysis is very time consuming and expensive.

Beta particles are easily detected by several types of instruments, including the common Geiger-Mueller (GM) counter. However, detection of specific beta-emitting radionuclides, such as tritium-3 (^{3}H) and strontium-90 (^{90}Sr), requires chemical separation first.

The high-energy photons from gamma-emitting radionuclides are relatively easy to detect. Because the photons from each gamma-emitting radionuclide have a characteristic energy, gamma emitters can be simply identified in the laboratory with only minimal sample preparation prior to analysis. Gamma-emitting radionuclides, such as cesium-137 (^{137}Cs), can even be measured in soil by field detectors called in-situ detectors.

Gamma radiation originating from naturally occurring radionuclides in soil and rocks on the earth's surface is a primary contributor to the background external radiation exposure measured in air. Cosmic radiation from outer space is another contributor to the external radiation background. External radiation is easily measured with devices known as environmental dosimeters.

HOW ARE RESULTS REPORTED?

Scientific Notation. Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very large. A very small number may be expressed with a negative exponent, for example, 1.3

Table HI-1. Radionuclides and Their Half-lives.

Symbol	Radionuclide	Half-life[a,b]	Symbol	Radionuclide	Half-life
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.12 d
^{243}Am	Americium-243	7,370 yr	^{59}Ni	Nickel-59	7.6 x 10^4 yr
^{125}Sb	Antimony-125	2.77 yr	^{63}Ni	Nickel-63	100.1 yr
^{41}Ar	Argon-41	1.822 hr	^{238}Pu	Plutonium-238	87.7 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.4110 x 10^4 yr
^{140}Ba	Barium-140	12.752 d	^{240}Pu	Plutonium-240	6.564 x 10^3 yr
^{7}Be	Beryllium-7	53.3 d	^{241}Pu	Plutonium-241	14.35 yr
^{14}C	Carbon-14	5,730 yr	^{242}Pu	Plutonium-242	3.7633 x 10^5 yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.28 x 10^9 yr
^{144}Ce	Cerium-144	284.9 d	^{226}Ra	Radium-226	1.60 x 10^3 yr
^{134}Cs	Cesium-134	2.065 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.04 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.703 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.271 yr	^{103}Ru	Ruthenium-103	39.26 d
^{152}Eu	Europium-152	13.537 yr	^{106}Ru	Ruthenium-106	73.59 d
^{154}Eu	Europium-154	8.593 yr	^{90}Sr	Strontium-90	28.74 yr
^{3}H	Tritium	12.33 yr	^{99}Tc	Technetium-99	2.111 x 10^5 yr
^{129}I	Iodine-129	1.57 x 10^7 yr	^{232}Th	Thorium-232	1.41 x 10^{10} yr
^{131}I	Iodine-131	8.021 d	^{233}U	Uranium-233	1.592 x 10^5 yr
^{55}Fe	Iron-55	2.73 yr	^{234}U	Uranium-234	2.457 x 10^5 yr
^{59}Fe	Iron-59	44.503 d	^{235}U	Uranium-235	7.038 x 10^8 yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468 x 10^9 yr
^{87}Kr	Krypton-87	1.272 hr	^{90}Y	Yttrium-90	64.1 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	244.26 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	64.02 d

a. From: http://hps.org/publicinformation/radardecaydata.cfm

b. d = days; hr = hours; min = minutes; s = seconds; yr = years

x 10^{-6}. To convert this number to its decimal form, the decimal point is moved left by the number of places equal to the exponent (six, in this case). The number 1.3 x 10^{-6} may also be expressed as 0.0000013. When considering large numbers with a positive exponent, such as 1.0 x 10^6, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0 x 10^6 represents one million and may also be written as 1,000,000.

Unit Prefixes. Units for very small and very large numbers are often expressed with a prefix. One common example is the prefix kilo (abbreviated k), which means 1,000 of a given unit. One kilometer, therefore, equals 1,000 meters. Table HI-2 defines the values of commonly used prefixes.

Units of Radioactivity. The basic unit of radioactivity used in this report is the curie (abbreviated Ci). The curie is based on the disintegration rate occurring in 1 gram of the radionuclide radium-226, which is 37 billion (3.7 x 10^{10}) disintegrations per second (becquerels). For any other radionuclide, 1 Ci is the amount of the radionuclide that produces this same decay rate.

Table HI-2. Multiples of Units.

Multiple	Decimal Equivalent	Prefix	Symbol
10^6	1,000,000	mega-	M
10^3	1,000	kilo-	k
10^2	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	µ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.000000000000000001	atto-	a

Units of Exposure and Dose (Table HI-3). Exposure, or the amount of ionization produced by gamma or X-ray radiation in air, is measured in terms of the roentgen (R). Dose is a general term to express how much radiation energy is deposited in something. The energy deposited can be expressed in terms of absorbed, equivalent, and/or effective dose. The term rad, which is short for radiation absorbed dose, is a measure of the energy absorbed in an organ or tissue. The equivalent dose, which takes into account the effect of different types of radiation on tissues and therefore the potential for biological effects, is expressed as the roentgen equivalent man or “rem.” Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of “effective dose” was developed.

The Système International (SI) is the official system of measurement used internationally to express units of radioactivity and radiation dose. The basic SI unit of radioactivity is the Becquerel (Bq), which is equivalent to one nuclear disintegration per second. The number of curies must be multiplied by 3.7 x 10^{10} to obtain the equivalent number of becquerels. The concept of dose may also be expressed using the SI units, Gray (Gy) for absorbed dose (1 Gy = 100 rad) and sievert (Sv) for effective dose (1 Sv = 100 rem).

Concentrations of Radioactivity in Environmental Sample Media. Table HI-4 shows the units used to identify the concentration of radioactivity in various sample media.

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the true value of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value which is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). For concentrations of greater than or equal to three times the uncertainty, there is 95 percent probability that the radionuclide was detected in a sample. For example, if a radionuclide is reported for a sample at a concentration of 10 ± 2 pCi/L, that radionuclide is considered to be detected in that sample because 10 is greater than 3 × 2 or 6. On the other hand, if the reported concentration of a radionuclide (e.g., 10 ± 6 pCi/L) is smaller than three times its associated uncertainty, then the sample probably does not contain that radionuclide (i.e., 10 is less than 3 × 6 or 18). Such low concentrations are considered to be undetected by the method and/or instrumentation used.

Table HI-3. Names and Symbols for Units of Radioactivity and Radiological Dose Used in this Report.

Symbol	Name
Bq	Becquerel
Ci	Curie (37,000,000,000 Bq)
mCi	Millicurie (1×10^{-3} Ci)
µCi	Microcurie (1×10^{-6} Ci)
mrad	Millirad (1×10^{-3} rad)
mrem	Millirem (1×10^{-3} rem)
R	Roentgen
mR	Milliroentgen (1×10^{-3} R)
µR	Microroentgen (1×10^{-6} R)
Sv	Sievert (100 rem)
mSv	Millisievert (100 mrem)

Table HI-4. Units of Radioactivity.

Media	Unit
Air	Microcuries per milliliter (µCi/mL)
Liquid, such as water and milk	Picocuries per liter (pCi/L)
Soil and agricultural products	Picocuries per gram (pCi/g) dry weight
Annual human radiation exposure, measured by environmental dosimeters	Milliroentgens (mR) or millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor

Mean, Median, Maximum, and Minimum Values. Descriptive statistics are often used to express the patterns and distribution of a group of results. The most common descriptive statistics used in this report are the mean, median, minimum, and maximum values. Mean and median values measure the central tendency of the data. The mean is calculated by adding up all the values in a set of data and then dividing that sum by the number of values in the data set. The median is the middle value in a group of measurements. When the data are arranged from largest (maximum) to smallest (minimum), the result in the exact center of an odd number of results is the median. If there is an even number of results, the median is the average of the two central values. The maximum and the minimum results represent the range of the measurements.

Statistical analysis of many of the air data reported in this annual report indicate that the median is a more appropriate representation of the central tendency of those results. For this reason, some of the figures present the median value of a data group. For example, Figure HI-2 illustrates the minimum, maximum, and median of a set of air measurements. The vertical lines drawn above and below the median represent the range of values between the minimum and maximum results.

HOW ARE DATA REPRESENTED GRAPHICALLY?

Charts and graphs often are used to compare data and to visualize patterns, such as trends over time. Four kinds of graphics are used in this report to represent data: pie charts, column graphs, line plots, and contour lines.

A ***pie chart*** is used in this report to illustrate fractions of a whole. For example, Figure HI-3 shows the approximate contribution to dose that a typical

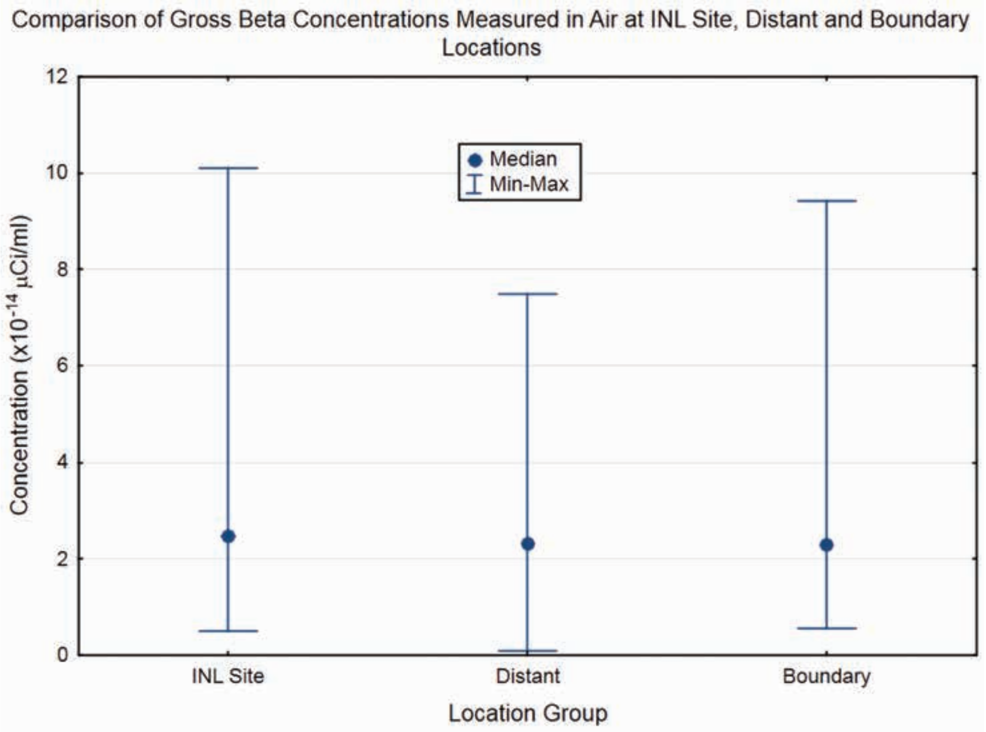
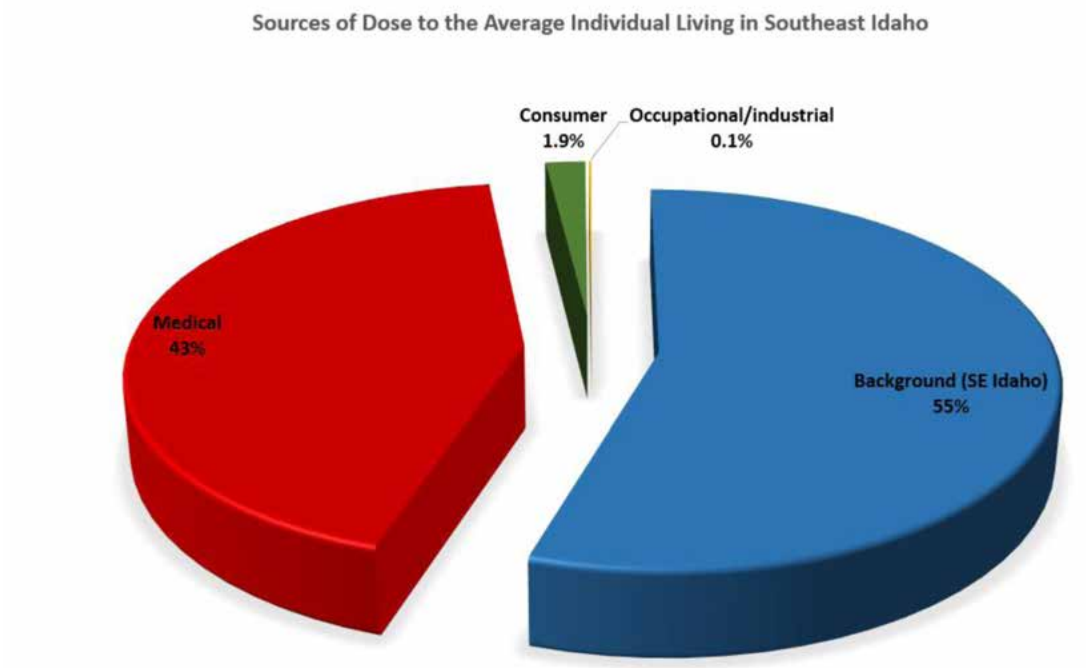


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.



	Effective dose (mrem)	% of Total
Background	383	55
Medical	300	43
Consumer	13	1.9
Occupational/industrial	0.8	0.1
TOTAL	697	100

Figure HI-3. Data Presented Using a Pie Chart.

person might receive while living in southeast Idaho. The percentages are derived from the table in the lower left-hand corner of the figure. The medical, consumer, and occupational/industrial portions are from National Council on Radiation Protection and Measurements Report No. 160 (NCRP 2009). The contribution from background (natural radiation, mostly radon) is estimated in Table 7-4 of this report.

A ***column or bar chart*** can show data changes over a period of time or illustrate comparisons among items. Figure HI-4 illustrates the maximum dose (mrem) calculated for the maximally exposed individual from 2007 through 2016. The maximally exposed individual is a hypothetical member of the public who is exposed to radionuclides from airborne releases through various environmental pathways and the media through which the radionculides are transported (i.e., air, water, and food). The chart shows the general decreasing trend of the dose over time.

A ***plot*** can be useful to visualize differences in results over time. Figure HI-5 shows the strontium-90 measurements in three wells collected by USGS for 21 years (1996–2016). The results are plotted by year. The plot shows a decreasing trend with time.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of tritium in groundwater around the Idaho Nuclear Technology and Engineering Center (INTEC). Each contour line, or isopleth, represents a specific concentration of the radionuclide in groundwater. It was estimated from measurements of samples collected from wells around INTEC. Each contour line separates areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of

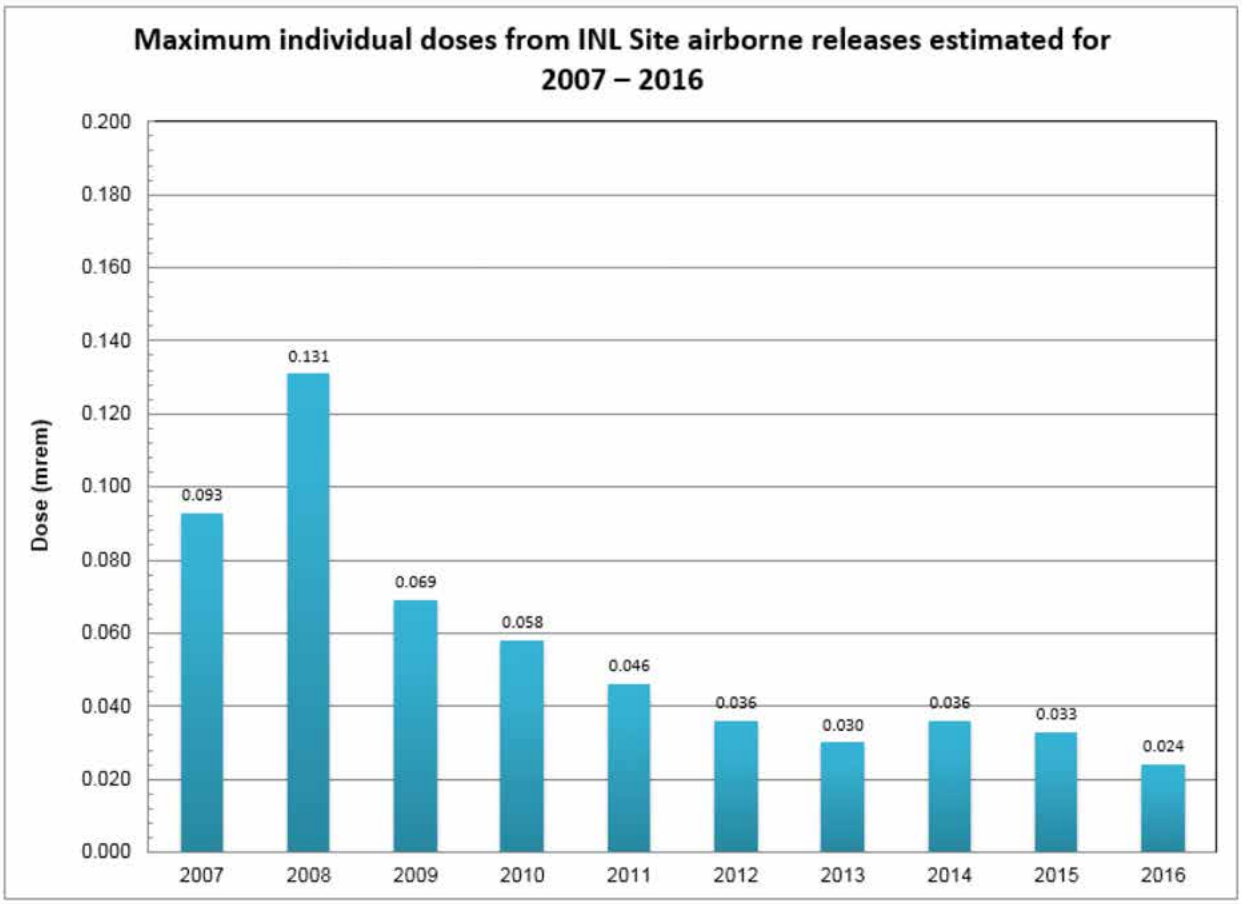


Figure HI-4. Data Plotted Using a Column Chart.

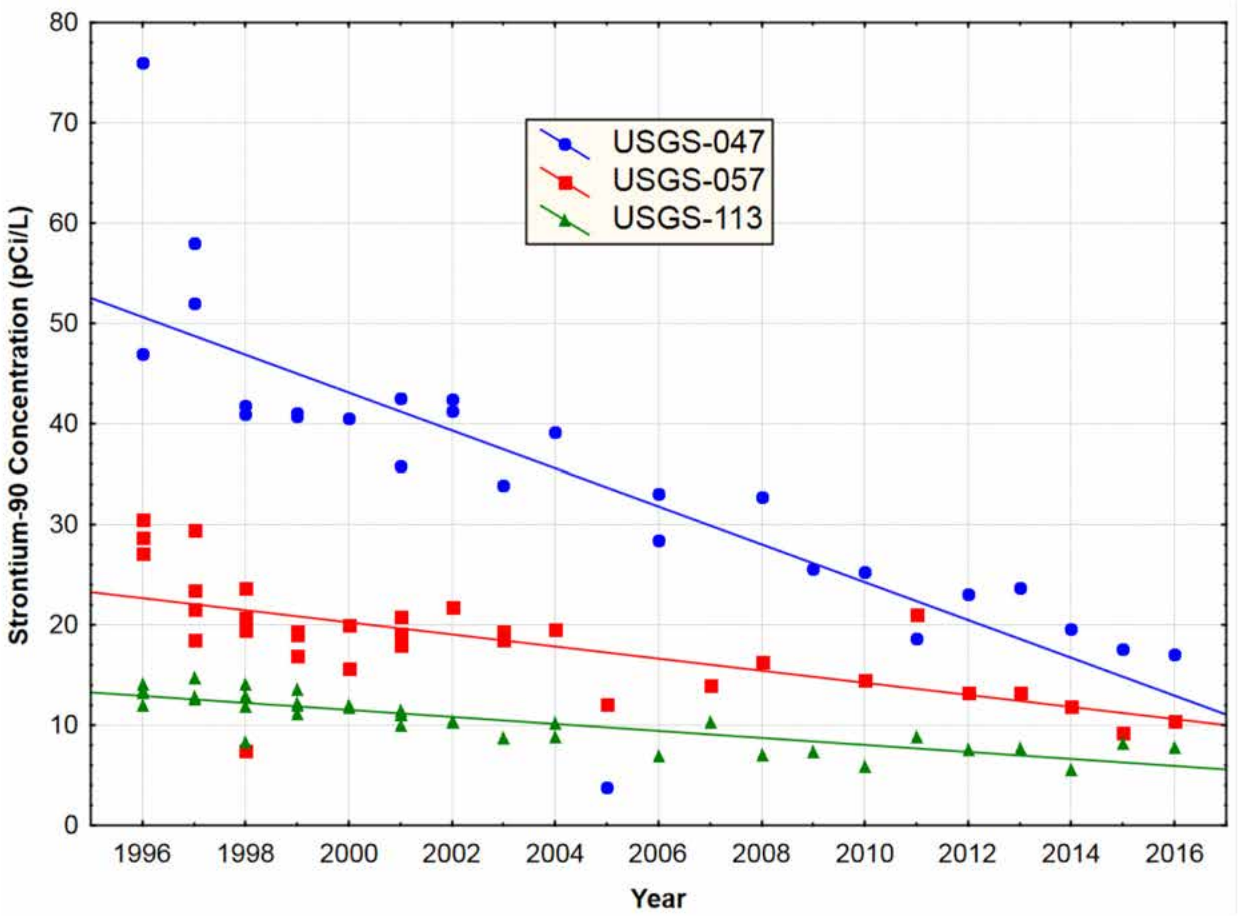


Figure HI-5. Data Plotted Using a Linear Plot.

the radionuclide in groundwater from INTEC where it as injected into the aquifer in the past.

HOW ARE RESULTS INTERPRETED?

To better understand data, results are compared in one or more ways, including:

- Comparison of results collected at different locations. For example, measurements made at INL Site locations are compared with those made at locations near the boundary of the INL Site and distant from the INL Site to find differences that may indicate an impact (Figure HI- 2).

- Trends over time or space. Data collected during the year can be compared with data collected at the same location or locations during previous years to see if concentrations are increasing, decreasing, or remaining the same with time. See, for example, Figure HI-4, which shows a general decrease in dose over time. Figure HI-6 illustrates a clear spatial pattern of radionuclide concentrations in groundwater decreasing with distance from the source.

- Comparison with background measurements. Humans are now, and always have been, continuously exposed to ionizing radiation from natural background sources. Background sources include natural radiation and radioactivity as well as radionuclides from human activities. These sources are discussed in the following section.

WHAT IS BACKGROUND RADIATION?

Radioactivity from natural and fallout sources is detectable as background in all environmental media. Natural sources of radiation include: radiation of extraterrestrial origin (called cosmic rays), radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides), and radionuclides present at the time of the formation of the earth (called primordial radionuclides). Radiation

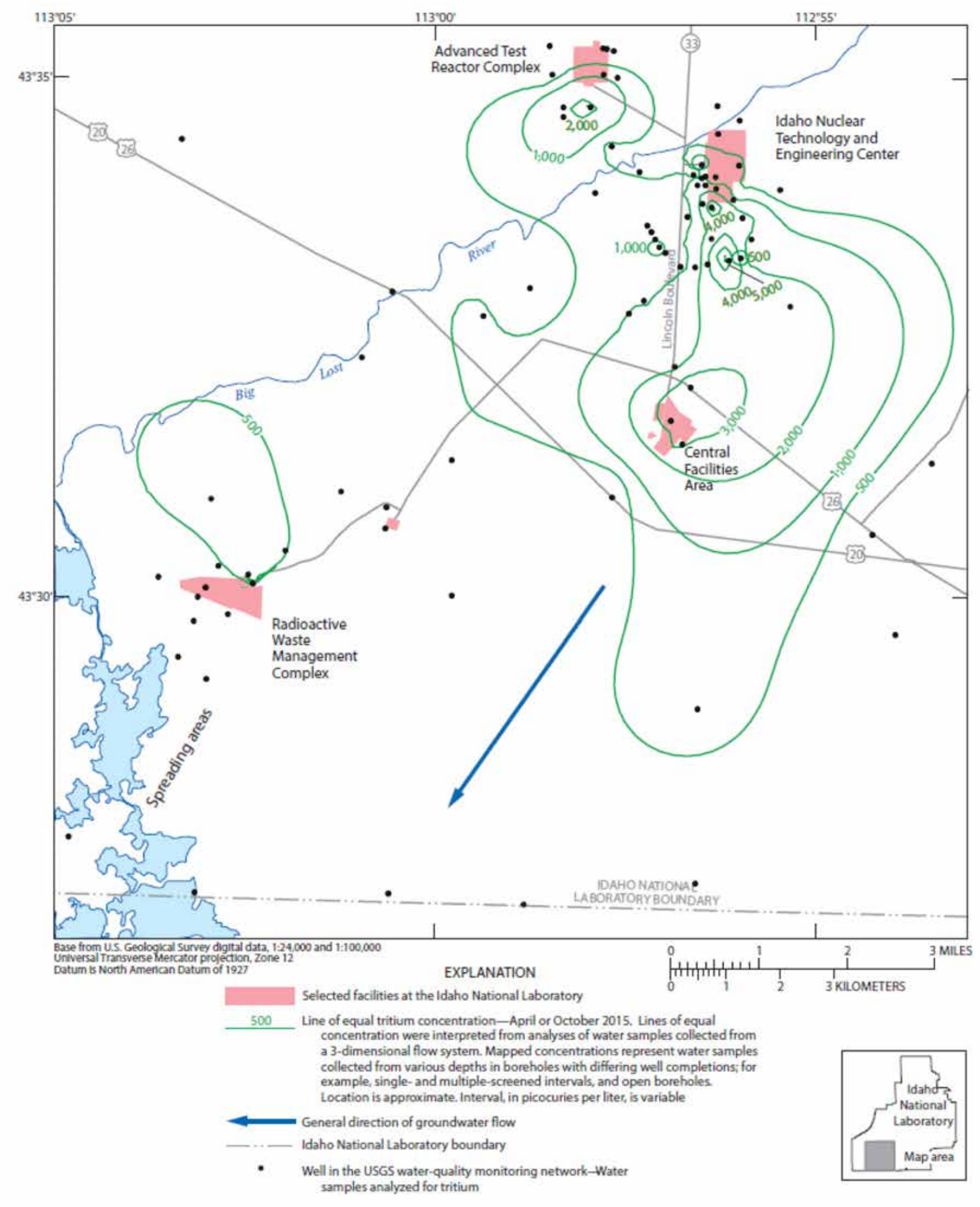


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal tritium concentration in water samples collected at the same depth from wells on the INL Site.

that has resulted from the activities of modern man is primarily fallout from past atmospheric testing of nuclear weapons. One of the challenges to environmental monitoring on and around the INL Site is to distinguish between what may have been released from the INL Site and what is already present in background from natural and fallout sources. These sources are discussed in more detail below.

Natural Sources. Natural radiation and radioactivity in the environment, that is natural background, represent a major source of human radiation exposure (NCRP 1987, 2009). For this reason, natural radiation frequently is used as a standard of comparison for exposure to various human-generated sources of ionizing radiation. An individual living in southeast Idaho was estimated in 2016 to receive an average dose of about 383 mrem/yr (3.8 mSv/yr) from natural background sources of radiation on earth (Figure HI-7). These sources include cosmic radiation and naturally occurring radionuclides.

Cosmic radiation is radiation that constantly bathes the earth from extraterrestrial sources. The atmosphere around the earth absorbs some of the cosmic radiation, so doses are lowest at sea level and increase sharply with altitude. Cosmic radiation is estimated, using data in NCRP (2009), to produce a dose of about 57 mrem/yr (0.57 mSv/yr) to a typical individual living in southeast Idaho (Figure HI-7). Cosmic radiation also produces cosmogenic radionuclides, which are found naturally in all environmental media and are discussed in more detail below.

Naturally occurring radionuclides are of two general kinds: cosmogenic and primordial. Cosmogenic radionuclides are produced by the interaction of cosmic radiation within the atmosphere or in the earth. Cosmic rays have high enough energies to blast apart atoms in the earth's atmosphere. The result is the continuous production of radionuclides, such as ^{3}H, beryllium-7 (^{7}Be), sodium-22 (^{22}Na), and carbon-14 (^{14}C). Cosmogenic radionuclides, particularly ^{3}H and ^{14}C, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. Concentrations are generally higher at mid-latitudes than at low- or high-latitudes. Cosmogenic radionuclides contribute only about 1 mrem/yr to the total average dose, mostly from ^{14}C, that might be received by an adult living in the United States (NCRP 2009). Tritium and ^{7}Be are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site (Table HI-5), but contribute little to the dose which might be

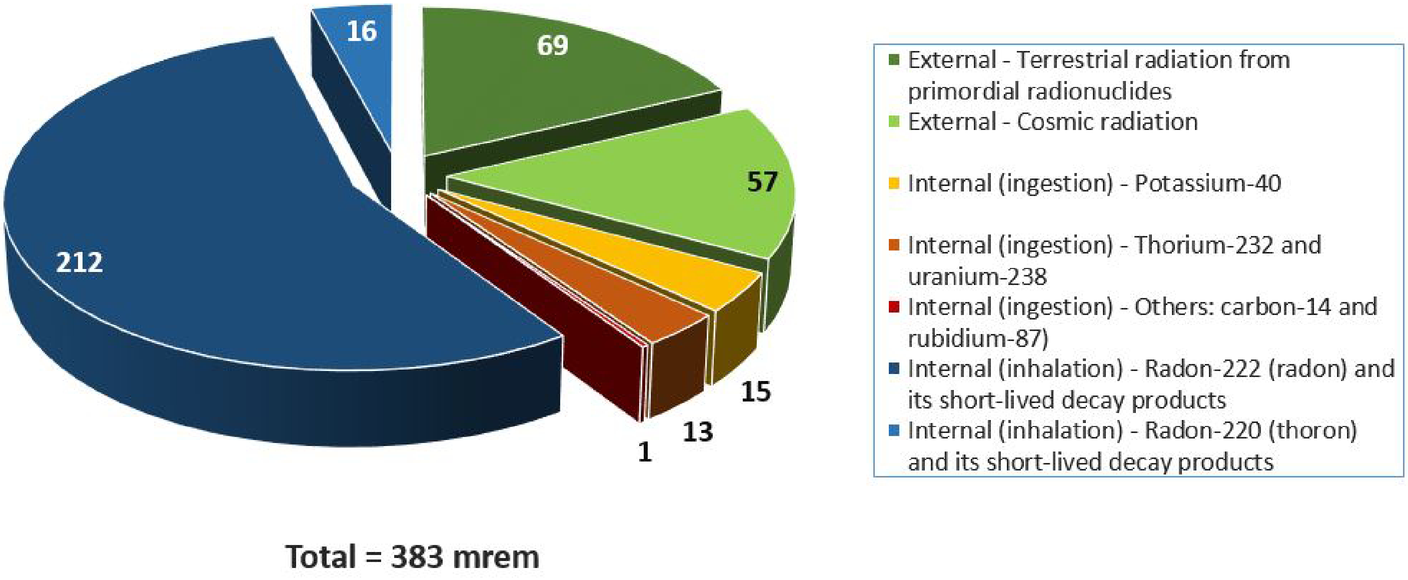


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2016).

received from natural background sources.

Primordial radionuclides are those that were present when the earth was formed. The primordial radionuclides detected today are billions of years old. The radiation dose to a person from primordial radionuclides comes from internally deposited radioactivity, inhaled radioactivity, and external radioactivity in soils and building materials. Three of the primordial radionuclides, potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th), are responsible for most of the dose received by people from natural background radioactivity. They have been detected in environmental samples collected on and around the INL Site (Table HI-5). The external dose to an adult living in southeast Idaho from terrestrial natural background radiation exposure (74 mrem/yr or 0.74 mSv/yr) has been estimated using concentrations of ^{40}K, ^{238}U, and ^{232}Th measured in soil samples collected from areas surrounding the INL Site from 1976 through 1993. This number varies slightly from year to year based on the amount of snow cover. Uranium-238 and ^{232}Th are also estimated to contribute 13 mrem/yr (0.13 mSv/yr) to an average adult through ingestion (NCRP 2009).

Potassium-40 is abundant and measured in living and nonliving matter. It is found in human tissue and is a significant source of internal dose to the human body (approximately 15 mrem/yr [0.15 mSv/yr] according to NCRP [2009]). Rubidium-87 (^{87}Rb), another primordial radionuclide, contributes a small amount (< 1 mrem/yr) to the internal dose received by people but is not typically measured in INL Site samples.

Uranium-238 and ^{232}Th each initiate a decay chain of radionuclides. A radioactive decay chain starts with one type of radioactive atom called the parent that decays and changes into another type of radioactive atom called a progeny radionuclide. This system repeats, involving several different radionuclides. The parent radionuclide of the uranium decay chain is ^{238}U. The most familiar element in the uranium series is radon, specifically radon-222 (^{222}Rn). This is a gas that can accumulate in buildings. Radon and its progeny are responsible for most of the inhalation dose (an average of 200 mrem/yr [2.0 mSv/yr] nationwide) produced by naturally occurring radionuclides (Figure HI-7).

The parent radionuclide of the thorium series is ^{232}Th. Another isotope of radon (^{220}Rn), called thoron, occurs in the thorium decay chain of radioactive atoms. Uranium-238, ^{232}Th, and their progeny often are detected in environmental samples (Table HI-5).

Global Fallout. The United States, the USSR, and China tested nuclear weapons in the atmosphere in the 1950s and 1960s, which resulted in the release of radionuclides into the upper atmosphere. This is referred to as fallout from weapons testing. Concerns over worldwide fallout rates eventually led to the Partial Test Ban Treaty in 1963, which limited signatories to underground testing. Not all countries stopped atmospheric testing, though. France continued atmospheric testing until 1974, and China until 1980. Additional fallout, but to a substantially smaller extent, was produced by the Chernobyl and Fukushima nuclear accidents in 1986 and 2011, respectively.

Table HI-5. Naturally Occurring Radionuclides that Have Been Detected in Environmental Media Collected on and around the INL Site.

Radionuclide	Half-life	How Produced?	Detected or Measured in:
Beryllium-7 (^{7}Be)	53.3 da	Cosmic rays	Rain, air
Tritium (^{3}H)	12.33 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.28×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.41×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.468×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.457×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,600 yr	^{238}U progeny	Water

Most of the radionuclides associated with nuclear weapons testing and the Chernobyl and Fukushima accidents have decayed and are no longer detected in environmental samples. Radionuclides that are currently detected in the environment and typically associated with global fallout include ^{90}Sr and ^{137}Cs. Strontium-90, a beta-emitter with a 29-year half-life, is important because it is chemically similar to calcium and tends to lodge in bone tissues. Cesium-137, which has a 30-year half-life, is chemically similar to potassium, and accumulates rather uniformly in muscle tissue throughout the body.

The deposition of these radionuclides on the earth's surface varies by latitude, with most occurring in the northern hemisphere at approximately 40^{o}. Variation within latitudinal belts is a function primarily of precipitation, topography, and wind patterns. The dose produced by global fallout from nuclear weapons testing has decreased steadily since 1970. The annual dose rate from fallout was estimated in 1987 to be less than 1 mrem (0.01 mSv) (NCRP 1987). It has been nearly 30 years since that estimate, so the current dose is even lower.

WHAT ARE THE RISKS OF EXPOSURE TO LOW LEVELS OF RADIATION?

Radiation protection standards for the public have been established by state and federal agencies based mainly on recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). The ICRP is an association of scientists from many countries, including the United States. The NCRP is a nonprofit corporation chartered by Congress. Through radiation protection standards, exposure of members of the general public to radiation is controlled so that risks are small enough to be considered insignificant compared to the risks undertaken during other activities deemed normal and acceptable in modern life.

Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. There are a large amount of data showing the effects of receiving high doses of radiation, especially in the range of 50 to 400 rem (0.5 to 4.0 Sv), delivered acutely (all at once.) These are largely data resulting from studies of the survivors of the Japanese atomic bombing and of some relatively large groups of patients who were treated with substantial doses of X-rays.

It is difficult to estimate risks from low levels of radiation. Low-dose effects are those that might be caused by doses of less than 20 rem (0.2 Sv), whether delivered acutely or spread out over a period as long as a year (Taylor 1996). Most of the radiation exposures that humans receive are very close to background levels. Moreover, many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its effects. For this reason, government agencies make the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of health effects. Cancer is considered by most scientists to be the primary health effect from long-term exposure to low levels of radiation.

Each radionuclide represents a somewhat different health risk. However, health physicists (radiation protection professionals) currently estimate that overall, if each person in a group of 10,000 people is exposed to 1 gray (100 rad) of ionizing radiation in small doses over a lifetime, we would expect 580 people to die of cancer than would otherwise (EPA 2011). For low-LET radiation (i.e., beta and gamma radiation) the dose equivalent in Sv (100 rem) is numerically equal to the absorbed dose in Gy (100 rad). Therefore, if each person in a group of 10,000 people is exposed to 1 rem (0.01 Sv) of ionizing radiation in small doses over a lifetime, we would expect around 6 people to die of cancer than would otherwise. For perspective, most people living on the eastern Snake River Plain receive over 383 mrem (3.8 mSv) every year from natural background sources of radiation.

DOE limits the dose to a member of the public from all sources and pathways to 100 mrem (1 mSv) and the dose from the air pathway only to 10 mrem (0.1 mSv) (DOE Order 458.1). The doses estimated to maximally exposed individuals from INL Site releases are typically well below 1 mrem per year.

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Stink Bug

Acronyms

ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ARP	Accelerated Retrieval Project
ASER	Annual Site Environmental Report
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
BBS	breeding bird survey
bls	below land surface
CAA	Clean Air Act
CCA	Candidate Conservation Agreement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CTF	Contained Test Facility
CWA	Clean Water Act
CWP	Cold Waste Pond
DCS	Derived Concentration Standard
DEQ	Department of Environmental Quality (state of Idaho)
DEQ-INL	Department of Environmental Quality – Idaho National Laboratory
DEQ-INL OP	Department of Environmental Quality – INL Oversight Program
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DQO	Data Quality Objective
DWP	Drinking Water Monitoring Program
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor-I
EFS	Experimental Field Station
EIS	Environmental Impact Statement
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
FFA/CO	Federal Facility Agreement and Consent Order
Fluor Idaho	Fluor Idaho, LLC
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GEL	GEL Laboratories, LLC
GHG	greenhouse gas
GPRS	Global Positioning Radiometric Scanner
GWMP	Groundwater Monitoring Program
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
ISB	in situ bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
ISU	Idaho State University
ISU-EAL	Idaho State University – Environmental Assessment Laboratory
IWTU	Integrated Waste Treatment Unit
LED	Light-emitting Diode
LEMP	Liquid Effluent Monitoring Program
LOFT	Loss-of-Fluid Test
LTV	Long-Term Vegetation
Ma	Million years
MAPEP	Mixed Analyte Performance Evaluation Program

MCL	Maximum Contaminant Level
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MESODIF	Mesoscale Diffusion Model
MFC	Materials and Fuels Complex
MLLW	Mixed Low-level Waste
MPLS	Males Per Lek Surveyed
NA	Not Applicable
NAIP	National Agricultural Imaging Program
NCRP	National Council on Radiation Protection and Measurements
ND	Not Detected
NERP	National Environmental Research Park
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOAAARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory Field Research Division
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
OCVZ	Organic Contamination in the Vadose Zone
ORAU-REAL	Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory
OSLD	Optically Stimulated Luminescence Dosimeters
PE	Performance Evaluation
PLN	Plan
QA	Quality Assurance
QAPjP	Quality Assurance Project Plan
QC	Quality Control
QIP	Quality Implementation Plan
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Adventure
ROD	Record of Decision
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
RTP	Radiological Traceability Program
RWMC	Radioactive Waste Management Complex
SA	Supplement Analysis
SDA	Subsurface Disposal Area
SGCA	Sage-grouse Conservation Area
SHPO	State Historic Preservation Office
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level
SNF	Spent Nuclear Fuel
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	Trichloroethylene
TLD	Thermoluminescent Dosimeter
TMI	Three Mile Island
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WAG	Waste Area Group
WAI	Wastren Advantage, Inc.
WIPP	Waste Isolation Pilot Plant
WNS	White-nose Syndrome
WRP	Wastewater Reuse Permit

Units

Bq	becquerel
C	Celsius
cfm	cubic feet per minute
CFU	colony forming unit
Ci	curie
cm	centimeter
cps	counts per second
d	day
F	Fahrenheit
ft	feet
g	gram
gal	gallon
Gy	gray
ha	hectare
keV	kilo-electron-volts
kg	kilogram
km	kilometer
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6}) curies
µg	microgram
µR	microroentgen
µS	microsiemen
µSv	microsievert
Ma	million years
mCi	millicurie
MeV	mega electron volt
mg	milligram
MG	million gallons
mGy	milligray
mi	mile
min	minute
mL	milliliter
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard
yr	year

Rocky Mountain High Adventure Students

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1. Introduction

Townsend's Big-Eared Bat
Corynorhinus townsendii

1. INTRODUCTION

This annual report is prepared in compliance with the following U.S. Department of Energy (DOE) orders:

- DOE Order 231.1B, "Environment, Safety and Health Reporting"
- DOE Order 436.1, "Departmental Sustainability"
- DOE Order 458.1, "Radiation Protection of the Public and the Environment."

The purpose of the report, as outlined in DOE Order 231.1B, is to present summary environmental data to:

- Characterize site environmental performance
- Summarize environmental occurrences and responses during the calendar year
- Confirm compliance with environmental standards and requirements
- Highlight significant facility programs and efforts.

This report is the principal document that demonstrates compliance with DOE Order 458.1 requirements and, therefore, describes the DOE Idaho National Laboratory (INL) Site impact on the public and the environment with emphasis on radioactive contaminants.

1.1 Site Location

The INL Site encompasses about 2,305 square kilometers (km^2) (890 square miles [mi^2]) of the upper Snake River Plain in southeastern Idaho (Figure 1-1). Over 50 percent 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 63 km (39 mi) from north to south and is approximately 61 km (38 mi) at its broadest east-west portion. By highway, the southeast boundary is approximately 40 km (25 mi) west of Idaho Falls. Other towns surrounding the INL Site include Arco, Atomic City, Blackfoot, Rigby, Rexburg, Terreton, and Howe. Pocatello is 85 km (53 mi) to the southeast.

Federal lands surround much of the INL Site, including Bureau of Land Management lands and Craters of the Moon National Monument and Preserve to the southwest, Challis National Forest to the west, and Targhee National Forest to the north. Mud Lake Wildlife Management Area, Camas National Wildlife Refuge, and Market Lake Wildlife Management Area are within 80 km (50 mi) of the INL Site. The Fort Hall Indian Reservation is located approximately 60 km (37 mi) to the southeast.

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94 percent of the land on the INL Site is open and undeveloped. The INL Site has an average elevation of 1,500 m (4,900 ft) above 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 INL Site.

About 60 percent of the INL Site is open to livestock grazing. Controlled hunting is permitted on INL Site land but is restricted to a very small portion of the northern half of the INL Site.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.3 cm/yr [8.40 in./yr]), warm summers (average daily temperature of 18.3°C [65.0°F]), and cold winters (average daily temperature of -7.4°C [18.7°F]), with all averages based on observations at Central Facilities Area from 1950 through 2016 (NOAA 2017). The altitude, intermountain setting, and latitude of 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 day-to-night temperature fluctuations.

Basalt flows cover most of the Snake River Plain, producing rolling topography. Vegetation is dominated by big sagebrush (*Artemisia tridentata*). Beneath these shrubs are grasses and wildflowers adapted to the harsh climate. A total of 409 different kinds (taxa) of

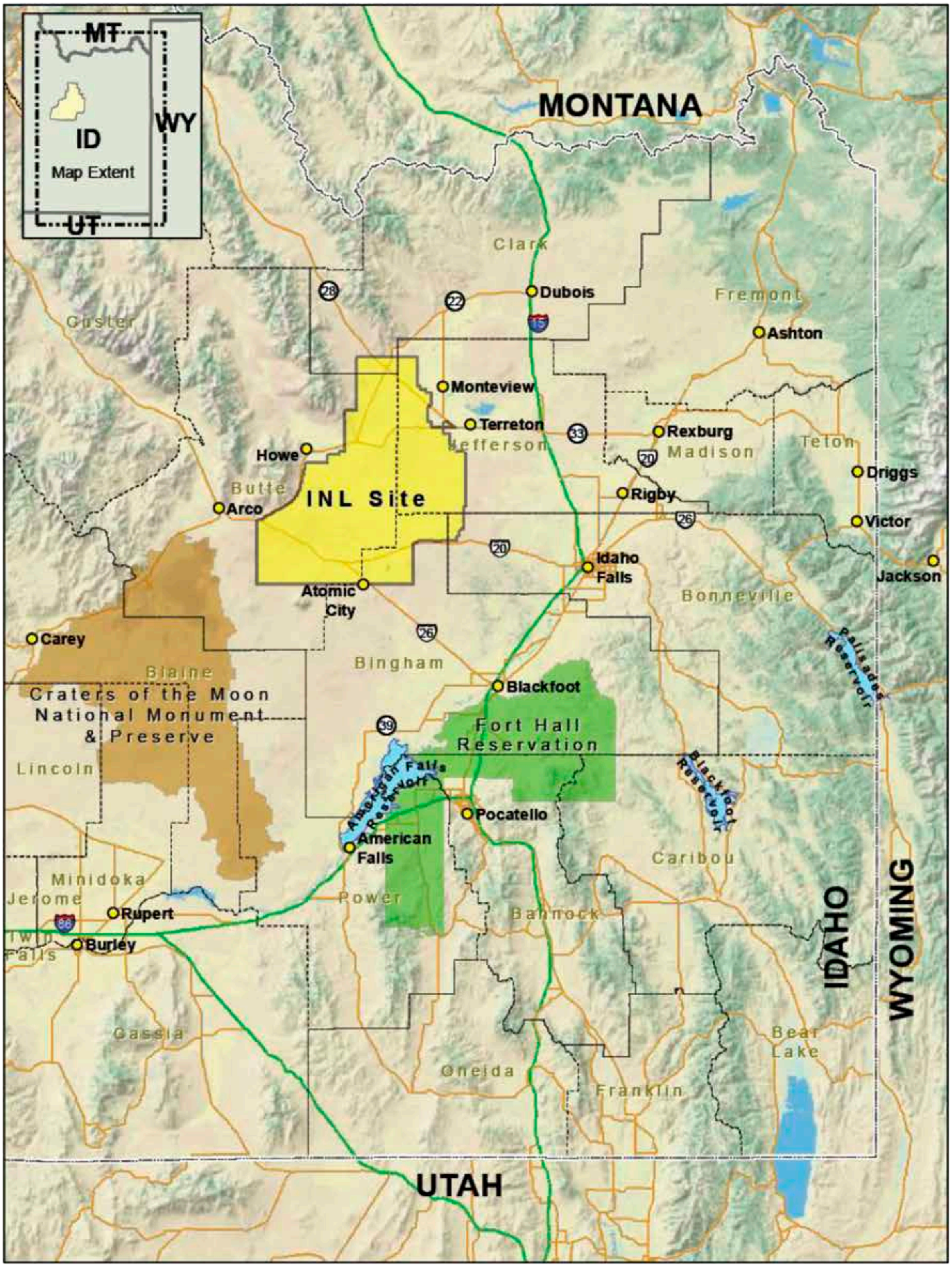

Figure 1-1. Location of the Idaho National Laboratory Site.

plants have been recorded on the INL Site (Anderson et al.1996).

Vertebrate animals found on the INL Site include small burrowing mammals, snakes, birds, and several game species. Published species records include six fishes, one amphibian, nine reptiles, 164 birds, and 39 mammals (Reynolds et al. 1986).

The Big Lost River on the INL Site flows northeast, ending in a playa area, called the Big Lost River Sinks, on the northwestern portion of the INL Site. Here, the river evaporates or infiltrates the subsurface, with no surface water moving off the INL Site.

The fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-2), which stretches 320 km (199 mi) from Island Park to King Hill, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 247 to 370 billion m^3 (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from the Henry's Fork and the South Fork of the Snake River, and to a lesser extent from the Big Lost River, Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The eastern Snake River Plain aquifer emerges in springs along the Snake River between Milner and Bliss, Idaho. Crop irrigation is the primary use of both surface water and groundwater on the Snake River Plain.

1.3 History of the INL Site

The geologic events that have shaped the modern Snake River Plain took place during the last 2 million years (Ma) (Lindholm 1996; ESRF 1996). The plain, which arcs across southern Idaho to Yellowstone National Park, marks the passage of the earth's crust over a plume of melted mantle material.

The volcanic history of the Yellowstone-Snake River Plain volcanic field is based on the time-progressive volcanic origin of the region, characterized by several large calderas in the eastern Snake River Plain, with dimensions similar to those of Yellowstone's three giant Pleistocene calderas. These volcanic centers are located within the topographic depression that encompasses the Snake River drainage. Over the last 16 Ma, there was a series of giant, caldera- forming eruptions, with the most recent at Yellowstone National Park 630,000 years ago. The youngest silicic volcanic centers correspond to the Yellowstone volcanic field that are less than 2 Ma old and are followed by a sequence of silicic centers at about 6 Ma ago, southwest of Yellowstone. A third group of centers, approximately 10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the Snake River Plain are approximately 16 Ma and are distributed across a 150-km-wide (93-mi-wide) zone in southwestern Idaho and northern Nevada; they are the suspected origin of the Yellowstone-Snake River Plain (Smith and Siegel 2000).

Humans first appeared on the upper Snake River Plain approximately 11,000 years ago. Tools recovered from this period indicate the earliest human inhabitants were hunters of large game. The ancestors of the present-day Shoshone and Bannock people came north from the Great Basin around 4,500 years ago (ESRF 1996).

People of European descent began exploring the Snake River Plain between 1810 and 1840; these explorers were trappers and fur traders seeking new supplies of beaver pelts.

Between 1840 (by which time the fur trade was essentially over) and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed forcing the native populations onto the reservation at Fort Hall. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

A railroad was opened between Blackfoot and Arco, Idaho, in 1901. By this time, a series of acts (the Homestead Act of 1862, the Desert Claim Act of 1877, the Carey Act of 1894, and the Reclamation Act of 1902) provided sufficient incentive for homesteaders to attempt building diversionary canals to claim the desert. Most of these canal efforts failed because of the extreme porosity of the gravelly soils and underlying basalts.

During World War II, large guns from U.S. Navy warships were retooled at the U.S. Naval Ordnance Plant in Pocatello, Idaho. These guns needed to be tested, and the nearby uninhabited plain was put to use as a gunnery range, known then as the Naval Proving Ground. The U.S. Army Air Corps also trained bomber crews out of the Pocatello Airbase and used the area as a bombing range.

After the war ended, the nation turned to peaceful uses of atomic power. DOE's predecessor, the U.S.

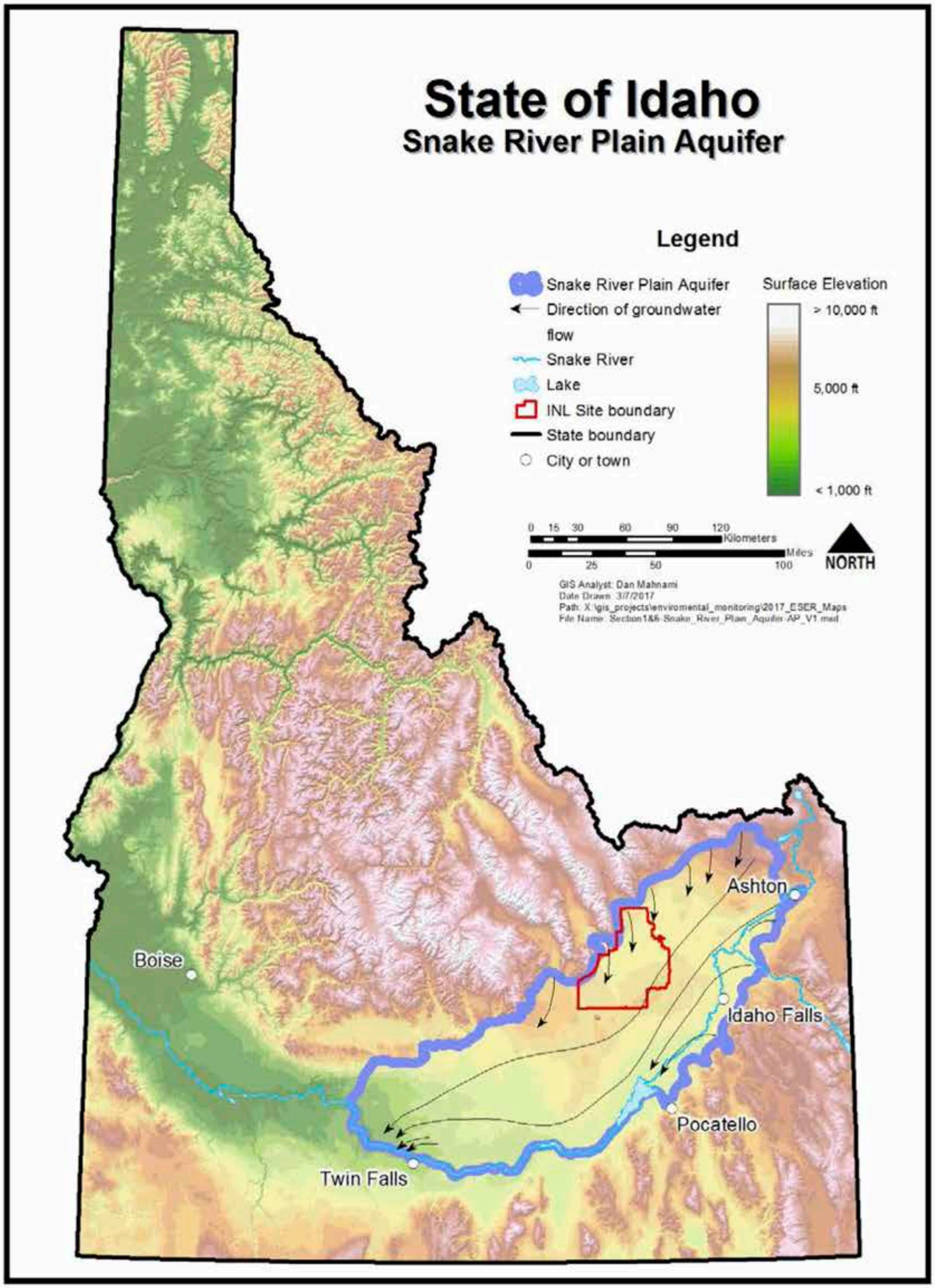

Figure 1-2. INL Site in Relation to the Eastern Snake River Plain Aquifer.

Atomic Energy Commission, needed an isolated location with ample groundwater supply on which to build and test nuclear power reactors. The relatively isolated Snake River Plain was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station in 1949.

In 1951, Experimental Breeder Reactor-I became the first reactor to produce useful electricity. In 1955, the Boiling-Water Reactor Experiments-III reactor provided electricity to Arco, Idaho – the first time a nuclear reactor powered an entire community in the United States. The laboratory also developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas.

The National Reactor Testing Station was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory in 1997 to reflect the Site's leadership role in environmental management. The U.S. Atomic Energy Commission was renamed the U.S. Energy Research and Development Administration in 1975 and reorganized to the present-day DOE in 1977.

With renewed interest in nuclear power, DOE announced in 2003 that Argonne National Laboratory-West and the Idaho National Engineering and Environmental Laboratory would be the lead laboratories for development of the next generation of power reactors, and on February 1, 2005, the Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West became the Idaho National Laboratory.

1.4 Populations Near the INL Site

The population of the region within 80 km (50 mi) of the INL Site is estimated, based on the 2010 census and projected growth, to be 327,823. Over half of this population (177,046) resides in the census divisions of Idaho Falls (107,520) and northern Pocatello (69,526). Another 29,372 live in the Rexburg census division. Approximately 20,188 reside in the Rigby census division and 15,644 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

1.5 Idaho National Laboratory Site Primary Program Missions and Facilities

The INL Site mission is to operate a multi-program national research and development laboratory and to complete environmental cleanup activities stemming from past operations. The U.S. Department of Energy, Idaho Operations Office (DOE-ID) receives implementing direction and guidance primarily from two DOE Headquarters offices, the Office of Nuclear Energy and the Office of Environmental Management. The Office of Nuclear Energy is the Lead Program Secretarial Office for all DOE-ID-managed operations on the INL Site. The Office of Environmental Management provides direction and guidance to DOE-ID for environmental cleanup on the INL Site and functions in the capacity of Cognizant Secretarial Office. Naval Reactors operations on the INL Site report to the Pittsburgh Naval Reactors Office, fall outside the purview of DOE-ID, and are not included in this report.

1.5.1 Idaho National Laboratory

The INL mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems, and unique national and homeland security capabilities. Its vision is to be the preeminent nuclear energy laboratory, with synergistic, world-class, multi-program capabilities and partnerships. To fulfill its assigned duties during the next decade, INL will work to transform itself into a laboratory leader in nuclear energy and homeland security research, development, and demonstration. This transformation will be the development of nuclear energy and national and homeland security leadership highlighted by achievements such as demonstration of Generation IV reactor technologies; creation of national user facilities, including the Advanced Test Reactor, Wireless, and Biomass Feedstock National User Facilities; the Critical Infrastructure Test Range; piloting of advanced fuel cycle technology; the rise to prominence of the Center for Advanced Energy Studies; and recognition as a regional clean energy resource and world leader in safe operations. Battelle Energy Alliance, LLC, is responsible for management and operation of the INL.

1.5.2 Idaho Cleanup Project

The Idaho Cleanup Project (ICP) Core involves the safe environmental cleanup of the INL Site, which was contaminated with waste generated during World War II-era conventional weapons testing, government-owned research and defense reactor operations, laboratory research, fuel reprocessing, and defense missions at other DOE sites. The lead contractor on the project recently transitioned from CH2M-WG Idaho, LLC, to Fluor Idaho, LLC. The project focuses on meeting Idaho Settlement Agreement (DOE 1995) and environmental cleanup milestones while reducing risks to workers. Protection of the Snake River Plain aquifer, the sole drinking water source for more than 300,000 residents of eastern Idaho, was the principal concern addressed in the Settlement Agreement.

On June 1, 2016, the scopes of work previously executed by CH2M-WG Idaho, LLC, and the Idaho Treatment Group were merged into a single ICP contract, which was awarded to Fluor Idaho, LLC. The majority of cleanup work under the contract is driven by regulatory compliance agreements. The two foundational agreements are: the 1991 Comprehensive Environmental Response Compensation and Liability Act (CERCLA)-based Federal Facility Agreement and Consent Order (FFA/CO), which govern the cleanup of contaminant releases to the environment; and the 1995 Idaho Settlement Agreement, which governs the removal of transuranic waste, spent nuclear fuel and high-level radioactive waste from the state of Idaho. Other regulatory drivers include the Federal Facility Compliance Act-based Site Treatment Plan (treatment of hazardous wastes), and other environmental permits, closure plans, federal and state regulations, Records of Decision and other implementing documents.

The ICP Core involves treating a million gallons of sodium-bearing liquid waste; removing targeted transuranic waste from the Subsurface Disposal Area; placing spent nuclear fuel in dry storage; selecting a treatment for high-level waste calcine; treating both remote- and contact-handled transuranic waste for disposal at the Waste Isolation Pilot Plant (WIPP); and demolishing and disposing of more than 200 contaminated structures, including reactors, spent nuclear fuel storage basins, and laboratories used for radioactive experiments.

1.5.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) prepares and ships contact-handled transuranic and mixed low-level waste out of Idaho for disposal. AMWTP is managed and operated by Fluor Idaho, LLC (Fluor Idaho). Operations at AMWTP retrieve, characterize, treat, package, and ship transuranic waste currently stored at the INL Site. The project's schedule is aligned with court-mandated milestones in the 1995 Idaho Settlement Agreement (DOE 1995) among the state of Idaho, U.S. Navy, and DOE to remove waste from Idaho. The majority of waste AMWTP processes resulted from the manufacture of nuclear weapons' components at DOE's former Rocky Flats Plant in Colorado. This waste was shipped to Idaho in the 1970s and early 1980s for storage and contains industrial debris, soil, and sludge, and is contaminated with transuranic radioactive elements (primarily plutonium). Most of the waste is "mixed waste" that is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents. Since 1999, more than 56,891 m^3 (74,411 yd^3) of transuranic waste have been shipped off the INL Site or certified for disposal at WIPP in Carlsbad, New Mexico.

1.5.4 Primary Idaho National Laboratory Site Facilities

Most INL Site buildings and structures are located within developed areas that are typically less than a few square miles and separated from each other by miles of undeveloped land. DOE controls all land within the INL Site (Figure 1-3).

In addition to the INL Site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, 40 km (25 mi) east of the INL Site.

Central Facilities Area – The Central Facilities Area is the main service and support center for the INL Site's desert facilities. Activities at the Central Facilities Area support transportation, maintenance, medical, construction, radiological monitoring, security, fire protection, warehouses, and instrument calibration activities. It is operated by the INL contractor.

Critical Infrastructure Test Range Complex – The Critical Infrastructure Test Range Complex encompasses a collection of specialized test beds and training complexes that create a centralized location where government agencies, utility companies, and military customers can work together to find solutions for many of the nation's most pressing security issues. The Critical Infrastructure Test Range Complex provides open landscape, technical employees, and specialized facilities for performing work in three main areas: physical security, contraband detection, and infrastructure testing. It is operated by the INL contractor.

Idaho Nuclear Technology and Engineering Center – The Idaho Chemical Processing Plant was established in the 1950s to recover usable uranium from spent nuclear fuel used in DOE and Department of Defense reactors. Over the years, the facility recovered more than $1 billion worth of highly enriched uranium that was returned to the government fuel cycle. In addition, an innovative high-level liquid waste treatment process known as calcining was developed at the plant. Calcining reduced the volume of liquid radioactive waste generated during reprocessing and placed it in a more stable granular solid

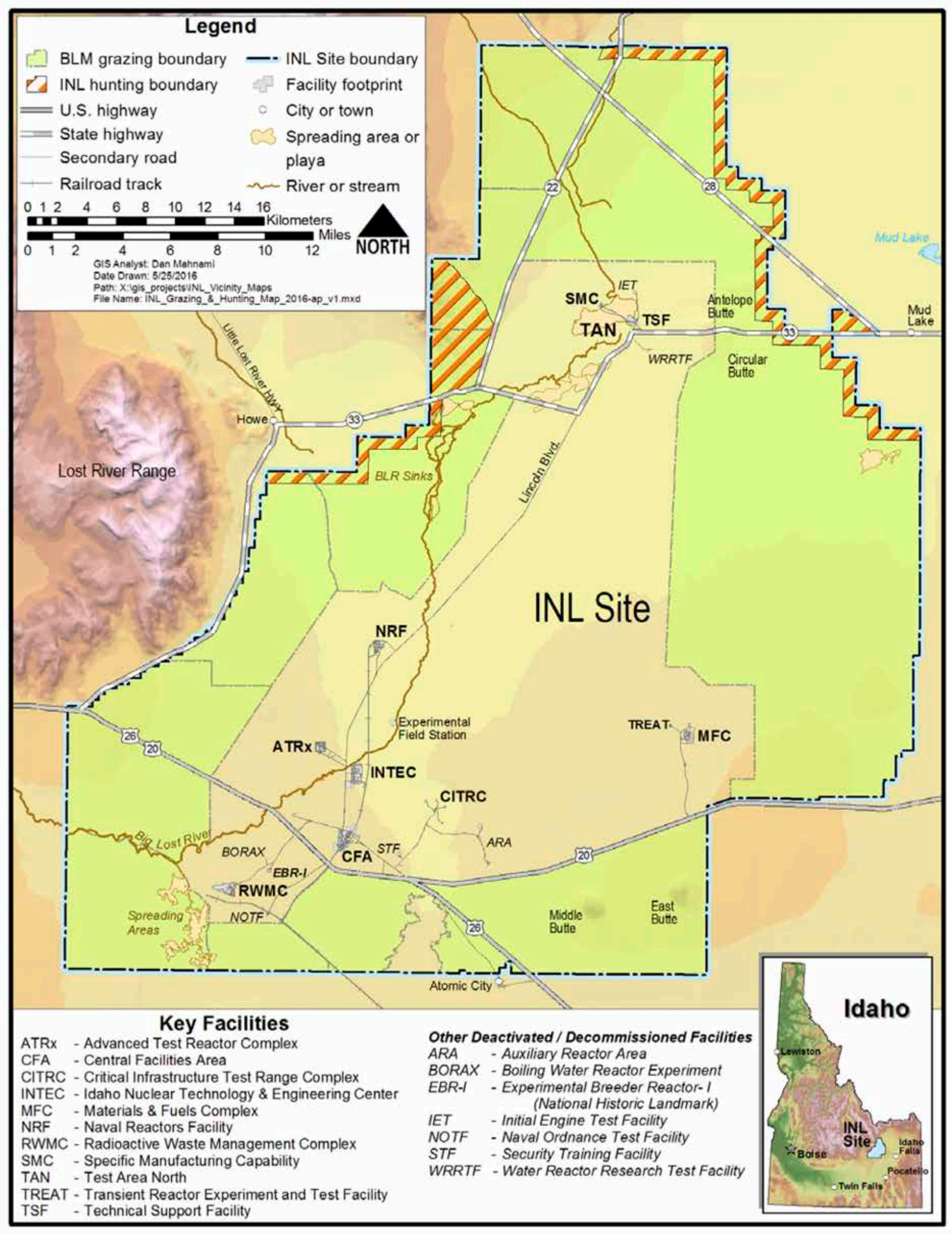

Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

form. In the 1980s, the facility underwent a modernization, and safer, cleaner, and more efficient structures replaced most major facilities. Reprocessing of spent nuclear fuel was discontinued in 1992. In 1998, the plant was renamed the Idaho Nuclear Technology and Engineering Center. Current operations include start-up and operation of the Integrated Waste Treatment Unit, designed to treat about 3,406,871 liters (900,000 gallons) of sodium-bearing liquid waste and closure of the remaining liquid waste storage tank, spent nuclear fuel storage, environmental remediation, disposing of excess facilities, and management of the Idaho CERCLA Disposal Facility. The Idaho CERCLA Disposal Facility is the consolidation point for CERCLA-generated wastes within the INL Site boundaries. The Idaho Nuclear Technology and Engineering Center is operated by Fluor Idaho, the ICP Core contractor.

Materials and Fuels Complex – The Materials and Fuels Complex is a prime testing center for advanced technologies associated with nuclear power systems. This complex is the nexus of research and development for new reactor fuels and related materials. As such, it will contribute to increasingly efficient reactor fuels and the important work of nonproliferation –harnessing more energy with less risk. Facilities at the Materials and Fuels Complex also support manufacturing and assembling components for use in space applications. It is operated by the INL contractor.

Naval Reactors Facility – The Naval Reactors Facility (NRF) is operated by Bechtel Marine Propulsion Corporation.

As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 436.1, 458.1, and 414.1D. Therefore, NRF is excluded from this report. The director of the Naval Nuclear Propulsion Program, establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2016).

Radioactive Waste Management Complex – Since the 1950s, DOE has used the Radioactive Waste Management Complex (RWMC) to manage, store, and dispose of waste contaminated with radioactive elements generated in national defense and research programs. RWMC provides treatment, temporary storage, and transportation of transuranic waste destined for WIPP.

The Subsurface Disposal Area is a 39-hectare (96-acre) radioactive waste landfill that was used for more than 50 years. Approximately 14 of the 39 hectares (35 of 96 acres) contain waste, including radioactive elements, organic solvents, acids, nitrates, and metals from historical operations such as reactor research at the INL Site and weapons production at other DOE facilities. A CERCLA Record of Decision (OU-7-13/14) was signed in 2008 (DOE-ID 2008) and includes exhumation and off-site disposition of targeted waste. Through December 2016, 1.79 of 2.30 hectares (4.43 of the required 5.69 acres) have been exhumed and 5,594 m^3 (7,316 yd^3) of waste have been shipped out of Idaho. The total volume of waste certified for disposal and not shipped is 887 m^3 (1,160 yd^3), due to suspension of operations at WIPP. Cleanup of RWMC is managed by the ICP Core contractor.

Advanced Test Reactor Complex – The Advanced Test Reactor (ATR) Complex was established in the early 1950s and has been the site for operation of three major test reactors: the Materials Test Reactor (1952–1970), the Engineering Test Reactor (1957–1982), and the Advanced Test Reactor (1967–present). The current primary mission at the ATR Complex is operation of the Advanced Test Reactor, the world's premier test reactor used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The ATR is a National Science User Facility. The ATR Complex also features the ATR Critical Facility, Test Train Assembly Facility, Radiation Measurements Laboratory, Radiochemistry Laboratory, and the Safety and Tritium Applied Research Facility – a national fusion safety user facility. The ATR Complex is operated by the INL contractor.

Research and Education Campus – The Research and Education Campus (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 where researchers work on a wide variety of advanced scientific research and development projects. As the name implies, the REC uses both basic science research and engineering to apply new knowledge to products and processes that improve quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. The Center for Advanced Energy Studies, designed to promote education and world-class research and development, is also located at the REC. Two new laboratory facilities, the Energy Systems Laboratory and the Energy Innovation Laboratory, were constructed in 2013 and 2014. Other facilities envisioned over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure close to current campus buildings. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory.

The DOE Radiological and Environmental Sciences Laboratory (RESL) is located within the REC. RESL provides a technical component to DOE oversight of contractor operations at DOE facilities and sites. As a reference laboratory, RESL conducts cost-effective measurement quality assurance programs that help assure key DOE missions are completed in a safe and environmentally responsible manner. By assuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, RESL assures the reliability of data on which decisions are based. RESL's core scientific capabilities are in analytical chemistry and radiation calibrations and measurements. In 2015, RESL expanded their presence in the REC with the addition of a new building for the DOE Laboratory Accreditation Program. The new DOE Laboratory Accreditation Program facility adjoins the RESL facility and provides irradiation instruments for the testing and accreditation of dosimetry programs across the DOE Complex.

Test Area North – Test Area North (TAN) was established in the 1950s to support the government's Aircraft Nuclear Propulsion program with the goal to build and fly a nuclear-powered airplane. When President Kennedy cancelled the nuclear propulsion program in 1961, TAN began to host a variety of other activities. The Loss-of-Fluid Test (LOFT) reactor became part of the new mission. The LOFT reactor, constructed between 1965 and 1975, was a scaled-down version of a commercial pressurized water reactor. Its design allowed engineers, scientists, and operators to create or recreate loss-of-fluid accidents (reactor fuel meltdowns) under very controlled conditions. The LOFT dome provided containment for a relatively small, mobile test reactor that was moved in and out of the facility on a railroad car. The Nuclear Regulatory Commission incorporated data received from these accident tests into commercial reactor operating codes. Before closure, the LOFT facility conducted 38 experiments, including several small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island (TMI) in Pennsylvania. In October 2006, the LOFT reactor and facilities were decontaminated, decommissioned, and demolished.

Additionally, TAN housed the TMI-2 Core Offsite Examination Program that obtained and studied technical data necessary for understanding the events leading to the TMI-2 reactor accident. Shipment of TMI-2 core samples to the INL Site began in 1985, and the program ended in 1990. INL Site scientists used the core samples to develop a database that predicts how nuclear fuel will behave when a reactor core degrades.

In July 2008, the TAN Cleanup Project was completed. The TAN Cleanup Project demolished 44 excess facilities, the TAN Hot Shop, and the LOFT reactor. Environmental monitoring continues at TAN. See Waste Area Group 1 status in Table 2-1.

The Specific Manufacturing Capability Project is located at TAN. This project is operated for the Department of Defense by the INL contractor and manufactures protective armor for the Army M1-A1 and M1-A2 Abrams tanks.

1.6 Independent Oversight and Public Involvement and Outreach

DOE encourages information exchange and public involvement in discussions and decision making regarding INL Site activities. Active participants include the public; Native American tribes; local, state, and federal government agencies; advisory boards; and other entities in the public and private sectors.

The roles and involvement of selected organizations are described in the following sections.

1.6.1 Citizens Advisory Board

The INL Site Environmental Management Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on ICP activities to DOE-ID. The Citizens Advisory Board consists of 12 to 15 members who represent a wide variety of key perspectives on issues of relevance to Idaho citizens. They come from a wide variety of backgrounds, including environmentalists; natural resource users; previous INL Site workers; and representatives of local government, health care, higher education, business and the general public. Their diverse backgrounds assist the ICP Environmental Management program in making decisions and having a greater sense of how the cleanup efforts are perceived by the public. Additionally, one board member represents the Shoshone-Bannock

Tribes. Members are appointed by the DOE Environmental Management Assistant Secretary and serve voluntarily without compensation. Three additional liaisons (nonvoting) include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality. The liaisons provide information to the Citizens Advisory Board on their respective agencies' policies and views.

The Citizens Advisory Board is chartered by DOE through the Federal Advisory Committee Act. The Citizens Advisory Board's charter is to provide input and recommendations to DOE on topics such as cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of nonstock pile nuclear materials, excess facilities, future land use and long-term stewardship, risk assessment and management, and cleanup science and technology activities. More information about the Board's recommendations, membership, and meeting dates and topics can be found at www.inlcab.energy.gov.

1.6.2 Site-wide Monitoring Committees

Site-wide monitoring committees include the INL Site Monitoring and Surveillance Committee and the INL Site Water Committee. The INL Site Monitoring and Surveillance Committee was formed in March 1997, and meets every other month, or as needed, to coordinate activities among groups involved in environmental monitoring on and off the INL Site. This standing committee includes representatives of DOE-ID; INL Site contractors; the Environmental Surveillance, Education, and Research contractor; Shoshone-Bannock Tribes; the state of Idaho Department of Environmental Quality (DEQ)-INL Oversight Program; the National Oceanic and Atmospheric Administration; NRF; and U.S. Geological Survey. The INL Site Monitoring and Surveillance Committee has served as a valuable forum to review monitoring, analytical, and quality assurance methodologies; to coordinate efforts; and to avoid unnecessary duplication.

The INL Site Water Committee was established in 1994 to coordinate drinking-water-related activities across the INL Site and to provide a forum for exchanging information related to drinking water systems. In 2007, the INL Site Water Committee expanded to include all Sitewide water programs: drinking water, wastewater, storm water, and groundwater. The Committee includes monitoring personnel, operators, scientists, engineers, management, data entry, validation representatives of the DOE-ID, INL Site contractors, U.S. Geological Survey, and NRF, and serves as a forum for coordinating water-related activities across the INL Site and exchanging technical information, expertise, regulatory issues, data, and training.

The INL Site Water Committee interacts on occasion with other committees that focus on water-related topics or programs, such as the INL Site Monitoring and Surveillance Committee.

1.6.3 INL Environmental Oversight and Monitoring Agreement

A new five-year Environmental Oversight and Monitoring Agreement (DOE-ID 2015) between DOE-ID, Naval Reactors Laboratory Field Office/Idaho Branch Office, and the state of Idaho was signed September 2015. The new Environmental Oversight and Monitoring Agreement governs the activities of the DEQ-INL Oversight Program and DOE-ID's cooperation in providing access to facilities and information for non-regulatory, independent oversight of INL Site impacts to public health and the environment. The first agreement established in 1990 created the state of Idaho INL Oversight Program.

The DEQ-INL Oversight Program's main activities include environmental surveillance, emergency response, and public information. More information can be found on the DEQ-INL Oversight Program website at www.deq.idaho.gov.

1.6.4 Environmental Education Outreach

The Environmental Surveillance, Education, and Research (ESER) program provides the DOE Idaho Operations Office with technical support on National Environmental Policy Act environmental analyses, such as wildlife surveys; ecological compliance, including threatened and endangered species assessment; and offsite environmental sampling of air, surface water, soil, plants, and animals. The ESER Educational Program's mission is to:

- Increase public awareness of the INL Offsite Environmental Surveillance Program and ESER ecological and radioecological research
- Increase public understanding of surveillance and research results
- Provide an education resource for local schools.

This program accomplishes this mission by providing communication and educational outreach relating to data gathered and evaluated in the performance of all

ESER tasks. Priority is placed on those communities surrounding the INL Site, touching other parts of southeast Idaho as resources allow. Emphasis is placed on providing the public and stakeholders with valid, unbiased information on qualities and characteristics of the INL Site environment and impacts of INL Site operations on the environment and public.

Involvement of students, especially K-12, is emphasized. During 2016, ESER created and presented educational programs to over 15,000 students in their classrooms. Presentations cover physical science, biological science, and ecological science subjects, are adapted for grade level, and are aligned with Idaho State Science Standards.

The ESER Education Program worked together with DOE, the INL contractor, the ICP Core contractor, and other businesses and agencies to present community outreach programs including Earth Day and the Idaho Falls Water Festival.

The ESER Education Program, the Museum of Idaho, Idaho Fish and Game, and Idaho State University (ISU) collaborated on teacher outreach program development. This program is designed to educate teachers about native Idaho habitats, to provide tools and hands-on activities that can be adapted to their classrooms, and to introduce them to experts who may serve as classroom resources. The team taught four two-day workshops for ISU credit: 1) Contrast: Idaho Mountains and Deserts; 2) Wonderful Wetlands; 3) Water of the West (river and stream habitats); and 5) Energy Sources.

An additional teachers' workshop through ISU was initiated in 2016 after receiving a grant from the Idaho Department of Education. This workshop, called Bring Idaho Alive in Your Classroom, consisted of four seminars presented by local scientists during the spring semester: Idaho Geology, Idaho Weather, Idaho Plants and Idaho Animals. The summer semester for this two-credit class included a day at the INL Site with the INL Cultural Resources team, a day in Idaho Falls with Museum of Idaho and City of Idaho Falls historians, and a day learning global positioning system/geographic information system technology with ESER scientists.

In 2016, the ESER Education Program participated in the Idaho iSTEM Conference at Eastern Idaho Technical College. As well as working on the organizing committee, Wastren Advantage Inc. (WAI) organized and presented one of the six tracks available for teachers at the conference. The track, entitled "In the News: Teaching Ecology in Context," included 20 hours of coursework presented by the WAI ESER Program, Friends of the Teton River, Idaho Department of Environmental Quality, Idaho Department of Water Resources, and U.S. Geological Survey.

The ESER Education Program and the Museum of Idaho offered the Rocky Mountain Adventure (RMA) summer science camp to educate students about environmental issues in their community and to encourage environmental careers. This weeklong summer camp for children in grades 4–9 is designed to provide an appreciation for and understanding of southeastern Idaho's native habitats (Figure 1-4). The ESER Education Program and the Museum of Idaho also offered the RMA High Adventure Camp. This camp is for students who have previously taken the RMA camp. High Adventure participants learn how to become better at observing and questioning the world around them so that they can take the next step of improving their surroundings. The hikes and activities for this camp are a little more difficult than the other camps, thus the name High Adventure.

The ESER Program, in partnership with the Idaho Falls Post Register newspaper, creates a weekly column for the Post Register called "Ask a Scientist." The column began in 2007, and in 2016 was sponsored by the ESER Program, WAI, the Post Register, INL, Idaho Department of Fish and Game, Idaho Department of Environmental Quality, and the Museum of Idaho. The column calls on the experience and knowledge of a panel of about 30 scientists (including many from ESER) representing businesses, organizations, and agencies in southeastern Idaho to answer questions from local students and adults. An archive of questions and answers may be found on the ESER website: www.idahoeser.com/nie.

In conjunction with "Ask A Scientist," the ESER program and the Museum of Idaho have teamed together on a project called "Meet A Scientist." "Meet A Scientist" is a free-to-the-public, monthly event held at the Museum of Idaho. A guest scientist is chosen based on a monthly theme. Scientists from the ESER Program, ISU, Museum of Idaho, Idaho Museum of Natural History, INL, Brigham Young University-Idaho, Phenomenal Physics, Dr. Roger Blew, and National Weather Service were presenters during 2016.

Figure 1-4. Rocky Mountain Adventure Summer Science Camp.

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2. Environmental Compliance Summary

Bald Eagle
Haliaeetus leucocephalus

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of non-permitted hazardous materials to the environment must be documented. Significant environmental compliance issues/actions in 2016 include:

- The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2016 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2017, in compliance with the Clean Air Act. The dose to a hypothetical Maximally Exposed Individual from airborne releases was estimated to be far below the regulatory limit of 10 mrem per year.
- Measurements of radionuclides in environmental media sampled on and around the INL Site in 2016 did not exceed Derived Concentration Standards established in DOE Order 458.1, "Radiation Protection of the Public and the Environment."
- DOE-ID issued the Annual NEPA Planning Summary in January 2016. DOE-ID did not initiate or prepare any environmental assessments or environmental impact statements in 2016.
- Naval Reactors and DOE-ID have initiated the development of a Bat Protection Plan for the INL Site. The Bat Protection Plan would allow the INL Site to proactively position itself to continue its missions if there was an emergency listing of a bat due to white-nose syndrome, a major threat to bats that hibernate in caves. Bats are currently monitored by biologists using acoustical detectors set at hibernacula and important habitat features (caves and facility ponds) used by these mammals on the INL Site.
- Forty-five environmental permits have been issued to the INL Site, primarily by the state of Idaho Department of Environmental Quality, to ensure clean air and water standards are met.
- During 2014, the shipment of transuranic waste was suspended due to the suspension of operations at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. The INL Site continues to process and certify transuranic waste for eventual shipment to WIPP. Although none was shipped in 2016, 2,900 m^3 (3,793 yd^3) was certified for disposal at WIPP and placed in to compliant storage.
- In 2016, approximately 1,629 m^3 (2,130 yd^3) of mixed low-level waste and 811 m^3 (1,061 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both.
- There were two reportable environmental releases at the INL Site in 2016 involving diesel fuel leaks.
- In 2016, 33 cultural resource reviews were completed for INL Site projects with potential to cause impacts to archaeological resources. Cultural resource reviews of projects that had the potential to impact INL historic architectural properties were also completed for 73 proposed activities in 2016.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Department of Energy Idaho National Laboratory Site (INL Site) with environmental protection requirements. Operations at the INL Site are subject to numerous federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders and U.S. Department of Energy (DOE) orders. These are listed in Appendix A.

2.1 Environmental Restoration and Waste Management

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release of chemically hazardous, radioactive substances, or both. Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. The INL Site was placed on the National Priorities List under CERCLA on November 29, 1989. U.S. Department of Energy, Idaho Operations Office (DOE-ID), the state of Idaho, and U.S. Environmental Protection Agency (EPA) Region 10 signed the Federal Facility Agreement and Consent Order (FFA/CO) in December 1991 (DOE 1991).

Environmental restoration is conducted under the FFA/CO and outlines how the INL Site will comply with CERCLA. It identifies a process for DOE-ID to work with its regulatory agencies to safely execute cleanup of past release sites.

The INL Site is divided into 10 waste area groups (WAG) (Figure 2-1) as a result of the FFA/CO, and each WAG is further divided into smaller cleanup areas called operable units. Field investigations are used to evaluate potential release sites within each WAG and operable unit when existing data are insufficient to determine the extent and nature of contamination. After each investigation is completed, a determination is made whether a "No Action" or "No Further Action" listing is possible, or if it is appropriate to proceed with an interim cleanup action, the Operable Unit-10-08 Plug-In Remedy action, or further investigation using a remedial investigation/feasibility study (RI/FS). Results from the RI/FS form the basis for risk assessments and alternative cleanup actions. This information, along with regulatory agencies' proposed cleanup plan, is presented to the public in a document called a proposed plan. After consideration of public comments, DOE, EPA and the state of Idaho develop a record of decision (ROD) that selects a cleanup approach from the alternatives evaluated. Cleanup activities then can be designed, implemented, and completed.

Since the FFA/CO was signed in December 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials. All 24 RODs that were scheduled have been signed and are being implemented. Comprehensive RI/FS have been completed for WAGs 1-5, 7-9, and 6/10 (6 is combined with 10). Active remediation is completed at WAGs 1 (excluding Operable Unit 1-07B), 2, 4, 5, 6, 8, and 9. Institutional Controls and Operations and Maintenance activities at these sites are ongoing and will continue to be monitored under the *Site-wide Institutional Controls and Operations and Maintenance Plan* (DOE-ID 2017b). The status of ongoing active remediation activities at WAGs 1, 3, 7, and 10 are described in Table 2-1.

Documentation associated with the FFA/CO is publicly available in the CERCLA Administrative Record and can be accessed at https://ar.icp.doe.gov.

2.1.2 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE orders, regulates radioactive wastes and the radioactive part of mixed wastes. A RCRA hazardous waste permit application contains two parts: Part A and Part B. Part A of the RCRA hazardous waste permit application consists of EPA Form 8700-23, along with maps, drawings and photographs, as required by 40 CFR 270.13. Part B of the RCRA hazardous waste permit application contains detailed, site-specific information as described in applicable sections of 40 Code of Federal Regulations (CFR) through 270.27. The INL Site currently has two RCRA Part A permit volumes and seven Part B permit volumes. Parts A and B are considered a single RCRA permit and are comprised of several volumes.

RCRA Reports. As required by the state of Idaho, the INL Site submitted the 2016 Idaho Hazardous Waste Generator Annual Report on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remaining in storage.

RCRA Closure Plan. On April 21, 2016, DEQ submitted correspondence to the DOE-ID acknowledging the completion of closure activities for the Materials and Fuels Complex Experimental Fuels Facility.

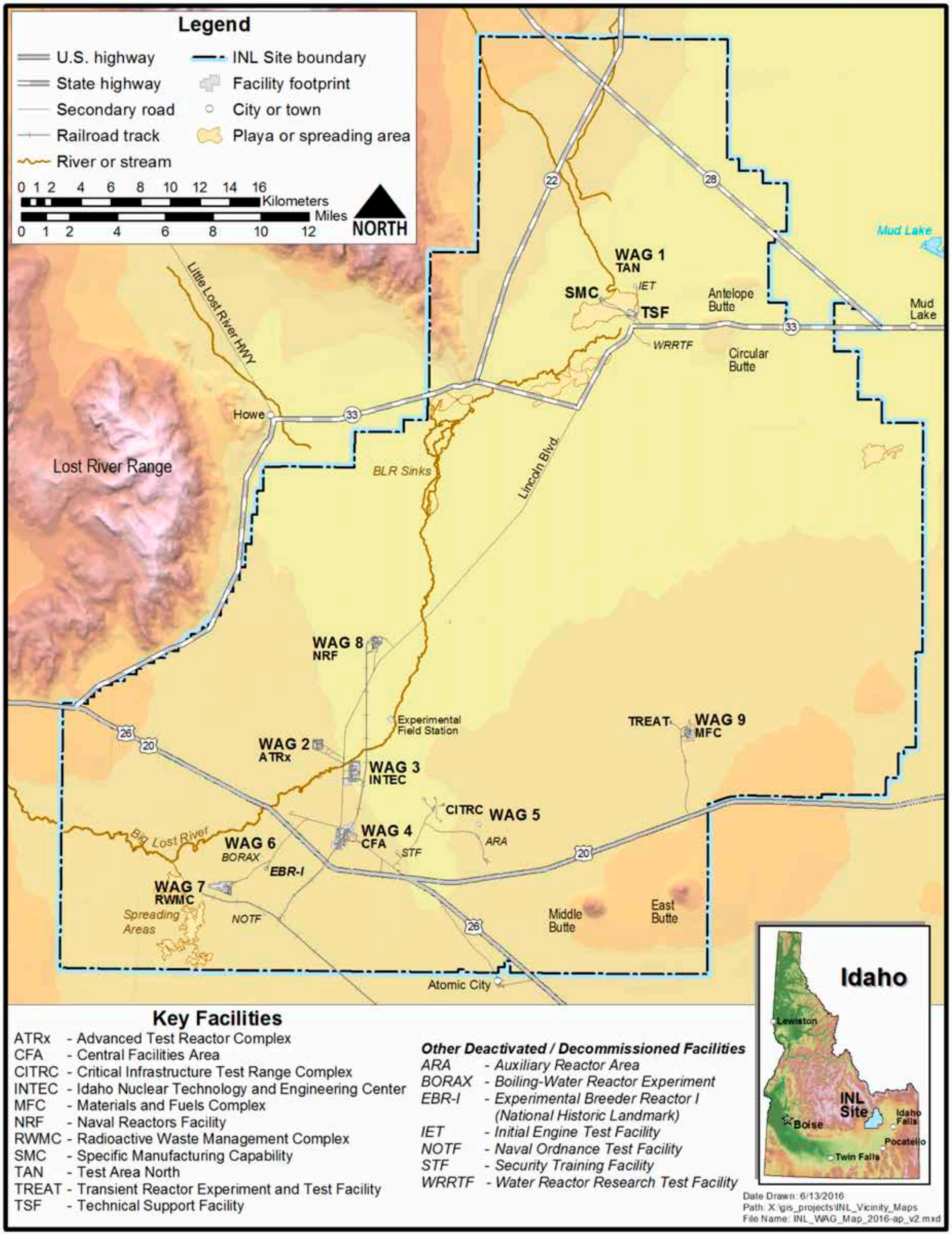

Figure 2-1. Map of INL Site Showing Facilities and Corresponding WAGs.

Table 2-1. 2016 Status of Active WAGs Cleanup.

Waste Area Group	Facility	Status
1	Test Area North	Groundwater cleanup of trichloroethene for Operable Unit 1-07B continued through 2016. The New Pump and Treat Facility generally operated four days per week, except for downtime due to maintenance, to maintain trichloroethene concentrations in the medial zone below specified targets. The in situ bioremediation transitioned into a rebound test in 2012 to determine the effectiveness of the remedy to date. The test plan was revised in 2016, and will be finalized in early 2017, to establish how the groundwater cleanup at Test Area North will continue. During 2015, two wells were constructed and further in situ bioremediation continues in a specific area where previous efforts had not achieved the desired reduction in contaminant levels. All institutional controls (IC) and operations and maintenance (O&M) requirements were maintained during 2016.
3	Idaho Nuclear Technology and Engineering Center	The ICDF disposes of contaminated soils and debris from CERCLA remediation operations to reduce risk to the public and the environment. The facility continues to receive small amounts of liquid and solid waste periodically for disposal in the ICDF evaporation ponds and disposal cells, respectively. The ICDF evaporation ponds are sampled annually in accordance with ICDF Complex Operational and Monitoring Sampling and Analysis Plan, and results are sent to the Environmental Protection Agency and the state of Idaho Department of Environmental Quality. Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately 9 million gallons of anthropogenic recharge to the northern perched water zones. Remedial actions were taken at the Tank Farm Facility to reduce water infiltration that potentially could transport contaminants from the perched water to the underlying aquifer. Perched and groundwater monitoring under and near the facility will continue until the risk posed by contamination left in place is below target levels. All institutional controls and operations and maintenance requirements were maintained in 2016. An interim impermeable barrier (asphalt) will be placed over the western two-thirds of the Tank Farm during 2017, to further reduce infiltration of precipitation water until a final cover is constructed after INTEC closure.
7	Radioactive Waste Management Complex	WAG 7 includes the Subsurface Disposal Area (SDA), a 39-hectare (97-acre) radioactive waste landfill that is the major focus of remedial response actions at the Radioactive Waste Management Complex (Figure 3-2). Waste is buried in approximately 14 of the 39 hectares (35 of the 96 acres) within 21 unlined pits, 58 trenches, 21 soil vault rows, and, on Pad A, an above-grade disposal area. Disposal requirements have changed in accordance with laws and practices current at the time of disposal. Initial operations were limited to shallow, landfill disposal of waste generated at the INL Site. Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the Radioactive Waste Management Complex for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. A variety of radioactive waste streams were disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of

Table 2-1. 2016 Status of Active WAGs Cleanup. (cont.)

Waste Area Group	Facility	Status
		transuranic waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste was disposed of in the SDA. Disposal of waste from offsite generators was discontinued in the early 1990s, and disposal of contact-handled waste was discontinued at the end of FY 2008. Currently, only remote-handled, low-level waste is being disposed in the SDA. The Operable Unit 7-13/14 ROD (DOE-ID 2008) was signed in 2008. The ROD is consistent with DOE's obligations for removal of transuranic waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the state of Idaho and DOE, effective July 3, 2008 (U.S. District Court 2008). The ROD calls for exhuming and packaging a minimum of 6,238 m^3 (8,159 yd^3)—measured as 7,485 m^3 (9,790 yd^3) packaged—of targeted waste from a minimum combined area of 2.3 hectares (5.69 acres). Targeted waste for retrieval contains transuranic elements (e.g., plutonium), uranium, and collocated organic solvents (e.g., carbon tetrachloride). Targeted waste retrievals in specific areas of the SDA commenced in 2005. The retrieved targeted waste is packaged, certified, and shipped out of Idaho. As of December 2016, 7,729 m^3 (10,109 yd^3) of targeted waste has been retrieved and packaged from a combined area of 1.79 hectares (4.43 acres). In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of continued vapor-vacuum extraction and treatment of solvent vapors from the subsurface, in situ grouting of specified waste forms containing mobile contaminants (completed 2010), constructing an evapotranspiration surface barrier over the entire landfill, and long-term management and control following construction. Construction will be complete by 2028.
10	10-04 INL Site-wide Miscellaneous Sites and Comprehensive RI/FS	Operable Unit 10-04 addresses long-term stewardship functions—ICs and O&M for sites that do not qualify for Unlimited Use/Unrestricted Exposure (UU/UE)—and explosive hazards associated with historical military operations on the INL Site. All institutional controls and operations and maintenance requirements were maintained in 2016 under the Site-wide IC/O&M Plan. A CERCLA five-year review was also completed during 2015 and finalized in February 2016 to verify that implemented cleanup actions continue to meet cleanup objectives documented in RODs.
	10-08 INL Site-wide Groundwater, Miscellaneous Sites, and Future Sites	Operable Unit 10-08 addresses Site-wide groundwater, miscellaneous sites, and future sites. Response actions for Operable Unit 10-08 are mostly complete and ongoing activities are groundwater monitoring and the evaluation and remediation of any potential new sites that are discovered. Groundwater monitoring continued in 2016 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

RCRA Inspection. For fiscal year 2016, DEQ conducted an annual RCRA inspection of the INL Site from May 16 through May 17, 2016. On August 30, 2016, DEQ issued a warning letter to DOE and the responsible INL Site contractor. The warning letter stated that two apparent violations, both at the Materials and Fuels Complex, were documented in association with the INL Site annual inspection.

RCRA Consent Order. On September 23, 2016, due to DOE's inability to meet commitments to initiate waste treatment in the Integrated Waste Treatment Unit (IWTU) and cease use of the Idaho Nuclear Technology and Engineering Center (INTEC) tanks, DEQ notified DOE that pursuant to the provisions under Section VII of the Fifth Modification to the NON-CO, penalties begin accruing in the amount of $3,600 per day on October 1, 2016.

2.1.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider and analyze potential environmental impacts of proposed actions and explore appropriate alternatives to mitigate those impacts, including a no action alternative. Agencies are required to inform the public of the proposed actions, impacts, and alternatives and consider public feedback in selecting an alternative. DOE implements NEPA according to procedures in the CFR (40 CFR 1500; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Order 451.1B, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. DOE-ID issued the Annual NEPA Planning Summary on January 26, 2016. The summary is a requirement of DOE Order 451.1B, and is prepared to inform the public and other DOE elements of the:

- Status of ongoing NEPA compliance activities
- Environmental Assessments (EAs) expected to be prepared in the next 12 months
- Environmental Impact Statements (EISs) expected to be prepared in the next 24 months
- Planned cost and schedule for completion of each NEPA review identified.

The NEPA Planning Summary identified a proposed EA and an ongoing supplement analysis (SA). An EA was proposed to analyze the potential impacts of development of the Sample Preparation Laboratory. Due to a reduction in project scope, it was later determined that an EA was not required. Started in 2015, an SA was prepared to analyze shipping 25 commercial spent nuclear fuel (SNF) rods to the INL from the Byron Nuclear Power Station in Illinois for research purposes. A draft SA was completed and released for public comment. Before completion of the SA, it was determined that the state of Idaho would not allow the shipment of the fuel rods within the required timeframe, and the project was cancelled.

2.1.4 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA), which is administered by EPA, requires regulation of production, use, or disposal of chemicals. TSCA supplements sections of the Clean Air Act (CAA), the Clean Water Act (CWA), and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with TSCA is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls. Polychlorinated biphenyls-containing light ballasts are being removed at buildings undergoing demolition. The ballasts are disposed, off the INL Site, at a TSCA-approved disposal facility.

2.1.5 DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE Order 458.1, "Radiation Protection of the Public and the Environment," establishes requirements to protect the public and the environment against undue risk from radiation 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 so that exposure to a member of the public is maintained within the dose limits established in this order
- Control the radiological clearance of DOE real and personal property
- Ensure that potential radiation exposures to members of the public are as low as reasonably achievable
- Ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public
- Provide protection of the environment from the effects of radiation and radioactive material.

The Order sets the public dose limit at a total effective dose not to exceed 100 mrem/yr (1 mSv/yr) above background radiation levels. Chapter 8 presents dose calculations for INL Site releases for 2016.

DOE Standard DOE-STD-1196-2011, Derived Concentration Technical Standard supports implementation of DOE Order 458.1. The standard defines the quantities used in the design and conduct of radiological environmental protection programs at DOE facilities and sites. These quantities, Derived Concentration Standards

(DCSs), represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year via each of the following pathways: ingestion of water, submersion in air, and inhalation. Measurements of radionuclides in environmental media sampled on and around the INL Site were all below appropriate DCSs.

In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public. DOE Order 458.1 specifies limits for unrestricted release of property to the public. All INL Site contractors use a graded approach for release of material and equipment for unrestricted public use. Material has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from non-radiological areas and includes the following:

- Personal items or materials
- Documents, mail, diskettes, compact disks, and other office media
- Paper, cardboard, plastic products, aluminum beverage cans, toner cartridges, and other items for recycling
- Office trash
- Non-radiological area housekeeping materials and associated waste
- Breakroom, cafeteria, and medical wastes
- Medical and bioassay samples
- Other items with an approved release plan.

Items originating from non-radiological areas within the INL Site's controlled areas not in the listed categories are surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces).

When the process knowledge approach is employed, the item's custodian is required to sign a statement that specifies the history of the material and confirms that no radioactive material has passed through or contacted the item. Items advertised for public sale via an auction are also surveyed by the contractor prior to shipment to the INL Site property/excess warehouse where the materials are again resurveyed on a random basis by personnel prior to release, giving further assurance that material and equipment are not being released with inadvertent contamination.

All contractors complete material surveys prior to release and transport to the state-permitted landfill at the Central Facilities Area. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the offsite treatment, storage, and disposal facilities that can accept low-level contamination. All INL Site contractors continue to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is recycled.

2.1.6 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1, "Radioactive Waste Management," was issued to ensure that all DOE radioactive waste is managed in a manner that protects the environment as well as worker and public safety and health.

2.1.7 Federal Facility Compliance Act

The Federal Facility Compliance Act requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The INL Site Proposed Treatment Plan was submitted to the state of Idaho and EPA on March 31, 1995. This plan outlined DOE-ID's proposed treatment strategy for Site mixed-waste streams, called the backlog, and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities. The Federal Facility Compliance Act Consent Order and Site Treatment Plan was finalized and signed by the state of Idaho on November 1, 1995 (DEQ 1995). A status of Site Treatment Plan milestones for 2016 is provided.

During 2016, four *Idaho National Laboratory Site Treatment Plan* (ICP 2016) milestones were met and one milestone extension associated with the sodium-bearing waste treatment facility was requested. An extension was requested for the (P-5) milestone to commence operations due to delays associated with the startup of the sodium-bearing waste treatment facility (IWTU). DEQ favored no change to the milestone. The following milestones were completed:

- Sodium-Bearing Waste Schedule for System Backlog – (P-6)
- Commercial Backlog Treatment/Disposal – 10 m^3 (13.08 yd^3)
- Original Volume Transuranic-Contaminated Waste Backlog Treatment/Processing – 4,500 m^3 (5,885.78 yd^3)
- Remote-handled Waste Disposition Project (sodium-contaminated waste), Schedule for System Backlog.

2.1.8 1995 Settlement Agreement

On October 16, 1995, DOE, the U.S. Navy, and the state of Idaho entered into an agreement that guides management of SNF and radioactive waste at the INL Site. The Agreement (DOE 1995) limits shipments of DOE and Naval SNF into the state and sets milestones for shipments of SNF and radioactive waste out of the state. DOE must have Idaho SNF in dry storage by 2023, and all SNF out of Idaho by the end of 2035.

The Settlement Agreement also requires DOE to ship all waste stored as transuranic waste on the INL Site in 1995, when the agreement was signed, out of Idaho by December 31, 2018. The estimated volume of that waste was 65,000 m^3 (85,016 yd^3). There is an additional requirement to ship an annual three-year running average of 2,000 m^3 (2,616 yd^3) of that waste out of the state. In February 2014, the shipment of transuranic waste was curtailed due to the suspension of the WIPP operations in Carlsbad, New Mexico. The INL Site continued to process and certify stored waste subject to the Settlement Agreement for shipment offsite. The annual three-year running average of Settlement Agreement waste stored as transuranic waste shipped out of Idaho over the past three years was 1,509 m^3 (1,974 yd^3). Due to curtailment of shipments to WIPP, Idaho was unable to ship any Settlement Agreement transuranic waste out of Idaho in calendar year 2016. Although none was shipped, 2,900 m^3 (3,793 yd^3) was certified for disposal at WIPP and placed in to compliant storage.

2.1.9 Advanced Mixed Waste Treatment Project

Operations at Advanced Mixed Waste Treatment Project (AMWTP) require retrieval, characterization, treatment, packaging, and shipment of transuranic waste currently stored at the INL Site. The vast majority of the waste the AMWTP processes resulted from the manufacture of nuclear components at DOE's Rocky Flats Plant in Colorado. The waste contains industrial debris, such as: rags, work clothing, machine parts, and tools, as well as, soil and sludge. This waste is contaminated with transuranic radioactive elements (primarily plutonium).

Due to the temporary closure of WIPP as the result of an upset condition caused by waste received from the Los Alamos National Laboratory during 2014, the AMWTP did not ship stored transuranic waste to the WIPP. Despite the WIPP closure, AMWTP continued to certify waste for disposal at WIPP once operations resume. During 2016, the AMWTP certified 34l m^3 (446 yd^3) of stored transuranic waste to the WIPP for a cumulative total of 45,467 m^3 (59,469 yd^3) of transuranic waste shipped off the INL Site or certified for shipment. The AMWTP shipped offsite 904 m^3 (1,182 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 11,426 m^3 (14,945 yd^3) of mixed low-level waste shipped offsite. A combined cumulative total of 56,891 m^3 (74,411 yd^3) of stored waste has been shipped offsite or certified for shipment once WIPP reopens. Due to suspension of WIPP operations, AMWTP was not able to ship a large quantity of waste that would otherwise have been sent to WIPP. This has resulted in a large backlog of waste that is certified for WIPP disposal, but will be compliantly stored at AMWTP until WIPP resumes operations. The current backlog of certified waste stored at AMWTP is 2,900 m^3 (3,793 yd^3)

2.1.10 High-Level Waste and Facilities Disposition

The DOE and ICP contractor, Fluor Idaho, LLC, (Fluor Idaho) continue a four-phased approach to start-up of the IWTU, designed to process the remaining 900,000 gal of liquid waste stored at the INTEC. These wastes are stored in three stainless steel, underground tanks. The waste was originally scheduled to be processed by the end of 2012, but a number of technical problems have delayed start-up of IWTU.

Assembling a team of nationwide experts on fluidized bed technology, Fluor developed a four-phased approach to assessing IWTU, implementing design and mechanical modifications, testing and verifying the changes, and eventually operating the facility and completing processing of the remaining liquid waste.

Three of the tanks currently contain liquid waste, and a fourth is always kept empty as a spare. All four will be closed in compliance with hazardous waste regulations. A total of 11 other liquid storage tanks have been emptied, cleaned, and closed.

2.1.11 Low-Level and Mixed Radioactive Waste

In 2016, approximately 1,629 m^3 (2,130 yd^3) of mixed low-level waste and 811 m^3 (1,061 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 26.6 m^3 (34.79 yd^3) of newly generated, low-level waste was disposed at the Subsurface Disposal Area in 2016 (Figure 2-2).

2.1.12 Spent Nuclear Fuel

SNF is nuclear fuel that has been withdrawn from a nuclear power reactor following irradiation and the constituent elements have not been separated. SNF contains unreacted uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. DOE's SNF is from development of nuclear energy technology (including foreign and domestic research reactors), national defense, and other programmatic missions. At the INL Site, SNF is managed by Fluor Idaho, the Idaho Cleanup Project (ICP) Core contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility, and the INL contractor at the Advanced Test Reactor (ATR) Complex and Materials and Fuels Complex (MFC).

With the publication of a ROD in May of 1995, DOE established its complex-wide strategy for management of SNF. The relevant provision of the preferred alternative, with the associated EIS, mandated that the Savannah River Site SNF program would receive aluminum-clad SNF, and the INL Site SNF program would receive all other fuel types for consolidation prior to ultimate dispositioning. The ROD selected the preferred alternative.

The 1995 Idaho Settlement Agreement put into place milestones for the management of SNF at the INL Site:

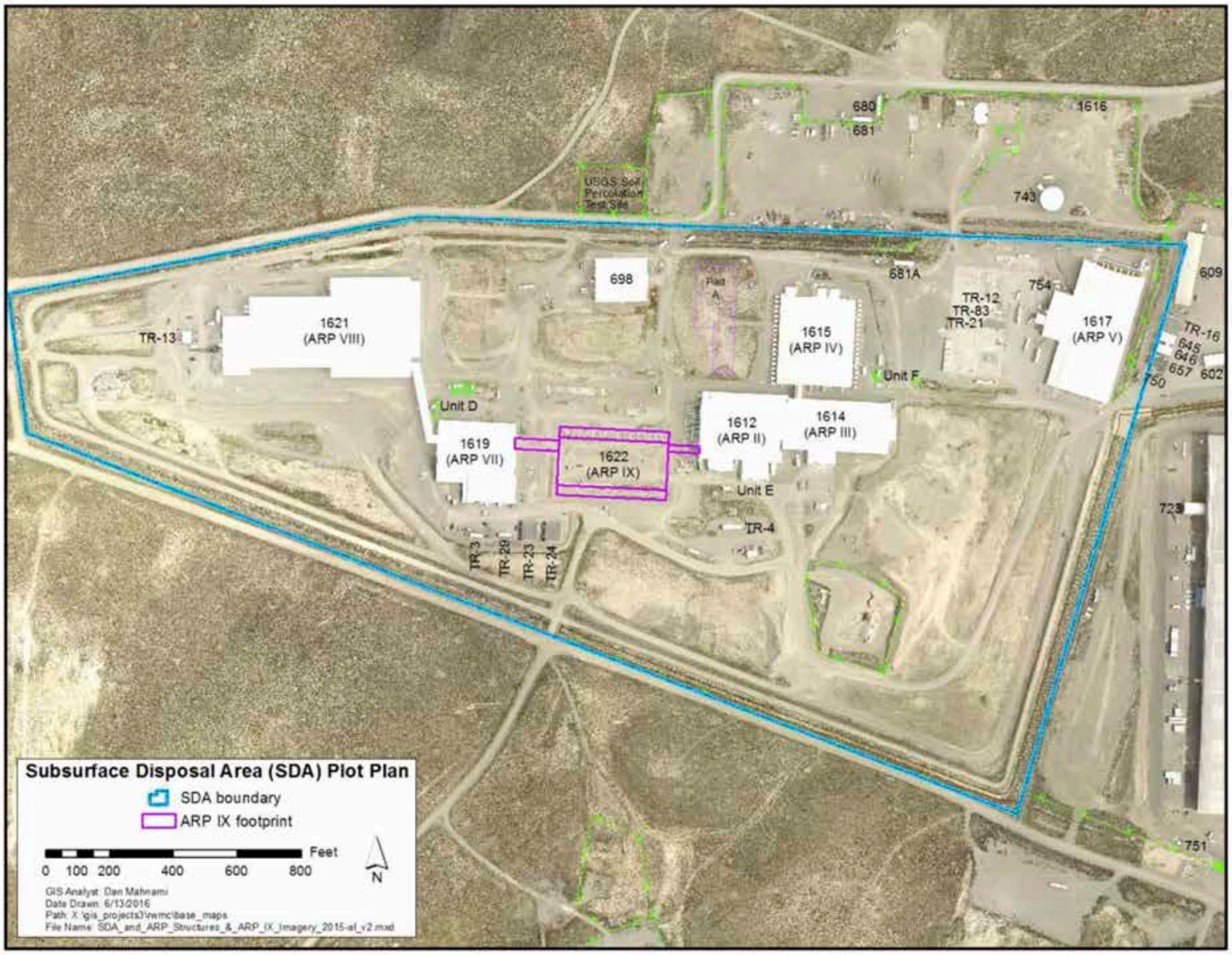

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2016).

- DOE shall complete the transfer of spent fuel from wet storage facilities by December 31, 2023 (Paragraph E.8)
- DOE shall remove all spent fuel, including naval spent fuel and Three Mile Island spent fuel, from Idaho by January 1, 2035 (Paragraph C.1).

Meeting these remaining milestones comprise the major objectives of the SNF program.

2.2 Air Quality and Protection

2.2.1 Clean Air Act

The Clean Air Act (CAA) is the basis for national air pollution control. Congress passed the original CAA in 1963, which resulted in non-mandatory air pollution standards and studies of air pollution, primarily from automobiles. Amendments to the CAA are passed periodically, with significant amendments enacted in 1970, 1977, and 1990. These amendments contained key pieces of legislation that are considered basic elements of the CAA, which are listed below:

- ***National Ambient Air Quality Standards***. The National Ambient Air Quality Standards establish permissible exposure levels for six pollutants (criteria air pollutants) identified as primary contributors to health-related deaths and illnesses. The six pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, particulates, and sulfur oxides.
- ***State Implementation Plans***. A state may assume responsibility for the CAA by developing an EPA-approved state implementation plan. A state implementation plan contains the laws and regulations a state will use to administer and enforce the provisions of the CAA. The state of Idaho has been delegated authority for the CAA.
- ***New Source Performance Standards***. The New Source Performance Standards program is a permitting performance standard for specific industry source categories. The standard targets sources that contribute significantly to air pollution and ensures the sources meet ambient air quality standards. The criteria air pollutants are the focus of the New Source Performance Standards Program.
- ***Prevention of Significant Deterioration***. The Prevention of Significant Deterioration program applies to new major sources or major modifications to existing sources where the source is located in an area that is designated as attainment or unclassifiable/attainment with the National Ambient Air Quality Standards. An attainment area is one that meets the national primary or secondary ambient air quality standards. An unclassifiable/attainment area is one that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standards but it is reasonably believed to be in attainment and is not contributing to nearby violations. The INL Site is an unclassifiable/attainment area.
- ***National Emissions Standards for Hazardous Air Pollutants (NESHAP)***. The NESHAP program regulates emissions of hazardous air pollutants from a published list of industrial sources. The source categories must meet control technology requirements for these hazardous air pollutants. The state of Idaho has supplemented the federal NESHAP list of hazardous air pollutants with the State List of Toxic Air Pollutants.

  The state of Idaho has not been delegated authority for one key subpart of the NESHAP program. Specifically, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H), is regulated by EPA. Subpart H applies to facilities owned or operated by DOE, including the INL Site. The DOE-ID submits an annual NESHAP Subpart H report to EPA and the DEQ. The latest report is *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2016 INL Report for Radionuclides* (DOE-ID 2017a). The annual NESHAP Subpart H report uses an EPA-approved computer model to calculate the hypothetical maximum individual effective dose equivalent to a member of the public resulting from INL Site airborne radionuclide emissions. The calculations for this code are discussed further in Chapter 8, "Dose to the Public and Biota."
- ***Stratospheric Ozone Protection Program***. The Stratospheric Ozone Protection Program limits emissions of chlorofluorocarbons, halons, and other halogenic chemicals that contribute to the destruction of stratospheric ozone.
- ***Enforcement Provisions***. Enforcement provisions establish maximum fines and penalties for CAA violations.

- ***Operating Permit Program***. The Operating Permit Program provides for states to issue federally enforceable operating permits to applicable stationary sources. The permits aid in clarifying operating and control requirements for stationary sources. The Idaho Air Quality program is primarily administered through a permitting process that sets conditions under which facilities that generate air pollutants may operate. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is exempt from permitting. If the source is not exempted, the type of permit required depends on the type of emission, emitting source or both. Two primary types of air permits have been issued to the INL Site (Table 2-2).
- ***Permit to Construct***. An air quality permit to construct is required of new or modified stationary sources, such as buildings, structures or equipment that may emit pollutants into the air. State of Idaho air regulations and guidelines are used to apply for all permits to construct.
- ***Title V Operating Permit***. A Title V operating permit, also known as a Tier I operating permit, is required for major sources. Major sources emit, or have the potential to emit per year, 10 tons or more of one hazardous air pollutant, 25 tons or more of any combination of hazardous air pollutants, or 100 tons or more of any regulated air pollutant. EPA promulgated regulations in July 1992 that established the Tier I requirements for state programs. Through the state implementation plan, Idaho has approved one Tier I operating permit for the INL Site.

For calendar year 2016, no compliance deviations were reported in the Tier I Operating Permit Annual Compliance Certification. One onsite regulatory inspection during 2016, which covered compliance for facility specific permits to construct and the Tier I Operating Permit, concluded that the facility was operating in compliance with permit conditions and requirements.

Table 2-2. Environmental Permits for the INL Site (2016).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	13
Title V Operating Permit	1
Groundwater:	
Injection Well	3
Well construction	14
Surface Water:	
Wastewater Reuse Permits	4
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2
Part B	7[a]
Ecological:	
Migratory Bird Treaty Act Special Purpose Permit	1

a. The Part B permit is a single permit comprised of several volumes.

2.3 Water Quality and Protection

2.3.1 Clean Water Act

The Clean Water Act (CWA) passed in 1972, established goals to control pollutants discharged to United States surface waters. Among the main elements of the CWA are effluent limitations for specific industry categories set by EPA and water quality standards set by states. The CWA also provided for the National Pollutant Discharge Elimination System permit program, requiring permits for discharges into regulated surface waters.

The INL Site complies with an Industrial Wastewater Acceptance permit for discharges to the city of Idaho Falls publicly owned treatment works. The city of Idaho Falls is required by the National Pollutant Discharge Elimination System permit program to set pretreatment standards for nondomestic discharges to publicly-owned treatment works. This program is set out in Title 8, Chapter 1 of the Municipal Code of the city of Idaho Falls. The INL Research Center is the only INL Site facility that is required to have an Industrial Wastewater Acceptance permit. The Industrial Wastewater Acceptance permit contains special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements and effluent concentration limits for specific parameters. All discharges in 2016 were within compliance levels established in the INL Research Center Wastewater Acceptance permit.

2.3.2 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) establishes rules governing the quality and safety of drinking water. The Idaho DEQ promulgates the SDWA according to the Idaho Administrative Procedures Act (IDAPA) 58.01.08, "Idaho Rules for Public Drinking Water Systems."

The eastern Snake River Plain aquifer is the source for the 12 active public water systems at all the facilities on the INL Site. All INL Site public water systems sample their drinking water as required by the state of Idaho. Chapter 6 contains details on drinking water monitoring.

2.3.3 State of Idaho Wastewater Reuse Permits

Wastewater consists of spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter that may contribute to water pollution. Methods of reusing treated wastewater include irrigation, commercial toilet flushing, dust control, and fire suppression. Land application is one method of reusing treated wastewater. It is a natural way of recycling water to provide moisture and nutrients to vegetation, and recharge to groundwater.

To protect health and prevent pollution of surface and ground waters, the state of Idaho requires anyone wishing to land apply wastewater to obtain a wastewater reuse permit. The Idaho DEQ issues the reuse permits in accordance with IDAPA 58.01.17 "Recycled Water Rules," IDAPA 58.01.16 "Wastewater Rules," and IDAPA 580.01.11 "Ground Water Quality Rule." All wastewater reuse permits consider site-specific conditions and incorporate water quality standards for ground water protection. The following facilities have wastewater reuse permits at the INL Site to land apply wastewater:

- Central Facilities Area Sewage Treatment Plant
- Advanced Test Reactor Complex Cold Waste Ponds
- Idaho Nuclear Technology and Engineering Center New Percolation Ponds
- Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond.

Chapter 5 contains details on wastewater reuse monitoring.

2.4 Other Environmental Statutes

2.4.1 Endangered Species Act

The Endangered Species Act (ESA):

- Provides a means whereby the ecosystems endangered and threatened species depend on may be conserved
- Provides a program to the conservation of such endangered and threatened species and their habitat
- Takes steps, as appropriate, to achieve the purposes of the international treaties and conventions on threatened and endangered species.

The act requires that all federal departments and agencies seek to conserve endangered and threatened species and use their authorities to further the purposes of this act.

Personnel in the Environmental Surveillance, Education, and Research Program conduct ecological research, field surveys, and NEPA evaluations regarding ecological resources on the INL Site. Particular emphasis is given to threatened and endangered species and species of special concern identified by the U.S. Fish and Wildlife Services (FWS) and Idaho Department of Fish and Game.

One species has been categorized under the ESA which occurs or may occur on the INL Site. Table 2-3 presents a list of that species and the likelihood of its occurrence on the INL Site. Several species have been removed from the list based on the limited likelihood they would occur on the INL Site. On August 13, 2014, the FWS withdrew a proposal to list the North American Wolverine (*Gulogulo luscus*) in the contiguous United States as a threatened species under the ESA. The wolverine has not been documented at the INL Site, but may pass through it.

On October 3, 2014, the FWS determined threatened status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (*Coccyzus americanus*). The rare species is known to breed in river valleys in southern Idaho (Federal Register, Vol. 79 No. 192, October 3, 2014), but has only been observed once near the INL Site at Atomic City.

FWS conducted a status review and, in September 2015, announced that the greater sage-grouse does not warrant protection under the ESA. FWS made this determination based upon reduction in threats, which caused the Service to initially designate the bird "warranted but precluded" in 2010. Federal, state, and private land-use conservation efforts were major factors in accomplishing threat reduction, such as the *Candidate Conservation Agreement for Greater Sage-grouse on the INL Site* that DOE and FWS signed in October 2014. The voluntary agreement includes conservation measures that protect sage-grouse and its habitat while allowing DOE flexibility in accomplishing its missions.

Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves. This disease is caused by a cold-adapted fungus (*Geomyces destructans*) and has killed at least 5.5 to 6.7 million bats in seven species. Many species of bats could be at risk for significant decline or extinction due to this disease. At least two species of bats that occupy the INL Site could be affected by WNS if this disease arrives in Idaho: the little brown myotis (*Myotis licifugus*) and the big brown bat (*Eptesicus fuscus*). In 2010, the little brown myotis was petitioned for emergency listing under the ESA, and the FWS is collecting information on both species to determine if, in addition to existing threats, this disease may be increasing the extinction risk of these bats. Biologists from the Environmental Surveillance, Education, and Research Program have initiated a monitoring program using acoustical detectors set at hibernacula and important habitat features (caves and facility ponds) used by these mammals on the INL Site. Naval Reactors and DOE-ID have initiated the development of a Bat Protection Plan for the INL Site. The Bat Protection Plan would allow the INL Site to proactively position itself to continue its missions if there was an emergency listing of a bat due to WNS. The monitoring data will be incorporated into the development of that plan.

2.4.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits taking any migratory bird, or any part, nest, or egg of any such bird, without authorization from the U.S. Department of the Interior. Permits may be issued for scientific collecting, banding and marking, falconry, raptor propagation, depredation, import, export, taxidermy, waterfowl sale and disposal, and special purposes. In July 2013, DOE-ID received a Special Purpose Permit for limited nest relocation and destruction and the associated take of migratory birds if absolutely necessary for mission-critical activities. The permit would be applied in very limited and extreme situations where no other recourse is practicable.

DOE-ID exercised the permit to destroy one active migratory bird nest in 2016. A Canada goose nest containing five eggs was removed and disposed at the ATR Complex. The nest had been constructed in a fenced area next to a radioactive wastewater pond and relocation of the nest was not feasible. As required by the permit, DOE-ID submitted an annual report to FWS by January 31, detailing reportable activities related to migratory birds.

Table 2-3. INL Species Designated Under the ESA and Occur, or May Occur, on the INL Site.

Species	Designation	Presence on INL Site
Yellow-billed cuckoo (*Coccyzus americanus*)	Threatened	Documented once on south border of INL Site.

2.4.3 Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) is Title III of the 1986 Superfund Amendments and Reauthorization Act to CERCLA. EPCRA is intended to help local emergency response agencies better prepare for potential chemical emergencies and to inform the public of the presence of toxic chemicals in their communities. The INL Site's compliance with key EPCRA provisions is summarized in the following subsections and in Table 2-4.

Section 304 – Section 304 requires owners and operators of facilities where hazardous chemicals are produced, used, or stored to report releases of CERCLA hazardous substances or extremely hazardous substances that exceed reportable quantity limits to state and local authorities (i.e., state emergency response commissions and local emergency planning committees). There were no CERCLA-reportable chemicals released at the INL Site during 2016.

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make safety data sheets describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities are also required to report inventories of all chemicals that have material safety data sheets to state and local officials and local fire departments. The INL Site satisfies the requirements of Section 311 by submitting a quarterly report to state and local officials and fire departments, identifying chemicals that exceed regulatory thresholds. In compliance with Section 312, the annual Emergency and Hazardous Chemical Inventory (Tier II) Report is provided to local emergency planning committees, the state emergency response commission, and local fire departments by the regulatory due date of March 1. This report includes the types, quantities, and locations of hazardous chemicals and extremely hazardous substances stored at the INL Site and Idaho Falls facilities that exceed regulatory thresholds.

Section 313 – Section 313 requires facilities to submit a Toxic Chemical Release Inventory Form annually for regulated chemicals that are manufactured, processed or otherwise used above applicable threshold quantities. Releases under EPCRA 313 reporting include transfers to waste treatment and disposal facilities off the INL Site, air emissions, recycling, and other activities. The INL Site submitted Toxic Chemical Release Inventory Forms for ethylbenzene, lead, naphthalene, nitric acid, and nitrate compounds to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – There were two reportable environmental releases at the INL Site during calendar year 2016:

- On January 20, 2016, a spill of approximately 25.0 L (6.6 gal) of diesel fuel from a degraded flexible transfer line was discovered on the ground near the ATR 786-M-1 diesel generator. Although the quantity of diesel fuel spilled was below the reportable quantity of 94.6 L (25 gal), the spill could not be cleaned up within the 24-hour time limit. Therefore, notification was made to the DEQ. The spill material was remediated and disposed.
- On January 27, 2016, the DEQ was notified in accordance with IDAPA 58.01.02.851.01, "Reporting of Suspected Releases for All Petroleum Storage Tank Systems," of a suspected leak of diesel fuel from an above ground diesel storage tank system at ATR Complex. Although the tank is above ground, the majority of the piping is located underground. The pipelines and tank were isolated on January 27, 2016, to prevent potential continued discharge. As required by IDAPA 58.01.02.851.03, "Release

Table 2-4. INL Site EPCRA Reporting Status (2016).

EPCRA Section	Description of Reporting	2016 Status
Section 304	Extremely Hazardous Substance Release Notification	Not Required
Section 311-312	Material Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

Investigation and Confirmation Steps," a "tightness test" was performed and it was determined that there was a leak in the underground pipe run from TRA-627, Fuel Oil Pumphouse, to the diesel generator supply tank. Excavation around the pipe and additional tests were being performed to identify the specific location of the leak and the boundary of the plume to support corrective action. The release was estimated to be greater than 37,854.1 L (10,000 gal) to the soil and is believed to have occurred gradually over time based upon a discrepancy in product usage identified in conjunction with generator emission reporting.

2.4.4 Executive Order 11988 – Floodplain Management

Executive Order 11988 requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requests consider flood hazards and floodplain management. It is the intent of Executive Order 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA. 10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an EIS under NEPA, alternative floodplain evaluation requirements are established through the INL Site Environmental Checklist process.

For the Big Lost River, DOE-ID has accepted the *Big Lost River Flood Hazard Study, Idaho National Laboratory, Idaho* (Bureau of Reclamation 2005). This flood hazard report is based on geomorphological models and has undergone peer review. All activities on the INL Site requiring characterization of flows and hazards are expected to use this report.

For facilities at TAN, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).

2.4.5 Executive Order 11990 – Protection of Wetlands

Executive Order 11990 requires each federal agency to issue or amend existing regulations and procedures to ensure wetlands are protected in decision-making. It is the intent of this executive order that federal agencies implement wetland requirements through existing procedures, such as those established to implement NEPA. The 10 CFR 1022 regulations contain DOE policy and wetland environmental review and assessment requirements through the applicable NEPA procedures. In instances where impacts of actions in wetlands are not significant enough to require the preparation of an EIS under NEPA, alternative wetland evaluation requirements are established through the INL Site Environmental Checklist process. Activities in wetlands considered waters of the United States or adjacent to waters of the United States also may be subject to the jurisdiction of Sections 404 and 402 of the Clean Water Act.

The only area of the INL Site currently identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The FWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2016, no actions took place or impacted potential jurisdictional wetlands on the INL Site.

2.5 Cultural Resources Protection

INL Site cultural resources are numerous and represent at least 13,000 years of human land use in the region. Protection and preservation of cultural resources under the jurisdiction of federal agencies, including DOE-ID, are mandated by a number of federal laws and their implementing regulations. DOE-ID has tasked the implementation of a cultural resource management program for the INL Site to Battelle Energy Alliance's Cultural Resource Management Office. Appendix B details compliance with cultural resources management requirements.

REFERENCES

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10 CFR 1022, 2017, “Compliance with Floodplain and Wetland Environmental Review Requirements,” Code of Federal Regulations, Office of the Federal Register.

40 CFR 61, Subpart H, 2017, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 270, 2017, “EPA Administered Permit Programs: The Hazardous Waste Permit Program”, *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 1500, 2017, “National Environmental Policy Act (NEPA), Purpose, Policy, and Mandate,” *Code of Federal Regulations*, Office of the Federal Register.

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Executive Order 11990, 1977, “Protection of Wetlands.”

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IDAPA 58.01.08, 2014, “Idaho Rules for Public Drinking Water Systems,” Idaho Administrative Procedures Act.

IDAPA 58.01.11, 2014, “Ground Water Quality Rule,” Idaho Administrative Procedures Act.

IDAPA58.01.16, 2014, “Wastewater Rules,” Idaho Administrative Procedures Act.

IDAPA 58.01.17, 2014, “Recycled Water Rules,” Idaho Administrative Procedures Act.

IDAPA 58.01.02.851.01 “Reporting of Suspected Releases for All Petroleum Storage Tank Systems,” Idaho Administrative Procedures Act.

IDAPA 58.01.02.851.03, “Release Investigation and Confirmation Steps,” Idaho Administrative Procedures Act.

USGS, 1997, *Simulation of Water-Surface Elevations for a Hypothetical 100-Year Peak Flow in Birch Creek at the Idaho National Engineering and Environmental Laboratory, Idaho, U.S. Geological Survey Water-Resources Investigations Report 97-4083*, DOE/ID-22138, U.S. Geological Survey.

3. Environmental Program Information

Sage Thrasher
Oreoscoptes montanus

The U.S. Department of Energy (DOE) is committed to protection of the environment and human health. DOE strives to be in full compliance with environmental laws, regulations, and other requirements that protect the air, water, land, and natural, archeological, and cultural resources potentially affected by operations and activities conducted at the Idaho National Laboratory (INL) Site. This policy is implemented by integrating environmental requirements, pollution prevention, and sustainable practices into work planning and execution, as well as taking actions to minimize impact of INL operations and activities.

DOE employs the environmental management system (EMS) modeled by the International Organization for Standardization (ISO) Standard 14001 to help establish policy, objectives, and targets at the INL Site to reduce environmental impacts and increase operating efficiency through a continuing cycle of planning, implementing, evaluating, and improving processes. The two main contractors have established EMSs for their respective operations. The INL contractor successfully completed ISO 14001 system audits in 2016. The new Idaho Cleanup Project (ICP) Core contractor began the process of adapting the previous contractor’s EMS to meet the requirements of the ISO 14001 standard and will undergo a certification audit in 2017.

The INL Site Sustainability program implements sustainability strategies and practices that will meet key DOE sustainability goals, including: reduce greenhouse gas emissions; reduce energy and potable water intensity; reduce fleet petroleum consumption; divert nonhazardous solid waste and construction and demolition debris; and use energy from renewable sources. The 2017 INL Site Sustainability Plan with FY 2016 Annual Report was submitted to DOE Headquarters in 2016 to present the INL Site’s performance status and planned actions for meeting goals.

Sustainability accomplishments completed in 2016 included the transfer of electrical loads powering the Advanced Test reactor from 50-year-old diesel-powered generators to a commercial utility. This represented a 100 percent reduction of greenhouse gases from this facility.

3. ENVIRONMENTAL MANAGEMENT SYSTEM

An Environmental Management Systems (EMS) provides a framework of elements following a plan-do-check-act cycle that when established, implemented, and maintained, will foster improved environmental performance. An EMS focuses on three core concepts: pollution prevention, environmental compliance, and continuous improvement. The primary system components are 1) environmental policy, 2) planning, 3) implementation and operation, 4) checking and corrective action, and 5) management review.

The framework U.S. Department of Energy (DOE) has chosen to employ for EMSs and sustainable practices is the International Organization for Standardization (ISO) Standard 14001 (Environmental Management Systems). The ISO 14001 model uses a system of policy development, planning, implementation and operation, checking, corrective action, and management review; ultimately, ISO 14001 aims to improve performance as the cycle repeats. The EMS must also meet the criteria of Executive Order (EO) 13693, “Planning for Federal Sustainability in the Next Decade,” and DOE Order 436.1, “Departmental Sustainability,” which require federal facilities to put into practice EMSs. Sites must maintain their EMS as being certified or conforming to the ISO 14001standard in accordance with the accredited registrar provisions or self-declaration instructions. In 2015, ISO released a new standard, ISO 14001:2015 which replaces the ISO 14001:2004 standard. New EMSs and recertification of existing EMSs, required every three years, will need to meet the new standard.

The two main Idaho National Laboratory (INL) Site contractors have established EMSs for their respective operations. The INL Site management and operating contractor, Battelle Energy Alliance (BEA) maintains an EMS in conformance with ISO 14001:2004 and certified by an accredited registrar. In 2016, BEA successfully completed two ISO 14001:2004 surveillance audits to maintain registration of their EMS. No nonconformities or opportunities for improvement were identified in either audit. Numerous system strengths were noted. BEA began the process of adapting the EMS to meet the requirements of the ISO 14001:2015 standard, including conducting a gap analysis and having the accredited auditor perform a gap analysis. In 2017, BEA will undergo a recertification audit, by an external, accredited auditor, to determine conformance to the ISO 14001:2015 standard. The INL Environmental Policy can be found at: www.inl.gov/wp-content/uploads/2014/09/16-50070-R2_ENV_Policy.pdf.

2016 was a year of transition for the Environmental Management contractors. The new ICP Core contractor, Fluor Idaho, LLC, largely adopted the previous ICP contractor's ISO 14001:2004 compliant EMS and integrated the AMWTP operations into the EMS. Fluor Idaho, LLC, then began the process of adapting the EMS to meet the requirements of the ISO 14001:2015 standard. In 2017, Fluor Idaho, LLC, will undergo a certification audit, by an external, accredited auditor, to determine conformance to the ISO 14001:2015 standard. The ICP Environmental Policy can be found at: fluor-idaho.com/Portals/0/Documents/Environmental_POL201.pdf.

Through implementation of each EMS, the INL Site contractors have identified the aspects of their operations that can impact the environment and determine which of those aspects are significant. Aspects that have been identified as significant include: air emissions; discharging to surface, storm or ground water; disturbing cultural or biological resources; generating and managing waste; releasing contaminants; and using, reusing, recycling, and conserving resources.

Both INL Site contractors had effective EMS performance in 2016. The INL Site contractors completed nearly 90 percent of EMS Objectives and Targets in fiscal year 2016. All EMS performance metrics reported at FedCenter scored either A or B (on an A to D scale). Additionally, both contractors received a FedCenter site score of green (the best) which focuses on sustainability goals outlined in EO 13693.

3.1 Sustainability Requirements

On March 25, 2015, President Obama issued EO 13693, "Planning for Federal Sustainability in the Next Decade." The EO superseded EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," and EO 13423, "Strengthening Federal Environmental, Energy, and Transportation Management."

The objective of EO 13693 is "to maintain federal leadership in sustainability and greenhouse gas emission reductions." To demonstrate federal leadership, this executive order expanded and extended the previously established agency-wide goals.

EO 13693 required federal agencies to establish greenhouse gas reduction goals. In a letter to the Council of Environmental Quality and Office of Management and Budget dated June 23, 2015, DOE committed to agency-wide reductions of 50 percent for scope one and two and 25 percent for scope three. These reductions are relative to a fiscal year 2008 baseline.

On May 22, 2011, DOE issued DOE Order 436.1 "Departmental Sustainability." The order defines requirements and responsibilities for managing sustainability at DOE to ensure that the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges; advances sustainable, efficient and reliable energy for the future; institutes wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and ensures that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan. DOE Idaho Operations Office submitted the *FY 2017 INL Site Sustainability Plan with the FY 2016 Annual Report* to DOE Headquarters in December 2016 (DOE-ID 2016). This year, the plan reports performance to the EO 13514 goals and contains strategies and activities to facilitate progress for the INL Site to meet the goals and requirements of EO 13693 in 2017.

3.2 Sustainability Accomplishments

There were many projects and activities completed in fiscal year 2016 that contributed toward goal attainment progress; some of the more significant include:

- The Advanced Test Reactor "Transition to Commercial Power" Project transferred the powering of critical safe-shutdown electrical loads from 50-year-old diesel-powered generators to commercial utility power with an uninterruptible power supply (Figure 3-1). Ending continuous operation of the diesel generators eliminated greenhouse gas emissions from the combustion of 851,718 liters (225,000 gal) of diesel fuel annually and provides an annual net reduction of greenhouse gas emissions

Figure 3-1. Commercial Utility Power with Uninterruptable Power Supply at the ATR Complex.

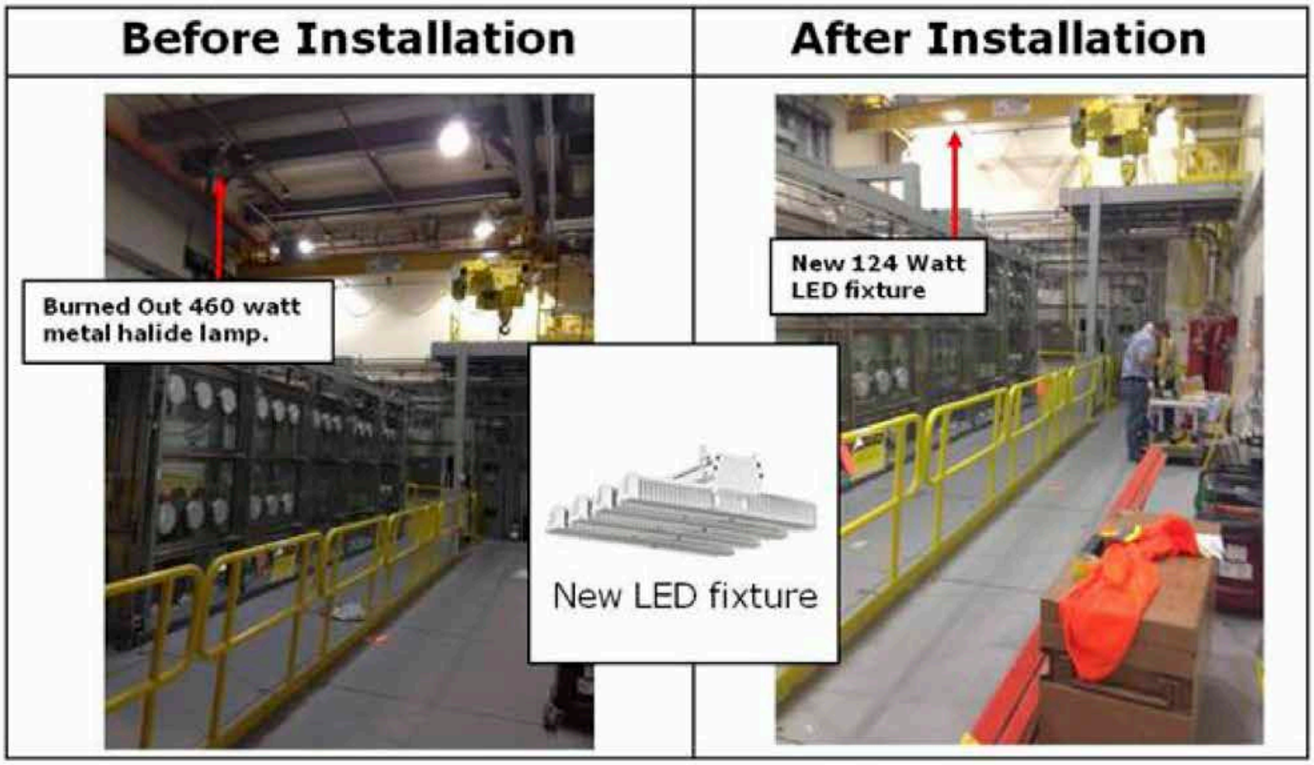

Figure 3-2. New LED Lighting Fixtures at AMWTP.

of 892 metric tons (983 tons) of carbon dioxide equivalent. This corresponds to a 100 percent reduction of process-related stationary combustion emissions for the Advanced Test Reactor area, and a 28 percent reduction of overall INL stationary combustion emissions.

- New light-emitting diode (LED) lighting fixtures were installed at AMWTP in fiscal year 2016 (Figure 3-2). This project provided environmental, financial, and employee indoor work environment improvements.
- Electric use was reduced by more than 29,000 kWh
- Reduced maintenance for lamp and ballast replacement with the corresponding universal waste reductions as the LED components are estimated to last for over 10 years
- Incentive payments from Idaho Power totaled more than $132,000, which helped to pay the project costs off in less than one year
- The new LED fixtures provide significantly increased and better quality light, improving the indoor environmental quality of the workplace.

INL also implemented significant water reduction projects, including xeriscaping at a facility in Idaho Falls (IF-603) for total recurring estimated water savings of 6.1 million liter/yr (1.6 million gal/yr) (Figure 3-3).

3.3 Climate Change Adaptation

The University of Idaho participated in the development of a climate change vulnerability assessment for INL. The published report describes the outcome of that assessment. The climate change happening now is expected to continue in the future. University of Idaho and INL used a common framework for assessing vulnerability that considers exposure (future climate change), sensitivity (system or component responses to climate), impact (exposure combined with sensitivity), and adaptive capacity (capability of INL to modify operations to minimize climate change impacts) to assess vulnerability.

Figure 3-3. Xeriscaping at Idaho Falls Facility (IF-603).

Analyses of climate change (exposure) revealed that warming occurring at the INL Site will continue in the coming decades with increased warming in the future, and warming will continue under scenarios of greater greenhouse gas emissions. Projections of precipitation are more uncertain, with multiple models exhibiting somewhat wetter conditions and more wet days per year. Additional impacts relevant to the INL Site include estimates of more wildfire-burned area and increased evaporation and transpiration, leading to reduced soil moisture and plant growth.

In fiscal year 2016, University of Idaho experts determined that an update to the vulnerability study was not needed based on updated climate models. However, impacts to operating systems and affected buildings will continue to be evaluated. Additionally, several INL Emergency Management procedures were updated to better prepare INL for natural phenomenon.

INL maintained corporate-level policies that articulate the requirements for achieving a basic direction, purpose, and consistency in all business and administrative practices. These policies apply to all organizations and serve as a basis for lower-tiered policies, implementing guidance, and procedures. INL has established an underlying set of performance benchmarks called "standards of performance" that serve to clarify expectations associated with each of the policies and to facilitate objective evaluation of policy implementation.

Three standards of performance are tiered directly to climate change management:

- ***Safety and Security Leadership: Environmental Stewardship***. Human life and health are valued above all else, safekeeping the nation's assets is essential, and INL environmental stewardship is a highest priority.
- ***Emergency Management and Business Continuity***. INL is ready to respond and recover from threats, man-made events, and natural disasters while coordinating resources across the Site and public sector response organizations and maintaining business continuity.
- ***Sustainability***. The INL Site maintains a sustainable laboratory by applying social, environmental, and resource-responsible approaches into planning and operations.

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Big Lost River Sinks Area

4. Environmental Monitoring Programs: Air


Clark's Nutcracker
Nucifraga columbiana

An estimated total of 1,856 Ci (6.87 × 10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents from Idaho National Laboratory (INL) Site facilities in 2016. The highest contributors to the total release were the Advanced Test Reactor Complex at 56.3 percent, Idaho Nuclear Technology and Engineering Center at 39.8 percent, and the Radioactive Waste Management Complex at 3.8 percent of the total.

The INL Site environmental surveillance programs emphasize measurements of airborne contaminants in the environment because air is the most important transport pathway from the INL Site to receptors living outside the INL Site boundary. Because of this pathway, samples of airborne particulates, atmospheric moisture, and precipitation were collected on the INL Site, at INL Site boundary locations, and at distant communities and were analyzed for radioactivity in 2016.

Particulates were filtered from air using a network of low-volume air samplers and the filters were analyzed for gross alpha activity, gross beta activity, and specific radionuclides, primarily strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). Results were compared with detection levels, background measurements, historical results, and radionuclide-specific Derived Concentration Standards (DCSs) established by U.S. Department of Energy to protect human health and the environment. Gross alpha and gross beta activities were used primarily for trend analyses and indicated that fluctuations were observable that correlate with seasonal variations in natural radioactivity.

Strontium-90 was not detected in any of the quarterly composited air filters collected on and off the INL Site. Americium-241 was reported in three composited samples collected on the INL Site during the first quarter and in one sample collected during the third quarter at Blackfoot. The concentrations measured were just above the detection levels, within the range of values measured historically, and well below the DCS for ^{241}Am. Plutonium-239/240 was detected in two samples collected during the third quarter at Blackfoot and FAA Tower and in one sample collected at Atomic City during the fourth quarter. The results were just above the detection limit, within historical measurements, and below the DCS for $^{239/240}$Pu. The concentrations of ^{241}Am and $^{239/240}$Pu measured in air samples are consistent with historical measurements associated with global fallout. No other human-made radionuclides were detected in air filters.

Airborne particulates were also collected biweekly around the perimeters of the Subsurface Disposal Area of the Radioactive Waste Management Complex and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility at the Idaho Nuclear Technology and Engineering Center. Gross alpha and gross beta activities measured on the filters were comparable with historical results and no new trends were identified in 2016. Detections of americium and plutonium isotopes were comparable to past measurements and are likely due to resuspended soils contaminated from past burial practices at the Subsurface Disposal Area. The results were below the DCSs established for those radionuclides

Atmospheric moisture and precipitation samples were obtained at the INL Site and off the INL Site and analyzed for tritium. Tritium detected in samples was most likely present due to natural production in the atmosphere and not INL Site releases. All measured results were below health-based regulatory limits.

4. ENVIRONMENTAL MONITORING PROGRAMS: AIR

Idaho National Laboratory (INL) Site facilities have the potential to release radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations (Figure 4-1). Review of historical environmental data and modeling of environmental transport of radionuclides show that air is the most important radionuclide transport pathway to members of the general public (DOE-ID 2014a). The INL

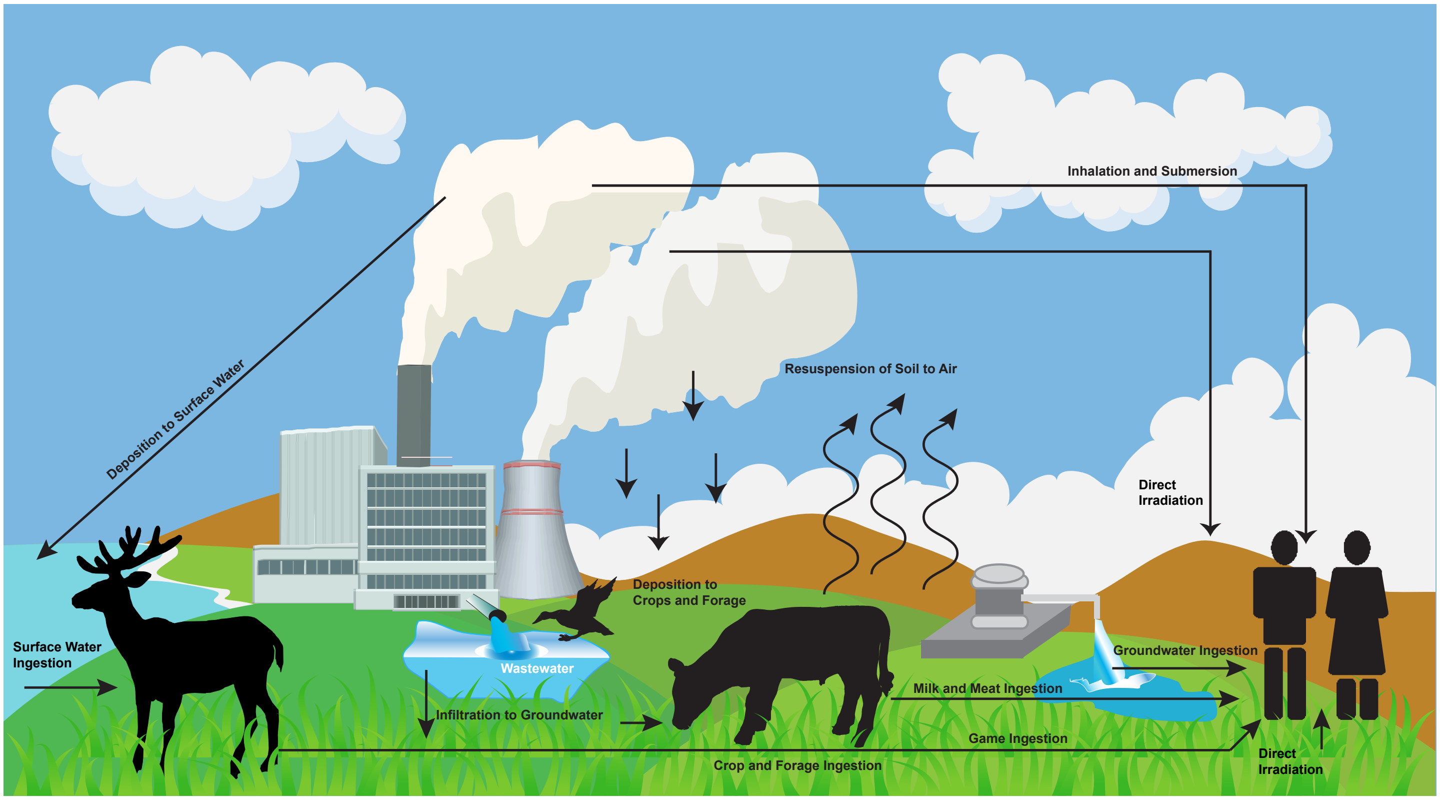

Figure 4-1. Potential Exposure Pathways to Humans from the INL Site.

Site air monitoring programs emphasize measurement of airborne radioactive contaminants because air has the potential to transport measureable amounts of radioactive materials to receptors in a relatively short period of time and can directly expose human receptors located off the INL Site.

This chapter presents results of radiological analyses of airborne effluents and ambient air samples collected on and off the INL Site. The results include those from the INL contractor, the Idaho Cleanup Project (ICP) Core contractor, and the Environmental Surveillance, Education, and Research Program (ESER) contractor. Table 4-1 summarizes the air monitoring activities on and off the INL Site. Details may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014b).

4.1 Organization of Air Monitoring Programs

The INL contractor documents airborne radiological effluents at INL facilities in an annual report prepared in accordance with the 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." Section 4.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2016 INL Report for Radionuclides* (DOE-ID 2017). The report also documents the estimated potential dose received by the general public due to INL Site activities.

Ambient air monitoring is conducted by the INL contractor and the ESER contractor to ensure that the INL Site remains in compliance with the U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment." The INL contractor collects air samples and air moisture samples primarily on the INL Site. In 2016, the INL contractor collected approximately 2,300 air samples (primarily on the INL Site) for various radiological analyses and air moisture samples at four sites for tritium analysis. The ESER contractor collects air samples across a 23,390 km^2 (9,000 mi^2) region that extends from locations on and around the INL Site to locations near Jackson, Wyoming. In 2016, the ESER contractor collected approximately 2,000 air samples, primarily off the INL Site, for various radionuclides. The ESER contractor also collects air moisture and precipitation samples at select locations for tritium analysis. Figure 4-2 shows the regional ambient air monitoring locations. Ambient air monitoring by the INL and ESER contractors is discussed in Section 4.3.

Table 4-1. Air Monitoring Activities by Organization.

Area/Facility[a]	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
	Airborne Effluents[b]	Low-volume Charcoal Cartridges (Iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation
ICP Core Contractor[d]							
INTEC	●		●	●	●		
RWMC	●		●	●	●		
INL Contractor[e]							
MFC	●						
INL/Regional		●	●	●	●	●	
Environmental Surveillance, Education, and Research Program[f]							
INL/Regional		●	●	●	●	●	●

a. INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex, INL = INL Site facilities as shown in Table 4-2, Regional = locations outside of the INL Site as shown in Table 4-3

b. Facilities that required monitoring during 2016 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities."

c. Gamma-emitting radionuclides are measured by the ICP Core contractor monthly and by the ESER contractor and the INL contractor quarterly. Strontium-90, plutonium-238, plutonium-239/240, and americium-241 are measured by the INL, ICP Core, and ESER contractors quarterly.

d. The ICP Core contractor monitors waste management facilities to demonstrate compliance with DOE Order 435.1, "Radioactive Waste Management."

e. The INL contractor monitors airborne effluents at MFC and ambient air outside INL Site facilities to demonstrate compliance with DOE Order 458.1, "Radiation Protection of the Public and the Environment."

f. The ESER contractor collects samples on, around, and distant from the INL Site to demonstrate compliance with DOE Order 458.1, "Radiation Protection of the Public and the Environment."

The ICP Core contractor monitors air around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." These facilities are the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) near the Idaho Nuclear Technology and Engineering Center (INTEC). These locations are shown in Figure 4-2. Section 4.4 discusses air sampling by the ICP Core contractor in support of waste management activities.

Unless specified otherwise, the radiological results reported in the following sections are considered statistically positive detections. See the Supplemental Report to this Annual Site Environmental Report entitled *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report* for more information.

Meteorological data have been collected at the INL Site since 1950 by the National Oceanic and Atmospheric Administration (NOAA). The data have historically been tabulated, summarized, and reported in several climatography reports for use by scientists at the INL

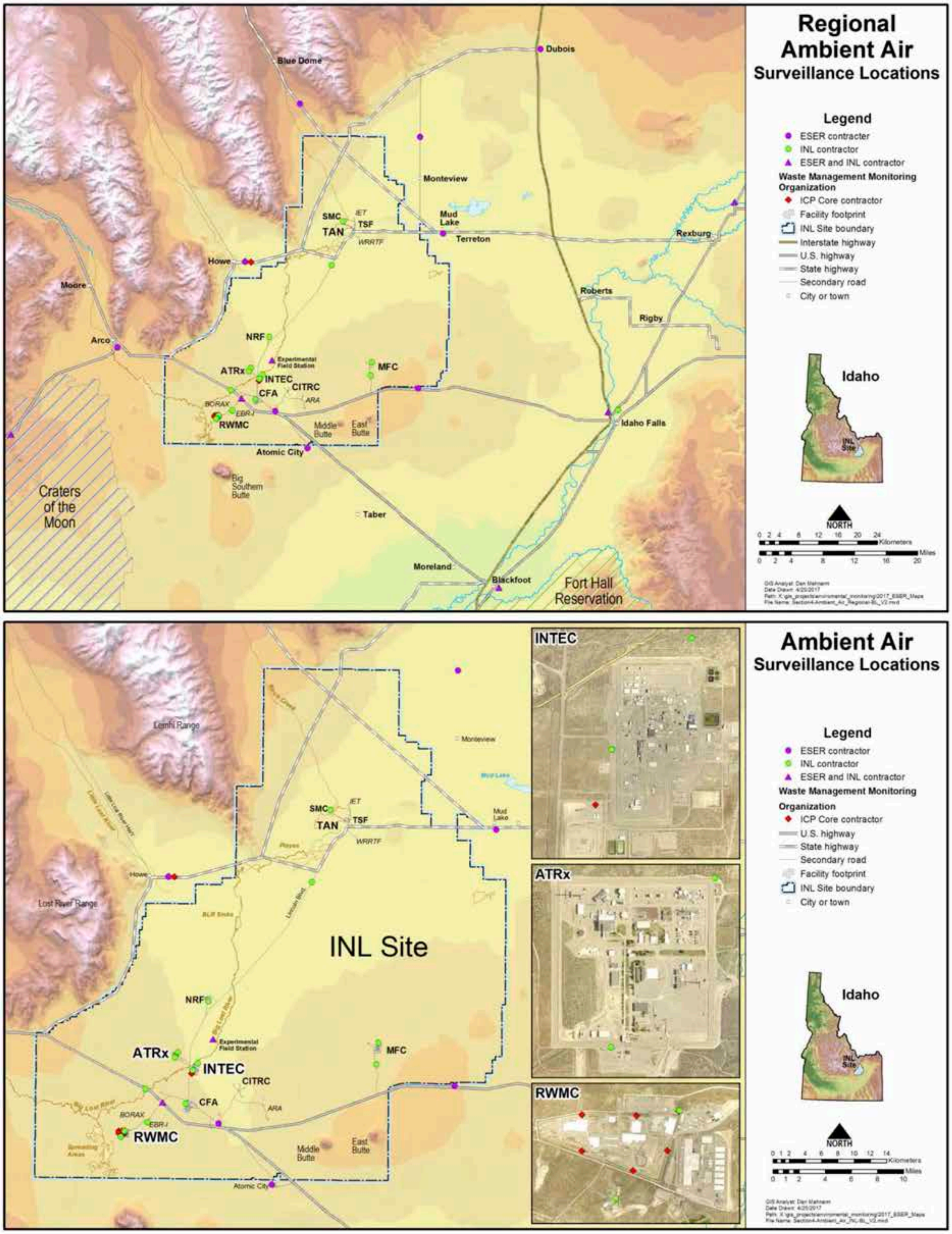

Figure 4-2. INL Site Environmental Surveillance Air Sampling Locations (regional [top] and on the INL Site [bottom]).

Site to evaluate atmospheric transport and dispersion from INL sources. The latest report, *Climatography of the Idaho National Laboratory, 3rd Edition* (Clawson et al. 2007), was prepared by the Field Research Division of the Air Resources Laboratory of NOAA and presents over 10 years (1994–2006) of quality-controlled data from the NOAA INL mesonet meteorological monitoring network (niwc.noaa.inel.gov/climate/INL_Climate_3rdEdition.pdf). More recent data are provided by the Field Research Division to scientists modeling the dispersion of INL Site releases and resulting potential dose impact (see Chapter 8 in this annual report and *Meteorological Monitoring*, a supplement to this annual report).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines airborne effluent concentrations from its regulated emission sources as required under state and federal regulations. Radiological air emissions from INL Site facilities are also used to estimate the dose to a hypothetical maximally exposed individual (MEI), who is a member of the public (see Chapter 8 of this report). Radiological effluents and the resulting potential dose for 2016 are reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2016 INL Report for Radionuclides* (DOE-ID 2017), referred to hereafter as the National Emission Standards for Hazardous Air Pollutants (NESHAP) Report.

The NESHAP Report describes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAP regulation: these are primarily stacks at the Advanced Test Reactor (ATR) Complex, the Materials and Fuels Complex (MFC), the Advanced Mixed Waste Treatment Project (AMWTP), and Idaho Nuclear Technology and Engineering Center (INTEC)
- Releases from all other point sources (stacks and exhaust vents)
- Nonpoint—or diffuse—sources, otherwise referred to as fugitive sources, which include radioactive waste ponds, buried waste, contaminated soil areas, and decontamination and decommissioning operations.

INL Site emissions include all three airborne emission categories and are summarized in Table 4-2. The radionuclides included in this table were selected because they contribute 99.9 percent of the cumulative dose to the MEI estimated for each facility area. During 2016, an estimated 1,856 Ci (6.87×10^{13} Bq) of radioactivity were released to the atmosphere from all INL Site sources. The 2016 release is within the range of releases from previous years and is consistent with the continued downward trend observed over the last 10 yrs. For example, reported releases for 2005, 2010, and 2015 were 6,614 Ci, 4,320 Ci, and 1,870 Ci, respectively.

The following facilities were contributors to the total emissions (Figure 4-3):

- ***Advanced Test Reactor (ATR) Complex Emissions Sources (56.3 percent of total INL Site source term)*** – Radiological air emissions from ATR Complex are primarily associated with ATR operations. These emissions include noble gases, iodines, and other mixed fission and activation products, but are primarily relatively short-lived noble gases. Other radiological air emissions are associated with sample analysis, site remediation, and research and development activities. Another emission source is the INL Radioanalytical Chemistry Laboratory, in operation since 2011. Activities at the lab include wet chemical analysis to determine trace radionuclides, higher level radionuclides, inorganic, and general purpose analytical chemistry. High-efficiency particulate air filtered hoods are located in the laboratory, including the radiological control room, which is used for analysis of contaminated samples.
- ***Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (39.8 percent of total INL Site source term)*** – Radiological air emissions from INTEC sources are primarily associated with the Three Mile Island Unit 2 Independent Spent Fuel Storage Installation (CPP-1774) and emission sources that are exhausted through the Main Stack, including liquid waste operations, such as the Process Equipment Waste Evaporator and the Liquid Effluent Treatment and Disposal. These radioactive emissions include both particulate and gaseous radionuclides. Additional radioactive emissions are associated with remote-handled transuranic and mixed waste management operations, dry storage of spent nuclear fuel, and maintenance and servicing of contaminated equipment.

  The ICDF is located outside the fenced boundary of INTEC. Radiological emissions from this facility are

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2016).[a]

		Airborne Effluent (Ci)[b]								
Radionuclide[c]	Half-Life[d]	ATR Complex[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	Total
Am-241	432.2 y	2.21E-05	NS[f]	—[g]	9.84E-06	6.98E-07	—	6.69E-04	—	7.02E-04
Am-243	7,370 y	NS	4.21E-09	—	—	2.20E-06	—	NS	—	2.20E-06
Ar-41	1.822 h	7.05E+02	NS	—	—	—	—	—	NS	7.05E+02
Br-82	1.47 d	—	NS	—	—	—	—	—	8.52E-04	8.52E-04
C-14	5,730 y	NS	NS	—	NS	1.97E-03	7.70E-01	2.63E-01	—	1.04E+00
Cf-252	2.645 y	—	—	—	—	5.99E-08	—	—	—	5.99E-08
Cm-244	18.1 y	NS	1.65E-08	—	NS	NS	—	NS	—	1.72E-08
Cm-248	349,000 y	—	NS	—	—	1.69E-09	—	—	—	1.74E-09
Co-60	5.271 y	9.71E-03	NS	—	2.20E-05	2.15E-07	NS	NS	—	9.74E-03
Cs-137	30.04 y	6.18E-03	NS	—	1.56E-02	2.08E-06	9.60E-05	NS	—	2.19E-02
Eu-152	13.537 y	1.03E-04	NS	—	NS	NS	—	—	—	1.03E-04
H-3	12.33 y	2.86E+02	5.80E-01	—	1.16E+02	2.02E-01	NS	7.00E+01	3.26E-02	4.72E+02
I-125	59.4 d	1.00E-03	—	—	—	—	—	—	—	1.00E-03
I-129	15,700,000 y	NS	—	—	1.95E-02	4.56E-05	2.60E-05	—	—	1.96E-02
I-131	8.02 d	2.37E-03	—	—	—	8.28E-03	NS	—	—	1.06E-02
Kr-85	10.56 y	—	—	—	6.23E+02	NS	NS	NS	—	6.23E+02
Kr-87	1.272 h	6.92E+00	—	—	—	—	—	—	—	6.92E+00
Kr-88	2.84 h	2.30E+00	—	—	—	—	—	—	—	2.30E+00
Np-237	2,140,000 y	NS	NS	—	NS	4.31E-07	—	NS	—	4.31E-07
Pu-238	87.76 y	NS	NS	—	1.07E-04	2.88E-08	—	2.27E-07	—	1.07E-04
Pu-239	24,110 y	8.46E-06	NS	—	1.95E-04	5.18E-07	2.50E-06	2.11E-04	—	4.17E-04
Pu-240	6,564 y	NS	NS	—	1.01E-04	NS	—	1.26E-05	—	1.13E-04
Pu-241	14.4 y	NS	NS	—	2.90E-03	NS	—	NS	—	2.91E-03
Pu-242	373,300 y	NS	NS	—	—	4.45E-07	—	NS	—	4.46E-07
Sr-85	64.84 d	NS	NS	—	—	1.96E-04	—	—	—	1.96E-04
Sr-90	28.74 y	1.88E-02	NS	—	1.26E-02	3.95E-06	4.80E-05	NS	1.02E-06	3.15E-02
Tc-99m	6.01 h	4.08E-04	—	3.00E-06	—	—	—	—	—	4.11E-04
U-233	159,200 y	NS	NS	—	NS	7.48E-06	—	NS	—	7.51E-06
U-234	245,700 y	NS	NS	—	1.65E-07	8.31E-07	—	NS	1.25E-08	1.01E-06
U-238	4,468,000,000 y	NS	NS	—	7.37E-08	NS	—	NS	6.94E-08	1.70E-07
Xe-135	9.14 h	1.31E+01	—	—	—	—	—	—	—	1.31E+01
Xe-138	14.08 m	2.55E+01	—	—	—	—	—	—	—	2.55E+01
Total Ci released[h]		1.05E+03	5.80E-01	3.00E-06	7.38E+02	2.72E-01	7.94E-01	7.03E+01	3.44E-02	1.86E+03
Dose (mrem)[i]		5.60E-03	4.36E-06	3.30E-12	6.01E-03	4.01E-06	1.40E-04	2.53E-03	1.35E-07	1.43E-02

a. Radionuclide release information provided by the INL contractor.

b. One curie (Ci)= 3.7 x 10^{10} becquerels (Bq) estimated from waste disposal in the landfill and evaporation pond operations.

- ***Radioactive Waste Management Complex (RWMC)–Advanced Mixed Waste Treatment Project (AMWTP) Emissions Sources (3.8 percent of total INL Site source term)*** – Emissions from RWMC-AMWTP result from various activities associated with the facility's mission to complete environmental cleanup of the area, as well as to store, characterize, and treat contact-handled and remote-handled transuranic waste prior to shipment to off-site licensed disposal facilities. Under the current contractor, various projects are being conducted to achieve these objectives: Waste retrieval activities at the various Accelerated Retrieval Projects (ARPs); operation of the Resource Conservation and Recovery Act (RCRA) Sludge Repackage and Debris Repackage waste processing projects; operation of the three organic contaminated vadose zone (OCVZ) treatment units; storage of waste within the Type II storage modules at AMWTP; storage and characterization of waste at the Drum Vent and Characterization facilities; and treatment of wastes at the Transuranic Storage Area-Retrieval Enclosure. Approximately 20 emission point sources located at RWMC-AMWTP were reported in the National Emission Standards for Hazardous Air Pollutants - Calendar Year 2016 INL Report for Radionuclides (DOE-ID 2017), of which three of these sources are continuously monitored stacks. Monitoring of the radionuclide emissions from the CERCLA ARP facilities and WMF-1617 (ARP V) and WMF-1619 (ARP VII) is achieved with the Environmental Protection Agency-approved ambient air monitoring program, which has been in place since 2008.

  Estimates of radiological emissions from the RWMC-AMWTP sources show that transuranic radionuclides americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and plutonium-239/240 ($^{239/240}$Pu) account for the majority of emissions from waste exhumation and processing activities, while releases of tritium (^{3}H) and carbon-14 (^{14}C) are associated with the operation of the OCVZ units, and ^{3}H with the groundwater pumped from RWMC production wells.

- ***Central Facilities Area (CFA) Emissions Sources (0.031 percent of total INL Site source term)*** – Minor emissions occur from CFA where work with small quantities of radioactive materials is conducted. This includes sample preparation and verification and radiochemical research and development. Other minor emissions result from groundwater usage.

- ***Materials and Fuels Complex (MFC) Emissions Sources (0.015 percent of total INL Site source term)*** – Radiological air emissions at MFC are primarily associated with spent fuel treatment at the Fuel Conditioning Facility, waste

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2016).[a] (cont.)

Radionuclide[c]	Half-Life[d]	Airborne Effluent (Ci)[b]								
		ATR Complex[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	Total

c. Includes only those radionuclides which collectively contribute ≥ 99.9 percent of the total dose to the MEI estimated for each INL Site facility (see footnote i). Other radionuclides not shown in this table account for less than 0.1 percent of the dose estimated for each facility.

d. m = minutes, d = days, h = hours, y = years

e. ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), TAN = Test Area North (including Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range)

f. NS = not significant. The radionuclide contribution to total facility dose was estimated to be < 0.1% of the total facility dose.

g. A long dash signifies the radionuclide was not reported to be released to the air from a facility in 2016.

h. Each column total includes all radionuclides released from that specific area, including those not shown in this table, and thus may be greater than the sum of the row values.

i. The annual dose (mrem) for each facility was calculated at the location of the hypothetical maximally exposed individual using estimated radionuclide releases and methodology recommended by the Environmental Protection Agency. See Chapter 8 for detail.

characterization at the Hot Fuel Examination Facility, and fuel research and development at the Fuel Manufacturing Facility. These facilities are equipped with continuous emission monitoring systems. On a regular basis, the effluent streams from the Fuel Conditioning Facility, Hot Fuel Examination Facility, Fuel Manufacturing Facility, and other non-continuous emission monitoring radiological facilities are sampled and analyzed for particulate radionuclides. Gaseous and particulate radionuclides may also be released from other MFC facilities during laboratory research activities, sample analysis, waste handling and storage, and maintenance operations.

- ***Test Area North (TAN) Emissions Sources (0.002 percent of total INL Site source term)*** – The main emissions sources at TAN are the Specific Manufacturing Capability (SMC) project, and the New Pump and Treat Facility. Radiological air emissions from the Specific Manufacturing Capability project are associated with processing of depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny. Low levels of strontium-90 (^{90}Sr) and ^{3}H are present in the treated water from the New Pump and Treat Facility and are released to the atmosphere by the treatment process.

The estimated radionuclide releases (Ci/yr) from INL Site facilities, shown in Table 4-2, were used to calculate the dose to the hypothetical MEI, who is assumed to reside near the INL Site perimeter. The estimated dose to the MEI in calendar year 2016 was 0.014 mrem/yr (0.14 µSv/yr). Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report. Tritium contributed to approximately 23 percent of the MEI dose, followed by iodine-129 (^{129}I) at approximately 19 percent. Other contributors to the MEI dose include ^{90}Sr (13 percent), cesium-137 (^{137}Cs) (12 percent), argon-41 (^{41}Ar) (12 percent), ^{241}Am (7 percent), plutonium isotopes (5 percent), cobalt-60 (^{60}Co) (4 percent), and ^{14}C (2 percent).

4.3 Ambient Air Monitoring

Ambient air monitoring is conducted on and off the INL Site to determine the impact of INL Site releases. Filters are collected weekly by the INL and ESER contractors from a network of low-volume air monitors

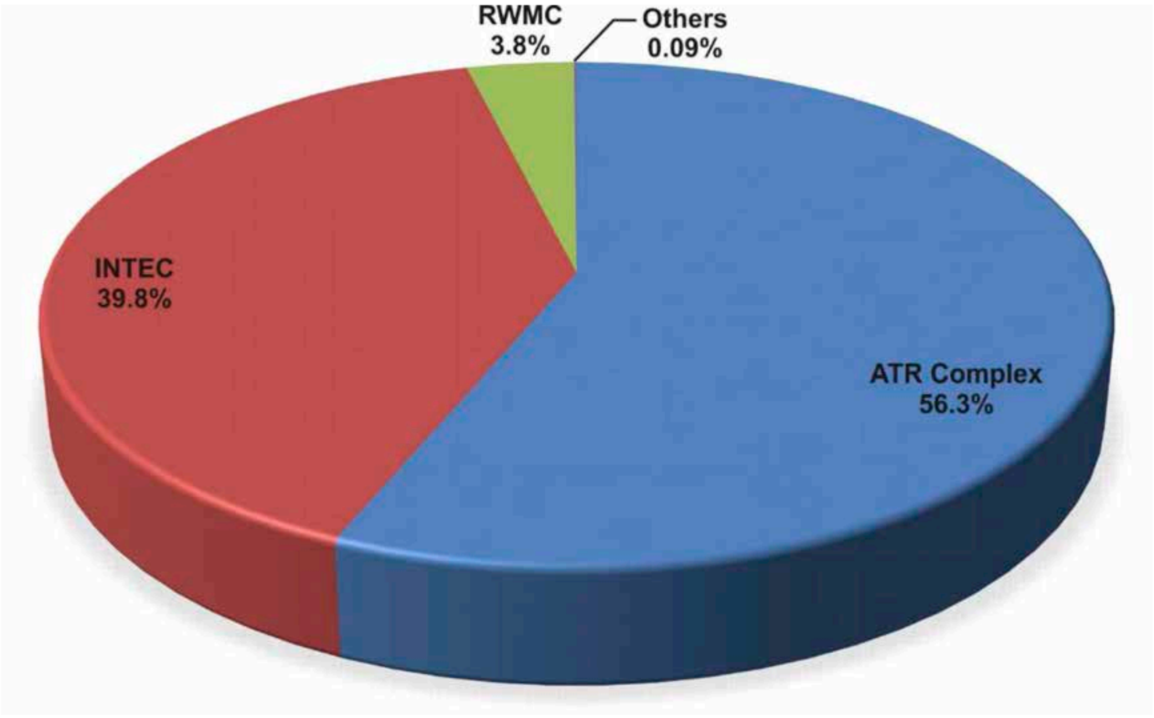

Figure 4-3. Percent Contributions in Ci, by Facility, to Total INL Site Airborne Releases (2016).

Table 4-3. INL Site Ambient Air Monitoring Summary (2016).

Medium Sampled	Type of Analysis	Locations and Frequency							Minimum Detectable Concentration (MDC)
		Frequency	Onsite			Offsite			
			INL[a]	ESER[b]	*Total*	INL[a]	ESER[b]	*Total*	
Air (low volume)	Gross alpha	Weekly	16	3	**19**	5	12	**17**	1 x 10^{-15} µCi/mL
	Gross beta	Weekly	16	3	**19**	5	12	**17**	2 x 10^{-15} µCi/mL
	Specific gamma[c]	Quarterly	16	3	**19**	5	12	**17**	2 x 10^{-16} µCi/mL
	Plutonium-238	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5 x 10^{-18} µCi/mL
	Plutonium-239/240	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5 x 10^{-18} µCi/mL
	Americium-241	Quarterly	16	2	**18**	5	4-5	**9-10**	4.6 x 10^{-18} µCi/mL
	Strontium-90	Quarterly	16	2	**18**	5	4-5	**9-10**	3.4 x 10^{-17} µCi/mL
	Iodine-131	Weekly	16	3	**19**	5	12	**17**	1.5 x 10^{-15} µCi/mL
	Total particulates	Weekly	–	3	**3**	–	12	**12**	10 µg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	–	–	1[e]	**1**	1 x 10^{-15} µCi/mL
	Gamma scan	Continuous	–	–	–	–	1[e]	**1**	Not applicable
	Specific gamma[c]	Annually[f]	–	–	–	–	1[e]	**1**	1 x 10^{-14} µCi/mL
	Isotopic U and Pu	Every four yrs	–	–	–	–	1[e]	**1**	2 x 10^{-18} µCi/mL
Air (atmospheric moisture)	Tritium	3–6/quarter	2	–	**2**	2	4	**6**	2 x 10^{-13} µCi/mL (air)
Air (precipitation)[g]	Tritium	Monthly	–	1	**1**	–	1	**1**	100 pCi/L
		Weekly	–	1	**1**	–	–	**–**	

a. Low volume (LV) air samplers are operated on the INL Site by the INL contractor at the following locations: ATR Complex (two air samplers), CFA, EBR-I, EFS, Highway 26 Rest Area, INTEC (two air samplers), Gate 4, MFC (two air samplers), NRF, RWMC (two air samplers), SMC, and Van Buren. In addition, there are two rotating duplicate samplers for QA. In 2016, they were at CFA and INTEC. The INL contractor also samples offsite (i.e., outside INL Site boundaries) at Blackfoot, Craters of the Moon, Idaho Falls, IRC, and Sugar City. (ATR = Advanced Test Reactor; CFA = Central Facilities Area; EBR-I = Experimental Breeder Reactor-1; EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center; IRC = INL Research Center; MFC = Materials and Fuels Complex; NRF = Naval Reactors Facility; PBF = Power Burst Facility; RWMC = Radioactive Waste Management Complex; SMC = Specific Manufacturing Capability)

b. The Environmental Surveillance, Education, and Research (ESER) contractor operates LV samplers on the INL Site at Main Gate, EFS, and Van Buren. Offsite locations include Arco; Atomic City; Blackfoot; Blue Dome; Craters of the Moon; Dubois; FAA Tower; Howe; Idaho Falls; Monteview; Mud Lake; and Sugar City. In addition, there are two rotating duplicate samplers for QA. In 2016, they were at Blackfoot and Sugar City.

c. The minimum detectable concentration shown is for cesium-137.

d. The Environmental Protection Agency (EPA) RadNet stationary monitor at Idaho Falls runs 24 hours a day, seven days a week, and sends near-real-time measurements of gamma radiation to EPA's National Analytical Radiation Environmental Laboratory (NAREL). Filters are collected by ESER personnel for the EPA RadNet program and sent to NAREL. Data are reported by the EPA's RadNet at http://www.epa.gov/radnet/radnet-databases-and-reports.

e. Gross beta scans were conducted by ESER personnel through June 2015. All scans and analyses are now performed by EPA at NAREL.

f. If gross beta activity is greater than 1 pCi/m^3, then a gamma scan is performed at NAREL. Otherwise an annual composite is analyzed.

g. Precipitation samples are collected onsite at EFS and at CFA when available. Samples are collected offsite at Idaho Falls.

(Table 4-3). At each monitor, a pump pulls air (about 57 L/min [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm membrane filter and a charcoal cartridge. After a five-day holding time to allow for the decay of naturally-occurring radon progeny, the filters are analyzed in a laboratory for gross alpha and beta activity. Gross alpha and beta results are considered screenings because specific radionuclides are not identified. Rather, the results reflect a mix of alpha- and beta-emitting radionuclides. Gross alpha and beta radioactivity in air samples are usually dominated by the presence of naturally occurring radionuclides. Gross beta radioactivity is, with rare exceptions, detected in each air filter collected. Gross alpha activity is only occasionally detected, but it becomes more commonly detected during wildfires and temperature inversions. If the results are higher than those typically observed, sources other than background radionuclides may be suspected, and other analytical techniques can be used to identify specific radionuclides of concern. Gross alpha and beta activity are also examined over time and between locations to detect trends, which might indicate the need for more specific analyses.

The filters are composited quarterly by the ESER and INL contractors for laboratory analysis of gamma-emitting radionuclides, such as ^{137}Cs, which is a man-made radionuclide present in soil both on and off the INL Site due to historical INL Site activities and global fallout. The contaminated soil particles can become airborne and subsequently filtered by air samplers. Naturally occurring gamma-emitting radionuclides that are typically detected in air filters include beryllium-7 (^{7}Be) and potassium-40 (^{40}K).

The ESER and INL contractors also use a laboratory to radiochemically analyze the quarterly composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include ^{241}Am, ^{238}Pu, $^{239/240}$Pu and ^{90}Sr. They were selected for analysis because they have been detected historically in air samples and may be present due to resuspension of surface soil particles contaminated by INL Site activities or global fallout.

Charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) by the INL and ESER contractors. Iodine-131 is of particular interest because it is produced in relatively large quantities by nuclear fission, is readily accumulated in human and animal thyroids, and has a half-life of eight days. This means that any elevated level of ^{131}I in the environment could be from a recent release of fission products.

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the Experimental Field Station (EFS) and Van Buren Boulevard, and off the INL Site at Atomic City, Blackfoot, Craters of the Moon, Idaho Falls (by both contractors), and Sugar City. Air passes through a column of molecular sieve, which is an adsorbent material that adsorbs water vapor in the air. The molecular sieve is sent to a laboratory for analysis when the material has adsorbed sufficient moisture to obtain a sample. The laboratory extracts water from the material by distillation and determines tritium concentrations through liquid scintillation counting. Tritium is present in air moisture due to natural production in the atmosphere and is also released by INL Site facilities (Table 4-2).

Precipitation samples are collected by the ESER contractor at EFS, CFA, and Idaho Falls and analyzed for tritium using liquid scintillation counting in a laboratory.

4.3.1 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,200 charcoal cartridges (blanks and duplicates are in this count) in 2016. There were no statistically positive measurements of ^{131}I. During 2016, the ESER contractor analyzed 876 cartridges, usually in batches of 10 cartridges, looking specifically for ^{131}I. Iodine-131 was detected near the detection limit in one batch of nine cartridges collected on March 23, 2016. Further counting or subsets found no detectable ^{131}I.

Gross Activity – Gross alpha and beta results cannot provide concentrations of specific radionuclides. Because these radioactivity measurements include naturally occurring radionuclides (such as ^{40}K, ^{7}Be, uranium, thorium, and the daughter isotopes of uranium and thorium) in uncertain proportions, a meaningful limit cannot be adopted or constructed. However, elevated gross alpha and beta results can be used to indicate a potential problem, such as an unplanned release, on a timely basis. Weekly results are reviewed for changes in patterns between locations and groups (i.e., on site, boundary, and offsite locations) and for unusually elevated results. Anomalies are further investigated by reviewing sample or laboratory issues, meteorological events (e.g., inversions), and INL Site activities that are possibly related. If indicated, analyses for specific radionuclides may be performed. The data also provide useful information for trending of the total activity over time.

The concentrations of gross alpha and gross beta radioactivity detected by ambient air monitoring are summarized in Tables 4-4 and 4-5. Concentrations reported for samples collected by both INL and ESER contractors at common locations reflect all results except duplicate measurements. Results are discussed further below.

- ***Gross Alpha.*** Gross alpha concentrations measured on a weekly basis in individual air samples ranged

Table 4-4. Median Gross Alpha Concentrations in Ambient Air Samples Collected in 2016.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] $(\times 10^{-15}\ \mu\text{Ci/mL})$	Annual Median Concentration[c] $(\times 10^{-15}\ \mu\text{Ci/mL})$
Distant				
	Blackfoot	103[d]	-0.44 – 3.7	1.1
	Craters of the Moon	103[d]	0.03 – 4.8	0.9
	Dubois	52	0.29 – 3.0	1.0
	Idaho Falls	103[d]	-0.08 – 4.0	1.1
	Sugar City	101[d]	-0.15 – 4.0	1.2
	IRC[e]	51	-0.41 – 4.7	0.9
			Distant Median:	1.1
Boundary				
	Arco	51	0.23 – 5.7	1.1
	Atomic City	52	0.20 – 3.3	1.0
	Blue Dome	52	0.32 – 4.7	0.9
	FAA Tower	52	0.15 – 3.0	1.0
	Howe	52	0.43 – 4.7	1.1
	Monteview	52	0.24 – 3.5	1.1
	Mud Lake	51	0.45 – 4.3	1.2
			Boundary Median:	1.1
INL Site				
	ATR Complex (south side)	51	-0.18 – 5.5	1.2
	ATR Complex (NE corner)	51	-0.23 – 6.7	1.2
	Highway 26 Rest Area	51	-0.08 – 4.7	1.1
	CFA	51	-0.09 – 5.4	1.2
	EBR-I	51	-0.54 – 3.6	1.0
	EFS	102[d]	-0.6 – 5.1	1.0
	Gate 4	51	-0.16 – 4.4	1.3
	INTEC (NE corner)	51	-0.48 – 4.3	1.2
	INTEC (west side)	51	-0.15 – 4.4	1.5
	Main Gate	52	0.12 – 3.8	1.2
	MFC	51	-0.22 – 4.8	1.1
	MFCN	51	0.07 – 3.6	1.1
	NRF	51	-0.09 – 3.9	1.1
	RWMC	51	-0.42 – 4.3	1.3
	RWMCS	50	-0.22 – 4.4	1.1
	SMC	51	-0.24 – 3.8	1.2
	Van Buren Boulevard	103[d]	-1.3 – 5.1	1.2
			INL Site Median:	1.2

a. ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, FAA = Federal Aviation Administration, INTEC = Idaho Nuclear Technology and Engineering Center, IRC = INL Research Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability. See Figure 4-2 for locations on INL Site.

b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements which are made for quality assurance purposes.

c. All measurements made by INL and ESER contractors, with the exception of duplicate measurements, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

d. Includes all samples collected by the INL and ESER contractors at this location, with the exception of duplicate quality assurance samples. See Table 4-3.

e. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

Table 4-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2016.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median Concentration[c] ($\times 10^{-14}$ µCi/mL)
Distant				
	Blackfoot	103[d]	0.51 – 6.1	1.8
	Craters of the Moon	103[d]	0.31– 6.2	1.8
	Dubois	52	0.34 – 3.9	1.6
	Idaho Falls	103[d]	0.46 – 6.2	1.9
	Sugar City	101[d]	0.37 – 5.3	1.9
	IRC[e]	51	0.94 – 5.2	1.9
			Distant Median:	1.8
Boundary				
	Arco	51	0.27 – 5.9	1.7
	Atomic City	52	0.54 – 6.8	1.8
	Blue Dome	52	0.20 – 3.6	1.6
	FAA Tower	52	0.43 – 5.4	1.7
	Howe	52	0.43 – 5.9	1.7
	Monteview	52	0.45 – 6.3	1.7
	Mud Lake	52	0.53 – 6.6	1.8
			Boundary Median:	1.7
INL Site				
	ATR Complex (south side)	51	0.82 – 5.3	2.3
	ATR Complex (NE corner)	51	0.73 – 7.0	2.2
	Highway 26 Rest Area	51	0.97 – 5.9	2.3
	CFA	51	0.84 – 5.4	2.3
	EBR-I	51	0.51– 6.1	2.1
	EFS	102[d]	0.58 – 8.7	2.0
	Gate 4	51	1.1 – 6.1	2.5
	INTEC (NE corner)	51	0.98 – 5.6	2.2
	INTEC (west side)	51	0.74 – 6.4	2.1
	Main Gate	52	0.60 – 7.6	1.7
	MFC	51	0.82 – 5.0	2.0
	MFCN	51	0.88 – 5.6	2.2
	NRF	51	0.70 – 5.1	2.3
	RWMC	51	0.47 – 5.1	2.2
	RWMCS	50	0.94 – 6.0	2.4
	SMC	51	0.82 – 6.3	2.3
	Van Buren Boulevard	103[d]	0.60 – 6.4	1.9
			INL Site Median:	2.1

a. ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, FAA= Federal Aviation Administration, INTEC = Idaho Nuclear Technology and Engineering Center, IRC = INL Research Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability

b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements which are made for quality assurance purposes.

c. All measurements made by INL and ESER contractors, with the exception of duplicate measurements, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

d. Includes all samples collected by both the INL and ESER contractors at this location, with the exception of duplicate QA samples. See Table 4-3.

e. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

from a low of $(-1.3 \pm 1.6) \times 10^{-15}$ µCi/mL collected at Van Buren Boulevard during the week ending on April 6, 2016, to a high of $(6.7 \pm 1.8) \times 10^{-15}$ µCi/mL collected at the ATR Complex on August 3, 2016 (Table 4-4). The maximum result was within the range of concentrations (-4.0×10^{-16} to 9.6×10^{-15} µCi/mL) reported in previous Annual Site Environmental Reports (ASERs) from 2010–2015 and is attributed to naturally occurring gross alpha in smoke particles from regional wildfires.

The median annual gross alpha concentrations were typical of previous measurements. The maximum result is less than the Derived Concentration Standard (DCS) (DOE, 2011) of 3.4×10^{-14} µCi/mL for $^{239/240}$Pu (see Table A-2 of Appendix A), which is the most conservative specific radionuclide DCS that could be applied to gross alpha activity.

- ***Gross Beta.*** Weekly gross beta concentrations measured in air samples ranged from a low of $(0.197 + 0.50) \text{ x } 10^{-14}$ µCi/mL at Blue Dome during the week of March 09, 2016, to a high of $(8.74 \pm 0.13) \times 10^{-14}$ µCi/mL at EFS during the first week of January 2016 (Table 4-5). All results were within the range of concentrations ($-0.03 \times 10^{-14} – 6 \times 10^{-13}$ µCi/mL) reported in previous ASERs (2010–2015). In general, median airborne radioactivity levels for the three groups (INL Site, boundary, and distant locations) tracked each other closely throughout the year. The typical temporal fluctuations for natural gross beta concentrations in air were observed, with higher values typically occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). This pattern occurs over the entire sampling network, is representative of natural conditions, and is not caused by a localized source, such as a facility or activity at the INL Site. An inversion can lead to natural radionuclides being trapped close to the ground. In 2016, the most prominent inversion periods occurred in January and November. The maximum weekly gross beta concentration is significantly below the DCS of 2.5×10^{-11} µCi/mL (see Table A-2 of Appendix A for the most restrictive beta-emitting radionuclide in air, ^{90}Sr).
- ***Gross Activity Statistical Comparisons.*** Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected by the ESER contractor from the INL Site, boundary, and distant locations (see the supplemental report, Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report, for a description of methods used). If the INL Site were a significant source of offsite contamination, contaminant concentrations would be statistically greater at boundary locations than at distant locations. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2016. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2016 that can be attributed to expected statistical variation in the data and not to INL Site releases. Quarterly reports detailing these analyses are provided at www.idahoeser.com/Publications.htm#Quarterly.

  The INL Contractor compared gross beta concentrations from samples collected at onsite and offsite locations. Statistical evaluation revealed no significant differences between onsite and offsite concentrations. Onsite and offsite mean concentrations ($2.4 \pm 0.3 \times 10^{-14}$ and $2.2 \pm 0.3 \times 10^{-14}$ µCi/mL, respectively) showed equivalence at one sigma uncertainty and are attributable to natural data variation.

Specific Radionuclides – The ESER and INL contractors reported no detections of ^{90}Sr during 2016.

Plutonium-239/240 was detected in two composite samples collected by the ESER contractor during the third quarter at Blackfoot and FAA Tower and in one composite sample collected at Atomic City during the fourth quarter (Table 4-6). The approximate detection level for these three specific filter analyses (~ 4 ×

What is an inversion?

Usually within the lower atmosphere, the air temperature decreases with height above the ground. This is largely because the atmosphere is heated from below as solar radiation warms the earth's surface, which, in turn, warms the layer of the atmosphere directly above it. A meteorological inversion is a deviation from this normal vertical temperature gradient such that the temperature increases with height above the ground. A meteorological inversion is typically produced whenever radiation from the earth's surface exceeds the amount of radiation received from the sun. This commonly occurs at night or during the winter when the sun's angle is very low in the sky.

Table 4-6. Human-made Radionuclides Detected in Ambient Air Samples Collected in 2016.

Radionuclide	Result[a] (µCi/mL)	Location	Group	Quarter Detected
Americium-241	$(6.6 \pm 1.3) \times 10^{-18}$	Blackfoot[b,c]	Distant	3rd
	$(4.1 \pm 1.3) \times 10^{-18}$	Van Buren Boulevard[d]	INL Site	1st
	$(9.4 \pm 1.9) \times 10^{-18}$	CFA[d,e]	INL Site	1st
	$(4.4 \pm 1.4) \times 10^{-18}$	EBR-I[d,f]	INL Site	1st
Plutonium-239/240	$(2.0 \pm 0.53) \times 10^{-18}$	Blackfoot[b,c]	Distant	3rd
	$(1.5 \pm 0.45) \times 10^{-18}$	FAA Tower[b]	Boundary	3rd
	$(1.8 \pm 0.59) \times 10^{-18}$	Atomic City[b]	Boundary	4th

a. Results ± 1σ. Results shown are ≥ 3σ.
b. Sample collected by ESER contractor.
c. Duplicate sample collected at same location had no detectable ^{241}Am or $^{239/240}$Pu on the filter.
d. Sample collected by INL Contractor.
e. CFA = Central Facilities Area
f. EBR-I = Experimental Breeder Reactor No. 1

10^{-19} µCi/mL) was lower than those associated with the analyses of the other composite filter samples and is the lowest ever reported to the ESER program. The average detection level for the other composite filter samples was approximately 2×10^{-18} µCi/mL. In addition, a filter collected from a duplicate sampler located at Blackfoot during the third quarter was analyzed and $^{239/240}$Pu was not detected. The duplicate filter was analyzed using an alpha spectrometer with a higher detection level (3×10^{-18} µCi/mL) than that used for the other Blackfoot composite with the detectable concentration of $^{239/240}$Pu. Low levels of $^{239/240}$Pu present in soil (see Chapter 7) and thus particulates resuspended from soil into air is attributed to global fallout from past nuclear weapons testing. We can expect to occasionally detect this radionuclide, especially when detection levels are very low. The 2016 detections were all below the highest measurement (4.3×10^{-18} µCi/mL) reported in previous annual reports from 2010–2015 and well below the DCS for $^{239/240}$Pu in air (3.4×10^{-14} µCi/mL).

The laboratory reported a detection of ^{241}Am in the third quarterly composite sample collected by ESER at Blackfoot (Table 4-6). Similar to the $^{239/240}$Pu analysis described above, the detection level of ^{241}Am for this sample was lower (slightly) than that of the duplicate sample, which had no detectable ^{241}Am. The laboratory used by the INL contractor also reported traces of ^{241}Am in three quarterly composite samples (Table 4-6). The presence of this radionuclide in the environment may also be attributed to global fallout and may sometimes be detected, particularly if the detection level is low. The results were well below the DCS for ^{241}Am in air (4.1×10^{-14} µCi/mL). The maximum result (9.4×10^{-18} µCi/mL) is slightly higher than the maximum concentration (8.0×10^{-18} µCi/mL) reported previously in the annual reports from 2010–2015.

Natural ^{7}Be was detected in numerous ESER and INL contractor composite samples at concentrations consistent with past concentrations. Atmospheric ^{7}Be results from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in earth's atmosphere.

4.3.2 Atmospheric Moisture Monitoring Results

During 2016, the ESER contractor collected 57 atmospheric moisture samples. Table 4-7 presents the percentage of samples that contained detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in 30 ESER samples, with a high of 21.6×10^{-13} µCi/mL$_{air}$ at Sugar City in October. The highest concentration of tritium detected in an atmospheric moisture sample since 2010 was 28.3×10^{-13} µCi/mL$_{air}$ at Idaho Falls in 2014. The highest observed tritium concentration in a sample collected by the ESER contractor is far below the DCS for tritium in air (as hydrogen tritium oxygen) of 2.1×10^{-7} µCi/mL$_{air}$ (see Table A-2 of Appendix A).

In 2016, the INL contractor collected a total of 35 samples for atmospheric moisture on the INL Site at EFS and Van Buren Boulevard on the INL Site and at Idaho

Table 4-7. Tritium Concentrations[a] in Atmospheric Moisture Samples Collected On and Off the INL Site in 2016.

ESER Contractor				
	Atomic City	**Blackfoot**	**Idaho Falls**	**Sugar City**
Number of samples	12	15	16	14
Number of detections	7	7	6	10
Detection percentage	58%	47%	38%	71%
Concentration range (×10^{-13} µCi/mL_{air})[b]	-0.18 ± 0.64– 16.2 ± 2.0	-0.64 ± 1.4 – 9.9 ± 1.3	-3.3 ± 1.3 – 11.7 ± 1.9	-2.5 ± 1.7 – 21.6 ± 2.8
Mean concentration (×10^{-13} µCi/mL_{air})[b]	3.3	3.1	3.3	6.6
INL Contractor				
	Craters of the Moon	**EFS**	**Idaho Falls**	**Van Buren**
Number of samples	7	10	8	10
Number of detections	2	7	4	2
Detection percentage	29%	70%	50%	20%
Concentration range (×10^{-13} µCi/mL_{air})[b]	0.3 ± 2.3 – 10.7 ± 5.7	0.6 ± 2.2 – 18.5 ± 3.3	-3.2 ± 3.9 – 17.6 ± 8.8	-3.5 ± 1.7 – 13.1 ± 3.0
Mean concentration (×10^{-13} µCi/mL_{air})[b]	4.2	8.9	7.0	5.9

a. Results ± 1σ.
b. All measurements are included in this table and in computation of mean annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

Falls and Craters of the Moon off the INL Site (Table 4-7). The INL results were similar to those measured in samples collected by the ESER contractor. Tritium was detected in 43 percent of the samples collected and the maximum concentration measured was 18.5× 10^{-13} µCi/mL_{air} at EFS on August 31, 2016. This is well below the DCS for tritium in air and below the maximum measured in 2010.

The tritium measured in atmospheric moisture samples collected on and around the INL Site is probably natural and/or weapons testing fallout in origin.

4.3.3 Precipitation Monitoring Results

The ESER contractor collects precipitation samples weekly at EFS, when available, and monthly, when available, at CFA and off the INL Site in Idaho Falls. A total of 51 precipitation samples were collected during 2016 from the three sites. Tritium was detected in 31 samples, and detectable results ranged up to a high of 413 pCi/L at EFS during February. Table 4-8 shows the percentage of detections, the concentration range, and the mean concentration for each location. The highest concentration is well below the DCS level for tritium in water of 1.9 × 10^6 pCi/L and within the historical normal range (-62.1 –393 pCi/L) measured from 2010–2015, as reported in the previous annual reports. The results were also comparable to detections made by concentrations measured in atmospheric moisture and precipitation samples collected from 2010–2016. This confirms that the source of the tritium is environmental and not from INL Site releases.

Average annual tritium concentrations measured in atmospheric moisture and precipitation samples collected by the ESER Program for the past 10 years (from 2007–2016) are shown in Figure 4-4. The results are similar for each year. Statistical comparisons of both sets of data show that there is no difference between average annual tritium concentrations measured in atmospheric moisture and precipitation samples collected from 2010–2016. This confirms that the source of tritium is environmental and not from INL Site releases.

4.3.4 Suspended Particulates Monitoring Results

In 2016, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99 percent efficient for collection of particles greater than 0.3

Table 4-8. Tritium Concentrations in Precipitation Samples Collected in 2016.[a]

	Central Facilities Area	Experimental Field Station	Idaho Falls
Number of samples	11	28	12
Number of detections	6	19	6
Detection percentage	55%	68%	50%
Concentration range (pCi/L)	-173 ± 20.4 – 192 ± 26.7	-26.4 ± 25.1 – 413 ± 28.1	-7.82 ± 22.8 – 223 ± 26.0
Mean concentration (pCi/L)	54.2	121	78.8

a. All measurements are included in this table and in computation of mean annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

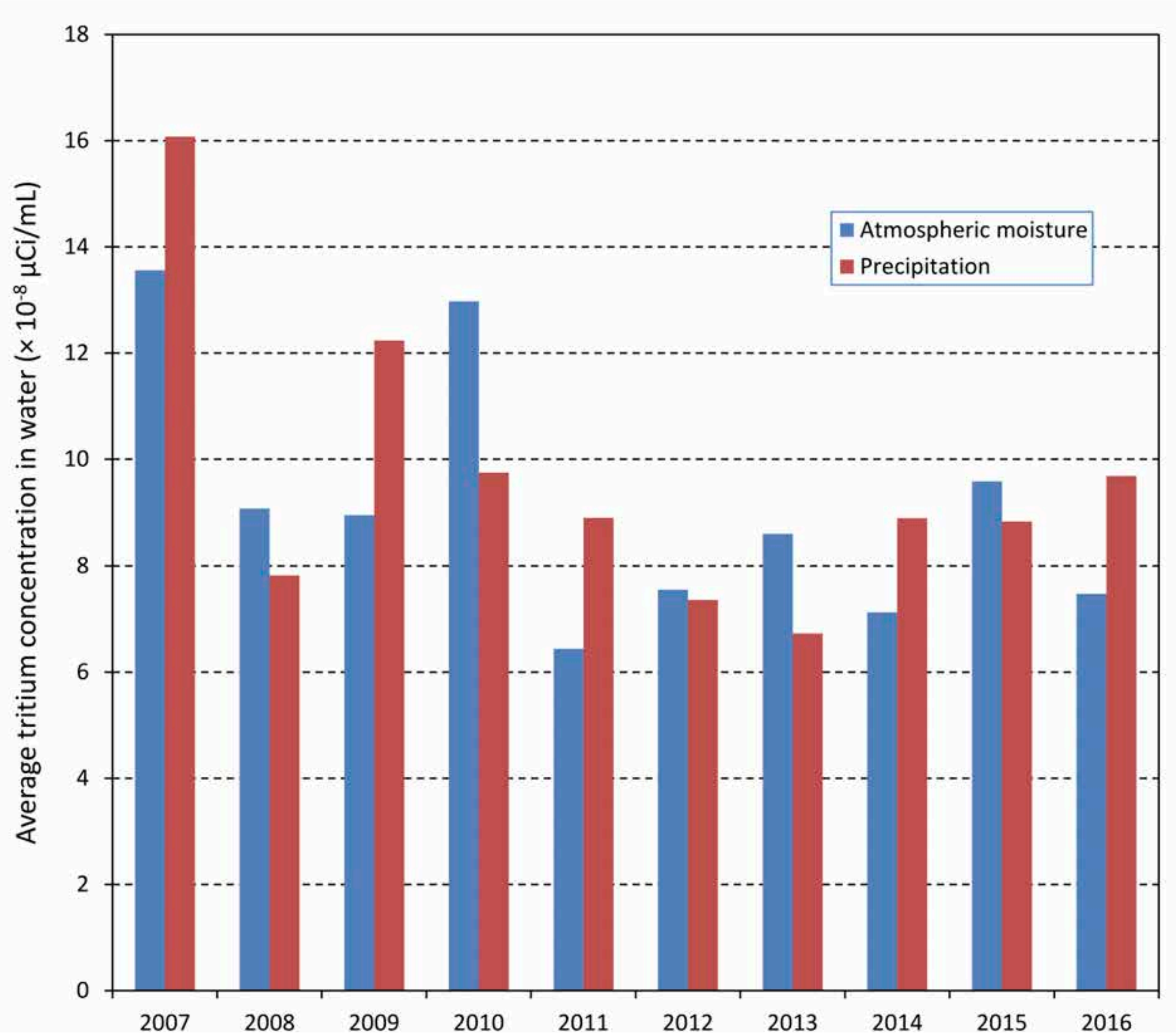

Figure 4-4. Average Annual Tritium Concentrations Measured in Atmospheric Moisture and Precipitation from 2007—2016.

µm in diameter. That is, they collect the total particulate load greater than 0.3 µm in diameter.

Mean annual particulate concentrations ranged from 6.7 µg/m^3 at Blue Dome to 25.0 µg/m^3 at Arco. In general, particulate concentrations were higher at offsite locations than at the INL Site stations. This is most likely influenced by agricultural activities off the INL Site.

4.4 Waste Management Environmental Surveillance Air Monitoring

4.4.1 Gross Activity

The ICP Core contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." Currently, ICP Core waste management operations are performed at the SDA at RWMC and the ICDF at INTEC. These operations have the potential to emit radioactive airborne particulates. The ICP Core contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2016 (Figure 4-5).

On September 24, 2015, a transformer near sample location SDA 6.3 blew a fuse, which caused the sampler to lose power. On October 18, 2015, the sampler was moved approximately 600 ft west to the closest available power source. The new location was designated as SDA 6.3A. In November 2016, the electrical lines were repaired and this sampler was moved back to its original location, SDA 6.3. At the same time, sampler locations SDA 4.3 and SDA 4.2 were moved approximately 500 ft to the east to resolve an issue with a faulty electrical box at the previous location. Their new locations were designated as SDA 4.3A and SDA 4.2A. Sampler location SDA 4.2A is a replicate sampler used for quality assurance purposes, and the data from that sampler are not used to summarize results. The ICP Core contractor also collected samples from a control location at Howe, Idaho (Figure 4-2), to compare with the results of the SDA and ICDF.

Samples were obtained using suspended particulate monitors similar to those used by the INL and ESER contractors. The air filters are 4 in. in diameter and are changed out on the closest working day to the first and 15th of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples.

Table 4-9 shows the median annual and range of gross alpha concentrations at each location. Gross alpha concentrations ranged from a low of $(0.66 \pm 0.21) \times 10^{-15}$ µCi/mL collected at SDA 9.3 on April 4, 2016, to a high of $(4.76 \pm 0.86) \times 10^{-15}$ µCi/mL at SDA 9.3 on August 24, 2016.

Table 4-10 shows the median annual and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of $(0.96 \pm 0.11) \times 10^{-14}$ µCi/mL at SDA 4.3 on May 2, 2016, to a high of $(6.13 \pm 0.52) \times 10^{-14}$ µCi/mL at INT 100.3 on November 15, 2016.

The gross alpha and gross beta results for the SDA and ICDF are comparable to historical results, as have been previously reported, and to measurements made at the control location (Howe), and no new trends were identified.

4.4.2 Specific Radionuclides

Air filters collected by the ICP Core contractor are composited monthly, analyzed in a laboratory by gamma spectroscopy, and radiochemically analyzed for specific alpha- and beta-emitting radionuclides.

In 2016, no human-made, gamma-emitting radionuclides were detected in air samples at the SDA at RWMC or at the ICDF at INTEC. However, human-made specific alpha- and beta-emitting radionuclides were detected at the SDA and at ICDF.

Table 4-11 shows human-made specific alpha- and beta-emitting radionuclides detected at the SDA and ICDF in 2016. These detections are consistent with levels measured in air at RWMC and ICDF in previous years. The values and locations for plutonium and americium detections remained consistent from 2015 to 2016. These detections shown in Table 4-11 are likely due to resuspension of contaminated soils as a result of early burial practices (Markham et al. 1978), previously flooded areas inside or northeast of the SDA, and ARP fugitive emissions. Studies of radionuclide concentrations in soils (Van Horn et al. 2012) confirm that $^{239/240}$Pu and ^{241}Am are still present in measurable amounts in surface soils surrounding RWMC, with maximum concentrations northeast of the SDA. Although radionuclides were detected, all detections were three to four orders of magnitude below the DCS reported in DOE (2011), and statistically false positives at the 95 percent confidence error are possible. The ICP Core contractor will continue to closely monitor radionuclides to identify trends.

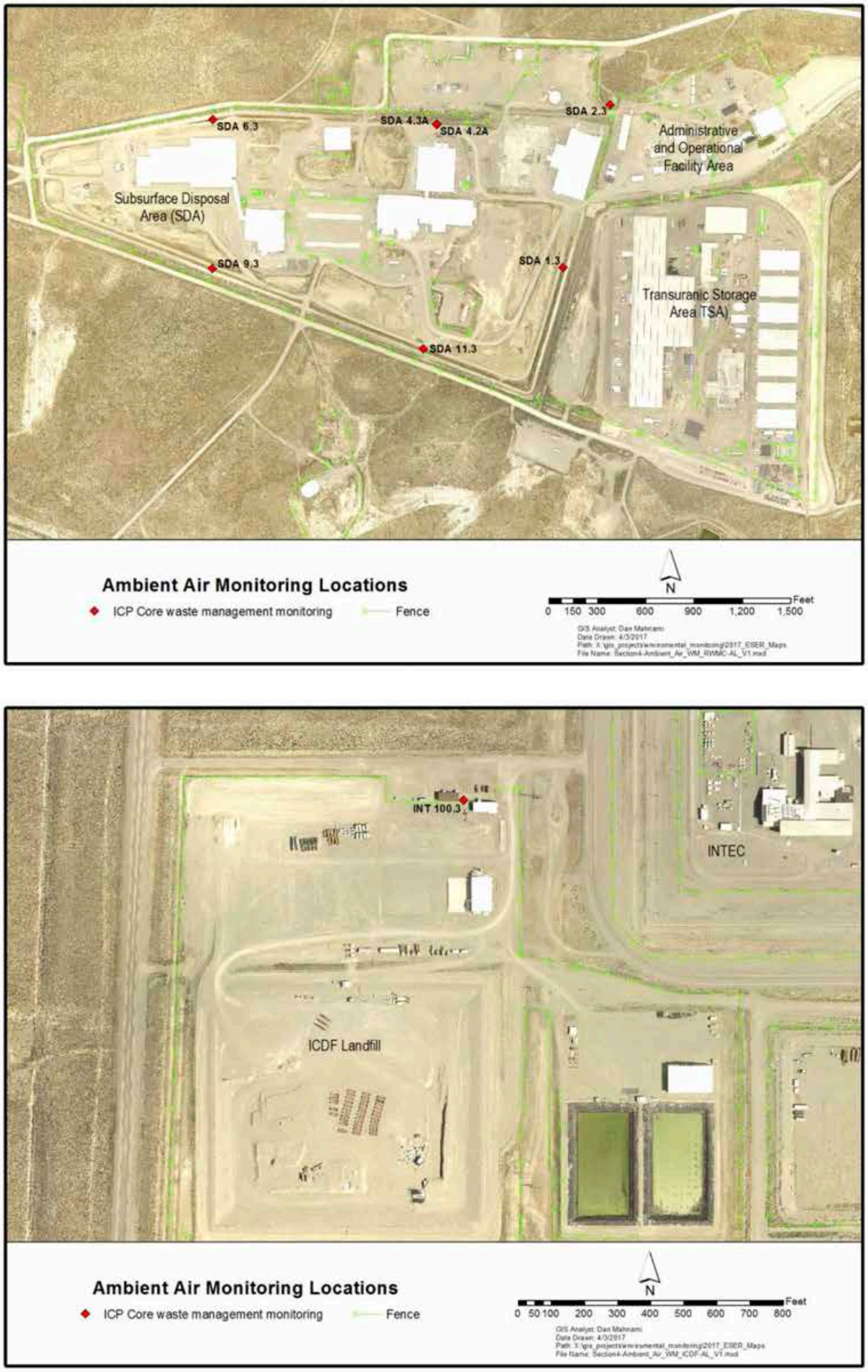

Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas (RWMC [top] and ICDF [bottom]).

Table 4-9. Median Annual Gross Alpha Concentration in Air Samples Collected at Waste Management Sites in 2016.[a]

Group	Location	No. of Samples	Range of Concentrations (× 10^{-15} µCi/mL)	Annual Median (× 10^{-15} µCi/mL)
Subsurface Disposal Area	SDA 1.3	26	0.74 – 3.77	1.90
	SDA 2.3	25	0.96 – 4.24	1.98
	SDA 4.3A[b]	22	0.72 – 4.63	1.40
	SDA 6.3[c]	24	0.92 – 4.39	1.61
	SDA 9.3	26	0.66 – 4.76	2.12
	SDA 11.3	26	0.84 – 4.12	1.60
Idaho CERCLA Disposal Facility	INT 100.3	25	0.96 – 4.46	1.90
Boundary	HOWE 400.4	22	0.80 – 4.30	1.38

a. Results ± 1σ.
b. Includes results from location SDA 4.3.
c. Includes results from location SDA 6.3A.

Table 4-10. Median Annual Gross Beta Concentration in Air Samples Collected at Waste Management Sites in 2016.[a]

Group	Location	No. of Samples	Range of Concentrations (× 10^{-14} µCi/mL)	Annual Median (× 10^{-14} µCi/mL)
Subsurface Disposal Area	SDA 1.3	26	1.51 – 6.02	2.79
	SDA 2.3	25	1.46 – 4.89	2.83
	SDA 4.3A[b]	22	0.96 – 4.43	1.96
	SDA 6.3[c]	24	1.19 – 4.19	2.35
	SDA 9.3	26	1.23 – 4.98	2.48
	SDA 11.3	26	1.26 – 5.22	2.45
Idaho CERCLA Disposal Facility	INT 100.3	25	1.48 – 6.13	2.75
Boundary	HOWE 400.4	22	1.34 – 5.08	2.41

a. Results ± 1σ.
b. Includes results from location SDA 4.3.
c. Includes results from location SDA 6.3A.

Table 4-11. Human-made Radionuclides Detected in Air Samples Collected at Waste Management Sites in 2016.[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Americium-241	(1.52 ± 0.46)E-18	SDA 4.3	1st
	(5.97 ± 0.90)E-18	SDA 2.3	2nd
	(7.98 ± 1.44)E-18	SDA 4.3	2nd
	(4.28 ± 0.80)E-18	SDA 1.3	3rd
	(1.47 ± 0.18)E-17	SDA 2.3	3rd
	(1.33 ± 0.17)E-17	SDA 4.3	3rd
	(2.93 ± 0.68)E-18	SDA 9.3	3rd
	(4.66 ± 0.84)E-18	SDA 4.3A	4th
Plutonium-238	(9.38 ± 3.10)E-19	SDA 4.3	2nd
	(1.33 ± 0.43)E-18	SDA 6.3	3rd
Plutonium-239/240	(1.40 ± 0.43)E-18	SDA 1.3	2nd
	(2.46 ± 0.51)E-18	SDA 2.3	2nd
	(5.90 ± 0.89)E-18	SDA 4.3A	2nd
	(1.36 ± 0.40)E-18	SDA 9.3	2nd
	(2.58 ± 0.62)E-18	SDA 1.3	3rd
	(6.53 ± 1.02)E-18	SDA 2.3	3rd
	(5.65 ± 1.04)E-18	SDA 4.3A	3rd
	(2.06 ± 0.59)E-18	SDA 6.3	3rd
	(2.90 ± 0.78)E-18	SDA 9.3	3rd
	(2.05 ± 0.54)E-18	SDA 11.3	3rd
Strontium-90	(4.02 ± 1.13)E-17	INT 100.3	3rd

a. Results ± 1σ. Results shown are ≥ 3σ.

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5. Environmental Monitoring Programs: Liquid Effluent Monitoring

Wastewater discharged to land surfaces and evaporation ponds at the Idaho National Laboratory (INL) Site is regulated by the state of Idaho groundwater quality and wastewater rules and requires a wastewater reuse permit. Liquid effluents and surface water runoff were monitored in 2016 by the INL contractor and the Idaho Cleanup Project Core contractor for compliance with permit requirements and applicable regulatory standards established to protect human health and the environment.

During 2016, permitted facilities were: Advanced Test Reactor Complex Cold Waste Pond; Central Facilities Area (CFA) Sewage Treatment Plant; Idaho Nuclear Technology and Engineering Center New Percolation Ponds; and Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond. These facilities were sampled for parameters required by their facility-specific permits, except in the case of the CFA Sewage Treatment Plant. Wastewater was not applied to the CFA land application area in 2016 and therefore no effluent monitoring was required. No permit requirements were exceeded in 2016. Additional liquid effluent and groundwater monitoring were performed in 2016 at these facilities to comply with environmental protection objectives of the U.S. Department of Energy (DOE). All parameters were below applicable health-based standards in 2016.

Surface water that runs off the Subsurface Disposal Area at the Radioactive Waste Management Complex during periods of rapid snowmelt or heavy precipitation is sampled and analyzed for radionuclides. The detected concentrations of americium-241, plutonium-239/240, and strontium-90 were approximately the same as those detected in previous years and did not exceed DOE Derived Concentration Standards.

5. ENVIRONMENTAL MONITORING PROGRAMS: LIQUID EFFLUENTS MONITORING

Operations at the Idaho National Laboratory (INL) Site may result in the release of liquid effluent discharges containing radioactive or nonradioactive contaminants. INL and Idaho Cleanup Project (ICP) Core personnel conduct liquid effluent monitoring through wastewater, liquid effluent, and surface water runoff sampling and surveillance programs. Sampling of groundwater related to sites of wastewater and direct discharges is also conducted as part of these programs.

Table 5-1 presents liquid effluent monitoring performed at the INL Site. A comprehensive discussion and maps of environmental monitoring, including liquid effluent monitoring and surveillance programs, performed by various organizations within and around the INL Site can be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014). To improve the readability of this chapter, data tables are only included when monitoring results exceed specified discharge limits, permit limits, or maximum contaminant levels. Data tables for other monitoring results are provided in Appendix C.

5.1 Wastewater and Related Groundwater Compliance Monitoring

Discharge of wastewater to the land surface is regulated by wastewater rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). Wastewater reuse permits require monitoring of nonradioactive constituents in the influent waste, effluent waste, and groundwater in accordance with the Idaho groundwater quality standards stipulated in the “Ground Water Quality Rule” (IDAPA 58.01.11). Some facilities may have specified radiological constituents monitored for surveillance purposes (not required by regulations). The permits specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2017a, 2017b; INL 2017a, 2017b, 2017c, 2017d, 2017e) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2016, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 5-2):

- Advanced Test Reactor (ATR) Complex Cold Waste Pond (Section 5.1.1)
- Central Facilities Area (CFA) Sewage Treatment Plant (STP) (Section 5.1.2)

Table 5-1. Liquid Effluent Monitoring at the INL Site.

Area/Facility[a]	Monitoring Requirements		
	Idaho Wastewater Reuse Permit[b]	DOE Order 458.1[c] Liquid Effluent Monitoring	DOE Order 435.1[d] Surface Runoff Surveillance
INL Contractor			
ATR Complex Cold Waste Pond	●	●	
CFA Sewage Treatment Plant	●		
MFC Industrial Waste Pond and Industrial Waste Ditch	●	●	
ICP Core Contractor			
INTEC New Percolation Ponds and Sewage Treatment Plant	●	●	
RWMC SDA surface water runoff		●	●

a. ATR = Advanced Test Reactor, CFA = Central Facilities Area, MFC = Materials and Fuel Complex, INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, SDA = Subsurface Disposal Area

b. Required by permits issued according to the Idaho Department of Environmental Quality Rules, Idaho Administrative Procedures Act 58.01.17, "Recycled Water Rules." This includes wastewater monitoring and related groundwater monitoring.

c. Paragraph 4(g) of DOE Order 458.1, "Radiation Protection of the Public and the Environment," establishes specific requirements related to control and management of radionuclides from DOE activities in liquid discharges. Radiological liquid effluent monitoring recommendations in *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE-HDBK-1216-2015) (DOE 2015) are followed to ensure quality. DOE Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard," (DOE 2011) supports the implementation of DOE Order 458.1 and provides Derived Concentration Standards as reference values to control effluent releases from DOE facilities.

d. The objective of DOE Order 435.1, "Radioactive Waste Management," is 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. This order requires that radioactive waste management facilities, operations, and activities meet the environmental monitoring requirements of DOE Order 458.1. The DOE Handbook suggests that potential impacts of storm-water runoff as a pathway to humans or biota should be evaluated.

- Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds and STP (Section 5.1.3)
- Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond (Section 5.1.4).

Additional effluent constituents are monitored at these facilities to comply with environmental protection objectives of DOE Order 458.1 and are discussed in Section 5.2. Surface water monitoring at the Radioactive Waste Management Complex is presented in Section 5.3.

5.1.1 Advanced Test Reactor Complex Cold Waste Pond

Description. The Cold Waste Pond (CWP) is located approximately 137 m (450 ft) from the southeast corner of the ATR Complex compound and approximately 1.2 km (0.75 mi) northwest of the Big Lost River channel (Figure 5-1). The existing CWP was excavated in 1982. It consists of two cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms and a depth of 3 m (10 ft). Total surface area for the two cells at the top of the berms is approximately 1.44 ha (3.55 acres). Maximum capacity is approximately 10.22 million gallons (MG).

Wastewater discharged to the CWP consists primarily of noncontact cooling tower blowdown, once-through cooling water for air conditioning units, coolant water from air compressors, and wastewater from secondary system drains and other nonradioactive drains throughout the ATR Complex. Chemicals used in the cooling tower and other effluent streams discharged to the CWP include commercial biocides and corrosion inhibitors.

DEQ renewed the wastewater reuse permit for the cold waste pond on November 20, 2014. The permit expires on November 19, 2019.

Table 5-2. 2016 Status of Wastewater Reuse Permits.

Facility[a]	Permit Status at End of 2015	Explanation
ATR Complex Cold Waste Pond	Permit issued	DEQ[b] issued Permit I-161-02 on November 20, 2014. The permit expires on November 19, 2019.
CFA Sewage Treatment Plant	Permit pending cancellation	DEQ issued Permit #LA-000141-03 on March 17, 2010. The permit expired on March 16, 2015. No wastewater was land applied since 2011 and Lagoon #3 failed seepage testing. The lagoons operate as a total evaporative system. DEQ will formally cancel the Reuse Permit upon closure of Lagoon #3.
INTEC New Percolation Ponds	Permit issued	DEQ issued Permit #LA-000130-05 on March 14, 2012, with a minor modification issued on June 1, 2016. The permit will expire on March 14, 2017. A reuse permit renewal application was submitted to DEQ in September 2016.
MFC Industrial Waste Pond and Industrial Waste Ditch	Permit issued	In 2010, DEQ issued Permit #LA-000160-01, effective May 1, 2010, to April 30, 2015. DEQ issued Permit WRU-I-0160-01 (formerly LA-000160-01), Modification 1 on June 21, 2012. A reuse permit renewal application was submitted to DEQ in October 2014, and issuance of new permit remained pending at end of 2016.

a. ATR = Advanced Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex

b. DEQ = Idaho Department of Environmental Quality

Wastewater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires monthly sampling of the effluent to the CWP. The minimum, maximum, and median results of all constituents monitored are presented in Table C-1. The total dissolved solids concentration in the effluent to the CWP ranged from 189 mg/L in the April 2016 sample to 1,300 mg/L in the March 2016 sample. Sulfate ranged from a minimum of 20.1 mg/L in the April 2016 sample to a maximum of 628 mg/L in the March 2016 sample. There are no effluent permit limits for total dissolved solids or sulfate. Concentrations of sulfate and total dissolved solids are higher during reactor operation because of the evaporative concentration of the corrosion inhibitors and biocides added to the reactor cooling water.

Groundwater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires groundwater monitoring, to measure potential impacts from the CWP, in April/May and September/October, at six groundwater wells (Figure 5-1). For 2016, none of the constituents exceeded their respective primary or secondary constituent standards and are presented in Table C-2 and Table C-2a. The metals concentrations continue to remain at low levels.

5.1.2 Central Facilities Area Sewage Treatment Plant

Description. The CFA STP serves all major buildings at CFA. The treatment facility is southeast of CFA, approximately 671 m (2,200 ft) downgradient of the nearest drinking water well (Figure 5-2).

A 1,500-L/min (400-gal/min) pump applies wastewater from a 0.2-ha (0.5-acre) lined polishing pond to approximately 30 ha (74 acres) of sagebrush steppe grassland through a computerized center pivot irrigation system; refer to Sections 5.2.2 and 7.2.2 for further information.

Wastewater Monitoring Results for the Wastewater Reuse Permit. DEQ issued a permit for the CFA STP on March 17, 2010. The permit requires effluent monitoring and soil sampling in the wastewater land application area

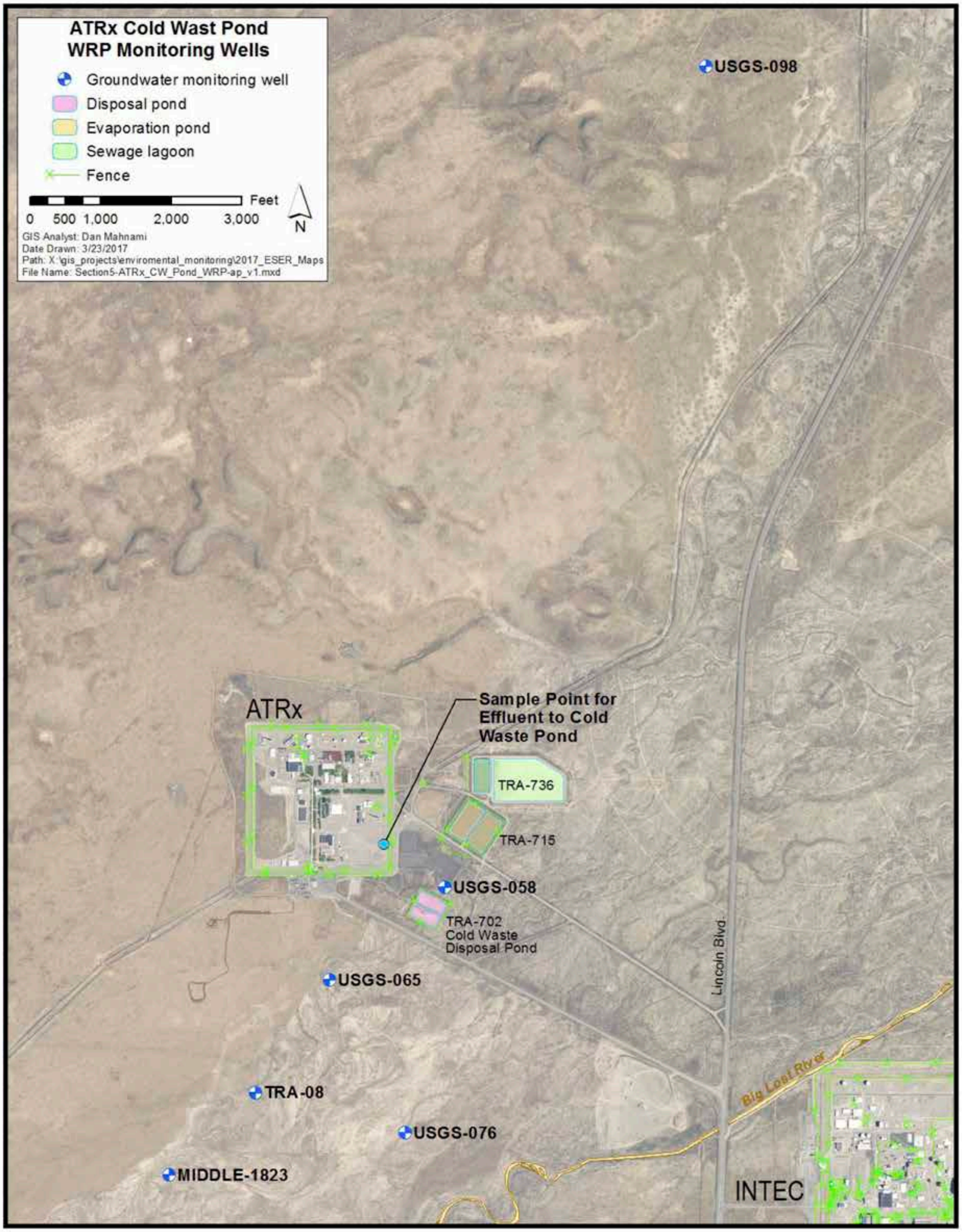

Figure 5-1. Permit Monitoring Locations for the ATR Complex Cold Waste Pond.

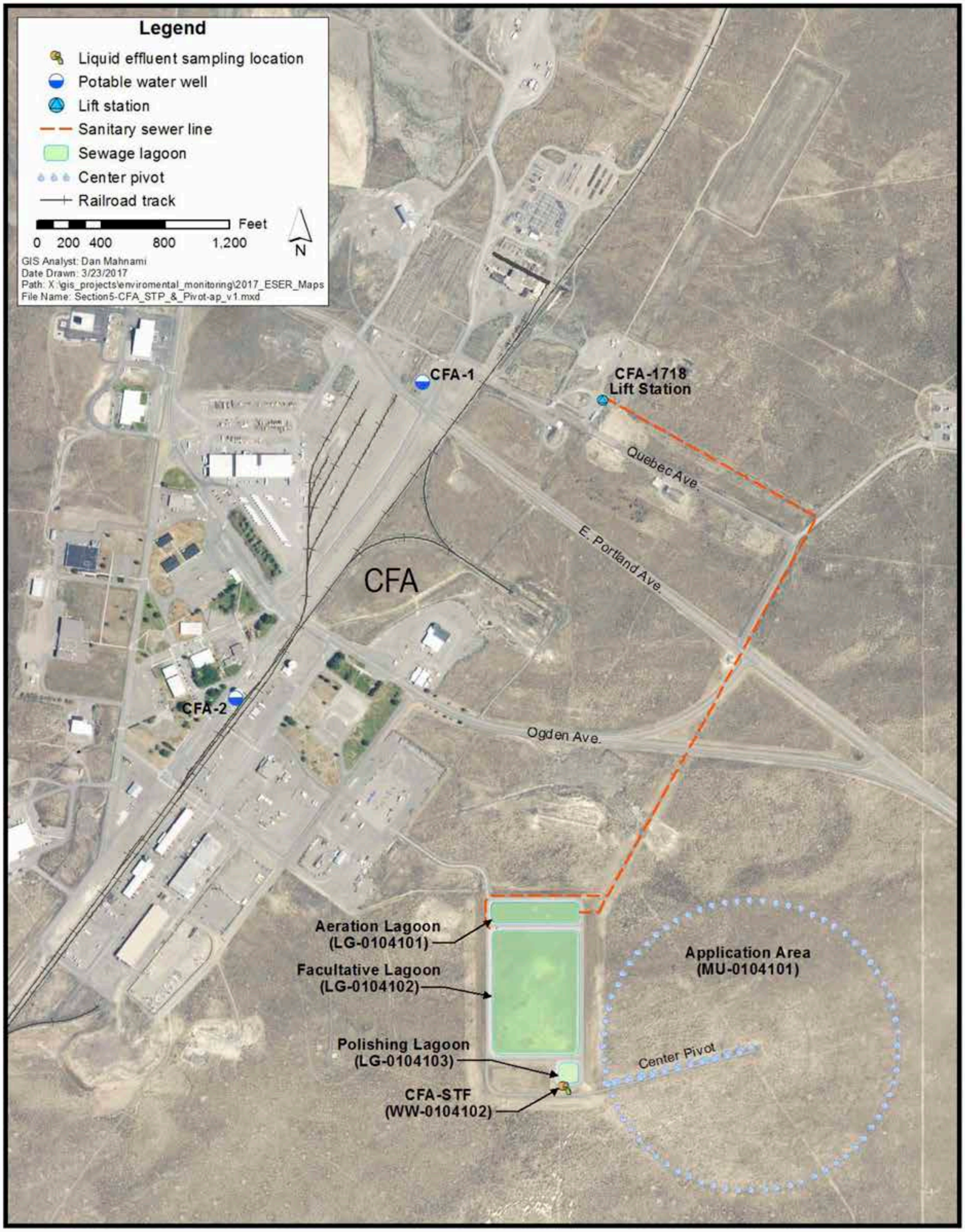

Figure 5-2. CFA Sewage Treatment Plant. Samples are collected at the irrigation pump pivot, sampling point CFA-STP.

(soil samples were required in 2010 and 2013). Effluent samples are collected from the pump pit (prior to the pivot irrigation system) monthly during land application. During the 2016 permit year, no wastewater was applied to the land application area; therefore, no effluent sampling was required by the permit.

Groundwater Monitoring Results for the Wastewater Reuse Permit. The wastewater reuse permit does not require groundwater monitoring at the CFA STP.

5.1.3 Idaho Nuclear Technology and Engineering Center New Percolation Ponds and Sewage Treatment Plant

Description. The INTEC New Percolation Ponds are composed of two unlined ponds excavated into the surficial alluvium and surrounded by bermed alluvial material (Figure 5-3). Each pond is 93 m × 93 m (305 ft × 305 ft) at the top of the berm and approximately 3 m (10 ft) deep. Each pond is designed to accommodate a continuous wastewater discharge rate of 3 MG per day.

The INTEC New Percolation Ponds receive discharge of only nonhazardous industrial and municipal wastewater. Industrial wastewater (i.e., service waste) from INTEC operations consists of steam condensates, noncontact cooling water, water treatment effluent, boiler blowdown wastewater, storm water, and small volumes of other nonhazardous liquids. Municipal wastewater (i.e., sanitary waste) is treated at the INTEC STP.

The STP is located east of INTEC, outside the INTEC security fence, and treats and disposes of sewage, septage, and other nonhazardous industrial wastewater at INTEC. The sanitary waste in four lagoons of the STP is treated by natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation). After treatment in the lagoons, the effluent is combined with the service waste and discharged to the INTEC New Percolation Ponds.

The INTEC New Percolation Ponds are permitted by DEQ to operate as a wastewater reuse facility under Wastewater Reuse Permit LA-000130-05. The permit became effective on March 14, 2012, with an expiration date of March 14, 2017. A reuse permit renewal application was submitted to DEQ in September 2016.

Wastewater Monitoring Results for the Wastewater Reuse Permit. Monthly samples were collected from CPP-769 (influent to STP), CPP-773 (effluent from STP), and CPP-797 (effluent to the INTEC New Percolation Ponds) (see Figure 5-4). As required by the permit, all samples are collected as 24-hour flow proportional composites, except pH and total coliform, which are collected as grab samples. The permit specifies the constituents that must be monitored at each location. The permit does not specify any wastewater discharge limits at these three locations. The 2016 monitoring results (minimum, maximum, and mean) for CPP-769, CPP-773, and CPP-797 are presented in Tables C-3, C-4, and C-5, respectively.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table C-6, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2016.

Groundwater Monitoring Results for the Wastewater Reuse Permit. To measure potential impacts to groundwater from wastewater discharges to the INTEC New Percolation Ponds, the permit requires that groundwater samples be collected from six monitoring wells as shown in Figure 5-3.

The permit requires that groundwater samples be collected semiannually during April/May and September/October and lists which constituents must be analyzed. Contaminant concentrations in the compliance wells are limited by primary constituent standards and secondary constituent standards, specified in IDAPA 58.01.11, “Ground Water Quality Rule.” All permit-required samples are collected as unfiltered samples, except aluminum, iron, manganese, and silver. The results of dissolved concentrations (i.e., filtered samples) of these four constituents are used for secondary constituent standard compliance determinations.

Table C-7 shows the 2016 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all constituents specified by the permit for the aquifer wells. Table C-8 presents similar information for the perched water wells. Perched water Well ICPP-MON-V-191 was dry during 2016, and, therefore, samples could not be collected.

Tables C-7 and C-8 show all permit-required constituents associated with the aquifer and perched water wells were below their respective primary constituent standards and secondary constituent standards in 2016.

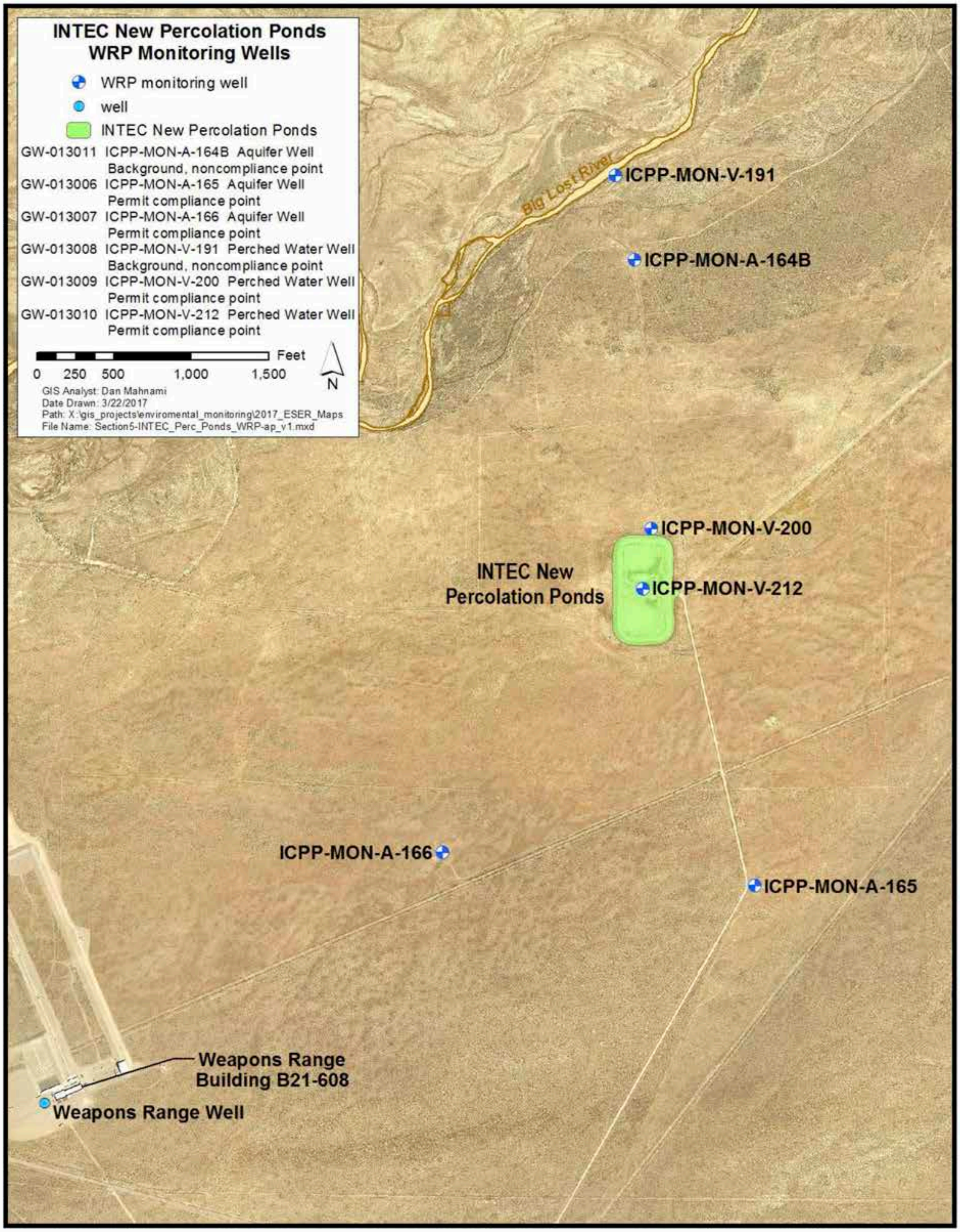

Figure 5-3. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds. (Weapons Range well is not a permitted well and is shown for location reference only).

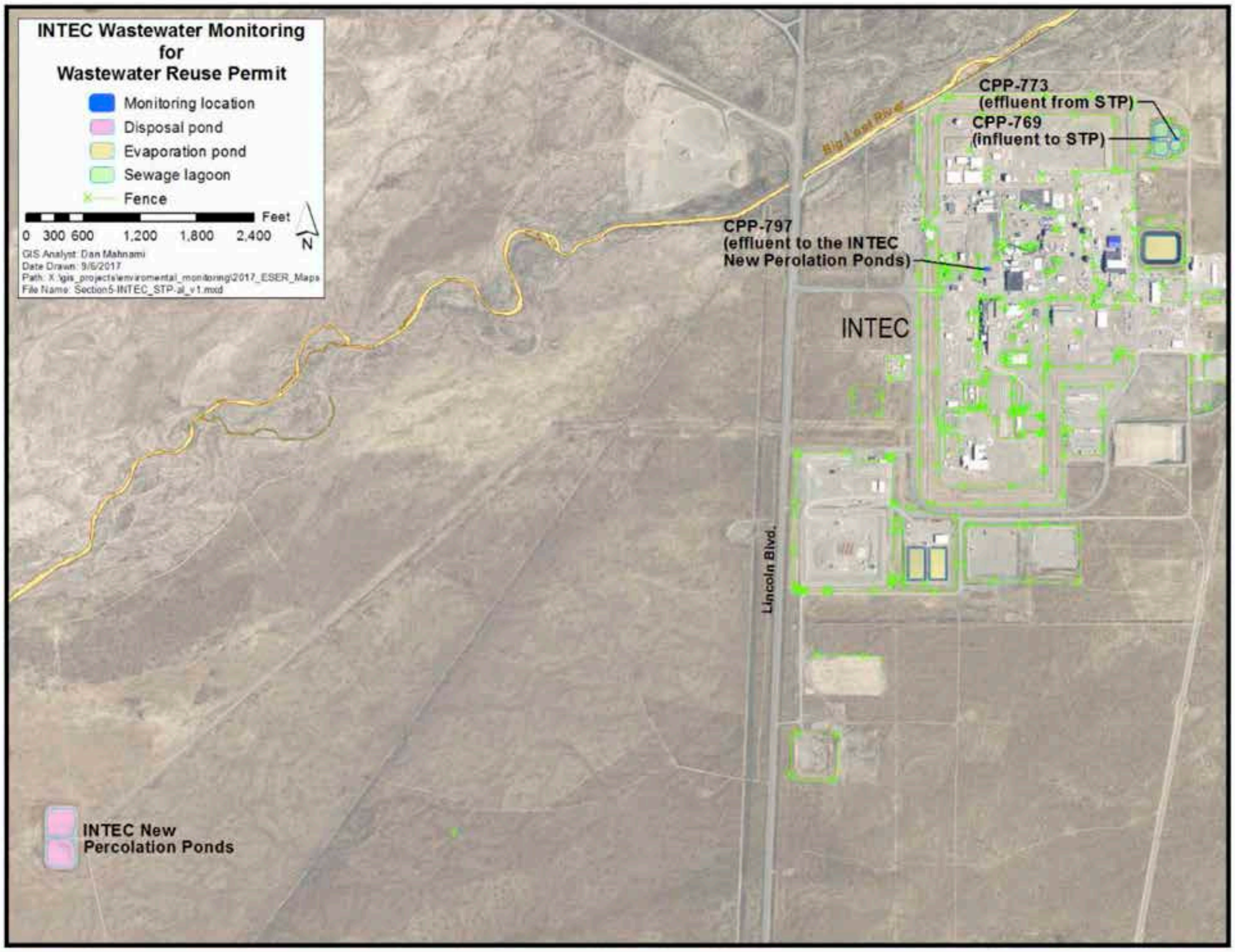

Figure 5-4. INTEC Wastewater Monitoring for Wastewater Reuse Permit.

5.1.4 Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond

Description. The MFC Industrial Waste Pond was first excavated in 1959 and has a design capacity of 285 MG at a maximum water depth of 3.96 m (13 ft) (Figure 5-5). The pond receives industrial wastewater from the Industrial Waste Pipeline, stormwater runoff from the nearby areas, and industrial wastewater from Ditch C. Industrial wastewater discharged to the pond via the Industrial Waste Pipeline consists primarily of noncontact cooling water, boiler blowdown, cooling tower blowdown and drain, air wash flows, and steam condensate. A small amount of wastewater discharged to the pond via Ditch C from the Industrial Waste Water Underground Pipe consists of intermittent reverse osmosis effluent and laboratory sink discharge from the MFC-768 Power Plant.

DEQ issued an initial permit in May 2010 for the MFC Industrial Waste Ditch and Industrial Waste Pond. A renewal application was submitted in October 28, 2014, and a draft permit for public comment was issued by DEQ on December 5, 2016. The 2016 activities were conducted to the initial permit in the absence of a finalized renewal permit. In 2016, a portion of the Industrial Waste Water Underground Pipe was decommissioned and relocated. The construction specifications and drawings were submitted to DEQ on April 27, 2016, resubmitted on May 12, 2016, and approved on May 23, 2016, per permit requirements. Construction was completed November 17, 2016.

Wastewater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline. The permit

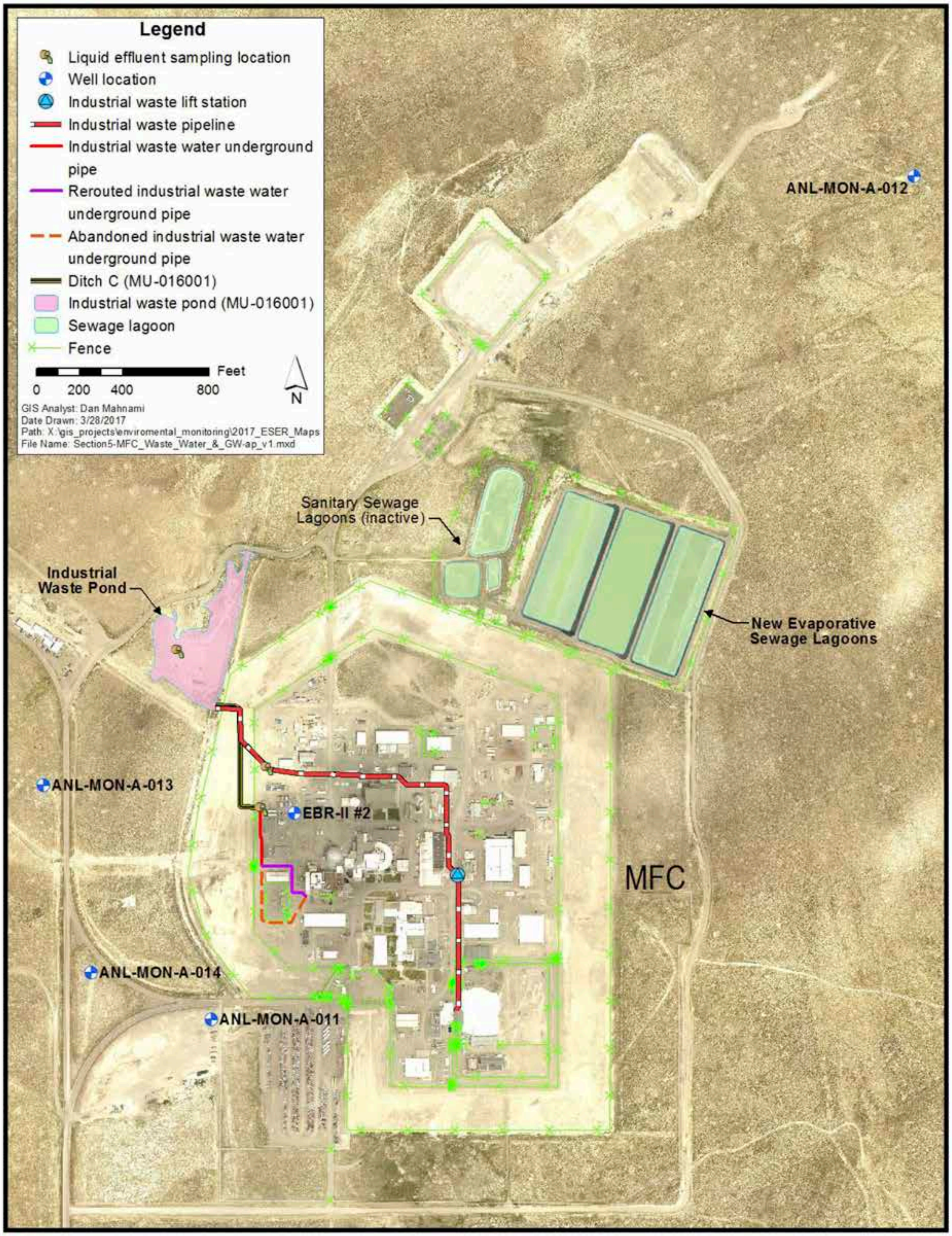

Figure 5-5. Wastewater and Groundwater Sampling Locations at the MFC.

requires quarterly samples of the discharge to Ditch C from the Industrial Waste Water Underground Pipe. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L). During 2016, no samples for total suspended solids or total nitrogen exceeded the permit limit (Table C-9). The minimum, maximum, and median results of all constituents monitored are presented in Tables C-10 and C-11.

Groundwater Monitoring Results for the Wastewater Reuse Permit. To measure potential impacts from the Industrial Waste Pond, the permit requires groundwater monitoring in April/May and September/October at one upgradient well and two downgradient wells (Figure 5-5).

The analytical results are summarized in Table C-12. Analyte concentrations in the downgradient wells were consistent with background levels in the upgradient well.

5.2 Liquid Effluent Surveillance Monitoring

The following sections discuss results of liquid effluent surveillance monitoring performed at each wastewater reuse permitted facility.

5.2.1 Advanced Test Reactor Complex

The effluent to the CWP receives a combination of process water from various ATR Complex facilities. Table C-13 lists wastewater surveillance monitoring results for those constituents with at least one detected result. Radionuclides detected in groundwater samples are summarized in Table C-14. All detected constituents including tritium, gross alpha, and gross beta were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

5.2.2 Central Facilities Area

The effluent from the CFA STP is monitored according to the wastewater reuse permit. No wastewater was land-applied in 2016; therefore, no effluent samples were collected at the treatment facility.

5.2.3 Idaho Nuclear Technology and Engineering Center

In addition to the permit-required monitoring summarized in Section 5.1.3, surveillance monitoring was conducted at the INTEC STP, prior to discharge into the INTEC New Percolation Ponds and the groundwater at the INTEC New Percolation Ponds. Table C-15 summarizes the results of radiological monitoring at CPP-773 and CPP-797, and Table C-16 summarizes the results of radiological monitoring at groundwater Wells ICPP-MON-A-165, ICPP-MON- A-166, ICPP-MON-V-200, and ICPP-MON-V-212.

Samples were collected from the CPP-773 effluent in March 2016 and September 2016 and analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-15, no gamma-emitting radionuclides, gross alpha, or total strontium was detected in any of the samples collected at CPP-773 in 2016. Gross beta was detected in both the March 2016 sample (17.7 pCi/L) and the September 2016 sample (19.5 pCi/L). These detections were below the derived concentration standard for gross beta found in Table A-2.

Twenty-four-hour flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. The monthly composite samples were analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-15, no gamma-emitting radionuclides or total strontium was detected in any of the samples collected at CPP-797 in 2016. Gross alpha was detected in the April 2016 sample (3.62 pCi/L) and the June 2016 sample (4.18 pCi/L), and gross beta was detected in all 12 samples collected in 2016. These detections were below the derived concentration standards for gross alpha and gross beta found in Table A-2.

Groundwater samples were collected from aquifer Wells ICPP-MON-A-165 and ICPP-MON-A-166 and perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 in April 2016 and September 2016 and analyzed for gross alpha and gross beta. As shown in Table C-16, gross alpha was detected in perched water Well ICPP-MON-V-212 (1.95 pCi/L) in April 2016. This detection was below the derived concentration standard for gross alpha found in Table A-2. Gross alpha was not detected in this well in September 2016. Gross alpha was not detected in any of the other three monitoring wells in 2016. Gross beta was detected in all four monitoring wells in April 2016 and September 2016. These detections were below the derived concentration standard for gross beta found in Table A-2.

5.2.4 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium (Figure 5-5). Annual samples are collected and analyzed for selected isotopes of americium, iron, strontium, plutonium, and uranium. Gross alpha, gross beta, potassium-40, and uranium isotopes were detected in 2016 and are comparable to levels reported in previous ASER reports (Table C-17).

5.3 Waste Management Surveillance Surface Water Sampling

Radionuclides could be transported outside Radioactive Waste Management Complex (RWMC) boundaries via surface water runoff. Surface water runs off the Subsurface Disposal Area (SDA) only during periods of rapid snowmelt or heavy precipitation. At these times, water may be pumped out of the SDA retention basin into a drainage canal, which directs the flow outside RWMC. The canal also carries runoff from outside RWMC that has been diverted around the SDA.

In compliance with DOE Order 435.1, the ICP Core contractor collects surface water runoff samples at the RWMC SDA from the location shown in Figure 5-6. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly, as compared to historical data. A field blank is also collected for comparison. Samples were collected quarterly during 2016.

Table 5-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The americium-241, plutonium-239/240, and strontium-90 concentrations are approximately the same as those reported in previous years and are well below DOE Derived Concentration Standards (DOE 2011).

The ICP Core contractor will sample quarterly during 2017, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation.

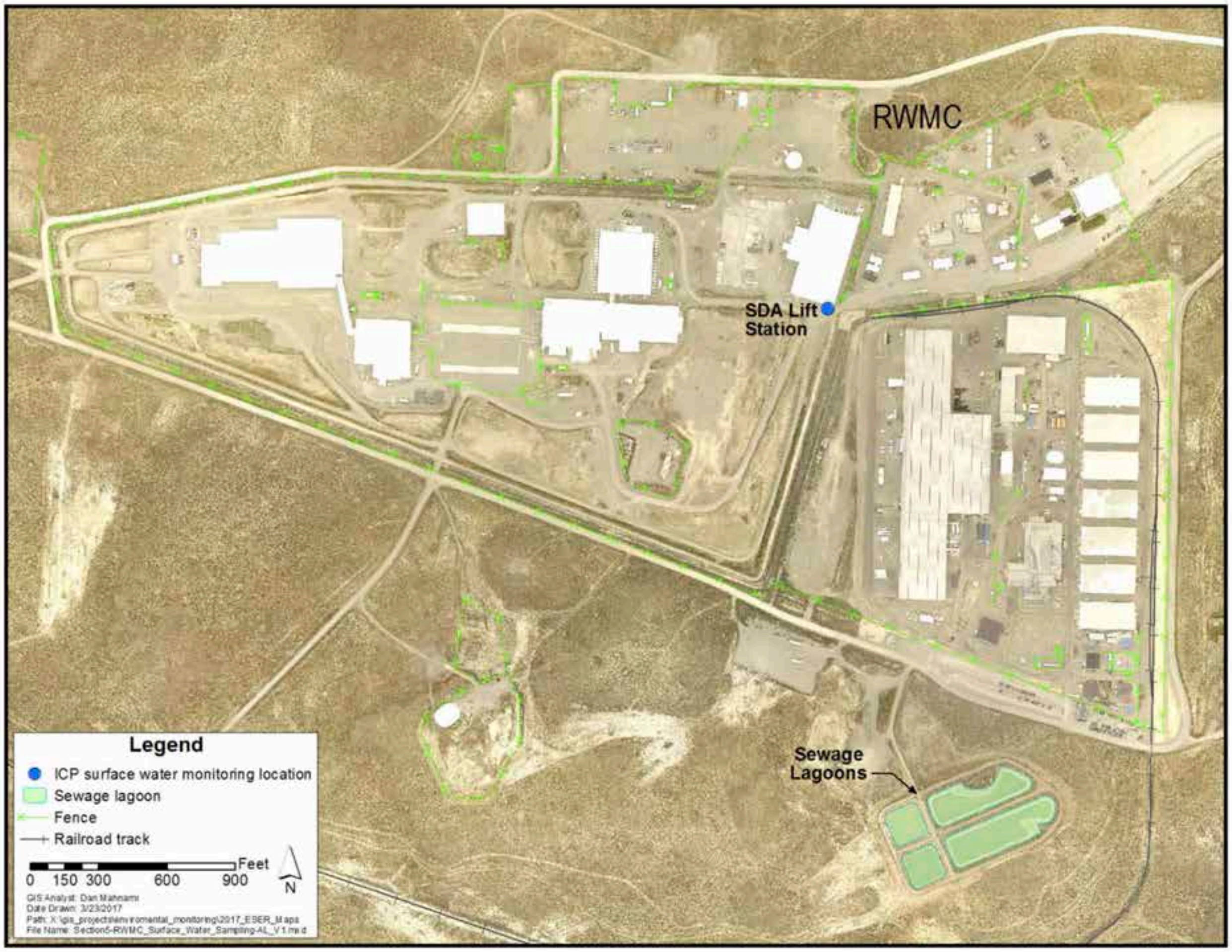

Figure 5-6. Surface Water Sampling Location at the RWMC SDA.

Table 5-3. Radionuclides Detected in Surface Water Runoff at the RWMC SDA (2016).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	0.178 ± 0.016	0.10
Plutonium-239/240	0.069 ± 0.010	0.05
Strontium-90	0.830 ± 0.115	0.08

a. Result ±1s. Results shown are >3s.
b. See DOE-STD-1196-2011, Table A-2 (DOE 2011).

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Penstemon on Big Lost River

6. Environmental Monitoring Programs: Eastern Snake River Plain Aquifer


Spreading Gilia
Ipomopsis polycladon

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site in the eastern Snake River Plain aquifer. These areas are regularly monitored by the U.S. Geological Survey (USGS), and reports are published showing the extent of contamination plumes. Results for most monitoring wells within the plumes show decreasing concentrations of tritium, strontium-90, and iodine-129 over the past 20 years. The decrease is probably the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

In 2016, USGS sampled 28 groundwater monitoring wells and one perched well at the INL Site for analysis of 61 purgeable (volatile) organic compounds (VOCs). Several purgeable organic compounds continue to be detected. Most of the concentrations were less than maximum contaminant levels (MCLs) established by the Environmental Protection Agency (EPA) for public drinking water supplies. One exception was carbon tetrachloride, detected in the production well at the RWMC. This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Trichloroethene was also detected above the MCL at a well at Test Area North (TAN). There is a known groundwater plume containing this contaminant which is being treated at TAN.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed at Waste Area Groups (WAGs) 1–5, WAG 7, and WAG 9 in 2016.

There are 12 drinking water systems on the INL Site. All contaminant concentrations measured in drinking water systems in 2016 were below regulatory limits. Because of the potential impacts to workers at Central Facilities Area (CFA) from an upgradient plume of radionuclides in the eastern Snake River Plain aquifer, the potential effective dose equivalent from ingesting radionuclides in water was calculated. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2016 was 0.149 mrem (1.49 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems.

6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain aquifer serves as the primary source for drinking water and crop irrigation in the upper Snake River Basin. This chapter presents the results of water monitoring conducted on and off the Idaho National Laboratory (INL) Site within the eastern Snake River Plain aquifer hydrogeologic system. This includes collection of water from the aquifer (including drinking water wells); downgradient springs along the Snake River where the aquifer discharges water (Figure 6-1); and an ephemeral stream (the Big Lost River), which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure that:

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities
- Areas of known underground contamination from past INL Site operations are monitored and trended
- Drinking water consumed by workers and visitors at the INL Site and by the public downgradient of the INL Site is safe
- The Big Lost River, which occasionally flows through the INL Site, is not contaminated by INL Site activities before entering the aquifer via playas on the north end of the INL Site.

Analytical results are compared to applicable regulatory guidelines for compliance and informational purposes. These include the following:

- State of Idaho groundwater primary and secondary constituent standards (Idaho Administrative Procedures Act [IDAPA] 58.01.11)
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water (40 Code of Federal Regulations [CFR] 141)
- U.S. Department of Energy (DOE) Derived Concentration Standards for ingestion of water (DOE Order 458.1).

6.1 Summary of Monitoring Programs

Four organizations monitor the eastern Snake River Plain aquifer hydrogeologic system:

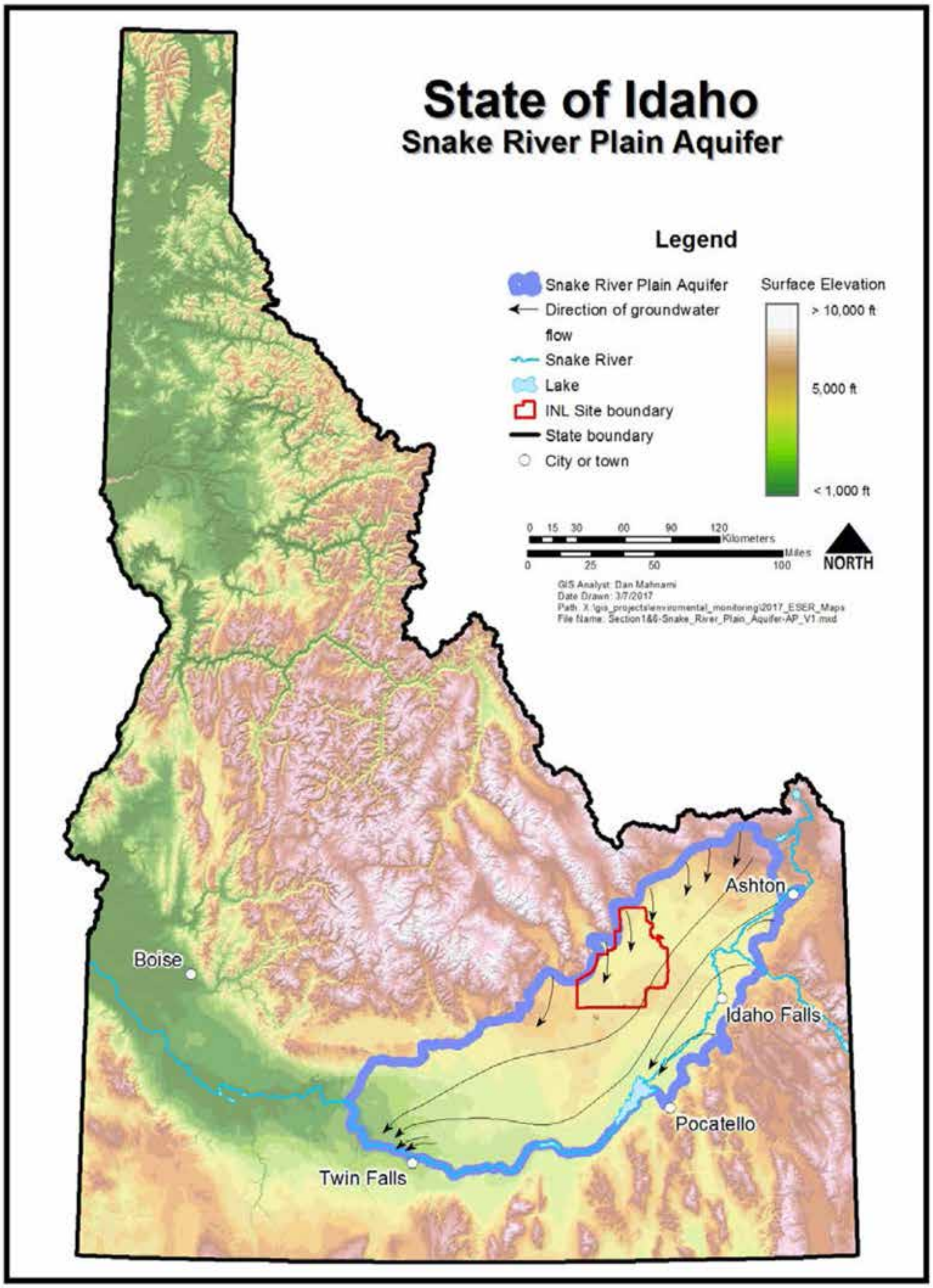


Figure 6-1. The Eastern Snake River Plain Aquifer and Direction of Groundwater Flow.

- The United States Geological Survey (USGS) INL Project Office performs groundwater monitoring, analyses, and scientific studies to improve the understanding of the hydrogeological conditions that affect the movement of ground water and contaminants in the eastern Snake River Plain aquifer underlying and adjacent to the INL Site. USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site (Figure 6-2) and at locations throughout the eastern Snake River Plain. Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2016, USGS personnel collected and analyzed over 1000 samples for radionuclides and inorganic constituents, including trace elements and 39 samples for purgeable organic compounds. USGS INL Project Office personnel also published seven documents covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Chapter 10.
- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site (Figure 6-3) for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water

Table 6-1. USGS Monitoring Program Summary (2016).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	51	51	4	1	1.5 pCi/L
Gross beta	51	51	4	1	3.4 pCi/L
Tritium	145	142	7	4	200 pCi/L
Gamma-ray spectroscopy	56	54	—[b]	—	—[c]
Strontium-90	85	82	—[b]	—	2 pCi/L
Americium-241	14	14	—[b]	—	0.03 pCi/L
Plutonium isotopes	14	14	—[b]	—	0.02 pCi/L
Iodine-129	0	0	—[b]	—	<1aCi/L
Specific conductance	145	142	7	4	Not applicable
Sodium ion	139	136	—[b]	—	0.1 mg/L
Chloride ion	145	142	7	4	0.1 mg/L
Nitrates (as nitrogen)	118	117	—[b]	—	0.05 mg/L
Fluoride	6	6	—[b]	—	0.1 mg/L
Sulfate	127	124	—[b]	—	0.1 mg/L
Chromium (dissolved)	73	71	—[b]	—	0.005 mg/L
Purgeable organic compounds[d]	28	39	—[b]	—	Varies
Trace elements	13	13	—[b]	—	Varies

a. Number of samples does not include 13 replicates and 3 blanks collected in 2016. Number of samples was different than the number of sites because one site for VOCs is sampled monthly, and several sites had pump problems and were not sampled, or in the case of surface water in the Big Lost River, three sites were dry. Number of sites does not include 24 zones from 11 wells sampled as part of the multi-level monitoring program.

b. No surface water samples collected for this constituent.

c. Minimum detectable concentration for gamma spectroscopic analyses varies depending on radionuclide.

d. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds.

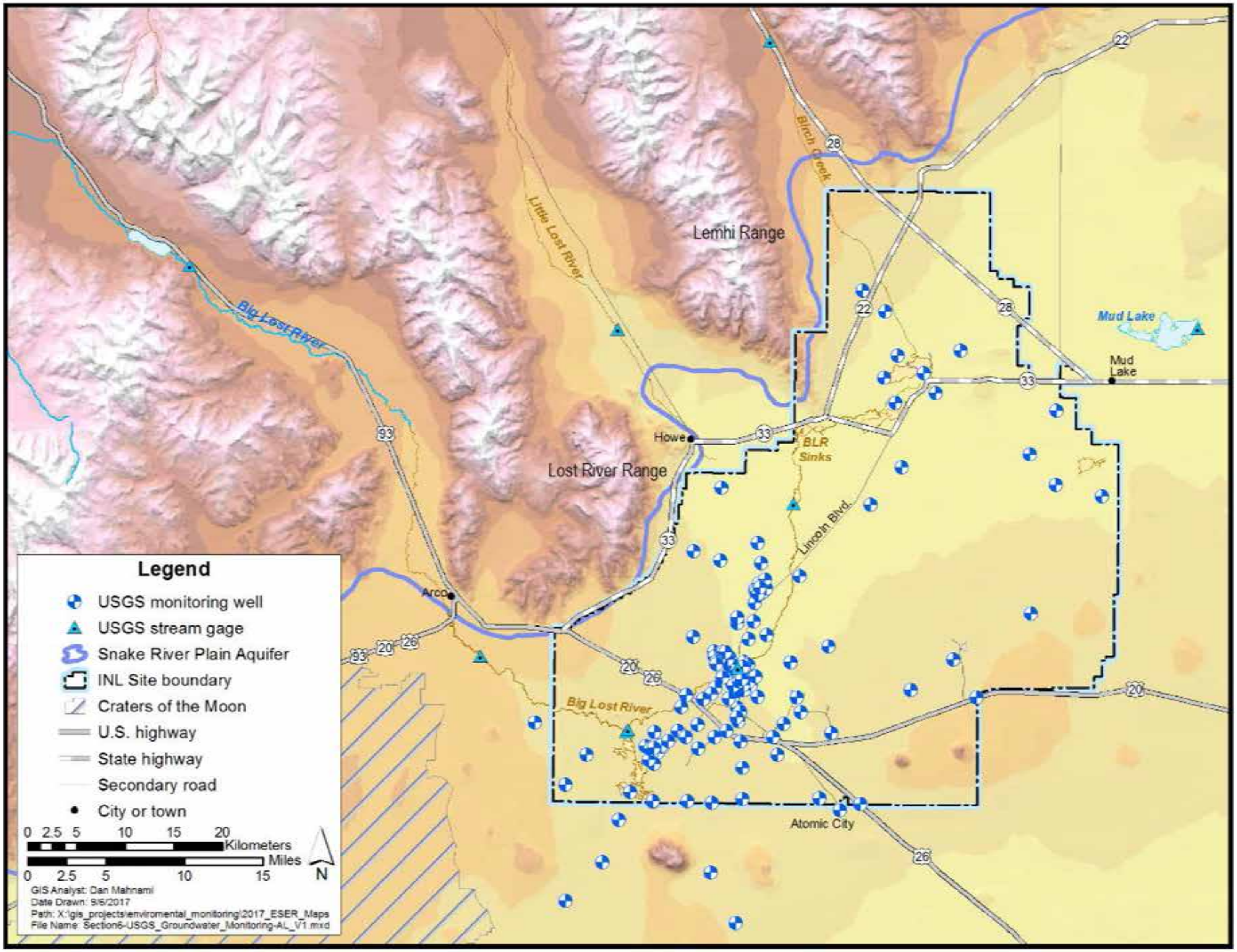


Figure 6-2. USGS Groundwater Monitoring Locations On and Off the INL Site.

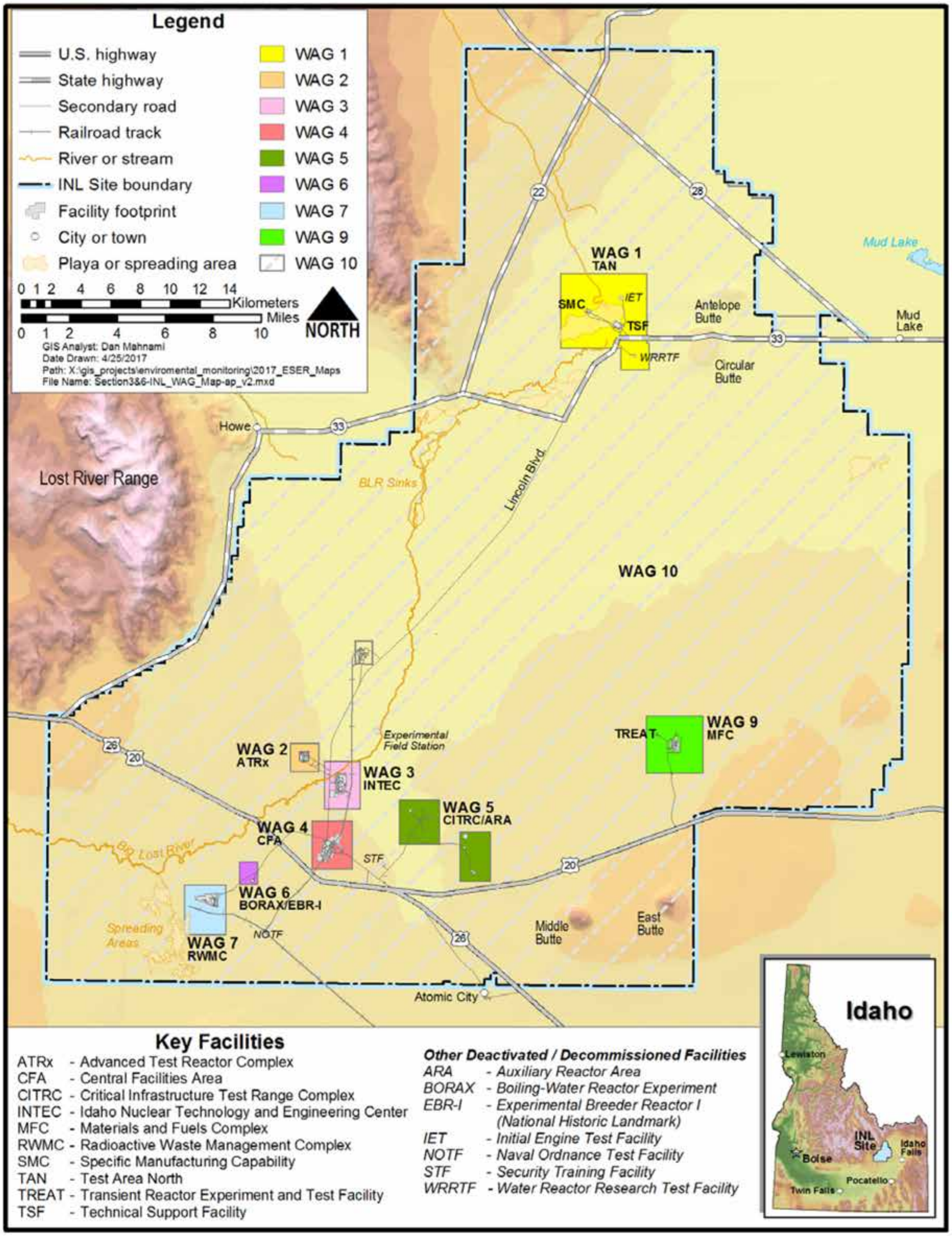


Figure 6-3. Map of the INL Site Showing Locations of Facilities and Corresponding WAGs.

monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and the Radioactive Waste Management Complex (RWMC). In 2016, the ICP Core contractor monitored groundwater at Test Area North (TAN), Advanced Test Reactor (ATR) Complex, INTEC, Central Facilities Area (CFA), and RWMC (WAGs 1, 2, 3, 4, and 7, respectively). Table 6-2 summarizes the routine monitoring for the ICP Core drinking water program. The ICP Core contractor collected and analyzed over 110 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, and volatile organic compounds (VOCs) in 2016.

- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9) and ATR Complex and drinking water at nine INL Site facilities: ATR Complex, CFA, Critical Infrastructure Test Range Complex (CITRC), Experimental Breeder Reactor-I (EBR-I), the Gun Range, Main Gate, MFC, TAN Contained Test Facility (CTF), and TAN/Technical Support Facility (TSF). Table 6-3 summarizes the routine groundwater and drinking water program. In 2016, the INL contractor sampled and analyzed 206 groundwater and 286 drinking water samples for radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples from around the INL Site, as well as samples from natural surface waters on and off the INL Site. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2016, the ESER contractor sampled and analyzed 26 surface and drinking water samples.

Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014) and the *Idaho National Laboratory Groundwater Monitoring Contingency Plan Update* (DOE-ID 2012).

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, including USGS, current and past contractors, and other groups. The following data management systems are used:

- The Environmental Data Warehouse is the official long-term management and storage location for INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS, and stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP Core Site Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.

Table 6-2. ICP Core Contractor Drinking Water Program Summary (2016).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	50 pCi/L screening level or 4 mrem/yr
Haloacetic acids	1 annually	0.06 mg/L
Total coliform	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli	6 to 8 monthly	See 40 CFR 141.63(c)
Nitrate	2 annually	10 mg/L (as nitrogen)
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	1 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Volatile organic compounds	2 quarterly	Varies

Table 6-3. INL Contractor Drinking Water Program Summary (2016).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha[a]	9 semiannually	15 pCi/L
Gross beta[a]	9 semiannually	4 mrem/yr
Tritium[a]	11 annually, 11 semiannually	20,000 pCi/L
Iodine-129[b]	1 semiannually	1 pCi/L
Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	9 triennially	Varies
Nitrate[c]	9 annually	10 mg/L (as nitrogen)
Microbes	13 quarterly 12 monthly 1 monthly during summer	If <40 samples/ month, no more than one positive for total coliform
Volatile organic compounds[d]	2 semiannually	Varies

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., TAN/TSF, TAN/CTF, ATR Complex raw/drinking water, CFA, Gun Range, EBR-1, CITRC, Main Gate, and MFC).
b. Iodine-129 is only sampled at the CFA water system.
c. Nitrate and microbes are sampled at all INL water systems.
d. Volatile organic compounds are only sampled at TAN/TSF water system.

Table 6-4. Environmental Surveillance, Education, and Research Surface and Drinking Water Program Summary (2016).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b]	Gross alpha	6 annually	4 semiannually	3 pCi/L
	Gross beta	6 annually	4 semiannually	2 pCi/L
	Tritium	6 annually	4 semiannually	100 pCi/L

a. Samples are co-located with the state of Idaho Department of Environmental Quality (DEQ) INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.
b. Onsite locations are the Big Lost River (if running) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at EFS, and at the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ INL Oversight Program at Alpheus Spring, Clear Springs, and at a fish hatchery at Hagerman. A duplicate sample is also collected at one location. The Big Lost River was not running during 2016.

- The USGS data management program involves putting all data in the National Water Information System, which is available online at www.waterdata.usgs.gov/id/nwis/qw.

6.3 U.S. Geological Survey Radiological Groundwater Monitoring at the Idaho National Laboratory Site

Historic waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain aquifer beneath the INL Site.

Presently, strontium-90 (^{90}Sr) is the only radionuclide that continues to be detected by the ICP Core contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and CFA and at TAN. Other radionuclides (e.g., gross alpha) have been detected above their primary constituent standard in wells monitored at individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen—a key component of water—it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent published USGS data (2015), are shown in Figure 6-4 (Bartholomay et al. 2017). The area of contamination within the 0.5-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000).

The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 10 years (Figure 6-5). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The tritium concentration in USGS-065 near ATR Complex increased from 2,460 ± 100 pCi/L in 2015 to 2,570 ± 90 pCi/L in 2016; the tritium concentration in USGS-114, south of INTEC, decreased from 5,750 ± 120 pCi/L in 2015 to 5,620 ± 120 in 2016.

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in Wells USGS-065 and USGS-114 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.3 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend when data through 2015 were analyzed (Bartholomay et al. 2017, Figure 15).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2017). The contamination originates at INTEC from historic injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain aquifer near ATR Complex during 2016. All ^{90}Sr at ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (1996–2016) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes (Table 6-1). Results for wells sampled in 2016 are available at waterdata.usgs.gov/id/nwis/. Monitoring results for 2012–2015 are summarized in Bartholomay et al. (2017). During 2012–2015, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in eight wells, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all samples analyzed were less than the reporting level. In 2012–2015, reportable concentrations of gross alpha radioactivity were observed in seven of the 59 wells and ranged from 6 ± 2 to 44 ± 9 pCi/L. Beta

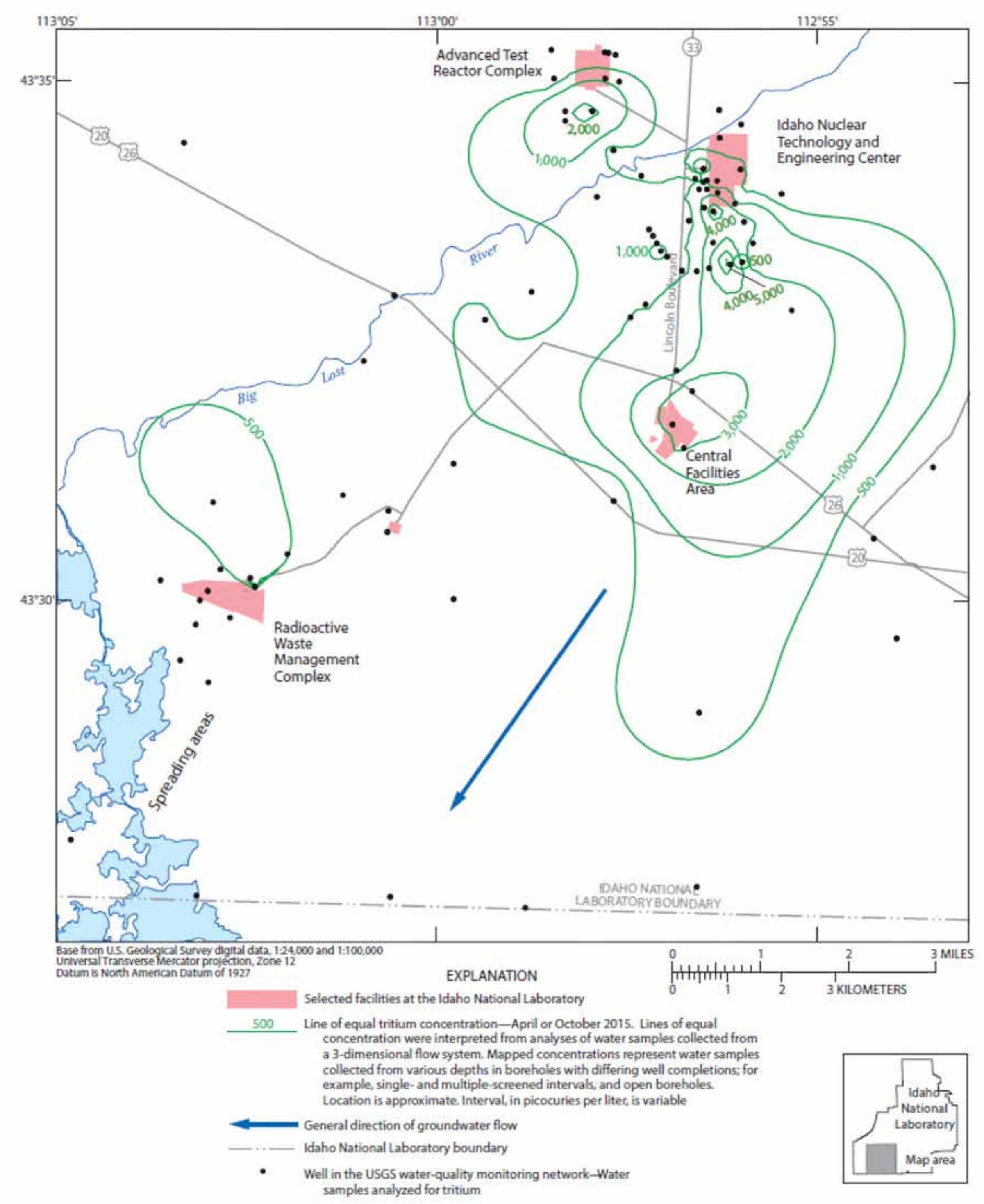


Figure 6-4. Distribution of Tritium in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

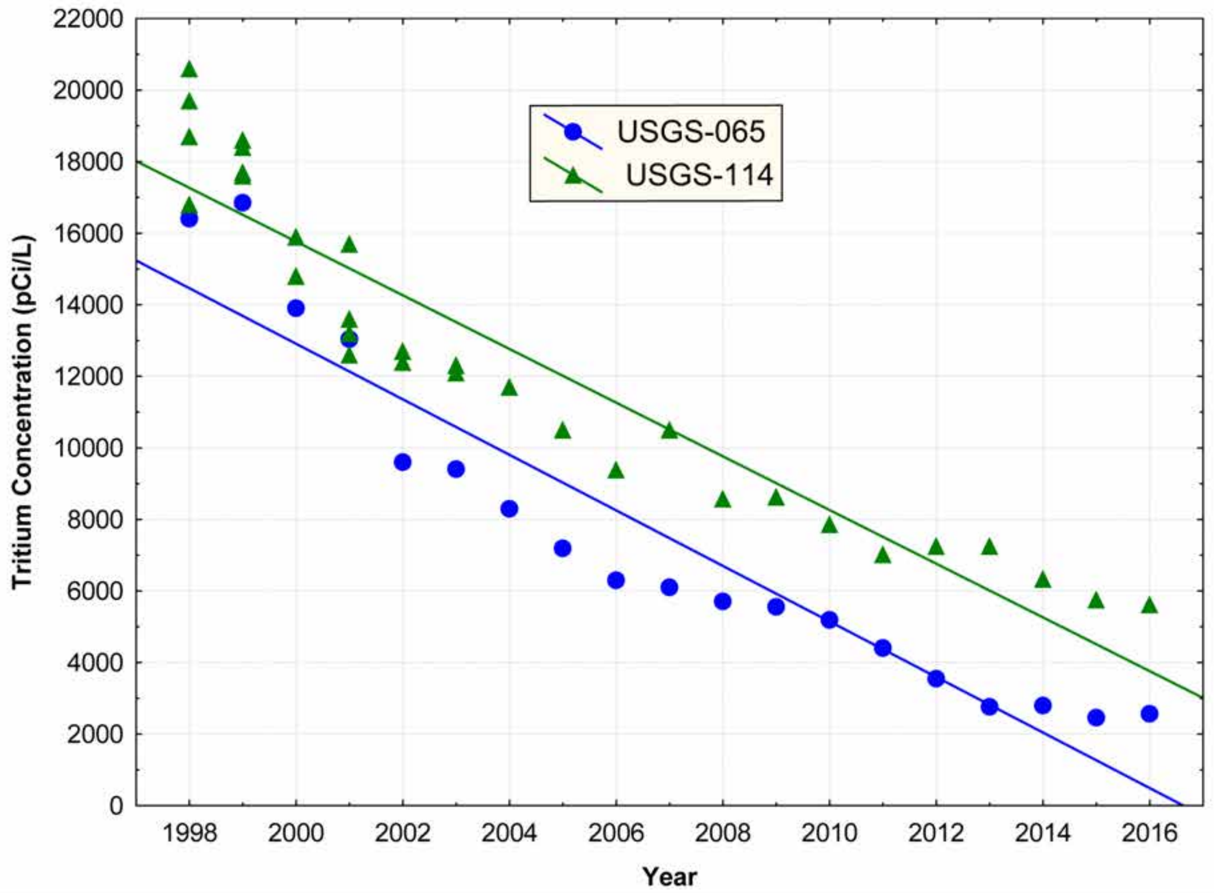


Figure 6-5. Long-term Trend of Tritium in Wells USGS-065 and -114 (1998–2016).

radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.1 ± 0.7 to 1010 ± 60 pCi/L (Bartholomay et al. 2017).

USGS periodically has sampled for iodine-129 (^{129}I) in the eastern Snake River Plain aquifer. Monitoring programs from 1977, 1981, 1986, 1990, 1991, 2003, and 2007 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009). The USGS sampled for 129I in wells at the INL Site in the fall of 2011 and in the spring and summer of 2012; results were published in Bartholomay (2013). Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, and 2011–2012 decreased from 1.15 pCi/L in 1990–1991 to 0.173 pCi/L in 2011–2012. The maximum concentration in 2011 was 1.02 ± 0.04 pCi/L in a monitoring well southeast of INTEC—the drinking water standard for ^{129}I is 1 pCi/L. Concentrations around INTEC showed slight decreases from samples collected in previous sample periods, and the decreases are attributed to discontinued disposal, as well as dilution and dispersion in the aquifer. The configuration and extent of ^{129}I in groundwater, based on the 2011–2012 USGS data (most current to date), are shown in Figure 6-8 (Bartholomay 2013).

6.4 U.S. Geological Survey Non-Radiological Groundwater Monitoring at the Idaho National Laboratory Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and selected other trace elements and purgeable organic compounds (Table 6-1). Bartholomay et al. (2017) provides a detailed discussion of results for samples collected during 2012–2015. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration was below the MCL in 2016 at 75.5 µg/L; this well has shown a long-term decreasing trend (Davis et al. 2015, Appendix D).

Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs (SMCLs) in all wells during 2015 (Bartholomay et al. 2017).

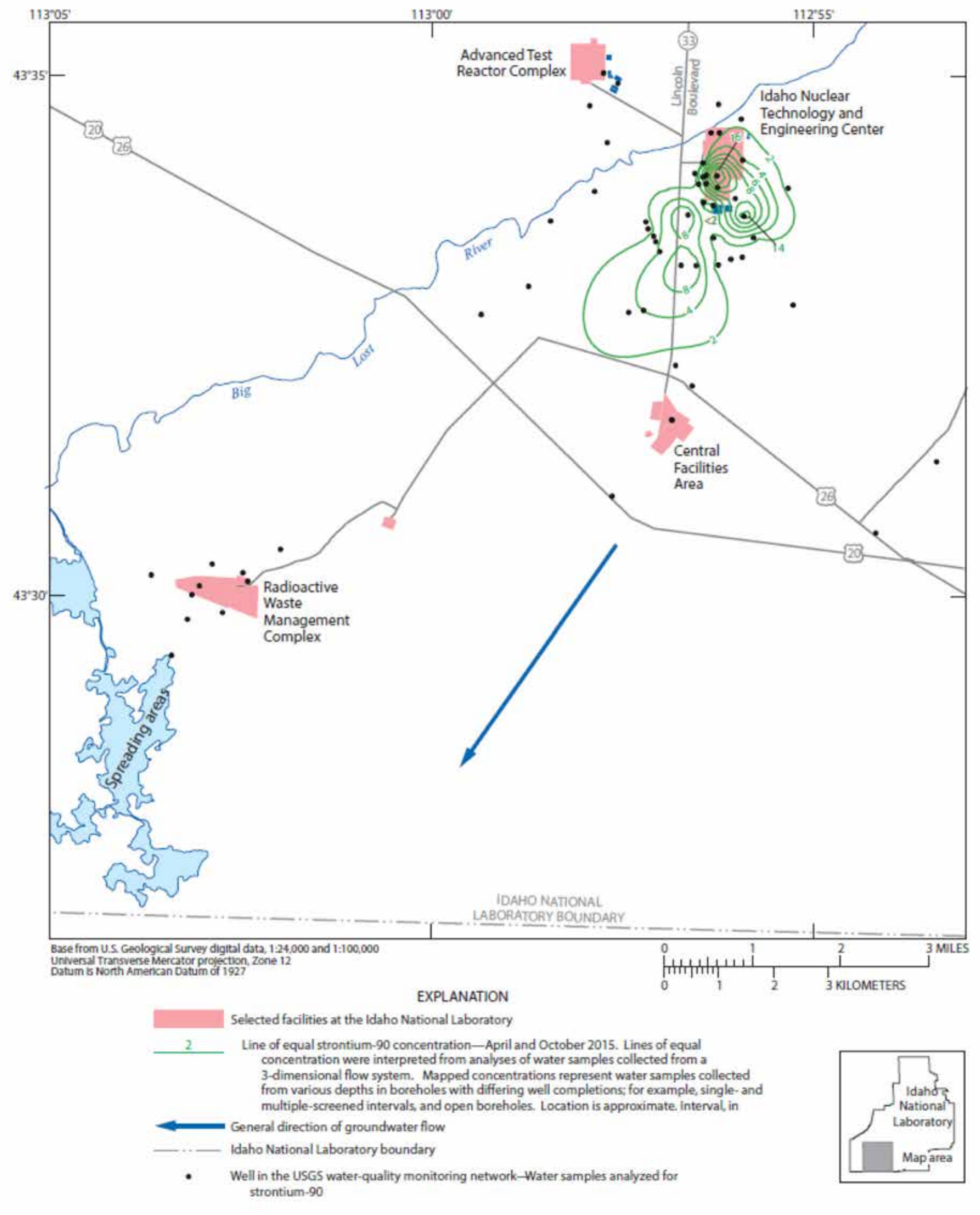


Figure 6-6. Distribution of ^{90}Sr in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

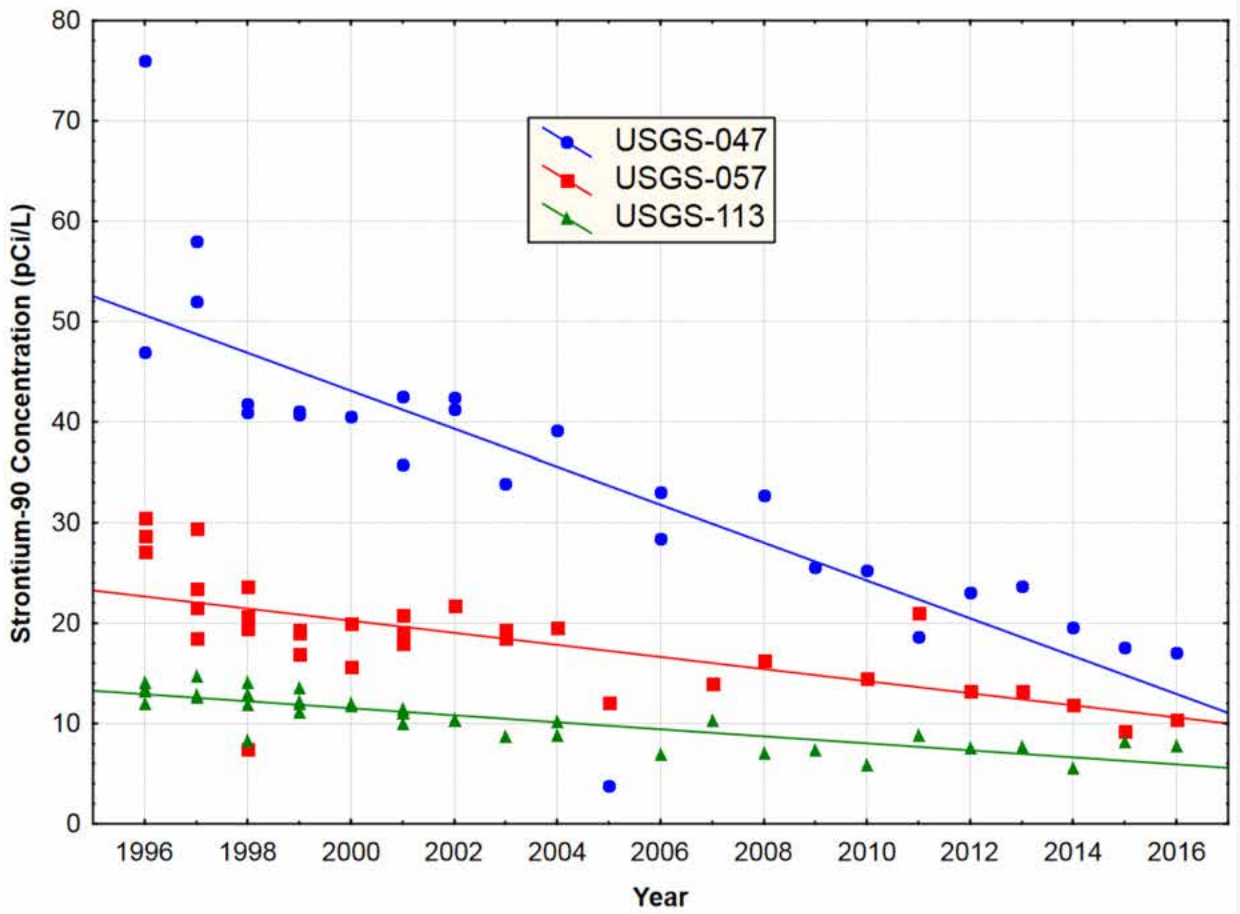


Figure 6-7. Long-term Trend of ^{90}Sr in Wells USGS-047,-057, and -113 (1995–2016).

VOCs are present in water from the eastern Snake River Plain aquifer because of historical waste disposal practices at INL. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2016. Samples from 28 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al. 2003; Knobel et al. 2008; Bartholomay et al. 2014). Ten purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-5).

Historically, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay et al. 2000). However, concentrations for all VOCs except tetrachloromethane (also known as carbon tetrachloride) were less than the MCL for drinking water (40 CFR 141, Subpart G). The production well at the RWMC was monitored monthly for tetrachloromethane during 2016, and concentrations exceeded the MCL of 5 µg/L during all 12 months (Table 6-6).

Concentrations have routinely exceeded the MCL for carbon tetrachloride in drinking water (5 µg/L) since 1998. (Note: VOCs are removed from the production well water prior to human consumption—see Section 6.6.4.) Trend test results for carbon tetrachloride concentrations in water from the RWMC production well indicate a statistically significant increase in concentrations has occurred since 1987; however, Bartholomay et al. (2017) indicated that more recent data collected since 2005 show a decreasing trend in the RWMC production well. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

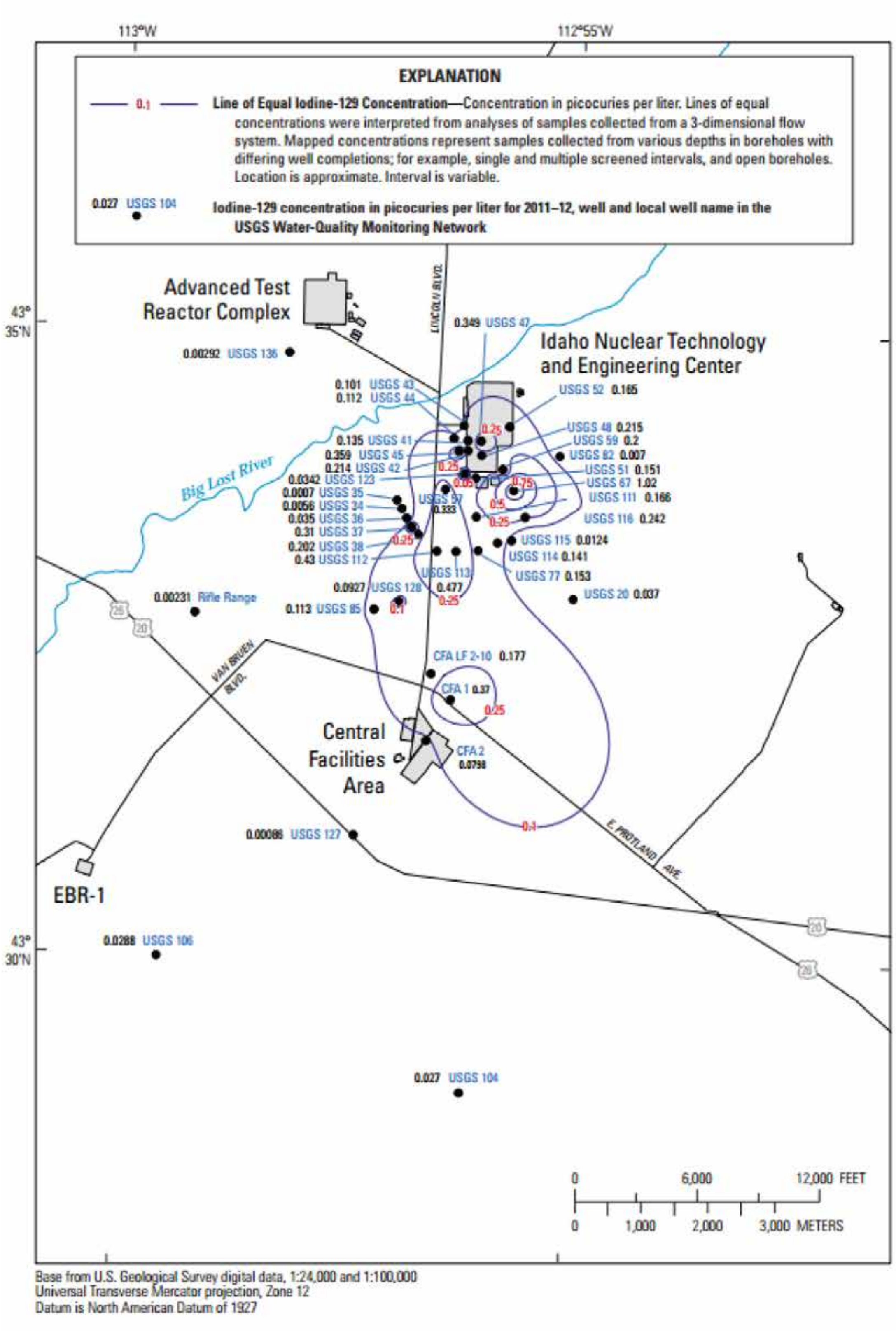


Figure 6-8. Distribution of ^{129}Iodine in the Snake River Plain Aquifer on the INL Site in 2011–2012 (from Bartholomay 2013).

Table 6-5. Purgeable Organic Compounds in Annual USGS Groundwater Well Samples (2016).

Constituent[a]	GIN 2	RWMC-M7S	USGS-087	USGS-88	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[b]	ND[c]	4.6	2.7	0.6	0.9
Trichloromethane (µg/L) (MCL=80)	0.1	1.0	0.3	0.4	0.1
1,1,1-Trichloroethane (µg/L) (PCS=200)[d]	ND	0.4	0.1	ND	ND
Tetrachloroethene (µg/L) (MCL=5)	2.6	0.4	0.1	ND	ND
Trichloroethene (µg/L) (PCS=5)	8.2	2.9	0.8	0.4	0.2

a. TAN-2271 contains 21.9 µg/L cis-1,2-Dichloroethene, 1.9 µg/L vinyl chloride; 56.4 µg/L trans-1,2-Dichloroethene; 0.1 µg/L 1,1-Dichloroethane; and 3.5 µg/L trichloroethene; USGS 77 contains 0.1 µg/L 1,1-Dichloroethane; USGS 119 contains 0.8 µg/L tetrachloromethane; USGS 144 contains 0.9 µg/L toluene.

b. MCL = maximum contaminant level from Environmental Protection Agency (40 CFR 141)

c. ND = not detected

d. PCS = primary constituent standard values from IDAPA 58.01.11

Table 6-6. Purgeable Organic Compounds in Monthly Production Well Samples at the RWMC (2016).

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL=5)[a]	6.3	5.9	6.5	6.5	5.5	5.6	5.7	5.5	5.9	5.4	5.7	6.4
Trichloromethane (µg/L) (MCL=80)[b]	2.1	2.5	2.2	2.1	2.6	1.9	1.6	1.6	1.6	1.9	2.0	2.0
Tetrachloroethene (µg/L) (PCS=5)[c]	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.4
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Trichloroethene (µg/L) (PCS=5)	3.7	4.2	3.8	3.7	4.2	3.8	3.6	3.5	3.8	3.5	3.8	4.3

a. MCL = maximum contaminant level values from the Environmental Protection Agency (40 CFR 141)

b. The MCL for total trihalomethanes is 80 µg/L. This MCL is based on concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and trichloromethane.

c. PCS = primary constituent standard values from IDAPA 58.01.11

Concentrations of tetrachloromethane from USGS-87 and USGS-120, south of the RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at USGS-88 (Davis et al. 2015).

Trichloroethene (TCE) exceeded the MCL of 5 µg/L from one sample collected from Well GIN 2 at TAN (Table 6-5). There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2016

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown in Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of CERCLA groundwater sampling can be found in the

WAG-specific monitoring reports within the CERCLA Administrative Record at www.ar.icp.doe.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.5.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 to measure the progress of the remedial action at TAN. The groundwater plume at TAN has been divided into three zones for the three different remedy components. The three remedy components work together to remediate the entire plume. The monitoring program and results are summarized by plume zone in the following paragraphs.

Hot Spot Zone (historical TCE concentrations exceeding 20,000 µg/L) – In situ bioremediation (ISB) was used in the hot spot (TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated ethene contaminants. The hot spot concentration was defined using data from 1997 (Figure 6-9) and is not reflective of current concentrations. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. In 2016, the ISB rebound test was split into two components: 1) an ISB rebound test for part of the area near the former injection Well TSF-05 and 2) ISB activities to treat the TCE source affecting TAN-28.

In 2016, an ISB rebound test was in progress for the part of the area near the former injection well TSF-05. During 2016, anaerobic conditions created by ISB remained in the hot spot area, and TCE concentrations were near or below MCLs in all the former ISB injection wells. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2017a).

Data from Wells TAN-28, TAN-30A, TAN-1860, and TAN-1861, located downgradient of the hot spot, are used to determine if ISB operations have reduced the downgradient flux of contaminants. Trends in TCE concentrations at Wells TAN-30A and TAN-1861 generally indicate that flux from the hot spot has been reduced at these wells, but the flux has not been reduced sufficiently at Wells TAN-28 and TAN-1860. Flow path analysis conducted after the first two years of the ISB rebound test determined that the cause of the higher TCE concentrations in TAN-28 and TAN-1860 was an untreated source area in the aquifer.

To address the TCE source affecting TAN-28, ISB injections were resumed in January 2016 into Well TAN-2272 and continued at a three-month interval throughout the year. The effect of the ISB injections into TAN-2272 will be evaluated in 2017.

Medial Zone (historical TCE concentrations between 1,000 and 20,000 µg/L) – A pump and treat system has been used in the medial zone. The pump and treat system involves extracting contaminated groundwater, circulating the groundwater through air strippers to remove VOCs like TCE, and reinjecting treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday–Thursday, except for shutdowns due to maintenance. All 2016 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone are based on data collected in 1997, before remedial actions started (Figure 6-9), and do not reflect current concentrations. TCE concentrations in the medial zone wells are significantly lower than the historically defined range of 1,000–20,000 µg/L. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 are used as indicators of groundwater TCE concentrations that migrate past the New Pump and Treat Facility extraction wells and were less than 60 µg/L in 2016.

Distal Zone (historical TCE concentrations between 5 and 1,000 µg/L) – Monitored natural attenuation is the remedial action for the distal zone of the plume, as defined by 1997 TCE concentrations (Figure 6-9). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Institutional controls are in place to protect current and future users from health risks associated with groundwater contamination until concentrations decline through natural attenuation to below the MCL.

TCE data collected in 2016 from the distal zone wells indicate that all wells are consistent with the model predictions, but additional data are needed to confirm that the monitored natural attenuation part of the remedy is on schedule for all wells in the distal portion of the plume to meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that the plume has expanded but is within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

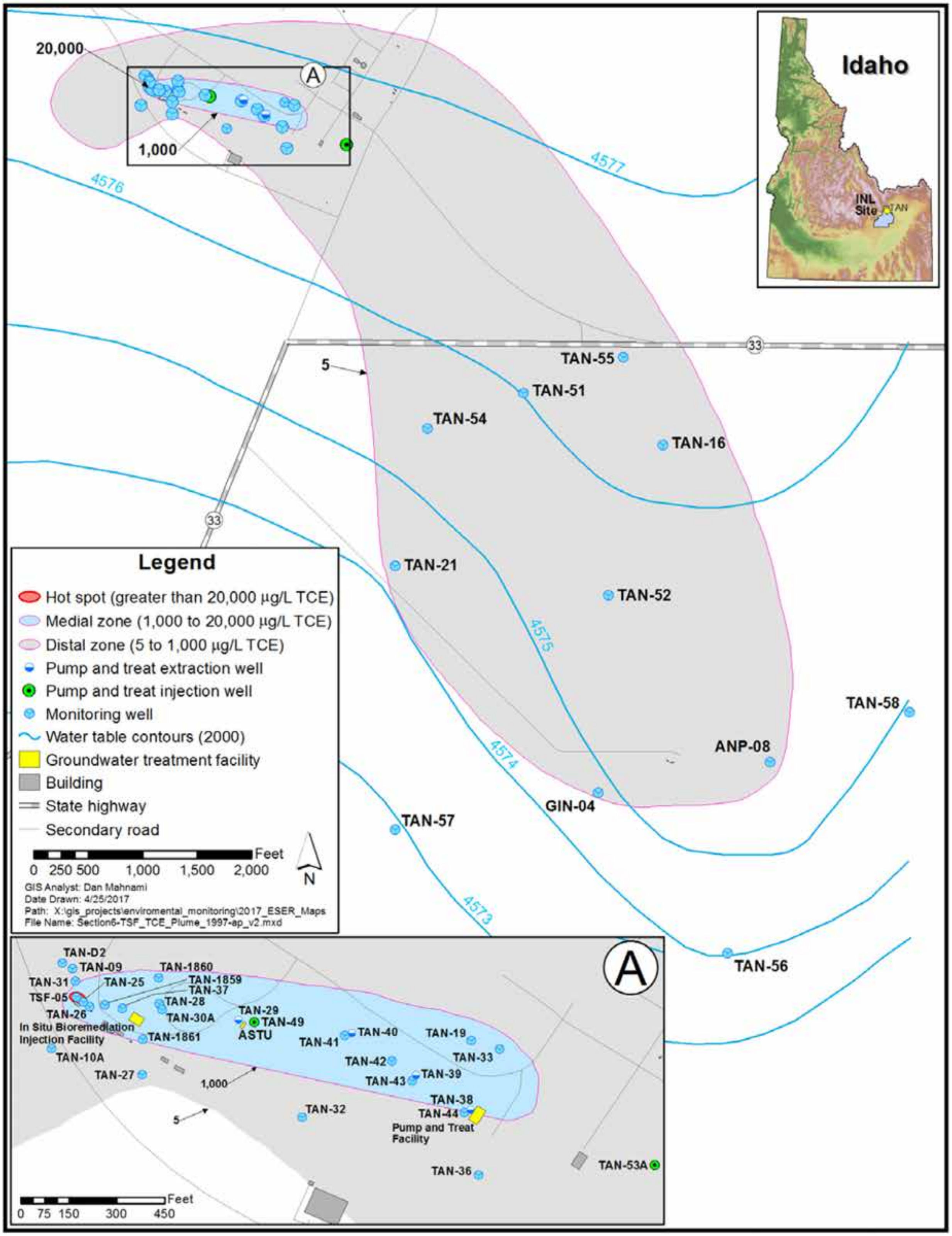


Figure 6-9. Trichloroethene Plume at TAN in 1997.

Radionuclide Monitoring – Strontium-90 and ^{137}Cs are expected to decline below their respective MCLs before 2095. However, ^{90}Sr and ^{137}Cs concentrations for wells in the source area show elevated concentrations compared to those prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to elevated concentrations of competing cations (calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer leading to enhanced ^{90}Sr and ^{137}Cs mobility. The elevated cation concentrations are due to ISB activities.

Strontium-90 and ^{137}Cs trends will be evaluated as competing cation concentrations decline toward background conditions to determine if they will meet the remedial action objective of declining below MCLs by 2095.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells at WAG 2, ATR Complex, during 2016. The locations of the wells sampled for WAG 2 are shown in Figure 6-10. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (cobalt-60), tritium, and chromium (filtered). The data for the October 2016 sampling event will be included in the Fiscal Year 2017 Annual Report for WAG 2 when it is finalized. The October 2016 sampling data are summarized in Table 6-7.

No analyte occurred above its MCL. The highest chromium concentration occurred in Well TRA-07 at 81.6 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well USGS-065 was also elevated at 80.9 µg/L. Although the chromium concentration was steady in TRA-07 and increased in USGS-065 from the previous year, the chromium concentrations in both wells are still in long-term decreasing trends.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all wells sampled. The highest tritium concentration was 6,270 pCi/L in Well TRA-07. In the past, Well TRA-08 had detections of ^{90}Sr, but ^{90}Sr has been below detection limits since October 2010.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by the WAG 2 models used for the Operable Unit 2-12 Record of Decision and the revised modeling performed after the first five-year review (DOE-NE-ID 2005).

The October 2016 eastern Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing similar groundwater flow directions. Water levels in the vicinity of ATR Complex fell approximately 0.11 m (0.37 ft) on average from October 2015 to October 2016.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 18 eastern Snake River Plain aquifer monitoring wells during 2016 (Figure 6-11). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2016 Annual Report (DOE-ID 2017b). Table 6-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, technetium-99 (^{99}Tc), total dissolved solids, and nitrate exceeded their respective drinking water MCLs in one or more of the eastern Snake River Plain aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Stron-

Table 6-7. WAG 2 Aquifer Groundwater Quality Summary for 2016.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2–3	81.6	1.88	0
Cobalt-60 (pCi/L)	100	0	ND[c]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	75–150	6,270	ND	0

a. MCL = maximum contaminant level
b. Background concentrations are from Knobel et al. (1992), except tritium, which is from Orr et al. (1991).
c. ND = not detected

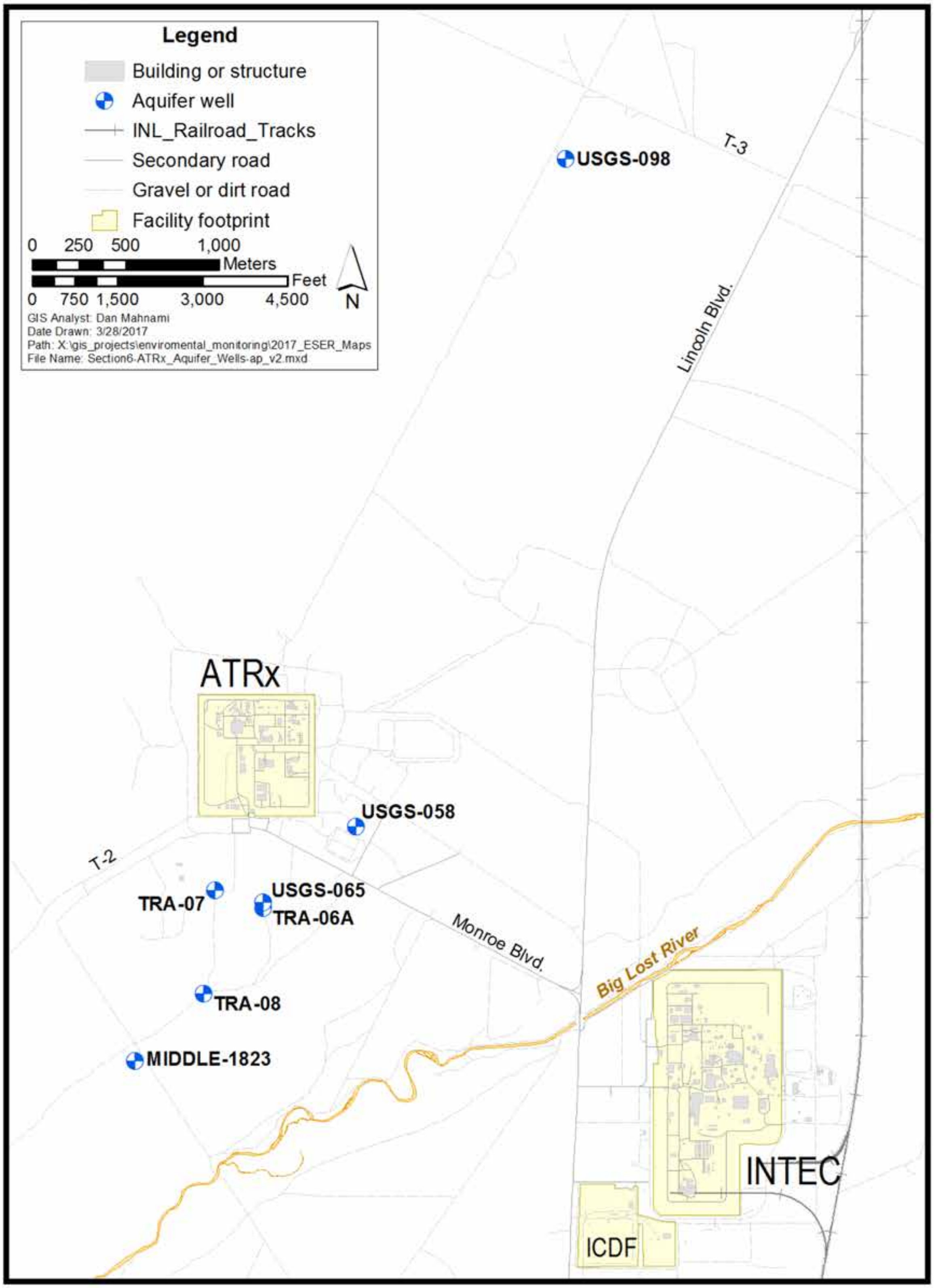


Figure 6-10. Locations of WAG 2 Aquifer Monitoring Wells.

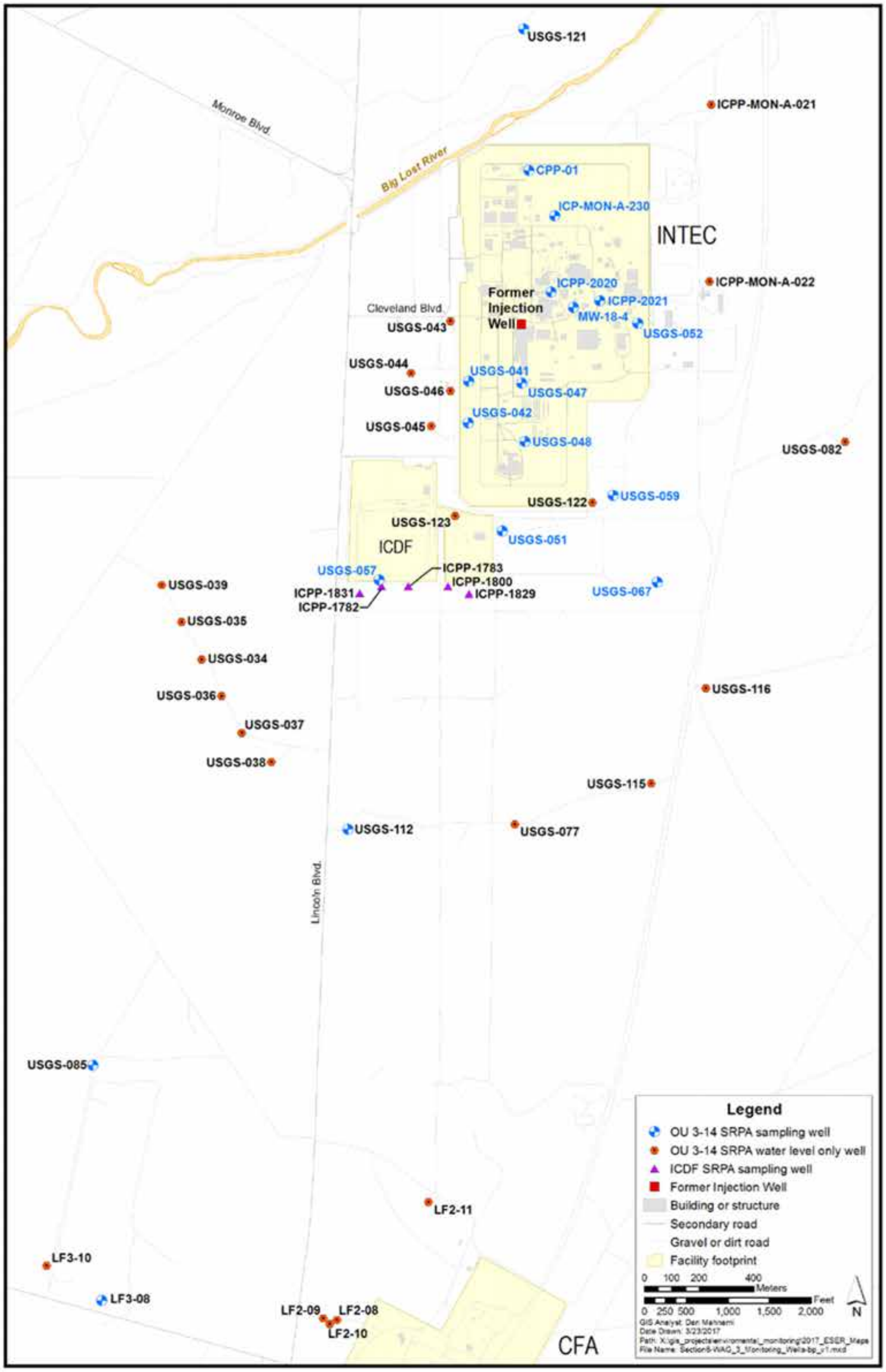


Figure 6-11. Locations of WAG 3 Monitoring Wells.

Table 6-8. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (Fiscal Year 2016).

Constituent	EPA MCL[a]	Units	Snake River Plain Aquifer Groundwater – April 2016: Maximum Reported Value[b]	Number of Results[c]	Results >MCL[c]
Gross alpha	15	pCi/L	3.79 ± 1.47 J	14	0
Gross beta	NA[d]	pCi/L	877 ± 22	14	NA
Cesium-137	200	pCi/L	5.96 ± 2.71 J	14	0
Strontium-90	8	pCi/L	**15.4 ± 1.45**[e]	14	6
Technetium-99	900	pCi/L	**1,290 ± 74.2**	14	1
Iodine-129	1	pCi/L	0.641 ± 0.308 J	14	0
Tritium	20,000	pCi/L	3,760 ± 430	14	0
Plutonium-238	15	pCi/L	ND[f]	14	0
Plutonium-239/240	15	pCi/L	ND	14	0
Uranium-233/234	15	pCi/L	2.57 ± 0.258	14	0
Uranium-235	15	pCi/L	0.0916 ± 0.041 J	14	0
Uranium-238	15	pCi/L	1.36 ± 0.164	14	0
Bicarbonate	NA	mg/L	148	14	NA
Calcium	NA	mg/L	71	14	NA
Chloride	250	mg/L	148	14	0
Magnesium	NA	mg/L	25.3	14	NA
Nitrate/Nitrite (as N)	10	mg/L	**14.1 J**	14	1
Potassium	NA	mg/L	5.14	14	NA
Sodium	NA	mg/L	36.6	14	NA
Sulfate	250	mg/L	38.3	14	0
Total dissolved solids	500	mg/L	**587**	14	1

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level
b. Data qualifier flags: J = estimated value
c. Does not include field duplicates.
d. NA = not applicable
e. **Bold** values exceed MCL.
f. ND = constituent not detected in any sample

tium-90 concentrations remained above the MCL (8 pCi/L) at six of the well locations sampled. During 2016, the highest ^{90}Sr level in eastern Snake River Plain aquifer groundwater was at monitoring Well USGS-047 (15.4 ± 1.45 pCi/L), located south (downgradient) of the former INTEC injection well. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events.

As in the past, ^{99}Tc was detected above the MCL (900 pCi/L) in one monitoring well within INTEC, but concentrations were below the MCL at all other locations. During 2016, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at monitoring Well ICPP-MON-A-230 (1,290 ± 74.2 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (14.1 mg/L as N). This was the only location where the nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations were similar or slightly lower than observed in previous years.

Iodine-129 was detected at two well locations, with the highest concentration reported at Well USGS-067 (0.641 ± 0.308 pCi/L). None of the groundwater samples exceeded the ^{129}I MCL of 1 pCi/L.

Tritium was detected in nearly all of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well USGS-51, near the former percolation ponds (3,760 ± 430 pCi/L), and Well ICPP-2021-AQ, southeast of the Tank Farm (2,550 ± 313 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotopes were detected in any of the eastern Snake River Plain aquifer groundwater samples. Uranium-238 was detected at all eastern Snake River Plain aquifer well locations, with the highest concentration at Well ICPP-MON-A-230 (1.36 ± 0.164 pCi/L) near the INTEC tank farm. Similarly, uranium-234 (^{234}U) also was detected in all groundwater samples, with concentrations ranging as high as 2.57 ± 0.258 pCi/L at Well ICPP-MON-A-230. Uranium-234 is the daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. Aside from Well ICPP-MON-A-230, uranium results for the other wells are consistent with background concentrations reported for Snake River Plain aquifer groundwater. Ratios of ^{234}U/^{238}U were similar to background ^{234}U/^{238}U activity ratios of 1.5 to 3.1 reported for the eastern Snake River Plain aquifer.

Uranium-235 was detected in only three groundwater samples: Wells USGS-067 (0.0916 ± 0.04 pCi/L), CPP-01 (0.0869 ± 0.0433), and ICPP-MON-A-230 (0.0778 ± 0.0387 pCi/L). An evaluation of uranium in groundwater near RWMC indicates that eastern Snake River Plain aquifer background 235U activities are generally less than 0.15 pCi/L (95 percent upper tolerance limit). Reported 235U concentrations in groundwater at INTEC have historically been slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

6.5.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: 1) CFA landfill monitoring and 2) monitoring of a nitrate plume south of CFA. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, fluoride, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2013). Four wells south of CFA were sampled for nitrate and other anions to monitor a nitrate plume downgradient of CFA. The CFA monitoring well locations are shown on Figure 6-12. Analytes detected in groundwater are compared to regulatory levels in Table 6-9. A complete list of the groundwater sampling results is contained in the *2016 Monitoring Report* (DOE-ID 2017c).

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed the groundwater MCL of 10 mg/L-N for nitrate. The nitrate concentration in CFA-MON-A-002 increased in 2016 to 14 mg/L-N, but the result is still consistent with a decreasing trend since 2006.

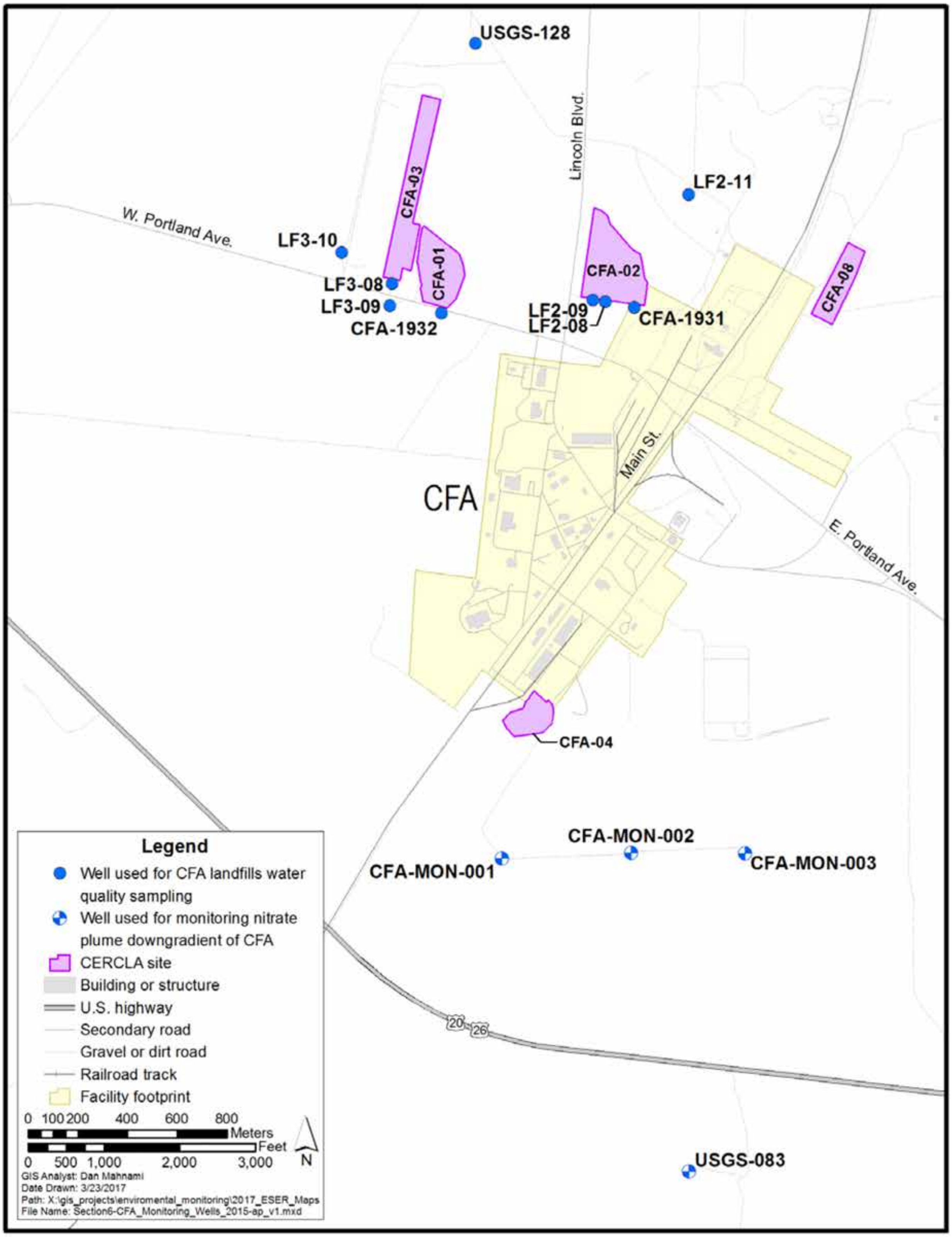
The nitrate concentration of 8.34 mg/L-N in Well CFA-MON-A-003 is below the MCL and within its historic range of 8 to 11 mg/L-N. Except for a 2005 spike, nitrate concentrations in Well CFA-MON-A-003 have been relatively consistent since monitoring started in 1995.

In 2016, no analyte exceeded an EPA MCL for the CFA Landfill monitoring. The SMCL for iron of 300 µg/L was exceeded in one well. However, the high iron concentration was inconsistent with the high dissolved oxygen level and slightly alkaline pH in this well. The elevated iron concentration is probably due to particles less than 0.45 microns that may have passed through the filter; or the filter may have experienced a minor breakthrough, despite precautions that were taken to guard against that occurring.

Water level measurements taken in the CFA in 2016 suggest that after the sharp drop in water levels from 2000–2005, water levels appear to be stabilizing, having declined only approximately 0.91 m (3 ft) since 2005. A water table map produced from water levels collected in August 2016 was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2017c).

6.5.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-NE-ID 2007).



GIS Analyst: Dan Mahnami
Date Drawn: 3/23/2017
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File Name: Section6-CFA_Monitoring_Wells_2015-ap_v1.mxd

Figure 6-12. Locations of WAG 4/CFA Monitoring Wells Sampled in 2016.

Table 6-9. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2016).

Compound	MCL[a] or SMCL[b]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*[c]	68.3	0
Fluoride (mg/L)	2	0.253	0
Sulfate (mg/L)	*250*	31	0
Nitrate/nitrite (mg-N/L)	10	**14**[d]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	64.4	0
Fluoride (mg/L)	2	0.22	0
Sulfate (mg/L)	*250*	37.8	0
Nitrate/nitrite (mg-N/L)	10	2.46	0
Common Cations			
Calcium (µg/L)	None	56,200	NA[e]
Magnesium (µg/L)	None	18,600	NA
Potassium (µg/L)	None	5,800	NA
Sodium (µg/L)	None	31,300	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	187	1
Arsenic (µg/L)	10	2.35	0
Barium (µg/L)	2,000	104	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	76.7	0
Copper (µg/L)	*1,300/1,000*	2.6	0
Iron (µg/L)	*300*	**566**	1
Lead (µg/L)	15	0.536	0
Manganese (µg/L)	50	18.4	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	123	NA
Selenium (µg/L)	50	2.42	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	8.08	NA
Zinc (µg/L)	*5,000*	357	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	100	0.86	0
Toluene	1000	15.5	0
Acetone	–	3.07	0

a. MCL = maximum contaminant level
b. SMCL = secondary maximum contaminant level
c. Numbers in *italic* text are for the secondary MCL.
d. **Bold** values exceed an MCL or SMCL.
e. NA = not applicable
f. ND = not detected

6.5.6 Summary of Waste Area Group 6 Groundwater Monitoring Results

Independent groundwater monitoring is not performed for WAG 6. Groundwater monitoring in the vicinity of WAG 6 is conducted in accordance with the WAG 10 Site-wide monitoring requirements, as discussed in Section 6.5.9.

6.5.7 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from monitoring wells near RWMC in November 2016 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 275 analyses performed, 12 met reportable criteria established in the Operable Unit 7-13/14 Field Sampling Plan (Forbes and Holdren 2014). Table 6-10 lists contaminants of concern that were detected above regional background concentrations, MCLs, or quantitation limits, and a discussion of those results follows.

- ***Carbon tetrachloride*** – Carbon tetrachloride was detected above the quantitation limit (1 µg/L) at six monitoring locations in November 2016 and exceeded its MCL (5 µg/L) in a field duplicate sample taken at Well M7S (Figure 6-13). The carbon tetrachloride concentrations remained relatively static or declined overall in wells near and downgradient of the RWMC (Figure 6-14).
- ***Carbon-14*** – Carbon-14 was the only reportable radiological analyte detection in 2016. It was detected in Well M3S at a concentration considerably below its MCL (Table 6-10).
- ***Trichloroethylene*** – Trichloroethylene concentrations exhibited little change in November 2016, as compared with previous results.
- ***Inorganic analytes*** – Inorganic analytes were not detected above reporting thresholds in groundwater samples in 2016.

As in previous years, groundwater level measurements in RWMC-area monitoring wells during 2016 indicate groundwater flow to the south-southwest (Figure 6-15).

6.5.8 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC are sampled twice a year by the INL contractor for selected radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters, as required under the WAG 9 Record of Decision (Figure 6-16; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

6.5.9 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2016), groundwater samples are collected every two years at the locations shown on Figure 6-17. In 2016, WAG 10 groundwater sampling was not performed. The next WAG 10 groundwater sampling event is scheduled for 2017.

6.6 Onsite Drinking Water Sampling

The INL and ICP Core contractors monitor drinking water to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act (40 CFR 141, 142). Parameters with primary MCLs must

Table 6-10. Summary of WAG 7 Aquifer Sampling and Analyses for Relevant Analytes in 2016.

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[a, b]	Concentration Maximum[a]	Number of Detections Greater Than MCL[a]	MCL[c]
Carbon tetrachloride	9	11	7	5.01µg/L	1	5 µg/L
Carbon-14	9	11	1	7 ± 2 pCi/L	0	2,000
Trichloroethylene	9	11	4	2.65 µg/L	0	5 µg/L

a. Includes field duplicate samples collected for quality control purposes.
b. Reported results are contaminants of concern at concentrations greater than regional background concentrations or quantitation limits. Background concentrations of carbon tetrachloride and trichloroethylene in the Snake River Plain aquifer are essentially zero; therefore, laboratory quantitation limits are used as reporting limits.
c. MCL = maximum contaminant level. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141).

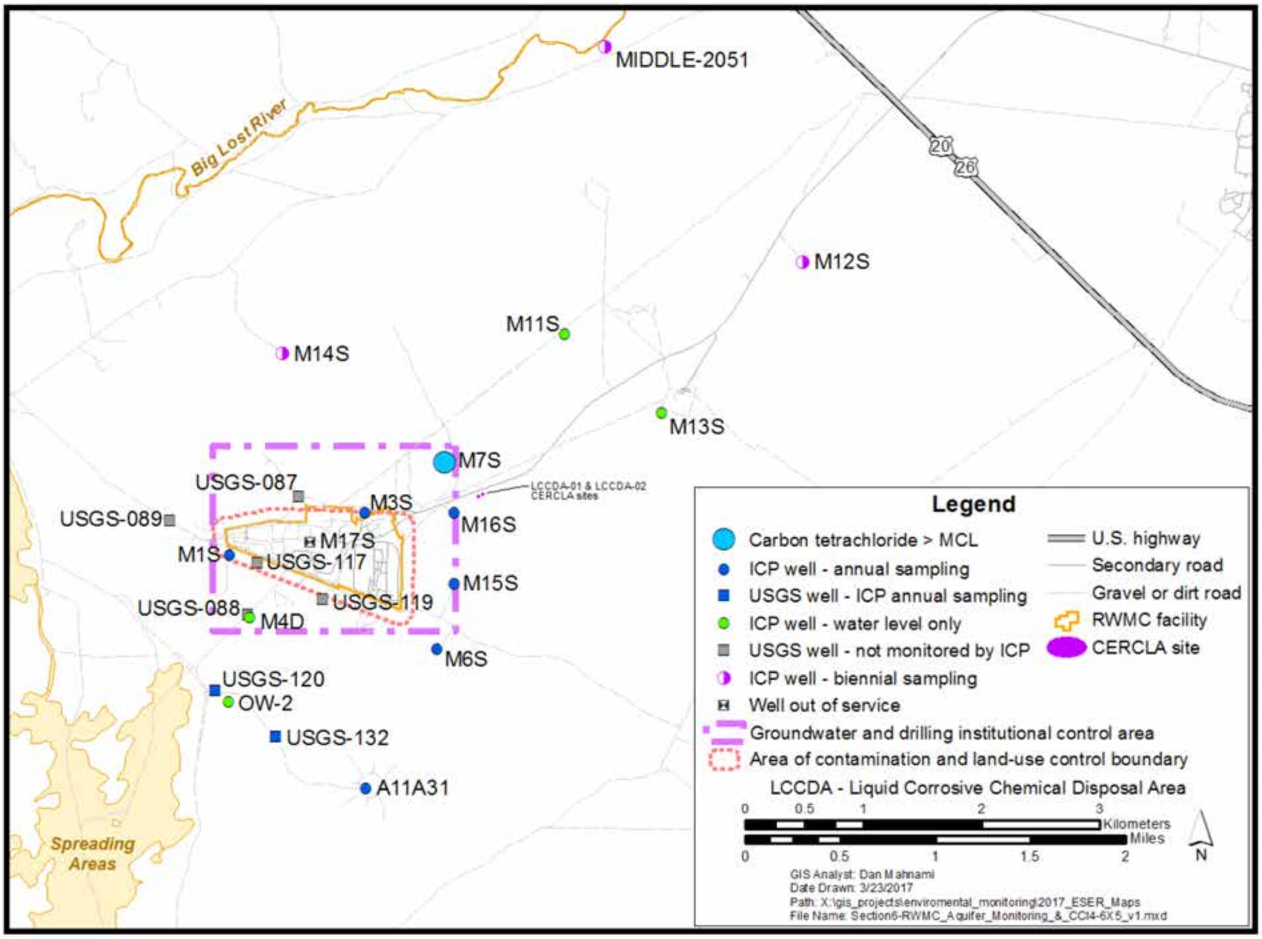

Figure 6-13. Aquifer Monitoring Wells Near the RWMC and the Location Where Carbon Tetrachloride Exceeded its MCL in November 2016.

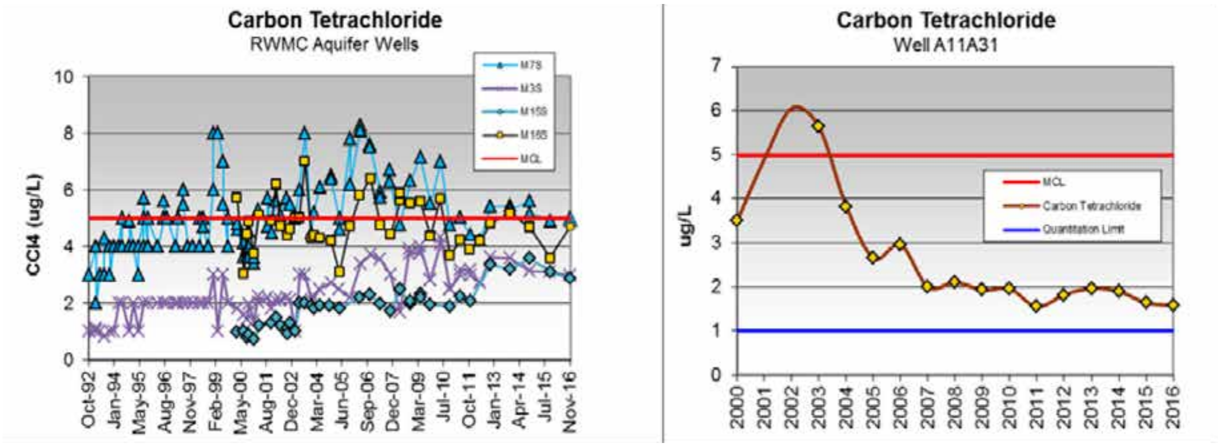

Figure 6-14. Concentration History of Carbon Tetrachloride for Wells Near, and Downgradient of, the Radioactive Waste Management Complex.

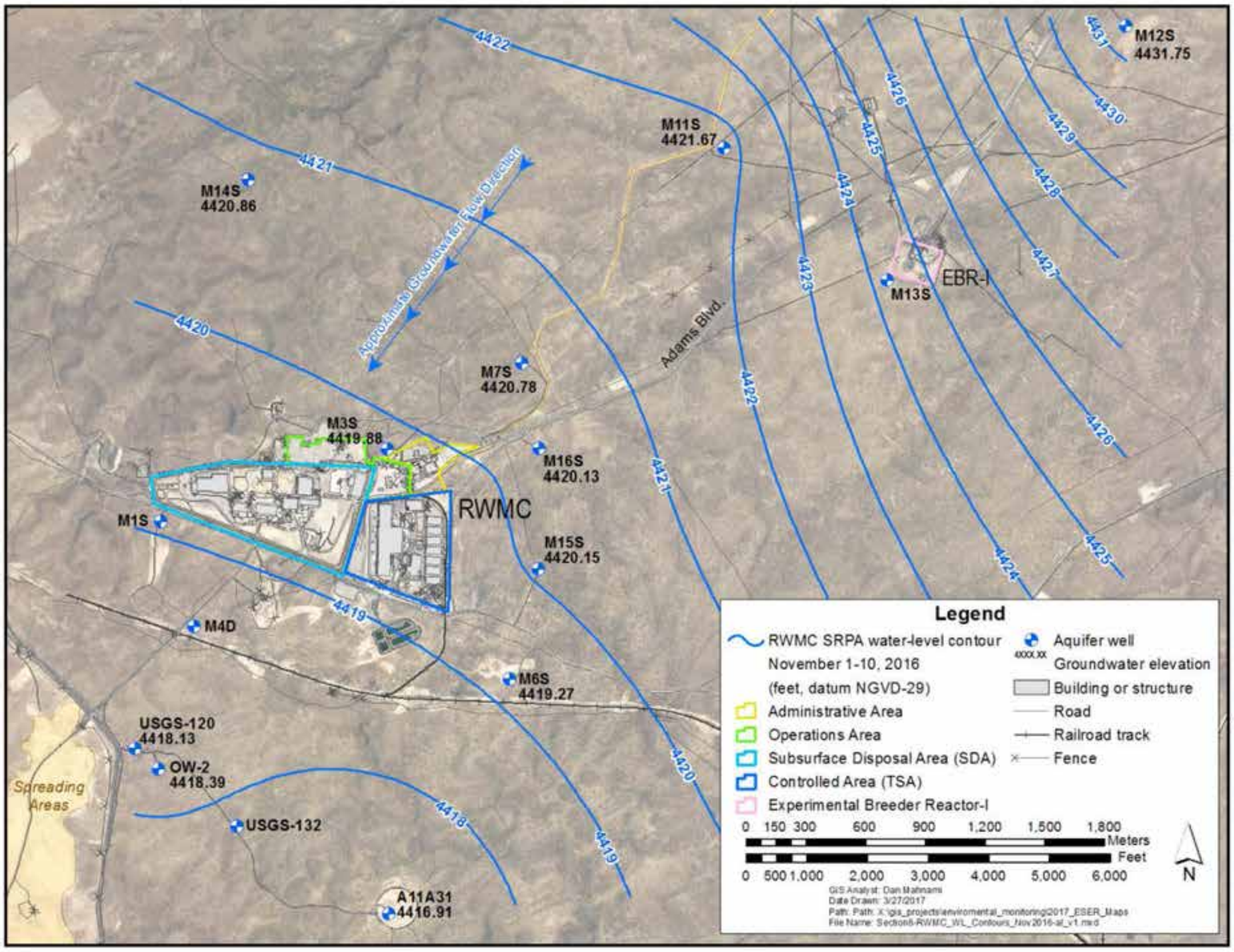

Figure 6-15. Groundwater-level Contours in the Aquifer Near the RWMC, Based on November 2016 Measurements.

be monitored at least once every three years. Parameters with secondary MCLs are monitored every three years based on a recommendation by the EPA (40 CFR 143). Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

Currently, the INL Site has 12 drinking water systems. The INL contractor and ICP Core contractor monitor these systems to ensure a safe working environment. The INL contractor monitors nine of these drinking water systems, ICP Core contractor monitors two, and Naval Reactors Facility monitors one. According to the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08), INL Site drinking water systems are classified as either non-transient or transient, non-community water systems. The five INL contractor transient, non-community water systems are at the EBR-I, Gun Range (Live Fire Test Range), CITRC, TAN/TSF, and the Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems. These systems are located at CFA, MFC, ATR Complex, and TAN/CTF. The two ICP Core contractor non-transient, non-community water systems are INTEC and the RWMC.

As required by the state of Idaho, the INL contractor and the ICP Core contractor Drinking Water Programs use EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and 40 CFR Parts 141–143. State regulations also require that analytical laboratories be certified by the state or by another state whose certification is recognized by Idaho. DEQ oversees the certification program and maintains a list of approved laboratories.

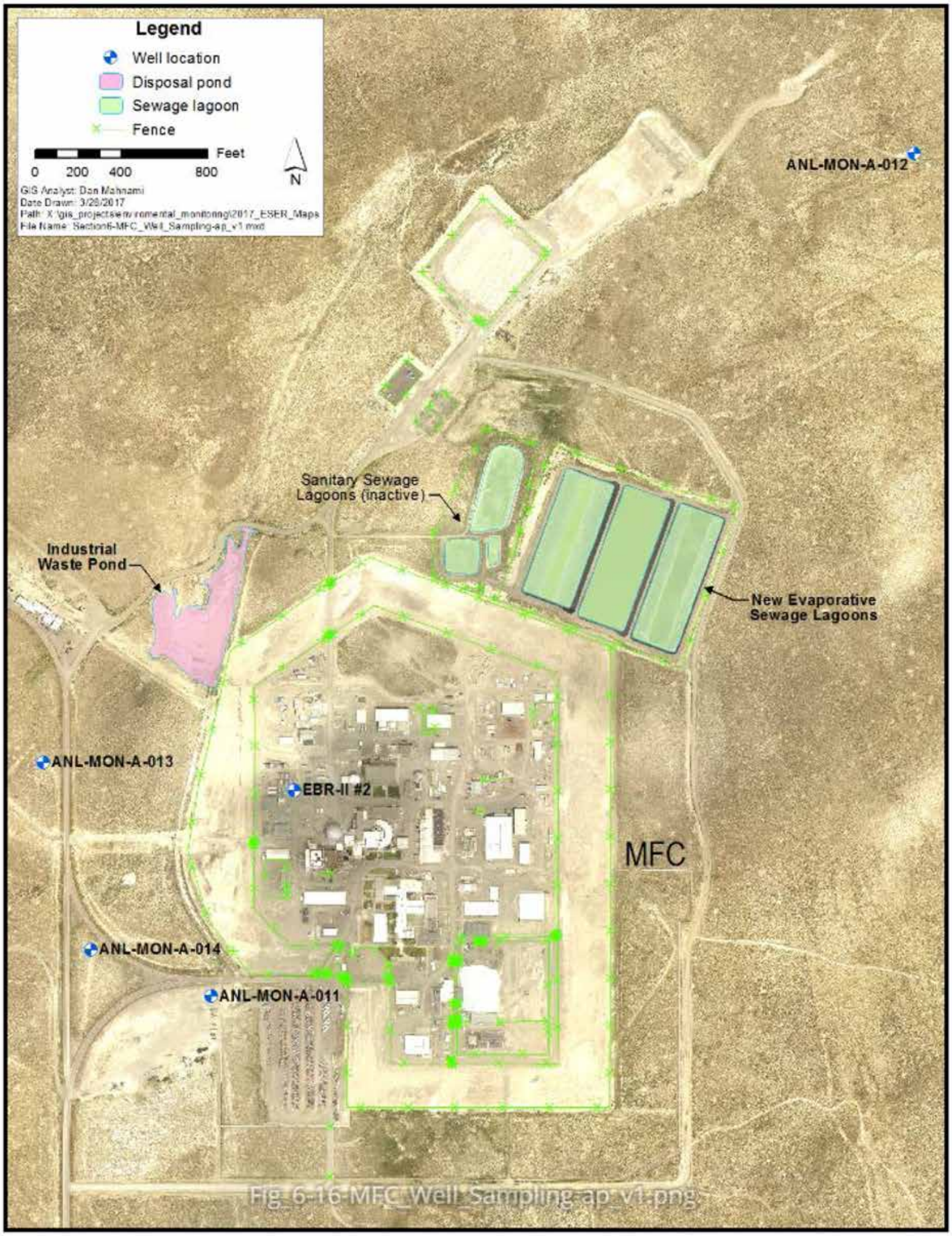

Figure 6-16. Locations of WAG 9 Wells Sampled in 2016.

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2016).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	05/03/2016	09/14/2016	05/02/2016	09/12/2016	05/03/2016	09/13/2016	05/03/2016	09/13/2016	5/04/2016	09/14/2016	
Radionuclides[c]											
Gross alpha (pCi/L)	ND[d]	ND	ND	ND (ND)[e]	ND	ND	ND	ND	ND	ND	15 pCi/L
Gross beta (pCi/L)	4.1 ±1.18	2.82 ±0.577	ND	3.33 ±0.599 (2.33 ±0.589)	5.15 ±1.13	2.39 ±0.651	4.34 ±0.941	3.12 ±0.604	3.45 ±0.816	3.07 ±0.666	4 mrem/yr
Uranium-233/234 (pCi/L)	1.54 ± 0.181	1.52 ± 0.239	1.01 ± 0.139	1.86 ±0.299 (1.35 ±0.239)	1.51 ±0.0182	1.46 ± 0.247	1.66 ±0.187	1.48 ± 0.270	1.58 ±0.188	1.20 ±0.235	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.639 ±0.103	0.782 ± 0.166	0.737 ±0.115	1.06 ±0.216 (1.01 ±0.203)	0.784 ± 0.12	0.675 ± 0.162	0.646 ± 0.103	1.00 ± 0.219	0.765 ±0.117	0.924 ±0.201	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	0.396 ±0.131	ND	0.258 ±0.116	0.068 ±0.0386	ND	0.14 ±0.0504	ND	0.0844 ±0.042	0.255 ±0.119	NE[f]
Metals											
Aluminum (µg/L)	15 U [15 U]	15 U [15 U]	15 U [15 U]	15 U (15 U) [15 U] ([15 U])	15 U [15 U]	15 U [15 U]	15 U [15 U]	15 U [15 U]	15 U [15 U]	15 U [15 U]	200
Antimony (µg/L)	1.0 U	1.0 U	1.0 U	1.0 U (1.0 U)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	6
Arsenic (µg/L)	1.7 U	2.3	1.7 U	1.71 (1.94)	1.7 U	1.98	1.71	1.86	1.7 U	1.9	50
Barium (µg/L)	35.9	34.9	38.9	39 (38.2)	37	35.5	36.2	34.8	37.5	35.6	2,000
Calcium (mg/L)	36.7	38.7	36.7	38.4 (37.7)	36.2	36.7	35.1	37.5	36.2	37.6	NE[f]
Chromium (µg/L)	2 U	3 U	2 U	3 U (3 U)	2.63	3 U	2.59	3 U	2 U	3 U	100
Copper (µg/L)	0.432	0.395	0.712	1.16 (0.35 U)	0.775	0.566	0.684	0.53	3.22	4.28	1,300
Iron (µg/L)	43.7 [30 U][f]	91.4 J[30 J]	58.2 [30 U]	30 J (30 J) [30 J] [(30 J)]	153 [30 U]	188 J[30 J]	30 U[30 U]	30 J [30 J]	30 U [30 U]	30 J [30 J]	300
Lead (µg/L)	0.5 U	0.5 U	0.5 U	0.5 U (0.5 U)	0.5 U	0.5 U	0.5 U	0.5 U	0.719	1.56	15
Magnesium (mg/L)	12.1	12.6 J	11.6	11.7 J (11.5 J)	12.0	11.8 J	11.7	11.9 J	11.9	11.9 J	NE
Manganese (µg/L)	1 U	1 U	2.73	1 U (1 U)	3.17	4.12	1 U	1 U	1 U	1 U	50

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2016). (cont.)

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Mercury (µg/L)	0.067 U	0.067 U	0.067 U	0.067 U (0.067 U)	0.067 U	0.067 U	0.067 U	0.067 U	0.067 U	0.067 U	2
Nickel (µg/L)	0.757	0.5 U	1.06	0.5 U (0.5 U)	1.95	0.666	0.62	0.5 U	2.41	7.34	NE
Potassium (mg/L)	3.30	3.21	3.49	3.57 (3.63)	3.44	3.37	3.20	3.23	3.34	3.55	NE
Selenium (µg/L)	1.5 U	2.0 U	1.5 U	2.0 U (2.0 U)	1.5 U	2.0 U	1.5 U	2.0 U	1.5 U	2.0 U	50
Sodium (mg/L)	18.4	18.1	18.0	16.7 (17.0)	18.8	17.0	19.1	17.3	17.8	16.6	NE
Vanadium (µg/L)	4.5 U	6.78	4.5 U	4.5 U (4.5 U)	4.6	4.5 U	4.5 U	4.5 U	4.5 U	4.5 U	NE
Zinc (µg/L)	3.5 U	3.5 U	10.2	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	15.8	21.7	5,000
Anions											
Chloride (mg/L)	16.1 J	17.3 J	16.3 J	(16.8 J)16.2 J	16.7 J	17.9 J	16.6 J	17.4 J	16.6	16.9 J	250
Nitrate-as nitrogen (mg/L)	2.14	2.13	2.05	2.04 (2.04)	2.07	2.07	2.17	2.11	2.11	2.08	10
Phosphorus (mg/L)	0.028 J	0.0408 J	0.0222 J	0.0395 J (0.0531)	0.0325 J	0.0523	0.02 J	0.0559	0.0353 J	0.0565	NE
Sulfate (mg/L)	18.1	18.1 J	17.3	17.8 J (17.8 J)	19.4	18.8 J	19.5	18.7 J	18.1	18.4 J	250
Water Quality Parameters											
Alkalinity (mg/L)	135	140	132	140 (141)	138	141	137	140	138	139	NE
Bicarbonate alkalinity (mg/L)	135	140	132	140 (141)	138	141	137	140	138	139	NE
Total dissolved solids (mg/L)	166 J	231	95.7 J	216 (237)	51.4 J	234	164 J	217	114 J	233	500
Total organic carbon (mg/L)	0.54 J	0.433 J	0.474 J	0.418 J (0.440J)	1.03	0.464 J	0.545 J	0.438 J	0.538 J	0.496 J	NE

a. EBR-II = Experimental Breeder Reactor II
b. PCS = primary constituent standard; SCS = secondary constituent standard
c. Result ± 1s.
d. ND = not detected; J = estimated concentration; U = not detected at the concentration shown
e. Results in parentheses are field duplicate. Results in brackets are filtered (i.e., dissolved) concentrations.
f. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
g. Concentrations shown in bold are above the Ground Water Quality Rule SCS. In 2016 no results exceeded the rule therefore none are bold.

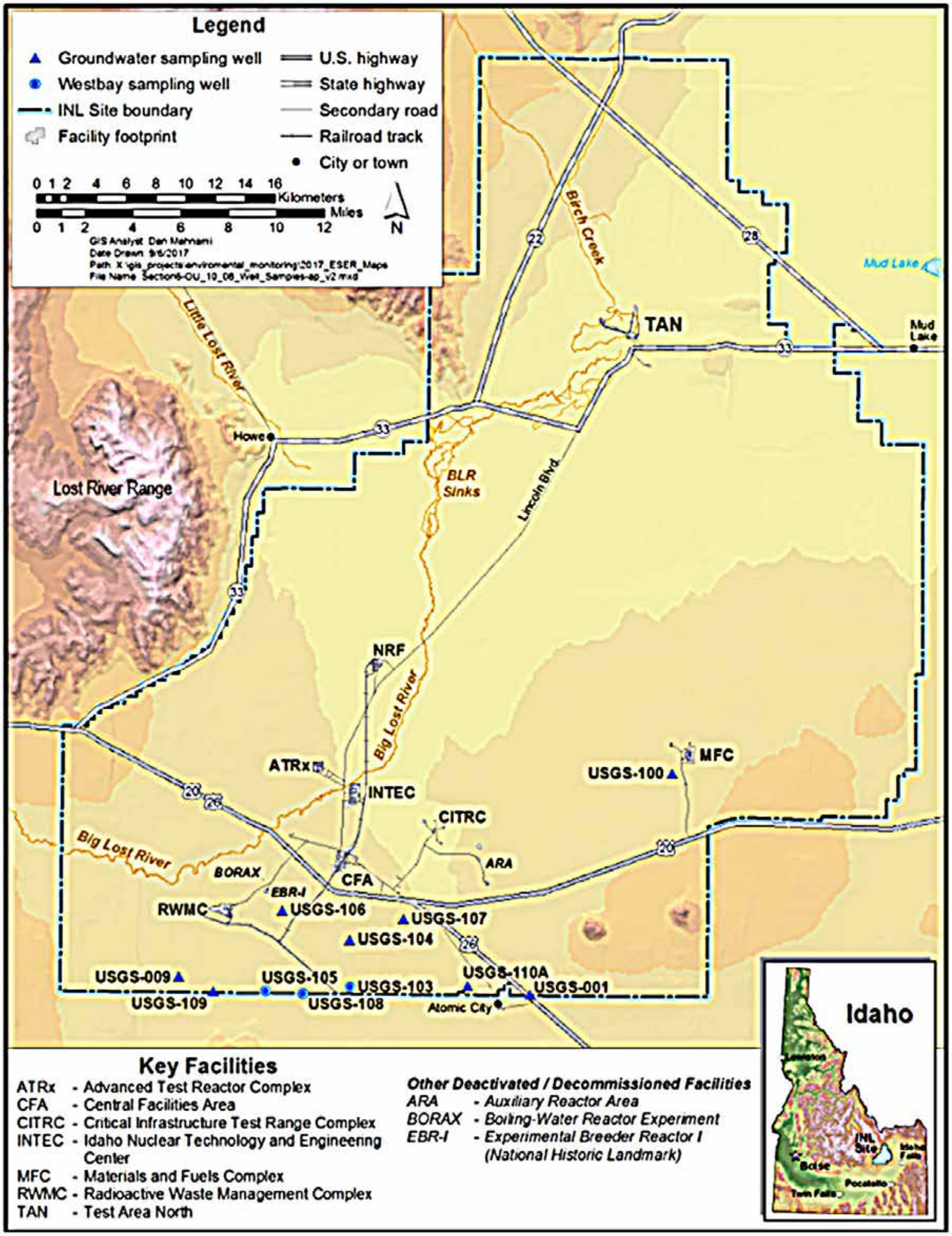

Figure 6-17. Well Locations Sampled for Operable Unit 10-08.

Because of historic or problematic contaminants in the drinking water systems, the INL and ICP Core contractors monitor certain parameters more frequently than required by regulation. For example, bacterial analyses are conducted monthly rather than quarterly at all nine INL contractor drinking water systems and at the two ICP Core contractor drinking water systems during months of operation. Because of known groundwater plumes near two INL contractor drinking water wells and one ICP Core contractor drinking water well, additional sampling is conducted for tritium at CFA, for trichloroethylene at TAN/TSF, and for carbon tetrachloride at RWMC. During 2016, DEQ performed a sanitary survey on the drinking water system at CFA. No deficiencies were identified.

6.6.1 INL Site Drinking Water Monitoring Results

During 2016, the INL contractor collected 286 routine samples and 15 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 39 non-routine samples after a water main was repaired, a building was brought into service, and maintenance repairs were performed. The laboratories used to analyze the drinking water samples are shown in Table 11-1. Table 6-12 summarizes monitoring results for 2016. The quality control program associated with these data is discussed in Section 11.3.2.4.

Drinking water systems at EBR-I, CITRC, Gun Range, Main Gate, MFC, ATR Complex, and TAN/CTF were well below regulatory limits for drinking water; therefore, they are not discussed further in this report. In addition, all water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 3.58 mg/L at CFA and 2.32 mg/L at MFC. Samples for VOCs, total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at MFC, TAN/CTF, and TAN/TSF. There was no detection of regulatory VOCs, TTHMS, or HAA5.

6.6.2 Central Facilities Area

The CFA water system serves approximately 500 people daily. Since the early 1950s, wastewater containing tritium was disposed to the eastern Snake River Plain aquifer through injection wells and infiltration ponds at INTEC and ATR Complex. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. Disposing of wastewater through injection wells was discontinued in the mid-1980s. In general, tritium concentrations in groundwater have been decreasing (Figure 6-18) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay. The laboratory used by the INL contractor for tritium analysis is shown in Table 11-1. Quality control is discussed in Section 11.3.2.4.

Table 6-12. Summary of INL Site Drinking Water Results (2016).

Constituent	MCL	ATR-Complex	CFA	CITRC	EBR-I	GUN RANGE	MAIN GATE	MFC	TAN CTF	TAN TSF
Gross Alpha	15 pCi/L	ND[a]	ND	ND	ND	ND-2.55	ND	ND	ND	ND
Gross Beta	50 pCi/L screening or 4 mrem	ND	4.79-5.44	2.89-4.81	2.28-2.51	ND-3.85	ND-4.18	ND-3.09	ND-3.88	2.80-3.04
Tritium	20,000 pCi/L	ND	2,830-2,900	ND	ND	454-670	ND	ND	ND	ND
Iodine-129[b]	1 pCi/L	-	ND-0.0122	-	-	-	-	-	-	-
Nitrate	10 mg/L	1.12	3.58	1.30	ND	1.22	ND	2.32	1.17	1.09
TTHMs	80 ppb	ND	ND	NA[c]	NA	NA	NA	ND	ND	NA
HAA5s	60 ppb	ND	ND	NA	NA	NA	NA	ND	ND	NA
VOCs	5 ppb for most VOCs	NA	NA	NA	NA	NA	NA	ND	ND	ND

a. ND = Not detected
b. Iodine-129 is only sampled at the CFA water system.
c. NA = Not applicable

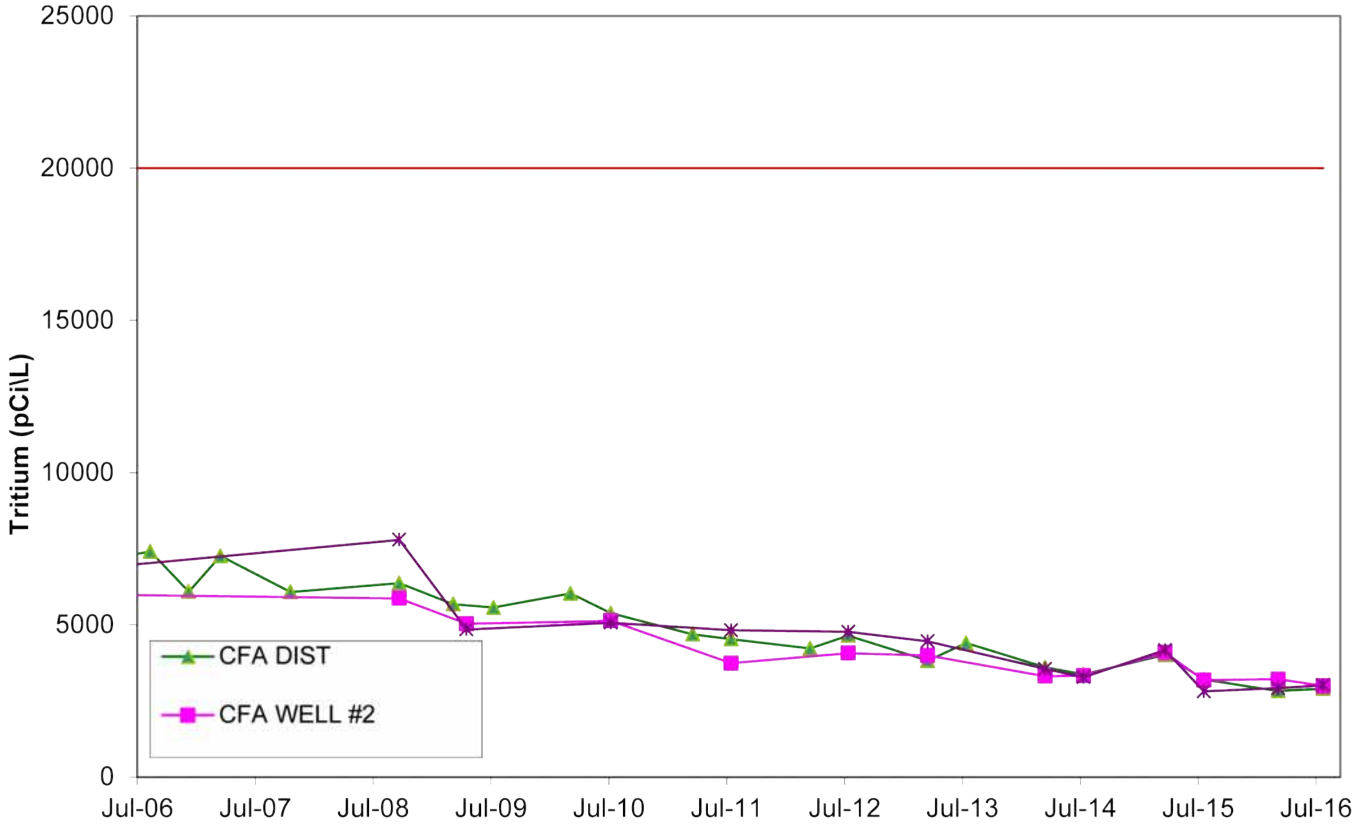

Figure 6-18. Tritium Concentrations in CFA Wells and Distribution System (2006–2016). Note: In 2016, CFA #1 Well was used 84 percent. CFA #2 Well was used 16 percent.

Prior to 2007, compliance samples for the CFA water distribution system were collected semiannually from Well CFA #1 at CFA-651 and Well CFA #2 at CFA-642 and quarterly from the distribution manifold at CFA-1603. Because the results were consistently below the MCL for tritium, the INL contractor decreased the tritium sampling frequency to semiannually at the CFA-1603 manifold and wells. During 2016, Well CFA# 1 was used to supply approximately 84 percent of drinking water at CFA. Well CFA# 2 was used to supply approximately 16 percent of the drinking water.

CFA Worker Dose. Because of the potential impacts to workers at CFA from an upgradient plume of radionuclides in the eastern Snake River Plain aquifer, the potential effective dose equivalent from radioactivity in water was calculated. For the 2016 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. The equation used to calculate the dose from water ingestion is:

$$Dose_{ingw} = TConc_{w} \times Ing_{w} \times EDC_{T}$$

where,

$Dose_{ingw}$ = effective dose from ingestion of water, mrem/yr (0.01 Sv/yr)

$TConc_{w}$ = average tritium concentration in drinking water, pCi/L

Ing_{w} = annual intake of water for an adult (L/yr)

EDC_{T} = effective dose coefficient for tritium ingested in water (mrem/pCi)

The values used for the variables used in the equation were:

$TConc_{w}$ = 2,865 pCi/L (average concentration in water in CFA distribution system for 2016)

Ing_{w} = 730 L/yr (calculated from Table 3 in DOE 2011)

EDC_T = 7.14×10^{-8} mrem/$pCi_{tritium}$ (calculated from Table A-1 of DOE 2011)

This calculation overestimates the actual dose since workers typically consume only about half their total intake during working hours and typically work only 240 days rather than 365 days per year. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2016, as calculated from samples taken from the CFA distribution system, was 0.149 mrem (1.49 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems.

6.6.3 Idaho Nuclear Technology and Engineering Center

Drinking water for INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (chlorine) is maintained throughout the distribution system. In 2016, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system. The analytical laboratories that analyzed the INTEC drinking water samples are presented in Table 11-1. Results are presented in Tables 6-13 and 6-14 and are discussed in the following paragraphs.

Four compliance samples and 38 surveillance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all samples were reported as absent.

One compliance sample was collected at CPP-614 on July 26, 2016, and analyzed for nitrate by EPA Method 353.2. The result was 0.6 mg/L, which is below the nitrate MCL of 10 mg/L.

Table 6-13. 2016 Compliance Monitoring Results for the INTEC Drinking Water System – PWS#6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(d)
E. coli	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(c)
Nitrate	1	1 per year	0.6 mg/L	NA[b]	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.006 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	< 0.002 mg/L	NA	0.06 mg/L

a. MCL = maximum contaminant level
b. NA = not applicable

Table 6-14. 2016 Surveillance Monitoring Results for the INTEC Drinking Water System – PWS #6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	38	3 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	38	3 per month	Absent	Absent	See 40 CFR 141.63(c)
Gross alpha	2	2 per year	3.72 pCi/L	ND – 3.72 pCi/L	15 pCi/L
Gross beta	2	2 per year	4.08 pCi/L	3.58 – 4.58 pCi/L	50 pCi/L screening level or 4 mrem
Tritium	1	1 per year	ND[b]	NA[c]	20,000 pCi/L
Strontium-90	1	1 per year	ND	NA	8 pCi/L

a. MCL = maximum contaminant level
b. ND = not detected
c. NA = not applicable

One compliance sample was collected at CPP-1666 on August 10, 2016, and analyzed for total trihalomethanes by EPA Method 524.2. The result was 0.006 mg/L, which is below the total trihalomethanes MCL of 0.080 mg/L.

One compliance sample was collected at CPP-1666 on August 10, 2016, and analyzed for haloacetic acids by EPA Method 552.2. Haloacetic acids were not detected (<0.002 mg/L) in the sample. The MCL for haloacetic acids is 0.060 mg/L.

A surveillance sample was collected at CPP-614 on February 23, 2016, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross alpha was detected at 3.72 pCi/L, below its MCL of 15 pCi/L. Gross beta was detected at 3.58 pCi/L, below its screening level of 50 pCi/L. Tritium and ^{90}Sr were reported as non-detects. Another surveillance sample was collected at CPP-614 on August 23, 2016, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected at 4.58 pCi/L, below its screening level of 50 pCi/L.

Three quality control samples (one field duplicate, one trip blank, and one performance evaluation sample) were collected in 2016. The results are summarized in Section 11.3.2.4.

6.6.4 Radioactive Waste Management Complex

The RWMC production well is located in building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (chlorine) is maintained throughout the distribution system. Historically, carbon tetrachloride, total xylenes, and other VOCs had been detected in samples collected at the WMF-603 production well and at WMF-604, the point of entry into the RWMC drinking water distribution system. In July 2007, a packed tower air stripping treatment system was placed into operation to remove the VOCs from the groundwater prior to human consumption.

In 2016, drinking water samples were collected from:

- The source (WMF-603)
- Point of entry to the distribution system (WMF-604)
- Various buildings throughout the distribution system
- Comfort stations WMF-TR-12, WMF-TR-13, and WMF-TR-29
- Potable water transfer tank (PW-TK-RW01).

The analytical laboratories that analyzed the RWMC drinking water samples are presented in Table 11-1. Results are presented in Tables 6-15 and 6-16 and are discussed in the following paragraphs.

Four compliance samples and 20 surveillance samples were collected from various buildings at RWMC and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all samples were reported as absent. Sixteen surveillance samples were collected from the comfort stations and the potable water transfer tank and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all 16 samples were reported as absent.

One compliance sample was collected at WMF-604 on July 26, 2016, and analyzed for nitrate by EPA Method 353.2. The result was 1 mg/L, below the nitrate MCL of 10 mg/L.

A surveillance sample was collected at WMF-604 on February 23, 2016, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross alpha was detected at 2.95 pCi/L, below its MCL of 15 pCi/L. Tritium was detected at 647 pCi/L, below its MCL of 20,000 pCi/L. Gross beta

Table 6-15. 2016 Compliance Monitoring Results for the RWMC Drinking Water System – PWS #6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(d)
E. coli	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(c)
Nitrate	1	1 per year	1.0 mg/L	NA[b]	10 mg/L (as nitrogen)
Xylenes (total)	4	1 per quarter	0.0006 mg/L	ND[c] – 0.0008 mg/L	10 mg/L

a. MCL = maximum contaminant level
b. NA = not applicable
c. ND = not detected

Table 6-16. 2016 Surveillance Monitoring Results for the RWMC Drinking Water System – PWS #6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	20	1 to 2 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	20	1 to 2 per month	Absent	Absent	See 40 CFR 141.63(c)
Volatile organic compounds	8	2 per quarter	0.004 mg/L	ND[b] – 0.0059 mg/L	0.002 – 10 mg/L[d]
Gross alpha	2	2 per year	2.95 pCi/L	ND – 2.95 pCi/L	15 pCi/L
Gross beta	2	2 per year	2.67 pCi/L	ND – 2.67 pCi/L	50 pCi/L screening level or 4 mrem
Tritium	1	1 per year	647 pCi/L	NA[c]	20,000 pCi/L
Strontium-90	1	1 per year	ND	NA	8 pCi/L

a. MCL = maximum contaminant level
b. ND = not detected
c. NA = not applicable
d. This range of MCLs encompasses the twenty-one organic contaminants listed in 40 CFR 141.61(a). The 0.0059 mg/L result was for carbon tetrachloride and the sample was collected from the RWMC Production Well at WMF-603 on May 2, 2016. Although this result was above the MCL for carbon tetrachloride (0.005 mg/L), it was not a compliance issue because WMF-603 is not the point-of-entry into the RWMC drinking water system. No other MCLs were exceeded.

and ^{90}Sr were not detected. Another surveillance sample was collected on August 23, 2016, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected at 2.67 pCi/L, below its screening level of 50 pCi/L.

Four compliance samples were collected at WMF-604 and analyzed for total xylenes by EPA Method 524.2. Total xylenes were not detected (<0.0005 mg/L) in the February 24, 2016, sample or the July 27, 2016, sample. Total xylenes were detected in the April 27, 2016, sample (0.00006 mg/L) and the November 10, 2016, sample (0.0008 mg/L), but they were below the total xylenes MCL of 10 mg/L.

Four surveillance samples were collected at WMF-604 and analyzed for VOCs by EPA Method 524.2. Carbon tetrachloride and trichloroethylene were not detected (<0.0005 mg/L) in any of the samples collected at WMF-604. No other VOCs were detected in any of the samples.

Four surveillance samples were collected at the WMF-603 production well and analyzed for VOCs by EPA Method 524.2. Total xylenes were not detected (<0.0005 mg/L) in any of the samples. Carbon tetrachloride was detected in all four samples and ranged in concentration from 0.0046 mg/L to 0.0059 mg/L. Trichloroethylene was also detected in all four samples and ranged in concentration from 0.0021 mg/L to 0.0033 mg/L. No other VOCs were detected in any of the samples.

Twelve quality control samples (two field blanks, three field duplicates, six trip blanks, and one performance evaluation sample) were collected. The results are summarized in Section 11.3.2.4.

6.7 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to less than 25 employees at TSF. The facility is served by a chlorination system. TSF #2 is sampled for surveillance purposes only (not required by regulations).

In the past, trichloroethylene contamination has been a concern at TSF. The principal source of this contamination was inactive injection Well TSF-05. Although regulations do not require sampling Well TSF #2, samples are collected to monitor trichloroethylene concentrations due to the historical contamination. Since mid-2006, concentrations appear to be declining but will have to be confirmed with the collection of additional data.

Figure 6-19 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system. Table 6-17 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2016 was ten times less than the reporting limit of 0.5 µg/L.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program performed by the ESER contractor, drinking water samples were collected off the INL Site for radiological analyses in 2016. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the state of Idaho DEQ-INL Oversight Program (DEQ-IOP) in May and November 2016. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. ESER also collected samples at Atomic City, Craters of the Moon, Howe, Idaho Falls, and the public rest area at Highway 20/26. A control sample of bottled water was also obtained. The samples were analyzed for gross alpha and gross beta activities and for tritium. The ESER con-

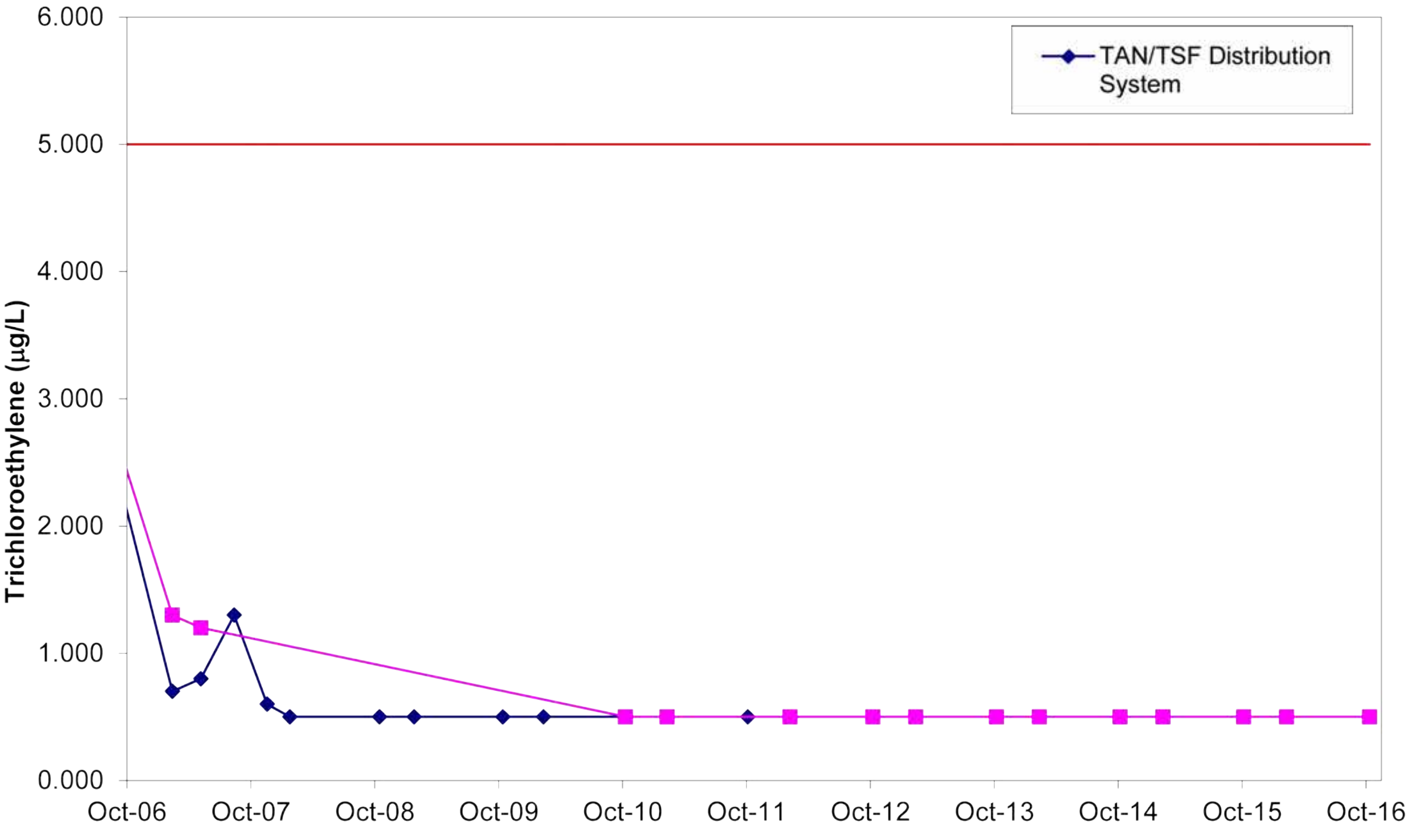

Figure 6-19. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2006–2016).

Table 6-17. Trichloroethylene Concentrations at TAN/TSF Well #2 and Distribution System (2016).

Location	Number of Samples	Trichloroethylene Concentration (µg/L) Minimum	Maximum	Mean	MCL[a]
TAN/TSF #2 (612)	2	<0.5	<0.5	<0.5	NA[b]
TAN/TSF Distribution (610)	1	<0.5	<0.5	<0.5	5.0

a. MCL = Maximum contaminant level (see Table A-4)

b. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

tractor results are shown in Table 6-18. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Gross alpha activity was detected statistically (above 3 σ) in three samples (Atomic City, the Rest Area at Highway 20/26, and Shoshone) collected in May 2016 at just above the minimum detectable concentration. Gross beta activity was detected statistically in all but four drinking water samples collected by ESER, including one of the bottled water samples. The results are below the screening level of 50 pCi/L for gross beta activity,

Table 6-18. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2016.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring	*Fall*	*EPA MCL*[b]
Atomic City	1.63 ± 0.49	-0.33 ± 0.42	15 pCi/L
Control (bottled water)	0.59 ± 0.22	0.77 ± 0.30	15 pCi/L
Craters of the Moon	1.26 ± 0.47	0.18 ± 0.21	15 pCi/L
Howe	0.49 ± 0.46	0.04 ± 0.51	15 pCi/L
Idaho Falls	1.13 ± 0.49	-0.93 ± 0.50	15 pCi/L
Minidoka	0.40 ± 0.52	0.01 ± 0.53	15 pCi/L
Mud Lake (Well #2)	0.58 ± 0.32	-0.09 ± 0.31	15 pCi/L
Rest Area (Highway 20/26)	1.66 ± 0.50	0.43 ± 0.41	15 pCi/L
Shoshone	5.16 ± 0.60	0.65 ± 0.46	15 pCi/L
Gross Beta			
	Spring	*Fall*	*EPA MCL*
Atomic City	3.03 ± 0.50	3.69 ± 0.51	4 mrem/yr (50 pCi/L)[c]
Control (bottled water)	0.39 ± 0.40	1.54 ± 0.43	4 mrem/yr (50 pCi/L)
Craters of the Moon	2.81 ± 0.49	2.08 ± 0.42	4 mrem/yr (50 pCi/L)
Howe	1.12 ± 0.49	2.30 ± 0.52	4 mrem/yr (50 pCi/L)
Idaho Falls	1.33 ± 0.49	2.48 ± 0.53	4 mrem/yr (50 pCi/L)
Minidoka	3.37 ± 0.53	3.61 ± 0.54	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	3.97 ± 0.48	4.02 ± 0.49	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	2.08 ± 0.50	2.14 ± 0.53	4 mrem/yr (50 pCi/L)
Shoshone	3.19 ± 0.52	1.43 ± 0.54	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	*Fall*	*EPA MCL*
Atomic City	34 ± 24	28 ± 24	20,000 pCi/L
Control (bottled water)	91 ± 24	22 ± 24	20,000 pCi/L
Craters of the Moon	56 ± 24	20 ± 24	20,000 pCi/L
Howe	51 ± 24	52 ± 25	20,000 pCi/L
Idaho Falls	55 ± 24	74 ± 25	20,000 pCi/L
Minidoka	32 ± 24	3 ± 24	20,000 pCi/L
Mud Lake (Well #2)	47 ± 24	59 ± 25	20,000 pCi/L
Rest Area (Highway 20/26)	94 ± 24	89 ± 25	20,000 pCi/L
Shoshone	90 ± 24	19 ± 24	20,000 pCi/L

a. Result ± 1σ. Results ≥ 3σ are considered to be statistically positive.

b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level

c. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

with a maximum of 4.02 ± 0.48 pCi/L. If gross beta activity exceeds 50 pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141). Gross beta activity has been measured at these levels historically in offsite drinking water samples. For example, the maximum level reported since 2010 in the past Annual Site Environmental Reports was 7.83 ± 0.61 pCi/L (Atomic City in spring of 2011).

Tritium was statistically detected in five of the drinking water samples, including one of the bottled water control samples, collected in 2016. The maximum result measured was 94.4 ± 24.2 pCi/L. The results were within historical measurements and well below the EPA MCL of 20,000 pCi/L. For example, the maximum tritium level reported since 2010 was 139 ± 22 pCi/L (Rest Area in spring of 2014).

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2016 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls, Clear Springs near Buhl, and a trout farm near Hagerman (see Figure 6-20). ESER contractor results are shown in Table 6-19. Gross alpha activity was detected in one sample, which was collected at Clear Springs. Gross beta activity was detected in all surface water samples. The highest result (8.47 ± 0.61 pCi/L) was measured at Alpheus Springs. Alpheus Springs has historically shown higher results, and these values are most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain aquifer. The maximum result measured since 2010 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

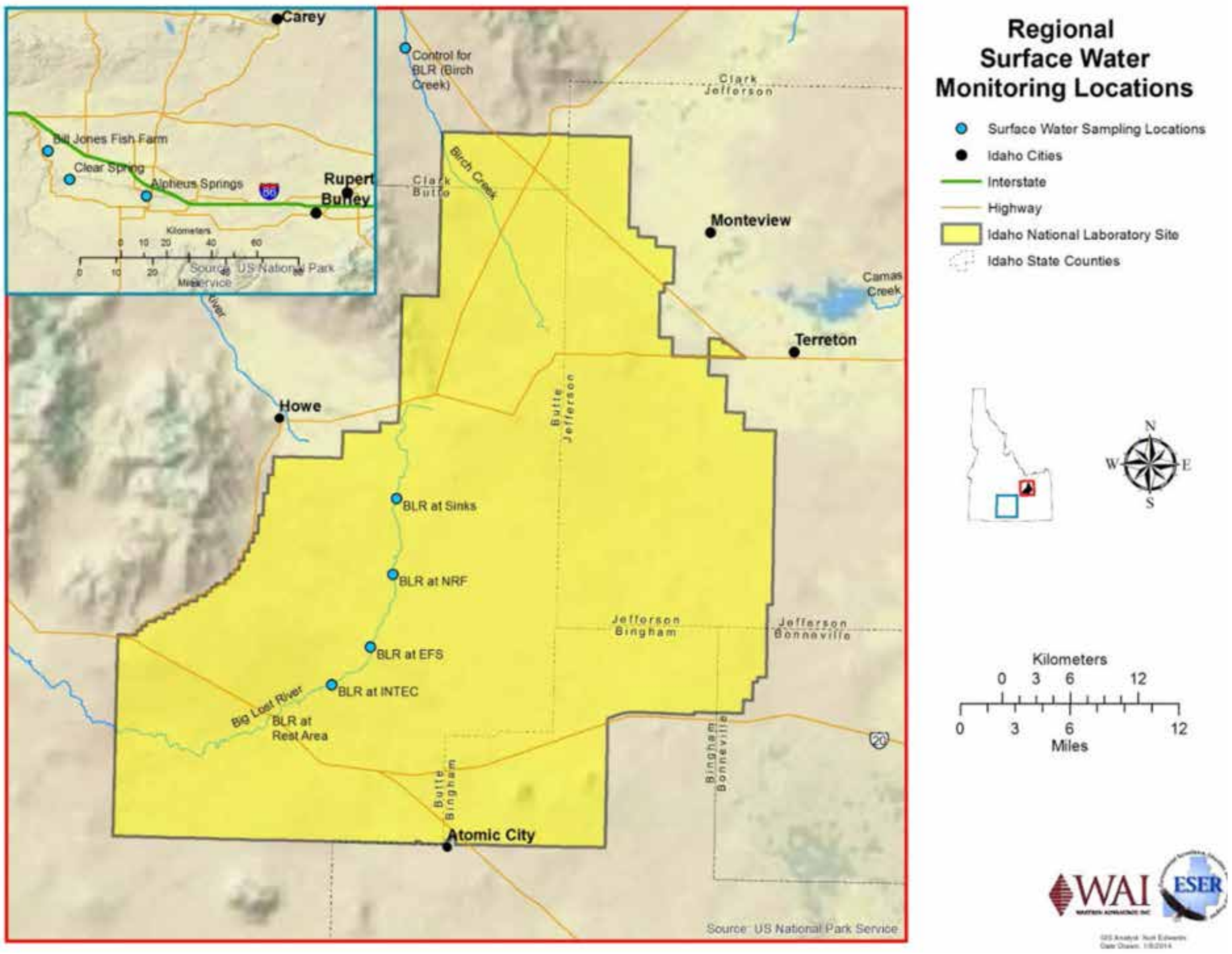

Figure 6-20. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-19. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2016.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring[b]	*Fall*[b]	*EPA MCL*[c]
Alpheus Springs-Twin Falls	0.62 ± 0.66	0.39 ± 0.62	15 pCi/L
Clear Springs-Buhl	2.37 ± 0.63	0.68 ± 0.61	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.41 ± 0.47	0.35 ± 0.41	15 pCi/L
Gross Beta			
	Spring	*Fall*	*EPA MCL*
Alpheus Springs-Twin Falls	6.12 ± 0.58	8.47 ± 0.61	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	4.00 ± 0.54	3.29 ± 0.55	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	4.40 ± 0.50	2.65 ± 0.48	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	*Fall*	*EPA MCL*
Alpheus Springs-Twin Falls	58 ± 24	80 ± 25	20,000 pCi/L
Clear Springs-Buhl	14 ± 24	9 ± 24	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	41 ± 24	82 ± 25	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s are considered to be statistically positive.
b. The springs and trout farm were sampled on May 16, 2016, and November 4, 2016.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

Tritium was detected in two of the six surface water samples collected by the ESER contractor. Concentrations were similar to those found in the drinking water samples and in other liquid media, such as precipitation throughout the year.

The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called Big Lost River Sinks (see Figure 6-20). The river then mixes with other water in the eastern Snake River Plain aquifer. Water in the aquifer then emerges about 100 miles (160 km) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The ESER contractor did not collect surface water samples from the Big Lost River on the INL Site in 2016, because the river contained no water at any time during the year.

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7. Environmental Monitoring Programs: Agricultural Products, Wildlife, Soil, and Direct Radiation


Pygmy Rabbit
Brachylagus idahoensis

Radionuclides released by Idaho National Laboratory (INL) Site operations and activities have the potential to be assimilated by agricultural products and game animals which can then be consumed by humans. These media are thus sampled because of the potential transfer of radionuclides to people through food chains. Radionuclides may also be deposited on soils and can be detected through radioanalysis of soil samples. Some human-made radionuclides were detected at low levels in agricultural products (milk, lettuce, and alfalfa) collected in 2016. The results could not be directly linked to operations at the INL Site and are likely attributed to natural production in the atmosphere, in the case of tritium, or to the presence of fallout radionuclides in the environment, in the instances of strontium-90 and cesium-137. All measurements were well below standards (Derived Concentration Standards) established by the U.S. Department of Energy for protection of human health.

No human-made radionuclides were detected in tissue samples of five road-killed animals sampled in 2016. Waterfowl were not collected on wastewater ponds in 2016 at the INL Site due to construction activities.

Soil samples were collected off the INL Site in 2016. Strontium-90, plutonium-239/240, and cesium-137 were detected at or below levels observed historically in the region and are likely due to deposition of fallout from above ground nuclear weapons test conducted prior to 1975. All results were below dose-based Environmental Concentration Guides established at the INL Site for protection of human health.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was estimated to be 117 mrem off the INL Site. The total background dose to an average individual living in southeast Idaho was estimated to be approximately 383 mrem per year.

Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex and the CERCLA disposal facility were near background levels.

7. ENVIRONMENTAL MONITORING PROGRAMS: AGRICULTURAL PRODUCTS, WILDLIFE, SOIL, AND DIRECT RADIATION

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2016. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a). The INL, Idaho Cleanup Project (ICP) Core, and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of INL and ICP Core contractor monitoring is on the INL Site, particularly on and around facilities (Table 7-1). The ESER contractor's primary responsibility is to monitor the presence of contaminants in media off the INL Site, which may originate from INL Site releases (Table 7-1).

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 4-1). Figure 7-1 shows the locations where samples were collected in 2016.

7.1.1 Milk

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows to milk, which is then ingested by humans. During 2016, the ESER contractor collected 129 milk samples (including duplicates) at various locations off the INL Site (Figure 7-1) and from commercially-available milk from out-

Table 7-1. Environmental Monitoring of Agricultural Products, Biota, Soil, and Direct Radiation at the INL Site.

	Media						
Area/Facility[a]	Agricultural Products (milk, lettuce, alfalfa, wheat, and potatoes)	Biota (waterfowl, large game animals)	Biota (vegetation)	CERCLA Ecological	Soil	Direct Radiation (global positioning radiometric scanner)	Direct Radiation
Environmental Surveillance, Education, and Research Program Contractor							
INL Site/Regional	•	•	•	•	•		•
Idaho National Laboratory Contractor							
INL Site							•
Regional							•
Idaho Cleanup Project Core Contractor							
ICDF[b]						•	
RWMC[c]			•		•	•	

a. INL Site = Idaho National Laboratory Site facility areas and areas between facilities
b. ICDF = Idaho CERCLA Disposal Facility
c. RWMC = Radioactive Waste Management Complex

side the state of Idaho. The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly in Idaho Falls and monthly at other locations around the INL Site. All samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine is an essential nutrient and is readily assimilated by cows that eat plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear reactors or weapons, is readily detected, and, along with cesium-134 (^{134}Cs) and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event such as the Chernobyl accident (Kirchner 1994) or the 2011 accident at Fukushima in Japan. Iodine-131 has a short half-life (eight days) and therefore does not persist in the environment. Past releases from experimental reactors at the INL Site and fallout from atmospheric nuclear weapons tests and Chernobyl are no longer present. Small amounts of ^{131}I were released in 2016 at the Materials and Fuels Complex (MFC) (approximately 8.3 mCi) and Advanced Test Reactor (ATR) Complex (approximately 2.4 mCi), but these quantities were not detected in air samples collected at or beyond the INL Site boundary (Chapter 4). Iodine-131 was not detected in any milk samples during 2016.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly by accumulating in many types of tissue, most notably in muscle tissue. It has a half-life of about 30 years and tends to persist in soil. If in soluble form, it can readily enter the food chain through plants. It is widely distributed throughout the world from historic nuclear weapons detonations, which occurred between 1945 and 1980, and has been detected in all environmental media at the INL Site. Regional sources include releases from INL Site facilities and resuspension of previously contaminated soil particles. Cesium-137 was not detected in any milk samples collected in 2016.

Strontium-90 is an important radionuclide because it behaves like calcium and can deposit in bones. Strontium-90, like ^{137}Cs, is produced in high yields from

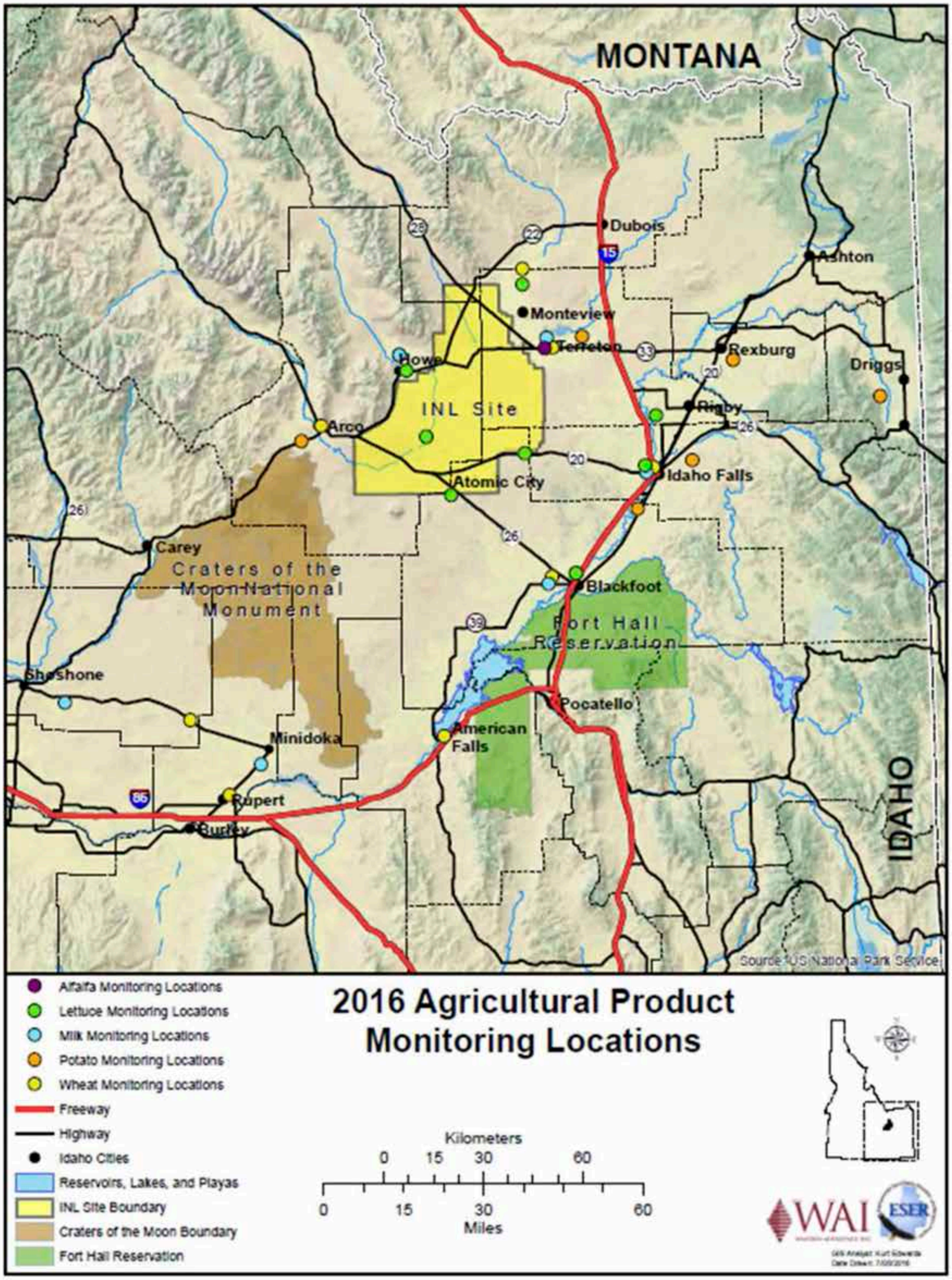


Figure 7-1. Locations of Agricultural Product Samples Collected (2016).

nuclear reactors or detonations of nuclear weapons. It has a half-life of 28 years and can persist in the environment. Strontium tends to form compounds that are more soluble than ^{137}Cs, and is therefore comparatively mobile in ecosystems. Strontium-90 was detected in 10 of the 14 milk samples analyzed, including the two control samples from outside the state. Detectable concentrations ranged from 0.23 pCi/L to 0.51 pCi/L at Blackfoot (Table 7-2). Overall, concentrations were fairly consistent in 2016 with those in 2014 and 2015 (but lower than 2012 and 2013). These levels were also consistent with levels reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by cows through ingestion of grass. Results from EPA Region 10, which includes Idaho, for a limited data set of seven samples collected over a 10-year period (2007–2016) ranged from 0 to 0.54 pCi/L (EPA 2017).

DOE has established Derived Concentration Standards (DCSs) (DOE 2011) for radionuclides in air and water. A DCS is the concentration of a radionuclide in air or water that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. There are no established DCSs for foodstuffs such as milk. For reference purposes, the DCS for ^{90}Sr in water is 1,100 pCi/L. Therefore, the maximum observed value in milk samples (0.51 pCi/L) is approximately 0.05 percent of the DCS for drinking water.

Tritium, with a half-life of about 12 yrs, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The environmental behavior of tritiated water is like that of water, and it can be present in surface water, precipitation, and atmospheric moisture. Tritium is formed by natural processes, as well as by reactor operation and nuclear weapons testing. Tritium enters the food chain through surface water that people and animals drink, as well as from plants that contain water. Tritium was detected in 10 of 14 milk samples analyzed, including one of the samples of store-bought organic milk (Ta-

Table 7-2. Strontium and Tritium Concentrations[a] in Milk Samples Collected Off the INL Site in 2016.

	Strontium-90	
Location	**May 2016**	**November 2016**
Blackfoot	0.51 ± 0.10	0.23 ± 0.05
Dietrich	0.50 ± 0.10	0.26 ± 0.07
Howe	-0.58 ± 0.10	0.03 ± 0.05
Idaho Falls	0.46 ± 0.10	0.41 ± 0.08
Minidoka	0.03 ± 0.09	0.12 ± 0.06
Terreton	0.48 ± 0.10	0.47 ± 0.07
AVERAGE	0.23	0.25
Control (Colorado)	0.34 ± 0.08	0.30 ± 0.06
	Tritium	
Location	**May 2016**	**November 2016**
Blackfoot	111.0 ± 23.5	122.0 ± 25.9
Dietrich	82.1 ± 23.2	-37.1 ± 25.2
Howe	70.9 ± 23.2	177.0 ± 26.5
Idaho Falls	89.0 ± 23.3	22.4 ± 25.0
Minidoka	63.8 ± 23.1	151.0 ± 26.5
Terreton	79.8 ± 23.3	90.4 ± 25.5
AVERAGE	82.8	87.6
Control (Colorado)	168.0 ± 24.5	42.1 ± 25.0

a. Concentration units are pCi/L. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected.

b. A negative result indicates that the measurement was less than the laboratory background measurement.

ble 7-2). Detectable concentrations varied from 71 pCi/L in a sample from Howe in May to 177 pCi/L in the other sample from Howe in November. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in water is 1,900,000 pCi/L. The maximum observed value in milk samples is approximately 0.009 percent of the DCS.

7.1.2 Lettuce

Lettuce was sampled in 2016 because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 4-1). Uptake of radionuclides by plants may occur through root uptake from soil or absorption of deposited material on leaves. For most radionuclides, uptake by foliage is the dominant process for contamination of plants (Amaral et al. 1994). For this reason, green, leafy vegetables, like lettuce, have higher concentration ratios of radionuclides to soil than other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site (Figure 7-1). The number and locations of gardens have changed from year to year depending on whether or not vegetables were available. Some home gardens were replaced with portable lettuce planters (Figure 7-2) because the availability of lettuce from home gardens was unreliable at some key locations. Also, the planters can be placed and lettuce collected at areas previously unavailable to the public, such as on the INL Site and near air samplers. The planters can allow radionuclides deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are placed in the spring, filled with soil, sown with lettuce seed, and self-watered through a reservoir.

Five lettuce samples were collected from portable planters at Atomic City, the Experimental Field Station (EFS), the Federal Aviation Administration Tower, Howe, and Monteview. In 2016, soil from the vicinity of the sampling locations was used in the planters. This soil was amended with potting soil as a gardener in the region would typically do when they grow their lettuce. In addition to the portable samplers, samples were obtained from gardens at Blackfoot, Idaho Falls, and Rigby. A control sample from an out-of-state location (Oregon) was obtained, and a duplicate sample was collected at Rigby.

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was detected in all of the lettuce samples collected locally but was not found in the control sample purchased at the grocery store. Figure 7-3 shows the average and range of all measurements (including those below detection levels) from 2012 through 2016. The maximum ^{90}Sr concentration of 241 pCi/kg, measured in the lettuce sample from EFS, was toward the upper end of the range of concentrations detected in the past five years. However, it was lower than the 2015 maximum value (372 pCi/kg), when the sample was grown in a portable lettuce sampler using soil from the vicinity of the sampling location with no added potting soil. These results were most likely from fallout

Figure 7-2. Portable Lettuce Planter.

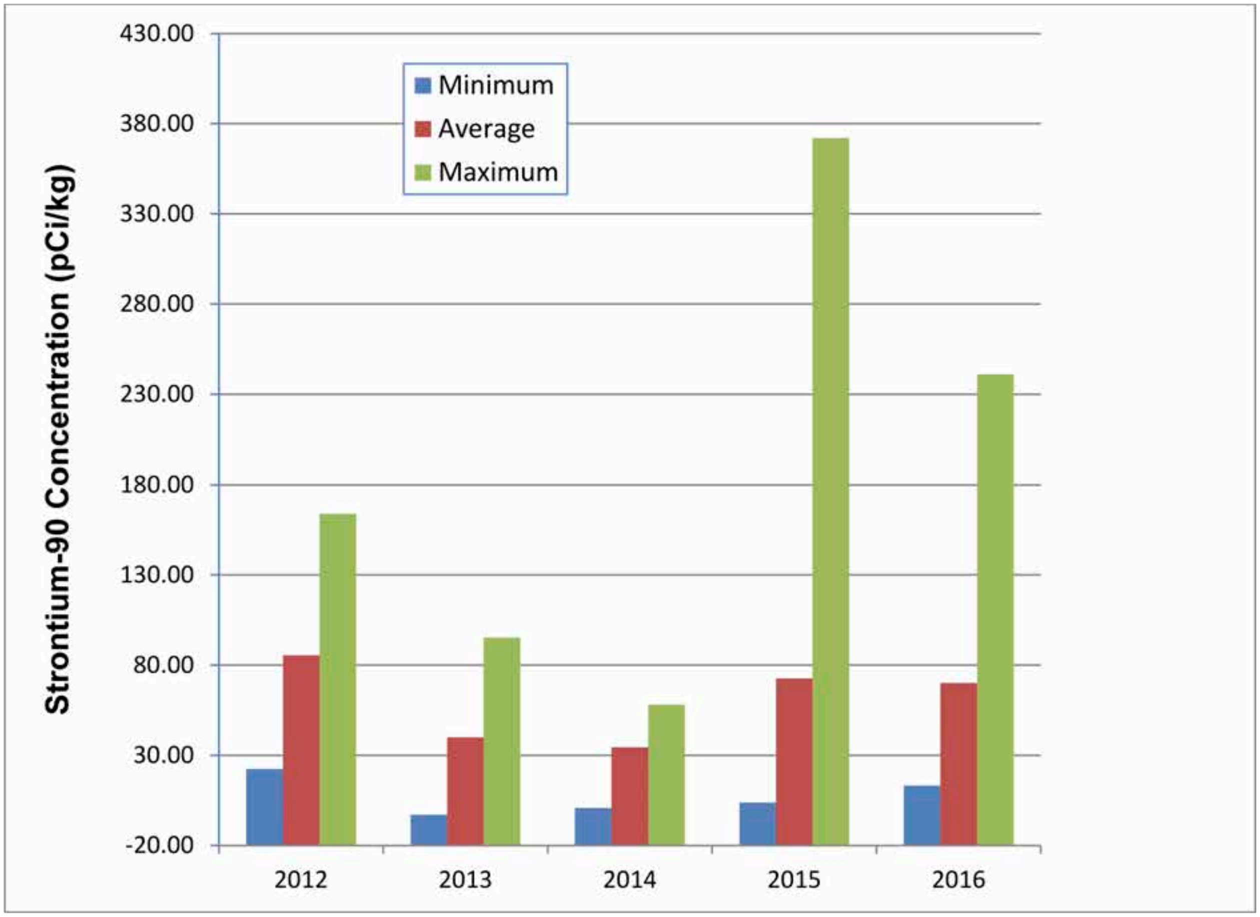


Figure 7-3. Strontium-90 Concentrations in Lettuce (2012–2016).

from past weapons testing and not INL Site operations. Strontium-90 is present in the environment as a residual of fallout from above-ground nuclear weapons testing, which occurred between 1945 and 1980.

No other human-made radionuclides were detected in any of the lettuce samples. Although ^{137}Cs from nuclear weapons testing fallout is measureable in soils, the ability of vegetation, such as lettuce, to incorporate cesium from soil in plant tissue is much lower than for strontium (Fuhrmann et al. 2003; Ng et al. 1982; Schulz 1965). In addition, the availability of ^{137}Cs to plants depends highly on soil properties, such as clay content or alkalinity, which can act to bind the radionuclide (Schulz 1965). Soils in southeast Idaho tend to be moderately to highly alkaline. Strontium, on the other hand, has a tendency to form compounds that are comparatively soluble. These factors could help explain why ^{90}Sr was detected in lettuce and ^{137}Cs was not.

7.1.3 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. The ESER contractor collected ten grain samples from areas surrounding the INL Site in 2016 and obtained one commercially-available sample from outside the state of Idaho (Figure 7-1). The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made, gamma-emitting radionuclides were found in any samples.

Two of the 11 grain samples collected in 2016 contained a detectable concentration of ^{90}Sr. A lower detection limit was achieved in 2016 and both detectable results were close to this lower limit. The measured concentrations were 3.0 pCi/kg from Arco and 3.6 pCi/kg from Idaho Falls. The concentrations of ^{90}Sr sometimes measured in grain are generally much less than those measured in lettuce and the frequency of detections is much lower. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990). As discussed in Section 7.1.2, strontium in soil from fallout is more bioavailable to plants than cesium.

7.1.4 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because they are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the ESER contractor at eight locations in the vicinity of the INL Site (including a duplicate) and obtained from one location outside eastern Idaho. None of the nine potato samples collected during 2016 contained a detectable concentration of any human-made, gamma-emitting radionuclides. Strontium-90 was detected in the sample from Idaho Falls at 8.3 pCi/kg. This radionuclide is present in the soil as a result of worldwide fallout from nuclear weapons testing, but it is only occasionally detected in potato samples. This is because potatoes, like grain, are generally less efficient at removing radioactive elements from soil than leafy vegetables such as lettuce.

7.1.5 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. This was in response to the DOE Headquarters Independent Oversight Assessment of the Environmental Monitoring program at the INL Site conducted during that year. The assessment team commented, with reference to the milk sampling program, that the ESER contractor should consider sampling locally-grown alfalfa offsite, along with collection of alfalfa usage data. Questionnaires were sent to each milk provider concerning what they feed their cows. All of the dairies feed their cows locally-grown alfalfa. A sample of alfalfa was collected in June from a location in the Mud Lake/Terreton area, the agricultural area where the highest potential offsite air concentration was calculated by the National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division (see Figure 8-6). (Note: The highest offsite air concentration used for estimating doses was located south of the INL Site; however, there is no agriculture conducted at that location.) The sample was divided into three subsamples and analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made, gamma-emitting radionuclides were found, but ^{90}Sr was detected in all three subsamples. The concentrations found ranged from 61 to 73 pCi/kg. This is typical of the range found in alfalfa samples since collection began in 2010 and the concentrations are more similar to those found in lettuce than in wheat and potatoes.

7.1.6 Large Game Animals

Muscle samples were collected by the ESER contractor from five game animals (three mule deer, one pronghorn, and one elk). Three thyroid and two liver samples were also obtained. The muscle samples were analyzed for ^{137}Cs because it is an analog of potassium and is readily incorporated into muscle and organ tissues. Thyroids are analyzed for ^{131}I because, when assimilated by many animal species, it selectively concentrates in the thyroid gland and is, thus, an excellent bioindicator of atmospheric releases.

No ^{131}I was detected in the thyroid samples. No ^{137}Cs or other human-made, gamma-emitting radionuclides were found in any of the muscle or liver samples.

In 1998 and 1999, four pronghorn, five elk, and eight mule deer muscle samples were collected as background samples from hunters across the western United States, including three from central Idaho; three from Wyoming; three from Montana; four from Utah; and one each from New Mexico, Colorado, Nevada, and Oregon (DOE-ID 2002a). Each background sample had small, but detectable, ^{137}Cs concentrations in the muscle. These concentrations likely can be attributed to the ingestion of plants containing radionuclides from fallout associated with above-ground nuclear weapons testing. Allowing for radioactive decay since the time of the study, background measurements would be expected to range from approximately 3.5 to 10 pCi/kg in 2016. With the exception of an immature deer sampled in 2008 that had elevated ^{137}Cs concentrations, all detected values were within this range.

7.1.7 Waterfowl

Waterfowl are collected in most years at ponds on the INL Site and at a location off the INL Site. The presence of radioactive wastewater ponds creates the potential for uptake of radionuclides by ducks. These ducks could then be hunted and subsequently consumed after leaving the INL Site. In 2016, the hypalon linings to the two radioactive wastewater ponds at the ATR Complex were in the process of being replaced. The dewatering of the ponds and the extensive construction activity at the ponds precluded their use by waterfowl during much of the period that sampling normally occurs. Waterfowl sampling is expected to resume in 2017.

7.2 Soil Sampling

7.2.1 Soil Sampling Off the INL Site

Above-ground nuclear weapons testing resulted in many radionuclides being distributed throughout the world via atmospheric deposition. Cesium-137, ^{90}Sr, plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am) can be detected in soil because of global fallout but could also be present from INL Site operations. These radionuclides are of particular interest because of their abundance resulting from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment due to long half-lives (e.g., $^{239/240}$Pu, with a half-life of 24,110 years). Soil samples are collected by the ESER contractor every two years (in even-numbered years). Results to date indicate that the source of these radionuclides is not from INL Site operations and is most likely derived from worldwide fallout activity (DOE-ID 2014b).

Soil was sampled by the ESER contractor in 2016. Soil sampling locations are shown in Figure 7-4. Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium isotopes.

Cesium-137 was above the detection limit in all the samples collected, and ^{90}Sr was present in all of the samples except one. Results for these two radionuclides from 1975, when the current offsite sampling program began, to 2016 are presented in Figure 7-5. Above ground nuclear weapons testing has been extremely limited since 1975, and no tests have occurred since 1980, so no ^{137}Cs and ^{90}Sr have been deposited on soil from sources outside the INL Site in that time. It would be expected that the concentrations of these two radionuclides would decrease over time from the levels measured in 1975 at a rate consistent with their approximate 30-year half-lives, unless the INL Site was having an impact. Figure 7-5 shows that ^{137}Cs follows the expected decay line fairly closely. Strontium-90 has been tracking below the expected line during the past several sampling cycles.

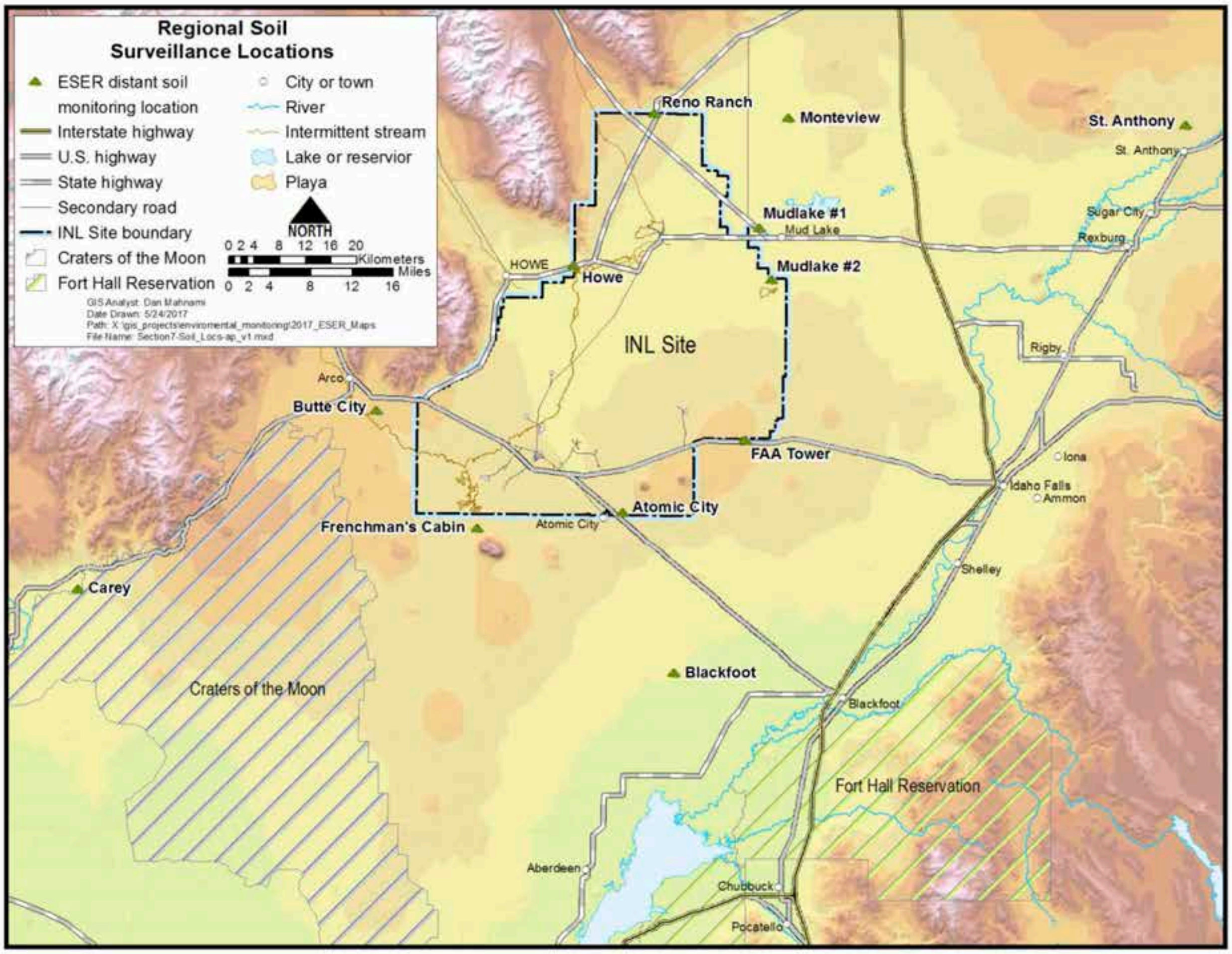


Figure 7-4. Soil Sampling Locations (2016).

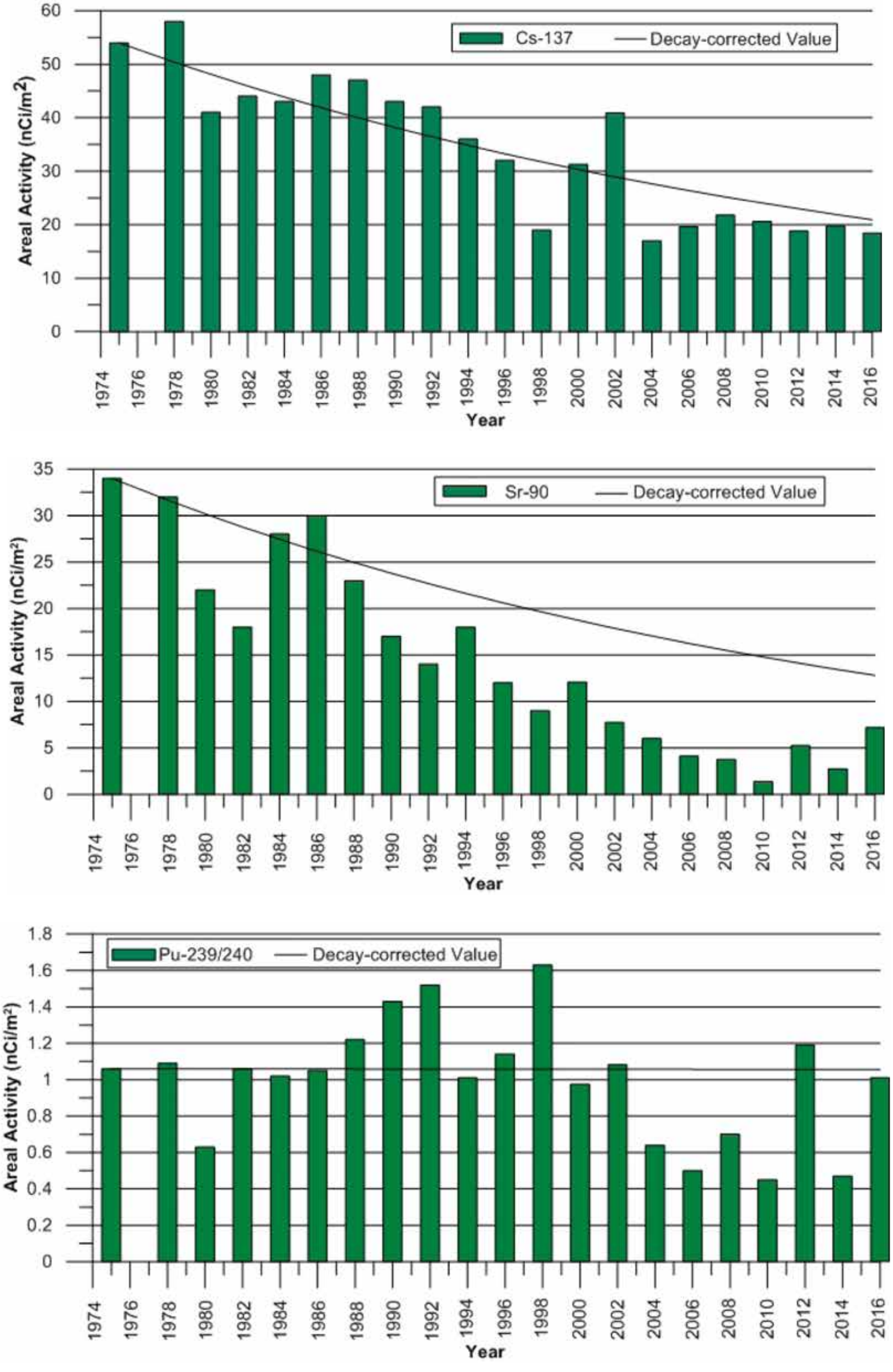


Figure 7-5. Mean Activities in Surface (0–5 cm [0–2 in.]) Soils Off the INL Site (1975–2016). The activities shown for 1975 are averages of results reported for samples collected 1970-1975 (DOE-ID 1977).

This may be because the samples represent the top 5 cm (2 in.) of soil and some of the ^{90}Sr may have migrated to deeper levels, or it is possible that some of the ^{90}Sr may have been taken up by vegetation. No accumulation of either radionuclide on soil as a result of operations at the INL Site is indicated.

Plutonium-239/240 was above the detection limit in all of the samples analyzed. No particular trend is indicated in the graph of $^{239/240}$Pu concentrations over time in Figure 7-5. This is consistent with the long half-life of the radionuclide, but the graph also does not indicate any accumulation over time from INL Site operations. Improved methodologies used in the analysis of the 2016 samples resulted in some lower detection limits for the transuranic radionuclides. This resulted in detectable concentrations reported in four samples for ^{238}Pu and four samples for ^{241}Am. All were near the detection limit and all were within the range considered to be background levels based on an analysis of historical soil data in the vicinity of the INL Site (BEA 2016).

7.2.2 Wastewater Reuse Permit Soil Sampling at Central Facilities Area

The Idaho Department of Environmental Quality issued a permit for the Central Facilities Area Sewage Treatment Plant on March 17, 2010. The permit required soil sampling in the wastewater land application area in 2010 and 2013. No soil samples were collected in 2016.

7.2.3 Onsite Soil Sampling

No routine soil sampling was completed in 2016.

Contaminated soil was discovered outside of a contamination area near the ATR evaporation ponds. Pre-work surveys were being performed in preparation for the ATR Complex Warm Waste Evaporation Pond liner replacement project. A radiological buffer area had been established to support surveys of the area surrounding the evaporation pond contamination area. A normally unoccupied area was surveyed and contamination was found in the soil. Following the discovery, the area was posted as a soil contamination area. Surveys of the road around the evaporation pond were conducted and no additional contamination was found. The ATR Evaporation Ponds are an actively managed ATR facility that is operated under a state of Idaho "Permit to Construct" (IDAPA 58.01.01.200) in the "Rules for the Control of Air Pollution in Idaho" (IDAPA 58.01.01). Upon end of useful life of the ATR Evaporation Ponds, the Permit will be terminated and the Facility will be cleaned up to regulations applicable at the time of closure.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) were historically used to measure cumulative exposures in air (in milliRoentgen or mR) to ambient ionizing radiation. The TLD packets contain four lithium fluoride chips and were placed about 1 m (about 3 ft) above the ground at specified locations. Beginning with the May 2010 distribution of dosimeters, the INL contractor began collocating optically stimulated luminescent dosimeters (OSLDs) with TLDs. The primary advantage of the OSLD technology over the traditional TLD is that the nondestructive reading of the OSLD allows for dose verification (i.e., the dosimeter can be read multiple times without destruction of the accumulated signal inside the aluminum oxide chips). TLDs, on the other hand, are heated, and once the energy is released, they cannot be reread. The last set of INL contractor TLD results were from November 2012. The ESER contractor began the use of OSLDs in November 2011 in addition to TLDs. In 2016, the ESER contractor TLDs were collected; however, results are not yet available. The ESER contractor and Idaho State University are working to resolve this issue. ESER contractor OSLD data are shown in Table 7-3.

Dosimeter locations are shown in Figure 7-6. The sampling periods for 2016 were from November 2015–April 2016 and May 2016–October 2016.

Using OSLD data collected by both the ESER and INL contractors, the mean annual ambient dose for distant locations was estimated at 118 mrem (1180 uSv) and for boundary locations at 115 mrem (1150 uSv) (Table 7-3). The mean annual ambient dose for all locations combined was 117 mrem (1170 uSv).

Dosimeters on the INL Site are placed at facility perimeters, concentrated in areas likely to detect the highest gamma radiation readings. Other dosimeters on the INL Site are located near radioactive materials storage areas and along roads. For decades, the number and locations of the INL Site area dosimeters have been relatively constant; however, factors affecting potential exposures have changed. These changes include a reduced number of operating nuclear reactors, personnel, and waste shipments; decontamination and demolition of numerous buildings and facilities; and remediation of radionuclide-contaminated pond and soil areas. Additionally, new projects have been added. Because of these changes and because years of TLD exposures at many established locations were equivalent to natural background, the INL contractor reduced the number of INL Site dosimetry

Table 7-3. Annual Environmental Radiation Doses Using OSLDs at All Offsite Locations (2012–2016).

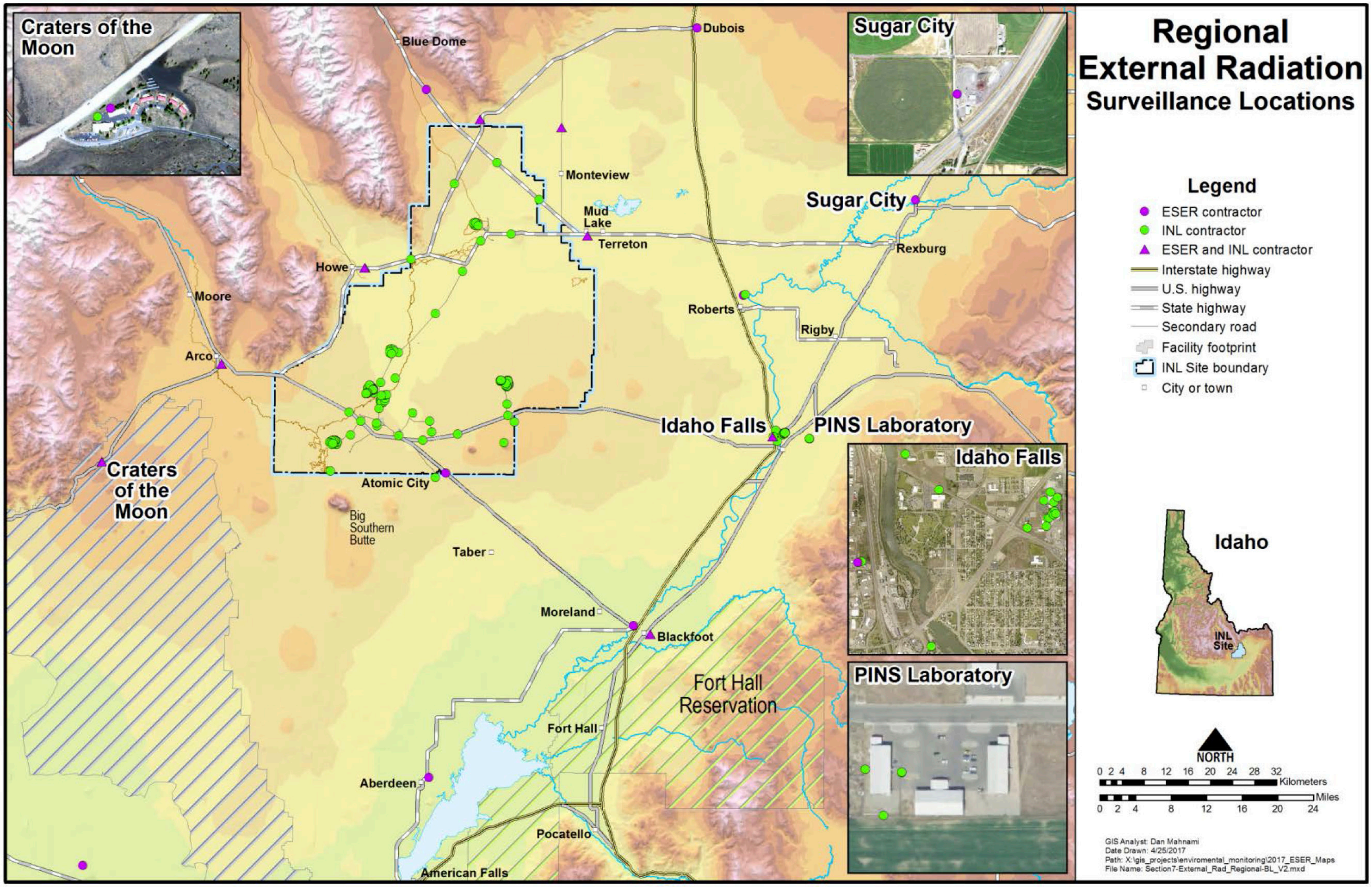
Location	2012	2013	2014	2015	2016
	mrem				
Distant Group					
Aberdeen[a]	128	119	112	119	117
Blackfoot[a]	113	107	NA[b]	114	118
Craters of the Moon[c]	125	109	117	120	116
Dubois[a]	96	90	95	90	103
IF-IDA[i,j]	NA[i]	NA[i]	NA[i]	109	107
Idaho Falls[c]	125	112	111	117	118
Jackson[a]	88	81	89	NA[d]	NA
Minidoka[e]	115	105	104	101	99
Mountain View[c]	114	104	108	108	111
Rexburg/Sugar City[f,g]	137	114	134	146	151
Roberts[a]/RobNOAA[k]	141	127	129	126	132
Mean[l]	118	107	111	116	118
Boundary Group					
Arco[c]	126	112	122	119	118
Atomic City[c]	129	114	118	117	125
Birch Creek Hydro[c]	112	101	105	103	107
Blue Dome[a]	96	86	84	95	103
Howe[b,h]	112	104	110	105	106
Monteview[c]	121	103	110	112	119
Mud Lake[c]	127	123	126	131	130
Mean[l]	117	106	111	112	115
Total mean[l] (Distant and Bounday)	118	107	111	114	116

a. Represents data collected by the ESER contractor only.
b. The dosimeter was in an area with elevated natural radioactivity levels for part of the year and does not represent background values.
c. Represents the mean of data collected by both the ESER contractor and the INL contractor.
d. Sampling was temporarily discontinued in October 2015 pending construction of a new sampling location.
e. Represents the mean of data collected by both the ESER and INL contractors during 2012 and 2013. The INL contractor discontinued sampling here in 2014.
f. Represents the mean of data collected by both the ESER and INL contractors from 2012–2014. The INL contractor discontinued sampling here in 2015.
g. Dosimeter was moved to Sugar City in July 2013.
h. The INL contractor dosimeter was missing for part of the time during 2012 and 2015 and was not included in the average for those years.
i. INL Contractor began sampling this location 2014
j. Represents data collected by INL Contractor only.
k. INL Contractor dosimeter moved to RobNOAA in November 2015.
l. Multiply mrem by 10 to obtain uSv.

at some locations and added other locations. In 2016, OSLD monitoring locations have been added near select Research and Education Campus facilities in Idaho Falls, specifically at the Department of Energy Laboratory Accreditation Program (IF-689). New monitoring locations were also added onsite at the Remote-Handled Low-Level Waste Disposal Facility. New locations are identified as *new* in Appendix D tables.

Dosimeters are received from the manufacturer in Glenwood, Illinois; placed in the field for six months; and then returned to the manufacturer for analysis. Tran-

Figure 7-6. Regional Direct Radiation Monitoring Locations (2016).



sit control dosimeters shipped with the field dosimeters are used to measure any dose received during shipment. Background radiation levels are highly variable; therefore, historical information establishes localized regional trends in order to identify variances. It is anticipated that 5 percent of the measurements will exceed the background dose. If a single measurement is greater than the background dose, it does not necessarily qualify that there is an unusually high amount of radiation in the area. When a measurement exceeds the background dose, the measurement is compared to other values in the area and to historical data to determine if the results may require further action as described in *Data Quality Objectives Supporting the Environmental Direct Radiation Monitoring Program for the Idaho National Laboratory* (INL 2015). The method for computing the background value as the upper tolerance limit (UTL) is described by EPA (2009) and EPA (2013). The ProUCL software has been used to compute UTLs, given all available data in the area, since 2007 (EPA 2013).

The 2016 direct radiation results and locations collected by the INL contractor are provided in Appendix D. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2016 reported values for field locations were primarily below the historic background six-month UTL. Table 7-4 shows the locations that exceeded the facility specific six-month UTL.

Neutron monitoring is conducted around buildings in Idaho Falls with sources that may emit or generate neutrons. In Idaho Falls, these buildings include the IF 675 Portable Isotopic Neutron Spectroscopy (PINS) facility, the IF-670 Bonneville County Technology Center (BCTC), and the IF 638 Physics Laboratory. Additional neutron dosimeters are placed at IRC along the south perimeter fence and at the Idaho Falls O 10 background location. The background level for neutrons is zero and the current neutron dosimeters have a detection limit of 10 mrem. The INL contractor follows the recommendations of the manufacturer to prevent environmental damage to the neutron dosimetry by wrapping each in aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed. Any dose measured above the detection limit is considered present due to sources inside the building. Most neutron dosimeters collected in 2016 were reported as “M” (dose equivalents below the minimum measurable quantity of 10 mrem). One location, IF-638W O-4, located in the IRC complex, had a reading of 20 mrem. Neutron dosimetry is deployed at IF 638 because the building houses an ^{241}AmBe sealed neutron source and the positive reading is probably due to this source.

Table 7-5 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (cosmic and terrestrial). This table includes the latest recommendations of the National Council of Radiation Protection and Measurements (NCRP) in Ionizing Radiation Exposure of the Population of the United States (NCRP 2009).

The terrestrial natural background radiation exposure estimate is based on concentrations of naturally occurring radionuclides found in soil samples collected from 1976 through 1993, as summarized by Jessmore et al. (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicated the average concentrations of uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2016, this resulted in a reduction in the effective dose from soil to a value of 69 mrem.

The cosmic component varies primarily with increasing altitude. Using Figure 3.4 in NCRP Report No. 160 (NCRP 2009), it was estimated that the annual cosmic radiation dose near the INL Site is approximately 57 mrem. Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Based on this information, the sum of the terrestrial and cosmic components of external radiation dose to a person residing on the Snake River Plain in 2016 was estimated to be 126 mrem/yr. This is slightly higher than the 117 mrem/yr measured at offsite locations using OSLD data. Measured values are typically within normal variability of the calculated background doses. Therefore, it is unlikely that INL Site operations contributed to background radiation levels at distant locations in 2016.

The component of background dose that varies the most is inhaled radionuclides. According to the NCRP,

Table 7-4. Dosimetry Locations Above the Six-month Background Upper Tolerance Limit (UTL)[a] (2016).

Location	Collect Date	Standard Deviation (mrem)	Background Level (UTL) (mrem)	Dose (gross in mrem)
ANL O-21[a]	5/2016	9.3	80.42	92.8
ICPP-A-020[a]	5/2016	21.4	102	214.3
ICPP-A-030[a]	5/2016	15.1	102	151.3
ICPP TreeFarm O-4[a]	5/2016	11.1	102	111.3
RWMC-A-013A	5/2016	10.6	85.78	105.7
TRA O-17[a]	5/2016	15.1	96.39	150.7
TRA O-18[a]	5/2016	12	96.39	119.8
TRA O-19[a]	5/2016	12.1	96.39	120.8
TRA O-20[a]	5/2016	14.7	96.39	146.7
TRA O-21[a]	5/2016	17.1	96.39	170.7
ANL O-15	11/2016	5.6	80.42	86.1
ANL O-20[a]	11/2016	8.2	80.42	81.9
ANL O-21[a]	11/2016	10.4	80.42	104.4
ANL O-22[a]	11/2016	8.8	80.42	87.9
ANL O-7	11/2016	8.7	80.42	87.2
ICPP O-15	11/2016	10.4	102	104.1
ICPP O-20[a]	11/2016	17.8	102	177.7
ICPP O-27[a]	11/2016	11.1	102	110.9
ICPP O-28[a]	11/2016	10.2	102	102
ICPP O-30[a]	11/2016	13.9	102	139.2
ICPP TreeFarm O-1[a]	11/2016	10.6	102	105.8
ICPP TreeFarm O-4[a]	11/2016	12.2	102	121.7
Monteview O-4	11/2016	6.8	65.74	68.4
NRF O-13[a]	11/2016	8.1	81.2	81.4
RWMC O-13A	11/2016	11.7	85.75	117
RWMC O-41	11/2016	16.6	131.3	136.4
RWMC O-9A	11/2016	8.6	85.78	86.3
TRA O-17[a]	11/2016	10.9	96.39	109
TRA O-19[a]	11/2016	67.3	96.39	672.7
TRA O-20[a]	11/2016	13.3	96.39	132.5
TRA O-21[a]	11/2016	14.1	96.39	141
TRA O-22[a]	11/2016	11.9	96.39	119.3

a. The UTL is the value such that 95 percent of all of the doses in the area are less than the UTL with 95 percent confidence. That is, only 5 percent of the doses should exceed the UTL.

the major contributor of effective dose received by a member of the public from ^{238}U plus decay products is short-lived decay products of radon (NCRP 2009). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of soil and rock in the area. The amount of radon also varies among buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-5 for this component of the total background dose. The NCRP also reports that the average dose received from thoron, a decay product of ^{232}Th, is 16 mrem.

People also receive an internal dose from ingestion of ^{40}K and other naturally occurring radionuclides in environmental media. The average ingestion dose to an adult living in the United States was reported in NCRP Report No. 160 to be 29 mrem/yr (NCRP 2009).

Table 7-5. Calculated Effective Dose from Natural Background Sources (2016).

Source of Radiation Dose	Total Average Annual Dose Calculated (mrem)	Measured[a] (mrem)
External irradiation		
Terrestrial	69[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	126	117
Internal irradiation (primarily ingestion)[e]		
Potassium-40	15	
Thorium-232 and uranium-238	13	
Others (carbon-14 and rubidium-87)	1	
Internal irradiation (primarily inhalation)[d]		
Radon-222 (radon) and its short-lived decay products	212	
Radon-220 (thoron) and its short-lived decay products	16	
Total	383	

a. Calculated from the average annual external exposure at all offsite locations measured using OSLDs (see Table 7-3).
b. Estimated using concentrations of naturally occurring radionuclide concentrations in soils in the Snake River Plain.
c. NA indicates terrestrial and cosmic radiation parameters were not measured individually but were measured collectively using dosimeters.
d. Estimated from Figure 3.4 of NCRP Report No. 160.
e. Values reported for average American adult in Table 3.14 of NCRP Report No. 160.

With all of these contributions, the total background dose to an average individual living in southeast Idaho was estimated to be approximately 383 mrem/yr (Table 7-5). This value was used in Table 8-3 to calculate background radiation dose to the population living within 50 mi of INL Site facilities.

7.4 Waste Management Surveillance Sampling

For compliance with DOE Order 435.1, "Radioactive Waste Management" (2011), vegetation and soil are sampled at Radioactive Waste Management Complex (RWMC), and direct surface radiation is measured at RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility.

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, vegetation is collected from four major areas and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Russian thistle is collected in even-numbered years, if available. Because of construction activities, there was an insufficient amount of Russian thistle to collect in 2016.

7.4.2 Soil Sampling at the Radioactive Waste Management Complex

The ICP Core contractor samples soil every three years. The triennial soil sample was previously collected in 2015, and the next samples will be collected in 2018. Results can be found in Section 7.4.2 of the 2015 ASER report (DOE-ID 2016).

7.4.3 Surface Radiation Survey at the Radioactive Waste Management Complex and the Idaho CERCLA Disposal Facility

Surface radiation surveys are performed to characterize gamma radiation levels near the ground surface at waste management facilities. Comparing the data from these surveys year to year helps to determine whether radiological trends exist in specific areas. This type of survey is conducted at the RWMC SDA to complement air and soil sampling and at the Idaho CERCLA Disposal Facility (ICDF) to complement air sampling. The SDA contains legacy waste that is in the process of being removed for repackaging and shipment to an off-Site disposal facility. The ICDF consists of a landfill and evaporation ponds, which serve as the consolidation points for CERCLA-generated waste within the INL Site boundaries.

A vehicle-mounted Global Positioning Radiometric Scanner (GPRS) system (Rapiscan Model GPRS-1111) is used to conduct these soil surface radiation (gross gamma) surveys to detect trends in measured levels of surface radiation. The GPRS system consists of two scintillator gamma detectors, housed in two separate metal cabinets, and a Trimble[1] global positioning system receiver, mounted on a rack located above the front bumper of a pickup truck. The detectors are approximately 36 in. above ground. The detectors and the global positioning system receiver are connected to a system controller and to a laptop computer located inside the cabin of the truck. The GPRS system software displays the gamma counts per second from the detectors and the latitude and longitude of the system in real time on the laptop screen. The laptop computer also stores the data files collected for each radiometric survey. During radiometric surveys, the pickup truck is driven five mi/hr (seven feet per second), and the GPRS system collects latitude, longitude, and gamma counts per second from both detectors. Data files generated during the radiological surveys are saved and transferred to the ICP Core spatial analysis laboratory for mapping after the surveys are completed. The maps indicate areas where survey counts were at or near background levels and areas where survey counts are above background levels. No radiological trends were identified in 2016, in comparison to previous years.

Figure 7-7 shows a map of the area that was surveyed at RWMC in 2016. Some areas that had been surveyed in previous years could not be accessed due to construction activities and subsidence restrictions. Although readings vary slightly from year to year, the 2016 results for most areas are comparable to previous years' measurements. The active low-level waste pit was covered during 2009, and, as a result of the reduced shine, elevated measurements from the buried waste in pits and trenches are more visible. Average background values near or around areas that were radiometrically scanned were generally below 750 counts per second. Most of the 2016 RWMC gross gamma radiation measurements were at background levels. The 2016 maximum gross gamma radiation measurement on the SDA was 17,859 counts per second, as compared to the 2015 measurement of 15,267 counts per second. As in previous years, the maximum readings were measured in a small area at the western end of the soil vault row SVR-7, and the size of that area has not increased.

The area that was surveyed at the ICDF is shown in Figure 7-8. The readings at the ICDF vary from year to year. These variations are related to the disposal and burial of new CERCLA remediation wastes in accordance with the ICDF waste placement plan (EDF-ER-286). In 2016, the readings were either at background levels or slightly above background levels (approximately 300 counts/second), which is expected until the facility is closed and capped.

7.5 CERCLA Ecological Monitoring

Ecological monitoring at the INL Site was conducted in accordance with the Record of Decision for Operable Unit 10-04 (DOE-ID 2002b) developed under CERCLA (42 USC § 9601 et seq.). The selected remedy was no action with long-term ecological monitoring to reduce uncertainties in the INL Site-wide ecological risk assessment.

After six years of data and observations from 2003 and 2008 to assess effects at the population level, it was determined that the no action decision is protective, and further ecological monitoring under CERCLA is not required (Holdren 2013). To validate the conclusion that further ecological monitoring under CERCLA is not required, the regulatory agencies requested additional analysis using the latest changes in ecological data (e.g., screening and toxicity values) to produce waste area group-level ecological risk assessments. Refined ecological risks were presented in a summary report (Van Horn 2013). Several individual release sites within the waste area groups were recommended for further evaluation in the next five-year review (planned to cover 2010–2014) to ensure the remedial action is protective of ecological receptors.

The five-year review, published in December 2015, considered toxicity, land-use projections, and endangered species listings and found no basis for further evaluation of potential ecological impacts. Individual sites tabulated

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[1] PRODUCT DISCLAIMER—References to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, do not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government, any agency thereof, or any company affiliated with the ICP Core.

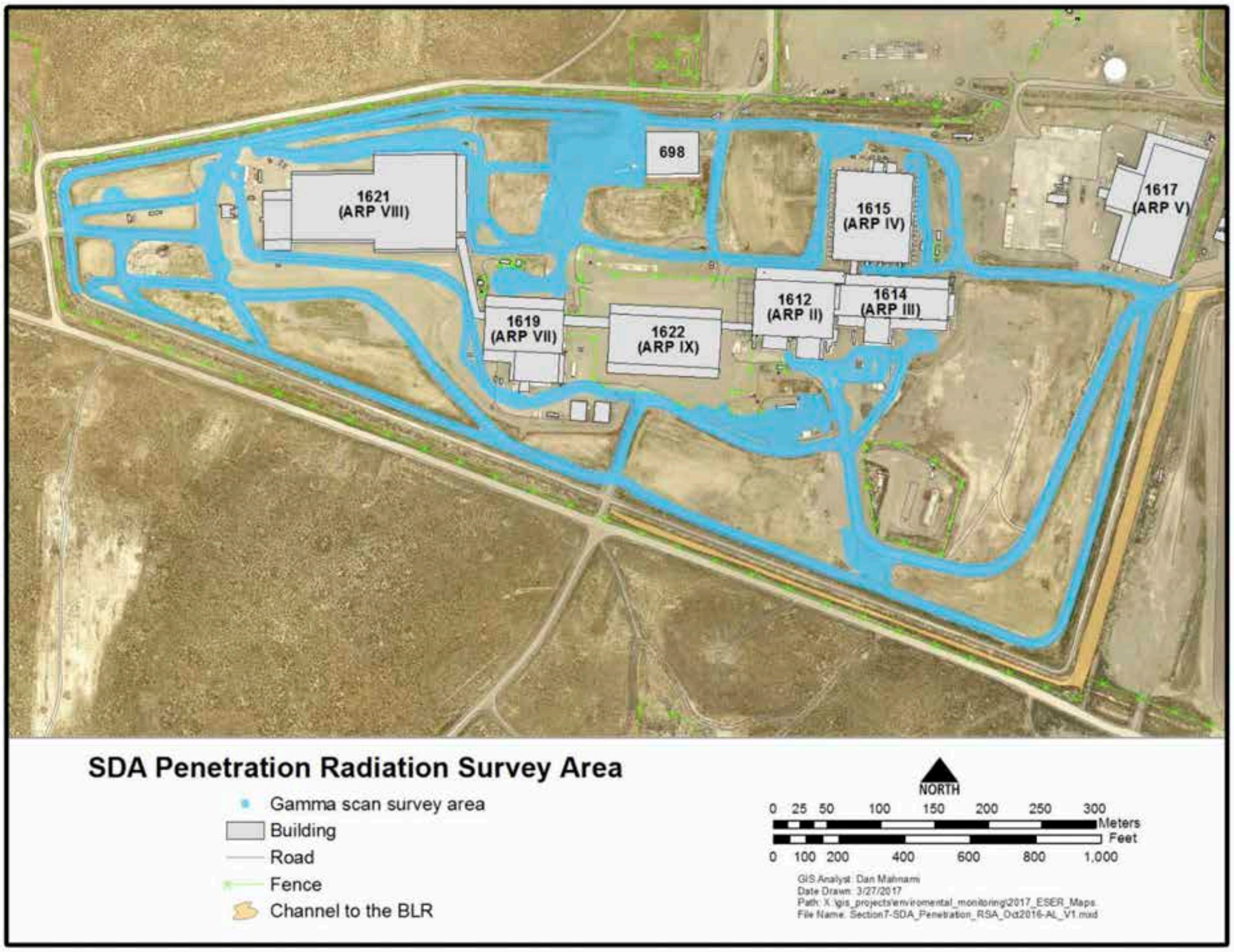

Figure 7-7. SDA Surface Radiation Survey Area (2016).

by Van Horn (2013) offer limited habitat and considerable human activity, and they are not significant in the context of the INL Site-wide population effects conclusion. The five-year review concluded that the no-action decision (DOE-ID 2015):

- Is protective at the population level
- Eliminates further consideration of the INL Site-wide no-action decision in future five-year reviews
- Defers evaluation of ecological protectiveness at Idaho Nuclear Technology and Engineering Center and RWMC until after the planned surface barriers are operational and functional.

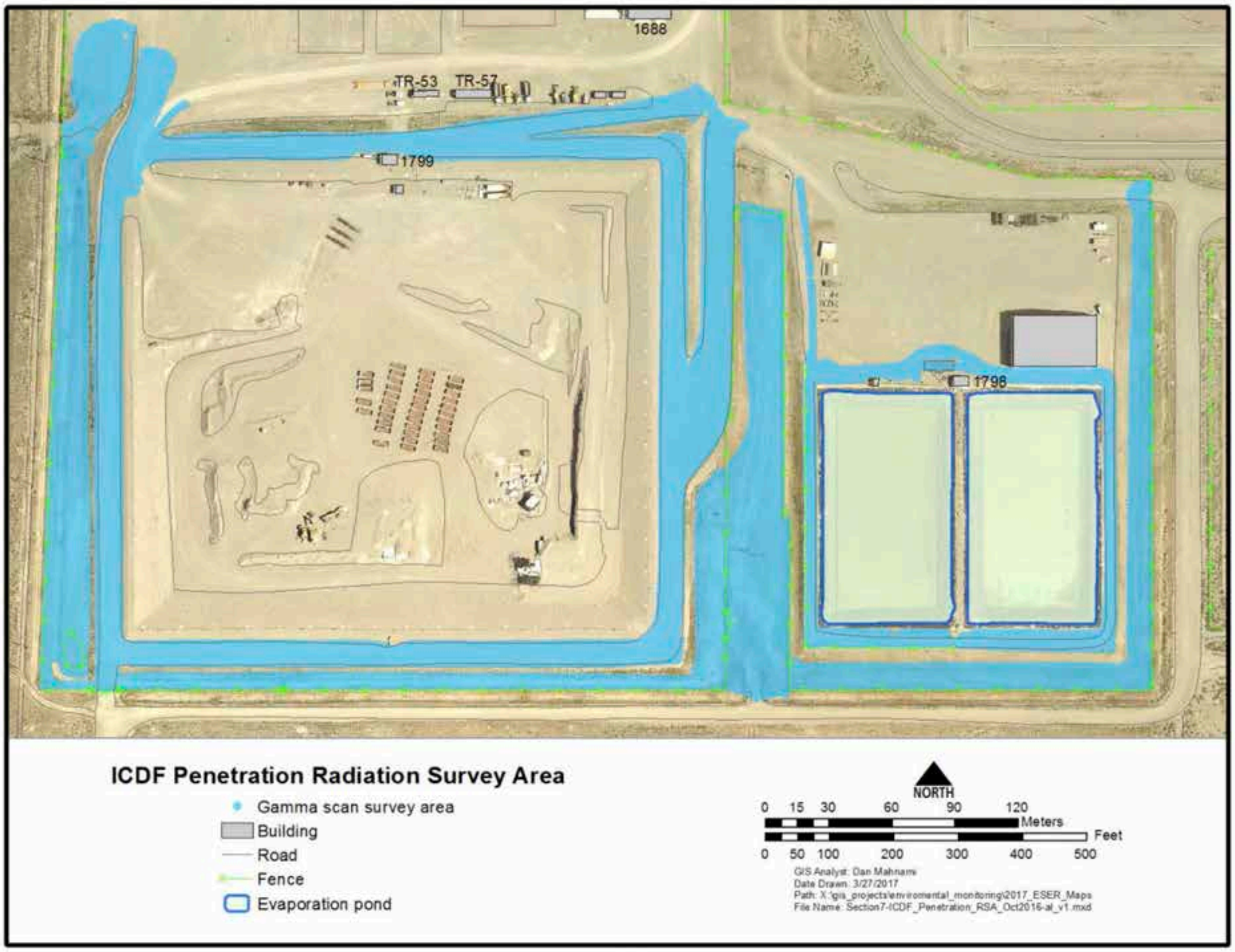

Figure 7-8. Idaho CERCLA Disposal Facility Surface Radiation Survey Area (2016).

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Horned Lark
Photo: Kristin Kaser

Hoary Bat
lasiurus cinereus

2016

8. Dose to the Public and Biota

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package 88-PC computer program is required by the U.S. Environmental Protection Agency to demonstrate compliance with the Clean Air Act. The dose to the hypothetical, maximally exposed individual (MEI) in 2016, as determined by this program, was 0.0143 mrem (0.143 µSv), well below the applicable standard of 10 mrem (100 µSv) per year. This dose is also far below the public dose limit of 100 mrem (1 mSv) established by the U.S. Department of Energy (DOE) for a member of the public.

The maximum potential population dose to the approximately 327,823 people residing within an 80 km (50 mi) radius of any INL Site facility was also evaluated. The population dose was calculated using reported releases, an air dispersion model (HYSPLIT) used by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division, and a dose calculation model (DOSEMM). For 2016, the estimated potential population dose was 4.42×10^{-2} person-rem (4.42×10^{-4} person-Sv). This dose is approximately 0.00003 percent of that expected from exposure to natural background radiation of 125,556 person-rem (1,256 person-Sv).

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Initially, the potential doses were screened using maximum concentrations of radionuclides detected in soil and effluents at the INL Site. Results of the screening calculations indicate that contaminants released from INL Site activities do not have an adverse impact on plants or animal populations. In the past, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds were used to estimate internal doses to the waterfowl and to a hunter who might have one. Waterfowl were not collected in 2016 due to restricted access to the pond area thus doses were not assessed.

No unplanned releases occurred from the INL Site in 2016, therefore, no doses were associated with unplanned releases.

8. DOSE TO THE PUBLIC AND BIOTA

DOE Order 458.1, Radiation Protection of the Public and the Environment, contains requirements for protecting the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the Department of Energy (DOE). In addition to requiring environmental monitoring to ensure compliance with the order, DOE Order 458.1 establishes a public dose limit. DOE sites must perform dose evaluations using mathematical models that represent various environmental pathways to demonstrate compliance with the public dose limit and to assess collective (population) doses. In the interest of protection of the environment against ionizing radiation, DOE also developed the technical standard DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. The Standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

40 CFR Part 61 Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*, establishes federal radiation dose limits for the maximally exposed member of the public from all airborne emissions and pathways. It requires that doses to members of the public from airborne releases be calculated using Environmental Protection Agency (EPA) approved computer models.

This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2016 environmental monitoring measurements.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 8-1).

Airborne radioactive materials are carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site, so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from ingestion of meat from wild game animals that access the INL Site. Ingestion doses were calculated from concentrations of radionuclides measured in game animals killed by vehicles on roads at the INL Site that had detectable levels of human-made radionuclides. External exposure to radiation in the environment (primarily from naturally occurring radionuclides) was measured directly using thermoluminescent dosimeters and optically stimulated luminescence dosimeters.

Water pathways were not considered major contributors to dose, because no surface water flows off the INL Site and no radionuclides associated with INL Site releases have been measured in public drinking water wells.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released by the facilities. During 2016, doses were calculated for the radionuclides and the data are presented in Table 4-2 and summarized in Table 8-1. Tritium (^{3}H) accounted for the largest percentage of the activity released and cumulative dose. Although noble gases were the radionuclides released in the largest quantities, with the exception of argon-41 (^{41}Ar) they contributed very little to the cumulative dose (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. Other radionuclides that contributed the most to the overall estimated dose (carbon-14 [^{14}C], cobalt-60 [^{60}Co], strontium-90 [^{90}Sr], iodine-129 [^{129}I], cesium-137 [^{137}Cs], americium-241 [^{241}Am], and plutonium [Pu] isotopes) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported.

The following two kinds of dose estimates were made using the release data:

- ***The effective dose to the hypothetical maximally exposed individual (MEI)***, as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. The Clean Air

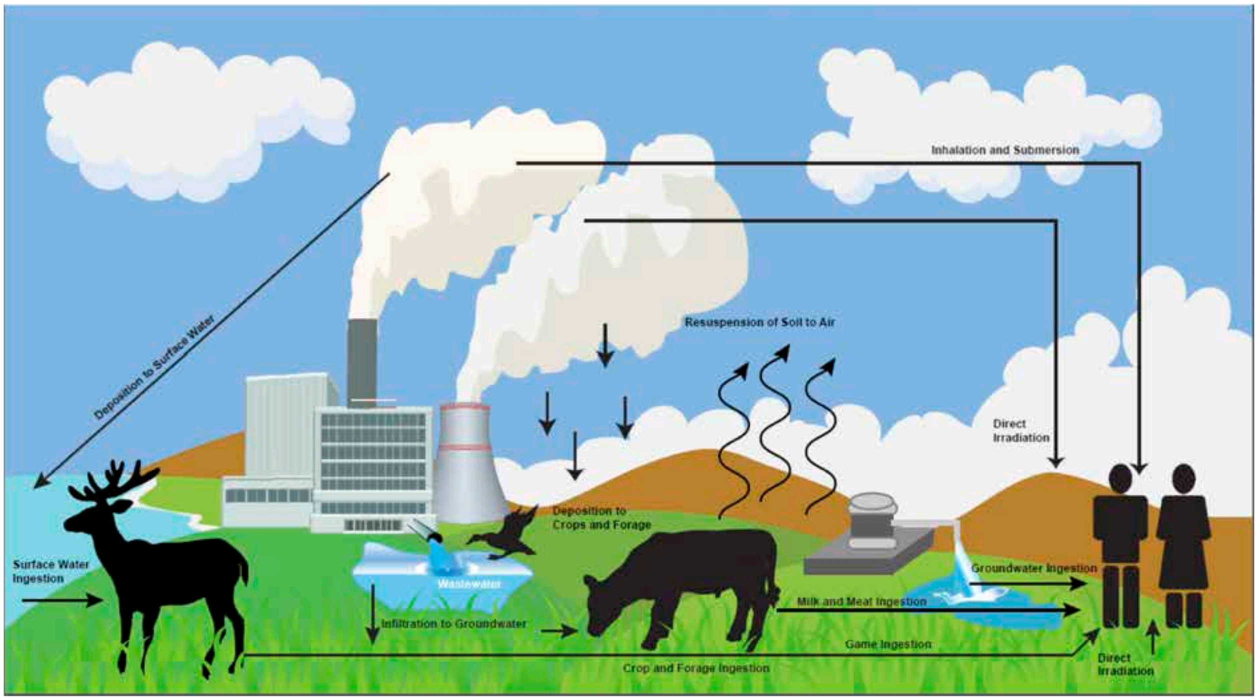

Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

Table 8-1. Summary of Radionuclide Composition of INL Site Airborne Effluents (2016).

	Total Curies[a] Released										
Facility[b]	Tritium	Noble Gases[c] ($T_{1/2} > 40$ days)	Noble Gases[d] ($T_{1/2} < 40$ days)	Fission and Activation Products[e] ($T_{1/2} < 3$ hours)	Fission and Activation Products[f] ($T_{1/2} > 3$ hours)	Total Radioiodine[g]	Total Radiostrontium[h]	Total Uranium[i]	Plutonium[j]	Other Actinides[k]	Other[l]
ATR Complex	2.86E+02	1.48E-19	7.60E+02	1.67E-01	2.68E-02	3.60E-02	1.88E-02	1.75E-09	8.46E-06	5.35E-03	3.12E-10
CFA	5.80E-01	2.14E-09	2.00E-05	1.74E-10	6.14E-07	—	6.27E-10	2.78E-08	1.36E-09	2.19E-08	6.76E-15
CITRC	—	—	—	—	3.00E-06	—	—	—	—	—	—
INTEC	1.16E+02	6.23E+02	—	—	1.59E-02	1.95E-02	1.26E-02	2.46E-07	3.30E-03	9.84E-06	—
MFC	2.02E-01	5.89E-02	—	2.25E-08	1.99E-03	8.33E-03	2.00E-04	8.35E-06	9.93E-07	3.39E-06	1.68E-11
NRF	1.20E-02	1.20E-02	—	—	7.70E-01	2.98E-05	4.80E-05	—	2.50E-06	—	—
RWMC	7.00E+01	2.88E-13	—	1.39E-19	2.63E-01	—	4.82E-10	1.35E-10	2.35E-04	6.69E-04	1.39E-10
TAN	3.26E-02	2.66E-06	3.91E-06	4.50E-04	1.35E-03	—	1.02E-06	8.28E-08	—	—	6.85E-12
Total	**4.72E+02**	**6.23E+02**	**7.60E+02**	**1.68E-01**	**1.08E+00**	**6.39E-02**	**3.17E-02**	**8.71E-06**	**3.55E-03**	**7.36E-04**	**4.75E-10**

a. One curie (Ci) = 3.7 x 10^{10} becquerels (Bq)

b. ATR Complex = Advanced Test Reactor Complex; CFA = Central Facilities Area; CITRC = Critical Infrastructure Test Range Complex; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex (including AMWTP = Advanced Mixed Waste Treatment Project); TAN = Test Area North (including SMC = Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range)

c. Noble gases ($T_{1/2} > 40$ days) released in 2016 = ^{39}Ar and ^{85}Kr (^{39}Ar release is negligible)

d. Noble gases ($T_{1/2} < 40$ days) released in 2016 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{133}Xe, ^{135}Xe, ^{135m}Xe and ^{138}Xe

e. Fission products and activation products ($T_{1/2} < 3$ hours) released in 2016 = ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{80}Br, ^{83}Br, ^{38}Cl, ^{60m}Co, ^{138}Cs, ^{178m}Hf, ^{142}La, ^{56}Mn, ^{97}Nb, ^{144}Pr, ^{89}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{81}Se, ^{81m}Se, ^{129}Te, ^{208}Tl and ^{91m}Y

f. Fission products and activation products ($T_{1/2} > 3$ hours) released in 2016 = ^{110}Ag, ^{133}Ba, ^{140}Ba, ^{7}Be, ^{10}Be, ^{207}Bi, ^{210m}Bi, ^{80m}Br, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{139}Ce, ^{141}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{153}Gd, ^{68}Ge, ^{71}Ge, ^{175}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{166m}Ho, ^{192}Ir, ^{42}K, ^{43}K, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{59}Ni, ^{63}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{147}Pm, ^{143}Pr, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{122}Sb,
^{124}Sb, ^{125}Sb, ^{46}Sc, ^{32}Si, ^{145}Sm, ^{151}Sm, ^{113}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{99}Tc, ^{99m}Tc, ^{127}Te, ^{129m}Te, ^{132}Te, ^{204}Tl, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{65}Zn, ^{95}Zr and ^{97}Zr

g. Radioiodine released in 2016 = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I

h. Radiostrontium released in 2016 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr

i. Uranium isotopes released in 2016 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U and ^{238}U

j. Plutonium isotopes released in 2016 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu

k. Other actinides released in 2016 = ^{241}Am, ^{243}Am, ^{249}Cf, ^{252}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{237}Np, ^{239}Np, ^{233}Pa, ^{228}Th, ^{229}Th, ^{230}Th and ^{232}Th

l. Other = radioisotopes of elements that are not noble gases, activation or fission products, radioiodine, radiostrontium, or actinides released in 2016

Act Assessment Package -1988 computer model, PC Version 4 (CAP88-PC V4) (EPA 2013), was used to predict the maximum downwind concentration at an offsite receptor location and estimate the dose to the MEI.

- ***The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility.*** For this calculation, the HYSPLIT model (Stein et al. 2015) was used to model atmospheric transport, dispersion, and deposition of radionuclides released to the air from the INL Site. The population dose was estimated using the DOSEMM model (Rood 2017) using dispersion and deposition factors calculated by HYSPLIT in order to comply with DOE Order 458.1.

The dose estimates considered air immersion dose from gamma-emitting radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from gamma-emitting radionuclides deposited on soil (see Figure 8-1). The CAP88-PC computer model uses dose and risk tables developed by the U.S. Environmental Protection Agency (EPA). Population dose calculations were made using the HYSPLIT to calculate dispersion and deposition factors, the methods described in Rood (2017), DOE effective dose coefficients for inhaled radionuclides (DOE 2011), EPA dose conversion factors for ingested radionuclides (EPA 2002), and EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (EPA 2002).

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAP regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (40 Code of Federal Regulations [CFR] 61, Subpart H). This includes releases from stacks and diffuse sources, such as resuspension of contaminated soil particles. EPA requires the use of an approved computer model such as CAP88-PC to demonstrate compliance with 40 CFR 61. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses average annual wind files based on data collected at multiple locations on the INL Site by National Oceanic and Atmospheric Administration (NOAA). Assessments are done for a circular grid of distances and directions from each source with a radius of 80 km (50 mi) around the facility. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food, and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk, and meat consumed by humans are made by coupling the output of the atmospheric transport models with the Nuclear Regulatory Commission Regulatory Guide 1.109 (NRC 1977) terrestrial food chain models.

The dose from INL Site airborne releases of radionuclides was calculated to the MEI to demonstrate compliance with NESHAP and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2016 INL Report for Radionuclides* (DOE-ID 2017). In order to identify the MEI, the doses at 62 offsite locations were calculated and then screened for the maximum potential dose to an individual who might live at one of these locations. The highest potential dose was determined to be to a hypothetical person living at Frenchman's Cabin, located 2.26 km south of the INL Site southern boundary. This location is inhabited only during portions of the year, but it must be considered as a potential MEI location according to NESHAP. An effective dose of 0.0143 mrem (0.143 µSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2016.

Figure 8-2 compares the maximum individual doses calculated for 2007-2016. All of the doses are well below the whole body dose limit of 10 mrem/yr (0.1 mSv/yr) for airborne releases of radionuclides established by 40 CFR 61. The highest dose was estimated in 2008 and was attributed primarily to plutonium-241 (^{241}Pu), which was reported to be released during the dismantling of facilities at Test Area North.

Although noble gases were the radionuclides released in the largest quantities (~75 percent of the total Ci released in 2016), they represented relatively smaller fractions of the cumulative dose from all pathways (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. For example, 38 percent of the total activity released was ^{41}Ar (Table 4-2), yet ^{41}Ar resulted in less than 12 percent of the estimated dose. On the other hand, radionuclides typically associated with airborne particulates (^{241}Am, ^{137}Cs, ^{129}I, ^{90}Sr and plutonium [Pu] isotopes 238, 239, 240 and 241) were a tiny fraction (less than 0.01 percent) of the total amount of radionuclides reported to be released (Table 4-2) yet resulted in ap-

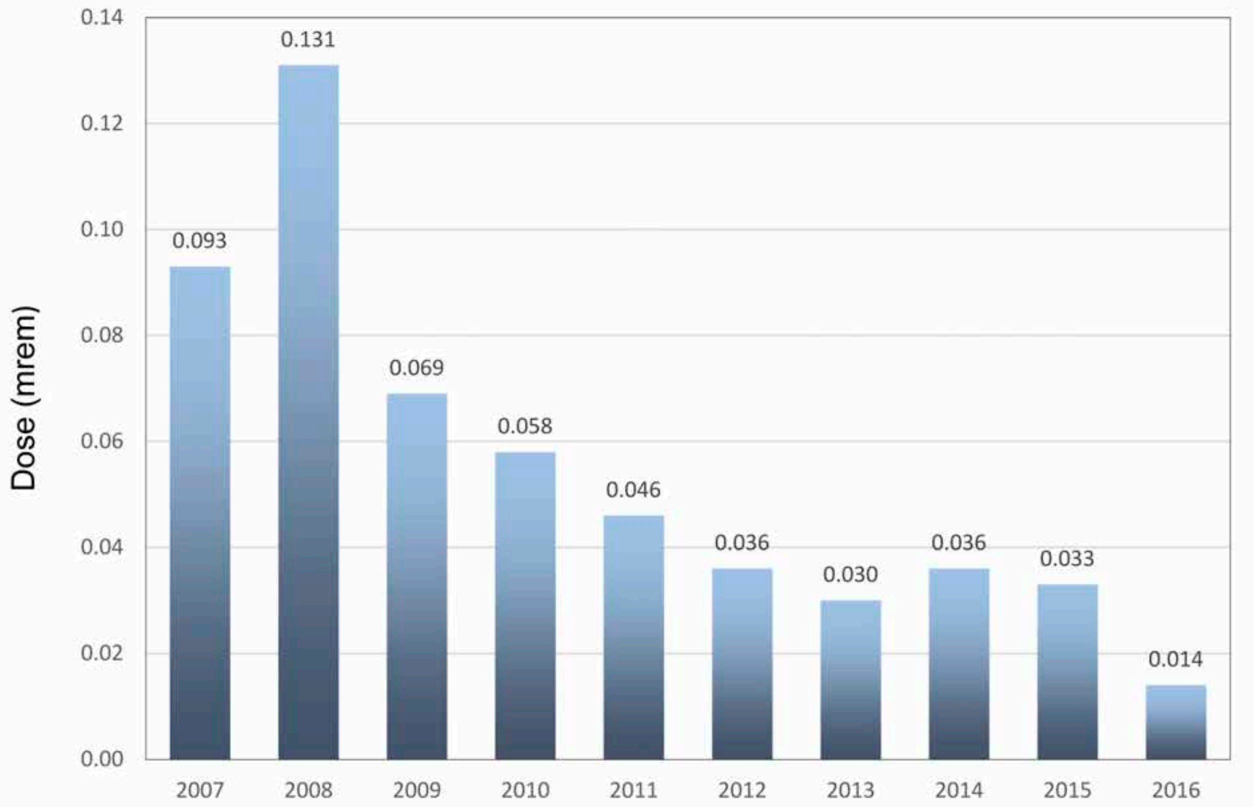

Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2007–2016.

proximately 58 percent of the estimated dose (Figure 8-3). The potential dose from ingesting or inhaling ^{241}Am is higher than that for other radionuclides because it is long-lived (half-life = 432.2 yrs) and a small amount that enters the body can get into the bones, where it can remain for many decades; a smaller amount can get into the liver and other organs, where it may remain for a few years as the body clears it. While in the body, ^{241}Am continues to expose the surrounding tissues to both alpha and gamma radiation. Tritium represented about 25 percent of the total activity released and contributed approximately 23 percent of the calculated dose to the MEI in 2016. Tritium interacts with the environment in a unique fashion because it may exchange with hydrogen atoms in water molecules in air. Therefore, tritium can follow water almost precisely through the environment. The dose calculations in CAP88-PC assume that doses from ingestion of food and water are directly proportional to modeled tritium concentrations in air.

Primary sources of the major radionuclides used to estimate the dose to the MEI (Figure 8-4) were identified during preparation of the annual NESHAP report (DOE-ID 2017) as follows:

- The dose from tritium emissions, which accounted for approximately 23 percent of the total dose to the MEI, results mainly from fugitive (i.e., non-point source) releases from beryllium blocks at the Radioactive Waste Management Complex (RWMC) and the Warm Waste Evaporation Pond (TRA-715-001) at the Advanced Test Reactor (ATR) Complex, and non-fugitive (i.e. point source) releases from the Three Mile Island (TMI-2) Independent Spent Fuel Storage Installation at Idaho Nuclear Technology and Engineering Center (INTEC), and emissions from the ATR main stack.
- Emissions of ^{241}Am, plutonium-239 (^{239}Pu), and plutonium-240 (^{240}Pu) were primarily from Accelerated Retrieval Projects (ARPs), at RWMC, the TMI-2 Independent Spent Fuel Storage Installation at INTEC and the Warm Waste Evaporation Pond (TRA-715-001) at the ATR Complex. These nuclides accounted for 13.0 percent of the total MEI dose.
- The major source of ^{90}Sr and ^{137}Cs resulting in dose to the MEI was from the Warm Waste Evaporation Pond at the ATR Complex, the TMI-2 Independent

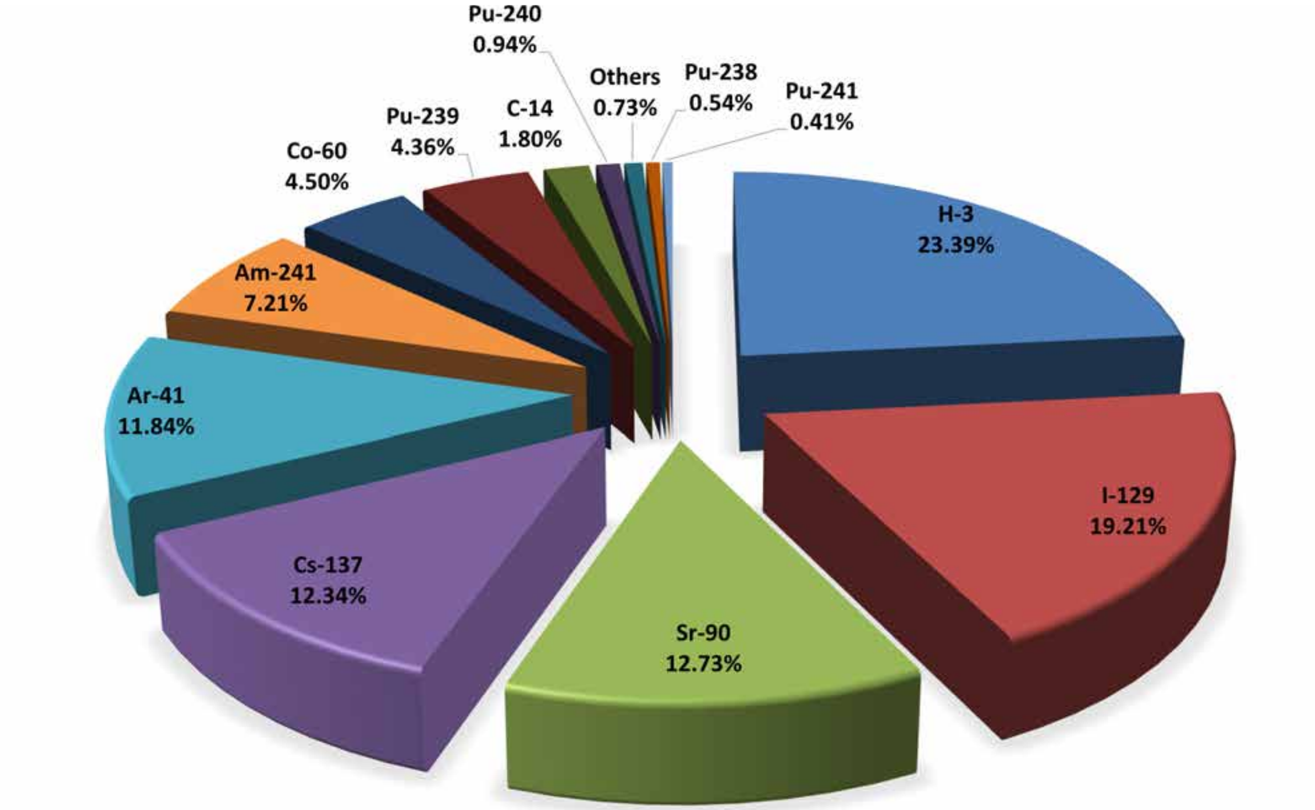

Figure 8-3. Radionuclides Contributing to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2016).

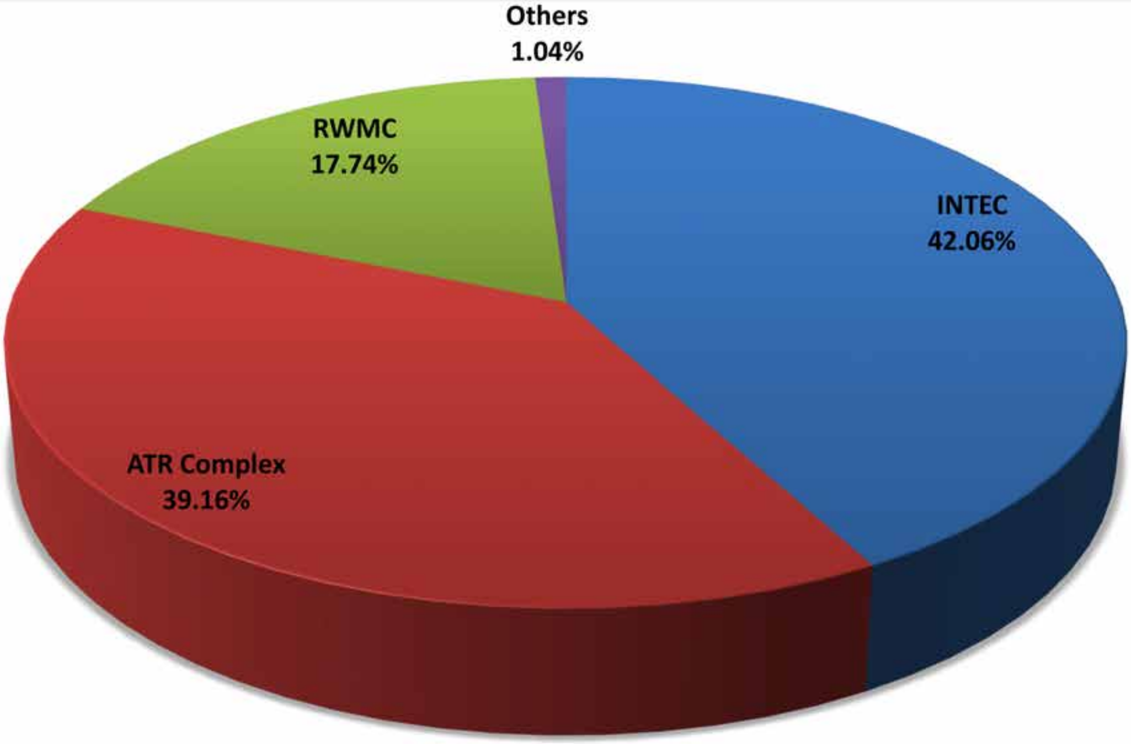

Figure 8-4. Percent Contributions, by Facility, to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2016).

Spent Fuel Storage Installation (INTEC) and the Main Stack (CPP-708-001) at INTEC. These nuclides accounted for 25.1 percent of the total MEI dose.

- Iodine-129 releases accounted for 19.2 percent of the total MEI dose and were primarily from the TMI-2 Independent Spent Fuel Storage Installation and the Main Stack (CPP-708-001) at INTEC.
- Airborne emissions of ^{41}Ar were primarily the result of operation of the Advanced Test Reactor at the ATR Complex and accounted for 11.8 percent of the total MEI dose.

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (NOAA ARL-FRD) adapted the widely used HYSPLIT transport and dispersion model for use at the INL Site. The model, in conjunction with meteorological data collected by NOAA, was used to estimate the dispersion and deposition of radionuclides estimated to be released from the INL Site activities during 2016 (see Table 4-2) The model and its capabilities are described on the NOAA ARL website www.arl.noaa.gov/HYSPLIT_info.php).

During 2016, the NOAA ARL-FRD continuously gathered meteorological data at 34 meteorological stations on and around the INL Site (see *Meteorological Monitoring*, a supplement to this Annual Site Environmental Report). The transport and dispersion of contaminants by winds and deposition onto the ground was projected by the HYSPLIT model using hourly averaged observations from the meteorological stations throughout 2016 together with regional topography. The model predicted dispersion and deposition resulting from releases from each facility at each of over 12,000 grid points projected on and around the INL Site. The Cartesian grid was designed to encompass the region within 80 km (50 mi) of INL Site facilities (Figure 8-5). In addition, 27 boundary receptor locations, representing actual residences around the INL Site, were included in the modeling.

Outputs from the NOAA HYSPLIT model were radionuclide concentrations and deposition amounts for a unit release (1 Ci/s) for each significant INL Site source calculated at 12,034 grid nodes across the model domain. These values were converted to dispersion and deposition factors for use in DOSEMM. The dispersion factor, often referred to as the X/Q value (concentration divided by source), was calculated by dividing the concentration (Ci/m^3) by the unit release rate (1 Ci/s) resulting in dispersion factor units of s/m^3. The deposition factor was calculated by dividing the total deposition (Ci/m^2) by the release time (seconds) and then by the unit release rate (1 Ci/s) to yield deposition factors in units in 1/m^2. Dispersion and deposition factors were calculated for each month of the year and were read into DOSEMM along with the annual radionuclide release rates from each source. Although annual release quantities were provided, monthly release quantities could have been used if available to account for seasonal variations in atmospheric dispersion.

The following radionuclides were modeled because each contributed to ≥ 0.1 percent of the total MEI dose calculated by CAP88-PC (see Figure 8-3): ^{3}H, ^{129}I, ^{90}Sr, ^{137}Cs, ^{41}Ar, ^{241}Am, ^{60}Co, ^{239}Pu, ^{14}C, ^{240}Pu, plutonium-238 (^{238}Pu), ^{241}Pu, krypton-85 (^{85}Kr), xenon-138 (^{138}Xe), krypton-88 (^{88}Kr), xenon-135 (^{135}Xe), and krypton-87 (^{87}Kr). In addition, iodine-131 (^{131}I), which contributed less than 0.1 percent of the total MEI dose, was included because it is specifically sampled for in the air monitoring network. Using DOSEMM, the actual estimated radionuclide emission rate (Ci/s) for each radionuclide and each facility was multiplied by the air dispersion and deposition factors that were calculated by HYSPLIT to yield an air concentration (Ci/m^3) and deposition (Ci/m^2) at each of the grid points over the time of interest (in this case, one year). The products were then used to calculate the effective dose (mrem) via inhalation, ingestion, and external exposure pathways at each grid point and at each boundary receptor location using the methodology described in Rood (2017).

Figure 8-6 displays the summation of all doses calculated from the modeling of all releases from all facilities as isopleths, ranging in value from 0.01 to 0.0001 mrem. The highest dose to an INL Site boundary receptor was estimated to be 0.01 mrem at Frenchman's Cabin (Receptor location #3). Frenchman's Cabin is also the location of the MEI used for the NESHAP dose assessment in 2016, which reported an estimated dose of 0.014 mrem to the MEI (see Section 8.2.1). The lowest dose (0.00007 mrem) was estimated at Receptor location #7.

To calculate the 80 km (50 mi) population dose, the number of people living in each census division was first estimated with data from the 2010 census extrapolated to 2016. The next step involved the use of the Geo-

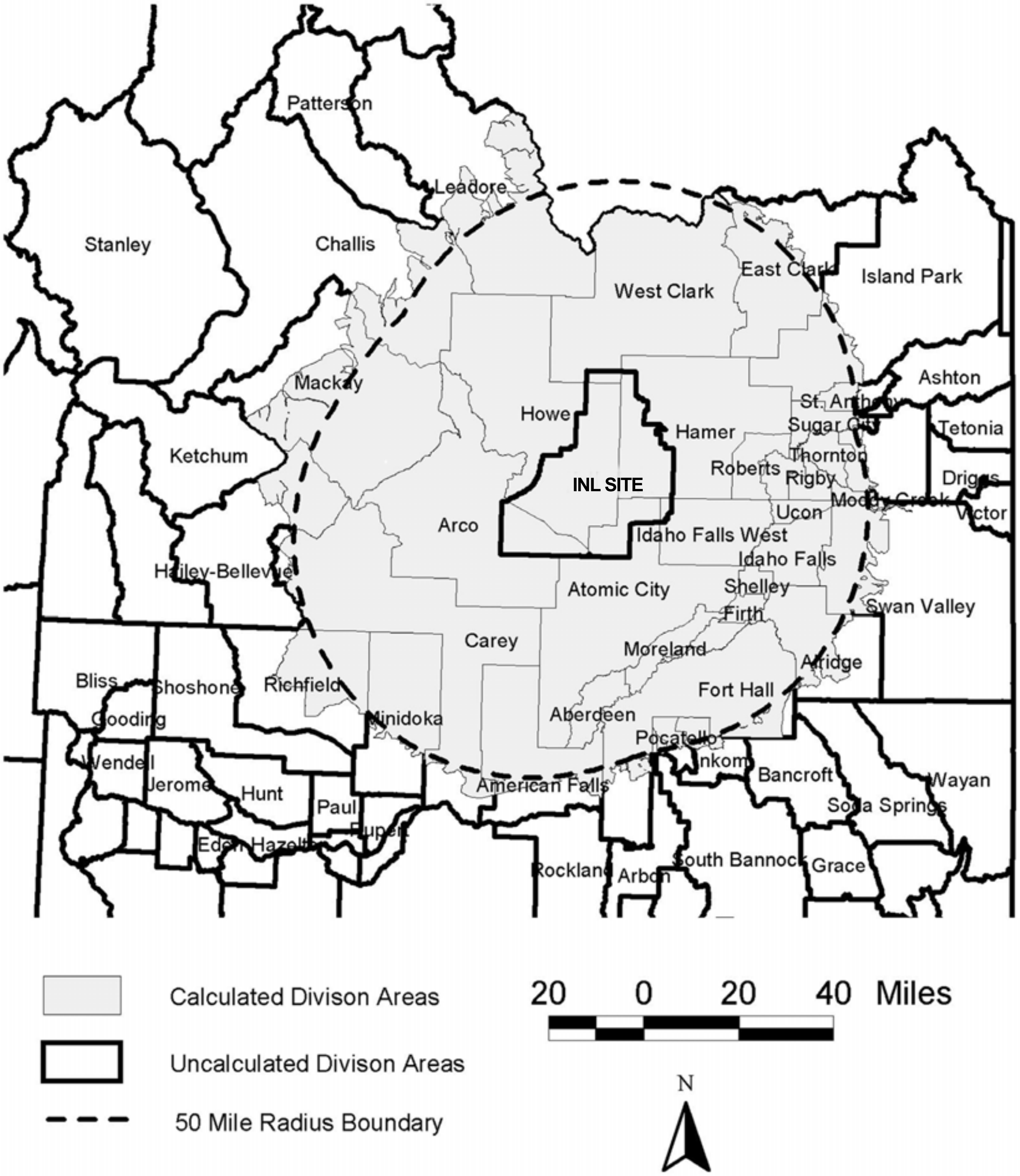

Figure 8-5. Region Within 50 miles of INL Site Facilities. Census Divisions used in the 50-mile population dose calculation are shown.

graphic Information System. The grid and dose values from DOSEMM were imported into the Geographic Information System project established and maintained by ESER. The doses within each census division were averaged and multiplied by the population within each of the divisions or portion of divisions within the 80-km (50-mi) area defined in Figure 8-5. These doses were then summed over all census divisions to result in the 80 km (50 mi) population dose (Table 8-2). The estimated potential population dose was 4.42 x 10^{-2} person-rem (4.42 x 10^{-4} person-Sv) to a population of approximately 327,823. When compared with the approximate population dose of 125,556 person-rem (1,256 person-Sv) estimated to be received from natural background radiation, this represents an increase of about 0.000035 percent. The largest collective dose was in the Arco census division due its proximity to the INL Site (see Figure 8-6).

The estimated population dose for 2016 is over an order of magnitude less than that calculated for 2015 (0.614 person-rem). This is because of the differ-

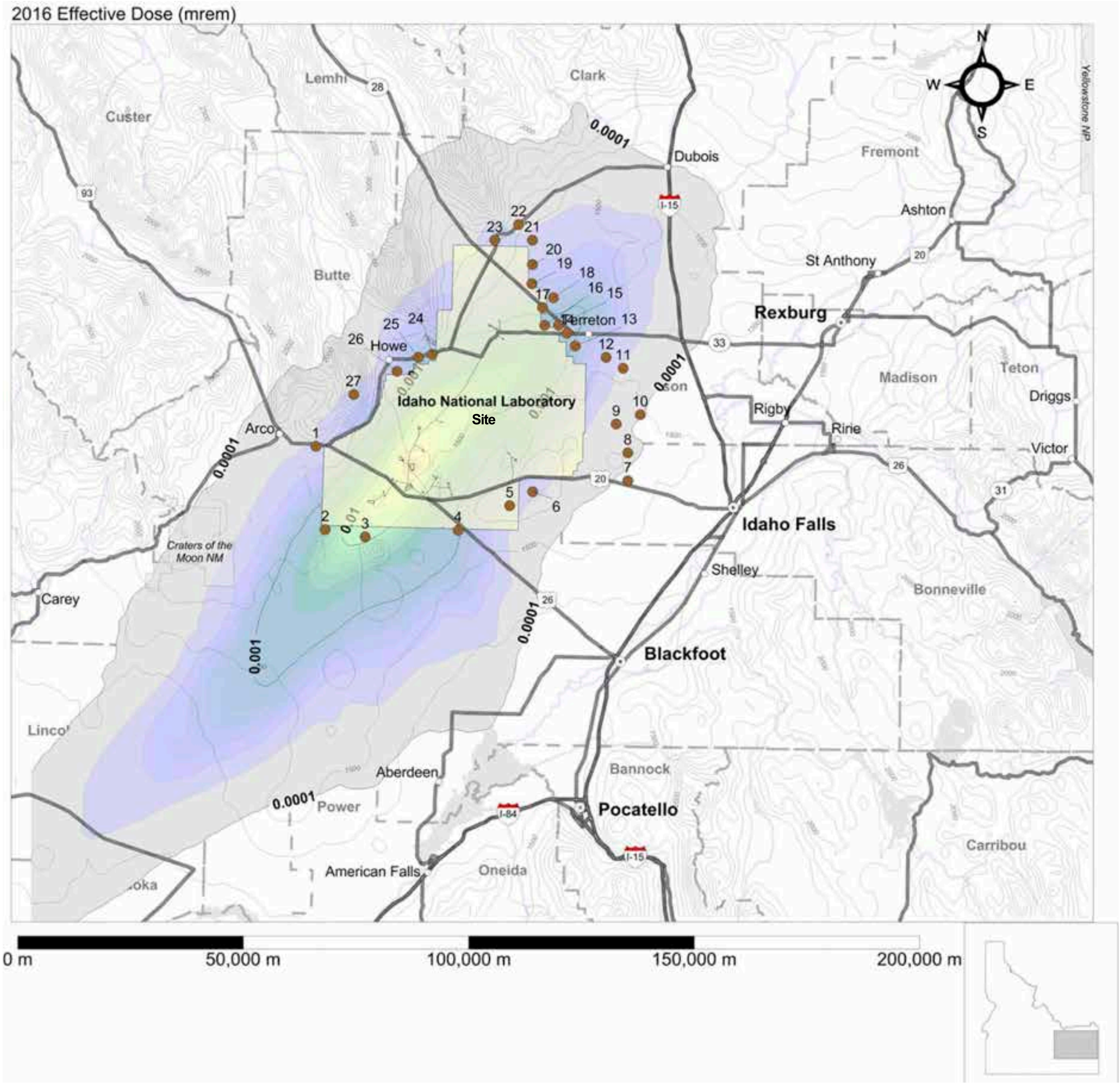

Figure 8-6. Dose Isopleth Map with Twenty-seven Boundary Receptor Locations Displayed (2016).

ent approach used to calculate the dose this year. The DOSEMM model (combined with HYSPLIT model output) produced gridded dose results, which were then used to estimate average doses within each census division. The biggest difference in the dose estimate can be attributed to the fact that last year the highest dose to a potential boundary resident was calculated using the methodology described in Appendix B of DOE-ID (2014). This conservative dose was then multiplied by the number of people in each census division and summed across census divisions to yield the population dose. In contrast, this year's dose was estimated for each census division by using an explicit estimate of the dose within each census division. For example, doses in Idaho Falls estimated with HYSPLIT and DOSEMM are substantially less that doses at the maximum boundary receptor. The average dose in the Idaho Falls census division multiplied by the population within the division would result in a lower population dose than if the Idaho Falls census division was multiplied by the dose at the maximum boundary receptor. Thus, this methodology represents a more realistic representation of dose than the previously used methodology.

The largest contributors to the average dose received by boundary receptors (Figure 8-6) were ^{129}I, contribut-

Table 8-2. Dose to Population within 80 km (50 miles) of INL Site Facilities (2016).

		Population Dose	
Census County Division[a,b]	Population[c]	Person-rem	Person-Sv
Aberdeen	3,531	8.67×10^{-4}	8.67×10^{-6}
Alridge	580	5.39×10^{-6}	5.39×10^{-8}
American Falls	8,466	3.04×10^{-3}	3.04×10^{-5}
Arbon (part)	30	1.15×10^{-6}	1.15×10^{-8}
Arco	2,628	2.07×10^{-2}	2.07×10^{-4}
Atomic City (division)	2,689	1.98×10^{-3}	1.98×10^{-5}
Blackfoot	15,644	3.78×10^{-4}	3.78×10^{-6}
Carey (part)	1,070	9.69×10^{-4}	9.69×10^{-6}
East Clark	82	1.11×10^{-5}	1.11×10^{-7}
East Madison (part)	289	7.80×10^{-6}	7.80×10^{-8}
Firth	3,276	8.14×10^{-5}	8.14×10^{-7}
Fort Hall (part)	4,507	1.63×10^{-4}	1.63×10^{-6}
Hailey-Bellevue (part)	6	4.39×10^{-7}	4.39×10^{-9}
Hamer	2,355	2.28×10^{-3}	2.28×10^{-5}
Howe	382	2.07×10^{-3}	2.07×10^{-5}
Idaho Falls	107,520	3.15×10^{-3}	3.15×10^{-5}
Idaho Falls, west	1,700	3.15×10^{-4}	3.15×10^{-6}
Inkom (part)	647	1.08×10^{-5}	1.08×10^{-7}
Island Park (part)	96	1.02×10^{-5}	1.02×10^{-7}
Leadore (part)	6	4.54×10^{-7}	4.54×10^{-9}
Lewisville-Menan	4,306	4.25×10^{-4}	4.25×10^{-6}
Mackay (part)	1,257	8.42×10^{-5}	8.42×10^{-7}
Moreland	10,646	5.86×10^{-4}	5.86×10^{-6}
Pocatello	69,526	1.97×10^{-3}	1.97×10^{-5}
Rexburg	29,372	1.79×10^{-3}	1.79×10^{-5}
Rigby	20,188	1.17×10^{-3}	1.17×10^{-5}
Ririe	2,004	4.31×10^{-5}	4.31×10^{-7}
Roberts	1,654	2.86×10^{-4}	2.86×10^{-6}
Shelley	8,869	3.05×10^{-4}	3.05×10^{-6}
South Bannock (part)	329	1.05×10^{-5}	1.05×10^{-7}
St. Anthony (part)	2,632	1.83×10^{-4}	1.83×10^{-6}
Sugar City	7,379	7.17×10^{-4}	7.17×10^{-6}
Swan Valley (part)	6,649	7.81×10^{-5}	7.81×10^{-7}
Ucon	6,649	2.97×10^{-4}	2.97×10^{-6}
West Clark	859	1.61×10^{-4}	1.61×10^{-6}
Total	**327,823**	**4.42×10^{-2}**	**4.42×10^{-4}**

a. The U.S. Census Bureau divides the country into four census regions and nine census divisions. The bureau also divides counties (or county equivalents) into census county divisions.

b. (Part) means only a part of the county census division lies within the 80 km (50 mi) radius of a major INL Site facility.

c. Population extrapolated to estimated 2016 values based on 2010 Census Report for Idaho.

ing over 50 percent of the estimated dose, and ^{241}Am, contributing 11 percent of the calculated dose. These were followed by tritium and ^{239}Pu, contributing about 8 and 7 percent, respectively. Strontium-90 and ^{41}Ar each contributed about 6 percent, and ^{14}C contributed nearly 4 percent. The relative contributions of these radionuclides to the average dose received by boundary receptors differ from the relative contributions of the same radionuclides to the MEI dose (Figure 8-3). For example, ^{129}I contributed about 19 percent of the dose to the MEI as compared to 50 percent of the average dose received by boundary receptors. This difference can be explained by the fact that a much higher air concentration of ^{129}I was projected at Frenchman's Cabin by the HYSPLIT model than was calculated using the CAP88-PC computer model. Tritium was estimated to produce nearly 23 percent of the dose to the MEI, as compared to 8 percent of the average dose received by boundary receptors. The difference can be attributed mainly to a higher concentration of tritium projected by CAP88-PC at Frenchman's Cabin, as well as the use of dose conversion factors in the CAP88-PC computer model, which are one and one-half to two times higher than the DOE dose conversion factors (DOE 2011) used to estimate the dose to a boundary resident. Other radionuclides, such as ^{41}Ar and ^{241}Am, resulted in slightly different doses to the MEI and the boundary receptors due to one or more factors: different air concentrations calculated by the two air dispersion models (CAP88-PC and HYSPLIT), different dose conversion values and agricultural transfer factors used by CAP88-PC and DOE, and different algorithms used to estimate deposition.

For 2016, INTEC contributed about 65 percent of the total population dose. The RWMC contributed more than 19 percent, and the ATR Complex accounted for just over 13 percent. All other facilities contributed a total of just under 2 percent of the total population dose.

8.3 Dose to the Public from Ingestion of Wild Game from the INL Site

The potential dose an individual may receive from occasionally ingesting meat from game animals continues to be studied at the INL Site. These studies estimate the potential dose to individuals who may eat waterfowl that briefly reside at wastewater disposal ponds at the ATR Complex and Materials and Fuels Complex (MFC), and game animals that may reside on or migrate through the INL Site.

8.3.1 Waterfowl

Waterfowl were not collected in 2016. The hypalon liners to the radiological wastewater ponds at the ATR Complex were being replaced and access to the pond areas was restricted during this period. Therefore the dose for an individual who might eat a contaminated duck was not estimated for 2016.

8.3.2 Big Game Animals

A study on the INL Site from 1972 to 1976 conservatively estimated the potential whole-body dose that could be received from an individual eating the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity found in these animals was 2.7 mrem (27 µSv) (Markham et al. 1982). Game animals collected at the INL Site during the past few years have generally shown much lower concentrations of radionuclides. In 2016, none of the five game animals collected (four mule deer and one pronghorn) had a detectable concentration of ^{137}Cs or other human-made radionuclides. Therefore, no dose would be associated with the consumption of these animals.

The contribution of game animal consumption to the population dose has not been calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford et al. 1983). The total population dose contribution from these pathways would, realistically, be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

8.4 Dose to the Public from Drinking Contaminated Groundwater from the INL Site

Tritium has previously been detected in three U.S. Geological Survey monitoring wells located along the southern boundary of the INL Site (Mann and Cecil, 1990). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration (3,400 ± 200 pCi/L) in 2016 is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). The maximum contaminant level corresponds to a dose from the drinking water ingestion pathway of 4 mrem/yr. An individual drinking water from these wells would hypothetically receive a dose of less than 0.2 mrem (2.0 µSv) in one year. Because these wells are not used for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to the MEI.

8.5 Dose to the Public from Direct Radiation Exposure along INL Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters and optically stimulated luminescence dosimeters (Figure 7-7). In 2016, the external radiation measured along the INL Site boundary was statistically equivalent to that of background radiation and, therefore, does not represent a dose resulting from INL Site operations.

8.6 Dose to the Public from All Pathways

DOE Order 458.1 establishes a radiation dose limit to a member of the general public from all possible pathways as a result of DOE facility operations. This limit is 100 mrem/yr (1 mSv/yr) above the dose from background radiation and includes the air transport, ingestion, and direct exposure pathways. For 2016, the only probable pathways from INL Site activities to a realistic MEI include the air transport pathway and ingestion of game animals.

The hypothetical individual, assumed to live at Frenchman's Cabin (Receptor 3 in Figure 8-6), would receive a calculated dose from INL Site airborne releases reported for 2016 (Section 8.2.1). No dose was calculated from eating game animals in 2016 (see Sections 8.3.1 and 8.3.2).

The dose estimate for an offsite MEI is presented in Table 8-3. The total dose was conservatively estimated to be 0.0143 mrem (1.43µSv) for 2016. The total dose calculated to be received by the hypothetical MEI for 2016 represents about 0.004 percent of the dose expected to be received from background radiation (383 mrem [3.8 mSv], as shown in Table 7.5) and is well below the 100 mrem/yr (1 mSv/yr) public dose limit above background established by DOE. As discussed in the Helpful Information section of this report, the 100 mrem/yr limit is far below the exposure levels that cause acute health effects.

The dose received by the entire population within 80 km (50 mi) of INL Site facilities was calculated to be 4.42×10^{-2} person-rem (4.42×10^{-4} person-Sv) (Table 8-2). This is approximately 0.000035 percent of the dose (125,556 person-rem, [1,256 person-Sv]) expected from exposure to natural background radiation in the region.

8.7 Dose to Biota

8.7.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following absorbed doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The first step in the graded approach uses conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media, termed "Biota Concentration Guides." Each Biota Concentration Guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organism populations. Instead, it is an indication that more realistic model assumptions may be necessary.

If the screening process indicates the need for a more site-specific analysis, an analysis is performed using site-representative parameters (e.g., distribution coefficients, bioconcentration factors) instead of the more conservative default parameters. This is Level 2 in RESRAD-Biota.

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters that represent contributions to the organism internal dose (e.g., body mass, consumption rate of food/soil, inhalation rate, lifespan, biological elimination rates) can be modified to represent site- and organism-specific characteristics. The kinetic model

Table 8-3. Contribution to Estimated Annual Dose to a Maximally Exposed Individual by Pathway (2016).

Pathway	Annual Dose to Maximally Exposed Individual		Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose		Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
	(mrem)	(µSv)		(person-rem)	(person-Sv)		
Air	0.0143	0.143	0.0143	0.04	0.0004	327,823	125,556
Waterfowl[c]	NA[d]	NA	NA	NA	NA	NA	NA
Big game animals	0	0	NA	0	0	NA	NA
Total pathways	**0.0143**	**0.143**	**0.0143**	**0.04**	**0.0004**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.

b. The individual dose from background was estimated to be 383 mrem (3.8 mSv) in 2016 (Table 7-4).

c. Waterfowl were not collected in 2016

d. NA = Not applicable

employs equations relating body mass to internal dose parameters. At Level 3, bioaccumulation (the process by which biota concentrate contaminants from the surrounding environment) can be modeled to estimate the dose to a plant or animal. Alternatively, concentrations of radionuclides measured in the tissue of an organism can be input into RESRAD-Biota to estimate the dose to the organism.

The final step in the graded approach involves an actual site-specific biota dose assessment. This would include a problem formulation, analysis, and risk characterization protocol similar to that recommended by EPA (1998). RESRAD-Biota cannot perform these calculations.

8.7.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2016 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s (Jessmore et al. 1994). In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with facilities shown in Figure 1-3 and include:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- INTEC
- Large Grid, a 24-mile radius around INTEC
- MFC
- Naval Reactors Facility
- RWMC
- Test Area North.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in INL Site soil were used (Table 8-4). The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, and 2015 (soil samples were not collected on the INL Site in 2016.)

Using the maximum radionuclide concentrations for all locations in Table 8-4, a screening level analysis was made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in ponds at the INL Site was for the MFC Industrial Waste Pond (Table C-17). The results for ura-

Table 8-4. Concentrations of Radionuclides in INL Site Soils, by Area.

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b]	
		Minimum	Maximum
ARA	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	3.02
	Strontium-90	2.10×10^{-1}	3.70×10^{-1}
	Plutonium-238	------[c]	3.90×10^{-3}
	Plutonium-239/240	1.30×10^{-2}	1.80×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
ATR Complex	Cesium-137	2.00×10^{-1}	6.10×10^{-1}
	Strontium-90	------	5.82×10^{-2}
	Plutonium-238	5.90×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	1.70×10^{-2}	2.18×10^{-2}
CITRC	Cesium-137	1.50×10^{-1}	1.90×10^{-1}
MFC	Cesium-134	4.00×10^{-2}	6.00×10^{-2}
	Cesium-137	1.20×10^{-1}	4.90×10^{-1}
	Cobalt-60	------	5.00×10^{-2}
	Plutonium-239/240	1.50×10^{-2}	2.90×10^{-2}
	Americium-241	4.30×10^{-3}	1.20×10^{-2}
INTEC	Cesium-134	------	8.00×10^{-2}
	Cesium-137	3.00×10^{-2}	3.54
	Strontium-90	4.90×10^{-1}	7.10×10^{-1}
	Plutonium-238	2.50×10^{-2}	4.30×10^{-2}
	Plutonium-239/240	1.10×10^{-2}	2.90×10^{-2}
	Americium-241	6.10×10^{-3}	8.10×10^{-3}
Air Monitors	Cesium-134	4.00×10^{-2}	5.00×10^{-2}
	Cesium-137	2.00×10^{-2}	9.70×10^{-1}
NRF	Cesium-134	------	6.00×10^{-2}
	Cesium-137	------	3.30×10^{-1}
	Plutonium-239/240	5.70×10^{-3}	1.60×10^{-2}
	Americium-241	4.30×10^{-3}	9.70×10^{-3}
RWMC	Cesium-134	3.00×10^{-2}	9.00×10^{-2}
	Cesium-137	1.20×10^{-1}	3.13
	Srontium-90	1.01×10^{-1}	3.49×10^{-1}
	Plutonium-238	2.19×10^{-3}	1.51×10^{-2}
	Plutonium-239/240	1.9×10^{-2}	9.46×10^{-1}
	Americium-241[d]	4.8×10^{-2}	6.35×10^{-1}
TAN/SMC	Cesium-134	4.00×10^{-2}	6.00×10^{-2}
	Cesium-137	1.10×10^{-1}	3.13
	Plutonium-239/240	1.25×10^{-2}	1.74×10^{-2}
	Americium-241	3.20×10^{-3}	5.70×10^{-3}
All	Cesium-134	3.00×10^{-2}	9.60×10^{-2}
	Cesium-137	2.00×10^{-2}	3.54
	Cobalt-60	------	5.00×10^{-2}
	Strontium-90	1.23×10^{-2}	7.10×10^{-1}
	Plutonium-238	2.19×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	5.70×10^{-3}	9.46×10^{-1}
	Americium-241[d]	3.20×10^{-3}	6.35×10^{-1}

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CITRC = Critical Infrastructure Test Range Complex; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability

b. Legend:

a.	Results measured in 2014 using in situ gamma spectroscopy.
b.	Results measured by laboratory analyses of soil samples collected in 2005.
c.	Results measured by laboratory analyses of soil samples collected in 2006.
d.	Results measured by laboratory analyses of soil samples collected in 2012.
e.	Result measured in 2013 using in situ gamma spectroscopy. Not measured in 2014.
f.	Result measured by laboratory analyses of soil samples collected in 2015.

c. '-----' indicates that only one measurement was taken and is reported as the maximum result.

d. The data were the results of laboratory analysis for Americium-241 in soil samples.

nium-233/234 ($^{233/234}$U) and uranium-238 (^{238}U) in Table C-17, 1.14 pCi/L and 0.68 pCi/ respectively, were thus used to represent surface water concentrations. When $^{233/234}$U was reported, it was assumed that he radionuclide present was ^{233}U.

The combined sum of fractions was less than one for both terrestrial animals (0.211) and plants (0.00201) and passed the general screening test (Table 8-5). Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

8.7.3 Aquatic Evaluation

Maximum radionuclide concentrations reported in Table C-17 (results for the MFC Industrial Waste Pond) were also used for aquatic evaluation. Potassium-40 reported in ponds was assumed to be of natural origin and was not included in the 2016 calculations.

The results shown in Table 8-6 indicate that INL Site-related radioactivity in ponds and liquid effluents is not harming aquatic biota. The combined sum of fractions was less than one for both aquatic animals (8.76E-03) and riparian animals (2.45E-03).

8.8 Doses from Unplanned Releases

No unplanned radioactive releases from the INL site were reported in 2016. As such, there are no doses associated with unplanned releases during 2016.

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Table 8-5. RESRAD-Biota 1.5 Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2016).

Terrestrial Animal						
	Water			Soil		
Nuclide	**Concentration (pCi/L)**	**BCG[a] (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Americium-241	0	2.02E+05	0.00E+00	0.635	3.89E+03	1.63E-04
Cobalt-60	0	1.19E+06	0.00E+00	0.05	6.92E+02	7.23E-05
Cesium-134	0	3.26E+05	0.00E+00	0.096	1.13E+01	8.50E-03
Cesium-137	0	5.99E+05	0.00E+00	3.54	2.08E+01	1.71E-01
Plutonium-238	0	1.89E+05	0.00E+00	0.043	5.27E+03	8.16E-06
Plutonium-239	0	2.00E+05	0.00E+00	0.946	6.11E+03	1.55E-04
Strontium-90	0	5.45E+04	0.00E+00	0.71	2.25E+01	3.16E-02
Uranium-233	1.14	4.01E+05	2.84E-06	0	4.83E+03	0.00E+00
Uranium-238	0.68	4.06E+05	1.68E-06	0	1.58E+03	0.00E+00
Summed	-	-	**4.52E-06**	-	-	**2.11E-01**

Terrestrial Plant						
	Water			Soil		
Nuclide	**Concentration (pCi/L)**	**BCG (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Americium-241	0	7.04E+08	0.00E+00	0.635	2.15E+04	2.95E-05
Cobalt-60	0	1.49E+07	0.00E+00	0.05	6.13E+03	8.16E-06
Cesium-134	0	2.28E+07	0.00E+00	0.096	1.09E+03	8.84E-05
Cesium-137	0	4.93E+07	0.00E+00	3.54	2.21E+03	1.60E-03
Plutonium-238	0	3.95E+09	0.00E+00	0.043	1.75E+04	2.46E-06
Plutonium-239	0	7.04E+09	0.00E+00	0.946	1.27E+04	7.46E-05
Strontium-90	0	3.52E+07	0.00E+00	0.71	3.58E+03	1.98E-04
Uranium-233	1.14	1.06E+10	1.08E-10	0	5.23E+04	0.00E+00
Uranium-238	0.68	4.28E+07	1.59E-08	0	1.57E+04	0.00E+00
Summed	-	-	**1.60E-08**	-	-	**2.00E-03**

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

Table 8-6. RESRAD-Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2016).

Aquatic Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Uranium-233	1.17	2.00E+02	5.71E-03	0.0785	1.06E+07	5.38E-09
Uranium-238	0.68	2.23E+02	3.05E-03	0.02975	4.28E+04	7.94E-07
Summed	-	-	**8.76E-03**	-	-	**7.99E-07**

Riparian Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Uranium-233	1.17	6.76E+02	1.69E-03	0.0785	5.28E+03	1.08E-05
Uranium-238	0.38	7.56E+02	7.56E-04	0.02975	2.49E+03	1.37E-05
Summed	-	-	**2.45E-03**	-	-	**2.45E-05**

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

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INL Site Sunrise

Greater Sage-grouse
Centrocercus urophasianus

9. Monitoring Wildlife Populations

Field data are routinely collected on several key groups of wildlife at the Idaho National Laboratory (INL) Site for information that can be used to prepare National Environmental Policy Act documents and to enable the U.S. Department of Energy, Idaho Operations Office (DOE-ID) to make informed decisions, based on species use of the INL Site and historical trends, for planning projects and complying with state and federal regulations, environmental policies and executive orders related to protection of wildlife. During 2016, sage-grouse, raven nest, midwinter eagle, breeding bird, bat, and rabbit/hare surveys were conducted on the INL Site and are highlighted as follows:

After greater sage-grouse (hereafter sage-grouse) were petitioned for listing under the Endangered Species Act (ESA), DOE-ID has worked to conserve the species and the sagebrush habitat upon which it relies on the INL Site. As a result, DOE-ID has reduced the likelihood that a sage-grouse ESA listing would impact future mission activities. In 2014, DOE-ID entered into a Candidate Conservation Agreement (CCA) with the U.S. Fish and Wildlife Service (FWS) and committed to implement conservation measures and objectives to avoid or minimize threats to sage-grouse and its habitats. The CCA established a population trigger that, if tripped by declining male lek attendance (a surrogate for population size), would initiate a prescribed response by FWS and DOE-ID. Lek route data collected by the Environmental Surveillance, Education, and Research (ESER) program suggest that the sage-grouse breeding population on the INL Site was stable to increasing from 1999–2006, after which it declined, perhaps until 2012. Male lek attendance has increased steadily during the past three years and is currently at 152 percent of the population trigger threshold.

The common raven (hereafter raven) preys upon sage-grouse eggs and chicks, and mated raven pairs may be more effective than unmated ravens at finding and depredating nests. To determine if mated raven pairs that use INL Site infrastructure (e.g. power lines) as nesting substrates are increasing, the ESER program began in 2014 to annually survey all infrastructure across the INL Site for active raven nests. Biologists documented 44 active raven nests on INL Site infrastructure in 2016, a 34 percent increase since 2014 and an average increase of 7.5 nests per year.

The midwinter eagle survey has been conducted every January, as part of the national Midwinter Bald Eagle Survey, since 1983. Along with identifying and documenting bald eagles, researchers also identify all raptors, golden eagles, ravens, and other selected bird species. In 2016, observers recorded more ravens than in any other year dating back to 2001. Rough-legged hawk observations were up steeply from last year and golden eagle observations were higher than any years since 2006. These higher numbers may be due, at least in part, to high jackrabbit abundance (see below).

The North American Breeding Bird Survey was developed in the 1960s by the FWS along with the Canadian Wildlife Service to document trends in bird populations. The INL Site has five official Breeding Bird Survey routes, established in 1985, and eight additional routes which border INL Site facilities. During 2016 surveys, over 3,000 Franklin's gulls were observed flying across the eastern side of the INL Site. This anomaly probably occurred because a food resource emerged somewhere to the southwest of the Site. Raven observations were the third highest since surveys began in 1985, and all three of the highest years have been since 2010. Two sagebrush-obligate songbirds—sagebrush sparrow and Brewer's sparrow—have been at historic lows since the large fires in 2010 and 2011, during which thousands of acres of sagebrush were destroyed.

Bats have been researched at the INL Site for several decades. Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves. To assess bat activity and species occurrence at critical features, a program of passive acoustic monitoring of bat calls was initiated in by ESER in 2012. In 2016 a program of active acoustic driving survey transects were continued for bats on the INL Site. In addition, monitoring of hibernating bat populations is conducted biennially.

Rabbit and hare surveys were reinstated in 2016 on a 45-km (30-mi) transect on the eastern side of the INL Site. These surveys were conducted from 1980–2007 to serve as an indicator of jackrabbit population eruptions for the benefit of neighboring agriculture producers. Peak jackrabbit populations can significantly increase nuisance wildlife issues at facilities, affecting INL Site operations by triggering false security alarms; attracting predators and scavengers to fenced areas; and increasing wildlife exclusion, deterrent, and carcass removal efforts. The purpose of the reinitiated surveys is to obtain current data on rabbit and hare populations and to determine if both jackrabbit and sage-grouse populations are peaking. In 2016, biologists observed a mean of 520 jackrabbits during three night-time spotlight surveys. This number is higher than any other year surveyed between 1980 and 2007, except 1981. Although it will take many years of data to determine if a correlation exists between jackrabbit and sage-grouse population trends, both sage-grouse and jackrabbit populations were at relatively high levels in 2016.

9. MONITORING WILDLIFE POPULATIONS

The Environmental Surveillance, Education, and Research Program (ESER) contractor has historically collected data on several key groups of wildlife that occupy the Idaho National Laboratory (INL) Site, including greater sage-grouse, raptors, rabbits/hares, breeding birds, and bats. These surveys provide the U.S. Department of Energy, Idaho Operations Office (DOE-ID) with an understanding of how these species use the INL Site, and context for analyzing historical trends. This information is often used in National Environmental Policy Act (NEPA 1970) documents and enables DOE-ID officials to make informed decisions for project planning and to maintain up-to-date information on potentially sensitive species on the INL Site. These surveys also support DOE-ID's compliance with several regulations, agreements, policies and executive orders including:

- Migratory Bird Treaty Act (MBTA) (1918)
- Bald and Golden Eagle Protection Act (1940)
- Executive Order 11514 (1970); Protection and Enhancement of Environmental Quality—(Created in furtherance of the purpose and policy of National Environmental Policy Act, directs federal agencies to monitor, evaluate, and control—on a continuing basis—their activities to protect and enhance the quality of the environment)
- Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (2011)
- Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service (FWS) regarding implementation of Executive Order 13186, responsibilities of federal agencies to protect migratory birds (Federal Register 2013)
- Candidate Conservation Agreement (CCA) for greater sage-grouse on the Idaho National Laboratory Site (DOE-ID and FWS 2014)
- MBTA Special Purpose Permit with FWS.

In the following sections, we summarize results from wildlife surveys conducted by the ESER contractor on the INL Site during 2016.

9.1 Sage-grouse

Populations of sage-grouse have declined in recent decades (Connelly et al. 2004), and the species' range-wide distribution across western North America has been reduced to nearly half of its historic distribution (Schroeder et al. 2004, Connelly et al. 2011a). Although the rate of decline of this species has slowed over the past two decades (Connelly et al. 2004, Garton et al. 2011), there is concern for the future of sage-grouse because of its reliance on sagebrush (*Artemisia spp*.), which is a central component in an ecosystem that has been greatly altered during the past 150 years and is currently at risk from a variety of threats (Knick et al. 2003, Connelly et al. 2004). Not only are healthy stands of sagebrush necessary year-round for sage-grouse to survive, but, during summer, young sage-grouse also require a diverse understory of native forbs and grasses. This vegetation provides protection from predators and supplies high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011b).

In 2014, DOE-ID entered into a CCA with the FWS to conserve sage-grouse and the habitats upon which it depends across the INL Site (DOE-ID and FWS 2014). This voluntary agreement established a Sage-Grouse Conservation Area (SGCA) where infrastructure development and human disturbance would be limited (Figure 9-1). To guard against sage-grouse declines, the CCA includes a population trigger that, if tripped by declining male lek attendance, would initiate an automatic response by both the FWS and DOE-ID. The population trigger is set to trip if there is a 20 percent or greater reduction in the three-year average peak male attendance on a set of 27 baseline leks within the SGCA.

The CCA established a monitoring program based on this trigger threshold and other criteria (Shurtliff et al. 2016). Part of the program includes annual surveys of sage-grouse leks on the INL Site. A lek is a traditional breeding site, located near nesting habitat, where sage-grouse return each spring to display and mate (Jenni and Hartzler 1978). Counting males annually at lek sites is the best way to document trends in sage-grouse abundance (Jenni and Hartzler 1978, Connelly et al. 2003,

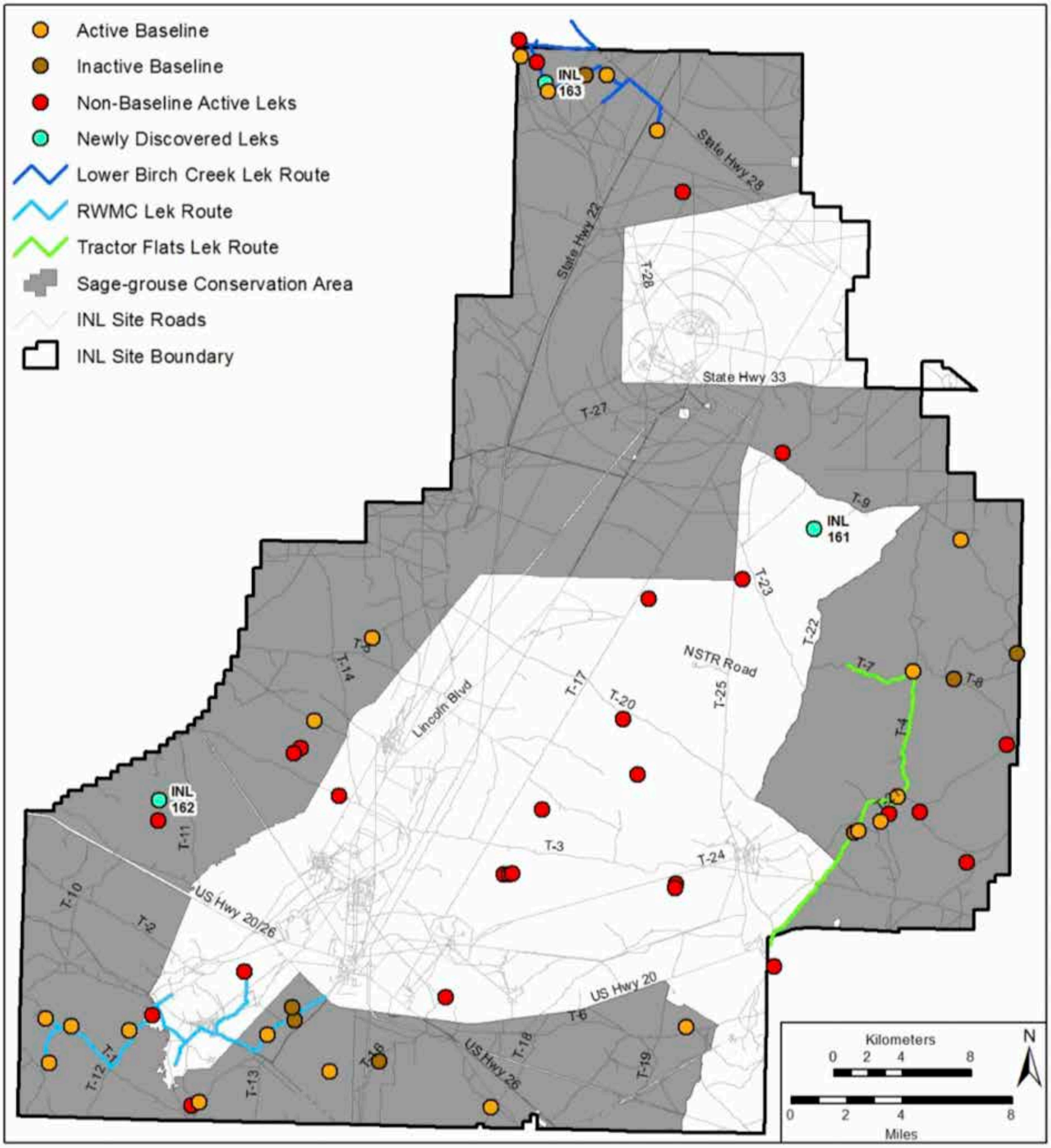


Figure 9-1. Twenty-seven Baseline Leks (Both Active and Non-active) and Other Active Leks that were Surveyed in 2016. One baseline lek was subsequently reclassified as inactive following the surveys. Also shown are three new leks discovered in 2016.

Garton et al. 2011). Because sage-grouse abundance varies naturally from year to year, biologists use a three-year running average of the peak male attendance across 27 baseline leks to calculate trends relative to the population trigger. In addition, other active and non-active leks on the INL Site are surveyed each year for the purpose of understanding population dynamics.

In 2013, DOE-ID formalized the following three monitoring tasks designed to track the number of male sage-grouse at active leks and document additional active leks on the INL Site (DOE-ID and FWS 2014). The general tasks and their purposes are:

1) ***Lek Census and Route Surveys*** – Surveys of all active leks on the INL Site, including leks on three Idaho Department of Fish and Game (IDFG) survey routes. A subset of these leks comprise the baseline set to which the CCA population trigger is linked. Inactive leks that are included on IDFG routes or the baseline set are also surveyed under this task.
2) ***Historical Lek Surveys*** – Surveys of sites where sage-grouse have been observed displaying in the past. The purpose is to determine if grouse still use those areas.
3) ***Systematic Lek Discovery Surveys*** – Surveys of poorly sampled regions of the INL Site. The purpose is to discover additional active leks, especially within the SGCA.

Task 1—Lek Census and Route Surveys

Summary of Results: The 3-year average peak male attendance (2014-2016) across the 27 baseline leks in the SGCA was 13 percent higher than last year and is now 152 percent of the population trigger threshold. Lek route data suggest that the sage-grouse breeding population on the INL Site was stable or increasing from 1999–2006, after which it declined, perhaps until 2012. Male lek attendance has increased steadily during the past three years.

In 2016, ESER biologists surveyed all 48 leks classified as active on or near the INL Site from three to seven times each (Shurtliff et al. 2017). These leks were partitioned into three different categories for analysis, with some leks occurring in more than one category.

SGCA Baseline Leks: With regard to the CCA population trigger, the most important category consists of the 27 leks that were used to establish the original value upon which the trigger is based. The sum of peak male attendance counts across the 27 leks in 2016 was 471, a 41 percent increase over 2015. The three-year mean (2014–2016) is now 384 males, which is 13 percent higher than last year's 2013–2015 mean (Figure 9-2), and 152 percent of the threshold (153 males) that would trigger prescribed action by DOE-ID and the FWS (DOE-ID and FWS 2014). The three-year mean has been stable or has increased each of the past three years.

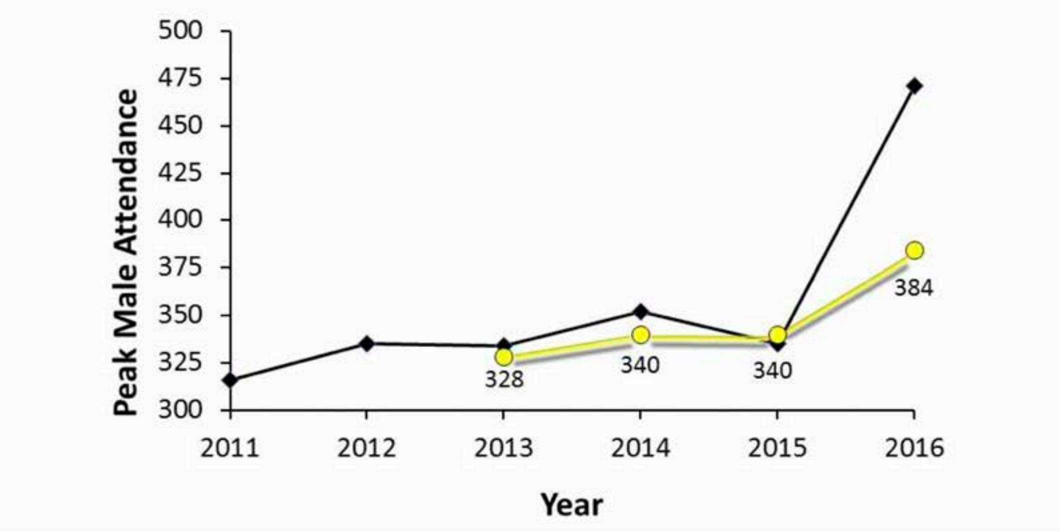


Figure 9-2. Peak Male Attendance on 27 Leks in the SGCA Used to Calculate the Original Baseline Value. Black diamonds represent annual counts, and yellow dots represent the three-year running average.

Following the 2016 field season, 19 baseline leks remain classified as active (one was reclassified as inactive). In each of the past four years, at least one baseline lek per year has been reclassified as inactive. These results should not be interpreted as evidence that eight leks have been abandoned in the past four years but rather that at least five years of data have accumulated for most leks, allowing for more precise lek classifications (Whiting et al. 2014). As noted above, the total number of male sage-grouse attending the active leks is higher than it has been since the baseline was established.

Other Active Leks: All other known active leks, whether in or out of the SGCA, which are not part of the baseline set described above, fall into a second analysis category. In 2016, we surveyed 30 additional (i.e., non-baseline) active leks a mean of 3.8 times each (range: 1–7, SD: 1.5), and serendipitously, discovered one new lek (INL 162, north of US Highway 20/26 on west portion of INL Site, see Figure 9-1). Average peak male attendance was 10.1 males per lek (range: 0–38, SD: 11.5), down from 10.6 males per lek in 2015 (*n* = 23) and 13.2 males per lek in 2014 (*n* = 20). The apparent downward trend is a reflection on the size of leks that have been added to the survey list in recent years. For example, the average peak male attendance at nine active leks surveyed in 2016 that were not classified as active in 2015 was 6.4 males.

Lek Routes: The third category includes all leks, both active and inactive, that are part of three lek routes established by the IDFG. These routes, Lower Birch Creek, Tractor Flats, and Radioactive Waste Management Complex (RWMC), have been monitored annually since 1999 and they provide historical context for interpreting abundance trends on the INL Site (Shurtliff et al. 2016).

The average number of males per lek surveyed (MPLS) decreased on the Tractor Flats route from a three-year mean of 39.1 (1999–2001) to a low of 7.6 in 2013 (Figure 9-3). During the past three years, however,

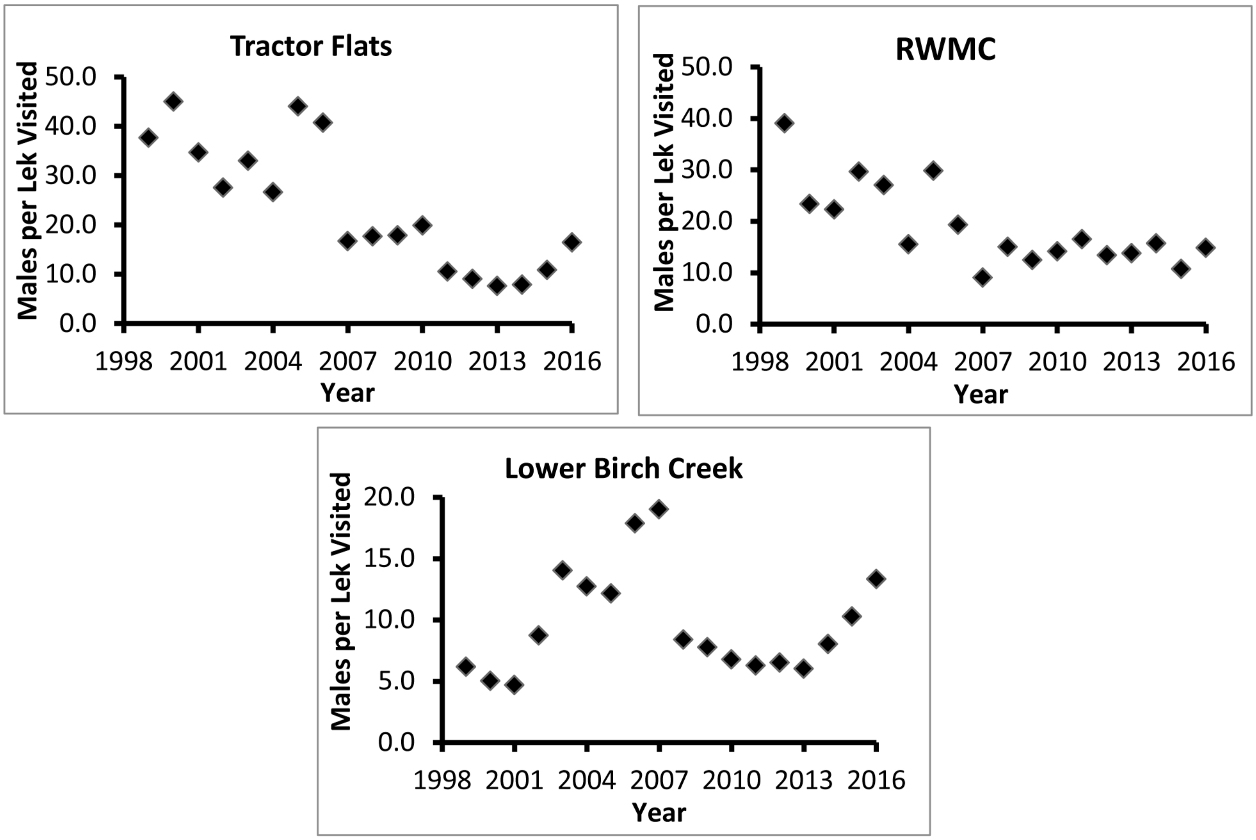


Figure 9-3. Mean Number of Males Per Lek Surveyed at Peak Male Attendance on Three IDFG Lek Routes from 1999-2016 on the INL Site. The number of leks visited each year increased over time as follows: Tractor Flats (3-7 leks), RWMC (2-9 leks), and Lower Birch Creek (6-10 leks). Note that the Y-axis is at a different scale

male attendance has increased steadily to 16.4 MPLS in 2016, which is the highest level since 2010 (19.8 MPLS). The RWMC lek route has been stable since 2008, ranging from 10.7–15.7 MPLS. The Lower Birch Creek route has exhibited low variability between consecutive years during the past nine years, and after declining from 8.4–6.0 MPLS between 2008 and 2013, the route has steadily increased each of the past three years, reaching 13.3 MPLS in 2016. Only three of the past 18 years had a higher MPLS than in 2016.

The downward trend on the Tractor Flats route since 1999 likely reflects local impacts of wildland fire on sage-grouse nesting habitat near the lek route. A 164 km^2 (40,539 acres) fire burned over a lek that was at the northern end of the route in 1999. By 2004, this lek, which was one of five on the route, was vacated. In 2010, the Jefferson fire burned 52 percent of the lek route (9.7 km) and one more of the six leks that were surveyed annually at that time. Therefore, by 2011, a third of the leks that were part of the official route were within a large burned area. No other lek routes had fires that burned over any leks or any part of the lek route.

Taken together, lek route data on the INL Site suggest that the sage-grouse breeding population was stable to increasing between 1999–2006, with a peak occurring from 2005–2007. By 2008, male attendance (and presumably abundance) was substantially lower and may have continued to decline through 2012. Male attendance has increased steadily during the past three years.

Task 2—Historical Lek Surveys

Summary of Results: No sage-grouse were observed on any of the 15 historical lek sites surveyed in 2016. Following the breeding season, ten of these lek sites were reclassified as inactive, and five remain to be surveyed in 2017.

During the past several decades, many leks have been documented on the INL Site as a result of surveys and opportunistic observations of displaying sage-grouse (Whiting and Bybee 2011). Prior to 2009, many of these historical lek sites had not been surveyed for nearly 30 years. Since 2009, ESER biologists have revisited a subset of historical leks each spring to determine if the leks remain active based on current criteria (DOE-ID and FWS 2014). The objective of Task 2 was to determine which historical leks are active before establishing new lek routes (DOE-ID and FWS 2014).

We surveyed all historical leks two times each, both inside (*n* = 7) and outside (*n* = 8) the SGCA. No sage-grouse were observed on any of these 15 potential lek sites. Following the 2016 surveys, we reclassified ten historical leks as inactive because they had been surveyed at least four years and there was no longer a chance of breeding activity being recorded in at least two out of five years (Whiting et al. 2014; Figure 9-4). Five historical leks remain, all of which will require one additional survey season before they can be reclassified. Because the status of these five leks remains in question, and because all of these are well outside the SGCA, none of the five leks were considered when we created new lek routes this year.

Task 3—Systematic Lek Discovery Surveys

Summary of Results: Two active leks were discovered in 2016. Five leks have been documented on the INL Site under Task 3 since 2013.

Known lek sites are few or absent across large portions of the SGCA (Figure 9-1), even though habitat in these areas often appears to be adequate to support sage-grouse breeding and nesting activities (DOE-ID and FWS 2014). The objective of Task 3 is to survey suitable sage-grouse habitat within and near the SGCA where no leks are known to exist. Since 2013, ESER has systematically searched for unknown leks each spring. If a lek is discovered, it is included thereafter in ESER's annual monitoring program.

Between March 28 and May 3, 2016, we completed 85 surveys (66 road, 19 remote) within the northeastern and southeastern sections of the INL Site and discovered one active sage-grouse lek (INL161, Figure 9-5). After two surveys, the high count on INL161 was seven males. Since surveys began in 2013, we have discovered five leks through Task 3.

9.1.1 Summary of Known Active Leks and of Changes in Lek Classification

At the end of the 2015 field season, 48 leks were classified as active on or near the INL Site, including two just outside the Site boundaries that are part of the IDFG survey routes. In 2016, two leks were downgraded to inactive status. One was burned over during the 2011 T-17 fire (Figure 9-6, northern-most red dot), and no males have been seen at that site since 2013. The other site (southern-most red dot) was formerly classified as an historical lek. Three males and 26 sage-grouse of unknown gender were seen at that site only once in 2014, and no more than one sage-grouse has been observed at

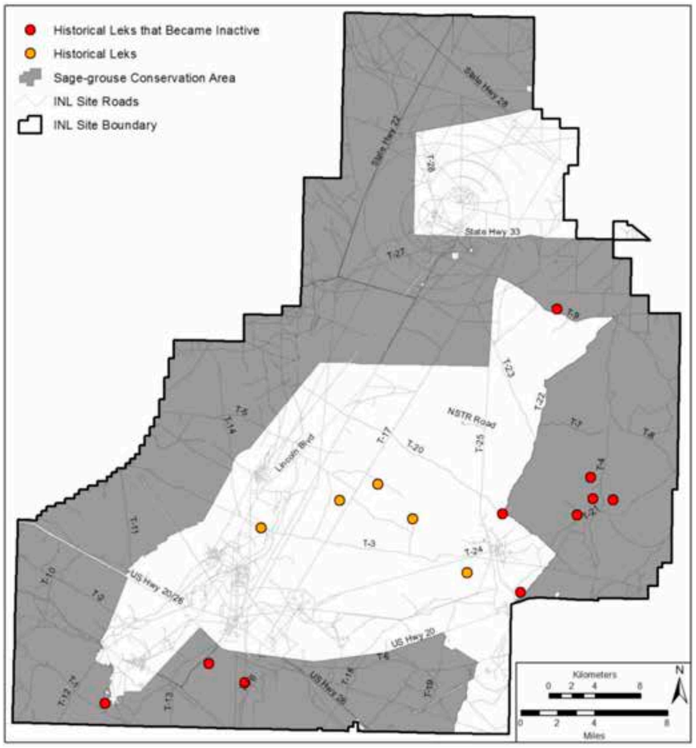


Figure 9-4. Historical Leks Surveyed in 2016. Those reclassified as inactive following the field season are shown in red.

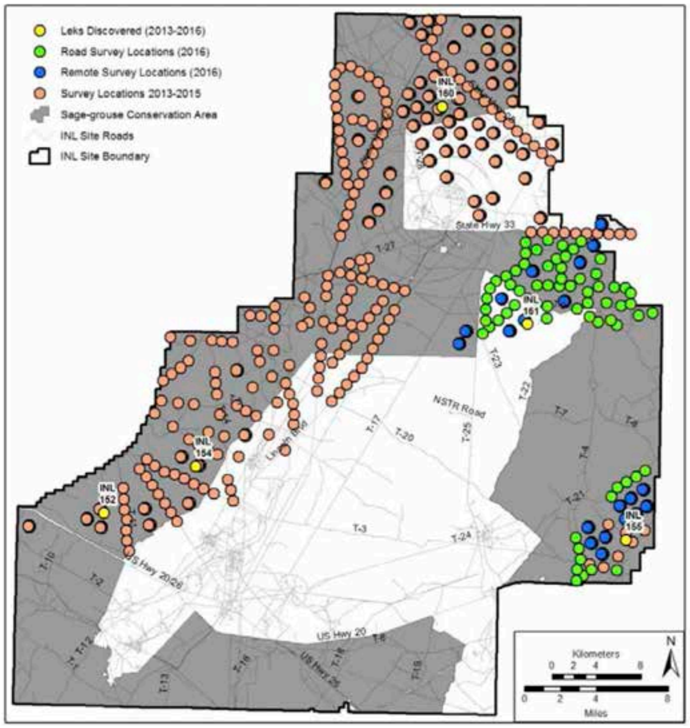


Figure 9-5. Locations of Task 3 Surveys Conducted Since 2013. All active leks discovered as a result of these surveys are indicated by yellow dots.

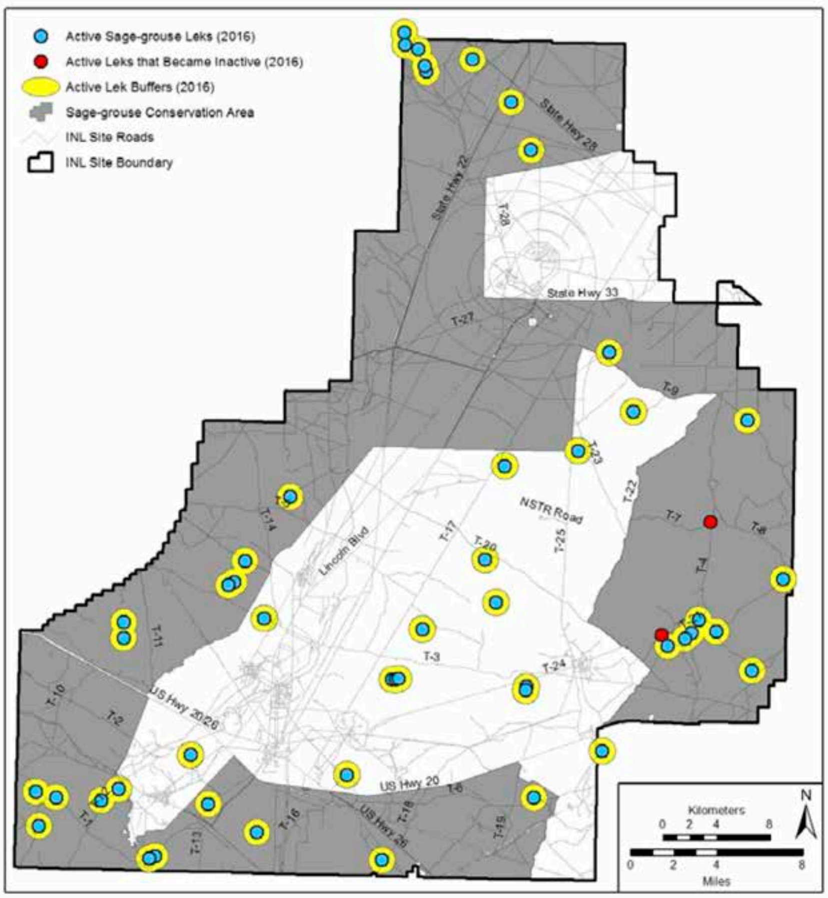


Figure 9-6. Following the 2016 Field Season, the Locations of 49 Active Leks and Two that were Reclassified as Inactive On or Near the INL Site.

that site before or since that day in 2014 during the past five years.

Three new leks were discovered in 2016 (one during discovery surveys and two Task 1 lek surveys; Figure 9-1). Therefore, the total number of known active leks on or near the INL Site is currently 49 (Figure 9-6).

9.2 Raven Nest Surveys

Summary of Results: Raven nesting on INL Site infrastructure increased 34 percent over three years, at an average rate of 7.5 nests per year. Power line nesting increased over the same period at an even higher rate—43 percent. We predict that two or three times the current number of raven nesting pairs could occupy INL Site infrastructure in the future. It is unclear if this substantial increase in nest predators would impact sage-grouse reproductive success, but ravens have been found to be effective nest predators elsewhere.

Background

The common raven is a native bird of high intelligence that adapts well to human disturbance and habitat fragmentation. Ravens prey on sage-grouse eggs and chicks, and consequently they may directly impact a species that DOE-ID is striving to conserve in partnership with other federal and state agencies. Raven observations made during annual breeding bird surveys have been steadily increasing over the past 30 years, mirroring trends across western North America (Sauer et al. 2014).

In the CCA, DOE-ID committed to support research aimed at developing methods for deterring raven nesting on utility structures (*Conservation Measure 10*; DOE-ID and FWS 2014). The objective of this task is to annually survey all man-made structures on the INL Site that could potentially be used by ravens as nesting substrates and document the number and location of active nest sites. These data will allow DOE-ID to determine the trend of raven nesting and decide how and when to begin testing nest deterrent designs.

Results and Discussion

Survey Results: We observed 46 active raven nests on man-made structures (Table 9-1), 35 of which (76 percent) were on power line structures. All power line nests were on transmission structures, including one on a large lattice structure next to a transmission line that is used for power grid tests. Eight active nests were at facilities (Table 9-2) and three were on towers (two meteorological towers and one cellular tower; Figure 9-7). Ravens nested on the same two towers within the SGCA that they occupied last year, despite efforts by the National

Table 9-1. Summary of Raven Nest Data Collected During Surveys of INL Site Infrastructure. Nests suspected of being second or third nest-building attempts by a single breeding pair were removed from columns labeled "Adjusted".

Year	Active Nests: (Total)	Active Nests: (Adjusted)	Active Nests: Percent Increase (Adjusted)	Power Line Nests: (Total)	Power Line Nests: (Adjusted)	Power Line Nests: Percent increase (Adjusted)	Nearest Nests (m)	Mean (σ) Nest Distance (m)
2014	35	29	N/A	29	23	N/A	1,525	3,366 (1,440)
2015	39	38	31	31	30	23	1,525	2,803 (1,282)
2016	46	44	16	35	33	10	1,216	3,220 (2,200)
Total / Mean	**120**	**111**	***34**	**95**	**86**	***43**	****1,422**	

*Percent increase from 2014 to 2016.
**Mean from 2014 to 2016.

Table 9-2. Facilities Surveyed for Raven Nests in 2016.

Facility	Active Raven Nest Confirmed	Substrate Supporting Active Nest
Advanced Mixed Waste Treatment Project (AMWTP)	Yes	Building Platform
Advanced Test Reactor (ATR) Complex	Yes	Effluent Stack
Central Facilities Area (CFA) Main Gate	Yes	Building Platform
Experimental Breeder Reactor I (EBR-1)	Yes	Airplane Engine
Experimental Sheep Station	Yes	Ornamental Tree
Idaho Nuclear Technology and Engineering Center (INTEC)	Yes	Effluent Stack
Naval Reactors Facility (NRF)	Yes	Effluent Stack
Specific Manufacturing Capability (SMC)/Test Area North (TAN)	Yes	Building Platform
CFA	No	N/A
Critical Infrastructure Test Range Complex (CITRC)	No	N/A
Materials & Fuels Complex (MFC)/Transient Reactor Test Facility (TREAT)	No	N/A
Radioactive Waste Management Complex (RWMC)	No	N/A

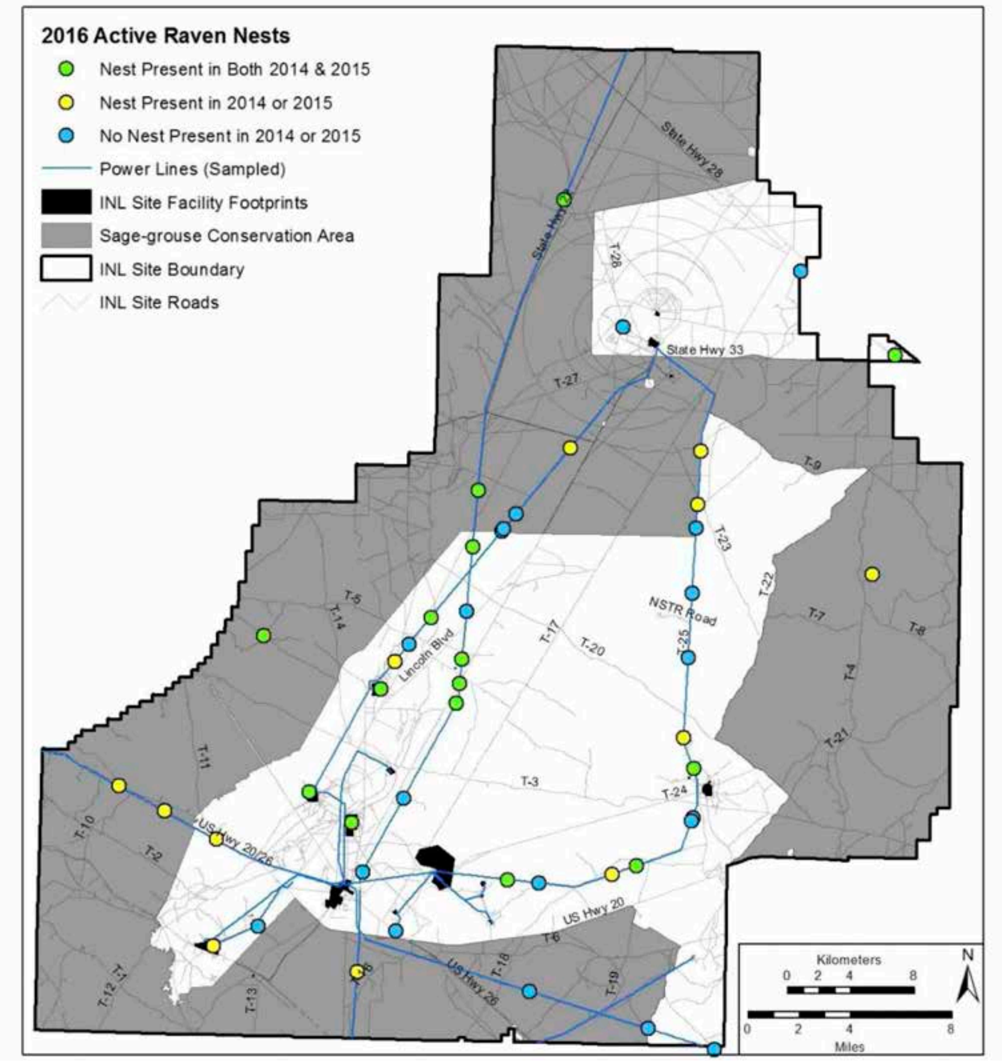


Figure 9-7. Results of 2016 Raven Nest Surveys. Each dot represents an active raven nest in 2016 (unadjusted nest locations). The color of the dot indicates if an active raven nest in 2014 or 2015 was present within 711 m of the 2016 nest (711 m is the radius of 1,422 m—the mean distance separating the two nearest raven nests in each year [Table 9-1]).

Oceanic and Atmospheric Administration to deter nesting on at least one of these towers by wrapping the top portion with wire (Shurtliff et al. 2017).

Trend Analysis: To analyze raven nesting trends on infrastructure from 2014–2016, we first reduced the total nest count for each year by disqualifying from analysis active nests that blew down during the nesting season, but for which there was evidence that the nest occupants rebuilt a second or third nest during the same season (Shurtliff et al. 2017). This adjusted value more precisely approximates the actual number of breeding pairs, compared to a simple count of active nests.

We removed one to six nests per year (all power-line nests) from the three-year dataset prior to analysis (Table 9-1). From 2014–2016, adjusted nest counts increased 34 percent, an average of 7.5 nests per year. The increase in nesting on power lines was 43 percent over the same time frame.

Nearest-Nest Distances: Using data from 2014–2016, we determined the straight-line distance from each active raven nest on the INL Site to the nearest active raven nest from the same year. Our aim was to learn how close territory-holding raven pairs would nest to each other so that we could estimate how many pairs could potentially occupy the INL Site. The shortest distance between any two active raven nests was 1,525 m in both 2014 (*n* = 26) and 2015 (*n* = 28) and 1,216 m in 2016 (*n* = 41).

Discussion

Raven use of infrastructure for nesting on the INL Site increased substantially (34 percent) over the past three years, and use of power lines was even higher (43 percent). Most ravens that nest on the INL Site occupy infrastructure rather than natural substrates (Howe et al. 2014), and although we did not survey natural substrates, it is probable that the increase we documented represents a general nesting trend on the INL Site (for more details, see Shurtliff et al. 2017).

Howe (2012) used methods similar to ours to monitor raven nests on INL Site infrastructure. Howe recorded 21, 26, and 29 active raven nests on man-made structures in 2007, 2008, and 2009, respectively. Beginning five years later, we recorded 35, 39, and 46 nests on infrastructure (unadjusted counts, 2014–2016; Table 9-2). Although it would be inappropriate statistically to combine the results from the two studies into a single analysis (Shurtliff et al. 2017), together, they suggest that increasing use of INL Site infrastructure by ravens for nesting is probably a long-term trend.

Looking to the future, we anticipate that the number of raven nests on INL Site infrastructure will continue to increase. Results from our nearest-neighbor analysis suggest that raven pairs defend territories on the INL Site that are probably at least 1,200 m in diameter (for simplicity, we assume the nest is the center of the territory). Based on availability of transmission structures and other assumptions (Shurtliff et al. 2017), we estimate that transmission structures on the INL Site could support as many as 133 raven nests simultaneously, or two to three times as many nests as we observed in 2016. Across the sage-grouse range, predation by ravens is not believed to limit population growth. However, evidence is mounting that at a local scale, raven predation may negatively affect sage-grouse reproductive success and population growth (Bui et al. 2010; Coates and Delehanty 2010; Lockyer et al. 2013). The raven nest monitoring task on the INL Site does not directly address impacts of raven predation on sage-grouse reproduction. However, ravens are opportunistic foragers, and we know they depredate sage-grouse nests on the INL Site (Howe and Coates 2015). It is unclear if increasing occupancy of the INL Site by ravens will reach a point where it substantially limits sage-grouse reproductive success. Measures to address threats posed by raven predation are discussed in Section 5 of the CCA, *Implementation of Conservation Measures.*

9.3 Midwinter Raptor, Corvid, and Shrike Surveys

Each January, hundreds of volunteers and wildlife professionals throughout the United States count eagles along standardized, non-overlapping survey routes as part of the Midwinter Bald Eagle Survey (Steenhof et al. 2008). These annual surveys commenced in 1979 and today are managed by the U.S. Geological Survey (USGS). The Midwinter Bald Eagle Surveys were originally established to develop a population index of wintering bald eagles in the lower 48 states, determine bald eagle distribution, and identify previously unrecognized areas of important winter habitat (Steenhof et al. 2008).

On the INL Site, Midwinter Bald Eagle Surveys have taken place since 1983. In early January of each year, two teams drive along established routes across the north and south of the INL Site and record the number and locations of all bald and golden eagles seen. Observers also record the same information for other raptors, common ravens, shrikes, and black-billed magpies they see along each route. Data are submitted to the regional coordinator of the USGS Biological Resource Division to be added to the nationwide database.

On January 7, 2016, ESER biologists completed two surveys along the traditional driving routes on the INL Site. Observers recorded a total of 369 target birds (Figure 9-8) on both routes. This is the third highest count in the past 16 years and is nearly triple the 16-year median

Rough-legged hawk – the most common raptor on the INL Site during winter. Courtesy:www.audubon.org/field-guide/bird/rough-legged-hawk.

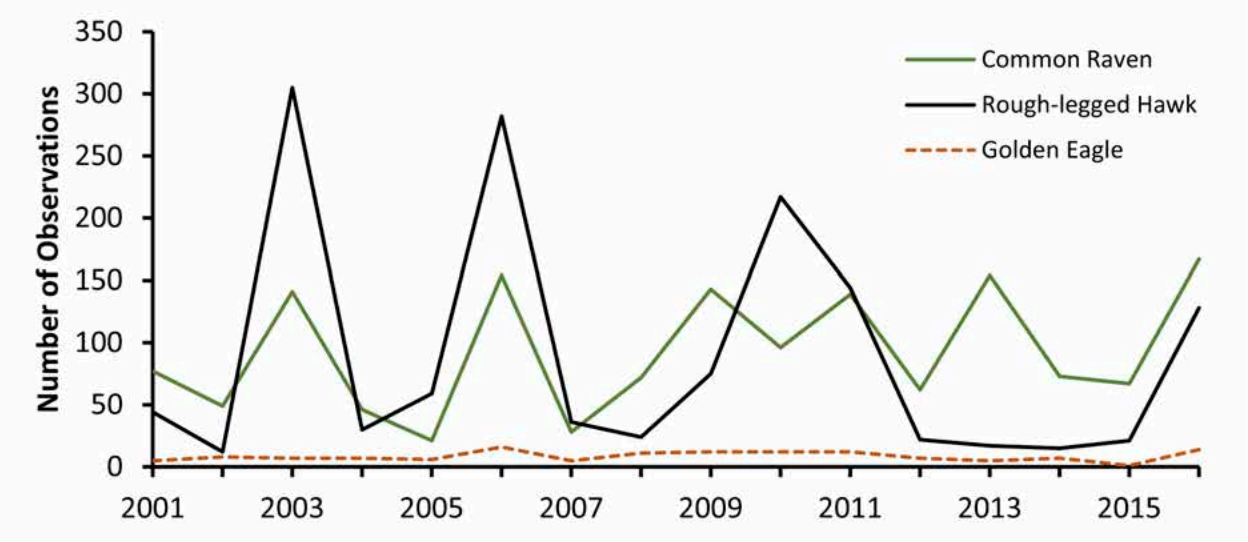


Figure 9-8. Trends of the Three Species Most Commonly Observed During Annual Midwinter Eagle Surveys. Data were pooled from the northern and southern routes.

of 128 birds. More common ravens were recorded (*n* = 167) than any time during past surveys dating back to 2001. As predicted last year (Annual Site Environmental Report [DOE-ID 2016]), rough-legged hawk observations were up steeply (*n* = 128) after four years of low counts (mean of 18.8 rough-legged hawks seen during each of the past four years). Golden eagle observations (*n* = 14) were higher than any year since 2006 and the second highest since at least 2001.

The importance of the mid-winter eagle count on the INL Site is that it contributes to a continent-wide effort to monitor trends in raptors and other species. The species highlighted above are wide-ranging (e.g., rough-legged hawks summer in the arctic), and habitat conditions on the INL Site may not influence species abundance, or may only have a minor impact. Perhaps the most useful information for DOE-ID that can be gleaned from these surveys is a clear picture that many species populations are cyclic. Understanding this ecological truism provides context for year-to-year observations.

9.4 Breeding Bird Surveys

The North American Breeding Bird Survey (BBS) was developed by the FWS along with the Canadian Wildlife Service to document trends in bird populations. Pilot surveys began in 1965 and immediately expanded to cover the United States east of the Mississippi and Canada, and by 1968 the surveys included all of North America (Sauer and Link 2011). The BBS program in North America is managed by the USGS and currently consists of over 4,100 routes, with approximately 3,000 of these being sampled each year. BBS data provide long-term species abundance and distribution trends across a broad geographic scale. These data have been used to estimate population changes for hundreds of bird species, and they are the primary source for regional conservation programs and modeling efforts (Sauer and Link 2011). Because of the broad spatial extent of the surveys, BBS data is the foundation for broad conservation assessments extending beyond local jurisdictional boundaries.

In 1985, five official BBS routes were established on the INL Site (i.e., remote routes) and eight additional survey routes were established near INL Site facilities (i.e., facility routes; Figure 9-9). Data from remote routes contribute to the USGS continent-wide analyses of bird trends, and they also provide information that local biologists can use to track and understand population trends. Data from facility routes may be useful in detecting whether INL activities cause measurable impacts on abundance and diversity of native birds.

We conducted surveys along the 13 remote and facility routes in June of 2016 and documented a total of 6,183 individuals from 53 bird species (Bybee and Shurtliff 2017). The six most abundant birds were Franklin's gull (*n* = 3,082), horned lark (*n* = 903), western meadowlark (*n* = 644), sage thrasher (*n* = 503),

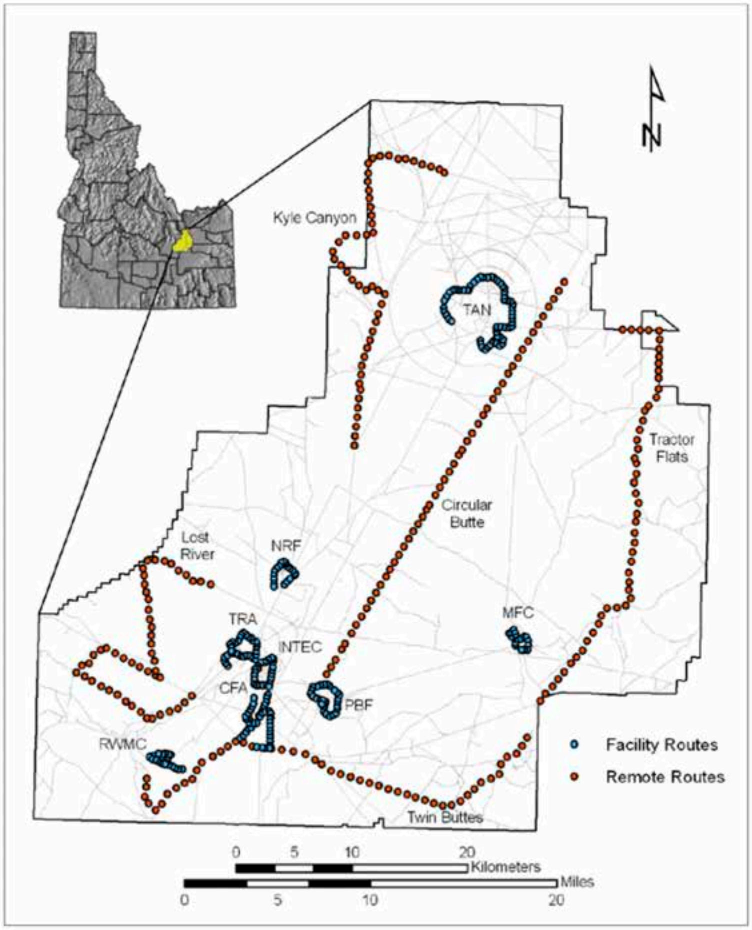


Figure 9-9. Breeding Bird Survey Routes on the INL Site. Blue dots represent survey points along facility routes and red dots represent the same for remote routes.

sagebrush sparrow (*n* = 216), and Brewer's sparrow (*n* = 193). These six species comprised > 89 percent of all observations, and with the exception of Franklin's gull, each was observed on every remote route. Horned lark, western meadowlark, sage thrasher, sagebrush sparrow, and Brewer's sparrow have been the five most abundant species in 23 of the 30 years of INL Site BBS (in the other years they were among the seven most abundant species).

Observers saw two species that had not previously been recorded during BBSs on the INL Site: a great egret and three Eurasian collared doves. The great egret is occasionally seen during migration and summer on the INL Site, though it does not breed there (i.e., no nesting has been recorded; Reynolds et al. 1986). The Eurasian collared dove is an invasive species that has expanded its range into Idaho in recent years. The three collared doves were seen on the eastern border of the INL Site near Mud Lake at the agriculture interface.

Five species were observed during the 2016 BBS that are considered Species of Greatest Conservation Need by the Idaho Department of Fish and Game (2013). These included the Franklin's gull (*n* = 3,082), ferruginous hawk (*n* = 13), long-billed curlew (*n* = 7), grasshopper sparrow (*n* = 5), and burrowing owl (*n* = 2).

The number of common ravens observed in 2016 was higher than any other year except 2010 and 2015 (Figure 9-10) (for clarity of presentation, data from 2010 were excluded as an outlier in the figure because 280 ravens were observed, mostly in a single, large flock). The common raven is an effective nest predator of sage-grouse, and DOE-ID is concerned about the potential impact common ravens may have on nesting sage-grouse (DOE-ID and FWS 2014). There is some evidence that territory-holding mated pairs may be primarily responsible for sage-grouse nest predation, rather than non-territorial juvenile flocks (Bui et al. 2010). It is unclear

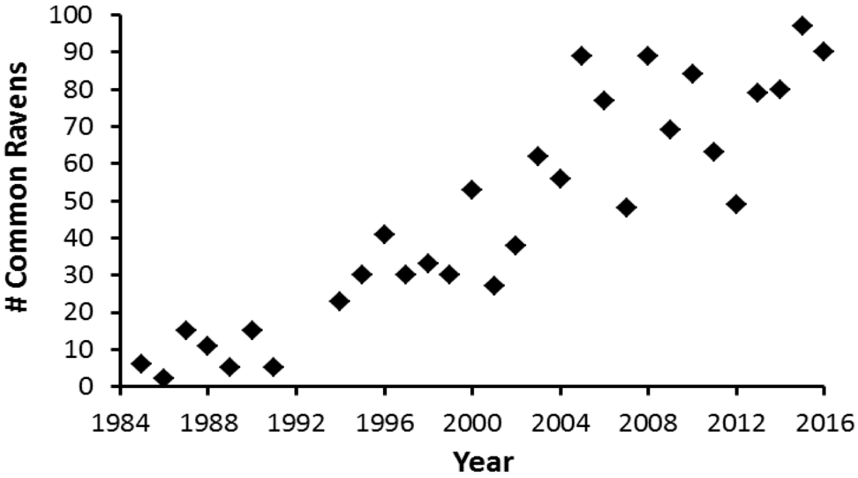


Figure 9-10. Common Raven Observations During Breeding Bird Surveys on the INL Site 1985−2016. No surveys were conducted in 1992 and 1993, and the data point in 2010 was removed because it represented an outlier (*n* = 280) caused by a single large flock flying overhead during one survey.

how many common ravens observed during the BBS are mated pairs and how many are unmated, but the trend reported here may not be a good indicator of the level of nest predation risk to sage-grouse.

Two sagebrush-obligate species (sagebrush sparrow and Brewer's sparrow) are at historically low levels on the INL Site, which is probably a consequence of losing large amounts of sagebrush-dominated communities during recent wildfires. Conversely, common raven observations continue to increase (which also may be driven by wildfires). The combination of loss of sagebrush-dominated communities and increased predators that raid nests of sagebrush obligates may affect the growth potential of some species, especially sage-grouse, which is a conservation concern for DOE-ID.

Three songbirds are sagebrush obligates, meaning that they specialize on and require sagebrush-dominated lands for survival. These are sage thrasher, sagebrush sparrow, and Brewer's sparrow. Sage thrasher was the most abundant sagebrush obligate (*n* = 503), followed by sagebrush sparrow (*n* = 216) and Brewer's sparrow (*n* = 193). Since 1985, sage thrasher counts have fluctuated, but appear to be stable.

Sagebrush and Brewer's sparrows, however, are at historically low levels (Figure 9-11). For the past six years (since 2011), sagebrush sparrow observations ranged from 161–237, all of which were lower than the previous low count of 241 individuals recorded in 1987. Brewer's sparrow observations in 2016 were 25 percent higher than in 2015, but still under 200 birds. Only in two years (1985 and 1988) prior to 2012 had observations been below 200 Brewer's sparrows. We attribute the decline in sagebrush and Brewer's sparrow to the loss of sagebrush habitats during large fires on the INL Site in 2010 and 2011.

9.5 Bats

Temperate insectivorous bats serve important roles in many ecosystems, providing concomitant ecosystem services of benefit to humans (Kunz and Reichard 2010, Cryan 2011). For example, insectivorous bats are very effective at suppressing populations of nocturnal insects, and some authors estimate the value of bats to the agricultural industry in the United States at roughly $22.9 billion each year through the suppression of insect pest species (Boyles et al. 2011). Moreover, insectivorous bats are effective top-down predators of forest insects (Boyles et al. 2011). In nutrient-poor environments bats can serve as nutrient "resets," feeding intensely on aerial insects in nutrient-richer areas (e.g., riparian corridors, ponds, agricultural fields, etc.) and then transporting and depositing nutrient-rich material, in the form of guano in nutrient-poorer upland roost sites or in caves (Kunz et al. 2011). In some cases bat guano may be the sole source of nutrient input for entire cave ecosystems (Kunz et al.

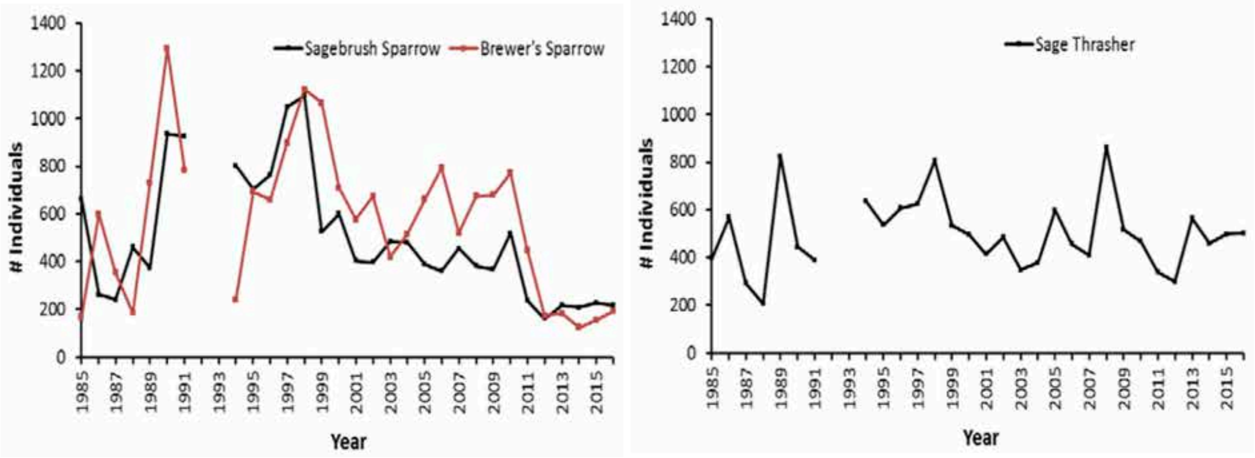


Figure 9-11. Trends of Three Sagebrush Obligates Recorded During Breeding Bird Surveys Since 1985. Surveys were not conducted in 1992 and 1993.

2011). Potential declines in populations of bats could have far-reaching consequences across ecosystems and biological communities (Miller 2001, Adams 2003, Blehert et al. 2009).

Established threats to bats have traditionally included human destruction and modification of hibernacula and other roost sites as well as pesticide use and loss of important foraging habitats through human development and habitat conversion. However, recent emerging threats (white-nose syndrome [WNS] and wind-energy development) have impacted populations of bats at levels without precedent, eclipsing these traditional threats in at least the eastern United States. WNS, first observed in a hibernation cave near Albany, New York in 2006, has been identified as a major threat to multiple bat species (Blehert et al. 2009; Foley et al. 2011; Kunz and Reichard 2010). The disease has swept northeast into Canada and south and west first along the Appalachian Mountains and then into the Midwest, affecting most major bat hibernation sites east of the Mississippi River and killing an estimated 5.5 to 6.7 million bats in seven species (Blehert et al. 2009; Foley et al. 2011). Documented declines of heavily impacted populations in the Northeast exceed 80 percent. How the disease will affect western bat species is uncertain. In March of 2016, a grounded little brown bat (*Myotis lucifugus*) found by some hikers near Seattle, Washington tested positive for the WNS organism and later was confirmed to have died from the disease. Shortly after this event, the WNS was identified in a silver-haired bat (*Lasionycteris noctivagans*) from the same area. WNS is considered one of the greatest wildlife crises of the past century with many once common bat species at risk of significant declines or even extinction (Kunz and Reichard 2010).

Wind-energy development is expanding rapidly across the western United States, and unprecedented mortality rates of bats have occurred recently at many of these facilities (Arnett et al. 2008; Cryan 2011; Cryan and Barclay 2009). Upper-end annual estimates for bat mortality from wind generation plants are approximately 900,000 individuals of mainly tree-roosting bat species (Smallwood 2013); however, widely accepted estimates remain elusive (Huso and Dalthorp 2014). Despite recent focus on emerging threats, direct impacts to hibernacula by humans remains the single most important conservation concern for bat populations in many areas (Adams 2003).

Over the past several decades, research and monitoring of bats have been conducted on the INL Site by contractors of DOE-ID in a somewhat ad hoc fashion. During that time, four theses, three reports, and one publication have been produced by contractors, university researchers, and graduate students. The majority of that research and monitoring occurred in the late 1980s and early 1990s. Of the 14 confirmed species of bats that reside in the state in Idaho, eleven of those species are documented to occupy the INL Site during some part of the year (Table 9-3). All eleven of these species may be detected at the INL Site in appropriate habitats through-

Table 9-3. Bat Species and the Seasons and Areas They Occupy on the INL Site, as well as Emerging Threats to These Mammals.

Common and Scientific Name	Distribution, Habitat, and Seasonal Occurrence	Affected by WNS	Affected by Wind Energy
Big Brown Bat[a] (*Eptesicus fuscus*)[b]	Site-wide; buildings, caves, and lava tubes; year-round	Yes	Yes
Hoary Bat[a] (*Lasiurus cinereus*)[c]	Patchy; riparian and junipers; summer resident at facilities and autumn migrant	No	Yes
Little Brown Myotis[a] (*Myotis lucifugus*)	Site-wide; roosts in buildings; summer resident and autumn transient	Yes	Yes
Long-legged Myotis (*Myotis volans*)	Site-wide; roosts in buildings; summer resident and autumn transient	Potentially	Potentially
Red Bat (*Lasiurus blossevillii* or *L. borealis*)[d]	Patchy; visits caves; possible autumn migrant or vagrant; not considered Idaho state species [e]	No	Yes
Silver-haired Bat[a] (*Lasionycteris noctivagans*)[c]	Patchy; riparian and junipers; summer resident at facilities and autumn migrant	No	Yes
Townsend's Big-eared Bat[a] (*Corynorhinus townsendii*)[b]	Caves, lava tubes and rocky areas; year-round	No	Potentially
Fringed myotis (*Myotis thysanodes*)	Unknown; caves and lava tubes; single high-certainty acoustic detection only	No	Yes
Brazilian free-tailed bat (*Tadarida brasiliensis*)[d]	Unknown; single dead specimen found at TAN; not considered Idaho state species	No	Yes
California Myotis (*Myotis californicus*)	Site-wide; buildings, caves, and lava tubes; summer resident	Potentially	Potentially
Yuma myotis (*Myotis yumanensis*)	Site-wide; buildings, caves, and lava tubes; summer resident	Yes	Potentially
Western Long-eared Myotis[a] (*Myotis evotis*)	Site-wide; caves and junipers; summer and autumn	Potentially	Potentially
Western Small-footed Myotis[a] (*Myotis ciliolabrum*)[b]	Site-wide; buildings, caves, and lava tubes; year-round	Potentially	Potentially

a. These species are designated as Type 2 Idaho Special Status Species by the BLM.
b. Year-round resident species
c. Migratory tree species
d. Possible vagrant
e. Detected acoustically only, possible vagrant

out the summer season. Three of them are year-round residents and have been documented hibernating in INL Site caves; two of the species are long-distance migrants with increased numbers detectable during fall migration (Table 9-3). An additional two species (western red bat [*Lasiurus blossevillii*] and Brazilian free-tailed bat [*Tadarida brasiliensis*]) are not listed as occurring in the state of Idaho and are possible vagrants at the INL Site (Table 9-3). To date, Brazilian free-tailed bats have not been detected acoustically at the INL Site. Several bat species detected at the INL Site are considered for different levels of protection by the FWS, Bureau of Land Management, Western Bat Working Group, and other conservation organizations (Table 9-3).

To assess bat activity and species occurrence at critical features, a program of passive acoustic monitoring of bat calls was initiated by ESER in 2012. In 2016, ESER continued monitoring bat activity using acoustical detectors set at hibernacula and other important habitat features (caves and facility waste water ponds) used by these mammals (Figure 9-12). Preliminary analysis of a pilot data set was initiated in 2015 and continued in 2016 (Figure 9-13). Over 800,000 ultrasonic files were collected during the 2016 summer activity season; nearly 590,000 of these files contained identifiable bat calls or fragments of bat calls. Initial species review of these data are consistent with on-going ESER monitoring efforts. Summer resident bat community appears to consist predominantly of western small-footed myotis (*Myotis ciliolabrum*), Townsend's big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), and western long-eared myotis (*Myotis evotis*) with some little brown myotis (*Myotis lucifugus*) and silver-haired bat (*Lasionycteris noctivagans*) detected at moderate levels at a few locations. Low levels of summer activity of hoary bat (*Lasiurus cinereus*) were detected through the summer at many features. Western small-footed myotis was the most commonly detected bat at all surveyed features.

Most identified bat species were detected at all features (both facilities and caves). One exception, Townsend's big-eared bat, appears to have a somewhat restricted distribution on the INL Site and, to date, has only been detected at two facilities, despite being detected at all caves. The two facilities (Materials and Fuels Complex and RWMC) where Townsend's big-eared bat has been detected are nearer to areas of the INL Site where typical Townsend's big-eared bat roost habitat (e.g., exposed rock outcrops, caves and cave-like features) is most common. Tree bats (hoary bats and silver-haired bats) were detected more frequently at facilities than caves. Patterns suggest both resident and migrant tree bats occur at INL Site facilities. The results of our passive monitoring program are providing critical information regarding bat distribution, ecology and conservation on the INL Site.

In conjunction with the IDFG, Bureau of Land Management (BLM), U.S. Forest Service (USFS), and FWS; the ESER program developed two preliminary active acoustic driving survey transects in 2014 for bats on the INL Site. Survey transects were developed consistent with the North American Bat Monitoring Program, a multi-agency, multi-national effort that is designed to standardize monitoring and management of bat species. Feasibility was assessed and preliminary data were collected on these transects during 2015. Driving transect surveys continued in 2016. High-flying, open-air foragers, big brown bats, and silver-haired bats, were detected most frequently on survey routes; however, commuting little brown bats were occasionally detected along Lincoln Boulevard in relative proximity to some facilities.

Figure 9-12. Typical Passive-acoustical Monitoring Station for Bats with a Microphone Mounted at the Top. (These devices record the echolocation calls of bats and were installed at cave openings and facility waste-water ponds.)

At least 17 out of 23 caves that are known to exist on the INL Site are used by several species of bats for winter hibernacula, as well as for summer day and night roosts. Lava caves are also an essential habitat during most of the year for three resident species. Much of the historic information concerning bats on the INL Site

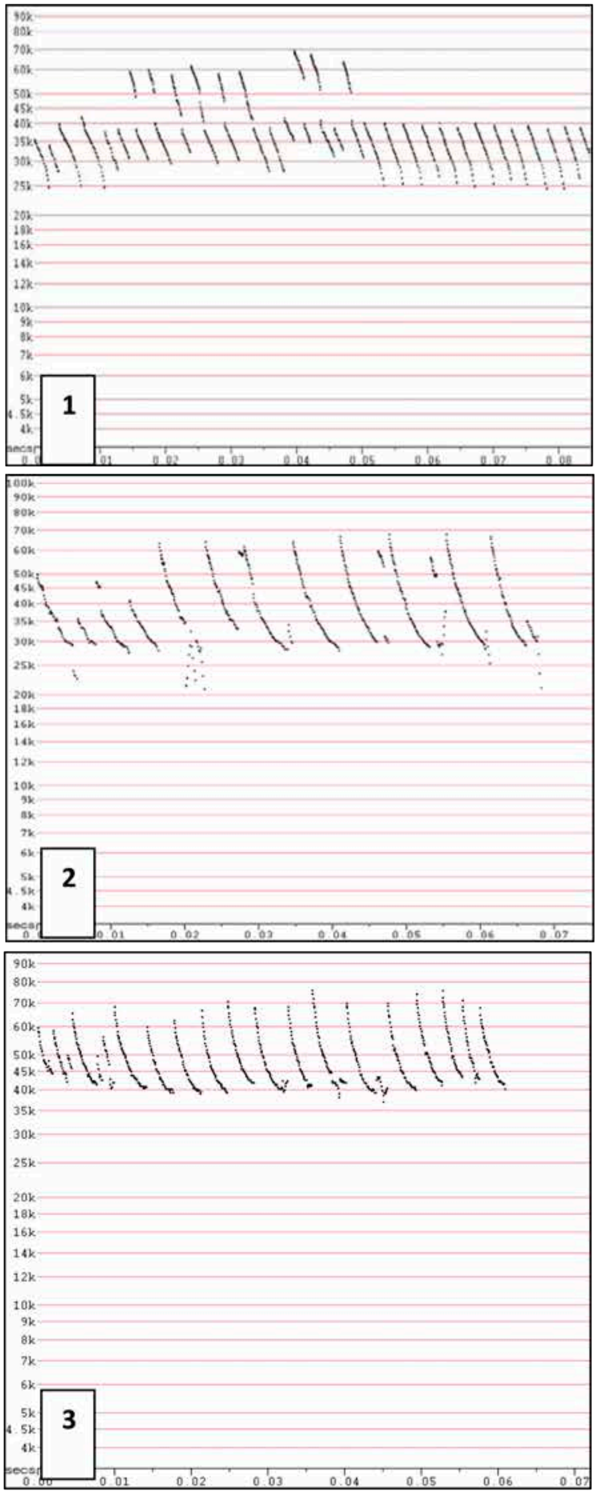


Figure 9-13. Sonograms (Frequency Versus Time Plots) of Bat Echolocation Calls of Three Species of Bats Recorded by AnaBat Detectors (1 = Townsend's big-eared bat, 2 = big brown bat, 3 = western small-footed myotis) from Caves on the INL Site.

comes from research that has centered on counting and trapping at caves (Genter 1986, Wackenhut 1990, Bosworth 1994, Doering 1996). In addition to being used as roost and hibernation areas, caves also provide habitat for concentrated patches of insect prey for these mammals. Indeed, in a number of cases, cold-trap crater caves that are too cool during summer to serve as day roosts will have high levels of evening activity as bats focus foraging at these sites. Beyond their use as roosts, caves at the INL Site serve as important habitat features for summer resident bats. Additionally, preliminary surveys indicate that caves may be used as stop-over habitat during fall migrations by previously undocumented forest bats, such as the hoary bat. Very little is known about the use of caves by migrating forest bats (Cryan 2011), and these areas may provide vital resources as bats traverse atypical habitats.

Currently, monitoring of hibernating bat populations is conducted biennially by ESER wildlife biologists at nine known INL Site hibernacula. Surveys are conducted in coordination with Bureau of Land Management and IDFG surveys conducted across the region. The winter of 2014–2015 was a scheduled survey year with surveys conducted mid-winter during early 2015 when numbers of hibernating bats are presumed highest and most stable. Caves will be counted again during the winter of 2016–2017. Current National Wildlife Health Center guidance for WNS surveillance recommends that hibernation counts be conducted as late as possible to increase the chances of detecting WNS infected bats.

To date, Townsend's big-eared bat is the most commonly counted over-wintering bat species, with western small-footed myotis being the second most common, but with far fewer numbers. Trends and numbers of those species have been stable over the past two counts in all nine hibernacula on the INL Site (Figure 9-14). Historically over-wintering big brown bats have been encountered, but not during the most recent surveys.

Passive acoustic monitoring at long-term stations operating at caves and facilities are revealing patterns of bat activity across the INL Site. An analysis of passive acoustic data collected at remote site (caves) and facility ponds indicated high variability and distinct patterns of activity across seasons with clear differences between developed and natural areas (Figure 9-15). Developed areas with anthropogenic structures (facilities, bridges, and culverts) are used as habitat by bats on the INL Site as well as natural areas. Developed areas, and their associated lands, occupy about 0.38 percent of the INL Site. Some of these facilities were constructed in the 1950s, and are surrounded by mature landscaping trees and wastewater ponds, which provide bats with vertical-structure habitat, water, and foraging areas. Patterns shown in Figure 9-15 reveal good levels of summer activity at both developed and natural sites. May and August peaks at facilities reveal transient use at facilities

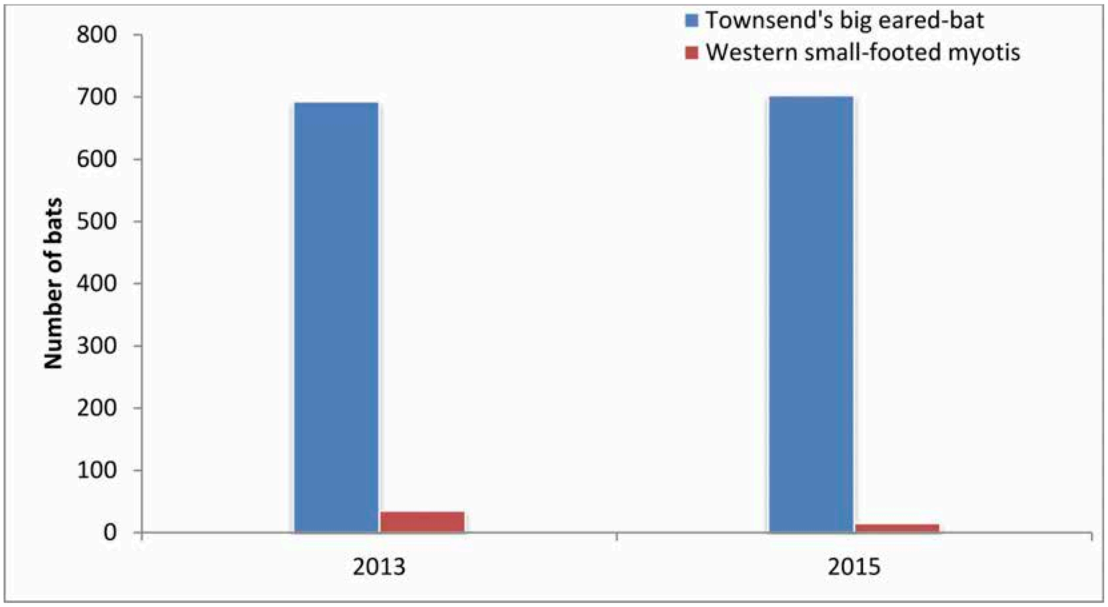
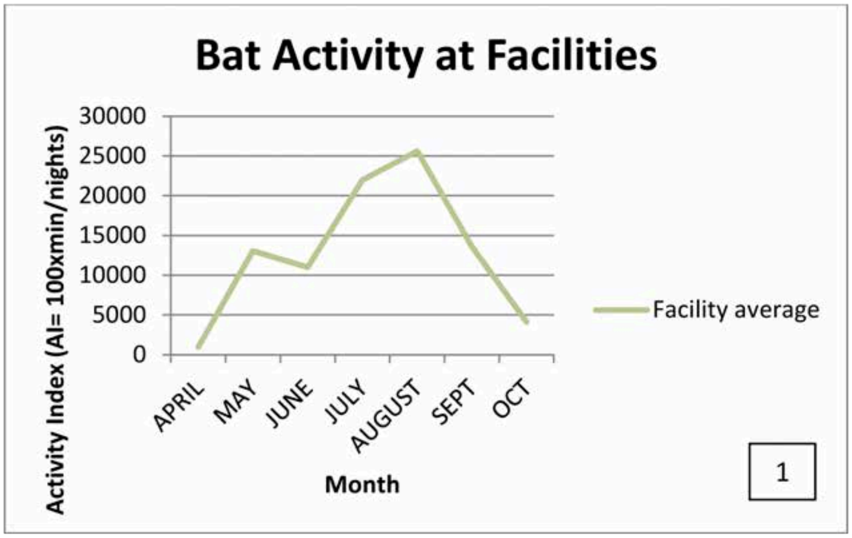


Figure 9-14. Number of Two Bat Species Counted at Known Hibernacula on the INL Site During the Past Two Biennial Survey Periods (Counts Appear Stable).



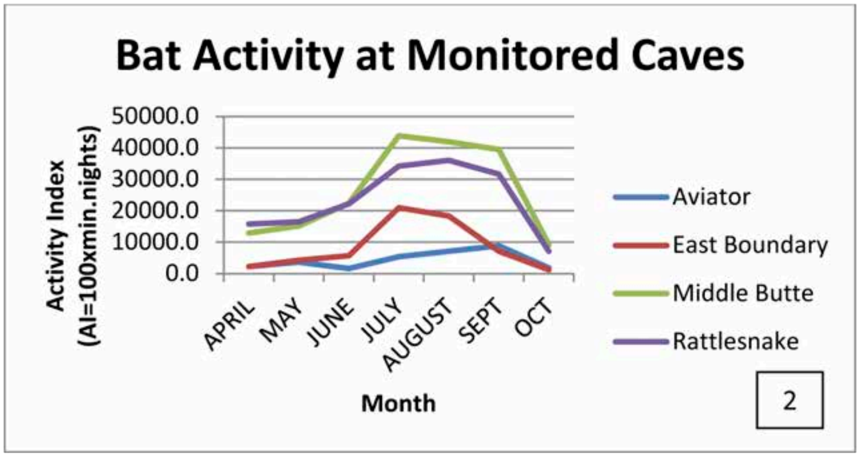


Figure 9-15. Average Relative Levels of Bat Activity across the Summer Activity Season (April–October) for Cave and Facility Acoustic Monitors. An Activity Index [AI] was used as a relative measure of bat activity and was calculated as 100 times the number of one minute intervals containing a bat call file divided by the number of nights the detector functioned during a given month.

as bats move back and forth between summer and winter habitats. Many of these transient bats are migrating tree bat species, likely using facility resources (landscaping trees and surface water) as stopover habitat. High levels of activity from July through September at caves indicate these area are important activity centers for resident bats and also serve as pre-hibernation gather sites (swarming sites).

9.6 Rabbits and Hares

Introduction

Rabbits (cottontails) and hares (jackrabbits) are ecologically important species in sagebrush landscapes. They are hunted by many avian and mammalian predators, and the abundance of some species, such as the golden eagle, is closely associated with the abundance of jackrabbit populations (Marzluff et al. 1997). Local research has confirmed that the abundance of coyotes and wintering raptors on the INL Site is strongly correlated with fluctuations in black-tailed jackrabbit abundance (Craig et al. 1984; Stoddart et al. 2001). Additionally, researchers found in Wyoming that sage-grouse and cottontail rabbit abundances demonstrated highly synchronized cycles over 26 years (Fedy and Doherty 2011). DOE-ID is interested in knowing when jackrabbit abundance peaks, because increased numbers of predators could result in increased predation on sage-grouse, especially after the jackrabbit population crashes. Furthermore, it is possible that the abundance of sage-grouse, jackrabbits, and other species respond to similar environmental cues (e.g., annual precipitation).

Methods

Night-time rabbit and hare surveys were initiated in 1980 on the INL Site in response to a population explosion of black-tailed jackrabbits that became a costly nuisance for landowners in southeastern Idaho. Jackrabbit populations tend to be cyclic, and the purpose of the surveys was to devise an early-warning system that farmers could use should jackrabbit abundance approach that experienced from 1980–1982. Nearly every spring from 1980–2007, biologists drove slowly along a 30-mi two-track route on the east side of the INL Site using spotlights to search for rabbits and hares of all species. Black-tailed jackrabbits made up nearly 100 percent of observations across all years. During a population peak in May 1981, 1,193 black-tailed jackrabbits were counted along the route. The population declined precipitously from 1981–1984, and the average number of black-tailed jackrabbits seen along the route from 1985–1989 was 1.8 individuals per year. Jackrabbit observations remained relatively low throughout the remaining years the survey was conducted (median of five jackrabbit observations per night between 1984 and 2007 [range: 0-142]), though there were small peaks in 1992 (n = 53), 2000 (n = 26), and 2007 (n = 142). The survey was discontinued after 2007 since DOE-ID determined it was not providing useful data, as jackrabbit numbers had remained low for over 20 years.

Recently, we have observed several indicators that jackrabbit abundance on the INL Site is once again high. For example, security personnel at several INL Site facilities reported that security alarms have been frequently triggered in recent months by the numerous jackrabbits that managed to get inside facility fences. After consulting with DOE-ID, ESER reinitiated rabbit and hare surveys in 2016. Assuming that these surveys continue in future years, we anticipate that the primary uses of the rabbit and hare data will be 1) to assist ESER in collecting more comprehensive data on cyclic population patterns that may trend with sage-grouse populations at the INL Site, and 2) to advise facility personnel when jackrabbit abundance begins to increase in the future so they can ensure that facility fences are in good repair before jackrabbit abundance reaches the point where they impact the work of facility forces.

Black-tailed jackrabbit on the INL Site.
Courtesy Troy Hansel.

Black-tailed jackrabbit seen near the survey route using a spotlight. Note the red eye shine, which is a helpful indicator of a jackrabbit's presence.

Results and Discussion

In 2016, we counted a mean of 520 jackrabbits (SD: 108, range: 396–570) during three spotlight surveys (Figure 9-16). This number is higher than any other year surveyed between 1980 and 2007, except 1981. The mean count in 2016 is more than an order of magnitude greater than counts in 19 of the 27 years rabbit and hare surveys were conducted.

Our ability to compare jackrabbit counts from 2016 with those of past years is limited since 1) we averaged counts from three surveys instead of making a single annual survey, 2) all surveys in 2016 occurred in June, whereas previous counts occurred primarily in May, and 3) a large section of the survey route and surrounding sagebrush-dominated habitat burned in 2010 during the Jefferson fire—the largest wildfire in the history of the INL Site. Prior to the Jefferson fire, 19.0 mi of the 30-mi survey route cut through sagebrush-dominated habitat. After the fire, only 13.8 mi of the route remained within sagebrush habitat. Jackrabbits are strongly associated with sagebrush since they feed on the shrub and seek cover in sagebrush stands during the day. Our surveys confirmed that jackrabbits do not feed far from sagebrush-dominated habitats (Figure 9-17).

Although it would not be appropriate to statistically compare the 2016 surveys with previous surveys for the above-stated reasons, we can, however, make useful conjectures about how jackrabbit abundance in 2016 compares to past years. Hypothetically, if the Jefferson fire had not occurred, jackrabbit counts would have been proportionately higher in 2016 since areas that would have remained dominated by sagebrush probably would have supported a similar density of jackrabbits as other sagebrush-dominated portions of the survey route. The fire reduced the amount of the route running through sagebrush habitat by 27 percent. Therefore, a coarse estimate is that we might have counted 715 jackrabbits had the Jefferson fire not burned. We therefore conclude that jackrabbit density on the eastern portion of the INL Site in 2016 was probably higher than during any other year the survey was conducted, with the exception of 1981.

Both jackrabbits and sage-grouse tend to cycle approximately every 10 years. Consequently, only long-term datasets could have the power to elucidate potential correlations between population trends. Although we do not yet have sufficient data to make a robust comparison between sage-grouse and jackrabbit datasets (primarily since jackrabbits have not been surveyed since 2007), it is interesting to note that in 2016, counts of male sage-grouse on the INL Site were higher than any other year since the last peak in 2006. When ESER ceased the jackrabbit surveys in 2007, total jackrabbit observations were higher than they had been at any other time since 1983 (Figure 9-16). Nine years later, we have documented a peak in jackrabbit abundance (though previous years could also have been higher). Therefore, initial comparisons support the hypothesis that jackrabbits and sage-grouse follow a similar cyclic pattern on the INL Site. Many more years of data are necessary before this observation can be supported statistically.

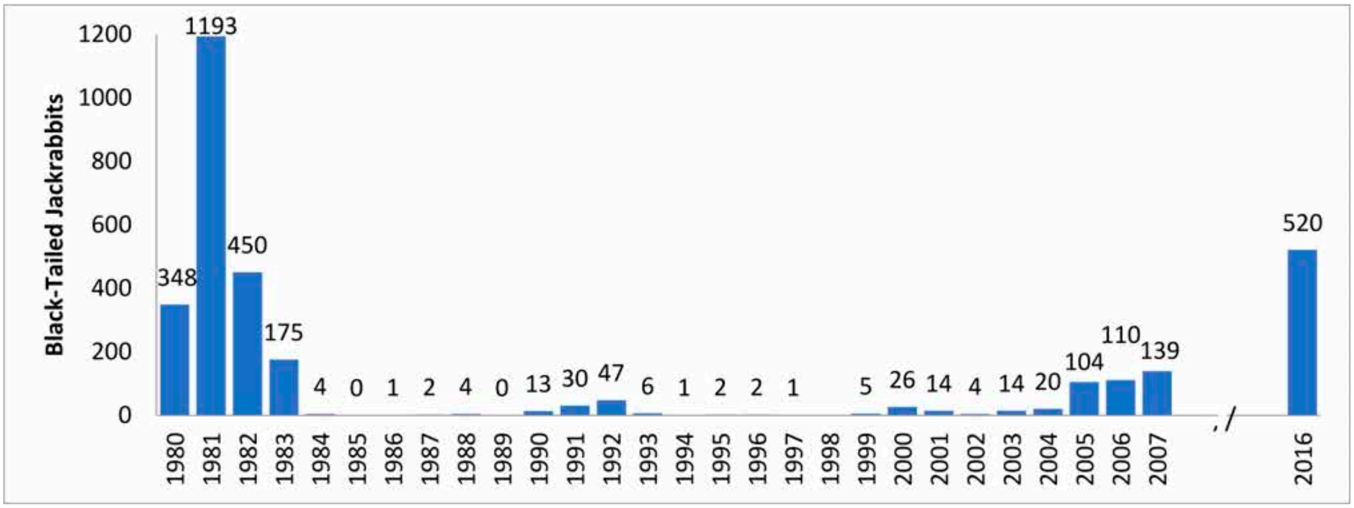


Figure 9-16. Jackrabbits Observed Along a Rabbit and Hare Spotlight Survey Route on the East Side of the INL Site. Surveys completed prior to 2008 consisted of a single survey each year, typically in May. The 2016 bar is the mean of three surveys completed in June. No survey was conducted in 1998.

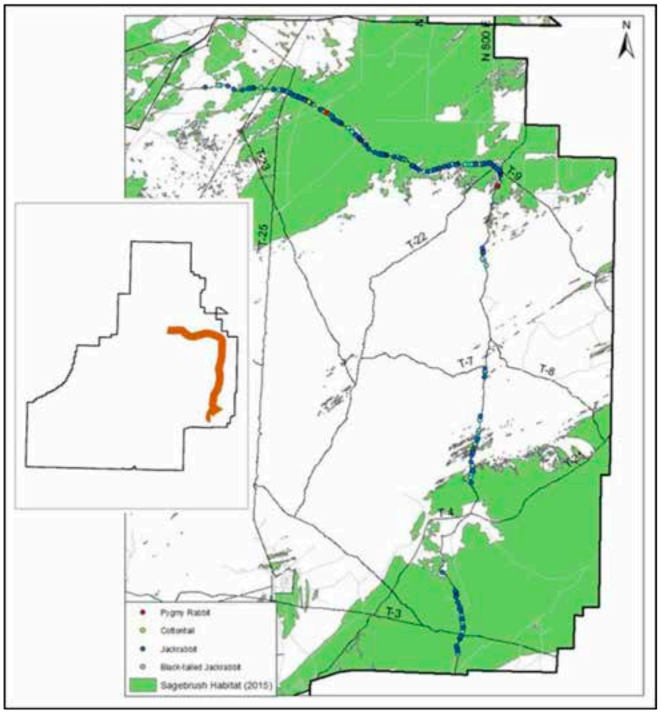


Figure 9-17. Rabbit and Hare Survey Route (Orange Line in Inset) and Results From One of the Three 2016 Surveys on the Eastern Side of the INL Site. Green polygons represent sagebrush habitat. Note that nearly all observations were of jackrabbits (black-tailed or unconfirmed species).

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10. Environmental Research at the Idaho National Laboratory Site


Burrowing Owl
Athene cunicularia

Ecological monitoring and research at the Idaho National Laboratory Site in 2016 was focused on: 1) monitoring the condition and conservation status of vegetation communities and sensitive plant species; 2) annual assessment of sagebrush habitat and restoration-based conservation efforts to support the Candidate Conservation Agreement (CCA) for Greater Sage-grouse; and 3) research supported through the National Environmental Research Park (NERP).

The monitoring of vegetation communities and sensitive plants species continued in 2016 through data collection across the INL Site using the Long-term Vegetation (LTV) transects and associated permanent plots established in 1951. The LTV project allows researchers to observe long-term vegetation changes and the potential impacts of these changes across the INL Site. A total of 89 plots were sampled for cover, density, and frequency by vascular species for the 13th time since 1950.

Sagebrush habitat monitoring and conservation measures to support the CCA were addressed by four tasks in 2016. The first entails resampling 75 plots, which have been sampled annually since 2013, to assess habitat condition. Absolute cover, height, and density of sagebrush and perennial grass/forbs were measured for this task. Sagebrush habitat distribution was also monitored in 2016 using imagery from 2015 which recently became available. Inventory and monitoring of cheatgrass, a threat to sagebrush habitat, continued with delineation of potential vectors of spread using imagery. Sagebrush habitat restoration continued in 2016 and seedling survival monitoring of shrubs planted in 2015 was completed.

During 2016, two ecological research projects were conducted on the Idaho National Environmental Research Park: 1) continued studies of ants and ant guests at the INL Site and 2) ecosystem responses of sagebrush steppe to altered precipitation, vegetation and soil properties. The INL Site was designated as a NERP in 1975. The National Environmental Research Parks provide rich environments for training researchers and introducing the public to ecological sciences. NERPs have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

The United States Geological Survey (USGS) has been studying the hydrology and geology of the eastern Snake River Plain and eastern Snake River Plain aquifer since 1949. The USGS INL Project Office collects data from research and monitoring wells to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water that compose the aquifer. Six reports were published in 2016 by the Idaho National Laboratory Project Office.

10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological monitoring and research performed at the Idaho National Laboratory (INL) (Sections 10.1 through 10.4) and research conducted on the eastern Snake River Plain and eastern Snake River Plain aquifer by the United States Geological Survey (Section 10.5) during 2016.

10.1 Ecological Monitoring and Research at the Idaho National Laboratory

Ecological monitoring and research on the INL Site generally falls into three categories; 1) Monitoring the condition and conservation status of vegetation communities and sensitive plant species, 2) Annual assessment of sagebrush habitat and restoration-based conservation measures to support the Candidate Conservation Agreement (CCA) for Greater Sage-grouse (*Centrocercus urophasianus*) on the INL Site (DOE-ID and FWS 2014), and 3) Research supported through the National Environmental Research Park (NERP).

Monitoring tasks in the first category are conducted to provide information to DOE about the abundance, distribution, condition, and conservation status of vegetation communities and sensitive plant species known or expected to occur on the INL Site. Results from these tasks are used to monitor overall health and condition of the sagebrush steppe ecosystem locally, to understand the potential causes and consequences of vegetation change over time and within a greater regional context, to make quantitative data available for land use planning, and to support environmental regulatory compliance (i.e., National Environmental Policy Act [NEPA]). Component tasks include the Long-term Vegetation (LTV) Survey, major vegetation classification and map updates, sensitive species reports, and any other monitoring necessary to address current concerns. Many of these tasks are completed on a rotational schedule, once every several years. Vegetation surveys to support the LTV were conducted in 2016.

The second set of ecologically-based tasks and activities include sagebrush habitat assessments, evaluation of risks to habitat, and conservation measures to improve habitat. These activities support the voluntary agreement U.S. Department of Energy, Idaho Operations Office (DOE-ID) entered into with the U.S. Fish and Wildlife Service (FWS) to conserve sage-grouse and the habitat they depend on across the INL Site (DOE-ID and FWS 2014). There are two habitat monitoring tasks, one to assess annual habitat condition and one to document habitat distribution across the INL Site. Because cheatgrass (*Bromus tectorum*) poses one of the greatest biological risks to sagebrush habitat, the third task is designed to target, inventory, and explore possible restoration options to areas with the potential to become vectors for cheatgrass spread. The fourth ecological monitoring task is to support the CCA is a conservation measure that includes planting sagebrush seedlings to hasten the return of viable habitat in burned areas.

The INL Site was designated as a NERP in 1975. According to the Charter for the National Environmental Research Parks, NERPs are intended to be outdoor laboratories where research can be carried out to achieve agency and national environmental goals. Those environmental goals are stated in the NEPA, the Energy Reorganization Act, and the Non-nuclear Energy Research and Development Act. These goals dictate that the task is to understand our environment sufficiently that we may enjoy its bounty without detracting from its value and eventually to evolve an equilibrium use of our natural resources. The desirability of conducting research on the NERP is enhanced by having access to relatively undisturbed sagebrush steppe habitat and no public access. Universities typically provide their own funding and the Environmental Surveillance, Education, and Research (ESER) Program facilitates researcher’s access to the INL Site. There are two ecological research projects ongoing through the Idaho NERP, one includes documenting ants and associated arthropods on the INL Site and the other is an ecohydrology study of sagebrush steppe.

10.2 Vegetation Communities and Sensitive Plant Species

10.2.1 The Long-term Vegetation Transects

The LTV transects and associated permanent plots were established on what is now the INL Site in 1950 for the purposes of assessing impacts of nuclear energy research and production on surrounding ecosystems (Singlevich 1951). Initial sampling efforts focused on potential fallout from nuclear reactors and the effects of radionuclides on the flora and fauna of the Upper Snake River Plain. After several years of sampling, however, the concentrations and any related effects of radionuclides on the sagebrush steppe ecosystem of the INL Site were determined to be negligible (Harniss 1968).

Because the LTV plots were widely distributed across two transects that bisect the INL Site (Figure 10-1) and vegetation abundance data had been collected periodically since their establishment, their utility as a basis for monitoring vegetation trends in terms of species composition, abundance, and distribution was eventually recognized. Vegetation data collection has continued on the LTV plots on a semi-regular basis, about once every five years. Eighty-nine LTV plots are still accessible and most have now been sampled regularly between 1950–2016, making the resulting dataset one of the oldest, largest, and most comprehensive for sagebrush steppe ecosystems in North America.

As the mission of the INL Site has grown and changed over the past 65 years, so too has the purpose and utility of the LTV project. Although the LTV project was initiated to address energy development at the INL Site, it is unique in its capacity to allow investigators to observe long-term vegetation change and the potential impacts of that change at the INL Site and across the region. Abiotic and biotic conditions (conditions created

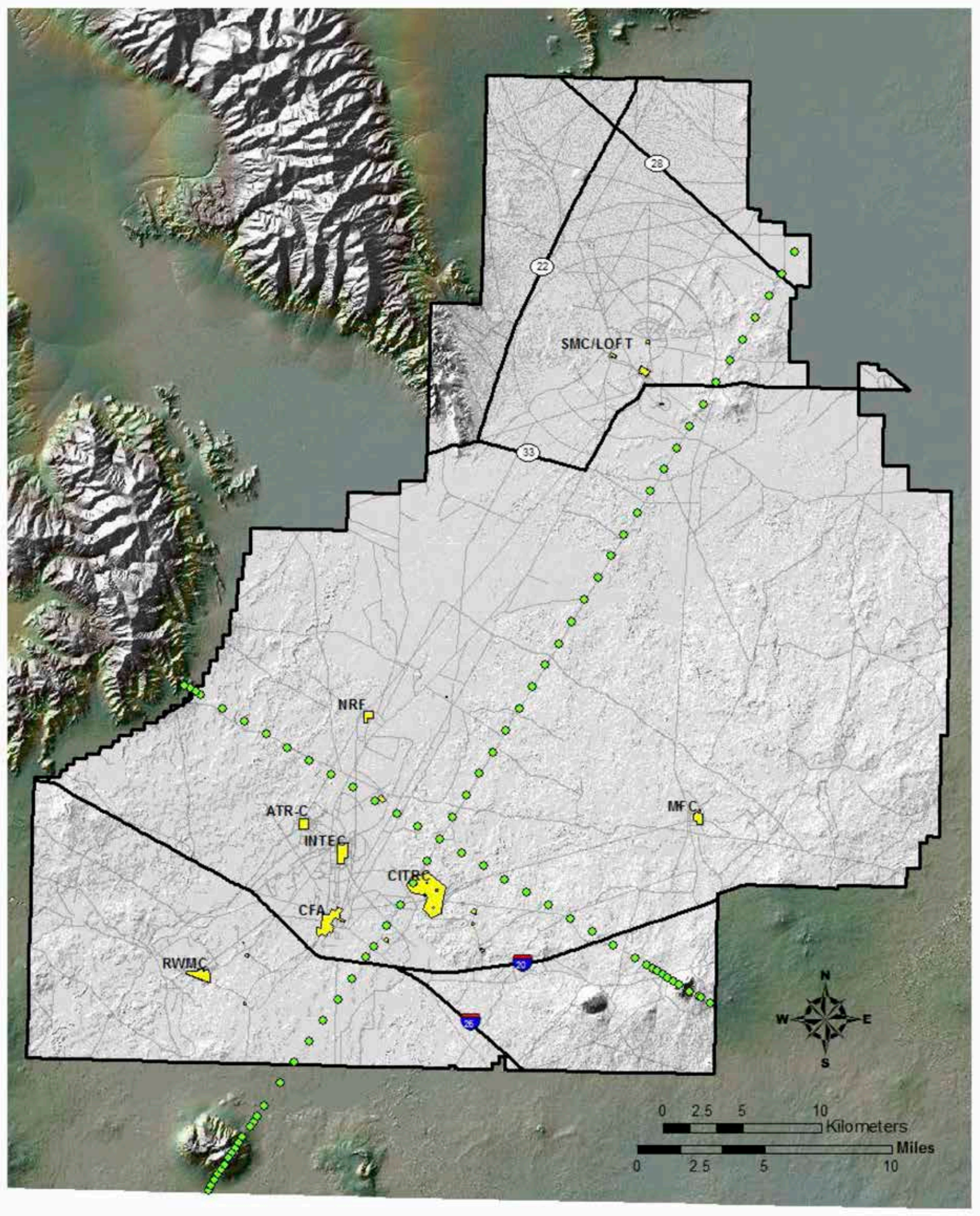

Figure 10-1. Long-term Vegetation Transects and Permanent Plot Locations on the INL Site.

by the physical environment and by other living organisms) have been characterized by rapid change over the past few decades. These changes include shifts in land cover, land use, and weather. Several large wildland fires have removed sagebrush from a large portion of the Upper Snake River Plain over the past twenty years; nearly

60,000 hectares (148,263 acres) have burned on the INL Site in the past seven years. Soil disturbance associated with fighting wildland fires and disturbance associated with general increases in the use of remote backcountry areas are notable throughout the Intermountain West. Concurrently, many of the hottest and driest years during the 60-yr weather record occurred during the past decade. All of these factors contribute to increasing stress on native plant communities and potentially set the stage for a period of dramatic change in vegetation across the region. The LTV project is documenting this change and may provide some context for understanding resistance and resilience in local sagebrush steppe.

Data were collected across the 89 active LTV plots for the 13th time between June and August of 2016. Plots were sampled for cover and density by species according to methodologies developed in 1950, with supplemental sampling protocols added in 1985. See Forman et al. (2010) for details of the project sample design. In addition, data have been collected for six consecutive years (2011–2016) on 11 LTV plots that were burned on August 25, 2011, in the T-17 fire (Figure 10-2), providing a rare opportunity to monitor fire recovery on a number of plots that were recently sampled and had been well-characterized for more than half a century prior to the fire.

There are three specific objectives for LTV data analysis following the most recent data collection efforts. The first is to provide an update to the standard long-term trend analyses that are reported subsequent to all comprehensive LTV sampling efforts (e.g., Forman et al. 2013, Chapter 2). These analyses provide a useful indicator of overall ecosystem health for sagebrush steppe at the INL Site, as well as benchmark values for specific vegetation characteristics that can be used for NEPA analyses and habitat assessments. The second objective is to summarize results from the pre- and post-fire cover data on the LTV plots burned in the T-17 fire; results will facilitate developing a framework for assessing post-fire vegetation condition and recovery trajectory. The third objective will address the spread and distribution of non-native plants across the INL Site. Data will be analyzed with the intent of characterizing non-native species abundance and distribution patterns and understanding how those patterns relate to changing weather patterns and land uses. A report detailing these objectives and all analytical results addressing these objectives will be finalized in 2018.

10.3 Sagebrush Habitat Monitoring and Restoration

10.3.1 Sagebrush Habitat Condition

Sage-grouse cannot survive without healthy sagebrush stands that meet certain criteria related to the condition and distribution of their habitat (Connelly et al. 2000). Sage-grouse use sagebrush dominated lands year-round and rely on sagebrush for food, nesting, and concealment from predators. Not only are healthy stands of sagebrush necessary for sage-grouse to survive, during summer young sage-grouse also require a diverse understory of native forbs and grasses. Vegetation cover provides protection from predators and supplies high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011).

This monitoring task, outlined in the sage-grouse CCA between the FWS and DOE-ID (DOE-ID and FWS 2014), provides ongoing assessment of habitat condition, allowing for comparisons of sagebrush habitat indicators on the INL Site with general sage-grouse habitat guidelines (e.g., Connelly et al. 2000). Habitat condition monitoring may also be used to track trends in the quality of habitat available to sage-grouse on the INL Site through time, as well as to identify the effects of threats that may impact habitat condition (e.g., increases in non-native weeds). Although these surveys weren't designed to address specific interactions between birds and their environment (i.e., nest site selection or foraging behaviors related to brood-rearing) they do provide an excellent index of the overall condition and composition of the plant communities considered to be appropriate habitat for sage-grouse on the INL Site.

Seventy-five habitat condition monitoring plots have been sampled annually since 2013. Forty-eight plots are located in areas currently mapped as sagebrush habitat and 27 are located in previously burned areas that are recovering to sagebrush habitat (Figure 10-3). Plots are sampled for vegetation cover and height by species and also for sagebrush density and juvenile frequency. In 2016, data were collected on all 75 annual plots between June and August. Data were summarized and results were compared to data values from previous years and to general recommended habitat guidelines (Connelly et al. 2000).

In areas currently identified as sagebrush habitat, mean sagebrush cover and height are within suggested optimal ranges for sage-grouse breeding and brood-rearing habitat; perennial herbaceous height also meets habitat recommendations, but perennial herbaceous cover was lower than guideline minimums.

Average perennial grass/forb cover on sagebrush habitat plots was about 2.5 percent lower in 2016 than specified for breeding and brood-rearing habitat (Table 10-1), but was much higher than it was on the same plots in 2013, the first year data were collected. Low herbaceous cover values, relative to habitat guidelines, do not appear to be a result of poor ecological condition, but rather the effect of soils and climate on the local ecosystem (Forman et al. 2013). All areas burned within the last

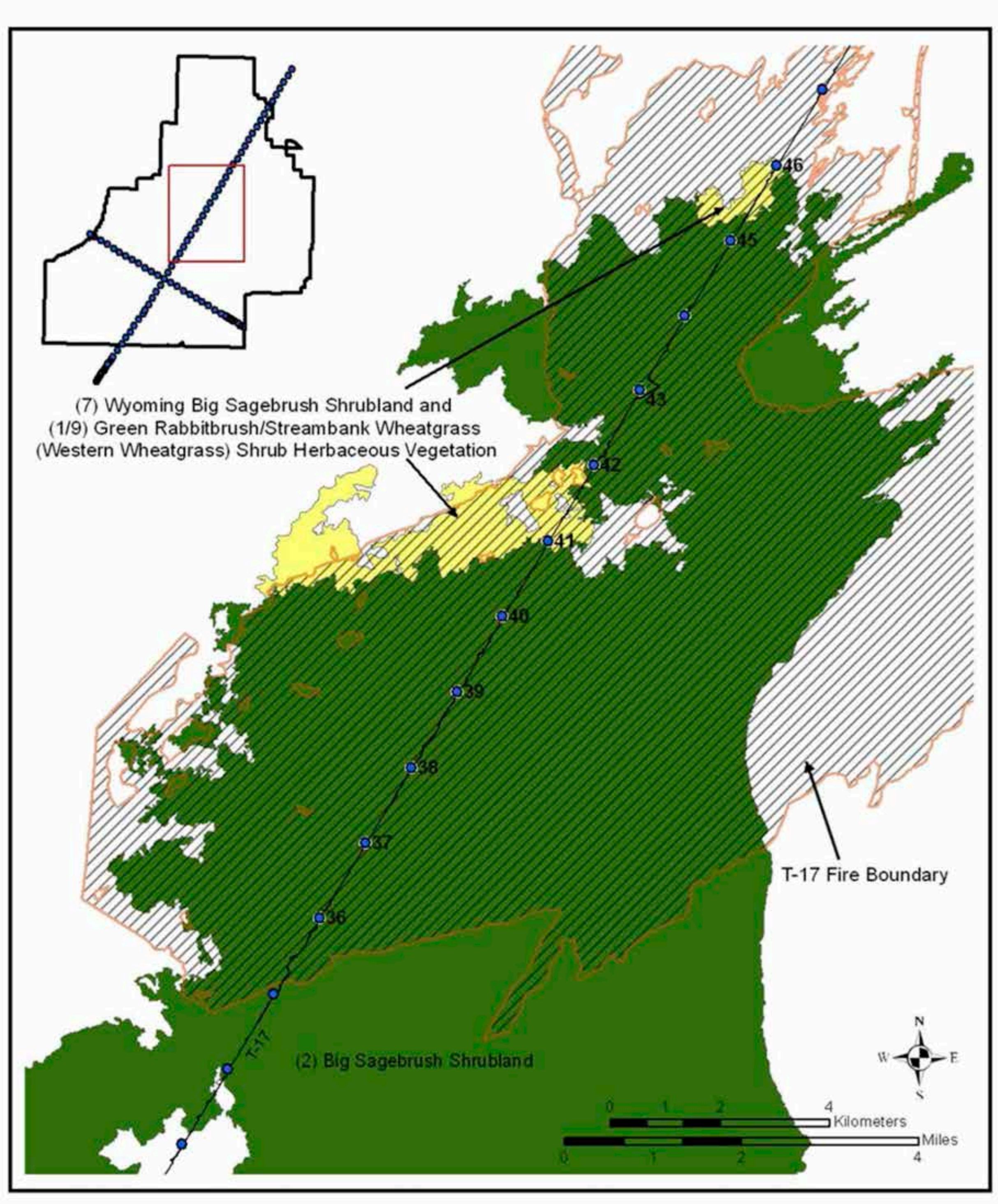

Figure 10-2. Location of 11 Long-term Vegetation Transect Plots that Burned During the 2011 T-17 Fire. Vegetation classes listed were characterized prior to the fire and are from Shive et al. (2011).

two decades largely lack sagebrush; many have otherwise recovered healthy native plant communities, while a few have non-native weed concerns.

Herbaceous functional groups are highly influenced by precipitation, and precipitation for three years prior to and up through most of the 2014 growing season, was below average. Total precipitation eventually exceeded annual averages in 2014 and approached annual averages in 2015 and 2016, but the timing of precipitation from August 2014–August 2016 was unusual for the region and certainly affected vegetation on the INL Site during the 2015 and 2016 growing seasons (see Shurtliff et. all 2017 for details). Cover from perennial herbaceous species, mean cheatgrass cover, and cover from all annual forbs was uncharacteristically low in 2013 and 2014 (Shurtliff et al. 2015) and was much higher than expected in 2015 and 2016 due to the anomalous precipitation patterns in those years. Increases in cheatgrass and Russian thistle (*Salsola kali*) between 2014 and 2016 are notable, particularly in the plots that are in recovering burned areas (details available in Shurtliff et al. 2017).

10.3.2 Sagebrush Habitat Distribution

The CCA between the FWS and DOE-ID (DOE-ID and FWS 2014) established two adaptive management triggers (population and habitat) that, if tripped, would initiate an automatic response by both agencies. The adaptive management trigger for sage-grouse habitat (i.e., sagebrush habitat) requires a response if the total area designated as sagebrush habitat within a pre-defined conservation area, the Sage-grouse Conservation Area (SGCA), is reduced by 20 percent or more relative to the 2013 baseline value of 78,558 hectares (194,120 acres; DOE-ID and FWS 2014; Shurtliff et al. 2017).

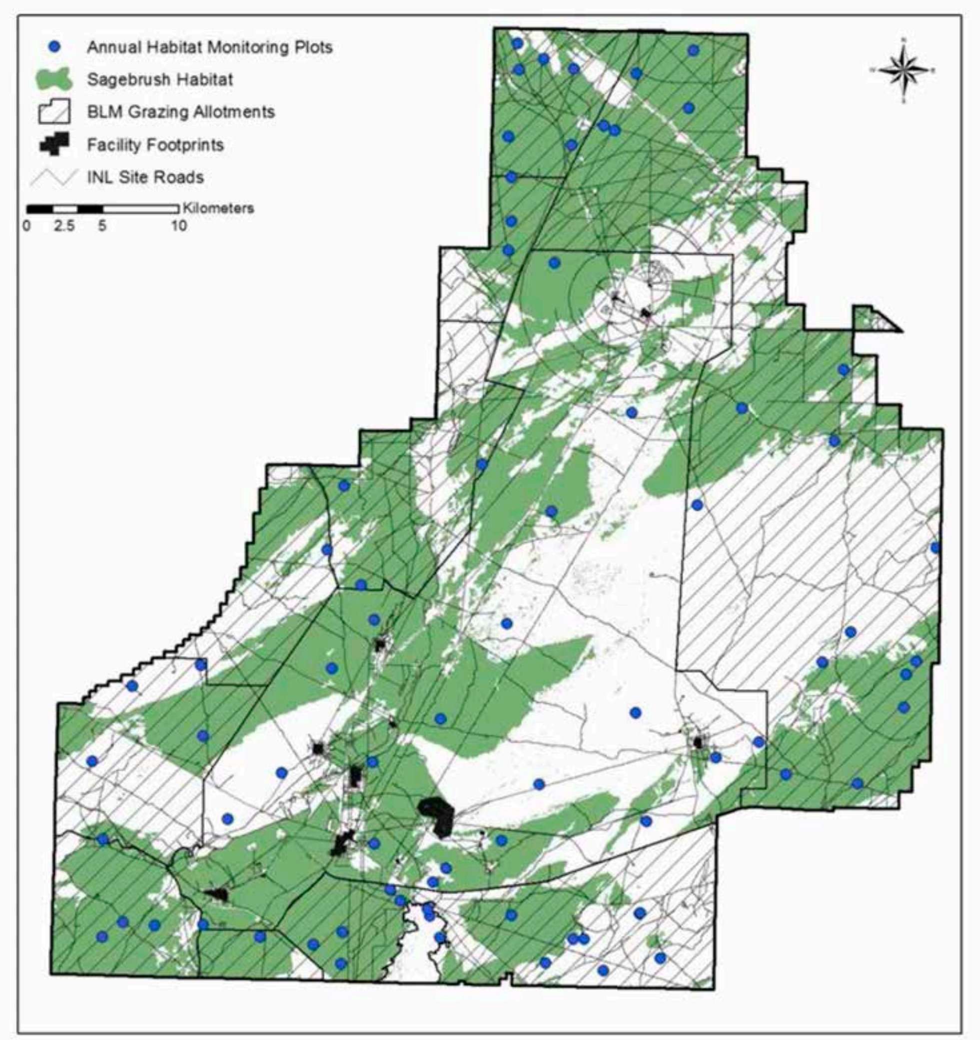

Figure 10-3. Sage-grouse Habitat Condition Monitoring Plots Sampled in 2016 on the INL Site.

Table 10-1. Summary of Selected Vegetation Measurements for Characterizing Condition of Current Sagebrush Habitat and Post-fire Recovering Non-sagebrush Areas on the INL Site in 2016. The mean marked by an * is elevated because it includes seven plots with notable seedling germination events (most seedlings will fail due to self-thinning); the adjusted mean sagebrush density (without the seven high-germination plots) is 3.09 individuals/m^2.

	Mean Absolute Cover (percent)	Mean Height (cm)	Mean Density (individuals/m^2)
Sagebrush Habitat Plots (n=48)			
Sagebrush	21.89	49.44	11.41*
Perennial Grass/Forbs	12.64	24.49	
Non-sagebrush Plots (n=27)			
Sagebrush	0.25	39.72	0.08
Perennial Grass/Forbs	23.05	33.65	

The baseline value was estimated from a detailed vegetation map completed in 2010 (Shive et al. 2011). Because the amount of sagebrush habitat changes over time as wildfires kills sagebrush stands and older burns are repopulated with the shrub, it is necessary for the ESER program to monitor the amount of sagebrush-dominated lands that wildfires burn each year and to survey burned areas to determine which vegetation classes are recovering in post-fire communities. In 2016, activities in this task included delineating one small fire that burned in summer of 2015 and removing burned areas from designated sagebrush habitat, making some minor adjustment to the baseline based on more detailed imagery, and collecting field data at plots distributed within the 2011 T-17 fire to assist with mapping the reestablishing vegetation classes.

On June 18, 2015, there was one small fire located north of the roadside, southwest of Central Facilities Area. This was a small human-caused wildland fire named “268 Fire” that burned prior to the collection of the 2015 Idaho National Agricultural Imaging Program (NAIP) imagery. The burned area boundary was digitized using 2015 NAIP imagery and a total of 1.5 hectares (3.7 acres) of sagebrush habitat was lost (Figure 10-4). The burned area was outside of the SGCA, so the baseline acreage of sagebrush habitat remained unchanged.

After reviewing the 2015 NAIP imagery in 2016, two unburned sagebrush habitat polygons were identified that were not included in the updated sagebrush habitat baseline calculation in 2015. The area of those polygons was added and the sagebrush habitat baseline value slightly increased to 78,558 hectares (194,120 acres). The baseline value has had two minor updates since the signing of the CCA, but the changes are a result of this task improving the accuracy of the sagebrush habitat distribution rather than any real changes due to disturbances that caused a loss.

Eighty plot arrays (sets of five co-located subplots; a total of 400 subplots) were sampled for naturally recovering vegetation classes during late-summer/fall 2016 within the area affected by the 2011 T-17 fire (Figure 10-5). The vegetation class recorded most often at these plot arrays was the Green Rabbitbrush/Streambank Wheatgrass (Western Wheatgrass) Shrub Herbaceous Vegetation class, documented at 146 (36.5 percent) subplots. The second most abundant class was the Needle and Thread Herbaceous Vegetation class, recorded at 88 (22 percent) subplots. The most common non-native herbaceous class was the Cheatgrass Semi-natural Herbaceous Vegetation, though it only occurred at 14 (3.5 percent) subplots. Although there were other subplots where non-native annual species were noted, the vast majority of locations within the T-17 fire are naturally recovering with native shrubs and grasses. Long-term natural sagebrush recovery is much more likely in post-fire communities dominated by native, perennial species than in areas dominated by weeds.

10.3.3 Identifying Non-Native Annual Grass Priority Restoration Areas

When firefighters construct wildland fire containment lines, they scrape away all vegetation, leaving swaths of disturbed bare ground that are susceptible to

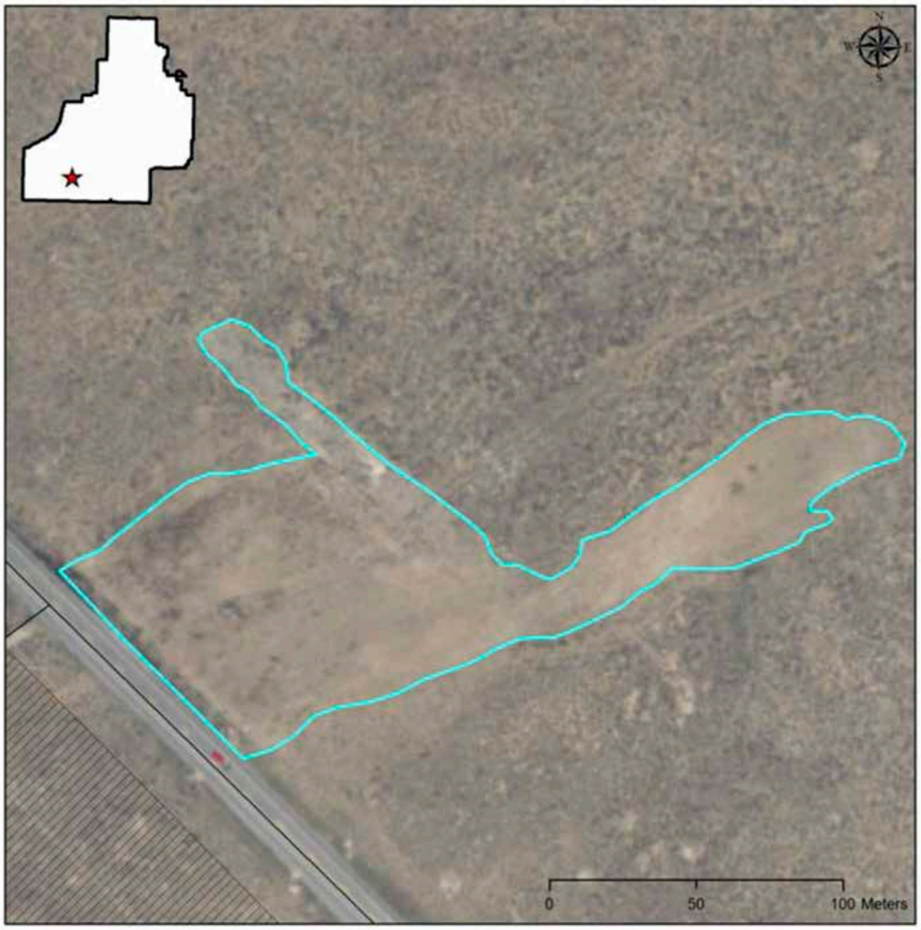

Figure 10-4. The Mapped Burned Area Boundary of the 2015 "268 Fire" on the INL Site. The striped polygon in the lower left corner represents the sage-grouse conservation area boundary.

non-native annual grass domination. Many containment lines on the INL Site have not had any post-fire rehabilitation to stabilize the soil and restore native vegetation communities. Consequently, those areas, that are often adjacent to relatively intact sagebrush and other native plant communities, have the potential to become a vector for the spread of non-native annual grasses and thereby reduce sagebrush habitat value for sage-grouse.

Habitat loss due to dominance by non-native grasses, primarily cheatgrass, is a substantial threat to sage-grouse across their range and was identified as a threat to sage-grouse at the INL Site in the CCA (DOE-ID and FWS 2014). This task was developed to address the threat of annual grasslands to sage-grouse, and its objectives are to inventory wildfire containment lines on the INL Site for cheatgrass dominance and to evaluate those areas for restoration priority (Shurtliff et al. 2016). Results from this task facilitate quantification of the effects of a known source of human-caused disturbance (i.e., containment lines) and provide an understanding how these disturbances are distributed across the landscape. This information will maximize conservation impacts by establishing revegetation priorities in degraded areas at risk for becoming a vector for cheatgrass spread.

To reduce the threat of annual grasslands, this task will be implemented in three phases, the first of which is to quantify the extent of containment lines. During Phase 2, ground-based surveys will be conducted to verify presence and estimate the abundance of non-native annual grasses on potentially weedy containment lines identified from Phase 1. This information will be used to develop a prioritized list of candidate restoration areas for future rehabilitation during Phase 3, that will include treating and revegetating prioritized areas as funding allows.

The first phase of this task was completed in 2016, and consisted of using aerial imagery to delineate the areas impacted by containment line development from

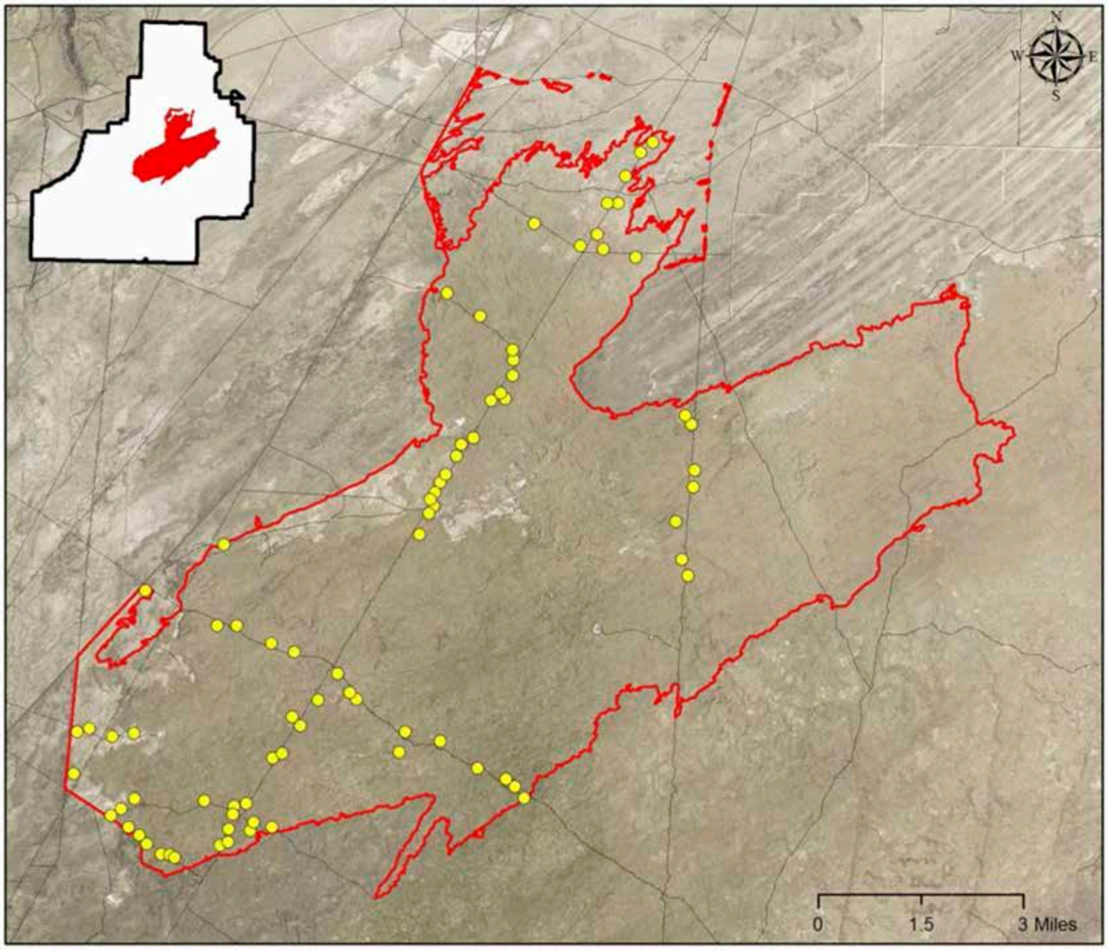

Figure 10-5. The Distribution of 2016 Field Plot Arrays (Yellow Points) Sampled Within the 2011 T-17 Fire on the INL Site. There are eighty plot areas depicted here; each array contains five subplots, for a total of 400 subplots sampled.

1994–2015. A total of 847 km (527 mi) of bladed containment lines on the INL Site that were observable on high-resolution NAIP imagery dating back to 2004 were mapped (Figure 10-6). The total area of soil disturbance, where vegetation was removed from containment line construction, was estimated to be 310–387 hectares (766–957 acres). The mapping results represent the majority of bladed containment lines from the most recent large wildland fires, but they are not intended to represent a comprehensive mapping of all containment lines ever bladed on the INL Site. Many of the bladed containment lines from wildland fires in the 1990s have had over a decade of natural recovery prior to this effort and would not be a high restoration priority (see Shurtliff et al. 2017 for detailed results).

Phase 2 of this project will begin in 2017. The mapped containment lines will be compared with aerial imagery, previously collected ground data, and institutional knowledge of the INL Site to select several areas for further ground-based assessment. Areas that are suspected to have had substantial soil disturbance and high cheatgrass cover will be surveyed and ranked according to restoration priority and feasibility. As new strategies and technologies for cheatgrass control become available, the restoration priority list will be used to select appropriate treatment sites (Phase 3).

10.3.4 Sagebrush Habitat Restoration

In the CCA for the INL Site (DOE-ID and FWS 2014), DOE committed to minimize the impact of habitat loss due to wildland fire and firefighting activities by taking steps to hasten sagebrush reestablishment whenever a fire burns >40 hectares (>99 acres). Although no wildfires >40 hectares have burned on the INL Site since 2012, DOE has voluntarily initiated an annually recur-

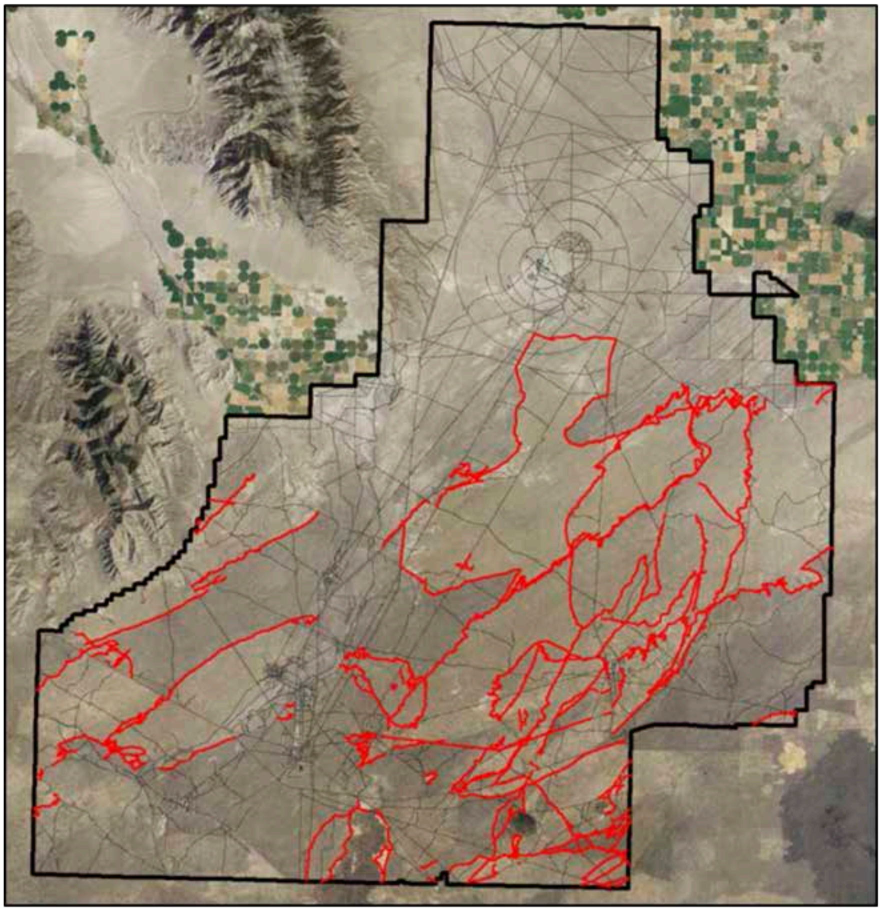

Figure 10-6. Distribution of Bladed Containment Lines (Plotted in Red) Mapped on the INL Site as of Fall 2016.

ring task to plant at least 5,000 sagebrush seedlings each fall in priority habitat restoration areas (DOE and FWS 2014, Section 9.4.4).

In 2014, sagebrush seeds were collected from a representative sample of stands across the INL Site. In 2015 and 2016, seeds were germinated and grown in greenhouses in 10-in^3 containers, and each fall the seedlings were planted into the selected priority restoration area (Figure 10-7). Approximately 5,000 seedlings were planted in 2015 and nearly 6,000 seedlings were planted in 2016. Seedlings were planted at a rate of about 198 sagebrush/hectare (80 sagebrush/acre). The goal of planting at this rate isn't necessarily to replace sagebrush at natural densities across a few acres, but rather to establish a seed source to hasten sagebrush reestablishment across larger restoration areas.

To assess the survivorship of sagebrush using this rehabilitation approach, a subset of at least 10 percent of the planted seedlings are selected for monitoring one and five years after planting. Seedlings are relocated, if possible, and are ranked as healthy, stressed, or dead (Figure 10-8). In 2016, surveys were completed for 501 of the 5,000 seedlings that were planted in 2015; 428 were relocated, of which, 129 (30 percent) were healthy, 238 (56 percent) were stressed, and 61 (14 percent) were dead. Thus, 86 percent of seedlings that we relocated survived the first year. Sixty-three of the seedlings marked in 2015 were not relocated. It is likely that many of these missing seedlings did not survive, though some live seedlings may have been missed, especially if they were stressed and in areas with relatively high background vegetation cover. A conservative estimate, assuming these 63 seedlings did not survive, lowers the estimate of seedling survivorship to 73 percent.

Precipitation patterns from fall 2015 to fall 2016 were not characteristic of a good recruitment year (Shurtliff et. al. 2017). Although fall and spring precipitation

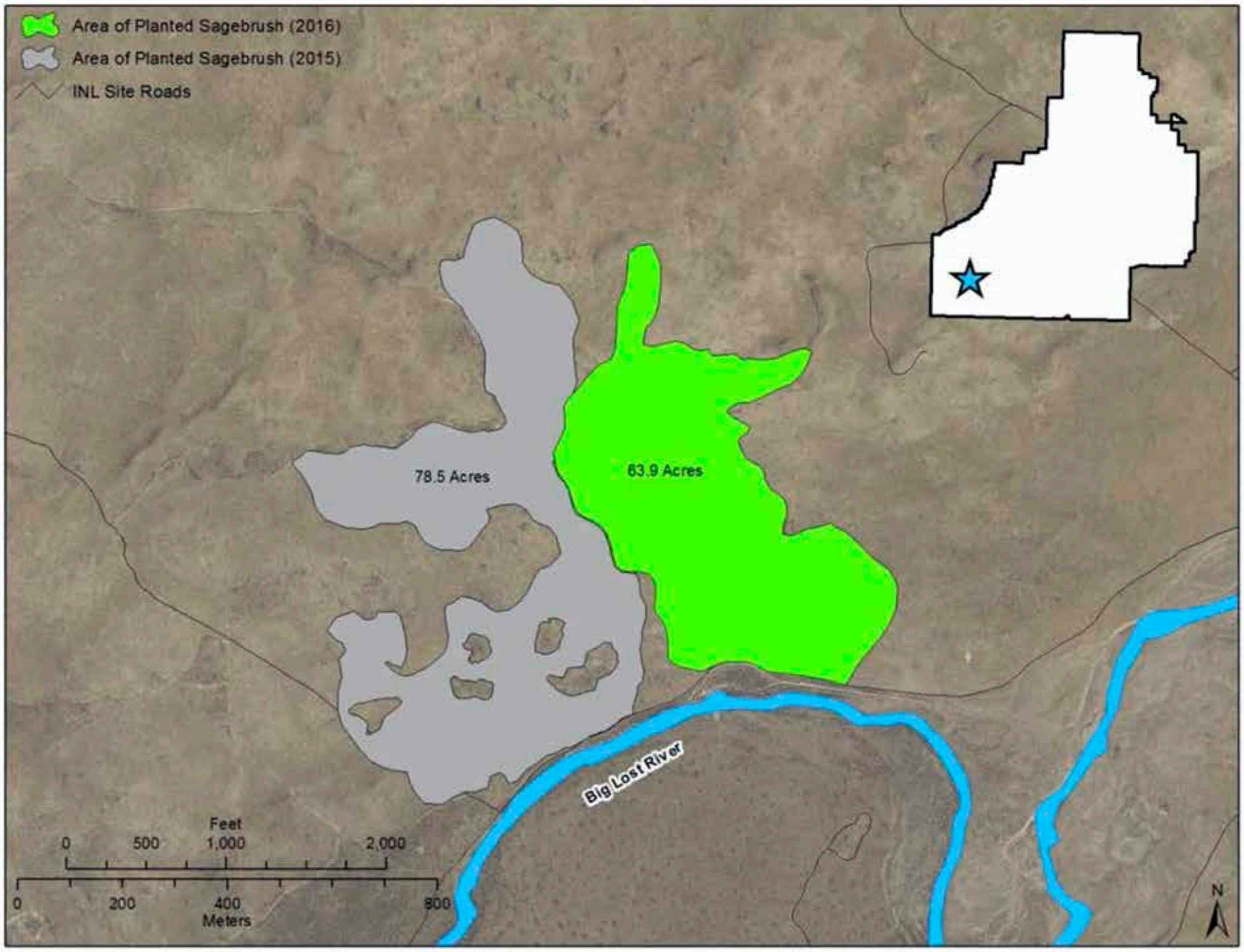

Figure 10-7. Areas Planted with Big Sagebrush Seedlings in 2015 and 2016. The star on the inset map shows the general location of the plots.

Figure 10-8. Examples of Sagebrush Seedling Conditions. From left to right: healthy, stressed, and dead.

was above or near average, summer growing season precipitation was far below average (Shurtliff et al. 2017). The lack of moisture during summer can strain young plants, and is likely responsible for the high levels of stressed plants we observed, as well as some of the seedling deaths. Though some of the stressed seedlings may perish in upcoming years, young sagebrush plants experience the highest mortality during the first year (Dettweiler-Robinson et al. 2013). In a review of 18 projects where containerized sagebrush seedlings were planted and survivorship was measured after one year (see Shurtliff et al. 2017 for details), researchers found that only seven projects (39 percent) reported survivorship of at least 73 percent (range 73–94 percent, mean 79 percent). Therefore, sagebrush establishment following the 2015 planting on the INL Site was higher than may be expected given the dry summer conditions.

10.4 Ecological Research at the Idaho National Environmental Research Park

10.4.1 Studies of Ants and Ant Guests at the INL Site

William H. Clark, Orma J. Smith Museum of Natural History, The College of Idaho, Caldwell, ID, 83605
bclark@collegeofidaho.edu

Clark and Blom (2007) gave a list of ants found at the INL Site. This has given us a base to study some ecological relationships between some of the ant taxa at the INL Site and a variety of ant guests. One such ant guest taxa, a desert beetle (Coleoptera: Tenebrionidae, *Philolithus elatus*) was collected in *Pogonomyrmex salinus* nests and is the subject of study and description (Clark et al. in prep). We have now taken photographs with light and scanning electron microscope, and we have observed a *Philolithus elatus* female ovipositing on a *Pogonomyrmex salinus* nest. The results will be published in Clark et al. (in prep) and have been presented in Clark et al. (2015). We are also working on a publication relating to past research at the INL Site involving cicadas and *Pogonomyrmex salinus* nests (Blom and Clark, in prep).

An undescribed species of Jerusalem cricket (Orthoptera: Stenopelmatidae, *Stenopelmatus* sp.) has been found at the INL Site. The *Stenopelmatus* was found in the ant nests during previous fieldwork. A series of live individuals, including both males and females, were needed for a proper species description. Live specimens were collected in July 2013, and additional specimens were collected during September 2014. In addition, one specimen was found in one of the excavated ant nests. They have been shipped to the specialist in the group for rearing and description. This relationship will require more study during future visits to the INL Site.

In addition, during 2015, we made field observations of predation on *Pogonomyrmex salinus*, and this turns out to be a different spider species as predator of the ant from what we have previously reported for the site (Clark and Blom 1992). The spider has since been identified as *Xysticus*, a member of the family Thomisidae (crab spiders). This family and genus are likely new records for the INL Site and are predators on *Pogonomyrmex salinus*.

During the 2016 field season, we continued research relating to the projects listed above. We observed many (most) nests of *Pogonomyrmex salinus* with small holes dug into them, presumably by heteromyid rodents (Figure 10-9). This interaction has been reported in the literature by Clark and Comanor (1973) for *Pogonomyrmex occidentalis*, but not yet reported for *Pogonomyrmex salinus*. These stores in ant nests may represent a significant food source for the rodents at INL.

Field research will continue into the foreseeable future.

Acknowledgments

Mary Clark assisted with the field work. Jim Berrian provided the spider identification. Bill Doering provided field access and other logistical assistance.

Figure 10-9. Typical Nest of the Harvester Ant, *Pogonomyrmex salinus* Olsen, at the Circular Butte Site at the Idaho National Laboratory Site, Showing Digging, Presumably by Heteromyid Rodents for Plant Seed Caches. W.H. Clark Photo. September 12, 2016.

10.4.2 Ecosystem Responses of Sagebrush Steppe to Altered Precipitation, Vegetation and Soil Properties

PI: Matthew J. Germino, Ph.D., Research Ecologist, United States Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, ID
Co-PI: Keith Reinhardt, Ph.D., Assistant Professor, Idaho State University, Pocatello, ID
Kevin Feris, Ph.D., Assistant Professor, Boise State University, Boise, ID
Kathleen Lohse, Ph.D., Assistant Professor, Idaho State University, Pocatello, ID
Marie-Anne deGraff, Ph.D., Assistant Professor, Boise State University, Boise, ID
David Huber, Ph.D. candidate, Idaho State University, Pocatello, ID
Patrick Sorenson, M.S., Boise State University, Boise, ID
Patricia Xochi Campos, M.S. candidate, Boise State University, Boise, ID
Kate McAbee, M.S. candidate, Idaho State University, Pocatello, ID
Andrew Bosworth, Science Teacher, Ririe High School, Ririe, ID

The INL Site and other landscapes with sagebrush steppe vegetation are experiencing a simultaneous change in climate and plant community composition that are impacting habitat for wildlife, wildfire risks, and ecosystem services such as forage. Determining the separate and combined/interactive effects of climate and vegetation change is important for assessing future changes on the landscape and for hydrologic processes. Over the last decade we transformed an experiment known as the "Protective Cap Biobarrier Experiment" (initiated by Dr. Jay Anderson and colleagues) that was originally designed to test options for protecting buried waste into what has become the longest running and most robust ecohydrology experiment in semiarid environments. The experiment is unique in enabling investigation of the two-way interaction of plants and soil water: the 72 plots differ in precipitation regime (ambient or doubling of annual precipitation added in winter or summer), the type of vegetation planted (native or the exotic crested wheatgrass), and soil depth (shallow, deep, and various horizons). The overall focus has been to compare the impacts of grass invasion and shifts in timing of precipitation on functioning of the whole ecosystem, including biogeochemistry, carbon storage, and other attributes that relate to resistance and resilience in a changing environment.

Since our last report we submitted or revised (in 2016) two additional papers that have 2017 publication dates. McAbee et al. (2017) found that irrigation increased ecosystem carbon uptake measured in large chambers placed over plots, leading to increased standing crop of vegetation only when the irrigation was added in winter and primarily in the native sagebrush steppe plots (and not non-native crested wheatgrass plots; Figure 10-10 reproduced from the article). Thus, the climate forecasts for future increase in winter vs. summer precipitation might lead to more carbon storage, although that effect may be lost where grass invasions have occurred, which is a vast and expanding problem. Campos et al. (2017) found that these differences were partly attributable to increased decomposition in summer-irrigated plots and greater stabilization of soil carbon with winter irrigation.

Our final irrigation treatments occurred in 2016 (summer) due to funding constraints, and we made detailed plant community assessments during this last irrigation season. We have considerable data sets from the last decade on plant community, population demography, and soil biogeochemical and microbial responses to publish. From here onward, our field assessments will focus periodically (i.e., every several to ~5 years) evaluate how the plant communities on plots respond to the cessation of long-term irrigation, which we expect to cause losses or increases in sagebrush (i.e., opposite effects reported in Germino and Reinhardt 2014) and that the native mortality will be compensated by increases in crested wheatgrass or other invasives (Prevéy et al. 2010a,b).

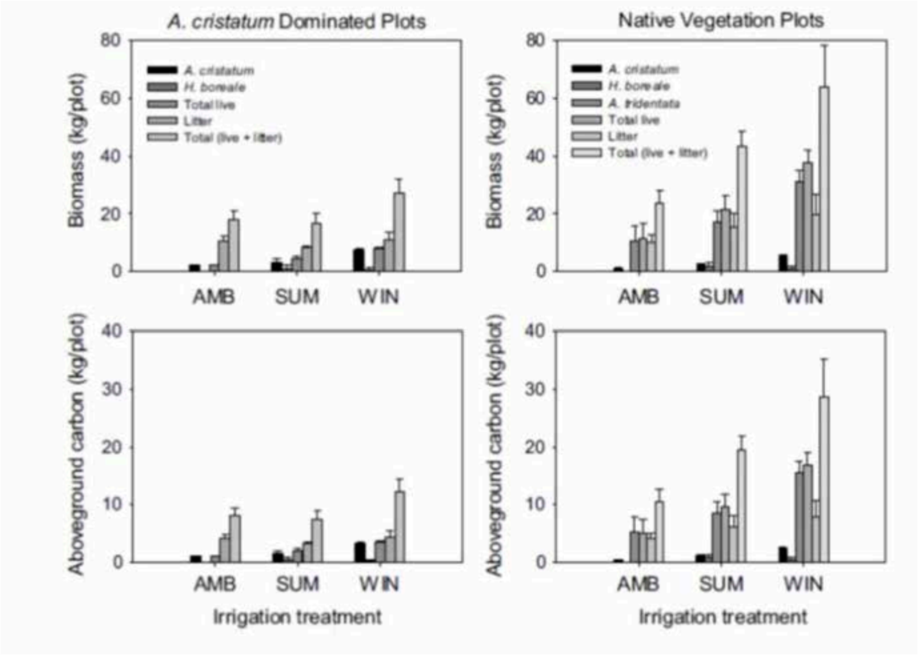

Figure 10-10. Aboveground Biomass and Stored C Among Functional Groups in Ambient (AMB), Summer (SUM), and Winter (WIN) Plots. Columns represent means and error bars represent one standard error of the mean. Harvest occurred at peak biomass (in early July for WIN plots, and in August for SUM and AMB plots). Abbreviations: AGCR (*A. cristatum*), HEBO (*H. borale*), ARTR (*A. tridentata*), total live (all living plant material, including phytomass and woody stems in the case of shrubs), litter (dead plant material, both standing and on the ground).

10.5 U.S. Geological Survey 2016 Publication Abstracts

In 1949, the USGS was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL Site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the ESRP and the ESRP aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells
- Drills new research and monitoring wells, providing information about subsurface water, rock, and sediment
- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities are used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and to improve understanding of the complex relationships between the rocks, sediments, and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse: http://id.water.usgs.gov/projects/INL/Pubs/index.html.

Six reports were published by the USGS INL Project Office in 2016. The abstracts of these studies and the publication information associated with each study are presented below.

10.5.1 Evaluation of Background Concentrations of Selected Chemical and Radiochemical Constituents in Water from the Eastern Snake River Plain Aquifer at and near the Idaho National Laboratory, Idaho (Bartholomay, R. C. and L. F. Hall, 2016)

The U.S. Geological Survey and Idaho Department of Environmental Quality Idaho National Laboratory (INL) Oversight Program in cooperation with the U.S. Department of Energy determined background concentrations of selected chemical and radiochemical constituents in the eastern Snake River Plain aquifer to aid with ongoing cleanup efforts at the INL. Chemical and radiochemical constituents including calcium, magnesium, sodium, potassium, silica, chloride, sulfate, fluoride, bicarbonate, chromium, nitrate, tritium, strontium-90, chlorine-36, iodine-129, plutonium-238, plutonium-239, -240 (undivided), americium-241, technetium-99, uranium-234, uranium-235, and uranium-238 were selected for the background study because they were either not analyzed in earlier studies or new data became available to give a more recent determination of background concentrations. Samples of water collected from wells and springs at and near the INL that were not believed to be influenced by wastewater disposal were used to identify background concentrations. Groundwater in the eastern Snake River Plain aquifer at and near the INL was divided into two major water types (western tributary and eastern regional) based on concentrations of lithium less than and greater than 5 micrograms per liter (µg/L). Median concentrations for each constituent were used to define the upper limit of background.

The upper limit of background concentrations for inorganic chemicals for western tributary water was 40.7 milligrams per liter (mg/L) for calcium, 15.3 mg/L for magnesium, 8.30 mg/L for sodium, 2.32 mg/L for potassium, 23.1 mg/L for silica, 11.8 mg/L for chloride, 21.4 mg/L for sulfate, 0.20 mg/L for fluoride, 176 mg/L for bicarbonate, 4.00 µg/L for chromium, and 0.655 mg/L for nitrate.

The upper limit of background concentrations for inorganic chemicals for eastern regional water was 34.05 mg/L for calcium, 13.85 mg/L for magnesium, 14.85 mg/L for sodium, 3.22 mg/L for potassium, 31.0 mg/L for silica, 14.15 mg/L for chloride, 20.2 mg/L for sulfate, 0.4675 mg/L for fluoride, 165 mg/L for bicarbonate, 3.00 µg/L for chromium, and 0.995 mg/L for nitrate.

The upper limit of background concentrations for radiochemical constituents for western tributary water was 34.15 ±2.35 picocuries per liter (pCi/L) for tritium, 0.00098 ±0.00006 pCi/L for chlorine-36, 0.000011 ±0.000005 pCi/L for iodine-129, <0.0000054 pCi/L for technetium-99, 0 pCi/L for strontium-90, plutonium-238, plutonium-239, -240 (undivided), and americium-241, 1.36 pCi/L with undetermined uncertainty for uranium-234, 0.025 ±0.001 pCi/L for uranium-235, and 0.541 ±0.001 pCi/L for uranium-238.

The upper limit of background concentrations for radiochemical constituents for eastern regional water was 5.43 ±0.574 pCi/L for tritium, 0.0002048 ±0.0000054 pCi/L for chlorine-36, 0.000000865 ±0.000000015 pCi/L for iodine-129, <0.0000054 pCi/L for technetium-99, 0 pCi/L for strontium-90, plutonium-238, plutonium-239, -240 (undivided), and americium-241, 1.32 ±0.77 pCi/L for uranium-234, 0.016 ±0.012 pCi/L for uranium-235, and 0.477 ±0.044 pCi/L for uranium-238.

10.5.2 Purgeable Organic Compounds at or near the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 2015 (Maimer, N. V., and R. C. Bartholomay, 2016)

During 2015, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, collected groundwater samples from 31 wells at or near the Idaho Nuclear Technology and Engineering Center (INTEC) at the Idaho National Laboratory for purgeable organic compounds (POCs). The samples were collected and analyzed for the purpose of evaluating whether purge water from wells located inside an areal polygon established downgradient of the INTEC must be treated as a Resource Conservation and Recovery Act listed waste.

POC concentrations in water samples from 29 of 31 wells completed in the eastern Snake River Plain aquifer were greater than their detection limit, determined from detection and quantitation calculation software, for at least one to four POCs. Of the 29 wells with concentrations greater than their detection limits, only 20 had concentrations greater than the laboratory reporting limit as calculated with detection and quantitation calculation software. None of the concentrations exceeded any maximum contaminant levels established for public drinking water supplies. Most commonly detected compounds were 1,1,1-trichoroethane, 1,1-dichloroethene, and trichloroethene.

10.5.3 Completion Summary for Boreholes TAN-2271 and TAN 2272 at Test Area North, Idaho National Laboratory, Idaho (Twining, B. V. et al. 2016)

In 2015, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, drilled and constructed boreholes TAN-2271 and TAN-2272 for stratigraphic framework analyses and long-term groundwater monitoring of the eastern Snake River Plain aquifer at the Idaho National Laboratory in southeast Idaho. Borehole TAN-2271 initially was cored to collect continuous geologic data, and then re-drilled to complete construction as a monitor well. Borehole TAN-2272 was partially cored between 210 and 282 feet (ft) below land surface (BLS) then drilled and constructed as a monitor well. Boreholes TAN-2271 and TAN-2272 are separated by about 63 ft and have similar geologic layers and hydrologic characteristics based on geologic, geophysical, and aquifer test data collected. The final construction for boreholes TAN-2271 and TAN-2272 required 10-inch (in.) diameter carbon-steel well casing and 9.9-in. diameter open-hole completion below the casing to total depths of 282 and 287 ft BLS, respectively. Depth to water is measured near 228 ft BLS in both boreholes. Following construction and data collection, temporary submersible pumps and water-level access lines were placed to allow for aquifer testing, for collecting periodic water samples, and for measuring water levels.

Borehole TAN-2271 was cored continuously, starting at the first basalt contact (about 33ft BLS) to a depth of 284 ft BLS. Excluding surface sediment, recovery of basalt and sediment core at borehole TAN-2271 was better than 98 percent. Based on visual inspection of core and geophysical data, material examined from 33 to 211 ft BLS primarily consists of two massive basalt flows that are about 78 and 50 ft in thickness and three sediment layers near 122, 197, and 201 ft BLS. Between 211 and 284 ft BLS, geophysical data and core material suggest a high occurrence of fractured and vesicular basalt. For the section of aquifer tested, there are two primary fractured aquifer intervals: the first between 235 and 255 ft BLS and the second between 272 and 282 ft BLS. Basalt texture for borehole TAN-2271 generally was described as aphanitic, phaneritic, and porphyritic. Sediment layers, starting near 122 ft BLS, generally were composed of fine-grained sand and silt with a lesser amount of clay. Basalt flows generally ranged in thickness from 2 to 78 ft and varied from highly fractured to dense with high to low vesiculation. Geophysical data and limited core material collected from TAN-2272 show similar lithologic sequences to those reported for TAN-2271.

Geophysical and borehole video logs were collected during certain stages of the drilling and construction process at boreholes TAN-2271 and TAN-2272. Geophysical logs were examined synergistically with available core material to confirm geologic and hydrologic similarities and suggest possible fractured network interconnection between boreholes TAN-2271 and TAN-2272. Natural gamma log measurements were used to assess the completeness of the vapor port lines behind 10-in. diameter well casing. Electromagnetic flow meter results were used to identify downward flow conditions that exist for boreholes TAN-2271 and TAN-2272. Furthermore, gyroscopic deviation measurements were used to measure horizontal and vertical displacement at all depths in boreholes TAN-2271 and TAN-2272.

After borehole construction was completed, single well aquifer tests were done within wells TAN-2271 and TAN 2272 to provide estimates of transmissivity and hydraulic conductivity. The transmissivity and hydraulic conductivity were estimated for the pumping well and observation well during the aquifer tests conducted on August 25 and August 27, 2015. Estimates for transmissivity range from 4.1 × 10^3 feet squared per day (ft^2/d) to 8.1 × 10^3 ft^2/d; estimates for hydraulic conductivity range from 5.8 to 11.5 feet per day (ft/d). Both TAN-2271 and TAN 2272 show sustained pumping rates of about 30 gallons per minute (gal/min) with measured drawdown in the pumping well of 1.96 ft and 1.14 ft, respectively. The transmissivity estimates for wells tested were within the range of values determined from previous aquifer tests in other wells near Test Area North.

Groundwater samples were collected from both wells and were analyzed for cations, anions, metals, nutrients, volatile organic compounds, stable isotopes, and radionuclides. Groundwater samples for most of the inorganic constituents showed similar water chemistry in both wells. Groundwater samples for strontium-90, trichloroethene, and vinyl chloride exceeded maximum contaminant levels for public drinking water supplies in one or both wells.

10.5.3 Properties of Pleistocene sediment in two wells in the west-central portion of the Big Lost Trough, eastern Snake River Plain, Idaho National Laboratory, Idaho (Mudge, C. M., 2016)

Sediment in cores from drillholes Naval Reactor Facility (NRF) 15 and United States Geologic Survey (USGS) 142 from the northern part of the Big Lost Trough (BLT) at the Idaho National Laboratory (INL) document an evolution of facies during Early Pleistocene time. Although more than 95 percent of the upper portions of these cores is basalt, sedimentary intervals, from 520 ft to 595 ft below land surface (BLS) in NRF 15 and from 732 ft to 837 ft BLS in USGS 142 were analyzed for grain size and petrologic analysis. The large difference in depth BLS between USGS 142 and NRF 15 is accounted for by variable subsidence across the BLT. Estimated ages, based on paleomagnetic signatures of the basalt, suggest that the intervals are 884 ka-988 ka. Each interval consists of clay that grades upward to coarse silt and sand. Through grain size analysis and visual inspection of the core each interval is interpreted to represent a lake that shallows upward into shoreline sands and loess.

Three depositional environments can be interpreted from the grain size data in each of these upward coarsening intervals. The lower part of each interval is clay dominated and coarse skewed with average grain-size of 6 to 8 phi. This interval is interpreted as a shallow lake deposit. The intervals then coarsen upward to a fine-skewed silty sand, interpreted as shoreline or eolian sediment. Parts of the upper portions of sedimentary intervals in NRF 15 display bimodal grain size distributions with peaks at 2 and 8 phi; this sediment is interpreted as loess.

Point counting reveals that sands in the shoreline facies are volcanic lithic arenites (58 percent lithics, and of those 63 percent are volcanic lithics with 54 percent of the volcanic lithics being felsitic volcanic grains). These sands are interpreted to reflect transport via the paleo-Big Lost River, and are most likely sourced from the Challis volcanics, which are primarily dacitic and rhyodacitic in composition. The detrital zircons in the sandy intervals at 840 and 780 feet in USGS 142 resemble samples previously described from the Big Lost River. The zircon age spectra have an age peak at 45 Ma that correlates most closely with a Challis volcanic source, and a Neoproterozoic age peak at 675 Ma that correlates with granitic rocks intruded into the Pioneer Mountains core complex.

10.5.4 Paleomagnetic Correlation of Basalt Flows in Selected Coreholes near the Advanced Test Reactor Complex, the Idaho Nuclear Technology and Engineering Center, and along the Southern Boundary, Idaho National Laboratory, Idaho (Hodges, M. K. V., and D. E. Champion, 2016)

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, used paleomagnetic data from 18 coreholes to construct three cross sections of subsurface basalt flows in the southern part of the Idaho National Laboratory (INL). These cross sections, containing descriptions of the subsurface horizontal and vertical distribution of basalt flows and sediment layers, will be used in geological studies, and to construct numerical models of groundwater flow and contaminant transport.

Subsurface cross sections were used to correlate surface vents to their subsurface flows intersected by coreholes, to correlate subsurface flows between coreholes, and to identify possible subsurface vent locations of subsurface flows. Correlations were identified by average paleomagnetic inclinations of flows, and depth from land surface in coreholes, normalized to the North American Datum of 1927. Paleomagnetic data were combined, in some cases, with other data, such as radiometric ages of flows. Possible vent locations of buried basalt flows were identified by determining the location of the maximum thickness of flows penetrated by more than one corehole.

Flows from the surface volcanic vents Quaking Aspen Butte, Vent 5206, Mid Butte, Lavatoo Butte, Crater Butte, Pond Butte, Vent 5350, Vent 5252, Tin Cup Butte, Vent 4959, Vent 5119, and AEC Butte are found in coreholes, and were correlated to the surface vents by matching their paleomagnetic inclinations, and in some cases, their stratigraphic positions. Some subsurface basalt flows that do not correlate to surface vents, do correlate over several coreholes, and may correlate to buried vents. Subsurface flows which correlate across several coreholes, but not to a surface vent include the D3 flow, the Big Lost flow, the CFA buried vent flow, the Early, Middle, and Late Basal Brunhes flows, the South Late Matuyama flow, the Matuyama flow, and the Jaramillo flow. The location of vents buried in the subsurface by younger basalt flows can be inferred if their flows are penetrated by several coreholes, by tracing the flows in the subsurface, and determining where the greatest thickness occurs.

10.5.5 Preferential flow, diffuse flow, and perching in an interbedded fractured-rock unsaturated zone (Nimmo, J. R., et al. 2016)

Layers of strong geologic contrast within the unsaturated zone can control recharge and contaminant transport to underlying aquifers. Slow diffuse flow in certain geologic layers, and rapid preferential flow in others, complicates the prediction of vertical and lateral fluxes. A simple model is presented, designed to use limited geological site information to predict these critical subsurface processes in response to a sustained infiltration source. The model is developed and tested using site-specific information from the Idaho National Laboratory in the Eastern Snake River Plain (ESRP), USA, where there are natural and anthropogenic sources of high-volume infiltration from floods, spills, leaks, wastewater disposal, retention ponds, and hydrologic field experiments. The thick unsaturated zone overlying the ESRP aquifer is a good example of a sharply stratified unsaturated zone. Sedimentary interbeds are interspersed between massive and fractured basalt units. The combination of surficial sediments, basalts, and interbeds determines the water fluxes through the variably saturated subsurface. Interbeds are generally less conductive, sometimes causing perched water to collect above them. The model successfully predicts the volume and extent of perching and approximates vertical travel times during events that generate high fluxes from the land surface. These developments are applicable to sites having a thick, geologically complex unsaturated zone of substantial thickness in which preferential and diffuse flow, and perching of percolated water, are important to contaminant transport or aquifer recharge.

10.5.6 Borehole deviation and correction factor data for selected wells in the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho (Twining, B. V., 2016)

The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, has maintained a water-level monitoring program at the Idaho National Laboratory (INL) since 1949. The purpose of the program is to systematically measure and report water-level data to assess the eastern Snake River Plain aquifer and long term changes in groundwater recharge, discharge, movement, and storage. Water-level data are commonly used to generate potentiometric maps and used to infer increases and (or) decreases in the regional groundwater system. Well deviation is one component of water-level data that is often overlooked and is the result of the well construction and the well not being plumb. Depending on measured slant angle, where well deviation generally increases linearly with increasing slant angle, well deviation can suggest artificial anomalies in the water table. To remove the effects of well deviation, the USGS INL Project Office applies a correction factor to water-level data when a well deviation survey indicates a change in the reference elevation of greater than or equal to 0.2 ft.

Borehole well deviation survey data were considered for 177 wells completed within the eastern Snake River Plain aquifer, but not all wells had deviation survey data available. As of 2016, USGS INL Project Office database includes: 57 wells with gyroscopic survey data; 100 wells with magnetic deviation survey data; 11 wells with erroneous gyroscopic data that were excluded; and, 68 wells with no deviation survey data available. Of the 57 wells with gyroscopic deviation surveys, correction factors for 16 wells ranged from 0.20 to 6.07 ft and inclination angles (SANG) ranged from 1.6 to 16.0 degrees. Of the 100 wells with magnetic deviation surveys, a correction factor for 21 wells ranged from 0.20 to 5.78 ft and SANG ranged from 1.0 to 13.8 degrees, not including the wells that did not meet the correction factor criteria of greater than or equal to 0.20 ft.

Forty-seven wells had gyroscopic and magnetic deviation survey data for the same well. Datasets for both survey types were compared for the same well to determine whether magnetic survey data were consistent with gyroscopic survey data. Of those 47 wells, 96 percent showed similar correction factor estimates (≤ 0.20 ft) for both magnetic and gyroscopic well deviation surveys. A linear comparison of correction factor estimates for both magnetic and gyroscopic deviation well surveys for all 47 wells indicate good linear correlation, represented by an r-squared of 0.88. The correction factor difference between the gyroscopic and magnetic surveys for 45 of 47 wells ranged from 0.00 to 0.18 ft, not including USGS 57 and USGS 125. Wells USGS 57 and USGS 125 show a correction factor difference of 2.16 and 0.36 ft, respectively; however, review of the data files suggest erroneous SANG data for both magnetic deviation well surveys. The difference in magnetic and gyroscopic well deviation SANG measurements, for all wells, ranged from 0.0 to 0.9 degrees. These data indicate good agreement between SANG data measured using the magnetic deviation survey methods and SANG data measured using gyroscopic deviation survey methods, even for surveys collected years apart.

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Sage-grouse on a Lek. Photo: Kristin Kaser

2016

11. Quality Assurance of Environmental Monitoring Programs

11. QUALITY ASSURANCE OF ENVIRONMENTAL MONITORING PROGRAMS

Quality assurance (QA) consists of the planned and systematic activities necessary to provide adequate confidence in the results of effluent monitoring and environmental surveillance programs (NCRP 2012). The main objective of an environmental monitoring program is to provide data of high quality so that the appropriate assessments and decisions based on those data can be made. This chapter presents information on specific measures taken by the effluent monitoring and environmental surveillance programs in 2016 to ensure the high quality of data collected and presented in this annual report as well as a summary of performance.

11.1 Quality Assurance Policy and Requirements

The primary policy, requirements, and responsibilities for ensuring QA in U.S. Department of Energy (DOE) activities are provided in:

- DOE Order 414.1D, “Quality Assurance”
- 10 Code of Federal Regulations (CFR) 830, Subpart A, “Quality Assurance Requirements”
- American Society of Mechanical Engineers NQA-1-2012, “Quality Assurance Requirement for Nuclear Facility Applications.”

These regulations specify 10 criteria of a quality program, shown in the box to the right. Additional QA program requirements in 40 CFR 61, Appendix B, must be met for all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H.

Required Criteria of a Quality Program

- Quality assurance program
- Personnel training and qualification
- Quality improvement process
- Documents and records
- Established work processes
- Established standards for design and verification
- Established procurement requirements
- Inspection and acceptance testing
- Management assessment
- Independent assessment

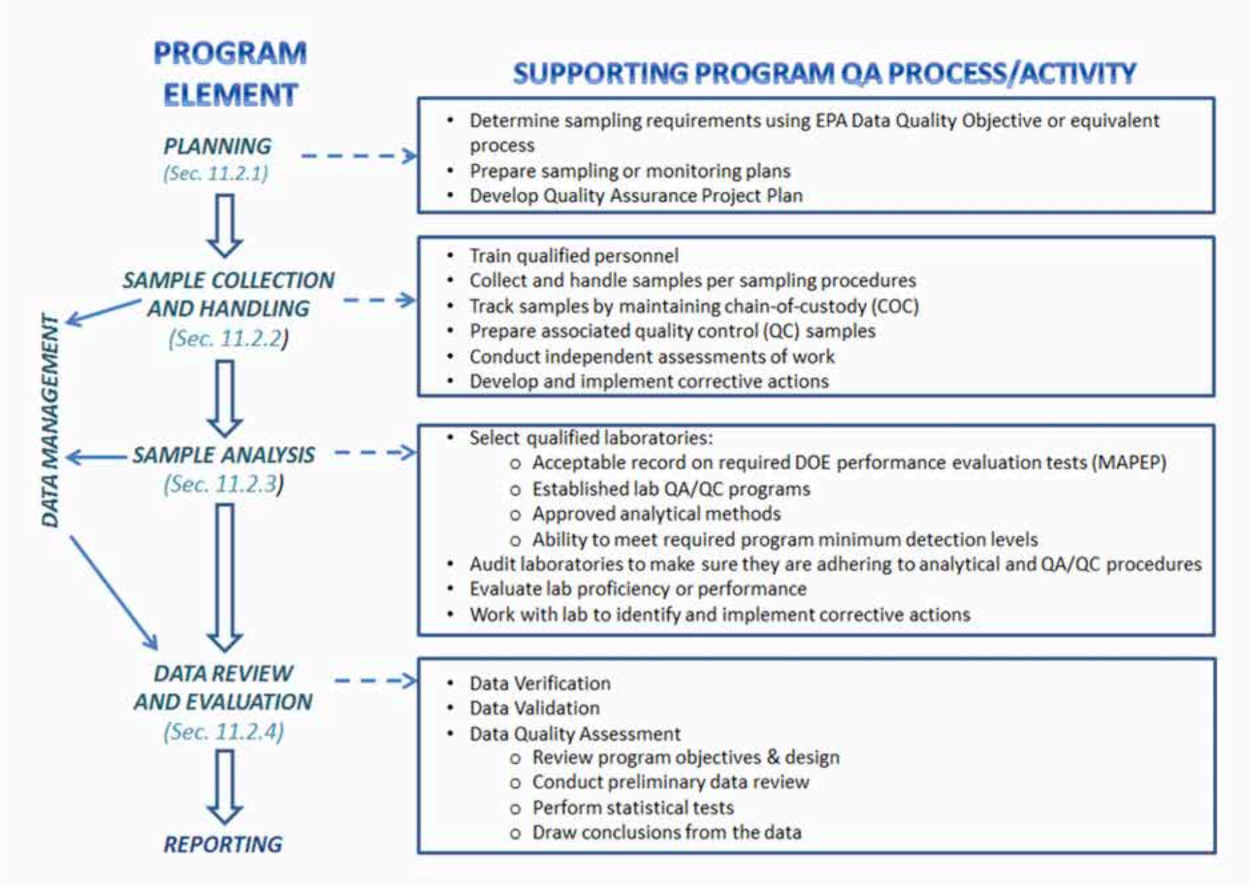
Each Idaho National Laboratory (INL) Site environmental monitoring organization incorporates QA requirements appropriate to its program to ensure that environmental samples are representative and complete and that data are reliable and defensible.

11.2 Program Elements and Supporting QA Processes

According to the National Council on Radiation Protection and Measurements (NCRP 2012), QA is an integral part of every aspect of an environmental monitoring program, from the reliability of sample collection through sample transport, storage, processing, and measurement, to calculating results and formulating the report. Uncertainties in the environmental monitoring process can lead to misinterpretation of data and/or errors in decisions based on these data. Every step in the radiological effluent monitoring and environmental surveillance should be evaluated for integrity, and actions should be taken to evaluate and manage data uncertainty. These actions include proper planning, sampling and measure-

What is the difference between Quality Assurance and Quality Control in an environmental program?

- Quality Assurance (QA) is an integrated system of management activities designed to ensure quality in the processes used to produce environmental data. The goal of QA is to improve processes so that results are within acceptable ranges.
- Quality Control (QC) is a set of activities that provide program oversight (i.e., a means to review and control the performance of various aspects of the QA program). QC provides assurance that the results are what is expected.



- Determine sampling requirements using EPA Data Quality Objective or equivalent process
- Prepare sampling or monitoring plans
- Develop Quality Assurance Project Plan

- Train qualified personnel
- Collect and handle samples per sampling procedures
- Track samples by maintaining chain-of-custody (COC)
- Prepare associated quality control (QC) samples
- Conduct independent assessments of work
- Develop and implement corrective actions

- Select qualified laboratories:
    - Acceptable record on required DOE performance evaluation tests (MAPEP)
    - Established lab QA/QC programs
    - Approved analytical methods
    - Ability to meet required program minimum detection levels
- Audit laboratories to make sure they are adhering to analytical and QA/QC procedures
- Evaluate lab proficiency or performance
- Work with lab to identify and implement corrective actions

- Data Verification
- Data Validation
- Data Quality Assessment
    - Review program objectives & design
    - Conduct preliminary data review
    - Perform statistical tests
    - Draw conclusions from the data

Figure 11-1. Flow of Environmental Monitoring Program Elements and Associated Quality Assurance Processes and Activities.

ment, application of quality control (QC) procedures, and careful analysis of data used for decision making.

The main elements of environmental monitoring programs implemented at the INL Site, as well as the QA processes/activities that support them, are shown in Figure 11-1 and are discussed below. Summaries of program-specific QC data are presented in Section 11.3. Documentation of the QA programs is provided in Section 11.4.

11.2.1 Planning

Environmental monitoring activities are conducted by a variety of organizations consisting of:

- Idaho National Laboratory (INL)
- Idaho Cleanup Project (ICP) Core
- Environmental Surveillance, Education, and Research (ESER) Program
- U.S. Geological Survey (USGS)
- National Oceanic and Atmospheric Administration (NOAA)
- Advanced Mixed Waste Treatment Project (AMWTP).

Each INL Site monitoring organization determines sampling requirements using the U.S. Environmental Protection Agency (EPA) Data Quality Objective (DQO) process (EPA 2006) or its equivalent. During this process, the project manager determines the type, amount, and quality of data needed to meet regulatory requirements, support decision making, and address stakeholder concerns.

Environmental Monitoring Plan. The *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014) summarizes the various programs at the INL Site. It describes routine compliance monitoring of airborne and liquid effluents; environmental surveillance of air, water (surface, drinking, and ground), soil, biota, agricultural products, and external radiation; and ecological and meteorological monitoring on and near the INL Site. The plan includes the rationale for monitoring, the types of media monitored, where the monitoring is conducted, and information regarding access to analytical results.

Quality Assurance Project Plan. Implementation of QA elements for sample collection and data assessment activities are documented by each monitoring contractor using the approach recommended by the EPA. The EPA policy on QA plans is based on the national consensus standard ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." The EPA approach to data quality centers on the DQO process. DQOs are project dependent and are determined on the basis of the data users' needs and the purpose for which data are generated. Quality elements applicable to environmental monitoring and decision making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001). These elements are categorized as follows:

- Project management
- Data generation and acquisition
- Assessment and oversight
- Data validation and usability.

A Quality Assurance Project Plan (QAPP) documents the planning, implementation, and assessment procedures for a particular project, as well as any specific QA and QC activities. It integrates all the technical and quality aspects of the project in order to provide a "blueprint" for obtaining the type and quality of environmental data and information needed for a specific decision or use. Each environmental monitoring and surveillance program at the INL Site prepares a QAPP.

11.2.2 Sample Collection and Handling

Strict adherence to program procedures is an implicit foundation of QA. In 2016, samples were collected and handled according to documented program procedures. Samples were collected by personnel trained to collect and properly process samples. Sample integrity was maintained through a system of sample custody records. Assessments of work execution were routinely conducted by personnel independent of the work activity, and deficiencies were addressed by corrective actions, which are tracked in contractor-maintained corrective action tracking systems.

QC samples were also collected or prepared to check the quality of sampling processes. They included the collection of trip blanks, field blanks, split samples, and field duplicates, which are defined as follows:

Trip Blank. A sample of analyte-free media taken from the sample preparation area to the sampling site and returned to the analytical laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples.

Field Blank. A clean, analyte-free sample that is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. A field blank is collected to assess the potential introduction of contaminants during sampling, storage, and transport.

Split Sample. A sample collected and later divided from the same container into two portions that are analyzed separately. Split samples are used to assess precision.

Field Replicates (duplicates or collocated samples). Two samples collected from a single location at the same time, stored in separate containers, and analyzed independently. In the case of air sampling, two air samplers are placed side by side and each filter is analyzed separately. Duplicates are useful in documenting the precision (defined in the box below) of the sampling process. Field duplicates also provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures (see Section 11.2.3).

11.2.3 Sample Analysis

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 11-1.

Precision

Precision is a measure of mutual agreement among individual measurements of the same property.

Results obtained from analyses of split or duplicate samples are compared and precision is expressed as standard deviation, variance, or range.

Table 11-1. Analytical Laboratories Used by INL Site Contractors and USGS Environmental Monitoring Programs.

Contractor and Program	Laboratory	Type of Analysis
ICP Core Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	Eurofins Eaton Analytical, Inc.	Inorganic and organic
ICP Core Environmental Program	ALS Laboratory Group – Fort Collins	Radiological
ICP Core Liquid Effluent Monitoring Program	ICP Core Wastewater Laboratory	Microbiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	GEL Laboratories, LLC	Inorganic and radiological
ICP Core Groundwater Monitoring Program	GEL Laboratories, LLC	Inorganic, organic, and radiological
	Southwest Research Institute	Inorganic, organic, and radiological
INL Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Inorganic
	Teton Microbiology Laboratory of Idaho Falls	Bacterial
	Eurofins Eaton Analytical, Inc.	Organic
INL Liquid Effluent and Groundwater Program	GEL Laboratories, LLC	Radiological and inorganic
INL Environmental Surveillance Program	ALS Laboratory Group – Fort Collins	Radiological
	Environmental Services In Situ Gamma Laboratory	^{131}I
	Landauer Inc.	Penetrating radiation (OSL and neutron dosimeters)
Environmental Surveillance, Education, and Research Program	Environmental Assessments Laboratory (EAL) at Idaho State University (ISU)–Pocatello, ID	Gross radionuclide analyses (gross alpha and gross beta), OSL dosimetry, liquid scintillation counting (tritium), and gamma spectrometry
	ALS Laboratory Group – Fort Collins, CO	^{90}Sr (1st quarter milk samples only)
	Oak Ridge Associated Universities (ORAL) – Radiological and Environmental Analytical Laboratory (REAL) – Oak Ridge, TN	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu)
U.S. Geological Survey	DOE's Radiological and Environmental Sciences Laboratory	Radiological
	USGS National Water Quality Laboratory	Nonradiological and low-level tritium and stable isotopes
	Purdue Rare Isotope Measurement Laboratory	Low-level ^{129}I
	GEL Laboratories	Radiological and nonradiological for the USGS Naval Reactors Facility sample program
	Test America Laboratories	Semi-volatile and volatile organic compounds for the USGS Naval Reactors Facility sample program

Laboratories used for routine analyses of radionuclides in environmental media were selected by each monitoring program based on each laboratory's capabilities to meet program objectives (such as ability to meet required detection limits) and past results in performance evaluation programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP) described in Section 11.3.1. Continued acceptable performance in programs such as MAPEP is required to remain as the contracted laboratory.

Each laboratory is audited as follows:

- Contracting environmental monitoring program personnel check adherence to laboratory and QA procedures
- DOE Consolidated Audit Program (DOECAP) audits laboratories used by the INL and ICP contractors.

DOECAP uses trained and certified personnel to perform in-depth audits of subcontract laboratories to review the following:

- Personnel training and qualification
- Detailed analytical procedures
- Calibration of instrumentation
- Participation in an inter-comparison program
- Use of blind controls
- Analysis of calibration standards.

Laboratories are required to provide corrective action plans for audit findings and are closed when DOECAP approves the corrective action plan.

Laboratory data quality is continually verified by internal laboratory QA/QC programs, participation in interlaboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Performance evaluation samples and blind spikes are used to measure accuracy (defined in box at right) and are described as follows:

Performance Evaluation Sample or Blind spike used to assess the accuracy of the analytical laboratory. Samples are spiked with known amounts of radionuclides or nonradioactive substances by suppliers whose spiking materials are traceable to National Institute of Standards and Technology (NIST). The contractor may submit these samples to the laboratory with regular field samples using the same labeling and sample numbering system. A third party may also submit samples independent of the contractor to evaluate the performance of the laboratory. The MAPEP is an example of this (see Section 11.3.1). The analytical results are expected to compare to the known value within a set of performance limits. Blind spikes are generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A double blind spike is a sample with concentration and identity unknown to both the submitter and the analyst.

Accuracy

Accuracy refers to the degree of agreement between a measured value and an accepted reference or true value. Two principal attributes of accuracy are precision and systematic error (bias). An accurate measurement is achieved with high precision and low systematic error (bias). Accuracy is monitored by performing measurements and evaluating results of control samples containing known quantities of the analytes of interest (performance evaluation sample or blind spike).

11.2.4 Data Review and Evaluation

Data generated from environmental monitoring or surveillance programs are evaluated in order to understand and sustain the quality of data. This allows the program to determine if the monitoring objectives established in the planning phase were achieved and determine if the laboratory is performing within QA/QC requirements.

An essential component of data evaluation is the availability of reliable, accurate, and defensible records for all phases of the program, including sampling, analysis, and data management.

Environmental data are subject to data verification, data validation, and data quality assessment. These terms are discussed below:

Data verification. The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements. The data verification process involves checking for common errors associated with analytical data. A review is first conducted to ensure all data and sample documentation are present and complete. In addition, the following may be reviewed: sample preservation and temperature, defensible chain-of-custody documentation and integrity, analytical hold-time compliance, correct test method, adequate analytical recovery, correct minimum detection limit, possible cross-contamination, and matrix interference (i.e., analyses affected by dissolved inorganic/organic materials in the matrix).

Data validation. Confirmation by examination and provision of objective evidence that the particular requirements for a specified intended use are fulfilled. Validation involves a more extensive process than data verification. According to the *DOE Handbook – Environmental Radiological Monitoring and Environmental Surveillance* (DOE 2015).

Validation confirms that the required number of samples and types of data were collected in accordance with the sampling/monitoring plan; confirms the usability of the data for the intended end use via validation of analyses performed and data reduction and reporting; and ensures requirements were met such as detection limits, QC measurements, impacts of qualifiers, etc.

Data quality assessment. Data quality assessment includes reviewing data for accuracy, representativeness, and fit with historical measurements to ensure that the data support their intended uses. A preliminary data assessment is also performed to determine the structure of the data (i.e., distribution of data [normal, lognormal, exponential, or nonparametric]); identify relationships/associations, trends, or patterns between sample points/variables or over time; identify anomalies; and select the appropriate statistical tests for decision making.

11.3 Quality Control Results for 2016

Results of the QC measurements for specific DOE-contracted environmental programs in 2016 are summarized in the following sections. The programs include results of the MAPEP proficiency tests as well as individual program QC sample data, including the use of duplicates, split samples, spiked samples, and blank analyses.

11.3.1 Mixed Analyte Performance Evaluation Program Proficiency Tests

The MAPEP (DOE 2016) is administered by DOE's Radiological and Environmental Sciences Laboratory (RESL). RESL conducts the MAPEP using a performance-based performance evaluation program that tests the ability of the laboratories to correctly analyze for radiological, nonradiological, stable organic, and inorganic constituents representative of those at DOE sites. RESL maintains the following accreditation:

- International Organization for Standardization (ISO) 17043 (2377.02) as a Performance Testing Provider
- ISO 17025 (2377.01) as a Chemical Testing Laboratory
- ISO G34 (2377.03) as a Reference Material Producer by the American Association for Laboratory Accreditation.

The DOE RESL participates in a Radiological Traceability Program (RTP) administered through NIST. The RESL prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards in all matrix types for analysis by the RESL to confirm their analytical capabilities. The RESL maintains NIST certifications in both preparation of performance evaluation material and analysis of performance evaluation samples on an annual basis. For further information on the RESL participation in the RTP, visit www.id.energy.gov/resl/rtp/rtp.html.

MAPEP distributes samples of air filter, water, vegetation, and soil for radiological analysis during the first and third quarters. Series 34 was distributed in March 2016, and Series 35 was distributed in August 2016.

Both radiological and nonradiological constituents are included in MAPEP. Results can be found at www.id.energy.gov/resl/mapep/mapepreports.html.

MAPEP laboratory results may include the following flags:

- A = Result acceptable, bias ≤ 20 percent
- W = Result acceptable with warning, 20 percent < bias < 30 percent
- N = Result not acceptable, bias > 30 percent
- L = Uncertainty potentially too low (for information purposes only)
- H = Uncertainty potentially too high (for information purposes only)
- QL = Quantitation limit

- RW = Report warning
- NR = Not reported.

MAPEP issues a letter of concern to a laboratory for sequential unresolved failures to help the laboratory identify, investigate, and resolve potential quality issues (www.id.energy.gov/resl/mapep/MAPEP-HB-1 Rev 1.pdf). A letter of concern is issued to any participating laboratory that demonstrates:

- "Not Acceptable" performance for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., plutonium-238 [^{238}Pu] in soil test 13 "+N" [+36 percent bias], ^{238}Pu in soil test 14 "-N" [-43 percent bias])
- "Not Acceptable" performance for a targeted analyte in two or more sample matrices for the current test session (e.g., cesium-137 [^{137}Cs] in water test 14 "+N" [+38 percent], ^{137}Cs in soil test 14 "+N" [+45 percent])
- Consistent bias, either positive or negative, at the "Warning" level (greater than ± 20 percent bias) for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., strontium-90 [^{90}Sr] in air filter test 13 "+W" [+26 percent], ^{90}Sr in air filter test 14 "+W" [+28 percent])
- Quality issues (flags other than "Acceptable") that were not identified by the above criteria for a targeted analyte in a given sample matrix over the last three test sessions (e.g., americum-241 [^{241}Am] in soil test 12 "-N" [-47 percent], ^{241}Am in soil test 13 "+W" [+24 percent], ^{241}Am in soil test 14 "-N" [-38 percent])
- Any other performance indicator and/or historical trending that demonstrate an obvious quality concern (e.g., consistent "false positive" results for ^{238}Pu in all tested matrices over the last three test sessions).

  NOTE: The above are examples for information purposes.

A more detailed explanation on MAPEP's quality concerns criteria can be found at www.id.energy.gov/resl/mapep/data/mapep_loc_final_4.pdf.

In 2016, each radiological laboratory used by the INL, ICP Core, and ESER contractors participated in the 2016 MAPEP Series 34 (March 2016) and 35 (August 2016). The laboratories evaluated were ALS-Fort Collins (ALS-FC), Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory (ORAU-REAL), Idaho State University-Environmental Assessment Laboratory (ISU-EAL), GEL Laboratories, LLC (GEL), and Test America, Inc. St Louis. The results of the MAPEP tests, as they pertain to the INL Site environmental programs, are presented below by laboratory.

ALS-Fort Collins. ALS is located in Fort Collins, Colorado. The INL and ICP Core contractors used ALS-FC for their ambient air programs. The isotopic analytes of common interest to the INL and ICP Core ambient air surveillance programs include: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu. Ambient air samples collected by the INL and ICP Core contractors were also analyzed by ALS-FC for gross alpha/beta and for gamma-emitting radionuclides, such as ^{241}Am, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{152}Eu, and ^{125}Sb. The same isotopic analytes and gamma-emitting radionuclides were analyzed for surface water samples collected by the ICP Core.

All analytes of interest were acceptable for MAPEP Series 34 and 35. The MAPEP results do not demonstrate any issues of concern for the 2016 data reported by ALS-FC. The INL and ICP Core contractors will continue to monitor the MAPEP results to determine if any trends warrant further action.

Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory (ORAU-REAL). The ORAU-REAL is located in Oak Ridge, Tennessee. The ESER contractor used ORAU-REAL for all 2016 sample medias (except for one milk sample set sent May 2016 to the ALS-FC) including: ambient air samples, milk (^{90}Sr only), and agricultural (^{90}Sr only) samples. ESER analytes of interest include: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu.

All analytes of interest were acceptable for MAPEP Series 34 and 35. The MAPEP results do not demonstrate any issues of concern for the 2016 data reported by ORAU-REAL. The ESER contractor will continue to monitor the MAPEP results to determine if any trends warrant further action.

Idaho State University Environmental Assessment Laboratory (ISU-EAL). The ISU-EAL is located in Pocatello, Idaho. The ESER contractor uses ISU-EAL to analyze samples for the following analytes of interest: tritium (^{3}H), gross alpha and gross beta, and multiple gamma spectroscopy radioisotopes. All analytes of interest were "A" (Acceptable), unless noted below. The MAPEP Series 34 and 35 flag results for ISU-EAL were:

- MAPEP Series 34 – "N" (Not Acceptable) for gamma spectroscopy analytes in soil: ^{134}Cs, ^{57}Co, ^{60}Co, ^{54}Mn, ^{40}K, ^{65}Zn
  - *NOTE – Values reported to MAPEP were incorrect due to the equation used for calculating the average. The equation included cells which contained zero (0) values resulting in a much smaller value. The corrected values would have received an "Acceptable" evaluation based on the MAPEP evaluation criteria. Future data tables will be independently verified prior to submission of results to MAPEP (ISU-EAL).*
- MAPEP Series 34 "N" (Not Acceptable) for Hydrogen-3 (^{3}H) analyte in water
- MAPEP Series 35 – "N" (Not Acceptable) for ^{134}Cs gamma spectroscopy soil sample.

Because there were two consecutive "N" (Not Acceptable) for ^{134}Cs in soil matrices for MAPEP Series 34 and Series 35, the DOE issued a "Potential Quality Concern – Cesium-134" to the ISU-EAL Laboratory Director. Cesium-134 has not been detected in any soils collected by ESER in the past, so this issue is not of great concern to the program. However, ESER personnel will continue to monitor the MAPEP results to see if any trends warrant further action.

GEL Laboratories, LLC. The INL and ICP Core drinking water, liquid effluent, and groundwater monitoring programs used GEL in Charleston, South Carolina, for inorganic, organic, and radiological analysis of samples. The MAPEP Series 34 and 35 flag results for GEL were:

- MAPEP Series 34 – "N" (Result not Acceptable) for radium-226
- MAPEP Series 35 – "W" (Acceptable with Warning) for mercury
- MAPEP Series 35 – "W" (Acceptable with Warning) for radium-226
- All other analytes of interest were "A" (Acceptable).

The MAPEP results for these INL and ICP Core programs reported by GEL do not demonstrate any issues of concern for the 2016 data. The improvement on the radium-226 analysis is noted. The programs will continue to monitor the MAPEP results to determine if any trends warrant further action.

Southwest Research Institute. The ICP Core groundwater monitoring programs used Southwest Research Institute in San Antonio, Texas, for inorganic, organic, and radiological analysis of samples. All analytes of interest were acceptable for MAPEP Series 34 and 35 for Southwest Research Institute. For all results reported by Southwest Research Institute, no issues of concern for the 2016 data were demonstrated.

11.3.2 Environmental Program Sample QC Results

Each INL Site contractor evaluates the overall effectiveness of its QA program through management and independent assessments. These assessments include measurement of data quality, including:

- ***Field duplicate analysis (precision)*** – Precision, as determined by analyses of field duplicate sample, is estimated using the relative percent difference (RPD) between the field duplicate result and the corresponding field sample result and is a measure of the variability in the process caused by the sampling uncertainty (matrix heterogeneity, collection variables, etc.) and measurement uncertainty (field and laboratory). An RPD of zero indicates a perfect duplication of results.
- ***Performance evaluation (PE) analysis (accuracy)*** – Accuracy is calculated by dividing the measured value by the known concentration in the spiked sample. A ratio of one indicates a completely accurate measure of a PE sample.
- ***Blank sample analysis*** – Field blank sample analyses are essentially the opposite of PE analyses. Results of these analyses are expected to be "zero" or more accurately below the minimum detectable concentration of a specific procedure. Any positive measurement may indicate the introduction of contamination.

The following sections provide brief discussions and summary tables of the 2016 QC results for field duplicates, PE samples, and blank analyses. Each discussion also addresses program completeness—the number of samples collected and analyzed expressed as a percentage of that required. Ideally, all (i.e., 100 percent) samples should be collected and analyzed.

11.3.2.1 Liquid Effluent and Groundwater Monitoring Program Quality Control Data

INL Contractor

The INL contractor Liquid Effluent Monitoring (LEMP) and Groundwater Monitoring Programs have specific QA/QC objectives for analytical data. Table 11-2 presents a summary of 2016 LEMP Groundwater Monitoring Programs QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness is to collect 100 percent of all required compliance samples. This goal was met in 2016.

Precision – Field Duplicates. Field duplicates are collected annually at each sample location, or 10 percent of the total samples collected, in order to assess measurement uncertainty and variability caused by sample heterogeneity and collection methods. In 2016, field duplicates were collected at the Advanced Test Reactor Complex Cold Waste Pond, USGS-098, Materials and Fuels Complex Industrial Waste Pipeline and the Industrial Waste Water Pond, and Well ANL-MON-A-12 at the Materials and Fuels Complex.

The INL contractor LEMP and GWMP requires that the RPD from field duplicates be less than or equal to 35 percent for 90 percent of the analyses. In 2016, these goals were met.

Accuracy – Performance Evaluation Samples. Accuracy of results was assessed using the laboratory's control samples, initial and continuing calibration samples, and matrix spikes. Additional performance evaluation samples (prepared by RESL) were submitted to the laboratory and analyzed for radiological constituents. The results for the spiked constituents were mostly in agreement with the known spiked concentrations.

Precision – Field Blank Samples. Engineering and administrative controls, including dedicated equipment and administrative scheduling, were implemented to control introduced contamination into the samples.

ICP Contractor

The ICP Core contractor has QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated following standard EPA protocols. Three types of LEMP QC samples are submitted for analysis: field duplicates, equipment rinsates, and performance evaluation samples. Table 11-3 presents a summary of 2016 QC criteria and performance results.

Completeness – Collection and Analysis. The ICP Core LEMP goal for completeness was to collect and successfully analyze 100 percent of all permit-required compliance samples. This goal was met in 2016. A total of 408 sample parameters were collected, submitted for analysis, and successfully analyzed.

The goal for completeness was to collect and successfully analyze 90 percent of the LEMP surveillance samples. This goal was exceeded in 2016; 100 percent of the samples were collected and analyzed. A total of 348 sample parameters were collected, and 348 parameters were successfully analyzed.

Precision – Field Duplicate Samples. To quantify measurement uncertainty from field activities, a nonradiological field duplicate sample is collected annually at CPP-769, CPP-773, and CPP-797 and analyzed for the permit-specific parameters. The RPD between the sample result and the field duplicate sample result (using only parameters with two detectable quantities) should be 35 percent or less for 90 percent of the parameters analyzed. Field duplicate samples were collected at CPP-769, CPP-773, and CPP-797 on March 9, 2016, and at CPP-769 on April 13, 2016 (biochemical oxygen demand only). Seventy-five percent of the results had an RPD of less than or equal to 35 percent.

A radiological field duplicate sample is collected annually at CPP-773 and analyzed for gross alpha, gross beta, total strontium activity, and gamma spectrometry. The mean difference determined from the sample result and the field duplicate sample result (using two statistically positive results) should be less than or equal to three for 90 percent of the parameters. A radiological field duplicate sample was collected from CPP-773 on September 27, 2016. Of the 24 parameters analyzed, only gross beta had two statistically positive results. The mean difference was calculated to be 0.66, which was less than the goal of 3.0.

Accuracy – Performance Evaluation Samples. During 2016, performance evaluation samples were submitted to the laboratory with routine wastewater monitoring samples on November 9, 2016. Eighty percent of the results were within their QC performance acceptance limits, which was less than the program goal of 90 percent.

Table 11-2. 2016 INL Liquid Effluent Monitoring Program, Groundwater Monitoring Program, and Drinking Water Program Quality Assurance/Quality Control Criteria and Performance.

Liquid Effluent Monitoring Program	Criterion	2016 Performance
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	100%
Precision		
Field Duplicates	Performed at each facility location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		

Groundwater Monitoring Program	Criterion	2016 Performance
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	100%
Precision		
Field Duplicates	Performed at each facility location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		

INL Drinking Water Monitoring Program	Criterion	2016 Performance
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	99.5%
Precision		
Field Duplicates	90%	100%
Field Blanks	90%	100%
Accuracy		
Performance Evaluation Samples Note: 13 out of 86 samples were QA/QC.	90%	100%

Table 11-3. 2016 ICP Core Liquid Effluent Monitoring Program, WRP Groundwater Monitoring Program, and Drinking Water Program Quality Assurance/Quality Control Goals and Performance.

ICP Core Liquid Effluent Monitoring Program	Criterion	2016 Performance
Completeness		
Compliance samples successfully collected	100%	100%
Compliance samples successfully analyzed	100%	100%
Surveillance samples collected and successfully analyzed	90%	100%
Precision		
Field duplicates	90%	76%
Equipment rinsates	90%	84%
Field blanks	90%	84%
Accuracy		
Performance evaluation samples	90%	80%
ICP Core WRP Groundwater Monitoring Program	**Criterion**	**2016 Performance**
Completeness		
Compliance samples successfully collected	100%	100%
Compliance samples successfully analyzed	100%	100%
Surveillance samples collected and successfully analyzed	90%	100%
Precision		
Field duplicates	90%	81%
Equipment rinsates	90%	96%
Field blanks	90%	100%
Accuracy		
Performance evaluation samples	90%	96%
ICP Core Drinking Water Monitoring Program	**Criterion**	**2016 Performance**
Completeness		
Compliance samples successfully collected	100%	100%
Compliance samples successfully analyzed	100%	100%
Surveillance samples collected and successfully analyzed	90%	100%
Precision		
Field duplicates	90%	100%
Field blanks	90%	100%
Trip blanks	90%	100%
Accuracy		
Performance evaluation samples	90%	100%

WRP = Wastewater Reuse Permit

Introduction of Contamination – Field Blank Samples. A field blank was collected on September 21, 2016. A total of 19 parameters were analyzed, and 16 of these parameters were not detected. Chloride, total phosphorus, and total suspended solids were detected. These field blank results indicate that some contamination may have been introduced during sample collection, storage, and transport.

Decontamination – Equipment Rinsate Samples. Equipment rinsate samples are collected annually and are used to evaluate the effectiveness of equipment decontamination. On June 15, 2016, a sample carboy associated with CPP-797 was decontaminated by the Idaho Nuclear Technology and Engineering Center (INTEC) licensed wastewater operators. After decontamination, deionized water was added to the carboy, and the rinsate samples were collected by LEMP personnel. A total of 19 parameters were analyzed, and 16 of those parameters were not detected. However, three parameters—chloride (0.120 mg/L), total Kjeldahl nitrogen (0.306 mg/L), and biochemical oxygen demand (2.16 mg/L)—were detected. The INTEC licensed wastewater operators were notified of the detections and reminded that CPP-797 sample carboys should be replaced with new carboys if they cannot be adequately decontaminated.

11.3.2.2 Idaho Cleanup Project Contractor Wastewater Reuse Permit Groundwater Monitoring Quality Control Data

The ICP Core contractor Wastewater Reuse Permit (WRP) GWMP has specific QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated following standard EPA protocols. Four types of QC samples are submitted for analysis: field duplicates, field blanks, equipment rinsates, and performance evaluation samples. Table 11-3 presents a summary of 2016 WRP GWMP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze 100 percent of all required compliance samples. This goal was met in 2016. A total of 240 sample parameters were collected and submitted for analysis, and 240 parameters were successfully analyzed. Some of the results were qualified during data validation, and the reported concentrations are provided in Tables C-6 and C-7. These qualified results are summarized in the 2016 Wastewater Reuse Report (ICP 2017).

The goal for completeness was to collect and successfully analyze 90 percent of the WRP GWMP surveillance samples. This goal was exceeded in 2016. Sixteen parameters, or 100 percent, were collected and successfully analyzed.

Precision-Field Duplicate Samples. To quantify measurement uncertainty from field activities, nonradiological field duplicate samples are collected semiannually and analyzed for the permit-specific parameters. The RPD between the sample result and the field duplicate sample result (using only parameters with two detectable quantities) should be 35 percent or less for 90 percent of the parameters analyzed. Field duplicate samples were collected from Well ICPP-MON-V-200 on April 5, 2016, and May 19, 2016; and from Well ICPP-MON-V-212 on September 14, 2016, and September 28, 2016. Eighty-one percent of the results had an RPD of less than or equal to 35 percent.

Radiological field duplicate samples are collected semiannually and analyzed for gross alpha and gross beta. Duplicate samples were collected from Well ICPP-MON-V-200 on April 5, 2016, and from Well ICPP-MON-V-212 on September 14, 2016. The mean difference determined from the sample result and the field duplicate sample result (using two statistically positive results) should be less than or equal to three for 90 percent of the parameters. Two of the four samples collected had statistically positive results, and both of these results had a mean difference of less than or equal to three.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory with routine groundwater monitoring samples on May 19, 2016, and September 14, 2016. Ninety-six percent of the performance evaluation sample results were within their QC performance acceptance limits—the program goal was 90 percent. The laboratory was requested to investigate the May 2016 fecal coliform sample result that did not meet its acceptance criteria. Summaries of the laboratory investigation is provided in the 2016 Wastewater Reuse Report (ICP 2017).

Introduction of Contaminants – Field Blank Samples. Field blanks were collected on April 6, 2016, and September 13, 2016, and analyzed for the permit-specific parameters. All results were below their respective detection/reporting limits for the April field blank and the September field blank, indicating that no contamination was introduced during sample collection, storage, and transport.

Introduction of Contaminants – Equipment Rinsate Samples. Equipment rinsates were collected on April 5, 2016; May 19, 2016; September 14, 2016; and September 28, 2016, and analyzed for the permit-specific parameters. All results were below their respective detection/reporting limits for the April and May rinsate samples, indicating that proper decontamination procedures were followed. For the September rinsate samples, all analytical results were below their respective detection/reporting limits, except for total dissolved solids (7.14 mg/L), chloride (0.104 mg/L), and total Kjeldahl nitrogen (0.108 mg/L). WRP GWMP personnel were notified of the detections.

11.3.2.3 Idaho Cleanup Project Contractor Groundwater Monitoring Quality Control Data

QA/QC samples and results for Waste Area Group (WAG) 1, WAG 3, and WAG 4 are discussed in the annual reports for Fiscal Year 2016 (DOE-ID 2017a; DOE-ID 2017b; DOE-ID 2017c) and for WAG 2 in the Fiscal Year 2017 report (DOE-ID 2017d). QA/QC samples and results for WAG 7 are discussed in the following paragraphs.

Completeness, Precision, Representativeness, Comparability – Field Sampling Plan. For the WAG 7 November 2016 groundwater monitoring sampling event at Radioactive Waste Management Complex (RWMC), the QA parameters of completeness, precision, representativeness, and comparability met the project goals and DQOs as specified in the Field Sampling Plan (Forbes and Holdren 2014), except as noted below.

Accuracy – Performance Evaluation Sample. The project objectives for accuracy were met with the exception of the performance evaluation sample described in the following paragraphs.

Double-blind performance evaluation samples containing known concentrations of selected radionuclides were prepared by RESL. The performance evaluation samples were submitted to the contract laboratory (GEL), along with the November 2016 RWMC aquifer groundwater samples, to assess analytical performance.

The analytical results reported by GEL were within acceptable limits, except for ^{239}Pu, ^{99}Tc, and ^{234}U. The ^{239}Pu and ^{99}Tc results differed from the known value by greater than 3-sigma and were not within ± 30% of the known concentration. Therefore, these results were deemed unacceptable. The ^{234}U result was not within ± 30% of the known concentration and was also evaluated as unacceptable. The analytical laboratory was notified of these discrepancies. The laboratory will investigate the results and perform the appropriate corrective action(s).

11.3.2.4 Drinking Water Program Quality Control Data

INL Contractor

The INL contractor Drinking Water Program has specific QA/QC objectives for analytical data.

Completeness – Collection and Analysis. The DQOs address completeness for laboratory and field operations. The criteria for completeness by laboratories is that at least 90 percent of the surveillance and 100 percent of the compliance samples submitted annually must be successfully analyzed and reported according to specified procedures. Similarly, the criteria for field data collection under the INL Environmental Support and Monitoring Services is that at least 90 percent of the surveillance and 100 percent of the compliance samples must be successfully collected on an annual basis and reported according to the specified procedures. These criteria were met. If a completeness criterion is not met, the problem will be evaluated, and it will be determined whether the quality of the remaining data is suspect and whether a corrective action is needed either in the field collection or laboratory analysis.

Precision – Field Duplicates. Drinking Water Program goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses. The Drinking Water Program submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

Precision for radiological data is evaluated by calculating the RPD with a goal of less than 35 percent. Results reported as nondetect are not used in the RPD calculation. For 2016, the Drinking Water Program reported 22 samples with detectable radiological quantities, which all met the RPD goal. For nonradiological data, precision is evaluated by calculating the RPD if the result in the first sample and the duplicate exceeded the detection limit by a factor of five or more.

Accuracy – Performance Evaluation Samples. Blind spike samples are used to determine the accuracy of laboratory analyses for concentrations of parameters in drinking water. Within each calendar year, the program lead determines the percentage of the samples collected (excluding bacteria samples) that are QA/QC samples, which include blind spikes. All blind spike percent recoveries must fall within the standards range.

Representativeness. Representativeness is ensured through use of established sampling locations, schedules, and procedures for field sample collections, preservation, and handling.

Comparability. Comparability is ensured through the use of 1) laboratory instructions for sample collection, preparation, and handling; 2) approved analytical methods for laboratory analyses; and 3) consistency in reporting procedures.

ICP Contractor

The ICP Core Drinking Water Program (DWP) has specific QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated or verified following standard EPA protocols. Four types of DWP QC samples are submitted for analysis: field duplicates, field blanks, trip blanks, and performance evaluation samples. Table 11-3 presents a summary of 2016 DWP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze 100 percent of all required compliance samples. This goal was met in 2016. A total of 16 parameters were collected and submitted for analysis, and 16 parameters were successfully analyzed. For the DWP surveillance samples, the goal for completeness was to collect and successfully analyze 90 percent of the samples. This goal was exceeded in 2016. A total of 95 parameters were collected and 100 percent of these parameters were successfully analyzed.

Precision – Field Duplicates. Field duplicate samples were collected on June 22, 2016 (nitrates), and November 10, 2016 (volatile organic compounds [VOCs]). The RPD determined from field duplicate samples should be 35 percent or less for 90 percent of the parameters analyzed. One hundred percent of the field duplicate sample results (with two detectable quantities) were within the program goal for RPD of less than or equal to 35 percent.

Radiological field duplicate samples were collected from CPP-614 on February 23, 2016, and analyzed for gross alpha, gross beta, ^{3}H, and ^{90}Sr. Only the gross beta results were statistically positive, and the mean difference was calculated to be 0.39, which was less than the program goal of three. On August 23, 2016, radiological field duplicate samples were collected from WMF-604 and analyzed for gross alpha and gross beta. Of the two parameters analyzed, only the gross beta result was statistically positive. The mean difference for gross beta was 1.22, which was less than the program goal of three.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory with routine drinking water samples on April 27, 2016 (VOCs), and August 10, 2016 (halogenated acetic acids). The results for 30 of the 30 performance evaluation sample parameters (100 percent) were within their QC performance acceptance limits, exceeding the program goal of 90 percent.

Introduction of Contaminants – Field Blank Samples. Field blanks were prepared as part of the January 27, 2016 (VOCs), and February 24, 2016 (VOCs), sampling events. One hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90 percent.

Introduction of Contaminants – Trip Blank Samples. Trip blanks were prepared as part of the January 27, 2016 (VOCs), February 24, 2016 (VOCs), April 27, 2016 (VOCs), July 27, 2016 (VOCs), August 10, 2016 (TTHMs), October 26, 2016 (VOCs), and November 10, 2016 (VOCs) sampling events. One hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90 percent.

11.3.2.5 Environmental Surveillance, Education, and Research Program Quality Control Data

Table 11-4 presents a summary of 2016 ESER QC analysis results.

Completeness – Collection and Analysis. The ESER contractor met its completeness goals of greater than 98 percent in 2016. Nine air samples were considered invalid because insufficient volumes were collected due to power interruptions (i.e., blown fuse and/or tripped breaker). All other samples were collected and analyzed as planned.

Table 11-4. 2016 ESER Surveillance Program Quality Assurance Elements.

QC Program Element - 2016	Criterion	Performance[a]
Completeness		
Surveillance Samples Successfully Completed	100 percent	99.8 percent
Submitted Surveillance Samples Successfully Analyzed	100 percent	100 percent
Accuracy		
Blind Spike Program[b]		
Idaho State University - Environmental Assessment Lab (EAL)	90 percent	98 percent
Oak Ridge Associated Universities - (ORAU)	90 percent	100 percent
ALS Environmental Laboratory – Fort Collins (ALS)	90 percent	100 percent
Precision		
Field Duplicates		
EAL	Differences within 3 standard deviations (3σ) or within ± 20 percent RPD	96.8 percent
ORAU		87.0 percent
Field Blanks		
EAL	± 3σ of Zero	92.7 percent
ORAU		94.4 percent

a. Sample matrices include: water (drinking, surface, and precipitation), air filter, milk, soil, TLD/OSLD, vegetation (wheat, alfalfa, potato, lettuce), and waterfowl. Big game (deer, elk, antelope) are also sampled on an as notified case-by-case basis; these samples are not included in sample percent completeness.

b. ISU-EAL - ESER requested analysis: gamma spec (i.e. ^{137}Cs, and ^{131}I), tritium, gross alpha, and gross beta.
ORAU - ESER requested analysis: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu.
ALS Completed a blind spike milk analysis in 2016.

Precision – Field Duplicate Samples. Field duplicate samples were collected for air, milk, lettuce, potatoes, grain, soil, and water to assess data precision and sampling bias. Most duplicate data were associated with the air sampling program. Duplicate air samplers were operated at two locations (Blackfoot and Sugar City) adjacent to regular air samplers. The objective was to have data close enough to conclude that there was minor sampling bias between the samplers and acceptable laboratory precision. The ESER QA program establishes that sample results should agree within three standard deviations. Any variation outside the predetermined criterion could be due to one of the samplers not operating correctly (e.g., a leak in one sampling system) or not operating within the same operating parameters (e.g., flow rate, sampling time). In addition, any variation outside the predetermined criterion could be attributed to inhomogeneous distribution of a contaminant in the sample medium so that true replication is not possible. The ISU-EAL sample and duplicate results agreed with each other in 96.8 percent and the ORAU-REAL in 87.0 percent of all environmental samples collected during 2016, indicating acceptable precision.

Accuracy – Performance Evaluation Samples. Accuracy is measured through the successful analysis of samples spiked with a known standard traceable to the NIST. Each analytical laboratory conducted an internal spike sample program using NIST standards to confirm analytical results.

As a check on accuracy, the ESER contractor provided blind spiked samples prepared by personnel at RESL, as described in Section 11.3.1, for soil, wheat, air particulate filter, milk, and water samples. All the acceptance criteria are for three-sigma limits and ± 30 percent of the known values for respective sample matrices. This is a double blind "spiked" sample—meaning that neither the ESER Program nor the laboratories know the value of the radioisotope that is in the sample submitted to the laboratories for sample analysis.

The ESER Program sent nine double blind spike sample sets to the ISU-EAL laboratory during the 2016 calendar year for gamma spectroscopy and liquid scintillation analysis. The following matrices were spiked for the 2016 year: water, air particulate filters, milk, and wheat. The ISU-EAL submitted sample results for 41 individual analytes that had recovery analysis completed by the RESL; 40 had an Agreement of "YES" and one had an Agreement "NO." This was a 98.0 percent (i.e., 40/41 x 100) performance in the ESER double blind spike program. There was one "False Positive" result for a soil blank sample analysis for ^{60}Co gamma spectroscopy result.

The ESER Program sent one double blind spike sample set to the ALS-FC laboratory during the 2016 calendar year for radiochemical analysis. The following matrices were spiked for the 2016 year: milk. The ALS-FC submitted sample results for 1 individual analyte that had recovery analysis completed by the RESL; one had an Agreement of "YES" or 100 percent (i.e., 1/1 x 100).

The ESER Program sent five double blind spike sample sets to the ORAU-REAL laboratory during the 2016 calendar year for radiochemical analysis. The following matrices were spiked for the 2016 year: water, air particulate filters, milk, and wheat. The ORAU-REAL submitted sample results for 14 individual analytes that had recovery analysis completed by the RESL; 14 had an Agreement of "YES" This was a 100 percent (i.e., 14/14 x 100) performance in the ESER double blind spike program.

Introduction of Contamination – Field Blanks. Field blank samples were submitted with each set of samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. Ideally, blank results should be within two standard deviations of zero and preferably within one standard deviation. In 2016, the ISU-EAL attained over 92.7 percent performance of blanks within one to three standard deviations of zero; the ORAU-REAL had a 94.4 percent performance of blanks with the above stated criterion.

Invalid Sample Results. There was one "J" flag, for low tracer recovery, reported for an AP Filter Composite analyzed by the ORAU Laboratory. This sample was replaced with another sample from the same quarter and analyzed with no flags. The "J" Flag sample was declared invalid and was not added to the ESER database sample results.

11.3.2.6 INL Environmental Surveillance Program Quality Assurance/Quality Control Data

The INL contractor analytical laboratories analyzed all Surveillance Monitoring Program samples as specified in the statements of work. These laboratories participate in a variety of intercomparison QA programs, including the DOE MAPEP and the EPA National Center for Environmental Research QA Program. These programs verify all the methods used to analyze environmental samples (see Table 11-5).

Completeness – Collection and Analysis. The INL Surveillance Monitoring Program met its completeness and precision goals. Samples were collected and analyzed from all available media as planned. Of approximately 1,200 air samples, six were invalid because of power interruptions (i.e., blown fuses and/or tripped breakers) and insufficient volumes.

Precision – Collocated Samples. The Environmental Surveillance Program rotates two replicate air samplers that are placed adjacent to regular samplers (currently at INTEC and the Central Facilities Area [CFA]) to allow for data comparisons. The collocated samples are collected at the same time, stored in separate containers, and analyzed independently. A mean difference calculation can be used to compare two radiological measurements that are reported with an associated uncertainty. For ambient air, because all the gross beta and beryllium-7 (^{7}Be) results were positive for the regular and replicate samples, these data are ideal as indicators of precision, and 99 percent of the mean difference values were less than the goal of three.

Introduction of Contaminants – Field Blanks. In 2016, the majority of the field blanks were within two standard deviations of zero for air. See Table 11-5 for details.

Accuracy – Performance Evaluation Samples. As an additional check on accuracy, the INL contractor provided blind spiked samples prepared by personnel at the RESL for air filter samples, which are composited by location quarterly and analyzed by gamma spectroscopy and radiochemistry. During 2016 for the four samples spiked with gamma emitters (i.e., ^{60}Co, ^{134}Cs, ^{137}Cs, ^{54}Mn, ^{65}Zn), ^{90}Sr, ^{238}Pu, and $^{239/240}$Pu, the results were in agreement with the known activity, except for one blank sample for which the laboratory reported a trace of $^{239/240}$Pu

Table 11-5. 2016 INL Environmental Surveillance Program Quality Assurance Elements.

QC Program Element - 2016	Criterion	Performance
Completeness		
Samples Collected		
Air	90 percent	99 percent
Samples Analyzed		
Air	90 percent	100 percent
Accuracy		
Performance Evaluation Samples		
Air[a]	Ideally 100 percent	99 percent
Precision		
Field Replicates/Duplicates		
Air	MD[b] < 3	
Gross Beta (weekly)	Ideally 100 percent	99 percent
Gamma Spec[c] (Quarterly)	Ideally 100 percent	100 percent
Laboratory Control Sample		
Air	LCS percent Recovery ± 25 percent	100 percent
Field Blanks		
Air	Ideally 100 percent within 2σ of zero	99 percent

a. Includes all results for gamma spectrometry and isotopic analysis.
b. Mean difference.
c. As Be-7.

(false positive). The false positive is believed to have resulted from interference from ^{210}Po as discussed below.

False Positive Sample Results. Naturally occurring ^{210}Po can cause interferences with accurate plutonium measurements. The laboratory reported traces of $^{239/240}$Pu and ^{238}Pu during 2016 in first and second quarter composite samples from CFA, Craters of the Moon, EFS, EBR-I, Gate 4, Idaho Falls, INTEC, IRC, MFC, NRF, RTC, RWMC, SMC, TRA, and VANB. The laboratory acknowledged that these results were likely false positives due to the presence of ^{210}Po contamination. Additionally, as noted above, the laboratory reported $^{239/240}$Pu to be present in an unspiked performance test sample from the first quarter of 2016, and discussions with the laboratory included the likelihood of ^{210}Po contamination and potential for high bias in the results. Because of this, these data are declared to be false positives. Beginning in the third quarter of 2016 the laboratory introduced a cleanup step in their procedure to remove ^{210}Po, and since that time no positive detections of plutonium have been reported.

11.3.2.7 ICP Core Environmental Surveillance for Waste Management Quality Control Data

Table 11-6 summarizes the 2016 ICP Core Environmental Surveillance Program for Waste Management QC analysis results.

Completeness. The ICP Core Environmental Surveillance Program for Waste Management completeness goal, which includes samples collected and samples analyzed, is 90 percent. The collection of air samples was 94.2 percent in 2016. For gross alpha and gross beta analysis, 11 days of sampling in a two-week period is required. During the time period from mid-July through August, high temperatures and smoke from wildfires caused the air monitors to shut down periodically. Therefore, the 11-day collection period was not met for several air monitors. Also, in November the two replicate air monitors were shut down and moved because of electrical improvements. This resulted in one sample collection time criterion being missed. The percentage of surface water samples collected was 100 percent. Overall sample collection for all media was 97.1 percent.

Table 11-6. 2016 ICP Core Environmental Surveillance Program Quality Assurance Elements.

QC Program Element - 2016	Criterion	Performance[a]
Completeness		
Surveillance samples successfully completed	90 percent	97.1 percent
Surveillance samples successfully analyzed	90 percent	100 percent
Accuracy		
Blind Spike Program[b]		
ALS Environmental Laboratory – Fort Collins (ALS)	90 percent	100 percent
Precision		
Field Replicates/Duplicates		
Differences within 3 standard deviations (3σ)	MD[b] > 3	99 percent
Laboratory Control Sample		
All media	Laboratory control sample percent recovery ±25 percent	100 percent
Field Blanks		
Air and surface water	Ideally 100 percent within 2α	99.1 percent

a. Sample matrices include: air filter and surface water.

b. Requested analyses—Gamma spectrometry and isotopic.

For air and surface water samples, 100 percent were analyzed.

Precision – Field Duplicate/Replicate Samples. The overall precision result for all media sampled was 99 percent. When used, a replicate air sampler is set adjacent to a regular sampler. The results are compared using the RPD or the standard deviation criterion (Equation 1), and the RPD is acceptable if it is within 20 percent. For ambient air, an overall average performance rate of 98.4 percent was achieved.

$$|R_1 - R_2| \leq 3(s_1^2 + s_2^2)^{1/2} \quad (1)$$

Where:

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample

s_1 = uncertainty (one standard deviation) associated with the laboratory measurement of the first sample

s_2 = uncertainty (one standard deviation) associated with the laboratory measurement of the duplicate sample.

Surface water samples are taken quarterly. In 2016, a field duplicate was taken during the fourth quarter sampling. When comparing results of the regular sample and the duplicate sample, precision was 100 percent.

Accuracy. The ICP Core contractor submitted air and surface water blind spike samples to ALS Laboratory Group for analysis in 2016 to check laboratory accuracy. These samples were prepared at the RESL as described in Section 11.3.1. All blind spike samples showed 100 percent satisfactory agreement (within ± 30 percent of the known value and within three-sigma), for all constituents of concern.

Laboratory Intercomparison QA Programs. ALS Laboratory Group participated in a variety of intercomparison QA programs, which verified all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the National Environmental Laboratory Accreditation Program (NELAP). The laboratory met the performance objectives specified by these two intercomparison QA programs.

Laboratory Control Samples (LCSs). All laboratory LCS recoveries were within their acceptance range of ± 25 percent recovery, indicating that the laboratory's radiochemical procedure is capable of recovering the radionuclide of interest.

Introduction of Contaminants – Field Blanks and Batch Blanks. In 2016, 99.1 percent of the field blanks were within two standard deviations of zero for both air and water.

For the first quarter isotopic air results, the laboratory reported that ^{238}U was detected in the batch blank. In the second quarter, $^{239/240}$Pu, ^{234}U, and ^{238}U were detected. Sample results were reported, even though there is a potential positive bias. The results were comparable to past results. The batch blanks for both the third and fourth quarters were nondetects.

Representativeness and Comparability. Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Both of these are ensured through the use of technical procedures and sampling procedures for sample collection and preparation, approved analytical methods for laboratory analyses, and consistency in reporting procedures.

Various QC processes designed to evaluate precision, accuracy, representativeness, completeness, and comparability of data are implemented in detailed procedures. All sampling procedures were reviewed in 2016 and updated to clarify procedures and training qualifications.

Surveillances. Periodic surveillances of procedures and field operations are conducted to assess the representativeness and comparability of data. In August 2015, the ICP Core QA program performed a triennial surveillance on the air sampling program. No findings were noted. Strengths were noted in sample collection and sample preparation for shipment to the off-Site laboratory.

11.3.2.8 U.S. Geological Survey Water Sampling Quality Control Data

Water samples are collected in accordance with a QA plan for quality-of-water activities by personnel assigned to the USGS INL project office; the plan was revised in 2014 (Bartholomay et al. 2014). Additional QA is assessed with QA/QC duplicates, blind replicates, replicates, source solution blanks, equipment blanks, field blanks, splits, trip blanks, and spikes (Bartholomay et al. 2014). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams et al. (1998), Bartholomay and Twining (2010), Rattray (2012), Davis et al. (2013), Rattray (2014); and Bartholomay et al. (2017). During 2016, the USGS collected 18 replicate samples, three field blank samples, three equipment blank samples, one source solution blank, and one trip blank sample. Evaluation of results will be summarized in future USGS reports.

11.4 Environmental Monitoring Program Quality Assurance Program Documentation

The following sections summarize how each monitoring organization at the INL Site implements QA requirements. An overview of the INL contractor environmental monitoring program, the ICP Core contractor, and ESER contractor documentation is presented in Table 11-7, Table 11-8, and Table 11-9, respectively.

11.4.1 Idaho National Laboratory Contractor

The INL contractor integrates applicable requirements from *Manual 13A—Quality Assurance Laboratory Requirements Documents* (INL 2014) into the implementing monitoring program plans and procedures for non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) monitoring activities. The program plans address the QA elements as stated in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001) to ensure that the required standards of data quality are met.

In addition, the INL contractor uses a documented approach for collecting, assessing, and reporting environmental data. To ensure that analytical work supports DQOs, environmental and effluent monitoring is conducted in accordance with PLN-8510, PLN-8515, and PLN-8540 (Table 11-7).

11.4.2 Idaho Cleanup Project Core Contractor

All CERCLA monitoring activities at the INL Site are conducted in accordance with the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10* (DOE-ID 2016), written in accordance with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988).

Table 11-7. INL Environmental Program Documentation.

Document/Media Type	Document No.[a] and Title
Program Documents	PLN-8510, Planning and Management of Environmental Support and Services Monitoring Services Activities
Data Management and Validation Documents	PLN-8101, Records Management Plan for Environmental Records PLN-8515, Data Management Plan for the INL Environmental Support and Services Monitoring Services Program PLN-8520, INL Sampling and Analysis Plan Table Entry Database, Software Management Plan GDE-8511, Inorganic Analyses Data Validation for INL GDE-8512, Radioanalytical Data Validation GDE-8513, Validation of Gas and Liquid Chromatographic Organic Data GDE-8514, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-8516, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry
Field Sampling Documents	GDE-9103, Conduct of Operations Guidance for Communications MCP-8523, Managing Hazardous and Non-Hazardous Samples LI-355, Working in Environmental Monitoring Services Sample Preparation Areas (SPA) LI-359, Cleaning of Environmental Monitoring Services Sampling Equipment
Groundwater Documents	LI-156, Groundwater Monitoring at the Materials and Fuels Complex LI-148, Accument Model AP85 Portable PH/Conductivity Meter Operating Instructions
Liquid Effluent Documents	PLN-8540, Idaho National Laboratory Liquid Effluent Monitoring Plan MCP-8540, Reporting Requirements for Liquid Effluent and Wastewater Reuse Permit Monitoring LI-8540, Liquid Effluent Sampling GDE-8544 , Collecting Samples Using a Peristaltic Pump GDE-8545, Collection of Soil Samples for the Central Facilities Area Sewage Treatment Plant Wastewater Reuse Permit LI-330, Groundwater Monitoring at the Advanced Test Reactor Complex
Drinking Water Documents	PLN-8530, Idaho National Laboratory Drinking Water Monitoring Plan LI-361, Sampling of INL Public Water Systems LI-370, Cross Connection Inspections and Backflow Prevention Device Testing PLN-8532, Cross Connect Database
Surveillance Documents	MCP-8550, Ambient Air Surveillance Instrumentation Calibration LI-351, Sampling Atmospheric Tritium LI-352, Low Volume Air Sampling Using DL-22 LI-321, In Situ Gamma Radiation Measurements LI-357, Collecting and Preparing Environmental Dosimetry LI-459, Surface Radiation Surveys Using GPRS LI-776, Soil Sampling
Other Documents	LI-458, Establishing Revegetation Performance Measures LI-353, Event Air Monitoring LI-14602, Asbestos Building Material Inspections and Sampling PLN-8560, BEA Asbestos Database Software Management Plan PLN-3059, Quality Assurance Project Plan for Environmental Monitoring Program Sampling LI-328, Idaho National Laboratory Miscellaneous Media Umbrella Sampling
Statement of Work Documents	SOW-4785, Validating Organic Analyses Data SOW-4786, Validating Inorganic Analyses Data SOW-4787, Validating Radioanalytical Analyses Data SOW-8500 REV. 4, Battelle Energy Alliance Statement of Work for Analytical Services

Table 11-7. INL Environmental Program Documentation. (cont.)

Document/Media Type	Document No.[a] and Title
Reference Documents	LRD-8000, Environmental Requirements for Facilities, Processes, Materials and Equipment LWP-8000, Environmental Instructions for Facilities, Processes, Materials, and Equipment

a. GDE = Guide
LI = Laboratory Instruction
LRD = Laboratory Requirements Document
LWP = Laboratory Wide Procedure
MCP = Management Control Procedure
PLN = Plan
PRD = Program Requirements Documents
SOW = Statement of Work

In addition, the ICP Core contractor uses the following program plans for environmental monitoring and surveillance: PLN-720, PLN-729, PLN-730, and PLN-1305 (Table 11-8).

11.4.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project maintains a QA program in accordance with 40 CFR 61, Appendix B, as required of all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in PLN-5231, Q*uality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System*, and AMWTP-PD-EC&P-03, *Quality Assurance Project Plan for the RCE/ICE NESHAPs Stack Monitoring System*.

11.4.4 Environmental Surveillance, Education, and Research Program

The ESER Program QA documentation (Table 11-9) consists of:

- *ESER Quality Management Plan for the Environmental Surveillance, Education, and Research Program*, which implements and is consistent with the requirements of 10 CFR 830, Subpart A, and DOE Order 414.1D
- *ESER Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program*, which provides additional QA requirements for monitoring activities.
- *ESER Quality Assurance Implementation Plan for the Environmental Surveillance, Education, and Research Program*. This Quality Assurance Implementation Plan (QIP) provides requirements, responsibilities, and authority for implementing the ESER QAPjP under a graded and tailored approach to all work activities for the ESER Program.

Analytical laboratories used by the ESER Program maintain their own QA programs consistent with DOE requirements.

11.4.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Water-Quality Activities and Water-Level Measurements, (Bartholomay et al. 2014) defines procedures and tasks performed by USGS project office personnel that ensure the reliability of water quality and water level data. The plan addresses all elements needed to ensure:

- Reliability of the water-quality and water-level data
- Compatibility of the data with data collected by other organizations at the INL Site
- That data meet the programmatic needs of DOE and its contractors and the scientific and regulatory communities.

The USGS conducts performance audits on field personnel collecting samples and on the analytical laboratories that analyze their environmental monitoring samples, with the exception of the DOE RESL. The RESL is assessed by the American Association of Laboratory Accreditation as an ISO 17025 Chemical Testing Laboratory. In addition, the USGS routinely evaluates its QC data and publishes analyses in USGS reports. Analyses of QA data collected from 2012–2015 are found in Bartholomay et al. (2017).

11.4.6 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration *Quality Program Plan, NOAA Air Resources Laboratory Field Research Division* (NOAA-ARLFRD

Table 11-8. ICP Core Environmental Program Documentation.

Document/Media Type	Document No.[a] and Title
Requirement Documents	PRD-5030, Environmental Requirements for Facilities, Processes, Materials, and Equipment MCP-3480, Environmental Instructions for Facilities, Processes, Materials, and Equipment
Data and Validation Documents	PLN-491, Laboratory Performance Evaluation Program PLN-1401, Transferring Integrated Environmental Data Management System Revised Data to the Environmental Data Warehouse GDE-201, Inorganic Analyses Data Validation for Sample and Analysis Management GDE-204, Guide to Assessment of Radionuclide Analysis of Performance Evaluation Samples GDE-205, Radioanalytical Data Validation GDE-206, Obtaining Laboratory Services for Sample Analysis GDE-239, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-240, Validation of Gas and Liquid Chromatographic Organic Data GDE-241, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-7003, Levels of Analytical Method Data Validation MCP-1298, Sample and Analytical Data Management Process for the Sample and Analysis Management Program
Sampling Documents	MCP-9439, Environmental Sampling Activities at the INL
Groundwater Documents	PLN, 1305, Wastewater Reuse Permit Groundwater Monitoring Program Plan SPR-162, Measuring Groundwater Levels and Sampling Groundwater TPR-6539, Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe TPR-7582, Well Inspection/Logging Using Down-Hole Cameras
Liquid Effluent Documents	PLN-729, Idaho Cleanup Project Liquid Effluent Monitoring Program Plan SPR-101, Liquid Effluent Sampling TPR-6539, Calibrating and Using the Hydolab Quanta Water Quality Multiprobe
Drinking Water Documents	PLN-730, Idaho Cleanup Project Drinking Water Program Plan SPR-188, Collecting Water Samples for Radiological Analysis SPR-189, Routine Collection of Samples for Coliform Bacteriological Analysis SPR-190, Sampling of Public Water Systems TPR-6555, Cross Connection Inspections and Backflow Prevention Assembly Testing
Surveillance Documents	PLN-720, Environmental Surveillance Program Plan SPR-106, Biotic Monitoring SPR-107, Waste Management Low-Volume Suspended Particulate Air Monitoring SPR-110, Surface Soil Sampling SPR-193, NESHAP Ambient Air Sampling for Accelerated Retrieval Project and RCRA Processing Operations SPR-213, Surface Water Sampling at Radioactive Waste Management Complex TPR-6525, Surface Radiation Surveys Using the Global Positioning Radiometric Scanner
Gamma Documents	TPR-7485, Filling Gamma Detectors with Liquid Nitrogen TPR-7859, Shipping Screen Gamma Scan TPR-7860, Germanium Detector Calibration and Performance Testing Using Gamma Vision
Documentation Documents	MCP-9227, Environmental Log Keeping Practices MCP-9235, Reporting Requirements for the INTEC Wastewater Reuse Permit Monitoring Program
Sample Management Documents	MCP-9228, Managing Nonhazardous Samples MCP-1394, Managing Hazardous Samples

Table 11-8. ICP Core Environmental Program Documentation. (cont.)

Document/Media Type	Document No.[a] and Title

[a] GDE = guide
MCP = management control procedure
PLN = plan
PRD = program requirements document
SPR = sampling procedure
TPR = technical procedure.

Table 11-9. ESER Program Documentation.

Document/ MediaType	Document No.[a] and Title
Program Description	DOE/ID-11088 Revision 4, Idaho National Laboratory Site Environmental Monitoring Plan
Document Management	QAP-1 Preparation, Review, and Approval of ESER Procedures QAP-2 Document Control QAP-3 Information Management
Quality Procedures	QAP-4 Assessments QAP-7 Measuring and Test Equipment QAPP, Environmental Surveillance Task – Quality Assurance Project Plan QMP, Quality Management Plan for the Environmental Surveillance, Education, and Research Program QIP, Quality Assurance Implementation Plan for the Environmental Surveillance, Education, and Research Program
Field Sampling Procedures	ESP-1.1, Low-Volume Air Sampler ESP-1.2, EPA High-Volume Air Sampling ESP-1.4, Precipitation Sampling ESP-1.5, Atmospheric Moisture Sampling ESP-1.6, Environmental Radiation Measurement ESP-1.9, Jackson WY Low-Volume Air Sampler ESP 2.1, Drinking Water Sampling ESP 2.2, Soil Sampling ESP 3.1, Milk Sampling ESP 3.2, Lettuce Sampling ESP 3.3, Wheat Sampling ESP 3.4, Potato Sampling ESP 3.5, Large Game Animal ESP 3.7, Bird Collection for Scientific Purposes ESP 3.8, Alfalfa Sampling ESP 4.1, Use of Lab Balances ESP 4.2, Sample Handling and Custody ESP 4.3, Sample Delivery for Analysis ESP 4.6, R-275 Series Gas Flowmeter Equipment ESP 4.8, Sample Retention
Data Analysis and Reporting	Statistical Methods Used in the Idaho National Laboratory Site Environmental Report, http://www.idahoeser.com/Annuals/2016/Supplements/Statistical_Methods_Supplement_Final.pdf Dose Calculation Methodology, http://www.idahoeser.com/Annuals/2013/PDFS/AppendixB.pdf

[a] ESP = Environmental Surveillance Program
QAP = Quality Assurance Procedure

1993) addresses the requirements of DOE Order 414.1D, and is consistent with American Society of Mechanical Engineers. Implementing procedures include regular independent system and performance audits, written procedures and checklists, follow-up actions, and continuous automated and visual data checks to ensure representativeness and accuracy. The plan and implementing procedures ensure that the INL Meteorological Monitoring Network meets the elements of *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015).

All the meteorological sensors in the Air Resources Laboratory Field Research Division tower network are inspected, serviced, and calibrated semiannually as recommended by American Nuclear Society guidelines of ANSI/ANS 3.11 2005. Unscheduled service also is performed promptly whenever a sensor malfunctions.

11.5 Duplicate Sampling among Organizations

The ESER contractor, INL contractor, and the Department of Environmental Quality (DEQ)-INL Oversight Program (DEQ-INL OP) collects air samples at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls and on the INL Site at the Experimental Field Station and Van Buren Boulevard Gate. The DEQ-INL OP Annual Report for 2016 has not been issued at this time. Results for 2015 are compared in the DEQ-INL OP Annual Report (www.deq.idaho.gov/media/60179327/inl-oversight-program-annual-report-2015.pdf).

DEQ-INL OP also uses a network of passive electret ionization chambers on and around INL to cumulatively measure radiation exposure. These measurements are then used to calculate an average exposure rate for the quarterly monitoring period. Radiation monitoring results obtained by DEQ-INL OP are compared with radiation monitoring results reported by the DOE and its INL contractors for these same locations to determine whether the data are comparable. DEQ-INL OP has placed several electret ionization chambers at locations monitored by DOE contractors, using TLDs (thermoluminescent dosimeters) and OSLDs (optically stimulated luminescent dosimeters). Comparisons of results may be found in the 2015 DEQ-INL OP Annual Report.

The DEQ-INL OP also collects surface water and drinking water samples at select downgradient locations in conjunction with the ESER contractor. Samples are collected at the same place and time, using similar methods. Sample-by-sample comparisons are provided in the DEQ-INL OP Annual Report for 2015.

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Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations apply, in whole or in part, to the Idaho National Laboratory (INL) or at the INL Site boundary:

- 36 CFR 79, 2017, "Curation of Federally-Owned and Administered Archeological Collections," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 36 CFR 800, "Protection of Historic Properties," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 50, 2017, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, 2017, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, Subpart H, 2017, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 112, 2017, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 122, 2017, "EPA Administered Permit Programs: the National Pollutant Discharge Elimination System," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 141, 2017, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 142, 2017, "National Primary Drinking Water Regulations Implementation," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 143, 2017, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 260, 2017, "Hazardous Waste Management System: General," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 261, 2017, "Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 262, 2017, "Standards Applicable to Generators of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 263, 2017, "Standards Applicable to Transporters of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 264, 2017, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 265, 2017, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 267, 2017, "Standards for Owners and Operators of Hazardous Waste Facilities Operating under a Standardized Permit," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 43 CFR 7, 2017, "Protection of Archeological Resources," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 17, 2017, "Endangered and Threatened Wildlife and Plants," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register

- 50 CFR 226, 2017, "Designated Critical Habitat," U.S. Department of Commerce, National Marine Fisheries Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 402, 2017, "Interagency Cooperation – Endangered Species Act of 1973, as Amended," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 424, 2017, "Listing Endangered and Threatened Species and Designating Critical Habitat," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 450–453, 2017, "Endangered Species Exemption Process," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 42 USC § 9601 et seq., 1980, "Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund)," United States Code.
- DOE Order 231.1B, 2011, "Environment, Safety, and Health Reporting," Change 2, U.S. Department of Energy
- DOE Order 435.1, 2001, "Radioactive Waste Management," Change 2, U.S. Department of Energy
- DOE Order 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy
- DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," U.S. Department of Energy
- DOE Standard 1196-2011, 2011, "Derived Concentration Technical Standard," U.S. Department of Energy
- Executive Order 11514, 1970, "Protection and Enhancement of Environmental Quality"
- Executive Order 11988, 1977, "Floodplain Management"
- Executive Order 11990, 1977, "Protection of Wetlands"
- Executive Order 12344, 1982, " Naval Nuclear Propulsion Program."
- Executive Order 12580, 1987, "Superfund Implementation"
- Executive Order 12856, 1993, "Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements"
- Executive Order 12873, 1993, "Federal Acquisition, Recycling, and Waste Prevention"
- Executive Order 13101, 1998, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition"
- Executive Order 13423, 2007, "Strengthening Federal Environmental, Energy, and Transportation Management"
- Executive Order 13514, 2009, "Federal Leadership in Environmental, Energy, and Economic Performance"
- Executive Order 13693, 2015, "Planning for Federal Sustainability in the Next Decade"
- IDAPA 58.01.01, 2014, "Rules for the Control of Air Pollution in Idaho," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.02, 2014, "Water Quality Standards," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.03, 2014, "Individual/Subsurface Sewage Disposal Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.05, 2014, "Rules and Standards for Hazardous Waste," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.06, 2014, "Solid Waste Management Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.08, 2014, "Idaho Rules for Public Drinking Water Systems," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.11, 2014, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.15, 2014, "Rules Governing the Cleaning of Septic Tanks," Idaho Administrative

Procedures Act, Idaho Department of Environmental Quality

- IDAPA 58.01.16, 2014, "Wastewater Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.
- IDAPA 58.01.17, 2014, "Recycled Water Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

U.S. Department of Energy (DOE) Order 458.1 Ch. 3 provides the principal requirements for protection of the public and environment at the INL Site. The DOE public dose limit is shown in Table A-1, along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

Derived Concentration Standards are established to support DOE Order 458.1 in DOE Standard 1196-2011 (DOE-STD-1196-2011), "Derived Concentration Technical Standard." These quantities represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year for each of the following pathways: ingestion of water, submersion in air, and inhalation. The Derived Concentration Standards used by the environmental surveillance programs at the INL Site are shown in Table A-2. The most restrictive Derived Concentration Standard is listed when the soluble and insoluble chemical forms differ. The Derived Concentration Standards consider only inhalation of air, ingestion of water, and submersion in air.

The Environmental Protection Agency National Ambient Air Quality Standards may be found at https://www.epa.gov/criteria-air-pollutants/naaqs-table.

Water quality standards are dependent on the type of drinking water system sampled. Tables A-4 through A-6 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 Code of Federal Regulations 141 (2014) and the Idaho groundwater quality values from IDAPA 58.01.11 (2012).

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

Radiation Standard	Effective Dose Equivalent (mrem/yr)	(mSv/yr)
DOE standard for routine DOE activities (all pathways)	100[a]	1
EPA standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

Table A-2. Derived Concentration Standards for Radiation Protection.

	Derived Concentration Standard[a]			Derived Concentration Standard	
Radionuclide	**In Air (µCi/ml)**	**In Water (µCi/ml)**	**Radionuclide**	**In Air (µCi/ml)**	**In Water (µCi/ml)**
Gross Alpha[b]	3.4×10^{-14}	1.7×10^{-7}	Antimony-125	3.1×10^{-10}	2.7×10^{-5}
Gross Beta[c]	2.5×10^{-11}	1.1×10^{-6}	Iodine-129[f]	3.8×10^{-10}	3.3×10^{-7}
Tritium (tritiated water)	2.1×10^{-7}	1.9×10^{-3}	Iodine-131[f]	2.3×10^{-9}	1.3×10^{-6}
Carbon-14	6.6×10^{-10}	6.2×10^{-5}	Iodine-132[f]	3.0×10^{-8}	9.8×10^{-5}
Sodium-24	7.0×10^{-9}	7.2×10^{-5}	Iodine-133[f]	7.2×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	__	Iodine-135[f]	1.6×10^{-8}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[d]	2.4×10^{-6}	__
Manganese-54	1.1×10^{-9}	4.4×10^{-5}	Xenon-133[d]	6.3×10^{-7}	__
Cobalt-58	1.7×10^{-9}	3.9×10^{-5}	Xenon-133m[d]	6.6×10^{-7}	__
Cobalt-60	1.2×10^{-10}	7.2×10^{-6}	Xenon-135[d]	7.8×10^{-8}	__
Zinc-65	1.6×10^{-9}	8.3×10^{-6}	Xenon-135m[d]	4.5×10^{-8}	__
Krypton-85[d]	3.6×10^{-6}	__	Xenon-138[d]	1.6×10^{-8}	__
Krypton-85m[d,e]	1.3×10^{-7}	__	Cesium-134	1.8×10^{-10}	2.1×10^{-6}
Krypton-87[d]	2.2×10^{-8}	__	Cesium-137	9.8×10^{-11}	3.0×10^{-6}
Krypton-88[d]	8.8×10^{-9}	__	Cesium-138	7.5×10^{-8}	3.1×10^{-4}
Rubidium-88	1.2×10^{-7}	3.2×10^{-4}	Barium-139	5.8×10^{-8}	2.4×10^{-4}
Rubidium-89	1.5×10^{-7}	6.6×10^{-4}	Barium-140	6.2×10^{-10}	1.1×10^{-5}
Strontium-89	4.6×10^{-10}	1.1×10^{-5}	Cerium-141	9.9×10^{-10}	4×10^{-5}
Strontium-90	2.5×10^{-11}	1.1×10^{-6}	Cerium-144	7.1×10^{-11}	5.5×10^{-6}
Yttrium-91m	3.1×10^{-7}	2.7×10^{-3}	Plutonium-238	3.7×10^{-14}	1.5×10^{-7}
Zirconium-95	6.3×10^{-10}	3.1×10^{-5}	Plutonium-239	3.4×10^{-14}	1.4×10^{-7}
Technetium-99m	1.7×10^{-7}	1.4×10^{-3}	Plutonium-240	3.4×10^{-14}	1.4×10^{-7}
Ruthenium-103	1.3×10^{-9}	4.2×10^{-5}	Plutonium-241	1.8×10^{-12}	7.6×10^{-6}
Ruthenium-106	5.6×10^{-11}	4.1×10^{-6}	Americium-241	4.1×10^{-14}	1.7×10^{-7}

a. Derived concentration standards are from DOE-STD-1196-2011 (*Derived Concentration Technical Standard)* and support the implementation of DOE Order 458.1. They are based on a committed effective dose equivalent of 100 mrem/yr (1 mSv) for ingestion or inhalation of a radionuclide during one year. Inhalation values shown represent the most restrictive lung retention class.

b. Based on the most restrictive human-made alpha emitter ($^{239/240}$Pu).

c. Based on the most restrictive human-made beta emitter (^{90}Sr).

d. The DCS for air immersion is used because there is no inhaled air DCS established for the radionuclide.

e. An "m" after the number refers to a metastable form of the radionuclide.

f. Particulate aerosol form in air.

Table A-3. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Level	Groundwater Quality Standard
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4	4
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/yr effective dose equivalent
Radium-226 plus -228 (pCi/L)	5	5
Strontium-90 (pCi/L)	8	8
Tritium (pCi/L)	20,000	20,000
Uranium (µg/L)	30	30
Arsenic (mg/L)	0.01	0.05
Antimony (mg/L)	0.006	0.006
Asbestos (fibers/L)	7 million	7 million
Barium (mg/L)	2	2
Beryllium (mg/L)	0.004	0.004
Cadmium (mg/L)	0.005	0.005
Chromium (mg/L)	0.1	0.1
Copper (mg/L)	1.3	1.3
Cyanide (mg/L)	0.2	0.2
Fluoride (mg/L)	4	4
Lead[a] (mg/L)	0.015	0.015
Mercury (mg/L)	0.002	0.002
Nitrate (as N) (mg/L)	10	10
Nitrite (as N) (mg/L)	1	1
Nitrate and Nitrite (both as N) (mg/L)	--[b]	10
Selenium (mg/L)	0.05	0.05
Thallium (mg/L)	0.002	0.002

a. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

b. No maximum contaminant level for this constituent.

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

Constituent	Maximum Contaminant Level (mg/L)	Groundwater Quality Standard (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	__	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	0.005	0.005
1,2-Dichloropropane	0.005	0.005
Ethylbenzene	0.7	0.7
Monochlorobenzene	0.1	0.1
Styrene	0.1	0.1
Tetrachloroethylene	0.005	0.005
Toluene	1.0	1.0
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.005	0.005
Trichloroethylene	0.005	0.005
Vinyl chloride	0.002	0.002
Xylenes (total)	10.0	10.0
Bromate	0.01	__
Bromodichloromethane	__	0.1
Bromoform	__	0.1
Chlorodibromomethane	__	0.1
Chloroform	__	0.002
Chlorite	1.0	__
Haloacetic acids (HAA5)	0.06	__
Total Trihalomethanes (TTHMs)	0.08	0.1

Table A-5. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Synthetic Organic Contaminants.

Constituent	Maximum Contaminant Level (mg/L)	Groundwater Quality Standard (mg/L)
Alachlor	0.002	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-Dichlorophenoxyacetic acid	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (silvex)	0.05	0.05
Benzo(a)pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

Table A-6. Environmental Protection Agency National Secondary Drinking Water Regulations and State of Idaho Groundwater Quality Standards for Secondary Contaminants.

Constituent	Secondary Standard[a]	Groundwater Quality Standard
Aluminum (mg/L)	0.05 to 0.2	0.2
Chloride (mg/L)	250	250
Color (color units)	15	15
Foaming agents (mg/L)	0.5	0.5
Iron (mg/L)	0.3	0.3
Manganese (mg/L)	0.05	0.05
Odor (threshold odor number)	3 threshold odor number	3
pH	6.5 to 8.5	6.5 to 8.5
Silver (mg/L)	0.1	0.1
Sulfate (mg/L)	250	250
Total dissolved solids (mg/L)	500	500
Zinc (mg/L)	5	5

a. The Environmental Protection Agency (EPA) has not established National Primary Drinking Water Regulations that set mandatory water quality standards (maximum contaminant levels) for these constituents because these contaminants are not considered a risk to human health. EPA has established National Secondary Drinking Water Regulations that set secondary maximal contaminant levels as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

Appendix B. Cultural Resource Reviews Performed at the INL Site

U.S. Department of Energy (DOE) Idaho National Laboratory (INL) Site cultural resources are numerous and represent at least 13,000 years of human land use on the northeastern Snake River Plain. They include:

- Prehistoric archaeological sites such as Aviators Cave, which is listed on the National Register of Historic Places
- Historic archaeological sites and trails such as Goodale's Cutoff, a northern spur of the Oregon Trail
- Important historic World War II and post-war sites such as the B-24 bomber crash, which has been selected to serve as an example of the impact and value of federal archaeology in the state of Idaho in celebration of the 50th anniversary of the National Historic Preservation Act
- Pioneering nuclear facilities like Experimental Breeder Reactor-I, which was the first reactor in the world to produce usable electrical power and is recognized as a National Historic Landmark
- Places and resources of importance to the Shoshone-Bannock Tribes
- A myriad of original historical data such as 1949 aerial photographs, as-built engineering and architectural drawings, maps, early technical reports, and oral histories.

Protection and preservation of cultural resources under the jurisdiction of federal agencies, including U.S. Department of Energy, Idaho Operations Office (DOE-ID), are mandated by a number of federal laws and their implementing regulations. Primary among them are the:

- ***National Historic Preservation Act (NHPA) of 1966, as amended*** – requires federal agencies to establish programs to locate, evaluate, and nominate to the National Register of Historic Places, historic properties under their jurisdiction and to do so in consultation with State Historic Preservation Offices (SHPO), Tribes, and stakeholders and to invite the Advisory Council on Historic Preservation to participate in the consultation. Federal agencies must establish programs to inventory and appropriately manage historic properties located on their lands (Section 110), take into account the effects of their undertakings on them, including mitigation when necessary (Section 106), involve tribes, SHPOs, the Advisory Council on Historic Preservation (Advisory Council), and stakeholders in decisions; inform and educate the public about the resources, and maintain artifact collections and archival materials at professional standards. The act also requires that this work and persons who complete this work must meet certain professional standards. Implementing regulations are found at 36 Code of Federal Regulations Part 800.
- ***National Environmental Policy Act of 1969, as amended*** – outlines the federal policy of general environmental protection and requires the use of natural and social sciences in planning and decision-making processes with regard to project impacts on the environment including historical, cultural, and natural resources that are important to national heritage.
- ***Archaeological Resource Protection Act of 1979, as amended*** – establishes permit requirements and civil and criminal penalties for unauthorized excavation, removal, damage, alterations, defacement, sale, purchase, exchange, transport, receipt of, or offer for sale of any archaeological resource that is more than 100 years old and that is located on federal or tribal lands. It fosters increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals in the execution of these duties. The Secretary of Interior is directed to submit an annual report to Congress that summarizes the federal archaeology program and results. Implementing regulations are found at 43 Code of Federal Regulations Part 7.
- ***American Indian Religious Freedom Act of 1978*** – prompts federal agencies to avoid interfering with access to sacred locations and traditional resources and to consult with interested tribes to aid in the protection and preservation of cultural and spiritual traditions and sites.
- ***DOE Policy 141.1*** – ensures that DOE programs integrate cultural resources management into their missions and activities and raises the level of awareness and accountability among DOE

contractors concerning the importance of cultural resource related legal and trust responsibilities.

Many INL Site cultural resources remain protected and undisturbed as a result of the area's closure to the general public beginning in 1942, and an active, comprehensive cultural resource management program. Through contract, DOE-ID has tasked Battelle Energy Alliance's (BEA) Cultural Resource Management Office (CRMO) with implementation of the program. The comprehensive *INL Cultural Resource Management Plan* (DOE-ID 2016) provides a tailored approach to comply with legal mandates and implements DOE cultural resource policies and goals, while meeting the unique needs of the INL Site. The plan is legitimized through a 2004 *Programmatic Agreement, Concerning Management of Cultural Resources on the INL Site* (DOE-ID 2004), between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho SHPO. DOE-ID's *Agreement in Principle* (DOE-ID 2012) with the Shoshone-Bannock Tribes is another important component of the overall approach to management of cultural resources at the INL Site.

Cultural resource management is structured to comply with a long list of statutes, executive orders, and regulations identified in Table B-1.

In response to these legal mandates, DOE has issued department-wide guidance. This includes DOE Order 436.1, "Departmental Sustainability," which outlines requirements to develop and maintain "policies and directives for environmental protection, including the conservation and preservation of natural and cultural resources." DOE Policy 141.1, "Management of Cultural Resources," provides additional guidance for integrating cultural resource management into DOE and contractor missions and activities and raising the level of awareness and accountability concerning the importance of the department's cultural resource-related legal and trust responsibilities. To incorporate Native American concerns into DOE activities and policy, DOE Order 144.1, "American Indian Tribal Government Interactions and Policy," communicates departmental, programmatic, and field office responsibilities for interacting with American Indian governments. Together these directives help to ensure that DOE maintains a program that reflects the spirit and intent of the legislative mandates.

DOE-ID has developed a broad program to structure INL Site compliance with the federal, state, and departmental requirements for cultural resource management. The cornerstone of the INL Site approach is the *INL Cultural Resource Management Plan* (DOE-ID 2016). This comprehensive plan was written specifically for INL Site resources and activities. It provides a tailored approach to comply with the legal mandates and to implement DOE-ID cultural resource policies and goals while meeting the unique needs of the INL Site. The plan is reviewed annually, updated as needed, and is legitimized by the following foundational agreements between DOE-ID and other parties:

- 1994 *Memorandum of Agreement (Middle Butte Cave)*, between DOE-ID and the Shoshone-Bannock Tribes (DOE-ID 1994)
- 1996 *Memorandum of Understanding for Curatorial Services, between DOE-ID and the Idaho Museum of Natural History* (DOE-ID 1996)
- 2004 *Programmatic Agreement Concerning Management of Cultural Resources on the INL Site*, between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho SHPO (DOE-ID 2004)
- 2012 *Agreement in Principle*, between DOE-ID and the Shoshone-Bannock Tribes (DOE-ID 2012).

The INL Site CRMO resides within DOE-ID's management and operations contractor, BEA. Cultural resource professionals within the CRMO coordinate cultural resource-related activities at the INL Site and implement the *INL Cultural Resource Management Plan* (DOE-ID 2016) with oversight by DOE-ID's cultural resource coordinator. Provisions to protect the unique cultural resources of the lands and facilities at the INL Site are included in environmental policies issued by BEA and other INL Site contractors and in company procedures that guide work completion.

B.1 Idaho National Laboratory Cultural Resource Project Reviews

The INL Site is an active facility where thousands of work orders for projects ranging from lawn care to new facility construction are processed each year. The *INL Cultural Resource Management Plan* (DOE-ID 2016) contains an approach for assessing and, when necessary, mitigating adverse impacts to cultural resources as a consequence of all activities large or small (NHPA Section 106). Under INL Site procedures, a cultural resource review is prompted whenever ground disturbance or major structural or landscape modifications are proposed.

Many cultural resource identification and evaluation studies were conducted in 2016, including archaeological

Table B-1. Statutes, Executive Orders, and Regulations Pertinent to Cultural Resource Management on the INL.

Federal Statutes	• **Antiquities Act of 1906** • **Federal Records Act of 1950** • **National Historic Preservation Act (NHPA) of 1966, as amended** • **National Environmental Policy Act (NEPA) of 1969** • **Archaeological and Historic Preservation Act of 1974** • **American Indian Religious Freedom Act (AIRFA) of 1978** • **Archaeological Resources Protection Act (ARPA) of 1979, as amended** • **Federal Cave Resources Protection Act of 1988** • **Native American Graves Protection and Repatriation Act (NAGPRA) of 1990** **Paleontological Resources Preservation Act of 2009**
State Statutes	• Idaho Code, Chapter 41: Idaho Historic Preservation Act • Idaho Code, Chapter 70: Burial Act and Idaho Cave Protection Act • Idaho Code, Chapter 5: Protection of Graves
Executive Directives	• Executive Order 11593, Protection and Enhancement of the Cultural Environment (1971) • Executive Memoranda, regarding Government-to-Government Consultation with Native American Tribal Governments (1994; 2004; 2009) • Executive Order 13007, Indian Sacred Sites (1996) • Executive Order 13175, Consultation and Coordination with Indian Tribal Governments (2000) • Executive Order 13287, Preserve America (2003) • Executive Memorandum of Understanding: Interagency Coordination and Collaboration for the Protection of Indian Sacred Sites (2012)
Regulations	• 10 CFR part 1021: National Environmental Policy Act • 36 CFR part 60: National Register of Historic Places • 36 CFR part 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places • 36 CFR part 65: National Historic Landmarks Program • 36 CFR part 67: Standards for Rehabilitation • 36 CFR part 68: Standards for the Treatment of Historic Properties • 36 CFR part 78: Waiver of Federal Responsibilities under Section 110 of the NHPA • 36 CFR part 79: Curation of Federally-Owned and Administered Archeological Collections • 36 CFR part 800: Protection of Historic Properties • 36 CFR part 1220+: National Archives and Records Administration • 43 CFR part 3: Protection of American Antiquities • 43 CFR part 7: Protection of Archaeological Resources • 43 CFR part 10: Native American Graves Protection and Repatriation Regulations

field surveys related to INL Site project activities (i.e., ground disturbance and building modifications) as well as broader research goals, archival and historic research, routine monitoring of sensitive resources and ground disturbance associated with active INL Site projects. Meaningful interaction with members of the Shoshone-Bannock Tribes (Figure B-1) and public stakeholders who value the largely undisturbed legacy of human history and prehistory that is preserved at the INL Site also occurred. The totals reported in this section are derived from two basic types of surveys 1) those related to INL Site project reviews (NHPA Section 106: 33 archaeological reviews and 73 historic architectural reviews), and 2) those related to CRMO research interests under NHPA Section 110. Field studies to support these projects totaled 10 throughout the year.

In 2016, 33 INL Site project reviews were completed to assess potential impacts to archaeological resources per the general requirements of Section 106 of the NHPA. Field investigations were completed for 10 of these proposed projects and 859 acres (3.48 km^2) that had never been surveyed for cultural resources were examined. Nearly all of the proposed projects were small in size (½ to 20 acres) (0.002 to 0.08 km^2) and included activities like parking lot improvements, fiber optic line installations, monitoring wells, gravel pit expansion, and road maintenance. Four of the proposed INL Site projects in 2016 were located in areas that had been previously surveyed for cultural resources. Per the guidelines of the *INL Cultural Resource Management Plan* (DOE-ID 2016), approximately five acres (0.02 km^2) of these previously surveyed areas were reexamined in 2016 because the original surveys were completed more than 10 years ago. Project-related surveys in 2016, resulted in the documentation of 36 previously unknown archaeological resources and reassessment of 16 previously recorded resources. All of these resources were recommended for avoidance or other protective measures during project implementation and none were adversely impacted by project activities in 2016. Cumulatively, (including 13,425 acres [54.3 km^2] of historic surveys that do not meet the terms of the Cultural Resource Management Plan), the total number of acres intensively surveyed for archaeological resources on the INL Site increased to 56,651 (229.3 km^2) with the addition of these surveys (approximately 10 percent of the 890 square mile [2,305 km^2] laboratory) and the total number of known archaeological resources was increased to 2,842.

Table B-2 provides a summary of the cultural resource reviews performed in 2016.

Figure B-1. Member of the Shoshone-Bannock Tribal Heritage Tribal Office Assisting with INL Site Project Surveys.

Table B-2. Summary of 2016 Cultural Resource Reviews.

Project No.	Project Title
BEA-16-01	INL Power Management Routine Maintenance
BEA-16-02	SMC-TAN Mowing
BEA-16-03	Wireless Test Bed 2016 (Pass Creek tests, Isolated Satellite Backhaul Network, Main Gate Shelter, RF Measurements-USG#74)
BEA-16-04	FORGE-GRRA
BEA-16-05	Spreading Area Soil Characterization
BEA-16-06	Small Modular Reactor
BEA-16-07	High Frequency Test Bed at STF
BEA-16-08	NVIS Antenna in Idaho Falls
BEA-16-09	CITRC small projects (PBF 638 transfer switches)
BEA-16-10	ICP/CWI/Fluor small projects (ATR CERCLA activities, TRA 655 DD&D, EBR-II Fuel, Injection Well Decommissioning)
BEA-16-11	CFA Main Range Shooting Platform
BEA-16-12	TREAT Developments (Parking Lot, MFC-721 Laydown Area Expansion, Lightning Rods)
BEA-16-13	CFA and MFC Firing Range Modifications
BEA-16-14	Projects Inside INL Fences
BEA-16-15	CFA Landfill Expansion
BEA-16-16	RRTR Use of Foam
BEA-16-17	USGS Well 142A
BEA-16-18	Department of Homeland Security (DHS) Domestic Nuclear Detection Office (DNDO) Assessments Directorate (ASD
BEA-16-19	Power Management Training Yard
BEA-16-20	USGS Well 144
BEA-16-21	Auxiliary Reactor Area (ARA)-632 Integrated Satellite Backhaul Network (ISBN) 3-Phase Power Upgrade
BEA-16-22	Mist Netting at Middle Butte Cave
BEA-16-23	NOAA-NASA Mars Methane Plume Test
BEA-16-24	NSTR Expansion
BEA-16-25	NHS Project M 2016
BEA-16-26	Power Grid Research 2016 (Vehicle access at IML, New poles at MFC Test Pad)
BEA-16-27	MFC Research Collaboration Building
BEA-16-28	Safeguards and Security Training Exercises
BEA-16-29	NHS Portable Restroom
BEA-16-30	Grazing 2016
BEA-16-31	LI-776 Long Term Soil Sampling
BEA-16-32	GSS Sagebrush planting
BEA-16-33	Trespasser Investigations

Cultural resource reviews of projects that had the potential to impact INL Site historic architectural properties were also completed for 73 proposed activities in 2016 (Table B-3). Most of these projects involved activities such as routine maintenance, internal equipment repair/replacement, and in-kind replacement, which have been determined categorically to pose no significant threats to historic properties. At the Advanced Test Reactor Complex, where the National Register-eligible Advanced Test Reactor is located, several projects were reviewed for activities such as bathroom remodels and repair/replace equipment. Numerous projects were also proposed at Materials and Fuels Complex facilities, due in part to preparation for restarting the Transient Reactor Test Facility reactor, as well as routine maintenance and repair of electrical, plumbing, fire system upgrades, and other activities categorically exempt from cultural resource concerns under the *INL Cultural Resource Management Plan* (DOE-ID 2016).

Information gathered during INL Site cultural resource investigations and reviews is managed as a valuable archive of INL Site cultural resources and a record of decision-making related to cultural resource compliance and ongoing resource and land management. These hard copy and electronic data provide the foundation for archaeological predictive modeling efforts that facilitate land use planning, in both the long- and short-term, and serve important roles in local and regional archaeological research. Important documents related to the historical development of the INL Site, the ground-breaking scientific research conducted throughout INL Site history, and inventories to identify historic properties associated with these activities are also preserved.

Table B-3. Summary of 2016 Architectural Properties Reviews.

Project No.	Project Title
BEA-16-H001	Remove Radioactive Liquid Waste Tank Facility Truck Loading Station Outside of the Hot Fuel Examination Facility
BEA-16-H002	Materials and Fuels Complex (MFC) Hot Fuel Examination Facility (HFEF) Purification System Modernization
BEA-16-H003	Materials and Fuels Complex (MFC) Machine Shop Reconfiguration and Installation Project
BEA-16-H004	Test Reactor Area (TRA)-653 Men's Shower Remodel
BEA-16-H005	Test Reactor Area (TRA)-653 Machine Shop Reconfiguration and Equipment Installation Project
BEA-16-H006	Hot Fuel Examination Facility (HFEF) Stack Sampling Tracer Gas Testing
BEA-16-H007	EBR-I window repair
BEA-16-H008	Test Area North (TAN)-614 Potable Water Pump Replacement
BEA-16-H009	Warm Waste Effluent Radiation Monitor and Transfer Pump M-54 Recirculation Evaluation and Modification
BEA-16-H010	Replace/Upgrade 670-HVA-3, Process Control Room Air Conditioner in TRA-670
BEA-16-H011	Test Reactor Area (TRA)-670 Primary Pump Pit Platform
BEA-16-H012	Test Reactor Area (TRA)-670 Control Room Break Room and 2nd Basement Bathroom Modification
BEA-16-H013	Advanced Test Reactor (ATR) Complex Road Repairs
BEA-16-H014	Power Burst Facility (PBF)-638 and Central Facilities (CF)-617 Manual Transfer Switch Installation
BEA-16-H015	Hot Fuel Examination Facility (HFEF) High Bay Crane Refurbishment
BEA-16-H016	MFC - Experimental Breeder Reactor II Final End State
BEA-16-H017	Replace tile in rest room, EBR-I
BEA-16-H018	Advanced Test Reactor (ATR)-1D-N and 2B-SE Asbestos Abatement and Insulation Installation
BEA-16-H019	Advanced Test Reactor (ATR)-C-3 2-Ton Crane Replacement
BEA-16-H020	Roof replacement/repair site wide

Table B-3. Summary of 2016 Architectural Properties Reviews. (cont.)

Project No.	Project Title
BEA-16-H021	Replace check valve for potable water MFC-782
BEA-16-H022	IT modification MFC-720
BEA-16-H023	Install Energy Innovation Laboratory (EIL) (Idaho Falls [IF]-688) Entry Vestibule and Dock Area Staircase
BEA-16-H024	Advanced Test Reactor High-Temperature Loop Inpile Tube and Large Inpile Tube Expansion Joint Gland Seal Design Modification
BEA-16-H025	Central Facilities Area (CFA) Live Fire Range Elevated Platform
BEA-16-H026	Advanced Test Reactor (ATR) Nuclear Instrumentation Replacement Project
BEA-16-H027	INL ICAM Project
BEA-16-H028	Radiological Response Training Range - modifications
BEA-16-H029	TRA-622 & TRA-628 Voice Paging System
BEA-16-H030	Repair of Analytical Laboratory Liquid Waste System
BEA-16-H031	Replace Tank TK-5175 in Materials and Fuels Complex (MFC)-765 Truck Lock
BEA-16-H032	Test and Evaluation Support - U.S. Department of Homeland Security (DHS) Domestic Nuclear Detection Office (DNDO) Assessments Directorate (ASD)
BEA-16-H033	Excess Facilities Deactivation and Demolition Rev 1 - DD&D of CFA-671
BEA-16-H034	Materials and Fuels Complex (MFC)-718 Decontamination and Decommissioning (D&D) and MFC Protected Area Intrusion Detection Upgrade
BEA-16-H035	Advanced Test Reactor (ATR) Loop Pump Replacement and Ancillary Equipment Replacement
BEA-16-H036	Materials and Fuels Complex (MFC) MFC-753 Compressor Installation
BEA-16-H037	Fuel Cycle Laboratory Glove Box in Fuel Cycle Facility (FCF)
BEA-16-H038	Radiation Monitoring and Seal System (RMSS) Stack Monitor and Damper Replacement
BEA-16-H039	INTEC – 102 Naval Reactor Cans to WIPP Disposition Project
BEA-16-H040	DD&D of CFA-637
BEA-16-H041	Test Reactor Area (TRA)-652 Ice Machine Installation
BEA-16-H042	IF-608 (IORC) Room E-8 Secure Area Office Modifications
BEA-16-H043	Surface Science Instrument Relocation to Safety and Tritium Applied Research Facility (STAR)
BEA-16-H044	Hot Fuel Examination Facility (HFEF) 1M Window and Tank Unit Replacement
BEA-16-H045	Test Reactor Area (TRA)-670 New Window in Advanced Test Reactor (ATR) Production Control Center
BEA-16-H046	Materials and Fuel Complex (MFC)-752 Analytical Laboratory Main Stack Modifications for Sample Probe Replacement
BEA-16-H047	Security modifications, MFC-752
BEA-16-H048	Potable Water System Hammer in TRA-608
BEA-16-H049	INTEC – Calcine Retrieval Demonstration
BEA-16-H050	Computer Network Connection for the Advanced Test Reactor Critical (ATR-C) Facility
BEA-16-H051	Transfer Waste Management Activities from Central Facilities Area (CFA)-637 to CFA-674
BEA-16-H052	Modify Rapid Insertion Port Argon Panels in the Hot Fuels Examination Facility
BEA-16-H053	2016 Materials and Fuels Complex (MFC) Campus Improvement Projects
BEA-16-H054	Materials and Fuels Complex (MFC)-752 Analytical Laboratory Installation of Air Conditioning Units

Table B-3. Summary of 2016 Architectural Properties Reviews. (cont.)

Project No.	Project Title
BEA-16-H055	Research and Education Campus (REC) Fiscal Year (FY) 2016 Through FY2017 Interior Updates
BEA-16-H056	Replace 670-M-15 Pressurizer Pump
BEA-16-H057	INTEC - Upgrade of the Emergency Communication System
BEA-16-H058	Repaint Floors in 1A and 2B Secondary Cubicles
BEA-16-H059	Lighting Replacements in Test Reactor Area (TRA)-653 (Weld Shop) and TRA-662 (Warehouse)
BEA-16-H060	Mount New Spill Kits in TRA-670
BEA-16-H061	670-M-42 and 670-M-43 Diesel Fuel Strainer Removal and Bypass
BEA-16-H062	Transient Reactor Test Facility (TREAT) Low-Enriched Uranium (LEU) Fuel Conversion Project
BEA-16-H063	DD&D - CFA-633 non-historic portions, FCA-690
BEA-16-H064	Office space lease and maintenance agreement
BEA-16-H065	Touch-up painting, EBR-I
BEA-16-H066	Bathroom remodel, MFC-752
BEA-16-H067	Sink Valve Replacement in Test Reactor Area (TRA)-670 Battery Room
BEA-16-H068	1A Secondary Cubicle Operations Storage Box
BEA-16-H069	Repair Asbestos Dry Wall in TRA-616
BEA-16-H070	Materials and Fuels Complex (MFC) Hot Fuels Examination Facility (HFEF) Facility Equipment Upgrades
BEA-16-H071	Remove Section of Reactor Top Hand Rail, TRA-670
BEA-16-H072	Lithium Aluminate Capsule Experiment (LACE)
BEA-16-H073	Adding airlines to TRA-666

The results of project-specific cultural resource reviews are documented in a number of ways per the requirements outlined in the *INL Cultural Resource Management Plan* (DOE-ID 2016). Recommendations tailored to specific projects and any cultural resources that may require consideration are delivered in official e-mail notes that become part of the project's National Environmental Policy Act-driven Environmental Checklist and permanent record. For larger projects, technical reports are often prepared to synthesize cultural resource information and recommendations. Two project-specific plans were prepared in 2016:

- INL/LTD-16-40022: *Preliminary Cultural Resource Investigations within Spreading Areas A and B on the Idaho National Laboratory*
- INL/LTD-16-38943: *Cultural Resource Investigations for the Idaho National Laboratory Power Grid Test Bed Enhancement Project.*

As a final mechanism to ensure that cultural resources are not subject to unmitigated harm from INL Site activities, employees are authorized to stop work at all DOE-ID, contractor, and/or subcontractor operations if they believe the work poses an imminent danger to human health and safety, or the environment, including irreplaceable cultural resources. Procedures are in place to make immediate notifications to appropriate parties (CRMO, DOE-ID, Shoshone-Bannock Tribes, state of Idaho, local law enforcement) in the event of any discoveries of this nature. Additionally, areas that have previously revealed unanticipated discoveries of sensitive cultural materials are routinely monitored for new finds. No cultural materials were unexpectedly discovered at the INL Site in 2016.

B.2 Idaho National Laboratory Cultural Resource Research

INL Site cultural resource investigations in 2016, were also conducted to further DOE-ID obligations under Section 110 of the NHPA to develop a broad understanding of all INL Site cultural resources, not only those located in active project areas. The 2016 NHPA Section 110 field project is a continued focus on analysis of regional volcanic glass sources. This research is a newly established collaborative effort between the CRMO and new partners, including the Bureau of Land Management and U.S. Forest Service.

This research is ongoing with the survey, systematic collection, and cataloging of regional obsidian sources. Additionally, with the use of a precision-calibrated portable x-ray fluorescence machine, a comprehensive dataset of volcanic glass sources from southern Idaho and surrounding regions is being characterized and isolated to each unique chemical signature of individual volcanic glass sources. As this regional obsidian source collection is established, the CRMO, federal agencies, local tribes and the research community will be able to source individual volcanic glass artifacts from the INL Site and surrounding regions to expand our knowledge of human movement and interactions on the Snake River Plain for the last 13,000 years. Such comprehensive analysis can be performed without damage or destruction to the archaeological record.

Additionally, in 2016, ongoing research on Pleistocene Lake Terreton (Figure B-2) continued in order to better understand historic lake levels. Native American occupation of the lakeshore coincides with some of the earliest spear points known in North America. Clovis, Folsom and a significant number of Haskett and Agate Basin points have been recovered from the area. By modeling these point locations on the landscape, researchers can potentially determine fluctuations in lake levels over the last 15,000 years. These data are likely to greatly expand our current understanding of land use patterns, human mobility and tool stone conveyance during a relatively enigmatic period in western North America.

B.3 Cultural Resource Monitoring

The CRMO conducts yearly cultural resource monitoring that includes many sensitive archaeological, historic architectural, and tribal resources. Under this monitoring program, there are four possible findings, based on the level of disturbance noted:

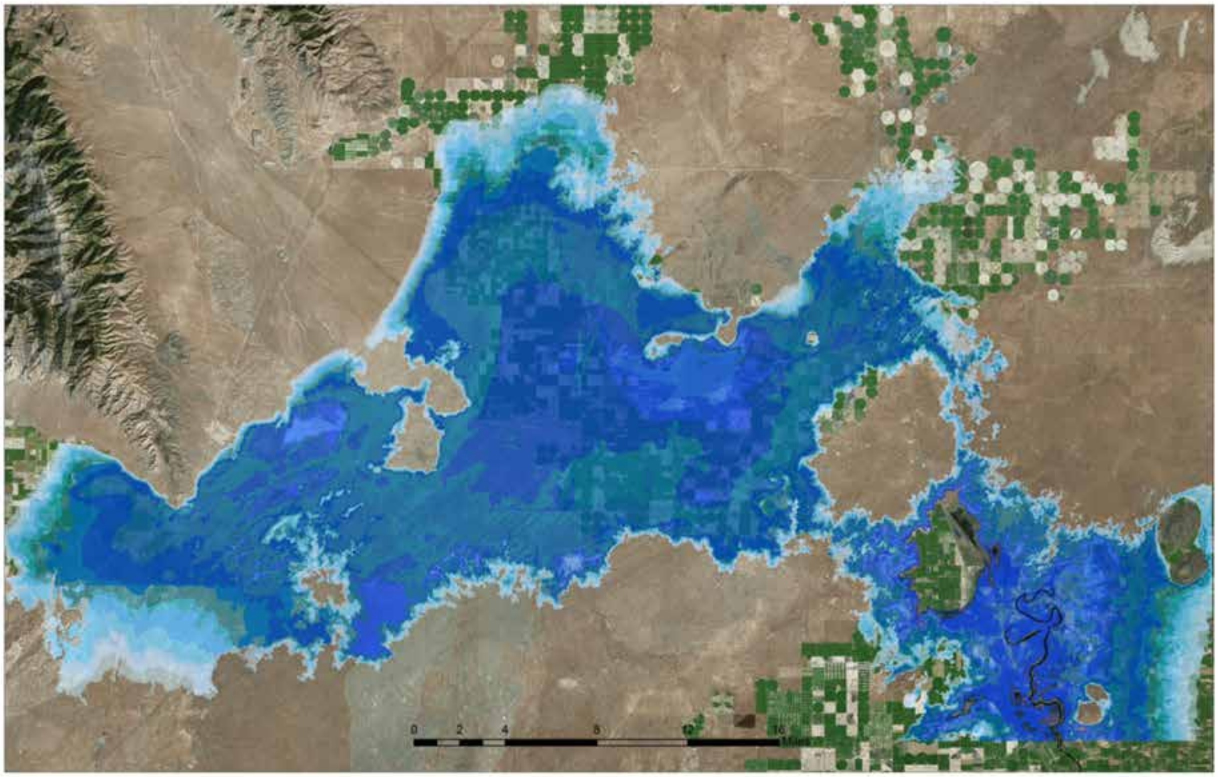

Figure B-2. Model of what Pleistocene Lake Terreton Might have Looked Like on the Snake River Plain 11,000 Years Ago.

- ***Type 1:*** no visible changes to a cultural resource (are noted) and/or a project is operating within the limits of cultural resource clearance recommendations
- ***Type 2:*** impacts are noted but do not threaten the integrity and National Register eligibility of a cultural resource and/or a project is operating outside of culturally cleared limitations
- ***Type 3:*** impacts are noted that threaten the integrity and National Register eligibility of a cultural resource and/or a project has been operating outside of culturally cleared limitations and impacts to cultural resources have occurred
- ***Type 4:*** impacts that threaten the integrity and National Register eligibility of a cultural resource are occurring during the monitoring visit, justifying the use of the INL Stop Work Authority.

If Type 2, 3, or 4 impacts are documented during monitoring, notifications are made to project managers, the DOE-ID Cultural Resources Coordinator, and other various parties, as appropriate and according to the nature and severity of the disturbance. Typically, Type 2 impacts can be corrected by CRMO personnel or with the cooperation of INL Site project managers, security personnel, and/or landlord organizations. In these instances, the impacts are only reported in summary fashion in year-end reports. Some Type 2 and all Type 3 or 4 impacts prompt formal investigations initiated by the CRMO. INL Site project managers, security, and/or landlord organizations, DOE-ID, and representatives from the Shoshone-Bannock Heritage Tribal Office (HeTO) may also participate in these investigations.

The INL Cultural Resource Monitoring Plan is contained in Appendix L of the *INL Cultural Resource Management Plan* (DOE-ID 2016). The monitoring plan describes the impact types, purpose of monitoring, process of selecting resources to be monitored each year, and how impacts will be documented.

In 2016, overall monitoring included surveillance of the following 23 individual cultural resource localities:

- Two locations with Native American human remains (one is a cave)
- Seven additional caves (one is listed on the National Register)
- Six prehistoric archaeological sites
- Four historic archaeological sites (two homesteads and two stage stations)
- Goodale's Cutoff, a historic trail and spur of the Oregon Trail
- Experimental Breeder Reactor-I, which is a National Historic Landmark
- CF-633 and related objects and structures
- Objects of significance to INL's Site's nuclear history (Aircraft Nuclear Propulsion program) on display at the Experimental Breeder Reactor-I public Visitors Center.

Several INL Site work processes and projects were also monitored in 2016 to confirm compliance with original CRMO recommendations and assess the effects of ongoing work. On one occasion, ground disturbing activities within the boundaries of the Power Burst Facility/ Critical Infrastructure Test Range Complex were observed by CRMO staff prepared to respond to any additional finds of Native American human remains. Additionally, the CRMO was notified during two trespass investigations conducted by INL Site security. Representatives from INL Site projects, DOE-ID, the Idaho SHPO, and the Shoshone-Bannock Tribe's HeTO participated in several of the trips in 2016.

Most of the cultural resources monitored in 2016, exhibited no adverse impacts, resulting in Type 1 impact assessments. However, Type 2 impacts were noted five times. Three previously reported Type 2 impacts were once again documented at the Experimental Breeder Reactor-I National Historic Landmark, including spalling and deterioration of bricks due to inadequate drainage, minimal maintenance, and rodent infestation. The Aircraft Nuclear Propulsion engines and locomotive on display at the Experimental Breeder Reactor-I Visitors Center also exhibited impacts related to long-term exposure. Finally, most of the Arco Naval Proving Grounds properties monitored at Central Facilities Area exhibited problems with lack of timely and appropriate maintenance as well as inadequate drainage. The CRMO is working with historic property landlords to attenuate these impacts. No new Type 3 or Type 4 impacts that adversely affected significant cultural resources and threatened National Register eligibility were documented in 2016.

Efforts to improve protection of archaeological sites at the INL Site are ongoing. An active security force monitors INL Site lands through ground patrols and security surveillance of public points of access. Trespassers are removed immediately upon detection and when appropriate, they have been prosecuted. Yearly on-line training modules remind INL Site employees of prohibitions on disturbing archaeological sites and targeted training is also conducted by CRMO program staff for INL Site employees likely to encounter archaeological sites in their work. In spite of active INL Site security oversight and comprehensive employee training, unauthorized visitation to sensitive cultural resources and some unauthorized removal of artifacts has been documented at the INL Site. The CRMO program has enlisted the help of DOE-ID Physical Security officers and United States federal agents experienced in enforcing the Archaeological Resource Protection Act to address these issues. In 2016, evidence of unauthorized artifact collection/trespassing occurred north of the Twin Buttes where the trespasser surrendered an artifact to security officers and locational information was obtained. The CRMO will return the artifact to its original location in 2017. Results of all monitoring and formal impact investigations are summarized annually in a year-end report to DOE-ID that is completed each year at the end of October. For 2016, the following report was prepared:

- INL/EXT-16-40545: *Idaho National Laboratory Cultural Resource Monitoring Report for Fiscal Year 2016.*

This report is available through the DOE-ID Cultural Resource Coordinator or the INL Site CRMO. Reports containing restricted data on site locations are not available to the public.

B.4 Stakeholder, Tribal, Public, and Professional Outreach

Outreach and education are important elements in the INL CRMO program and efforts are routinely oriented toward the general public, employees, and stakeholders such as the Idaho SHPO, Shoshone-Bannock Tribes, and cultural resource professionals. Tools that facilitate communication include activity reports, presentations, newspaper articles and interviews, periodic tours, regular meetings with Tribal representatives, and various INL Site-specific internal and external media outlets. Educational exhibits at the Experimental Breeder Reactor-I Visitor's Center (a National Historic Landmark) and the Big Lost River Rest Area on U.S. Highway 20/26 are also important public outreach tools.

In 2016, CRMO staff members spoke on a wide variety of general topics, including regional prehistory and history, World War II, nuclear history, historic preservation, careers, cultural resource management, archaeological resource protection, and Native American resources and sensitivities. Audiences ranged from the general public, students, and INL Site employees to civic groups, and cultural resource management professionals. Archaeological awareness and protection training is also routinely conducted on an as needed basis to various project personnel. The INL Site is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-Bannock Tribes have a government-to-government relationship with DOE-ID that is strengthened and maintained through an Agreement-in-Principle (AIP) between the Tribes and the DOE-ID (DOE-ID 2012). The AIP defines working relationships between the Shoshone-Bannock Tribes and DOE-ID and fosters a mutual understanding and commitment to addressing a variety of tribal concerns regarding protection of health, safety, and environment, including cultural resources of importance to the Tribes.

To aid with implementing cultural resource aspects of the AIP, a Cultural Resources Working Group comprised of representatives from the Shoshone-Bannock's HeTO, DOE-ID, and the CRMO was established in 1993. It was the first of its kind within the DOE complex and its regular Cultural Resources Working Group meetings enable issues and opportunities to be addressed in an environment of mutual respect and learning. Tribal input is sought for new and ongoing projects and a standing invitation is extended to comment on, visit, observe, and/or assist in INL Site CRMO field activities. The holistic view of cultural resources and cooperative spirit encouraged in this group foster an atmosphere of mutual respect that is conducive to open communication and effective consideration of tribal views in decisions regarding INL Site cultural resources and overall land management.

Summer internships offer a unique opportunity for students to participate in INL Site CRM research and compliance activities. In 2016, CRMO staff and a University of Idaho student collaborated to research an 11 mile section of Goodale's Cutoff, a spur or shortcut of the Oregon Trail. The Oregon Trail boasted several prominent cutoffs that strayed from the main route. Among these cutoffs, to name a few, were the Lander Road, Hudspeth's Cutoff, and the lesser known Jeffrey/Goodale Cutoff. These cutoffs were promoted as shorter and faster routes with Goodale's seeing heavy use starting in 1862 with increased Indian conflict on the main route.

Goodale's Cutoff (Figure B-3), which was initially called Jeffrey's Road, was promoted as early as 1852 by

John J. Jeffrey as a means of drawing business to his ferry across the Snake River and served as a guide for many pioneers travelling to Oregon. From 1852 to 1854, this cutoff saw limited traffic as the main route of the Oregon Trail was still vastly preferred over the cutoff (Dykes 1993). The earliest account of traffic on Jeffrey's Cutoff was recorded by Winfield Scott Ebey in 1854 (Doyle 1997). After the train voted to take the cutoff, they set out from Fort Hall towards the Big Southern Butte on August 3, 1854. Ebey's trail diary provides one of the most detailed accounts of the Cutoff, however, several other journals and diaries exist that help shed light on the emigrant experience along the Cutoff.

The central Idaho gold rush that occurred in the early 1860s, and increased fear of altercations with Native Americans prompted a resurgence of traffic through the Snake River Plains by way of Jeffrey's Cutoff. Tim Goodale, a scout and guide familiar with the region, set off with a large train of emigrants across the Cutoff in 1862. The Goodale Train—made up of 1,195 emigrants and 38 wagons; 795 men, 300 women and children (ISHS Ref. #51)—crossed Jeffrey's Road at the end of July in 1862. This train gained notoriety and the Cutoff was soon called Goodale's Cutoff (Dykes 1993).

From journals, we know that two prominent features along the route included Big Southern Butte and the Big Lost River. The collection of emigrant diaries ranging from 1854 to 1866 all tell the same story of leaving the Fort Hall area and crossing over 30 miles of desert without water, with the idea that water could be found at a spring on the northwestern flank of the Big Southern Butte. It was reported that water could be located halfway up the Butte, but only enough to slake the thirst of the weary travelers. However, the meager spring on the side of the Butte was only a trickle and there was never enough water for horses, oxen, and other livestock. The exhausted emigrants were only allowed a short rest before traveling almost 10 miles to the banks of the Big Lost River in order to water their weakened weary animals.

In July 1862, 12-year-old Nellie Slater, traveling from the Big Butte to the Big Lost River wrote:

Figure B-3. Discrete Wagon Ruts from Goodale's Cutoff on the INL Site.

> *"The place we are now at is at the foot of one of the Butte Mountains. . . . Father is very sick with the Flux. He has been sick for nearly two weeks but never thought he was so bad and is now almost speechless. He cannot help himself . . . came ten miles further to Lost Creek. It is a beautiful stream and runs smooth and swift. The country around is very rocky and broken with high mountains.*
>
> *July 26th – This morning at half past three o'clock Father breathed his last on earth. He was taken very bad in the night while crossing the desert, and kept getting worse until he died. . . . We buried him half a mile south of the creek, and four rods west of the road, beneath [an] Indian canopy.*"

Using Nellie Slater's description of the landscape and conducting pedestrian surveys, a few potential grave site locations were located. With the assistance of Anne Christensen and licensed cadaver dogs Rocco and Tessa, two graves were confirmed in the general vicinity and description based on the Slater Journal (Figure B-4). CRMO staff is planning on continuing research on Goodale's using historic journals and cadaver dogs to gain a better understanding of this significant historic resource.

Figure B-4. Very Discrete Rock Feature Located by Cadaver Dogs at a Gravesite.

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Appendix C. Chapter 5 Addendum

Table C-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Permit-Required Monitoring Results (2016).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.94	7.87	7.27
Conductivity (µS/cm)	380	1,453	475
Aluminum, filtered (mg/L)	0.015 U[b]	0.065	0.015 U
Chloride (mg/L)	9.56	42.1	9.89
Chromium, filtered (mg/L)	0.00273	0.0149	0.0040
Chromium, total (mg/L)	0.00307	0.0144	0.0041
Iron, filtered (mg/L)	0.033 U	0.269	0.0409
Manganese, filtered (mg/L)	0.001 U	0.00235	0.001 U
Nitrate + Nitrite as Nitrogen (mg/L)	0.877	3.91	0.96
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	-0.0693	0.772	0.0077
Nitrogen, Total (mg/L)[c]	0.877	4.682	0.96
Solids, Total Dissolved (mg/L)	189	1,300	253
Sulfate (mg/L)	20.1	628	28.1

a. Duplicate samples were collected in July and the results for the duplicate samples are included in the summary.

b. U qualifier indicates the result was below the detection limit.

c. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen. For results reported below the laboratory instrument detection limit and with a negative value, the sample results are considered zero when used in the calculation.

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2016).

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard PCS/SCS[a]
Sample Date:	***05/10/16***	***09/19/16***	***05/11/16***	***09/21/16***	***05/11/16***	***09/20/16***	***05/10/16***	***09/20/16***	***05/10/16***	***09/19/16***	
Water table depth (ft below ground surface)	429.70	430.43	476.62	477.66	485.04	485.98	490.24	491.19	494.56	495.49	NA[b]
Water table elevation (above mean sea level in ft)[c]	4,459.69	4,458.96	4,451.90	4,450.86	4,448.17	4,447.23	4,448.82	4,447.87	4,448.31	4,447.38	NA
Borehole correction factor (ft)[d]	2.53	2.53	NA	NA	NA	NA	0.63	0.63	NA	NA	NA
pH	7.84	7.31	7.94	7.47	7.98	7.79	7.86	7.77	7.90	7.84	6.5 to 8.5 (SCS)
Electrical Conductivity (µS/cm)	409	371	600	605	466	433	418	418	432	413	NA
Nitrite +Nitrite as Nitrogen (mg/L)	1.09 [1.09][e]	1.1	1.77	1.45	1.09	1.02	1.07	0.975	1.05	1.01	NA
Total Kjeldahl nitrogen (mg/L)	-0.0305 U[f] [-0.0434 U]	-0.0944 UJ[g]	0.00679 U	0.0361 J[h]	-0.0291 U	0.0387 J	-0.0577 U	-0.0775 UJ	-0.0168 U	-0.0848 UJ	NA
Total nitrogen[i] (mg/L)	1.09 [1.09]	1.1	<1.777	1.4861	1.09	1.0587	1.07	0.975	1.05	1.01	NA
Total dissolved solids (mg/L)	207 [200]	230	323	407	194	240	217	259	220	237	500 (SCS)
Aluminum (mg/L)	0.015 U [0.015 U]	0.015 U	0.015 U	0.015 U	0.015 U	0.015 U	0.0205	0.0425	0.015 U	0.015 U	0.2 (SCS)
Chloride (mg/L)	13.3 [13.3]	14 J	17	17.7 J	11.8	11.9 J	10.4	10.7 J	10.3	10.5 J	250 (SCS)
Chromium (mg/L) total	0.00566 [0.006]	0.00688	0.0747	0.082	0.011	0.0114	0.0285	0.0683	0.00923	0.0102	NA

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2016). (cont.)

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard PCS/SCS[a]
Sample Date:	***05/10/16***	***09/19/16***	***05/11/16***	***09/21/16***	***05/11/16***	***09/20/16***	***05/10/16***	***09/20/16***	***05/10/16***	***09/19/16***	
Iron filtered(mg/L)	0.030 U [0.030 U]	0.030 UJ	0.030 U	0.030 UJ	0.030 U	0.030 UJ	0.030 U	0.03 UJ	0.030 U	0.030 UJ	0.3 (SCS)
Manganese (mg/L) filtered	0.001 U [0.001 U]	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001U	0.00155	0.00267	0.05 (SCS)
Sulfate (mg/L)	21.3 [21.5]	21.7 J	146	150 J	34.3	34.5 J	46.5	45.5 J	35.4	35.4	250 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the State of Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b. In accordance with Reuse Permit I-161-02, Section 5.2.2, footnote a., compliance with the PCS for chromium, under the Reuse Permit, shall not apply.

b. NA = Not applicable

c. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

d. The United States Geological Survey performed gyroscopic surveys on wells TRA-08 and USGS-098 circa 2002 to 2005. The surveys revealed these two wells were not perfectly straight or vertical which can cause the water level measurements to be greater than the true distance from the measuring point on the well to the water table. The water table elevations for these two wells have been adjusted using the borehole correction factors that were determined from the gyroscopic surveys.

e. Results shown in brackets are the results from field duplicate samples.

f. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

g. UJ flag indicates the sample was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

h. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

i. Total nitrogen is calculated as the sum of the total Kjeldahl nitrogen (TKN) and nitrite nitrogen plus nitrate as nitrogen. For results reported as a negative value, results were assumed to be zero in the total calculation. For positive results reported below the instrument detection limit, the detection limit for that parameter is used in the calculation. The resulting total nitrogen is then reported as a less than (<) number.

Table C-2a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2016).

Well Name	USGS-058 (GW-016107)		Standard (PCS/SCS)[a]
Sample Date:	***05/11/16***	***09/21/16***	
Water table depth (ft below land surface)	472.98	473.90	NA[b]
Water table elevation (ft above mean sea level)[c]	4,448.91	4,447.99	NA
Borehole correction factor (ft)	NA	NA	NA
pH	7.94	7.38	6.5 to 8.5 (SCS)
Electrical Conductivity (µS/cm)	469	431	NA
Total dissolved solids (mg/L)	216	239	500 (SCS)
Sulfate (mg/L)	35.9	33.1 J[d]	250 (SCS)

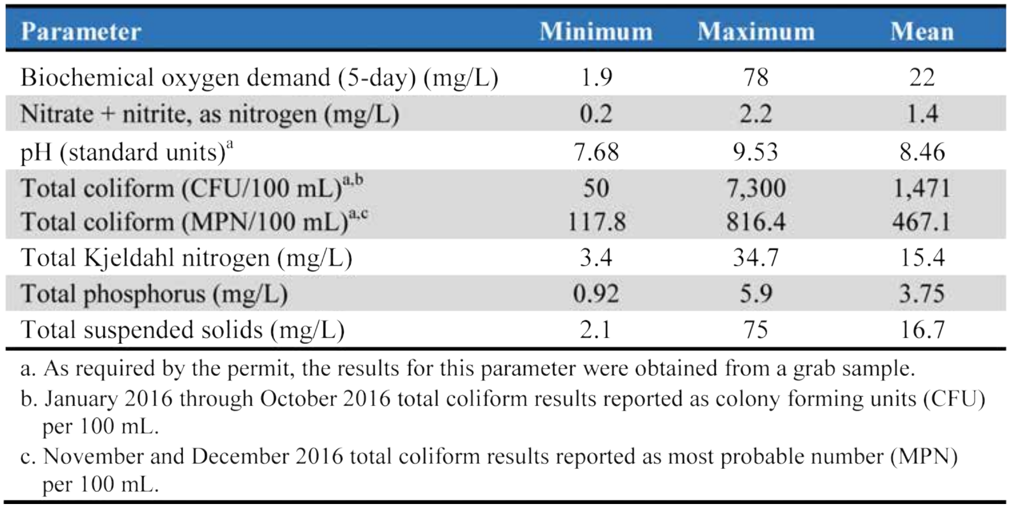
a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the State of Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.
b. NA = Not applicable
c. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).
d. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table C-3. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2016).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	89.6	313	178
Nitrate + nitrite, as nitrogen (mg/L)	-0.0372 U[a]	0.108	0.0342
Total Kjeldahl nitrogen (mg/L)	32.2	125	72.6
Total phosphorus (mg/L)	4.37	10.6	6.87
Total suspended solids (mg/L)	16.8	268	120

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table C-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2016).



Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	1.9	78	22
Nitrate + nitrite, as nitrogen (mg/L)	0.2	2.2	1.4
pH (standard units)[a]	7.68	9.53	8.46
Total coliform (CFU/100 mL)[a,b]	50	7,300	1,471
Total coliform (MPN/100 mL)[a,c]	117.8	816.4	467.1
Total Kjeldahl nitrogen (mg/L)	3.4	34.7	15.4
Total phosphorus (mg/L)	0.92	5.9	3.75
Total suspended solids (mg/L)	2.1	75	16.7

a. As required by the permit, the results for this parameter were obtained from a grab sample.

b. January 2016 through October 2016 total coliform results reported as colony forming units (CFU) per 100 mL.

c. November and December 2016 total coliform results reported as most probable number (MPN) per 100 mL.

Table C-5. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2016).

Parameter	Minimum	Maximum	Mean
Aluminum (mg/L)	0.068 U[a]	0.068 U	0.068 U
Arsenic (mg/L)	0.005 U	0.0103	0.0059
Biochemical oxygen demand (5-day) (mg/L)	1.01 U	23.2	6.07
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	12.9	133	24.6
Chromium (mg/L)	0.0055	0.0067	0.0060
Conductivity (µS/cm)	371	516	402
Copper (mg/L)	0.003 U	0.0144	0.0071
Fluoride (mg/L)	0.147	0.290	0.209
Iron (mg/L)	0.03 U	0.047	0.032
Manganese (mg/L)	0.002 U	0.002 U	0.002 U
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U
Nitrate + nitrite, as nitrogen (mg/L)	0.67	1.68	1.01
pH (standard units)[b]	6.38	8.76	8.01
Selenium (mg/L)	0.0015 U	0.002 U	0.0017 U
Silver (mg/L)	0.001 U	0.001 U	0.001 U
Sodium (mg/L)	9.5	67.9	16
Total coliform (CFU/100 mL)[b,c]	7	103	60
Total coliform (MPN/100 mL)[b,d]	21.8	686.7	354.6
Total dissolved solids (mg/L)	181	441	243
Total Kjeldahl nitrogen (mg/L)	-0.078 U	0.807	0.255
Total phosphorus (mg/L)	0.477	1.02	0.756
Total suspended solids (mg/L)	0 U	1.9	0.8

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

b. As required by the permit, the results for this parameter were obtained from a grab sample.

c. January 2016 through October 2016 total coliform results reported as colony forming units (CFU) per 100 mL.

d. November and December 2016 total coliform results reported as most probable number (MPN) per 100 mL.

Table C-6. Hydraulic Loading Rates for the INTEC New Percolation Ponds.

	Maximum Daily Flow	Yearly Total Flow
2016 Flow	977,400 gallons	188 MG[a]
Permit Limit	3,000,000 gallons	1,095 MG

a. MG = million gallons

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2016).

Parameter	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		Standard PCS/SCS[a]
Sample Date:	*4/6/2016*	*9/13/2016*	*4/6/2016*	*9/13/2016*	*4/5/2016*	*9/13/2016*	
Water table depth (ft below land surface)	504.92	504.92	512.12	513.12	503.92	504.99	NA[b]
Water table elevation (ft above mean sea level)[c]	4,447.99	4,447.99	4,447.42	4,446.42	4,448.25	4,447.18	NA
Aluminum (mg/L)[d]	0.068 U[e]	0.137	0.068 U	0.068 U	0.068 U	0.068 U	0.2 (SCS)
Arsenic (mg/L)	0.0017 U	0.0017 U	0.0017 U	0.0019	0.00881	0.0017 U	0.05 (PCS)
Biochemical oxygen demand (mg/L)	3.12	1.48[f]	2.93	1.15[f]	1.29	5.45[f]	NA
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005 (PCS)
Chloride (mg/L)	35.8	36.6	10.5	10.9	9.83	10.5	250 (SCS)
Chromium (mg/L)	0.00817	0.00884	0.00469	0.006	0.00636	0.0125	0.1 (PCS)
Coliform, fecal (MPN[g]/100 mL)	<1[h]	<1	<1[h]	<1	<1[h]	<1	<1 CFU[i]/100 ml (PCS)
Coliform, total (MPN/100 mL)	<1[h]	<1	<1[h]	<1	<1[h]	<1	1 CFU/100 ml (PCS)[j]
Copper (mg/L)	0.003 U	0.00728	0.003 U	0.00501	0.00382	0.00832	1.3 (PCS)
Fluoride (mg/L)	0.166	0.189	0.233	0.249	0.183	0.159	4 (PCS)
Iron (mg/L)[d]	0.030 U	0.030 U	0.046	0.0461	0.030 U	0.030 U	0.3 (SCS)
Manganese (mg/L)[d]	0.002 U	0.002 U	0.0101	0.00996	0.002 U	0.002 U	0.05 (SCS)
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.002 (PCS)
Nitrate, as nitrogen (mg/L)	1.22	1.04[f]	0.273	0.282[f]	1.04	0.912[f]	10 (PCS)
Nitrite, as nitrogen (mg/L)	0.161 U	0 U[f]	0.0333 U	0 U[f]	0 U	0 U[f]	1 (PCS)
pH (standard units)	8.02	7.78	7.99	7.73	7.90	7.69	6.5–8.5 (SCS)
Selenium (mg/L)	0.0015 U	0.002 U	0.0015 U	0.002 U	0.0015 U	0.002 U	0.05 (PCS)
Silver (mg/L)[d]	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.1 (SCS)

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2016). (cont.)

Parameter	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		Standard PCS/SCS[a]
Sample Date:	*4/6/2016*	*9/13/2016*	*4/6/2016*	*9/13/2016*	*4/5/2016*	*9/13/2016*	
Sodium (mg/L)	15.9	16.2	9.2	9.75	17.7	10.4	NA
Total dissolved solids (mg/L)	281	274	201	183	199	263	500 (SCS)
Total Kjeldahl nitrogen (mg/L)	0.0149 U	0.0943[k]	0.00128 U	0.128[k]	0.0631 U	-0.0413 U[k]	NA
Total phosphorus (mg/L)	0.0168 U	0.00209 U[k]	0.0303	0.0042 U[k]	0.0125 U	0.0235[k]	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.

b. NA = Not Applicable

c. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

d. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.

e. U flag indicates the result was reported as below the detection/reporting limit.

f. Biochemical oxygen demand, nitrate, and nitrite samples were collected on September 28, 2016, due to missed 48-hour hold time.

g. MPN = Most Probable Number

h. Total and fecal coliform samples were collected on May 18, 2016, due to laboratory subcontract issues.

i. CFU = Colony Forming Unit

j. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.

k. Total Kjeldahl nitrogen and total phosphorus samples were collected on September 28, 2016, due to temperature preservation issues.

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2016).

Parameter	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		Standard PCS/SCS[a]
Sample date:	*4/6/2016*	*9/15/2016*	*4/5/2016*	*9/14/2016*	*4/6/2016*	*9/14/2016*	
Depth to Water (ft below land surface)	Dry[b]	Dry[b]	111.15	119.78	236.32	236.54	NA[c]
Water table elevation (ft above mean sea level)[d]			4,841.82	4,836.67	4,722.02	4,721.80	NA
Aluminum (mg/L)[e]			0.068 U[f]	0.144 U	0.068 U	0.123 U	0.2 (SCS)
Arsenic (mg/L)			0.0017 U	0.00718	0.00237	0.00235	0.05 (PCS)
Biochemical oxygen demand (mg/L)			1.34	3.33 U	2.76	5.68	NA
Cadmium (mg/L)			0.001 U	0.001 U	0.001 U	0.001 U	0.005 (PCS)
Chloride (mg/L)			19.2	19.7	33	34.4	250 (SCS)
Chromium (mg/L)			0.0126	0.00716	0.00832	0.00101	0.1 (PCS)
Coliform, fecal (MPN[g]/100 mL)			< 1[h]	< 1	< 1[h]	< 1	< 1 CFU[i]/100 mL (PCS)
Coliform, total (MPN/100 mL)			< 1[h]	1	1[h]	6.3	1 CFU/100 mL (PCS)[j]
Copper (mg/L)			0.003 U	0.00586	0.003 U	0.00573	1.3 (PCS)
Fluoride (mg/L)			0.24	0.214	0.242	0.261	4 (PCS)
Iron (mg/L)[e]			0.030 U	0.030 U	0.030 U	0.0645	0.3 (SCS)
Manganese (mg/L)[e]			0.00414	0.002 U	0.0024	0.00264	0.05 (SCS)
Mercury (mg/L)			0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.002 (PCS)
Nitrate, as nitrogen (mg/L)			1.44	1.08	1.63	1.37	10 (PCS)
Nitrite, as nitrogen (mg/L)			0 U	0 U	0.189 U	0 U	1 (PCS)
pH (standard units)			7.48	7.43	7.84	7.64	6.5–8.5 (SCS)
Selenium (mg/L)			0.0015 U	0.002 U	0.0015 U	0.002 U	0.05 (PCS)

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2016). (cont.)

Parameter	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		Standard PCS/SCS[a]
Sample date:	*4/6/2016*	*9/15/2016*	*4/5/2016*	*9/14/2016*	*4/6/2016*	*9/14/2016*	
Silver (mg/L)[e]			0.001 U	0.001 U	0.001 U	0.001 U	0.1 (SCS)
Sodium (mg/L)			10.3	18.5	36.5	34.4	NA
Total dissolved solids (mg/L)			231	237	271	273	500 (SCS)
Total Kjeldahl nitrogen (mg/L)			0.0657 U	0.242	0.055 U	0.200	NA
Total phosphorus (mg/L)			0.218	0.18	0.0994	0.0748	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.

b. ICPP-MON-V-191 was dry in April and September 2016.

c. NA = not applicable

d. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

e. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.

f. U flag indicates the result was reported as below the detection/reporting limit.

g. MPN = Most Probable Number

h Total and fecal coliform samples were collected on May 18, 2016, due to laboratory subcontract issues.

i. CFU = Colony Forming Units

j. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.

Table C-9. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results in Discharges to the MFC Industrial Waste Pond (2016).[a]

Parameter	Minimum	Maximum	Median	Permit Level
Industrial Waste Water Underground Pipe				
Total nitrogen[b] (mg/L)	5.05	8.68	6.55	20
Total suspended solids (mg/L)	<0.8 U[c]	7.4	<1.0	100
Industrial Waste Pipeline				
Total nitrogen[b] (mg/L)	1.93	3.20	2.53	20
Total suspended solids (mg/L)	-0.3	3.6	<1.0	100

a. Duplicate samples were collected in September, and the results for the duplicate samples are included in the data summary.

b. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

c. U flag indicates the result was below detection limit.

Table C-10. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2016).[a]

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0017 U[b]	0.00275	0.0021
Barium (mg/L)	0.0357	0.0416	0.0374
Cadmium (mg/L)	0.00011 U	0.0003 U	0.0011 U
Chloride (mg/L)	17.9	139	68.3
Chromium (mg/L)	0.002 U	0.003 U	0.002 U
Fluoride (mg/L)	0.541	0.753	0.645
Iron[c] (mg/L)	0.033	0.266	0.119
Lead (mg/L)	0.0005 U	0.00139	0.0005 U
Manganese (mg/L)	0.001 U	0.00449	0.00247
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U
Nitrate + Nitrite as Nitrogen (mg-N/L)	1.93	2.94	2.42
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	-0.0197 U	0.263	0.114
Nitrogen, Total[d] (mg/L)	1.93	3.20	2.53
pH (standard units)	7.16	8.93	7.95
Phosphorus, Total (mg/L)	0.102 U	0.797	0.291
Selenium (mg/L)	0.0015 U	0.002 U	0.002 U
Silver (mg/L)	0.0001 U	0.00132	0.0004 U
Sodium (mg/L)	19.7	98.6	51.6
Sulfate (mg/L)	17.9	24.9	19.1
Solids, Total Dissolved (mg/L)	181	469	341
Solids, Total Suspended (mg/L)	-0.3	3.6	1.0 U
Zinc (mg/L)	0.0106	0.0358	0.019

a. Duplicate samples were collected in September and the results for the duplicate samples are included in the data summary.

b. U qualifier indicates the result was below the detection limit.

c. Permit-required analyte for groundwater monitoring but not for effluent monitoring.

d. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen. For results reported below the laboratory instrument detection limit and with a negative value, the sample results are considered zero when used in the calculation.

Table C-11. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2016).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.00397	0.00612	0.004855
Barium (mg/L)	0.0733	0.0993	0.0879
Cadmium (mg/L)	0.00011 U[a]	0.0003 U	0.000209 U
Chloride (mg/L)	42.6	67.0	45.3
Chromium (mg/L)	0.00505	0.00641	0.00549
Fluoride (mg/L)	1.07	1.72	1.40
Iron[b] (mg/L)	0.0463	1.24	0.218
Lead (mg/L)	0.0005 U	0.000376	0.0009
Manganese[b] (mg/L)	0.00355	0.00863	0.00451 U
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U
Nitrate + Nitrite as Nitrogen (mg/L)	4.22	7.68	5.68
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.833	1.00	0.877
Nitrogen, Total[c] (mg/L)	5.05	8.68	6.55
pH (standard units)	7.42	8.38	8.18
Phosphorus, total	0.739	2.97	2.07
Selenium (mg/L)	0.0015	0.00216	0.00175
Silver (mg/L)	0.0002 U	0.0004 U	0.0002 U
Sodium[b] (mg/L)	43.6	75.2	53.6
Sulfate (mg/L)	29.5	59.0	43.25
Solids, Total Dissolved (mg/L)	546	687	572
Solids, Total Suspended	0.8 U	7.4	1.0
Zinc (mg/L)	0.00811	0.364	0.0242

a. U qualifier indicates the result was below the detection limit.

b. Permit-required analyte for groundwater monitoring but not for effluent monitoring.

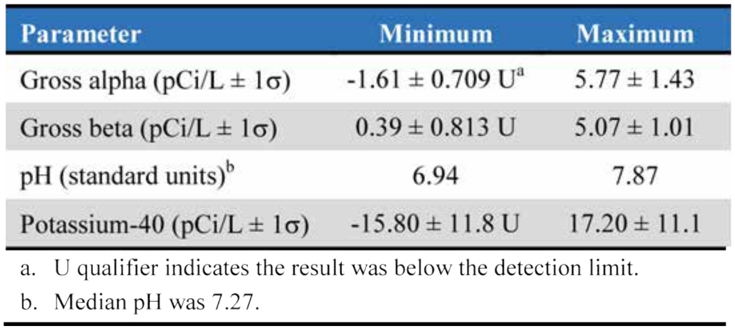
c. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

Table C-12. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2016).

Well Name	**ANL-MON-A-012 (GW-016001)**		**ANL-MON-A-013 (GW-016002)**		**ANL-MON-A-014 (GW-016003)**		
Sample Date:	***05/02/2016***	***09/12/2016***	***05/03/2016***	***09/13/2016***	***05/03/2016***	***09/13/2016***	**PCS/SCS[a]**
Water table depth (ft below land surface)	659.63	662.24	648.10	650.50	647.22	649.68	NA[b]
Water table elevation (ft above mean sea level)[c]	4,473.07	4,470.46	4,472.27	4,469.87	4,470.86	4,468.40	NA
pH (standard units)	8.14	7.40	7.92	7.34	7.87	7.43	6.5 to 8.5 (SCS)
Temperature (°C)	14.8	12.5	14.5	12.6	14.9	12.6	None
Electrical Conductivity (µS/cm)[d]	354	380	395	390	381	377	None
Nitrate as nitrogen (mg/L)	2.05	2.04	2.07	2.07	2.17	2.11	10 (PCS)
Phosphorus (mg/L)	0.0222 J[e]	0.0395 J	0.0325 J	0.0523	0.02 J	0.0559	None
Total dissolved solids (mg/L)	95.7 J	216	51.4 J	234	164 J	217	500 (SCS)
Sulfate (mg/L)	17.3	17.8 J	19.4	18.8 J	19.5	18.7 J	250 (SCS)
Arsenic (µg/L)	1.7 U[f]	1.71	1.7 U	1.98	1.71	1.86	50 (PCS)
Barium (µg/L)	38.9	39	37	35.5	36.2	34.8	2,000 (PCS)
Cadmium (µg/L)	0.11 U	0.3 U	0.11 U	0.3 U	0.11 U	0.3 U	5 (PCS)
Chloride (mg/L)	16.3 J	16.8 J	16.7 J	17.9 J	16.6 J	17.4 J	250 (SCS)
Chromium (µg/L)	2 U	3 U	2.63	3 U	2.59	3U	100 (PCS)
Iron (µg/L)	58.2	30 J	153	188 J	30 U	30 J	300 (SCS)
Lead (µg/L)	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	15 (PCS)
Manganese (µg/L)	2.73	1 U	31.7	4.12	1 U	1 U	50 (SCS)
Mercury (µg/L)	0.067 U	0.067 U	0.067 U	0.067 U	0.067 U	0.067 U	2 (PCS)
Selenium (µg/L)	1.5 U	2 U	1.5 U	2 U	1.5 U	2 U	50 (PCS)
Silver (µg/L)	0.2 U	0.4 U	0.2 U	0.4 U	0.2 U	0.4 U	100 (SCS)
Sodium (µg/L)	18,000	17,000	18,800	17,000	19,100	17,300	None
Zinc (µg/L)	10.2	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	5,000 (SCS)

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) from IDAPA 58.01.11 (Ground Water Quality Rule).
b. NA = Not applicable
c. Elevations are given in the National Geodetic Vertical Datum of 1929.
d. Conductivity (or specific conductance) is a measure of the ability to conduct electricity. One unit of measurement is Siemens (S) per m.
e. J flag indicates the associated value is an estimate and may be inaccurate or imprecise. See Section 4.4 for additional discussion.
f. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.

Table C-13. Advanced Test Reactor Complex Cold Waste Pond Surveillance Monitoring Results (2016).



Parameter	Minimum	Maximum
Gross alpha (pCi/L ± 1σ)	-1.61 ± 0.709 U[a]	5.77 ± 1.43
Gross beta (pCi/L ± 1σ)	0.39 ± 0.813 U	5.07 ± 1.01
pH (standard units)[b]	6.94	7.87
Potassium-40 (pCi/L ± 1σ)	-15.80 ± 11.8 U	17.20 ± 11.1

a. U qualifier indicates the result was below the detection limit.

b. Median pH was 7.27.

Table C-14. Radioactivity Detected in Surveillance Groundwater Samples Collected at the Advanced Test Reactor Complex (2016).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-065	05/11/16	Gross Alpha	ND[a]
		Gross Beta	4.47 (± 1.03) [b]
		Tritium	2,580 (± 299)
	09/21/16	Gross Alpha	2.83 (± 0.791)
		Gross Beta	5.33 (± 0.87)
		Tritium	2,270 (± 260)
USGS-098	05/10/16	Gross Alpha	ND ND[c]
		Gross Beta	ND 2.77 (± 0.798) [c]
		Tritium	ND ND [c]
	09/19/16	Gross Alpha	2.83 (± 0.791)
		Gross Beta	5.33 (± 0.87)
		Tritium	2,270 (± 260)
TRA-08	05/10/16	Gross Alpha	3.68 (± 1.29)
		Gross Beta	4.62 (± 1.12)
		Tritium	1,020 (± 157)
	09/20/16	Gross Alpha	ND
		Gross Beta	2.29 (± 0.697)
		Tritium	885 (± 136)
USGS-076	05/11/16	Gross Alpha	ND
		Gross Beta	ND
		Tritium	532 (± 116)
	09/20/16	Gross Alpha	ND
		Gross Beta	2.04 (± 0.494)
		Tritium	361 (± 102)
Middle-1823	05/10/16	Gross Alpha	ND
		Gross Beta	ND
		Tritium	638 (± 125)
	09/19/16	Gross Alpha	ND
		Gross Beta	2.32 (± 0.56)
		Tritium	681 (± 125)
USGS-058	05/11/16	Gross Alpha	ND
		Gross Beta	ND
		Tritium	848 (± 140)
	09/21/16	Gross Alpha	2.13 (± 0.665)
		Gross Beta	2.42 (± 0.697)
		Tritium	482 (± 108)

a. ND = Not detected

b. One sigma uncertainty shown in parentheses.

c. Analytical result from field duplicate sample collected on May 10, 2016, from well USGS-098.

Table C-15. Liquid Effluent Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2016).

Sample Date	Gamma Emitters[a] (pCi/L)	Gross Alpha[b] (pCi/L)	Gross Beta[b] (pCi/L)	Total Strontium (pCi/L)
Effluent from INTEC Sewage Treatment Plant (CPP-773)				
March 2016	ND[c]	ND	17.7 (±1.70)	ND
September 2016	ND	ND	19.5 (±0.63)	ND
Effluent to INTEC New Percolation Ponds (CPP-797)				
January 2016	ND	ND	7.04 (±1.20)	ND
February 2016	ND	ND	7.28 (±0.95)	ND
March 2016	ND	ND	6.01 (±0.64)	ND
April 2016	ND	3.62 (±1.18)	5.82 (±1.02)	ND
May 2016	ND	ND	5.67 (±0.93)	ND
June 2016	ND	4.18 (±1.23)	5.95 (±1.10)	ND
July 2016	ND	ND	4.93 (±0.79)	ND
August 2016	ND	ND	6.33 (±1.11)	ND
September 2016	ND	ND	4.03 (±0.68)	ND
October 2016	ND	ND	5.16 (±0.96)	ND
November 2016	ND	ND	9.20 (±1.07)	ND
December 2016	ND	ND	7.17 (±0.93)	ND

a. Gamma-emitting radionuclides include americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95.

b. Detected results are shown along with the reported 1-sigma uncertainty.

c. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table C-16. Groundwater Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2016).

Monitoring Well	Sample Date	Gross Alpha[a] (pCi/L)	Gross Beta[a] (pCi/L)
ICPP-MON-A-165	4/6/2016	ND[b]	4.86 (±0.59)
	9/13/2016	ND	5.92 (±0.99)
ICPP-MON-A-166	4/6/2016	ND	3.89 (±0.52)
	9/13/2016	ND	2.48 (±0.66)
ICPP-MON-V-200	4/5/2016	ND	6.24 (±0.80)
	9/14/2016	ND	3.14 (±0.82)
ICPP-MON-V-212	4/6/2016	1.95 (±0.53)	9.26 (±0.70)
	9/14/2016	ND	8.27 (±1.13)

a. Detected results are shown along with the reported 1-sigma uncertainty.

b. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table C-17. Radioactivity Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2016).[a]

Parameter[b] (pCi/L)	Minimum	Maximum
Gross alpha	0.37 ±6.78	4.11 ± 1.14
Gross beta	5.59 ± 1.25	12.5 ± 0.585
Uranium-238[c]	0.68 ± 0.13	0.68 ± 0.13
Uranium-233/234[c]	1.14 ± 0.175	1.14 ± 0.175
Potassium-40	-11.90 ± 12.4 U[d]	11.00 ± 15.2 U

a. Only parameters with at least one detected result are shown.

b. Detected results are shown along with the reported 1 σ uncertainty.

c. Parameter was analyzed in September only; therefore, the minimum and maximum are the same.

d. U qualifier indicates the result was below the detection limit.

Appendix D. Onsite Dosimeter Measurements and Locations

Location	mrem[a]	
	Nov. 2015 – April 2016	May 2016 – Oct. 2016
ARA O-1	56	73
PBF SPERT O-1	59	71

a. Ambient dose equivalent.

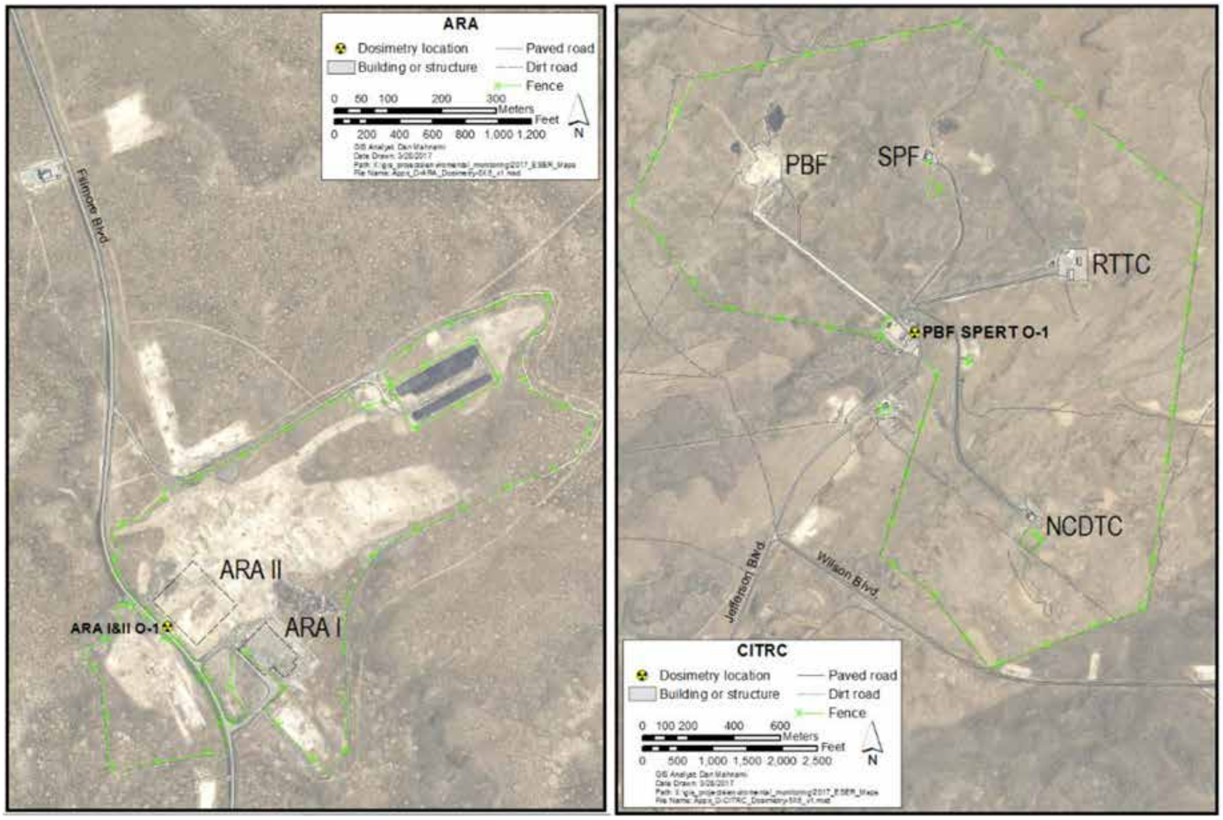


Figure D-1. Environmental Radiation Measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2016).

Location	mrem[a]		Location	mrem[a]	
	Nov. 2015 – April 2016	May 2016 – Oct. 2016		Nov. 2015– April 2016	May 2016 – Oct. 2016
RHLLW O-1	New	75	TRA O-14	60	70
RHLLW O-2	New	76	TRA O-15	64	67
RHLLW O-3	New	75	TRA O-16	65	77
RHLLW O-4	New	lost	TRA O-17	151	109
RHLLW O-5	New	70	TRA O-18	120	84
RHLLW O-6	New	77	TRA O-19	121	673
TRA O-1	60	77	TRA O-20	147	133
TRA O-6	62	72	TRA O-21	171	141
TRA O-7	67	72	TRA O-22	91	119
TRA O-8	65	79	TRA O-23	67	78
TRA O-9	71	81	TRA O-24	62	79
TRA O-10	72	96	TRA O-25	63	71
TRA O-11	78	88	TRA O-26	61	76
TRA O-12	71	81	TRA O-27	71	45
TRA O-13	65	78	TRA O-28	64	83

a. Ambient dose equivalent.

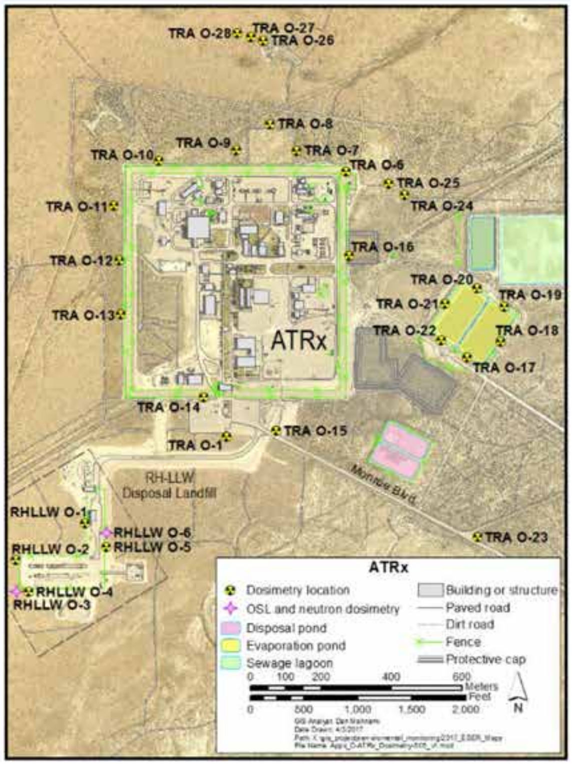


Figure D-2. Environmental Radiation Measurements at Advanced Test Reactor Complex (TRA) and Remote-Handled Low Level Waste Disposal Facility (RHLLW) (2016).

Location	mrem[a]	
	Nov. 2015 – April 2016	May 2016 – Oct. 2016
CFA O-1	64	74
LincolnBlvd O-1	64	69

a. Ambient dose equivalent.

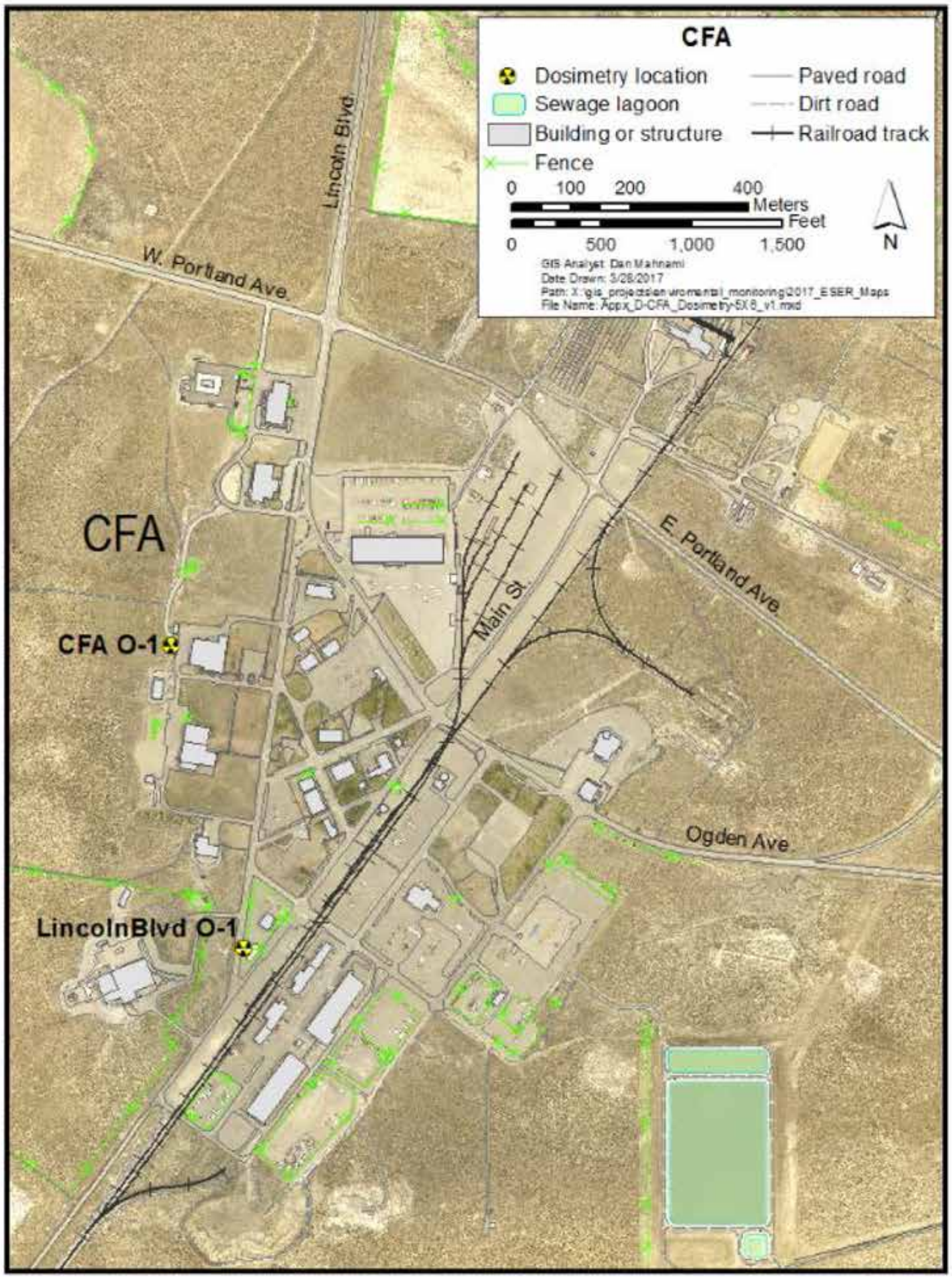


Figure D-3. Environmental Radiation Measurements at Central Facilities Area (2016).

Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016	Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016
ICPP O-9	79	88	ICPP O-26	61	71
ICPP O-14	81	89	ICPP O-27	96	111
ICPP O-15	86	104	ICPP O-28	86	102
ICPP O-17	67	73	ICPP O-30	151	139
ICPP O-19	79	76	TreeFarm O-1	98	106
ICPP O-20	214	178	TreeFarm O-2	77	88
ICPP O-21	85	81	TreeFarm O-3	82	97
ICPP O-22	83	90	TreeFarm O-4	111	122
ICPP O-25	65	76			

a. Ambient dose equivalent.

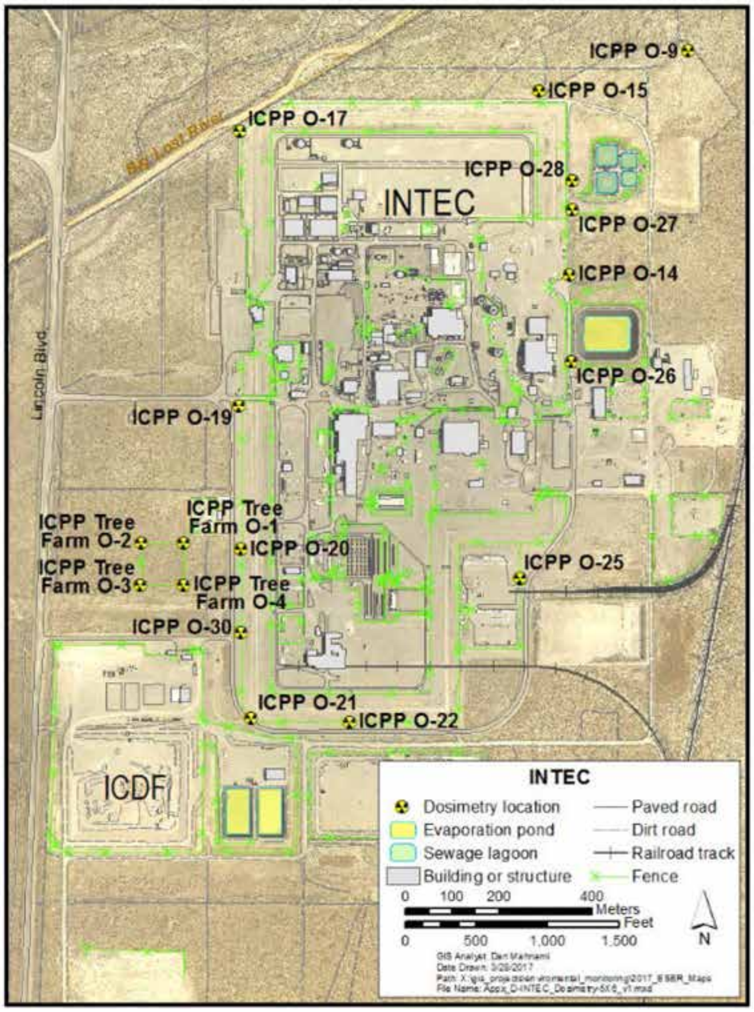


Figure D-4. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (2016).

Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016	Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016
IF-603N O-1	54	58	IF-670N O-31	51	60
IF-603E O-2	46	54	IF-670E O-32	47	54
IF-603S O-3	50	57	IF-670S O-33	56	59
IF-603W O-4	54	48	IF-670D O-34	57	60
IF-627 O-30	53	59	IF-670W O-35	62	62
IF-638N O-1	55	60	IF-689 O-7	New	46
IF-638E O-2	54	56	IF-689 O-8	New	42
IF-638S O-3	56	59	IRC O-39	55	58
IF-638W O-4	57	66			

a. Ambient dose equivalent.

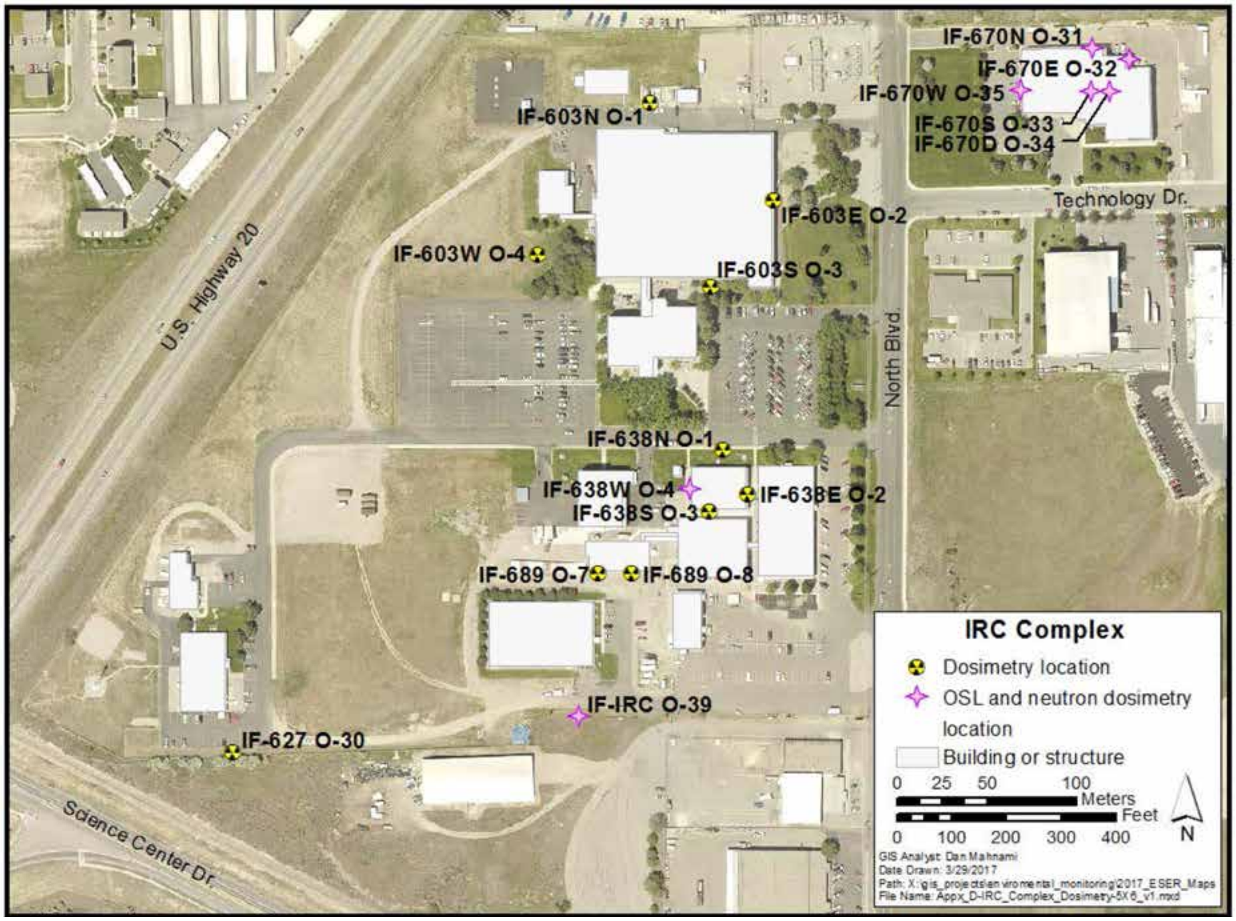


Figure D-5. Environmental Radiation Measurements at INL Research Center Complex (IRC) (2016).

	mrem[a]			mrem[a]	
Location	Nov. 2015 – April 2016	May 2016 – Oct. 2016	Location	Nov. 2015 – April 2016	May 2016 – Oct. 2016
ANL O-7	60	87	ANL O-24	58	66
ANL O-8	59	72	ANL O-25	lost	62
ANL O-12	54	65	ANL O-26	56	77
ANL O-14	60	67	TREAT O-1	69	77
ANL O-15	74	86	TREAT O-2	52	61
ANL O-16	64	77	TREAT O-3	75	lost
ANL O-18	63	72	TREAT O-4	71	75
ANL O-19	57	66	TREAT O-5	77	73
ANL O-20	74	82	TREAT O-6	75	71
ANL O-21	93	104	TREAT O-7	71	60
ANL O-22	80	88	TREAT O-8	62	71
ANL O-23	59	69			

a. Ambient dose equivalent.

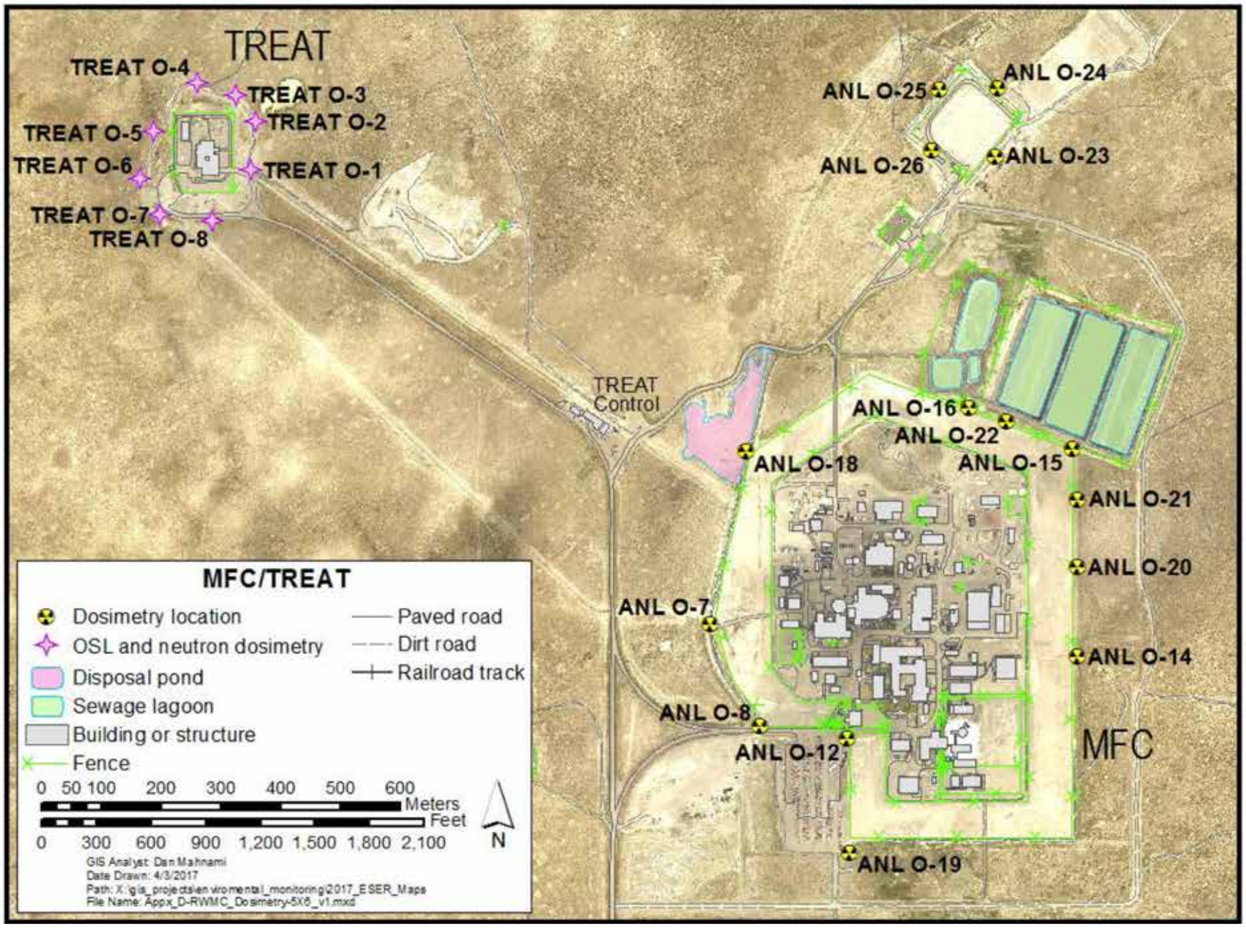


Figure D-6. Environmental Radiation Measurements at Materials and Fuels Complex (2016).

Location	Exposure[a] Nov. 2015 – April 2016	Exposure[a] May 2016 – Oct. 2016	Location	Exposure[a] Nov. 2015 – April 2016	Exposure[a] May 2016 – Oct. 2016
NRF O-4	67	76	NRF O-16	64	72
NRF O-5	71	81	NRF O-18	64	74
NRF O-11	67	74	NRF O-19	65	71
NRF O-12	67	68	NRF O-20	66	72
NRF O-13	61	81			

a. Ambient dose equivalent.

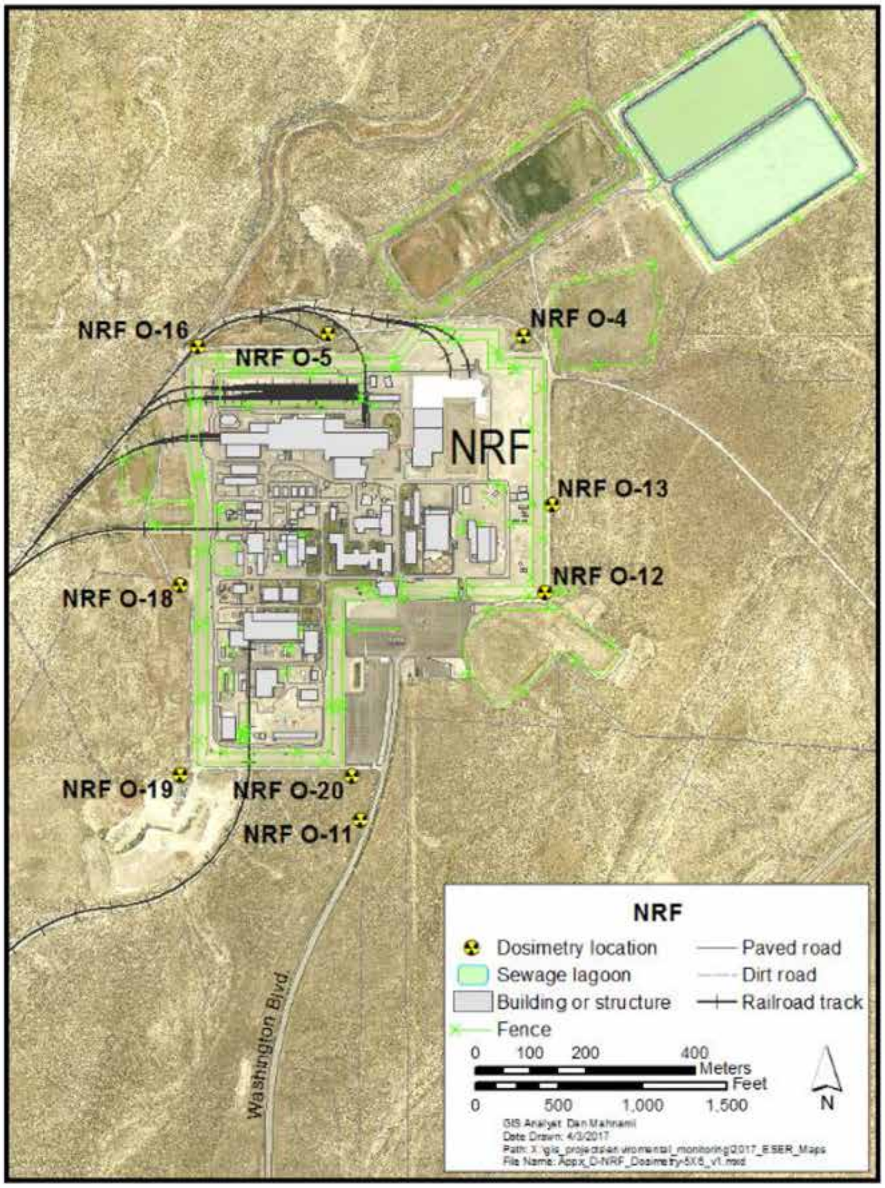


Figure D-7. Environmental Radiation Measurements at Naval Reactors Facility (2016).

Location	mrem[a] Nov. 2015 – April 2016	May 2016 – Oct. 2016
IF-675E O-31	50	55
IF-675D O-33	51	57
IF-675S O-34	55	62
IF-675W O-35	55	46

a. Ambient dose equivalent.

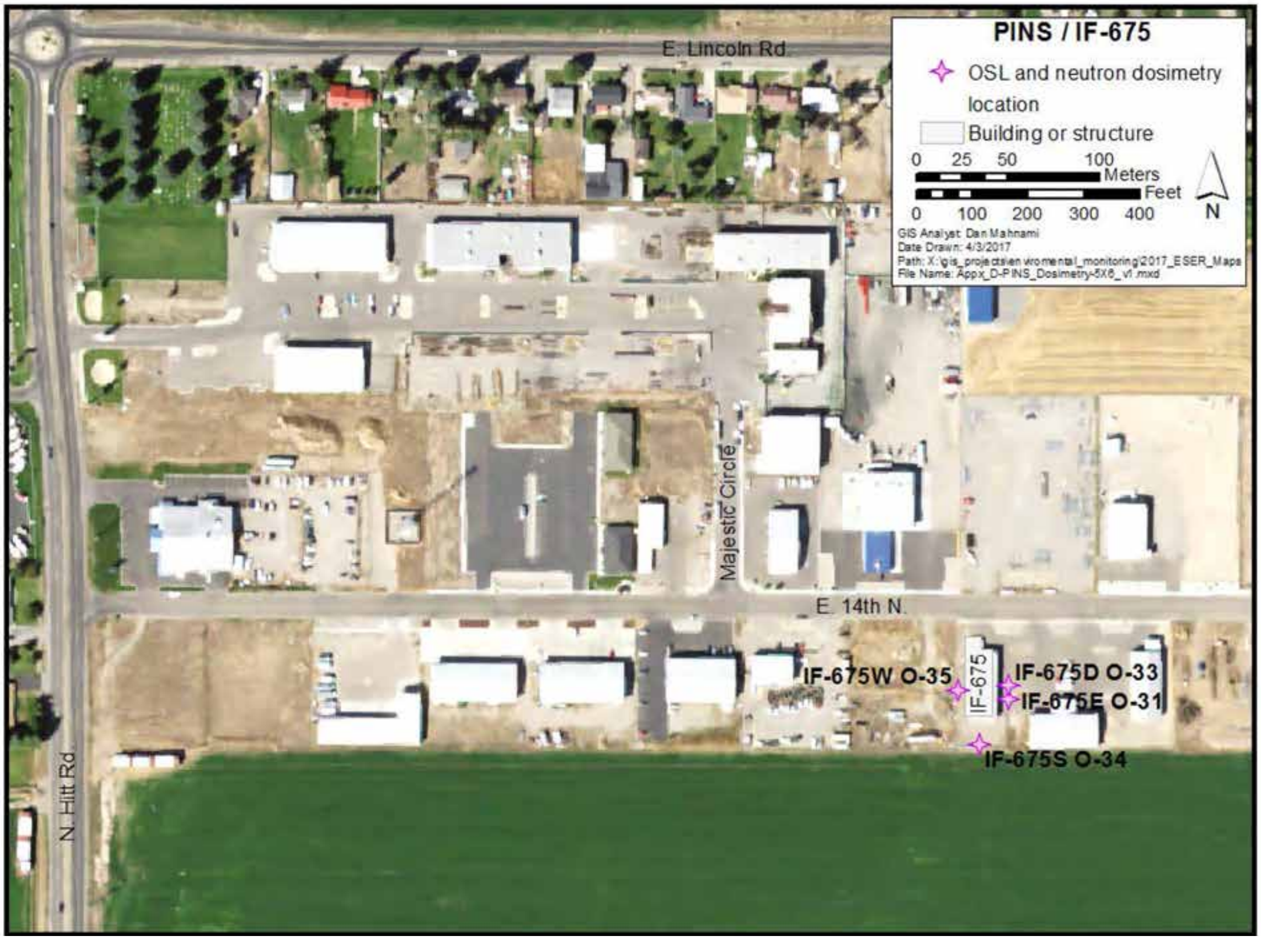


Figure D-8. Environmental Radiation Measurements at IF-675 PINS Facility (2016).

Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016	Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016
RWMC O-3A	60	70	RWMC O-25A	59	65
RWMC O-5A	60	67	RWMC O-27A	57	74
RWMC O-7A	60	75	RWMC O-29A	58	70
RWMC O-9A	77	86	RWMC O-39	60	73
RWMC O-11A	67	77	RWMC O-41	104	136
RWMC O-13A	106	117	RWMC O-43	62	73
RWMC O-19A	60	69	RWMC O-46	57	70
RWMC O-21A	50	74	RWMC O-47	60	85
RWMC O-23A	64	67			

a. Ambient dose equivalent.

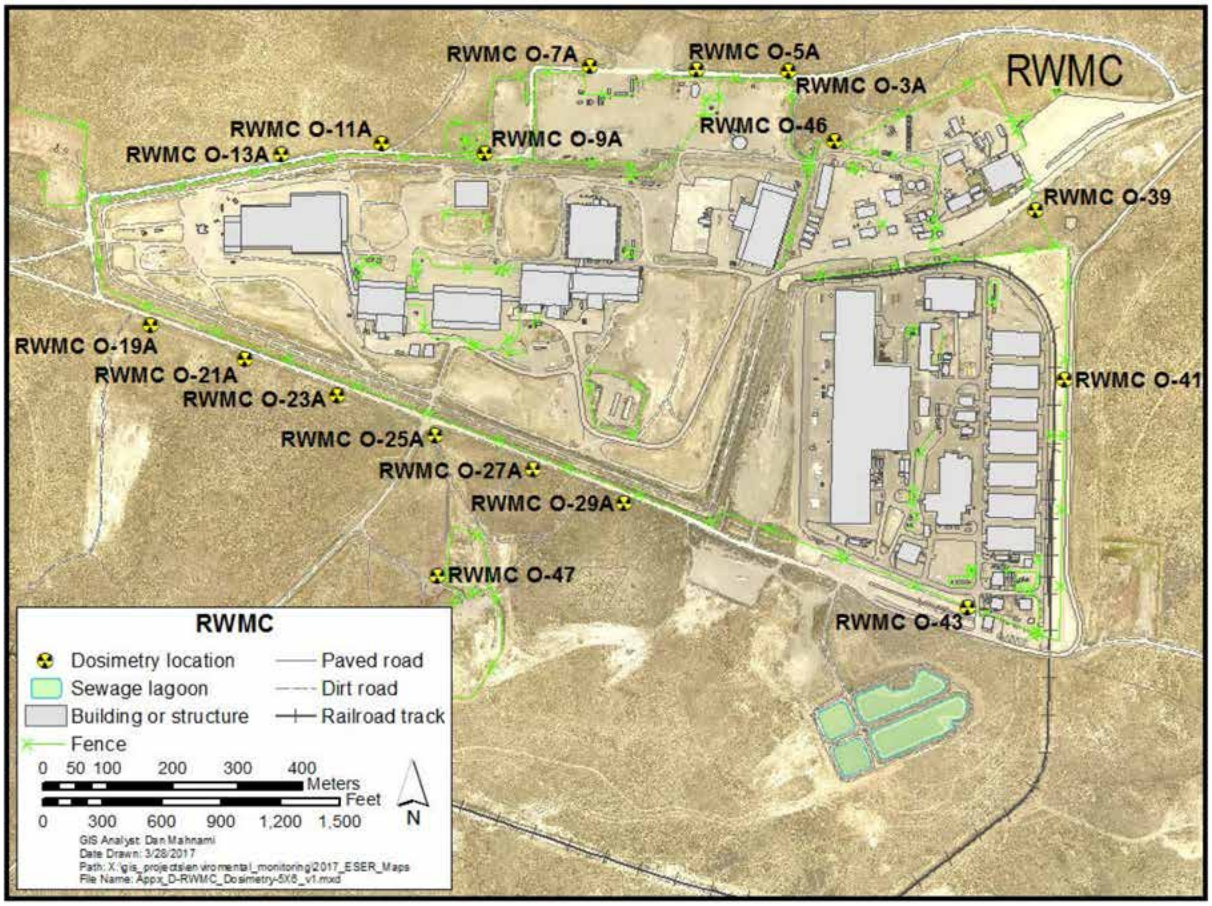


Figure D-9. Environmental Radiation Measurements at Radioactive Waste Management Complex (2016).

	mrem[a]			mrem[a]	
Location	Nov. 2015 – April 2016	May 2016 – Oct. 2016	Location	Nov. 2015 – April 2016	May 2016 – Oct. 2016
TAN LOFT O-6	60	77	TAN LOFT O-10	61	76
TAN LOFT O-7	67	77	TAN LOFT O-11	60	73
TAN LOFT O-8	52	64	TAN LOFT O-12	56	62
TAN LOFT O-9	52	61	TAN LOFT O-13	68	74

a. Ambient dose equivalent.

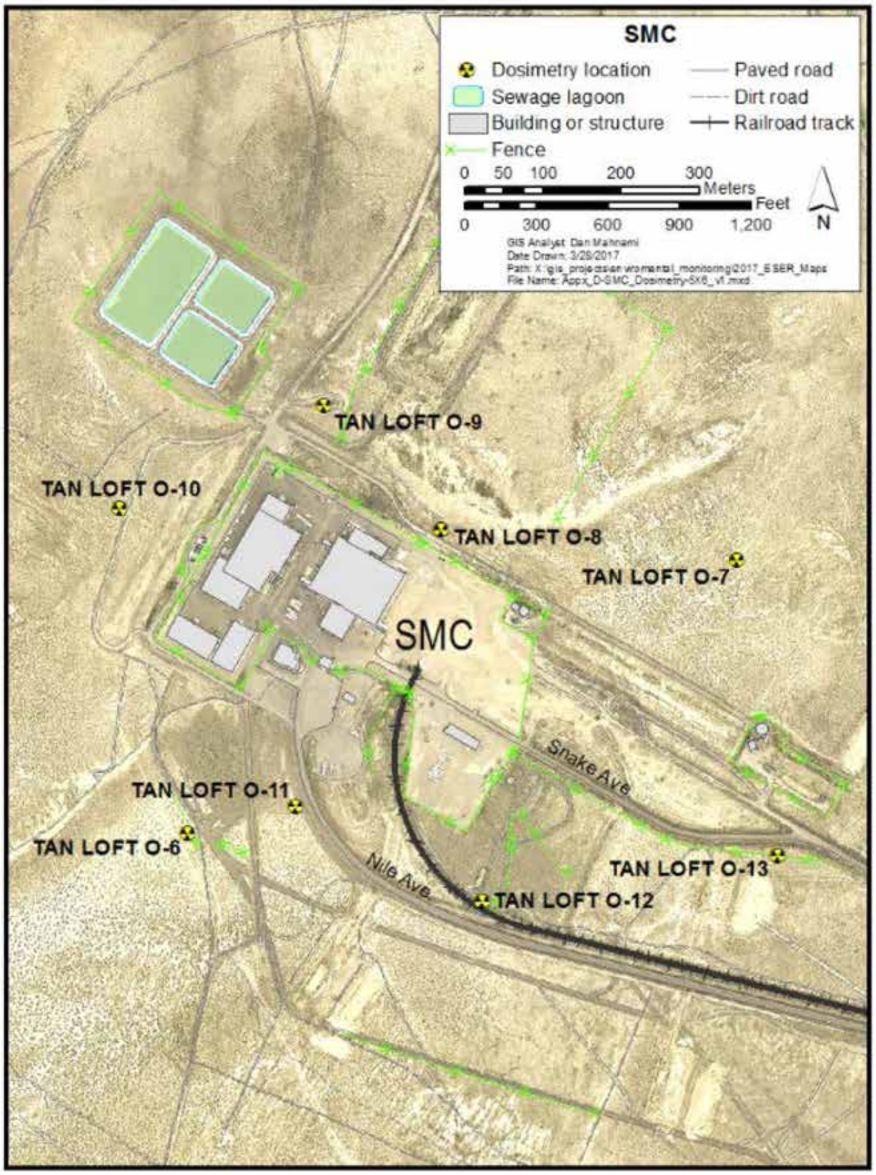


Figure D-10. Environmental Radiation Measurements at Test Area North (2016).

Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016	Location	mrem[a] Nov. 2015 – April 2016	mrem[a] May 2016 – Oct. 2016
EBR1 O-1	56	61	Hwy33 T17 O-3	49	63
EFS O-1	51	74	LincolnBlvd O-3	66	79
Gate4 O-1	55	68	LincolnBlvd O-5	64	72
Haul E O-1	61	57	LincolnBlvd O-9	63	76
Haul W O-2	55	69	LincolnBlvd O-15	68	78
Hwy20 Mile O-266	54	60	LincolnBlvd O-25	57	74
Hwy20 Mile O-270	57	76	Main Gate O-1	61	70
Hwy20 Mile O-276	56	68	Rest O-1	59	69
Hwy22 T28 O-1	47	59	VANB O-1	67	68
Hwy28 N2300 O-2	51	54			

a. Ambient dose equivalent.

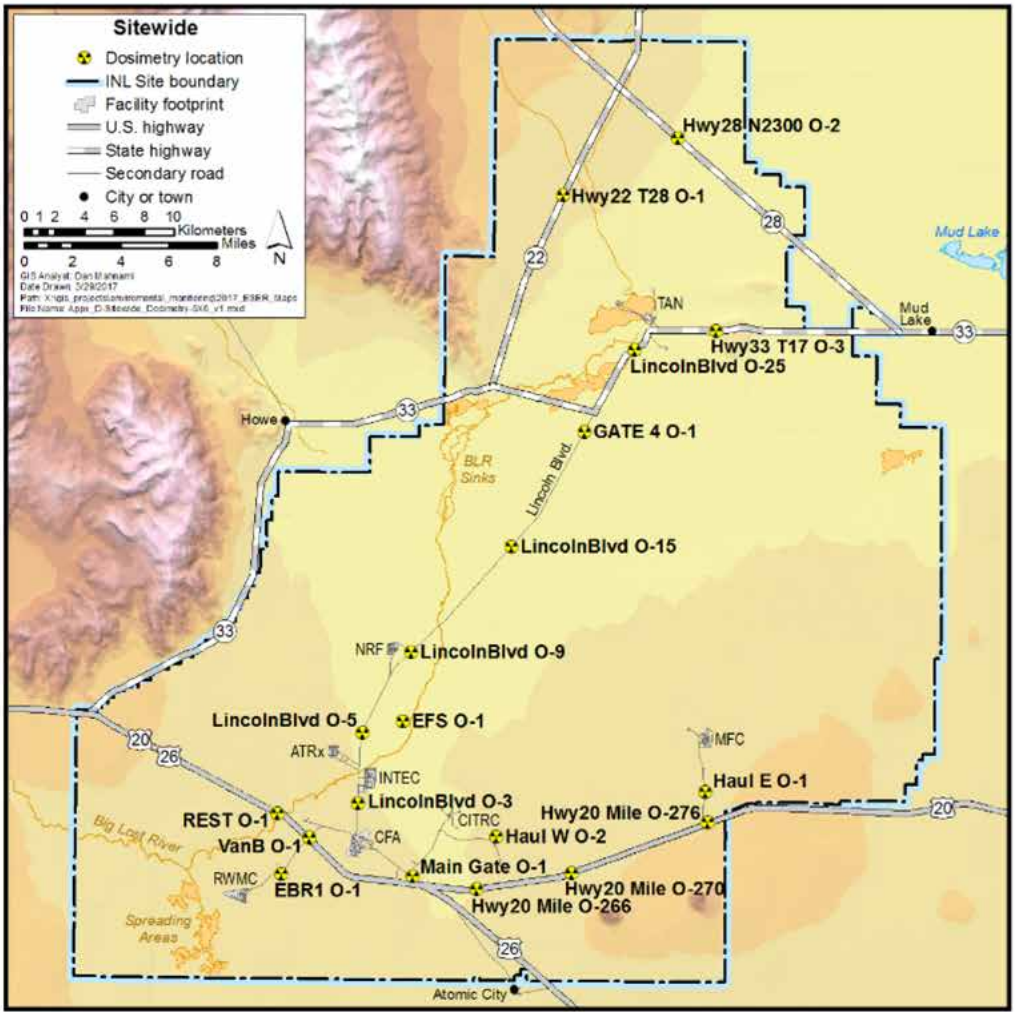


Figure D-11. Environmental Radiation Measurements at Sitewide Locations (2016).

Location	mrem[a] Nov. 2015–April 2016	mrem[a] May 2016 – Oct. 2016	Location	mrem[a] Nov. 2015–April 2016	mrem[a] May 2016 – Oct. 2016
Arco O-1	54	67	Mud Lake O-5	60	69
Atomic City O-2	57	71	Reno Ranch O-6	47	60
Blackfoot O-9	54	61	RobNOAA	57	65
Craters O-7	56	62	RRL3 O-1	59	lost
Howe O-3	41	60	RRL5 0-1	77	99
Idaho Falls O-10	55	58	RRL6 O-1	54	64
IF-IDA O-38	49	57	RRL17 O-1	55	62
Monteview O-4	56	68	RRL24 O-1	52	55

a. Ambient dose equivalent.

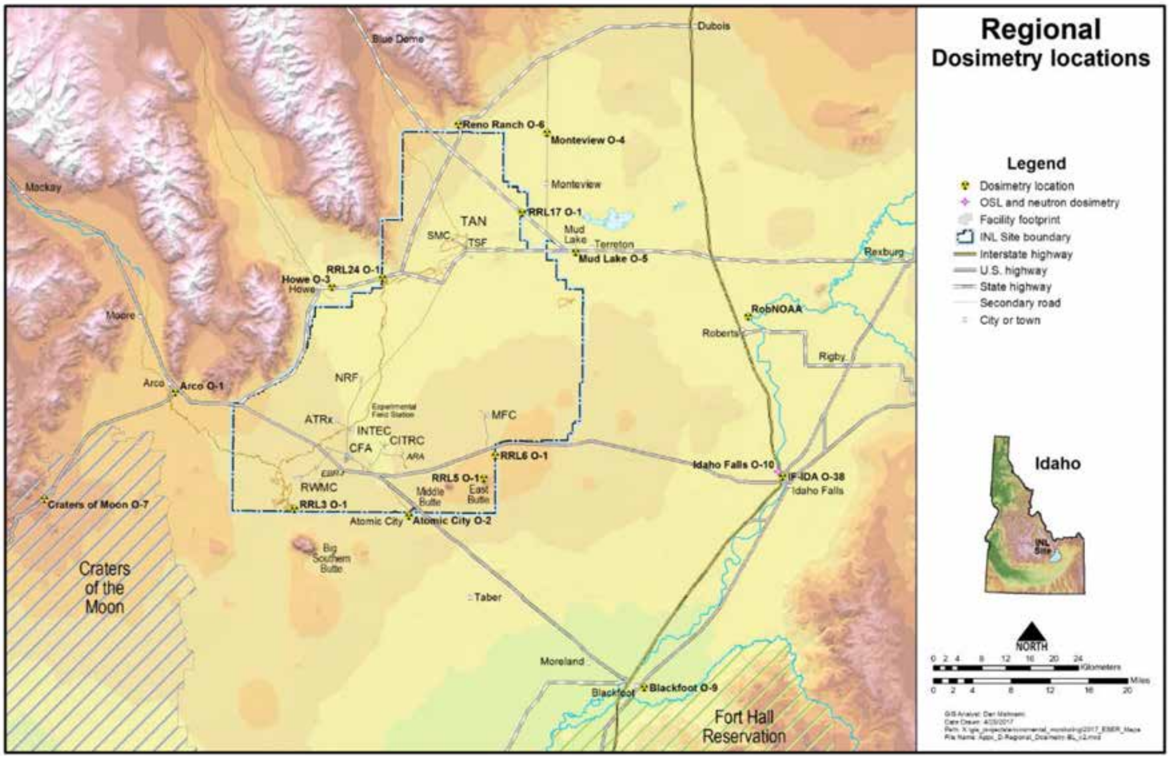


Figure D-12. Environmental Radiation Measurements at Regional Locations (2016).

Location	mrem[a]	
	Nov. 2015 – April 2016	May 2016 – Oct. 2016
IF-616N O-36	57	60
IF-665W O-37	56	54

a. Ambient dose equivalent.

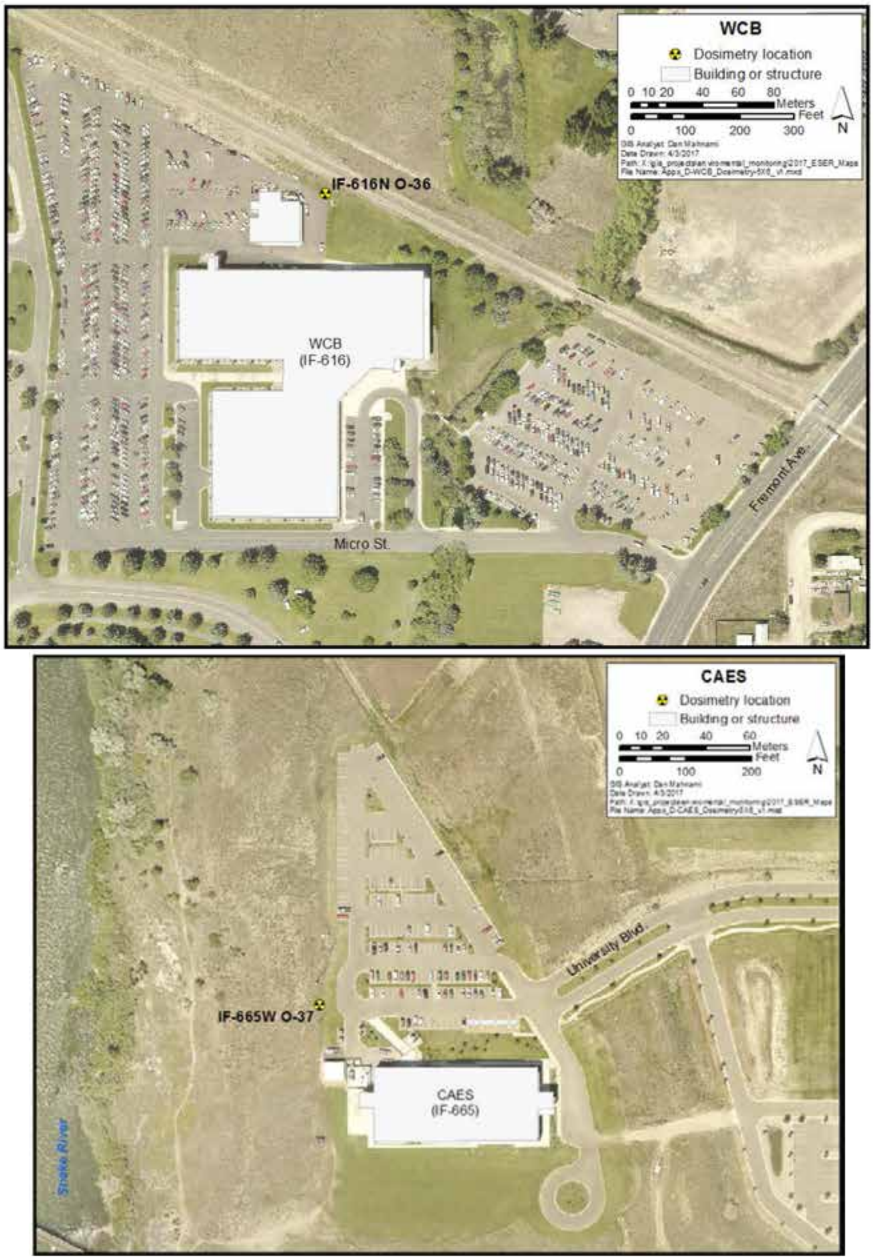


Figure D-13. Environmental Radiation Measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2016).

An optically stimulated luminescent dosimeter (OSLD).

Appendix E. Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the “true” value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium to lawrencium, including the naturally occurring radionuclides thorium and uranium, and the human-made radionuclides plutonium and americium.

alpha radiation: The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of approximately an inch. Despite its low penetration ability, alpha radiation is densely ionizing and, therefore, very damaging when ingested or inhaled.

ambient dose equivalent: Since the effective dose cannot be measured directly with a typical survey instrument or a dosimeter, approved simulation quantities are used to approximate the effective dose (see **dose, effective**). The ambient dose equivalent is the quantity recommended by the International Commission on Radiation Units and Measurements to approximate the effective dose received by a human from external exposure to ambient ionizing radiation.

anthropogenic radionuclide: Radionuclide produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission. The typically quoted average individual exposure from background radiation in southeastern Idaho is 360 millirems per year.

basalt: The most common type of solidified lava; a dense, dark grey, fine-grained, igneous rock that is composed chiefly of plagioclase, pyroxene, and olivine, often displaying a columnar structure.

becquerel (Bq): A quantitative measure of radioactivity. This is an alternate measure of activity used internationally. One becquerel of activity is equal to one nuclear decay per second. There are 3.7×10^{10} Bq in 1 Curie (Ci).

beta radiation: Radiation comprised of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly more penetrating than alpha, and it may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements, such as potassium-40, emit beta radiation.

bias: The tendency for an estimate to deviate from an actual or real event. Bias may be the tendency for a model to over- or under-predict.

bioremediation: The process of using various natural or introduced microbes or both to degrade, destroy, or otherwise permanently bond contaminants contained in soil or water or both.

biota concentration guide: The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded.

blank: Used to demonstrate that cross contamination has not occurred. See **field blank, laboratory blank, equipment blank,** and **reagent blank**.

blind sample: Contains a known quantity of some of the analytes of interest added to a sample media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in a person's custody if the item is 1) in the physical possession of that person, 2) within direct view of that person, or 3) placed in a secured area or container by that person.

comparability: A measure of the confidence with which one data set or method can be compared to another.

composite sample: A sample of environmental media that contains a certain number of sample portions collected over a time period. The samples may be collected from the same location or different locations. They may or may not be collected at equal intervals over a predefined period (e.g., quarterly).

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected under optimum conditions.

confidence interval: A statistical range with a specified probability that a given parameter lies within the range.

contaminant: Any physical, chemical, biological, radiological substance, matter, or concentration that is in an unwanted location.

contaminant of concern: Contaminant in a given media (usually soil or water) above a risk level that may result in harm to the public or the environment. At the INL Site, a contaminant that is above a 10^{-6} (1 in 1 million) risk value.

control sample: A sample collected from an uncontaminated area that is used to compare INL Site analytical results to those in areas that could not have been impacted by INL Site operations.

cosmic radiation: Penetrating ionizing radiation, both particulate and electromagnetic, that originates in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 300 millirem of natural background radiation that an average member of the U.S. public receives in a year.

curie (Ci): The original unit used to express the decay rate of a sample of radioactive material. The curie is a unit of activity of radioactive substances equivalent to 3.70×10^{10} disintegrations per second: it is approximately the amount of activity produced by 1 gram of radium-226. It is named for Marie and Pierre Curie who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. (See also **becquerel**)

D

data gap: A lack or inability to obtain information despite good faith efforts to gather desired information.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay products: Decay products are also called "daughter products." They are radionuclides that are formed by the radioactive decay of parent radionuclides. In the case of radium-226, for example, nine successive different radioactive decay products are formed in what is called a "decay chain." The chain ends with the formation of lead-206, which is a stable nuclide.

derived concentration standard (DCS): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose of 100 mrem (1 mSv). U.S. Department of Energy Order 458.1 "Radiation Protection of the Public and the Environment" establishes this limit and DOE Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard," provides the numerical values of DCSs.

deterministic effect: A health effect, the severity of which varies with the dose and for which a threshold is believed to exist. Deterministic effects generally result from the receipt of a relatively high dose over a short time period. Skin erythema (reddening) and radiation-induced cataract formation is an example of a deterministic effect (formerly called a nonstochastic effect).

diffuse source: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

direct radiation: External radiation from radioactive plumes or from radionuclides deposited on the ground or other surfaces.

dispersion: The process of molecular movement by physical processes.

dispersion coefficient: An empirical concentration, normalized to a unit release rate, used to estimate the concentration of radionuclides in a plume at some distance downwind of the source. The National Oceanic and Atmospheric Administration, using data gathered continuously at meteorological stations on and around the INL Site and the HYSPLIT transport and dispersino model, prepared the dispersion coefficients for this report.

dose: A general term used to refer to the effect on a material that is exposed to radiation. It is used to refer either to the amount of energy absorbed by a material exposed to radiation (see **dose, absorbed**) or to the potential biological effect in tissue exposed to radiation (see **dose, equivalent** and **dose, effective**). See also: **dose, population**.

dose, absorbed: The amount of energy deposited in any substance by ionizing radiation per unit mass of the substance. It is expressed in units of rad or gray (Gy) (1 rad = 0.01 gray).

dose, effective (E): The summation of the products of the equivalent dose received by specified tissues and organs of the body, and tissue weighting factors for the specified tissues and organs, and is given by the expression:

$$E = \sum_{T} w_T \sum_{R} w_R D_{T,R} \quad or \quad E = \sum_{T} w_T H_T$$

where H_T or $w_R D_{T,R}$ is the equivalent dose in a tissue or organ, T, and w_T is the tissue weighting factor. The effective dose is expressed in the SI unit Sievert (Sv) or conventional unit rem (1 rem = 0.01 Sv). (See **dose, equivalent** and **weighting factor**.)

dose, equivalent (HT): The product of absorbed dose in tissue multiplied by a quality factor, and then sometimes multiplied by other necessary modifying factors, to account for the potential for a biological effect resulting from the absorbed dose. For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rems (or sieverts). It is expressed numerically in rems (traditional units) or sieverts (SI units). (See **dose, absorbed** and **quality factor**.)

dose, population or collective: The sum of the individual effective doses received in a given time period by a specified population from exposure to a specified source of radiation. Population dose is expressed in the SI unit person-sievert (person-Sv) or conventional unit person-rem. (1 person-Sv = 100 person-rem.) (See **dose, effective**.)

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

dosimetry: The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

drinking water: Water for the primary purpose of consumption by humans.

duplicate sample: A sample collected from the same sampling location using the same equipment and sampling technique and placed into an identically prepared and preserved container. Duplicate samples are analyzed independently as an indication of gross errors in sampling techniques.

E

eastern Snake River Plain aquifer: One of the largest groundwater “sole source” resources in the United States. It lies beneath a rolling topography extending some 308 km (191 mi) from Ashton to King Hill, Idaho, and ranges in width from 64 to 130 km (40 to 80 mi). The plain and aquifer were formed by repeated volcanic eruptions that were the result of a geologic hot spot beneath the earth’s crust.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effluent: Any liquid discharged to the environment, including storm water runoff at a site or facility.

effluent waste: Treated wastewater leaving a treatment facility.

electrometallurgical treatment: The process of treating spent nuclear fuel using metallurgical techniques.

environment: Includes water, air, and land and the interrelationship that exists among and between water, air, and land and all living things.

environmental indicators: Animal and plant species that are particularly susceptible to decline related to changes, either physical or chemical, in their environment.

environmental media: Includes air, groundwater, surface water, soil, flora, and fauna.

environmental monitoring: Sampling for contaminants in air, water, sediments, soils, agricultural products, plants, and animals, either by direct measurement or by collection and analysis of samples. It is a combination of two distinct activities (effluent monitoring and environmental surveillance) that together provide information on the health of an environment.

equipment blank: Sample prepared by collecting uncontaminated water passed over or through the sampling equipment. This type of blank sample is normally collected after the sampling equipment has been used and subsequently cleaned. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning.

exposure: The interaction of an organism with a physical or chemical agent of interest. Examples of such agents are radiation (physical) and carbon tetrachloride (chemical).

exposure pathway: The mechanism through which an organism may be exposed to a contaminant. An example is the surface water pathway, whereby an organism may be exposed to a contaminant through the consumption of surface water containing that contaminant.

external dose or exposure: That portion of the dose received from radiation sources outside the body (i.e., external sources).

extremely hazardous chemical: A substance listed in the appendices to 40 CFR 355, "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing and deposited on the earth's surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage, and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning. Namely, any material that is fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission: The splitting of the nucleus of an atom (generally of a heavy element) into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the subsequent decay products of the radioactive fission fragments.

fissionable material: Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

flood plain: Lowlands that border a river and are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, and capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See **alpha radiation**.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See **beta radiation**.

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

hazardous air pollutant: See **hazardous substance**.

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200 ("Hazard Communication") and 40 CFR 370.2 ("Definitions").

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and it does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 ("Identification and Listing Hazardous Waste") or that exhibits one or more of four characteristics (corrosiveness, reactivity, flammability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: 1) In environmental surveillance, a localized area of contamination or higher contamination in an otherwise uncontaminated area. 2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth's surface. The hot spot does not move, but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process of water soaking into soil or rock.

influent waste: Raw or untreated wastewater entering a treatment facility.

inorganic: Relating to or belonging to the class of compounds not having a carbon basis; hydrochloric and sulfuric acids are called inorganic substances.

ionizing radiation: Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons, and light. High doses of ionizing radiation may produce severe skin or tissue damage.

isopleth: A line on a map connecting points having the same numerical value of some variable.

isotope: Two or more forms of an element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties. Examples of isotopes are plutonium-238, plutomium-239, and plutonium-241; each acts chemically like plutonium but have 144, 145, and 147 neutrons, respectively.

L

laboratory blank: A sample, usually deionized water, that is intended to contain none of the analytes of interest and is subjected to the same analytical or measurement process as other samples to establish a zero baseline or laboratory background value. Laboratory blanks are run before and after regular samples are analyzed to measure contamination that may have been introduced during sample handling, preparation, or analysis. A laboratory blank is sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) or composition (soil, filter, groundwater, or air) of a sample.

maximally exposed individual (MEI): A hypothetical member of the public whose location and living habits tend to maximize his or her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

millirem (mrem): A unit of radiation dose that is equivalent to one one-thousandth of a rem.

millisievert (mSv): The International System of Units (SI) for radiation dose and effective dose equivalent. The SI equivalent of the millirem (1 millisievert = 100 millirem).

minimum detection concentration (MDC): The lowest concentration to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDC are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. It does not include fallout radiation. Natural background radiation is comprised of several sources, the most important of which are:

- *Cosmic radiation*: Radiation from outer space (primarily the sun)
- *Terrestrial radiation*: Radiation from radioactive materials in the crust of the earth
- *Inhaled radionuclides*: Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Native American tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

optically stimulated luminescence dosimeter (OSLD): Used to measure direct penetrating gamma radiation through the absorption of energy from ionizing radiation by trapping electrons that are excited to a higher energy band. The trapped electrons in the OSLD are released by exposure to green light from a laser.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: 1) Pollutant or contaminant as defined by Section 101(33) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States. 2) Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance (QA): Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control (QC): Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor: The factor by which the absorbed dose (rad or gray) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, quality factor, has now been replaced by "radiation weighting factor" in the latest system of recommendations for radiation protection.

R

rad: Short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \text{ x } 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302 ("Designation, Reportable Quantities, and Notification"), the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory's ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk: In many health fields, risk means the probability of incurring injury, disease, or death. Risk can be expressed as a value that ranges from zero (no injury or harm will occur) to one (harm or injury will definitely occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public, and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals; which are usually denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapidly growing plants for the purpose of holding bare soil in place.

standard: A sample containing a known quantity of various analytes. A standard may be prepared and certified by commercial vendors, but it must be traceable to the National Institute of Standards and Technology.

standard deviation: In statistics, the standard deviation (SD), also represented by the Greek letter sigma σ, is a measure of the dispersion of a set of data from its mean.

stochastic effect: An effect that occurs by chance and which may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effect is cancer.

storm water: Water produced by the interaction of precipitation events and the physical environment (buildings, pavement, ground surface).

surface radiation: See **direct radiation**. Surface radiation is monitored at the INL Site at or near waste management facilities and at the perimeter of Site facilities.

surface water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Monitoring of parameters to observe trends but which is not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total effective dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above listed quantities. See also **hazardous chemical**.

traceability: The ability to trace history, application, or location of a sample standard and like items or activities by means of recorded identification.

transient noncommmunity water system: A water system that is not a community water system, and serves 25 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

transuranic (TRU): Elements on the periodic table with an atomic number greater than uranium (>92). Common isotopes of transuranic elements are neptunium-239 and plutonium-238.

transuranic waste: Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (radionuclide isotopes with atomic numbers greater than uranium [92]) per gram of waste with half-lives greater than 20 years.

tritium: A radioactive isotope of hydrogen, having three times the mass of ordinary hydrogen.

V

vadose zone: That part of the subsurface between the ground surface and the water table.

W

water quality parameter: Parameter commonly measured to determine the quality of a water body or sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

weighting factor (w_T): A multiplier that is used for converting the equivalent dose to a specific organ or tissue (T) into what is called the effective dose. The goal of this process is to develop a method for expressing the dose to a portion of the body in terms of an equivalent dose to the whole body that would carry with it an equivalent risk in terms of the associated fatal cancer probability. The equivalent dose to tissue (H_T) is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. (See **dose, equivalent** and **dose, effective**.)

wetland: An area inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

Calendar Year 2016

Wastren Advantage Inc.
120 Technology Drive
Idaho Falls, ID 83402
208.525.8250
www.idahoeser.com

U.S. Department of Energy
Idaho Operations Office

Idaho National Laboratory