Calendar Year 2018

Idaho National Laboratory

Site Environmental Report

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Idaho National Laboratory Site Environmental Report Calendar Year 2018

Environmental Surveillance, Education, and Research Program

U.S. Department of Energy, Idaho Operations Office

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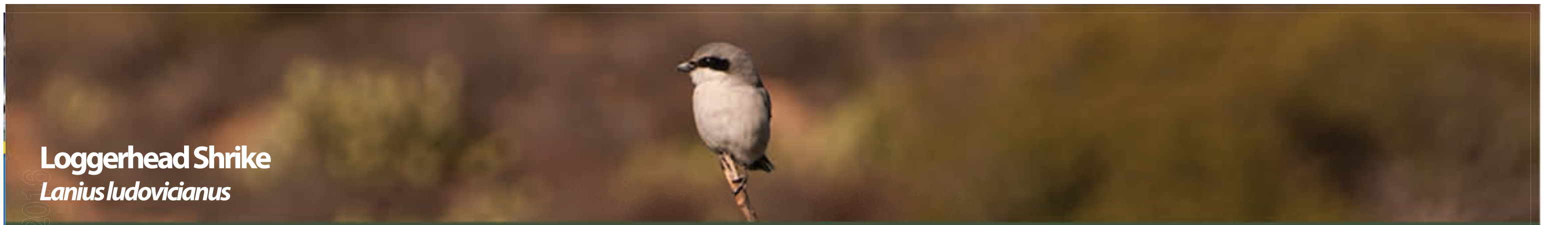
120 Technology Drive
Idaho Falls, ID 83401

Missouri foxtail cactus (*Escobaria missouriensis*)

Photo by: Kara G. Cafferty



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Silver Lupine (*Lupinus argenteus*)

Photo by: Peggy Scherbinske

Sage brush Sparrow
Artemisiospiza nevadensis

To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2018 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, 2018. 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 level 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/2018/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, U.S. Department of Energy awarded a five-year contract to Wastren Advantage, Inc., to manage the Environmental Surveillance, Education, and Research Program. Wastren Advantage, Inc. was purchased by VNSFS on January 17, 2018.

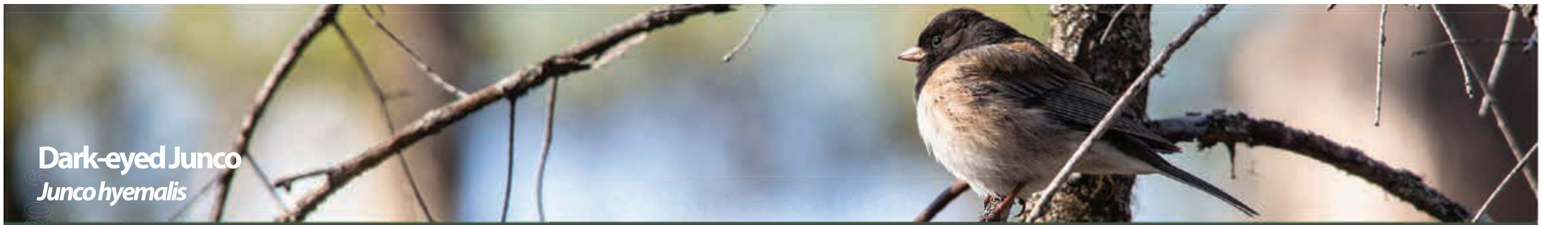
Other major contributors to the annual Idaho National Laboratory Site Environmental Report include the INL contractor (Battelle Energy Alliance, LLC); Idaho Cleanup Project Core contractor (Fluor Idaho, LLC); U.S. Department of Energy, Idaho Operations Office; National Oceanic and Atmospheric Administration;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

- INL (https://www.inl.gov/)
- Idaho Cleanup Project Core (https://fluor-idaho.com/About/About-Idaho-Cleanup-Project/Project-Overview)
- 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 (https://www.usgs.gov/centers/id-water)
- ESER Program (http://www.idahoeser.com/)

Included in the chapter headings of this report are photographs, as well as common and scientific names of birds and flora native to the INL Site. Photo credits: ESER Program and Tom Haney, Kara Cafferty and Peggy Scherbinske from BEA.

From atop East Butte on the INL Site.

Photo by: Kara G. Cafferty



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 options 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.

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

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.

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 by contractors and affiliated agencies and by independent researchers through the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data
- Provide supplemental technical data and reports that support the INL Site Environmental Report (http://www.idahoeser.com/Annuals/2018/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 2018 were: Battelle Energy Alliance, the management and operations contractor for the INL; and Fluor Idaho, which managed ongoing cleanup operations under the ICP Core 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 (NRF); Radioactive Waste Management Complex (RWMC); and Test Area North (TAN), which includes the Specific Manufacturing Capability (SMC). The Research and Education Campus is located in Idaho Falls. The locations of major facilities are shown in Figure ES-2 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 environment. Battelle Energy Alliance and Fluor Idaho have each established and implemented an EMS and each contributes 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.

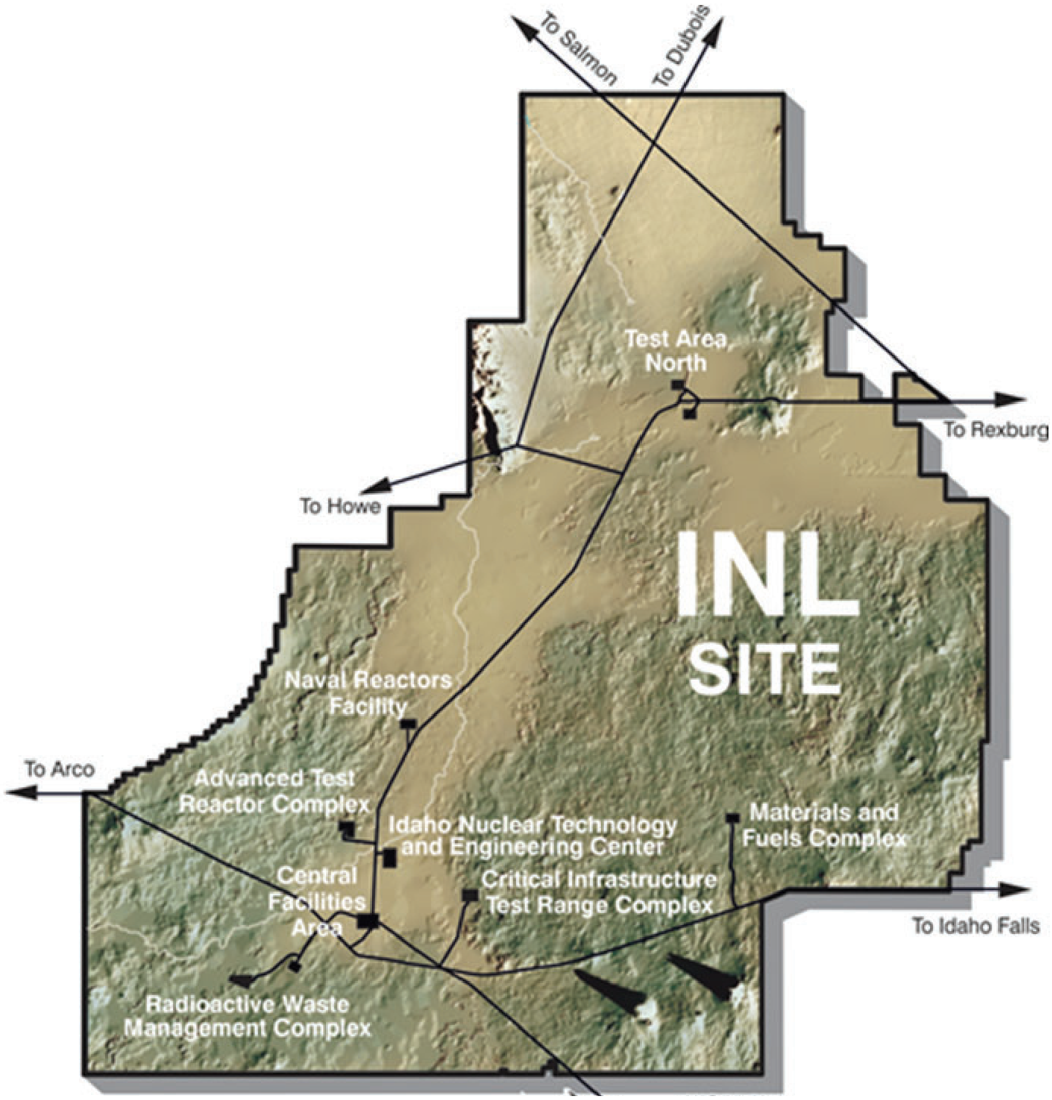


Figure ES-2. Idaho National Laboratory Site Facilities.

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 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 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 2018, all institutional controls and operational and maintenance requirements were maintained and active remediation continued on WAGs 1, 3, 7, and 10.

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 Core	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	Research and development of nuclear fuels. Pyro processing, 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 Core	Environmental remediation; and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. Advanced Mixed Waste Treatment Project 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 DOE's Radiological and Environmental Sciences Laboratory, INL administration, the INL Research Center, the Center for Advanced Energy Studies, and other energy and security research programs. Research is conducted at INL Research Center in robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. Center for Advanced Energy Studies 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	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 Specific Manufacturing Capability for the U.S. Department of Defense.

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

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 2018 from the air pathway was 0.01 mrem (0.1 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 2018 to be 383 mrem (3,830 µSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 337,643 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.0075 person-rem (0.0000075 person-Sv), below that expected from exposure to background radiation (129,317 person-rem or 1,293 person-Sv). The 50-mi population dose calculated for 2018 is slightly lower than that calculated for 2017 (0.0106 person-rem or 0.000106 person-Sv).

The maximum potential individual dose from consuming waterfowl contaminated at the INL Site, based on the highest concentrations of radionuclides measured in edible tissue of samples collected near the ATR Complex ponds, was estimated to be 0.016 mrem (0.16 µSv). There were no gamma-emitting radionuclides detected in big game animals sampled in 2018, hence there was no dose associated with consuming big game. When the dose estimated for the air pathway was summed with the dose from consuming contaminated waterfowl, assuming that the waterfowl is eaten by the same hypothetical individual, the representative person off the INL Site could potentially receive a total dose of 0.026 mrem (0.26 µSv) in 2018. This is 0.026 percent of the DOE health-based dose limit of 100 mrem/yr (1 µSv/yr) from all pathways for the INL Site.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located on the INL Site along the southern boundary. A hypothetical individual ingesting the maximum concentration of tritium (5,100 pCi/L) via drinking water from these wells would receive a dose of approximately 1 mrem (0.01 mSv) in one year. This is an unrealistic pathway

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2018).

Pathway	Annual Dose to Maximally Exposed Individual (mrem)	(µSv)	Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	0.01	0.1	0.01	0.0075	0.000075	337,643	129,317
Waterfowl	0.016	0.16	NA[c]	NA	NA	NA	NA
Big game animals	—[d]	—[d]	NA	NA	NA	NA	NA
Total pathways	**0.026**	**0.26**	**0.026**	**0.0075**	**0.000075**	**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 or 1,000 µSv/yr) total effective dose equivalent. It does not include dose from background radiation.
b. The individual dose from background radiation was estimated to be 383 mrem (3.8 mSv) in 2018 (Table 6-8).
c. NA = Not applicable
d. No radionuclide was detected in 2018, so no dose was calculated.

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 (20,000 pCi/L) corresponds to a dose of approximately 4 mrem (0.04 mSv [40 µSv/yr]).

A dose to a maximally exposed individual located in Idaho Falls near the DOE Radiological and Environmental Sciences Laboratory and the INL Research Center, within the Research and Education Campus, was calculated for compliance with the Clean Air Act. For 2018, the dose was conservatively estimated to be 0.006 mrem (0.06 µSv), which is 0.06 percent of the 10-mrem/yr federal standard.

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 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 1,477 curies (5.46×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2018. 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 2018, the INL contractor monitored ambient air at 16 locations on the 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 monitored ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at six 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 (^{137}Cs). Particulate filters were also composited quarterly by the INL, ICP Core, and ESER contractors and analyzed for specific alpha- and beta-emitting radionuclides, specifically strontium-90 (^{90}Sr), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). 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. 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 measurable in environmental air samples.

The INL contractor collected atmospheric moisture samples at three stations on and one station off the INL Site in 2018. The ESER contractor collected atmospheric moisture at one location on and three locations off the INL Site. Precipitation was collected at the same four locations. The INL and ESER 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	The Clean Air Act 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, (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2018.*	2.2.1 3.2 7.2.1
DOE/Order 458.1, Change 3	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 establishment of an Environmental Radiological Protection Program to ensure protection of the public and the environment against undue risk from radiation associated with radiological activities conducted at DOE facilities.	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 3 Chapter 4 Chapter 5 Chapter 6 Chapter 7
EPA/40 CFR 300	The Comprehensive Environmental Response, Compensation, and Liability Act provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning) of inactive hazardous waste disposal sites.	Nuclear research and other operations at the INL Site left behind contaminants 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 ICP Core.	2.1
EPA/40 CFR 109-140	The Clean Water Act establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with an Industrial Wastewater Acceptance permit issued by the state of Idaho for discharges to the City of Idaho Falls' publicly owned treatment works. All discharges in 2018 were within compliance levels established in the permit.	2.3.1
EPA/40 CFR 141-143	The Safe Drinking Water Act establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site has 12 active drinking water systems that are routinely sampled and analyzed as required by the state of Idaho and EPA.	5.6 2.3.2
EPA/40 CFR 270.13	The Resource Conservation and Recovery Act established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste.	The Idaho Department of Environmental Quality conducted two unannounced Resource Conservation and Recovery Act inspections of the INL Site in June and October of 2018. There were no violations cited.	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 2018, 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 the ATR Complex, 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 12 drinking water systems at the INL Site in 2018. 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 2018. The dose, 0.134 mrem (1.34 µSv), is below the EPA standard of 4 mrem/yr (0.04 mSv [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, $^{239/240}$Pu, and ^{90}Sr were detected in 2018 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 27,972 km^2 (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 2018, 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 ^{90}Sr concentrations over time.

Volatile Organic Compounds are present in water from the eastern Snake River Plain aquifer because of historical waste disposal practices at the INL Site. Several purgeable (volatile) organic compounds (VOCs) were detected by USGS in 27 groundwater monitoring wells and one perched well sampled at the INL Site in 2018. Most concentrations of the 61 compounds analyzed were either below the laboratory reporting levels or their respective primary contaminant standards. Trend test results for tetrachloromethane concentrations in water from the RWMC production well show a decreasing trend in the RWMC production well since 2005. The more recent decreasing trend indicates that remediation efforts designed to reduce VOC movement to the aquifer are having a positive effect. 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. Trichloroethylene (TCE) was detected above the contaminant standard in one well sampled by the USGS at TAN, 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 2018. 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. Strontium-90 and ^{137}Cs were present in wells in the source area at levels higher than those prior to starting in situ bioremediation. The elevated concentrations of these radionuclides are due to in situ bioremediation activities. The radionuclide concentrations will continue to be evaluated to determine if they will meet remedial action objectives by 2095.

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

Groundwater samples were collected from 18 aquifer monitoring wells at and near INTEC (WAG 3) during 2018. Stronium-90, technetium-99, and nitrate exceeded their respective drinking water maximum contaminant levels in one or more aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its maximum contaminant level by the greatest margin in a well south (downgradient) of the former INTEC injection well. All other well locations showed ^{90}Sr levels similar or slightly lower than those reported in previous samples.

Monitoring of groundwater at CFA (WAG 4) consists of CFA landfill monitoring and monitoring of a nitrate plume south of the CFA. Wells at the landfills were monitored in 2018 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 2018, and overall the data show a downward trend since 2006.

Groundwater samples were not collected from monitoring wells near the RWMC (WAG 7) in 2018 because of adverse weather conditions and equipment issues. The monitoring will resume in 2019.

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

Wells along the southern INL Site boundary (part of WAG 10) were not sampled in 2018. Sampling will resume in 2019.

Drinking water and surface water samples were sampled downgradient of the INL Site, as well as from the Big Lost River on the INL Site, and analyzed for gross alpha and beta activity, and tritium. The Big Lost River samples were also analyzed for gamma-emitting radionuclides. 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. No human-made gamma radionuclides were detected in Big Lost River samples. The data appear to show no discernible impacts from activities at the INL Site.

Monitoring of Agricultural Products, Wildlife, Soil 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 2018. The agricultural products were collected on, around, and distant from the INL Site by the ESER contractor.

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, alfalfa, and milk samples collected regionally.

No gamma-emitting radionuclides were detected in the two big game animals sampled in 2018. Cobalt-60, ^{65}Zn, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239/240}$Pu and ^{241}Am were detected in

some composited bat samples indicating that bats may have visited radioactive wastewater ponds, such as those at the ATR Complex. Cobalt-60, ^{65}Zn, ^{90}Sr, and ^{137}Cs were detected in tissues of waterfowl collected near the ATR Complex ponds indicating that they accessed the contaminated ponds.

Soil samples were collected off the INL Site by the ESER contractor in 2018. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am were detected in soil. The presence of these radionuclide is most likely due to global fallout and not INL Site operations. The INL contractor did not collect soils in 2018.

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 and bat populations on the INL Site. Monitoring in 2018 included sage-grouse lek surveys, raven nest surveys, midwinter raptor, corvid and shrike surveys, and breeding bird surveys. During 2018, operation and monitoring of permanent bat monitoring stations continued at the INL Site.

Forty-five sage-grouse leks were classified as active on or near the INL Site prior to the 2018 field season. After the field season, reclassification resulted in a net loss of one active lek. The total number of known active leks at or near the INL Site is currently 44.

The total number of active raven nests recorded on the INL Site was 5 percent higher in 2018, compared to 2017 with a total of 43 observed. Thirty-one of the 43 nests were located on powerline structures and eight located within facility boundaries, and four on cell or meteorological towers.

The 2018 midwinter raptor, corvid, and shrike count on the INL Site recorded lower golden eagle observations (6) than in 2017 (36), higher rough-legged hawk counts for the third year, and a continued high number of ravens.

The 2018 breeding bird survey showed that two sagebrush-obligate species (sagebrush sparrow and Brewer's sparrow) are at historically low levels, most likely due to losing large amounts of sagebrush-dominated communities during large wildfires in 2010 and 2011.

Passive acoustic monitoring at long-term stations operating at caves and facilities continues to reveal patterns of bat activity across the INL Site.

Environmental Research at the INL Site

The ESER Program maintains several ecological monitoring and research projects on the INL Site. The purpose of these projects is to assess the condition and conservation status of local vegetation, to monitor sagebrush habitat and conservation efforts to improve habitat, and to facilitate independent ecological research through the National Environmental Research Park (NERP). In 2018, ecological research and monitoring projects conducted through the ESER program included publication of the most recent data collected at 89 active long-term vegetation (LTV) plots, ongoing efforts to update a comprehensive INL Site vegetation map, and annual sagebrush habitat monitoring and sagebrush restoration.

Data are collected on the LTV plots are collected once every five years are were most recently collected in 2016. In 2018, a technical report describing the results of the 2016 data collection was published. Notable findings include continued decreases in sagebrush cover and perennial grass cover at the upper end of its historical range of variability.

Over the past decade, the INL Site vegetation map has become one of ESER's most important datasets and is used to support nearly every other ecologically based task, but it has become outdated due to wildland fire and shifts toward increased non-native species dominance. An update to the INL Site vegetation map was initiated in 2017. Through 2018, a new vegetation class list was developed, polygons were delineated from aerial photo interpretation, and accuracy assessment data were collected. The final updated map and accompanying report will be completed in 2019.

Two sagebrush habitat monitoring and restoration tasks were ongoing in 2018. Sagebrush habitat monitoring was completed on 125 plots and over the past six years sagebrush cover has been stable while cheatgrass cover has continued to increase. Sagebrush restoration efforts included planting over 25,000 seedlings on the Jefferson Fire. One-year survivorship monitoring of seedlings planted in 2017 indicated a minimum survivorship of 62 percent.

The land within the INL Site's borders became DOE's second National Environmental Research Park in 1975. All lands within the NERP serve as an ecological field laboratory where scientists from government agencies, universities, and private foundations may set up long-term research. On the INL Site, 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. The NERP also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act process for natural resources management 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 involves tracking rattlesnake movements through gestation and dispersal of young.

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 2018, the USGS published four research reports.

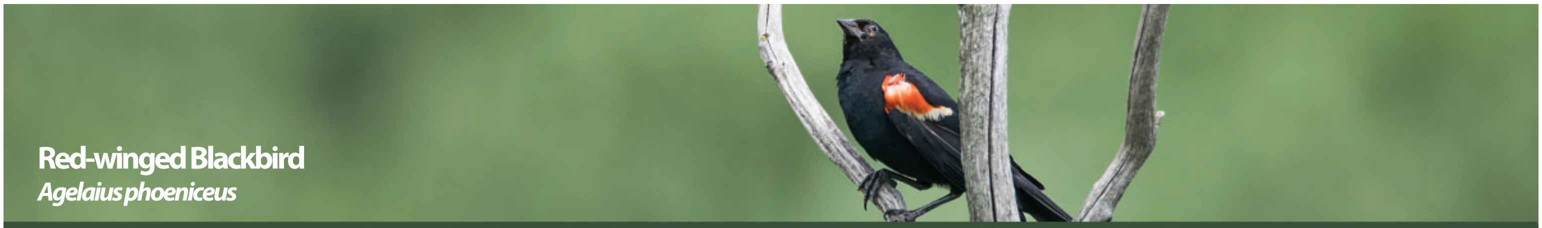
Quality Assurance

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 2018. 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 2018 were addressed with the laboratories and have been or are being resolved.

Long-eared Owl (*Asio otus*)

Photo by: Tom Haney



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 radio-waves, 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 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. Examples of alpha-emitting radionuclides include 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.

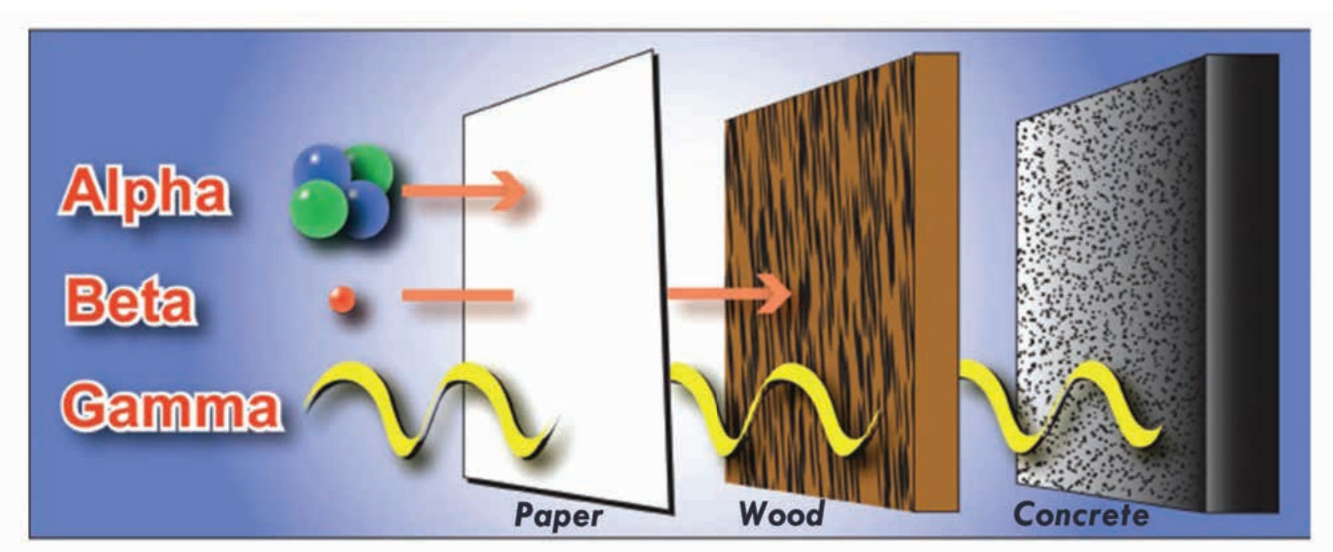


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

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 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 man-made 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 ^{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.

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

Symbol	Radionuclide	Half-life[a,b]	Symbol	Radionuclide	Half-life[a,b]
^{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	1.01×10^5 yr
^{125}Sb	Antimony-125	2.75856 yr	^{63}Ni	Nickel-63	100.1 yr
^{41}Ar	Argon-41	109.61 min	^{238}Pu	Plutonium-238	87.7 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.411×10^4 yr
^{140}Ba	Barium-140	12.752 d	^{240}Pu	Plutonium-240	6,564 yr
^{7}Be	Beryllium-7	53.22 d	^{241}Pu	Plutonium-241	14.35 yr
^{14}C	Carbon-14	5,700 yr	^{242}Pu	Plutonium-242	3.75×10^5 yr
^{141}Ce	Cerium-141	32.508 d	^{40}K	Potassium-40	1.251×10^9 yr
^{144}Ce	Cerium-144	284.91 d	^{226}Ra	Radium-226	1,600 yr
^{134}Cs	Cesium-134	2.0648 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.1671 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.7025 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.2713 yr	^{103}Ru	Ruthenium-103	39.26 d
^{152}Eu	Europium-152	13.537 yr	^{106}Ru	Ruthenium-106	373.59 d
^{154}Eu	Europium-154	8.593 yr	^{90}Sr	Strontium-90	28.79 yr
^{3}H	Tritium	12.32 yr	^{99}Tc	Technetium-99	2.111×10^5 yr
^{129}I	Iodine-129	1.57×10^7 yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.0207 d	^{233}U	Uranium-233	1.592×10^5 yr
^{55}Fe	Iron-55	2.737 yr	^{234}U	Uranium-234	2.455×10^5 yr
^{59}Fe	Iron-59	44.495 d	^{235}U	Uranium-235	7.04×10^8 yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468×10^9 yr
^{87}Kr	Krypton-87	76.3 min	^{90}Y	Yttrium-90	64.1 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	244.06 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	64.032 d

a. From ICRP Publication 107 (ICRP 2008)
b. d = days; hr = hours; min = minutes; s = seconds; yr = years

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, 1.3×10^{-6} (or 1.3E-06). 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 1.3×10^{-6} may also be expressed as 0.0000013. When considering large numbers with a positive exponent, such as 1.0×10^6, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0×10^6 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

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

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.

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). The uncertainty is often referred to as sigma (or σ). 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

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)
µSv	Microsievert (0.1 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

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.

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 is a box plot which shows the minimum, maximum, and median of a set of air measurements.

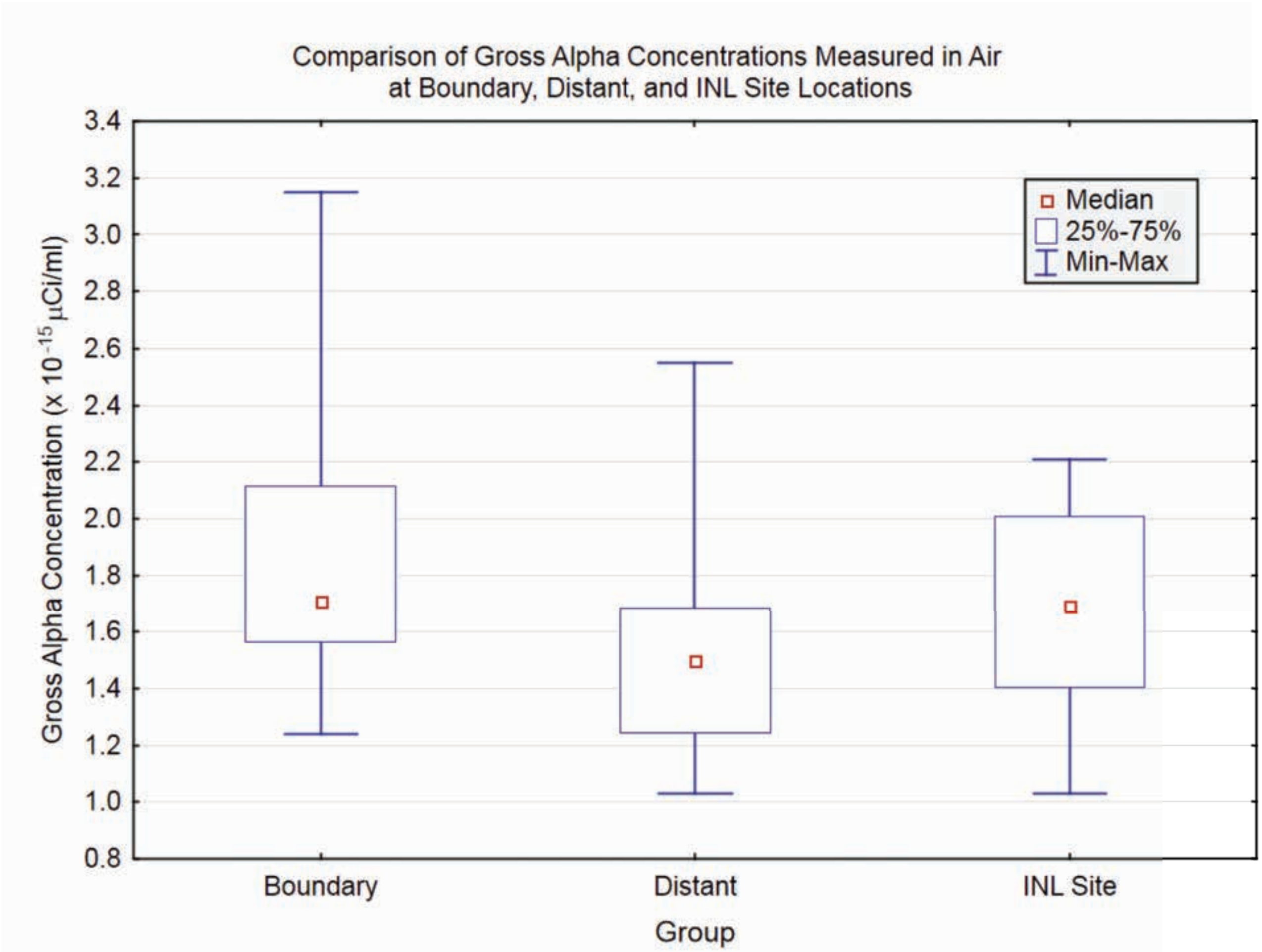


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results with a Box Plot. *The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile, and 75 percent of the measurements are less than the 75th percentile.*

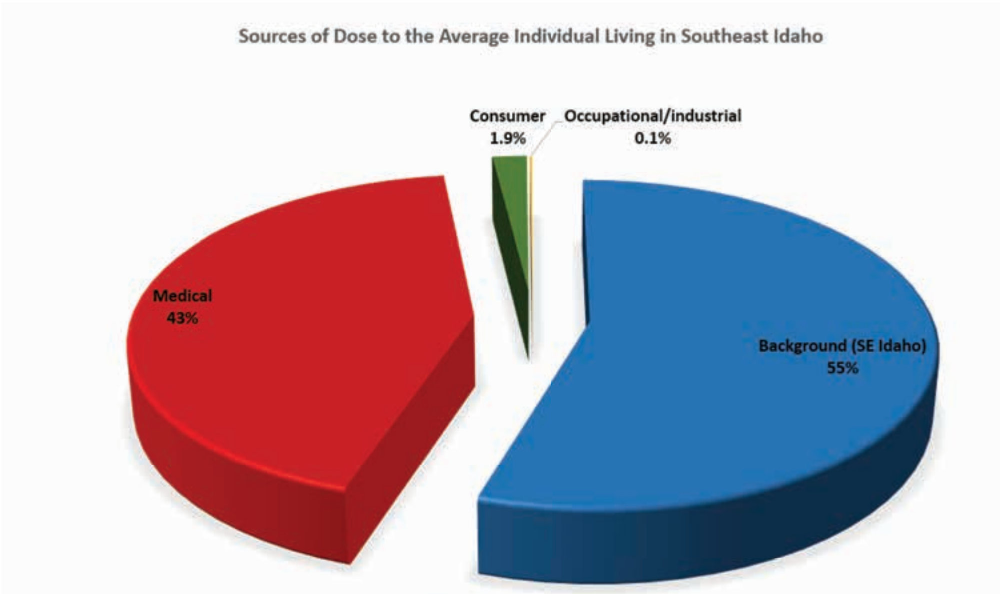
How are Data Represented Graphically?

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 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 7-7 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 2018. 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 radionuclides 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 ^{90}Sr measurements in two wells collected by USGS for 21 years (1998–2018). The results are plotted by year. The plot shows a decreasing trend with time.



	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.

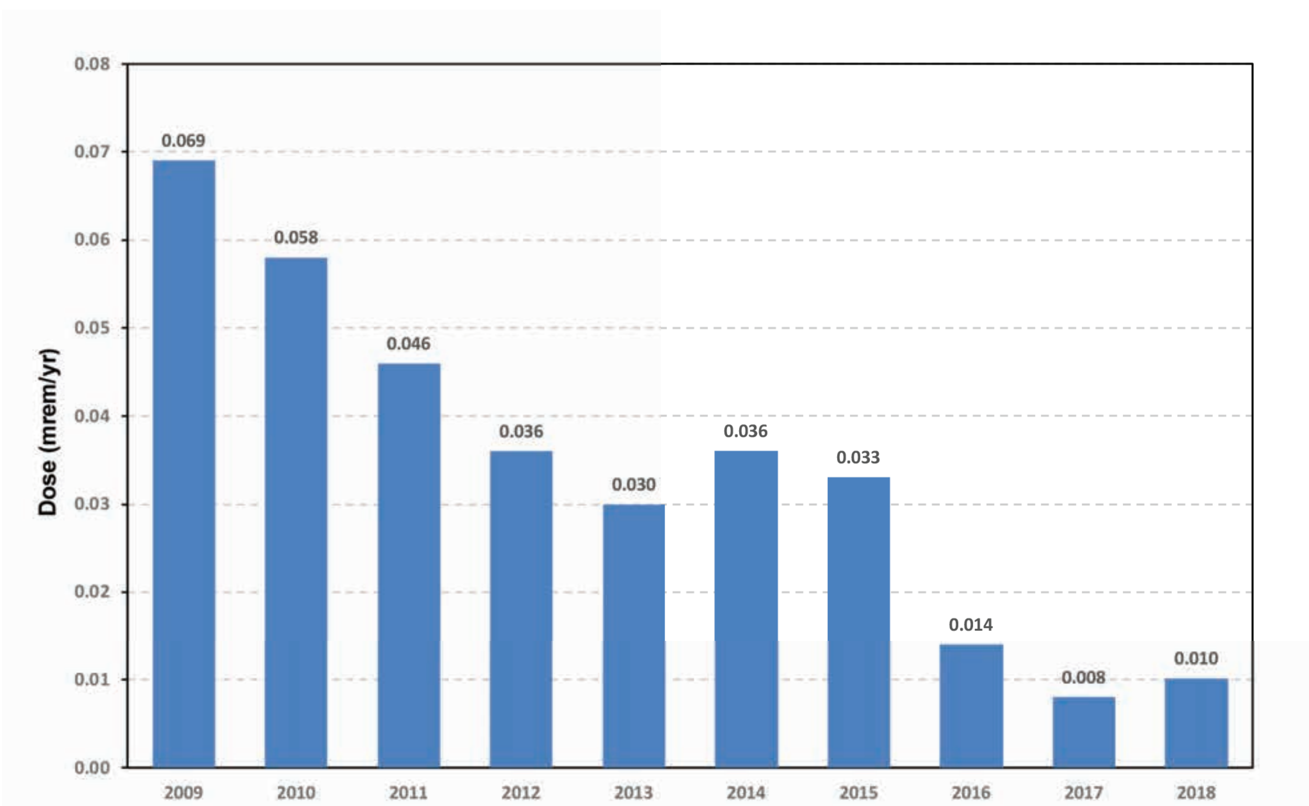


Figure HI-4. Data Plotted Using a Column Chart.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of ^{90}Sr in groundwater around 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 the radionuclide in groundwater from INTEC where it was 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 Idaho National Laboratory (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.

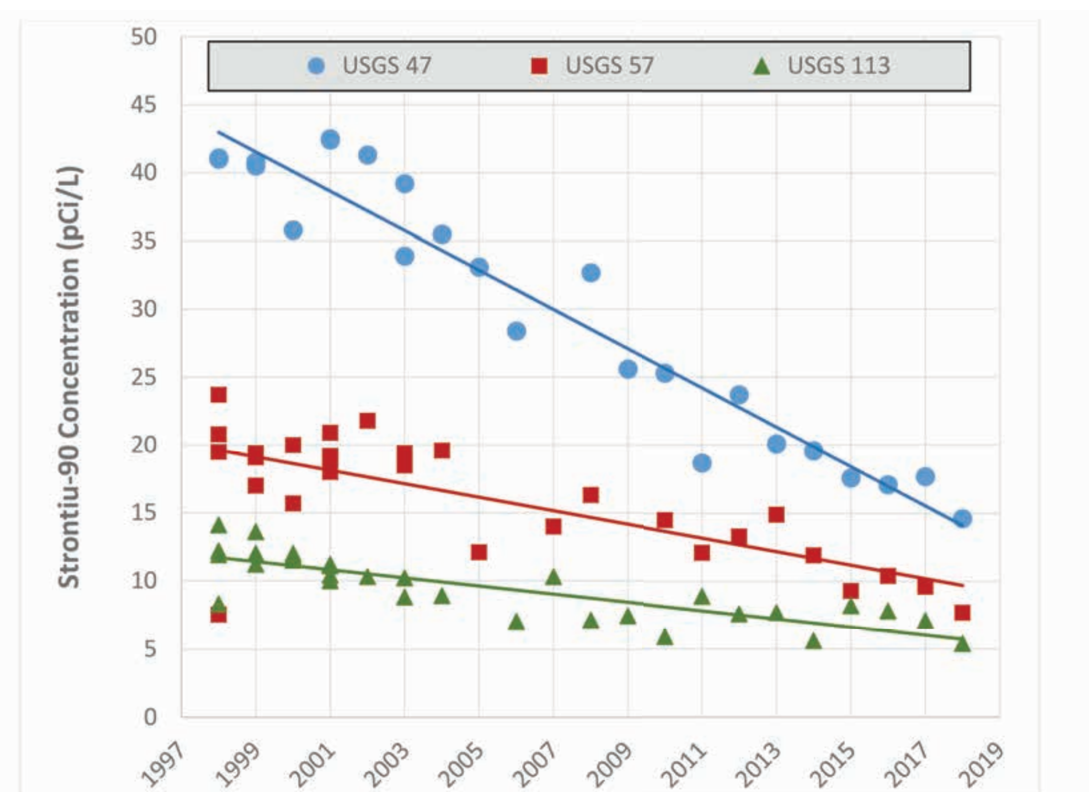


Figure HI-5. Data Plotted Using a Linear Plot.

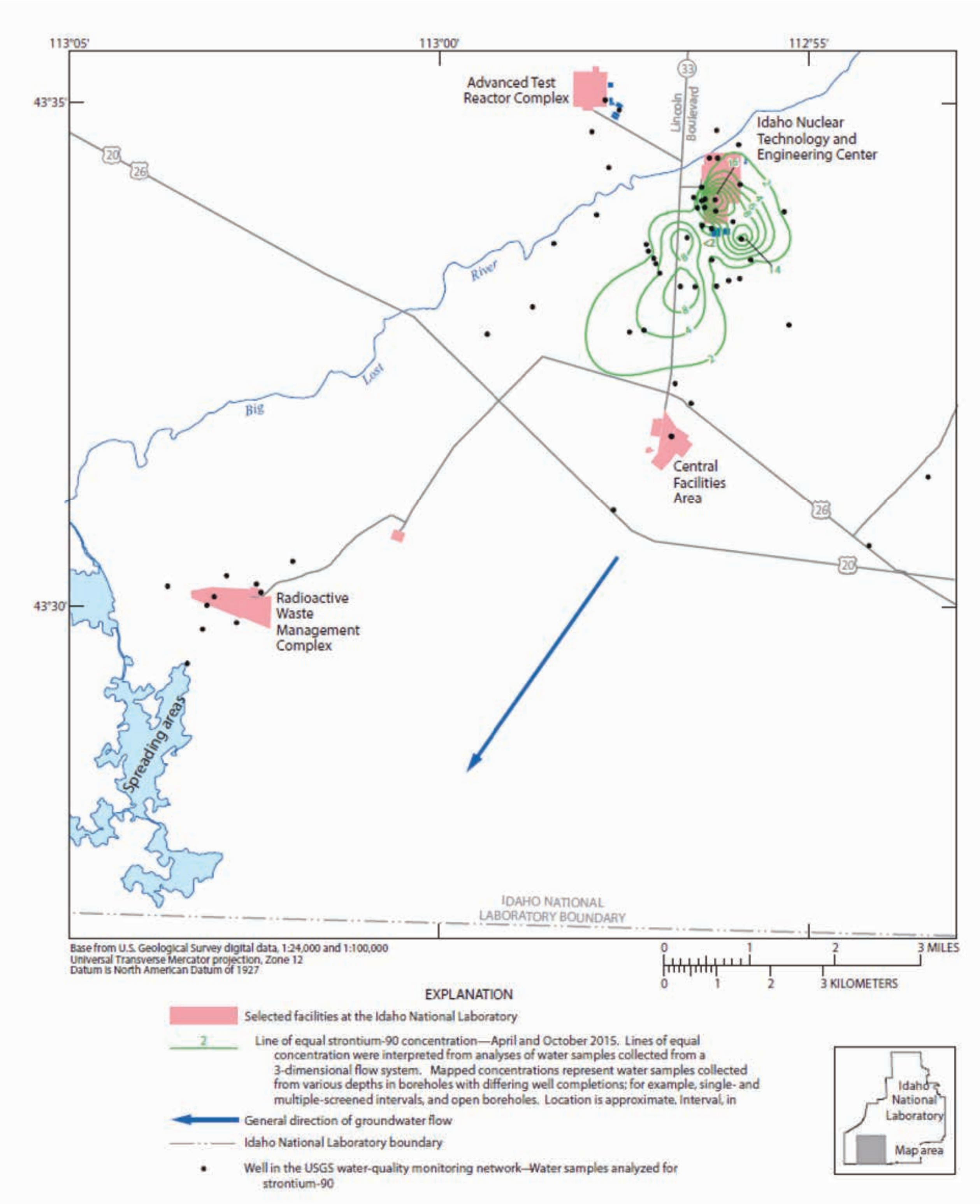


Figure HI-6. Data Plotted Using Contour Lines. *Each contour line drawn on this map connects points of equal strontium-90 concentration in water samples collected at the same depth from wells on the INL Site.*

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 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 2018 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, sodium-22 (^{22}Na), and carbon-14 (^{14}C). Cosmogenic

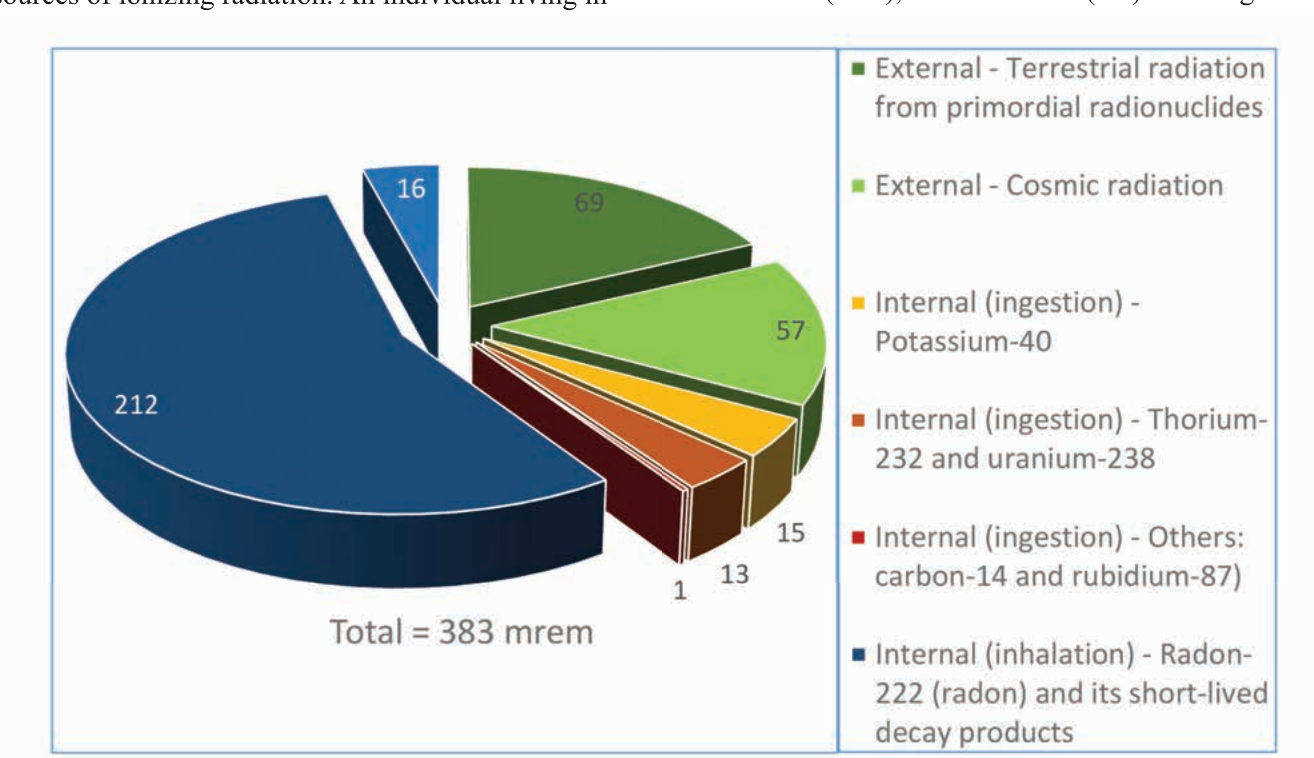


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2018).

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 that might be 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, 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).

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)	53.22 da	Cosmic rays	Rain, air
Tritium (^{3}H)	12.32 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.2516×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.405×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.468×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.455×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,600 yr	^{238}U progeny	Water

Global Fallout. The United States, the USSR, and China tested nuclear weapons in the atmosphere in the 1950s and 1960s. This testing resulted in the release of radionuclides into the upper atmosphere, and such a release 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 with the treaty. 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.

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 accumulate 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 assumed to be 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 and the National Council on Radiation Protection and Measurements. The International Commission on Radiological Protection is an association of scientists from many countries, including the United States. The National Council on Radiation Protection and Measurements 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.

A large amount of data exists concerning the effects of acute delivery (all at once) of high doses of radiation, especially in the range of 50 to 400 rem (0.5 to 4.0 Sv). Most of this information was gathered from the Japanese atomic bombing survivors and patients who were treated with substantial doses of X-rays. Conversely, information is limited and therefore it is difficult to estimate risks associated with low level exposure. Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. 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 while each radionuclide represents a somewhat different health risk. A 2011 report by the U.S. Environmental Protection Agency estimated a 5.8 x 10^{-2} Gy^{-1} cancer mortality risk coefficient for uniform whole-body exposure throughout life at a constant dose rate. Given a 1 gray (100 rad) ionizing radiation lifetime exposure this corresponds to 580 deaths, above normal cancer mortality rates, within an exposure group of 10,000 people. For low-linear energy transfer 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 six 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.

U.S. Department of Energy 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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Torrey's milkvetch (*Astragalus calycosus*)

Photo by: Kara Cafferty

Acronyms

ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ARP	Accelerated Retrieval Projects
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
BBS	breeding bird survey
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-IOP	Department of Environmental Quality – INL Oversight Program
DOE	U.S. Department of Energy
DOECAP-AP	DOE Consolidated Audit Program Accredited Program
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOSEMM	dose multi-media
DQO	data quality objective
DWP	Drinking Water Program
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor-I
EFS	Experimental Field Station
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
ESRP	Eastern Snake River Plain
ESER	Environmental Surveillance, Education, and Research
FFA/CO	Federal Facility Agreement and Consent Order
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GEL	GEL Laboratories, LLC
GP	Guiding Principles
GPRS	Global Positioning Radiometric Scanner
GWMP	Groundwater Monitoring Program
HAA5	haloacetic acids
HYSPLIT	Hybrid Single-particle Lagrangian Integrated Trajectory
IC	institutional control
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)
IRC	INL Research Center
ISB	in situ bioremediation
ISO	International Organization for Standardization
ISU-EAL	Idaho State University – Environmental Assessment Laboratory
IWTU	Integrated Waste Treatment Unit
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
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
MPLS	Males Per Lek Surveyed
NA	not applicable
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRF	Naval Reactors Facility
O&M	Operations & Maintenance
OSLD	optically stimulated luminescence dosimeter
PE	performance evaluation
PLN	plan
PWS	public water system
QA	Quality Assurance
QC	Quality Control
QSM	Quality System Manual
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
REST	Rest Stop
RI/FS	Remedial Investigation/Feasibility Study
RHLLW	Remote Handled Low-Level Waste Disposal Facility
RMA	Rocky Mountain Adventure
ROD	Record of Decision
RRTR	Radiological Response Training Range
RRTR-NTR	Radiological Response Training Range – Northern Test Range
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SGCA	Sage-grouse Conservation Area
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
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TREAT	Transient Reactor Experiment and Test Facility
TTHM	total trihalomethanes
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
VNSFS	Veolia Nuclear Solutions Federal Services
VOC	volatile organic compound
WAG	Waste Area Group
WIPP	Waste Isolation Pilot Plant
WMF	Waste Management Facility
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 (10^3) gram
km	kilometer (10^3) meter
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6}) curies
µg	microgram (10^{-6}) grams
µR	microroentgen (10^{-6}) roentgen
µS	microsiemen (10^{-6}) siemen
µSv	microsievert (10^{-6}) sievert
Ma	million years
mCi	millicurie (10^{-3}) curies
MeV	mega electron volt
mg	milligram (10^{-3}) grams
MG	million gallons
mGy	milligray (10^{-3}) gray
Ml	million liters
mi	mile
min	minute
mL	milliliter (10^{-3}) liter
mR	milliroentgen (10^{-3}) roentgen
mrad	millirad (10^{-3}) rad
mSv	millisievert (10^{-3}) sievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard
yr	year

Sunrise over East and Middle Buttes

Photo by: Peggy Scherbinske

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Horned Lark
Eremophila alpestris

1. Introduction

1. INTRODUCTION

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

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

The purpose of the report, as outlined in DOE O 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 O 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% 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% 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% of the INL Site is open to livestock grazing. Controlled hunting is permitted 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 21.5 cm/yr [8.45 in./yr]), warm summers (average daily temperature of 18.4°C [65.1°F]), and cold winters (average daily temperature of -7.4°C [18.7°F]), based on observations at Central Facilities Area from 1950 through 2017 (NOAA 2019). The altitude, intermountain setting, and latitude of the INL Site combine to produce a semi-arid 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. Over 400 different kinds (taxa) of plants have been recorded on the INL Site (Anderson et al. 1996). Vegetation is dominated by big sagebrush (*Artemisia tridentata*) with grasses and wildflowers beneath that have been adapted to the harsh climate. The INL Site is also home to many kinds of animals.

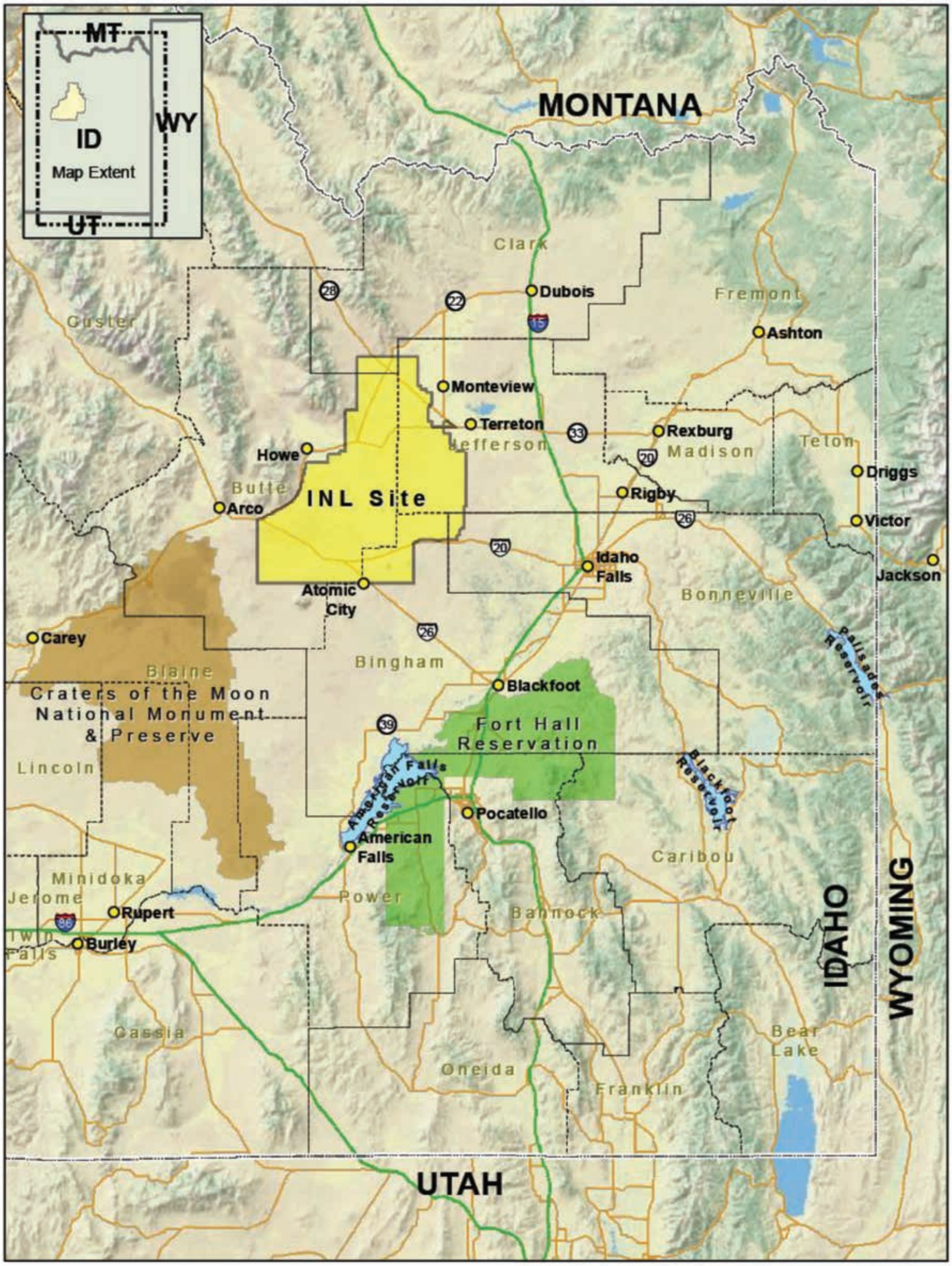

Figure 1-1. Location of the Idaho National Laboratory Site.

Vertebrate animals found on the INL Site include small burrowing mammals, snakes, birds, and several large mammals. 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 on the northwestern portion of the INL Site, called the Big Lost River Sinks. Here, the river evaporates or infiltrates to the subsurface, with no surface water moving off the INL Site. Normally the river bed is dry because of upstream irrigation and rapid infiltration into desert soil and underlying basalt (Figure 1-2). The river rarely flows onto the INL Site. Good carry over of water in the Mackay Reservoir paired with a large snowpack and above-normal water levels behind the Mackay Reservoir allowed the river to flow onto the INL for most of 2018 and fill the Big Lost River Sinks (Figure 1-2). River samples were collected in both 2017 and 2018 after being mostly dry since 2012.

Fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-3), which stretches 320 km (199 mi) from Island Park to King Hill, which is 9.7 km (6 mi) northeast of Glenns Ferry 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 Henrys 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). This 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, a series of giant, caldera-forming eruptions occurred, 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 and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed to relocate the native population to the Fort Hall Reservation. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

In 1901 a railroad was opened between Blackfoot and Arco, Idaho. 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 build 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

Figure 1-2. Big Lost River. *Dry riverbed in 2016 (upper). Flowing river in May 2017 (lower).*

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. Atomic Energy Commission, needed an isolated location with ample groundwater supply on which to build and test nuclear power reactors. In 1949, the Naval Proving Ground became the National Reactor Testing Station.

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.

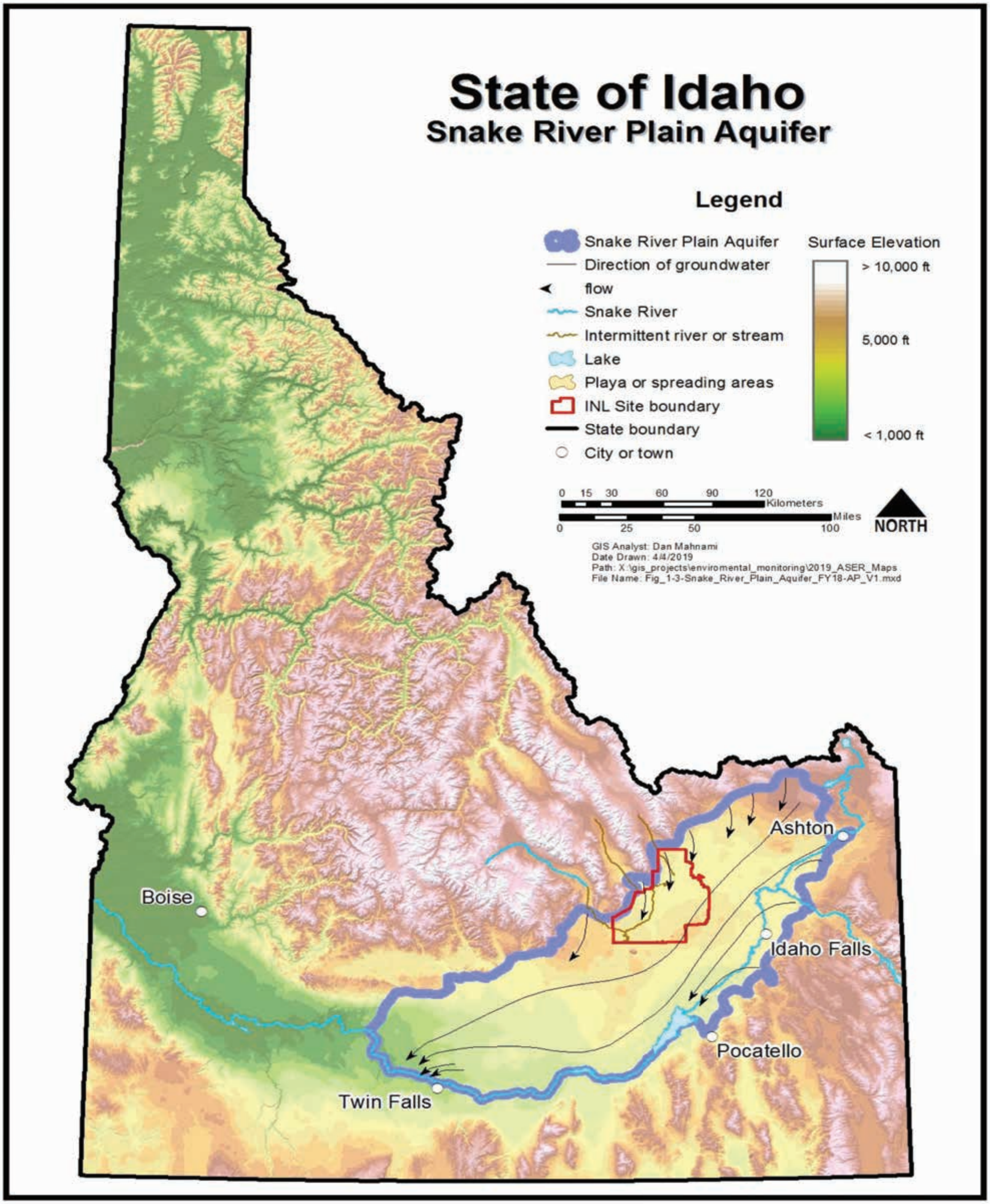

Figure 1-3. INL Site Relation to the Eastern Snake River Plain Aquifer.

Common Nighthawk
Chordeiles minor

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. On February 1, 2005, Battelle Energy Alliance took over operation of the laboratory, merged with Argonne National Laboratory-West, and the facility name was changed to Idaho National Laboratory. At this time the site's cleanup activities were moved to a separate contract, the Idaho Cleanup Project, which is currently managed by Fluor Idaho, LLC. Research activities, which include projects other than nuclear research such as National and Homeland Security projects, were consolidated in the newly named Idaho National Laboratory.

1.4 Human 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 337,643. Over half of this estimated population (180,806) resides in the census divisions of Idaho Falls (112,013) and northern Pocatello (68,793). Another 30,969 are projected to live in the Rexburg census division. Approximately 21,692 are estimated to reside in the Rigby census division and 15,974 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 discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure. Its vision is to change the world's energy future and secure our nation's critical infrastructure. 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 National Scientific User Facility, 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 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. Fluor Idaho, LLC, is responsible for the ICP Core.

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 (DOE 1991), which governs the cleanup of contaminant releases to the environment; and the 1995 Idaho Settlement Agreement (DOE 1995), 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; treating high-level waste calcine; treating both remote- and contact-handled transuranic waste for disposal at the Waste Isolation Pilot Plant in New Mexico; 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 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 1-4). 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 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 startup 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 Fluor Marine Propulsion Corporation.

As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE O 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

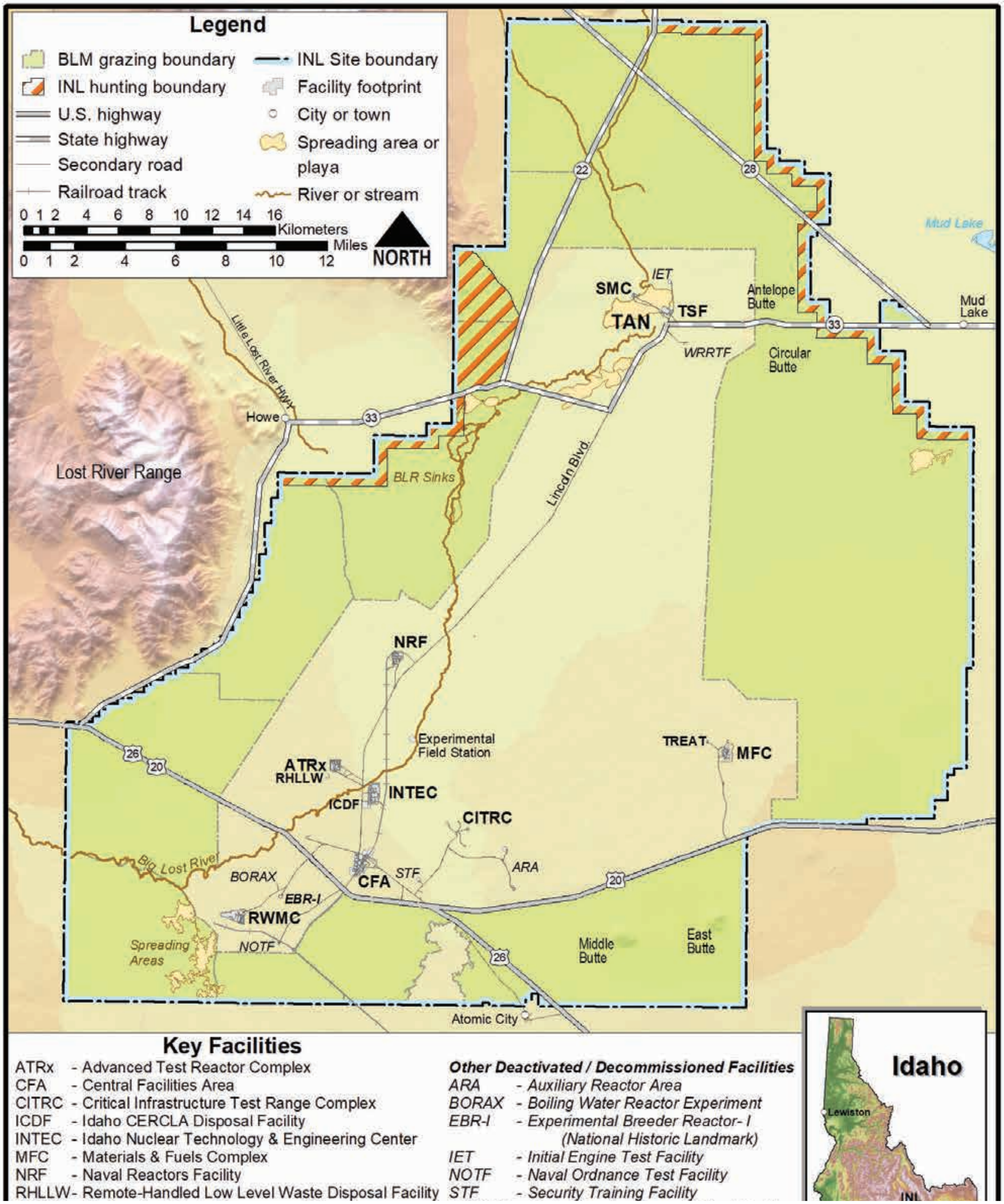

Figure 1-4. Location of the Idaho National Laboratory Site, Showing Facilities.

the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2018).

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 the Waste Isolation Pilot Plant.

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. 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 Scientific 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. 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. In 2018, the Idaho Board of Education and INL will begin construction of two new research facilities: the Cybercore Integration Center and the Collaborative Computing Center. 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 ensure key DOE missions are completed in a safe and environmentally responsible manner. By ensuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, RESL ensures 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 Idaho Cleanup Project 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 (DEQ). 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 https://www.energy.gov/em/icpcab.

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 (ESER) contractor; Shoshone-Bannock Tribes; the state of Idaho 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 Site-wide water programs: drinking water, wastewater, storm water, and groundwater. The committee includes monitoring personnel, operators, scientists, engineers, management, data entry, and validation representatives of the DOE-ID, INL Site contractors, U.S. Geological Survey, and NRF. The committee 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 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 Idaho DEQ was signed September 2015. The 2015 version is the latest in a succession of agreements that were first implemented in 1990. 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 ESER program provides the DOE-ID 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 2018, ESER created and presented educational programs to over 15,000 students in their classrooms. Presentations covering 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, INL contractor, ICP Core contractor, and other businesses and agencies to present community outreach programs including Earth Day, Idaho Wild and Wonderful River Day, STEM Day at the Zoo, and the Idaho Falls Water Festival.

The ESER Education Program, the Museum of Idaho, and Boise State University 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 Idaho State University credit: 1) Contrast: Idaho Mountains and Deserts, 2) Wonderful Wetlands, 3) Water of the West (river and stream habitats), and 4) Energy Sources.

An additional teachers' workshop through Boise State University was initiated in 2017 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: 1) Idaho Geology, 2) Idaho Weather, 3) Idaho Plants, and 4) 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 2018, the ESER Program also partnered with the Idaho Falls Zoo to present a teacher workshop called "Exotics and Natives in Idaho." The ESER Program presented native Idaho animals and their adaptations to life in this sagebrush-steppe desert. The zoo personnel presented exotics living at the Idaho Falls Zoo and adaptations to their native habitat. Teachers learned skills to compare and contrast characteristics from these animals and were given tools to teach their students these skills in accordance with Idaho State Science Standards (Figure 1-5).

In 2018, the ESER Education Program participated in the Idaho iSTEM Conference at Eastern Idaho Technical College (now College of Eastern Idaho). As well as working on the organizing committee, ESER 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 ESER Program and Idaho DEQ, 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 week long summer camp for children in Grades 4–9 is designed to provide an appreciation for and understanding of southeastern Idaho's native habitats (Figure 1-6). 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 2018 was sponsored by the ESER Program, the Post Register and INL. 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

Figure 1-5. STEM Day at the Zoo, Organized by the Idaho Falls Zoo.

Figure 1-6. Wild and Scenic Rivers Day at the Conant Valley Boat Dock, Organized by Idaho BLM.

and adults. An archive of questions and answers may be found on the ESER website: www.idahoeser.com/nie and a blog at www.idahoaskascientist.com.

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Blue Flax (*Linum lewisii*)
Photo Credit: Peggy Scherbinske

Sage Thrasher
Oreoscoptes montanus

2. Environmental Compliance Summary

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. Forty-nine environmental permits have been issued to the INL Site, primarily by the state of Idaho. There were no reportable environmental releases at the INL Site during calendar year 2018. In 2018, DOE Idaho (DOE-ID) operated in compliance with most of the requirements defined in governing documents. Instances of noncompliance were reported to regulatory agencies and resolved. Significant environmental compliance issues/actions in 2018 include:

- DOE-ID worked on three environmental assessments (EAs) in 2018 in compliance with the National Environmental Policy Act. Development continued from previous years on the Environmental Assessment for the Expansion of Capabilities at the National Security Test Range and Radiological Response Training Range at the Idaho National Laboratory. Development of the Environmental Assessment for the Expansion of Capabilities at Idaho National Laboratory Power Grid Test Bed was initiated. DOE-ID started and completed the Environmental Assessment for the Use of DOE-Owned High-Assay Low-Enriched Uranium Stored at Idaho National Laboratory (DOE/EA-2087) resulting in a Finding of No Significant Impact.
- Environmental restoration continued in 2018 at four active Waste Area Groups (WAGs). Six WAGS were previously remediated per the Federal Facility Agreement and Consent Order (FFA/CO) signed by the U.S. Department of Energy, Idaho Operations Office, U.S. Environmental Protection Agency and the State of Idaho in 1991. The FFA/CO outlines how the INL Site will comply with the Comprehensive Environmental Response, Compensation, and Liability Act.
- The FFA/CO requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. In 2018, two INL Site Treatment Plan (STP) milestones were met – Remote Handled Waste Disposition Project (24 m^3 [31.4 yd^3]) and Sodium Components Maintenance Shop Backlog (2 m^3 [2.6 yd^3]).
- During 2018, four INL STP milestones were not met. Due to unplanned events at the Waste Isolation Pilot Plant (WIPP) in 2014 and associated continuing impacts to the Idaho Cleanup Project (ICP) Core's waste certification authority, the "original volume transuranic contaminated waste" treatment milestone of 4,500 m^3 (5,886 yd^3) and the treatment of the remaining volume were not achieved in 2018. The original estimated volume of the transuranic waste at the INL Site was 65,000 m^3 (85,016 yd^3) and the total cumulative volume of transuranic waste shipped out of Idaho, as of December 2018, is 58,718 m^3 (76,800 yd^3). Additionally, the two treatment milestones for the sodium bearing waste could not be met due to several vital technical issues.
- The Integrated Waste Treatment Unit, designed to process liquid waste stored at the Idaho Nuclear Technology and Engineering Center (INTEC) by the end of 2012, has still delayed startup due to various technical problems.
- The state of Idaho Department of Environmental Quality (DEQ) has authority to implement the Clean Air Act. In 2018 the state conducted three onsite regulatory inspections and concluded that the facilities are operating in compliance with permit conditions and requirements.
- The Idaho DEQ has promulgated Safe Drinking Water Act regulations. Nine active drinking water systems at INL Site facilities were sampled according to these regulations and were well below regulatory limits for drinking water.
- Measurements of radionuclides in environmental media sampled on and around the INL Site in 2018 did not exceed Derived Concentration Standards established in DOE Order 458.1, "Radiation Protection of the Public and the Environment."

- 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 Site Sustainability program implements sustainability strategies and practices that will meet key DOE sustainability goals, including: reduce greenhouse gas (GHG) 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. Doe Idaho Operations Office reported performance to sustainability related requirements and goals in the 2018 INL Site Sustainability Plan.
- In 2018, 29 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 56 proposed activities.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the U.S. Department of Energy (DOE) 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 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, which 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 (WAGs) (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 regarding 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 can then 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/FSs 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 2017). The status of ongoing

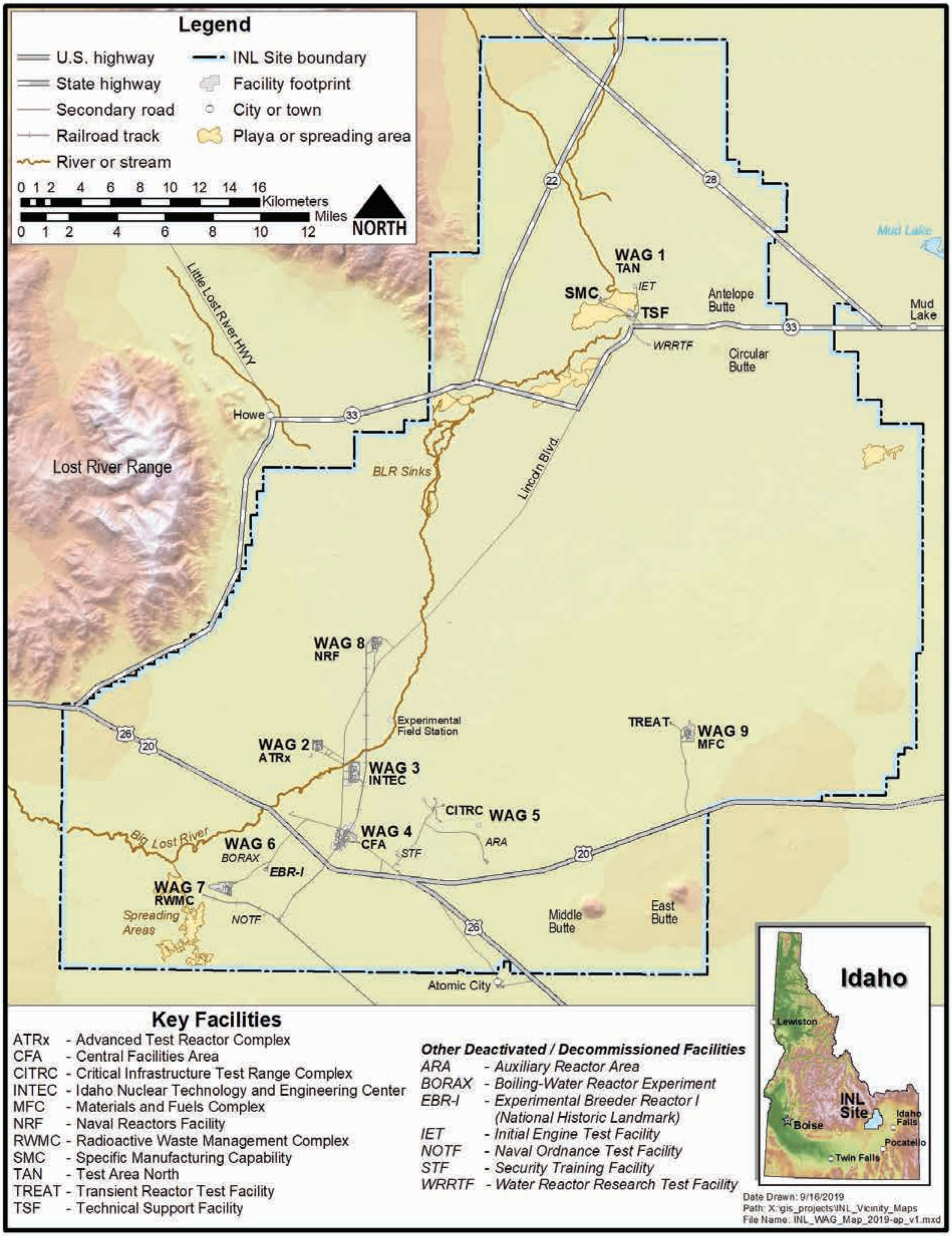

Figure 2-1. Map of INL Site Showing Facilities and Corresponding WAGs.

active remediation activities at WAGs 1, 3, 7, and 10 is 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 Code of Federal Regulations (CFR) 270.13. Part B of the RCRA hazardous waste permit application contains detailed, site-specific information as described in applicable sections of 40 CFR 262 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 that comprises several volumes.

RCRA Reports. As required by the state of Idaho, the INL Site submitted the 2018 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. There were no closure activities completed in 2018.

RCRA Inspection. For Fiscal Year (FY) 2018, there were no DEQ RCRA inspections of the INL Site.

RCRA Consent Order. On January 6, 2017, due to DOE's inability to meet commitments to initiate waste treatment in the Integrated Waste Treatment Unit (IWTU) and cease use of the INTEC tanks, DEQ assessed a penalty to DOE pursuant to the provisions under Section VII of the Fifth Modification to the Notice of Noncompliance-Consent Order, in the amount $2,190,000 for the period of noncompliance from March 30, 2017, to March 31, 2018. Supplemental Environmental Projects were utilized in lieu of the payment.

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 - 1508; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Policy 451.1, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. In 2018, DOE-ID worked on the preparation of three environmental assessments. Development continued from the previous year on the Environmental Assessment for the Expansion of Capabilities at the National Security Test Range and Radiological Response Training Range at the Idaho National Laboratory, and development was started on the Environmental Assessment for the Expansion of Capabilities at Idaho National Laboratory Power Grid Test Bed with completion expected in 2019. DOE-ID started and completed the *Environmental Assessment for the Use of DOE-Owned High-Assay Low-Enriched Uranium Stored at Idaho National Laboratory* (DOE/EA-2087) resulting in a Finding of No Significant Impact.

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 the TSCA is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls. For example, polychlorinated biphenyls-containing light ballasts are being removed at buildings undergoing demolition. The ballasts are disposed of off the INL Site at a TSCA-approved disposal facility.

2.1.5 INL Site Agreements

The FFA/CO 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 FFA/CO and Site Treatment Plan was signed by the state of Idaho on November

Table 2-1. 2018 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 2018. 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 revised test plan was 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. During 2017, a new well was constructed to better monitor the plume at its distal edge. All institutional controls (IC) and operations and maintenance (O&M) requirements were maintained during 2018.
3	Idaho Nuclear Technology and Engineering Center	The Idaho CERCLA Disposal Facility (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 the ICDF Complex Operational and Monitoring Sampling and Analysis Plan, and results are sent to the EPA and the state of Idaho DEQ. Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately nine 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 ICs and O&M requirements were maintained in 2018. An interim low-permeability asphalt barrier was 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 Idaho Nuclear Technology and Engineering Center (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 2-2). 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

Table 2-1. 2018 Status of Active WAGs Cleanup. (cont.)

Waste Area Group	Facility	Status
		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 DOE 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. Various types 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 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 of in the SDA. The Operable Unit 7-13/14 ROD (DOE/ID-11359, [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 2018, 8,821 m^3 (11,538 yd^3) of targeted waste has been retrieved and packaged from a combined area of 2.0 hectares (4.94 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	Operable Unit 10-04 addresses long-term stewardship functions—ICs and O&M for sites that do not qualify for Unlimited Use/Unrestricted Exposure—and explosive hazards associated with historical military operations on the INL Site. All ICs and O&M requirements were maintained in 2018, under the Site-wide IC/O&M Plan. A CERCLA

Table 2-1. 2018 Status of Active WAGs Cleanup. (cont.)

Waste Area Group	Facility	Status
	RI/FS	five-year review was 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 2018 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

1, 1995, and is updated annually (DEQ 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.

During 2018, two *Idaho National Laboratory Site Treatment Plan* (ICP 2017) milestones were met:

- Remote Handled Waste Disposition Project – 24 m³ (31.4 yd³)
- Sodium Components Maintenance Shop Backlog – 2 m³ (2.6 yd³).

During 2018, four Site Treatment Plan milestones were not met. The state of Idaho DEQ was notified that due to unplanned events at the Waste Isolation Pilot Plant (WIPP) and associated continuing impacts to the Idaho Cleanup Project (ICP) Core's waste certification authority, the "original volume transuranic contaminated waste" treatment milestone of 4,500 m³ (5,886 yd³) and the treatment of the remaining volume would not be achieved. Additionally, DEQ was notified that the treatment milestones for the sodium bearing waste would not be met due to a number of vital technical issues.

On October 16, 1995, DOE, the U.S. Navy, and the state of Idaho entered into an agreement (aka Idaho Settlement Agreement [ISA]) that guides management of Spent Nuclear Fuel (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.

The Site Treatment Plan and the ISA require DOE to process and ship all waste, respectively, stored as transuranic waste on the INL Site in 1995, when the agreements were signed, out of Idaho by December 31, 2018. The estimated volume of that waste was 65,000 m³ (85,016 yd³).

In February 2014, the shipment of transuranic waste was curtailed due to the suspension of the WIPP operations in Carlsbad, New Mexico. In April of 2017, shipments resumed to WIPP. In 2018, 208 shipments of the transuranic waste were shipped to WIPP, for a total of 488 m³ (638 yd³). The ISA includes a requirement to ship an annual three-year running average of 2,000 m³ (2,616 yd³) of that waste out of the state. The annual three-year running average of ISA transuranic waste shipped out of Idaho over the past three years was 2,050 m³ (2,681 yd³). Through December 2018, the cumulative volume of the transuranic waste shipped out of Idaho is 58,718 m³ (76,800 yd³).

The ICP Core manages and operates a number of projects to facilitate the disposition of radioactive waste as required by the ISA and Site Treatment Plan. The Advanced Mixed Waste Treatment Project (AMWTP) performs retrieval, characterization, treatment, packaging, and shipment of transuranic waste currently stored at the INL Site. The vast majority of the waste processed at AMWTP Project resulted from the manufacture of nuclear components at DOE's Rocky Flats Plant in Colorado. This waste is contaminated with transuranic radioactive elements (primarily plutonium).

The DOE and ICP Core contractor, Fluor Idaho, LLC, continue a four-phased approach to startup of the IWTU, designed to process the remaining 3,407,000 L (900,000 gal) of liquid waste stored at the INTEC. These wastes are stored in three stainless steel, underground tanks 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. The waste was originally scheduled to be processed by the end of 2012, but a number of technical problems have delayed startup of IWTU.

Fluor Idaho assembled a team of nationwide experts on fluidized bed technology to resolve issues with the IWTU identified during startup testing. The four-phased approach includes: implementing design and mechanical modifications; testing and verifying the changes; eventually operating the facility; and completing processing of the remaining liquid waste.

2.1.6 Low-Level and Mixed Radioactive Waste

In 2018, approximately 2,115 m^3 (2,766 yd^3) of mixed low-level waste and 1,205 m^3 (1,576 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 53.23 m^3 (69.62 yd^3) of newly generated, low-level waste was disposed of at the SDA in 2018 (Figure 2-2).

2.1.7 Spent Nuclear Fuel

Spent Nuclear Fuel (SNF) is nuclear fuel that has been withdrawn from a nuclear 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 ICP

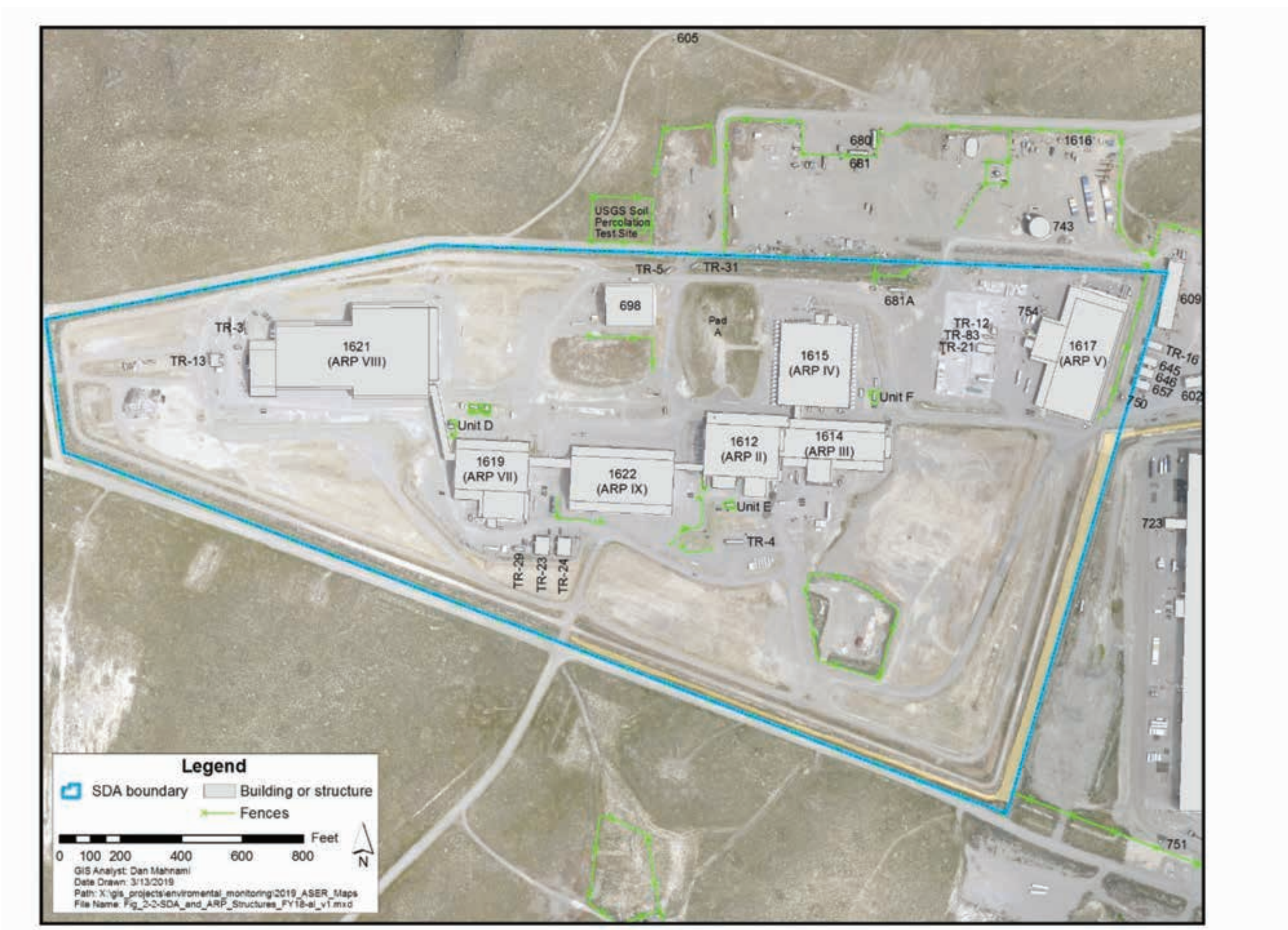

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2017).

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).

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

- 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, and several amendments containing key pieces of legislation have been passed with the latest in 1990, which resulted in the current CAA law. The CAA provides the EPA with broad authority to implement and enforce regulations to reduce air pollutant emissions with emphasis on cost-effective methods. In addition to EPA, states, tribes and local governments play a key role in the implementation of the CAA. The state of Idaho has been delegated authority to implement the CAA through the development of an EPA-approved state implementation plan.

During Calendar Year 2018, DEQ conducted three onsite regulatory inspections, which covered compliance for facility-specific Permits to Construct and the Tier I Operating Permit. The inspections concluded that the facilities were operating in compliance with permit conditions and requirements. The INL Site submitted a permit application to DEQ for a synthetic minor permit with a facility emission cap, which would change the INL Site's designation from a major source to an area source and replace the Tier I Operating Permit (Table 2-2). The permit was issued January 11, 2018.

Table 2-2. Environmental Permits for the INL Site (2018).

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

a. Part A and B are considered a single RCRA Permit that comprises 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 as well as regulating water quality standards for surface water. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES) permit program, requiring permits for discharges into regulated surface waters. The Idaho DEQ has been authorized by the EPA to assume permitting authority over the NPDES program. The DEQ program, called the Idaho Pollutant Discharge Elimination System (IPDES) is being implemented in a phased approach. DEQ assumed responsibility over Publicly-Owned Treatment Works (POTWs) and the EPA pretreatment program on July 1, 2018.

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 IPDES permit program to set pretreatment standards for nondomestic discharges to POTWs. 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 2018 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 establishes rules governing the quality and safety of drinking water. The Idaho DEQ promulgated the Safe Drinking Water Act regulations 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 5 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 that provides moisture and nutrients to vegetation, and it provides recharge to groundwater.

To protect health and prevent pollution of surface and groundwaters, 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 58.01.11 "Ground Water Quality Rule." All wastewater reuse permits consider site-specific conditions and incorporate water quality standards for groundwater protection. The following facilities have wastewater reuse permits at the INL Site to land apply wastewater:

- ATR Complex Cold Waste Ponds
- INTEC New Percolation Ponds
- MFC Industrial Waste Ditch and Industrial Waste Pond.

Chapter 4 contains details on wastewater reuse monitoring.

2.4 DOE Order 436.1 Departmental Sustainability

An Environmental Management System (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 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 requirements of DOE O 436.1, "Departmental Sustainability," which requires DOE sites to use their EMS as a platform for Site Sustainability Plan implementation. Sites must maintain their EMS as being certified or conforming to the ISO 14001 standard in accordance with the accredited registrar provisions or self-declaration instructions. In 2015, ISO released a new standard, ISO 14001:2015, which replaced the ISO 14001:2004 standard with implementation of the new standard by October 2018.

The two main INL Site contractors have established EMSs for their respective operations. The INL Site management and operating contractor, Battelle Energy Alliance (BEA), underwent a recertification audit in 2017 by an accredited registrar. In 2018, BEA had two surveillance audits. The May surveillance audit resulted in no nonconformities, one opportunity for improvement, and six system strengths; while the November surveillance audit resulted in no nonconformities, one opportunity for improvement, and nine system strengths. Both surveillance audits found the INL EMS in conformance with ISO 14001:2015 and recommended continued certification. The INL Environmental Policy can be found at: https://www.inl.gov/wp-content/uploads/2017/11/16-50070-R4_ENV_Policy_WEB-1.pdf.

The ICP Core contractor, Fluor Idaho, LLC, underwent a certification audit in 2017 by an accredited registrar. In 2018, Fluor Idaho had a surveillance audit in May that resulted in no nonconformities, two opportunities for improvement, and five system strengths. The surveillance audit found the Fluor Idaho EMS in conformance with ISO 14001:2015 and recommended continued certification. The Idaho Cleanup Project Core Environmental Policy can be found at: https://fluor-idaho.com/Content/documents/Community/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 groundwater; disturbing cultural or biological resources; generating and managing waste; releasing contaminants; and using, reusing, recycling, and conserving resources.

Both INL Site contractors had generally effective EMS performance in 2018. BEA completed 96% of EMS objectives in FY 2018. Fluor Idaho completed 45% of EMS objectives in FY 2018, although several additional objectives were completed shortly after the fiscal year. Both INL Site contractors' EMS performance metrics reported at FedCenter scored either A or B (on an A to D scale), and both contractors received a FedCenter site score of green (the best) which focuses on sustainability goals.

2.4.1 Sustainability

Executive Order (EO) 13834, "Efficient Federal Operations," was signed on May 17, 2018, which revoked EO 13693, "Planning for Federal Sustainability in the Next Decade," and directed agencies to meet statutory requirements related to energy and environmental performance in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. DOE O 436.1, "Departmental Sustainability," defines requirements and responsibilities for managing sustainability at DOE to ensure that the department carries out its missions in a sustainable manner.

DOE-ID reported performance to sustainability related requirements and goals in the FY 2019 INL Site Sustainability Plan (Table 2-3). The performance status listed in Table 2-3 relates to the goals as stated in EO 13693, with the understanding that pending Office of Management and Budget guidance implementing EO 13834 may change the sustainability requirements and goals.

Overall, the INL performance for 2018 met statutory requirements with the exception of energy intensity reduction, currently down 15% to the 2003 baseline, with a requirement of 30% that was to be achieved by 2015. Progress was made in FY 2018 on energy efficiency upgrades, but many identified energy-saving projects require significant investment and have not been deemed cost-effective considering low electric rates. INL will continue to implement cost-effective improvements when identified.

Energy and water evaluations required by Energy Independence and Security Act Section 432 are on track for completion during the current four-year cycle.

The INL did not retrofit additional buildings to meet the Guiding Principles (GP) in 2018. To date, the INL has achieved the GP at 18 of the 26 buildings needed to meet the goal by 2025. INL completed a significant building metering project, which will assist with docu-

Table 2-3. Summary Table of DOE-ID Sustainability Goals.

Prior DOE-ID Goal	Current Performance Status
Multiple Categories	
50% Scope 1 and 2 greenhouse gas emissions reduction by FY 2025 from a FY 2008 baseline.	Current performance pending data
Energy Management	
25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline.	INL energy intensity is 153,995 Btu/ft^2, a decrease of 15.8% from FY 2003
Energy Independence and Security Act Section 432 continuous (four-year cycle) energy and water evaluations.	INL completed energy and water evaluations in 28 buildings in FY 2018. For the second four-year audit cycle (June 1, 2016, through May 31, 2020) 63 audits have been completed.
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	INL meters 100% of its natural gas and 68.3% of its electric usage at the building level.
Water Management	
36% potable water intensity (gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline.	INL water intensity is 134.7, a decrease of 22.5 from FY 2007
Waste Management	
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	INL diverted 51.6% of its non-hazardous solid waste in FY 2018 by recycling 1,511,490 lb (685.6 MT) of materials.
Divert at least 50% of construction and demolition materials and debris.	INL diverted 66.1% (44,296,828 lb. or 20,902.7 MT) of its construction and demolition waste in FY 2018.
Fleet Management	
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter.	INL petroleum consumption was 587,007 gal, a reduction of 37% relative to FY 2005.
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	INL alternative fuel consumption was 282,470 gal in FY 2018, an increase of 270% over FY 2005.
Clean and Renewable Energy	
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	INL procured 18,737 MWh of renewable energy credits (RECs) from Idaho Falls Power at a total cost of $31,852. This purchase of new RECs, in addition to the 182 MWh of onsite generation (onsite generation from the solar walls, micro-grid, and small photovoltaic systems) totals 18,918 MWh (8.7%) of renewable energy for FY 2018.
Green Buildings	
At least 17% (by building count) of existing	At the end of FY 2018, 18 DOE-owned buildings

Table 2-3. Summary Table of DOE-ID Sustainability Goals. (cont.)

Prior DOE-ID Goal	Current Performance Status
buildings greater than 5,000 gross square feet to be compliant with the revised Guiding Principles for High Performance and Sustainable Buildings by FY 2025, with progress to 100% thereafter.	were compliant with the Guiding Principles, which represents 12% of INL buildings meeting the Guiding Principles.
Acquisition and Procurement	
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring bioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	INL reports indicate 97.7% of the contracts in FY 2018 contained applicable clauses. INL made improvements when incorporating requirements through effective implementation of procedures, clauses, policies, and enhanced work processes that increase the visibility, availability, and use of sustainable products.
Measures, Funding and Training	
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of EO 13693.	No additional Energy Savings Performance Contract projects were developed in FY 2018.
Electronic Stewardship	
Purchases – 95% of eligible acquisitions each year are Electronic Project Environmental Assessment Tool -registered products.	INL achieved 91.2% of eligible electronics acquisitions meeting Electronic Project Environmental Assessment Tool standards in FY 2018
Power management – 100% of eligible personal computers (PCs), laptops, and monitors have power management enabled.	Power management controls are in place on all eligible computer systems. At INL, 100% of eligible PCs, laptops, and monitors have power management controls.
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	At the end of FY 2018, 100% of managed INL equipment has duplex printing enabled, where possible.
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	At the end of FY 2018, 100% of managed INL equipment has duplex printing enabled, where possible.
Data Center Efficiency. Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	The Engineering Research Office Building High-Performance Computing core data center had a power usage efficiency of 1.39 in FY 2018.
Organizational Resilience	
Discuss overall integration of organizational resilience in emergency response, workforce, and operations procedures and protocols.	INL emergency plans and emergency plan implementing procedures were reviewed and revised, as necessary. Operating policies and procedures were evaluated to determine whether they should be modified to consider organizational risks.

menting the GPs in 13 targeted buildings by FY 2024. Overall, INL's established plan to meet the FY 2025 goal is on track.

2.5 Other Environmental Statutes

2.5.1 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 support 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 (see Chapter 8). Particular emphasis is given to threatened and endangered species and species of special concern identified by the U.S. Fish and Wildlife Service (FWS) and Idaho Department of Fish and Game.

One species that may occur on the INL Site has been categorized under the ESA. On October 3, 2014, the FWS determined threatened status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (*Coccyzus americanus*) (https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=3911). The rare species is known to breed in river valleys in southern Idaho, but has only been observed once near the INL Site at Atomic City.

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 (*Gulo gulo 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.

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* (DOE-ID and USFWS 2014) 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 (*Pseudogymnoascus 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 lucifugus*) 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 developed a Bat Protection Plan for the INL Site (DOE-ID 2018). The Bat Protection Plan allows the INL Site to proactively position itself to continue its missions if there is an emergency listing of a bat species due to WNS. The Plan is based upon monitoring data and other current knowledge of bat populations on the INL Site. Bat monitoring is discussed further in Chapter 8.

2.5.2 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. DOE-ID has 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. The permit also authorizes possession, salvage, and disposition of migratory birds killed through incidental take (mainly collisions with vehicles, windows, and other structures).

DOE-ID exercised the permit once in 2018. On July 9, 2018, an employee opened a roll up door on the side of a building, did not see a Barn Swallow nest attached to the door, and accidentally knocked the nest down. Up to three eggs were estimated to have been in the nest at the time of destruction. DOE-ID reported the event to FWS on July 10, 2018. As required by the permit, DOE-ID submitted an annual report to FWS by January 31, detailing reportable activities related to migratory birds. There were numerous salvage actions tracked, documented, and reported in compliance with permit requirements.

DOE-ID and INL Site contractors have permits from the state of Idaho to manage migratory birds and to collect other wildlife specimens for scientific research. The permits allow for the collection of bat carcasses and sampling of big game animal carcasses found on the INL Site, and for active harvest of waterfowl from INL Site wastewater ponds (the INL contractor also has a Special Purpose Permit that allows waterfowl collection). The animal samples are analyzed for radionuclides. Wildlife sampling and analysis is further discussed in Chapter 6.

2.5.3 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 2018.

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 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. In Calendar Year 2018, the chemical inventory report included 76 individual chemicals at INL Site facilities and nine at Idaho Falls facilities. Extremely hazardous substances ammonia, cyclohexylamine, lithium hydride, nitric acid, nitrogen dioxide, and sulfuric acid were among the chemicals reported.

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

Table 2-4. INL Site EPCRA Reporting Status (2018).

EPCRA Section	Description of Reporting	2018 Status
Section 304	Extremely Hazardous Substance Release Notification	Not Required
Section 311-312	Safety Data Sheet/Chemical Inventory Toxic	Required
Section 313	Chemical Release Inventory Reporting	Required

Common Nighthawk
Chordeiles minor

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 cumene, ethylbenzene, lead, naphthalene, nickel, nitric acid, nitrate compounds, and polycyclic aromatic compounds to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – There were no reportable environmental releases at the INL Site during Calendar Year 2018.

2.5.4 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 EO 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 Environmental Impact Statement 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 Test Area North, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).

2.5.5 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 EO 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 Environmental Impact Statement 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 CWA.

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 2018, no actions took place or impacted potential jurisdictional wetlands on the INL Site.

2.6 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.

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Executive Order 11988, 1977, "Floodplain Management."

Executive Order 11990, 1977, "Protection of Wetlands."

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IDAPA 58.01.11, 2019, "Ground Water Quality Rule," Idaho Administrative Procedures Act.

IDAPA 58.01.16, 2019, "Wastewater Rules," Idaho Administrative Procedures Act.

IDAPA 58.01.17, 2019, "Recycled Water Rules," Idaho Administrative Procedures Act.

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Big Southern Butte

Kildeer
Charadrius vociferus

3. Environmental Monitoring Programs: Air

2018

An estimated total of 1,370 Ci (5.07×10^{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 2018. The highest contributors to the total release were the Advanced Test Reactor (ATR) Complex at 76.2 percent, Materials and Fuel Complex (MFC) at 12.9 percent, the Radioactive Waste Management Complex (RWMC) at 4.37 percent, the Critical Infrastructure Test Range Complex at 3.91 percent, and Idaho Nuclear Technology and Engineering Center at 1.90 percent of 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 2018.

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 cesium-137 (^{137}Cs), americium-241 (^{241}Am), plutonium-239/240 ($^{239/240}$Pu), and strontium-90 (^{90}Sr). Results were compared with detection levels, background measurements, historical results, and radionuclide-specific Derived Concentration Standards (DCSs) established by DOE 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.

Specific alpha-emitting radionuclides (^{241}Am, ^{238}Pu, and $^{239/240}$Pu) were reported primarily during the second quarter. The concentrations measured were just above the detection levels and well below the radionuclide-specific DCSs developed by DOE to protect human health. Americium-241 was detected during the first quarter at Atomic City, during the second quarter at ATR Complex, MFC, Remote Handled Low-Level Waste Disposal Facility, and Van Buren Boulevard (from co-located samplers run by the ESER and INL contractors), and during the third quarter at RWMC. Plutonium-238 was also detected in the ESER Van Buren Boulevard sample during the second quarter.

Strontium-90 was detected in one of the quarterly composited air filters collected at Arco within measured background levels. 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 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 2018. 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 some 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.

3. 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 3-1). Reviews of historical environmental data and environmental transport modeling indicate that air is a key pathway from INL Site releases to members of the general public. The ambient air monitoring network is thus a critical component of the INL Site's environmental monitoring programs. It monitors for routine and unforeseen releases, provides verification that the INL Site is in compliance with regulatory standards and limits, and can be used to assess impact to the environment over time.

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 (ESER) Program contractor. Table 3-1 summarizes the air monitoring activities on and off the INL Site. Details may be found in the INL Site Environmental Monitoring Plan (DOE ID 2017).

3.1 Organization of Air Monitoring Programs

The INL contractor documents airborne radiological effluents at INL Site 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 3.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2018 INL Report for Radionuclides* (DOE-ID 2019), referred to hereafter as the National Emission Standards for Hazardous Air Pollutants (NESHAP) Report. 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

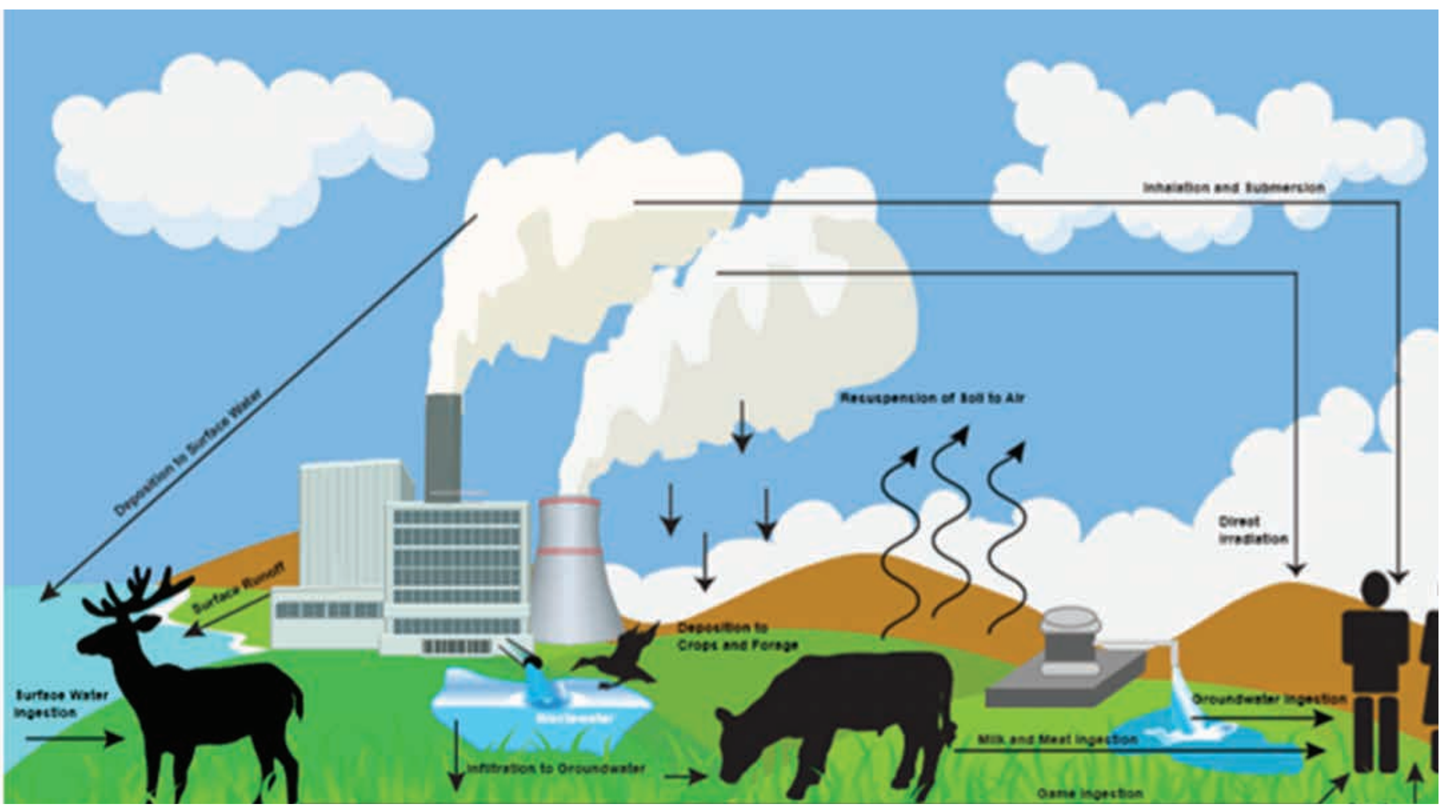


Figure 3-1. Potential Exposure Pathways to Humans from the INL Site.

Table 3-1. Radiological Air Monitoring Activities by Organization.

	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
Area/Facility[a]	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 Site/Regional		●	●	●	●	●	
ESER Program Contractor[f]							
INL Site/Regional		●	●	●	●	●	●

a. ESER = Environmental Surveillance, Education and Research, ICP = Idaho Cleanup Project, INL = Idaho National Laboratory, INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex
b. Facilities that required monitoring during 2018 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 O 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 O 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 O 458.1.

air samples and air moisture samples primarily on the INL Site (Figure 3-2). In 2018, the INL contractor collected approximately 1,100 air samples (including duplicate samples and blanks) for various radiological analyses. Air moisture samples were collected at four sites for tritium analysis.

The ESER contractor collects air samples primarily around the INL Site encompassing a region of 23,390 km^2 (9,000 mi^2) that extends to locations near Jackson, Wyoming (Figure 3-2). In 2018, the ESER contractor collected approximately 1,040 air samples (including duplicate samples and blanks) for various radionuclide analyses. The ESER contractor also collects air moisture and precipitation samples at four locations for tritium analysis.

The ICP Core contractor monitors air around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." These facilities are

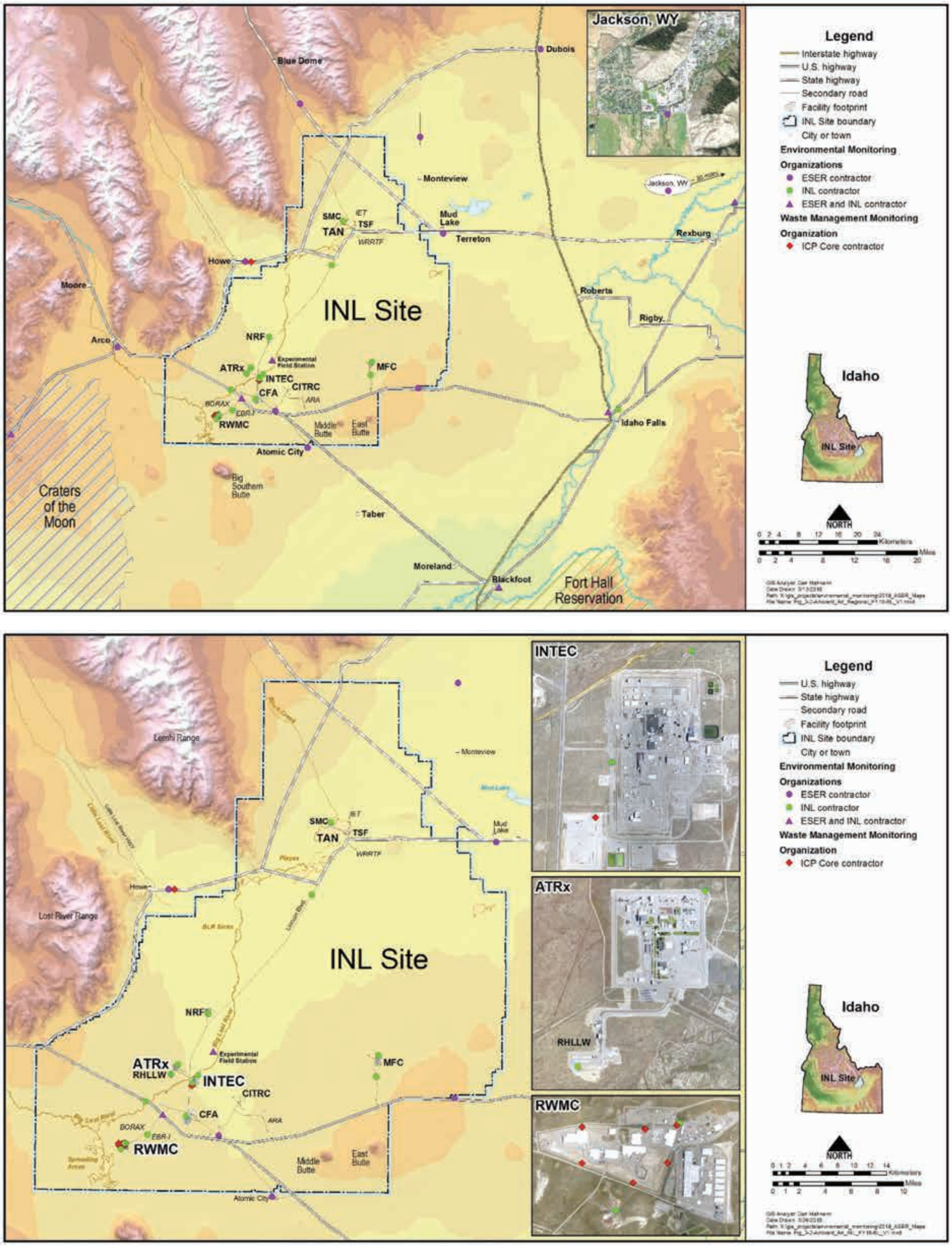


Figure 3-2. INL Site Environmental Surveillance Radiological Air Sampling Locations (regional [top] and on the INL Site [bottom]).

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 3-2. Section 3.4 discusses air sampling by the ICP Core contractor in support of waste management activities.

The National Oceanic and Atmospheric Administration (NOAA) has collected meteorological data at the INL Site since 1950. The data have historically been tabulated, summarized, and reported in several climatography reports for use by scientists to evaluate atmospheric transport and dispersion. The latest report, *Climatography of the Idaho National Laboratory*, 4th Edition (Clawson et al. 2018), was prepared by the Field Research Division of the Air Resources Laboratory of NOAA and presents over 20 years (1994–2015) of quality-controlled data from the NOAA INL mesonet meteorological monitoring network (https://niwc.noaa.inl.gov/climate/INL_Climate4th_Final2.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 7 in this annual report and *Meteorological Monitoring*, a supplement to this annual report).

3.2 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 potential dose to a hypothetical maximally exposed individual (MEI), who is a member of the public (see Chapter 7 of this report). Radiological effluents and the resulting potential dose for 2018 are reported in the NESHAP Report (DOE-ID 2019).

The NESHAP Report describes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAP regulation: these are primarily stacks at the Materials and Fuels Complex (MFC), the Advanced Mixed Waste Treatment Project (AMWTP), and 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, radiological test ranges, and decontamination and decommissioning operations.

INL Site emissions include all three airborne emission categories and are summarized in Table 3-2. The radionuclides included in this table were selected because they contribute 99.9% of the cumulative dose to the MEI estimated for each facility area. During 2018, an estimated 1,370 Ci (5.07×10^{13} Bq) of radioactivity was released to the atmosphere from all INL Site sources. The 2018 release is 11% greater than the previous year due mainly to increased and new activities on the INL Site.

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

- ***ATR Complex Emissions Sources (76.2% of total INL Site source term)*** – Radiological air emissions from ATR Complex are primarily associated with ATR operations. These emissions include noble gases, radioiodine, and other mixed fission and activation products. Other radiological air emissions are associated with sample analysis, site remediation, and research and development activities. The INL Radioanalytical Chemistry Laboratory, in operation since 2011, is another emission source at the ATR Complex. Activities at the lab include inorganic, general-purpose analytical chemistry, and wet chemical analysis for trace and high-level radionuclide determination. The laboratory contains high-efficiency particulate air filtered hoods which are used for analysis of contaminated samples.
- ***MFC Emissions Sources (12.9% of total INL Site source term)*** – The increase in air emissions associated with MFC is primarily due to new activities at the Radiochemistry Laboratory. Other activities associated with emissions from MFC include spent fuel treatment at the Fuel Conditioning Facility, waste characterization at the Hot Fuel Examination Facility, fuel research and development at the Fuel Manufacturing Facility, and operation of the Transient Reactor Test Facility (TREAT). These facilities are equipped with continuous emission monitoring systems. On a regular basis, effluent streams from Fuel Conditioning Facility, Hot Fuel Examination Facility, Fuel Manufacturing Facility and other non-continuous emission monitoring radiological facilities are sampled and analyzed for

Table 3-2. Radionuclide Composition of INL Site Airborne Effluents (2018).[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]	9.03E-07	NS	—	2.14E-05	—	4.44E-05
Ar-41	109.61 m	8.38E+02	NS	—	—	6.61E+01	—	—	NS	9.04E+02
Br-80m	4.4205 h	—	—	—	—	—	—	—	2.17E+00	2.17E+00
Br-82	35.3 h	NS	—	—	—	—	—	—	4.39E+00	4.39E+00
C-14	5,700 y	NS	NS	7.50E-01	1.67E-03	NS	7.80E-01	1.12E-01	—	1.64E+00
Cd-109	461.4 d	NS	NS	—	—	5.17E-03	—	—	—	5.17E-03
Cl-36	301,000 y	—	—	—	1.35E-06	2.66E-05	—	—	NS	2.80E-05
Cm-244	18.1 y	NS	1.46E-08	—	NS	—	—	NS	—	1.46E-08
Co-60	5.2713 y	8.93E-03	NS	—	1.29E-06	NS	NS	NS	—	8.93E-03
Cs-137	30.1671 y	5.86E-03	NS	—	3.56E-05	6.18E-02	5.90E-05	NS	—	6.78E-02
Eu-152	13.537 y	8.79E-05	NS	—	NS	—	—	—	—	8.79E-05
Eu-154	8.593 y	7.87E-05	NS	—	NS	—	—	—	—	7.87E-05
H-3	12.32 y	2.45E+02	5.09E-01	—	2.58E+01	3.74E-01	NS	6.44E+01	3.26E-02	3.36E+02
I-125	59.4 d	1.00E-03	—	—	—	—	—	—	—	1.00E-03
I-129	15,700,000 y	NS	NS	1.13E-05	1.57E-03	4.60E-05	4.80E-05	—	—	1.67E-03
I-131	8.0207 d	NS	NS	—	—	8.88E-02	NS	—	—	8.88E-02
K-42	12.36 h	—	—	—	—	—	—	—	3.95E-01	3.95E-01
Kr-85	10.756 y	NS	NS	5.70E+01	2.25E+00	NS	NS	—	—	5.93E+01
Kr-85m	4.48 h	NS	NS	—	—	8.17E+00	—	—	—	8.17E+00
Kr-87	76.3 m	7.00E+00	NS	—	—	8.56E+00	—	—	—	1.56E+01
Kr-88	2.84 h	NS	NS	—	—	7.78E+00	—	—	—	7.78E+00
Pu-238	87.7 y	NS	—	—	NS	NS	—	1.24E-05	—	1.24E-05
Pu-239	24,110 y	8.46E-06	NS	—	4.25E-07	NS	2.70E-06	3.06E-05	—	4.22E-05
Pu-240	6,564 y	NS	NS	—	9.03E-08	NS	—	7.01E-06	—	7.10E-06
Pu-241	14.35 y	NS	—	—	NS	NS	—	3.87E-05	—	3.87E-05
Sr-90	28.79 y	2.18E-02	NS	—	4.92E-06	NS	4.70E-05	NS	NS	2.19E-02
U-238	4,468,000,000 y	NS	NS	3.95E-05	NS	NS	—	NS	NS	3.95E-05
Xe-135	9.14 h	1.27E+01	NS	—	—	2.14E+00	—	—	—	1.48E+01
Xe-138	14.08 m	1.94E+01	NS	—	—	NS	—	—	—	1.94E+01
	Total Ci released[h]	1.12E+03	5.09E-01	5.78E+01	2.80E+01	9.33E+01	7.80E-01	6.45E+01	6.99E+00	1.37E+03[i]
	Dose (mrem)[j]	5.37E-03	4.34E-06	3.23E-04	1.15E-03	1.91E-03	1.74E-04	1.17E-03	7.57E-05	1.02E-02

Table 3-2. Radionuclide Composition of INL Site Airborne Effluents (2018).[a] (cont.)

	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

a. Radionuclide release information provided by the INL contractor.
b. One curie (Ci) = 3.7×10^{10} becquerels (Bq).
c. Includes only those radionuclides which collectively contribute 99.9% of the total dose to the MEI estimated for each INL Site facility. Other radionuclides not shown in this table account for less than 0.1% of the dose estimated for each facility.
d. Half-lives from ICRP (2008). 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 and Accelerated Retrieval Projects), TAN = Test Area North (including Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range)
f. NS = not significant. The radionuclide contribution was estimated to be < 0.1% of the total MEI dose from that facility.
g. A long dash signifies the radionuclide was not reported to be released to the air from the facility in 2018.
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. Total curies may be less than the total curies in Table 7-1 because Table 3-2 accounts only for radionuclides that collectively contribute 99.9% of the total dose to the MEI estimated for each INL Site facility.
j. The annual dose (mrem) for each facility was calculated at the location of the hypothetical MEI using estimated radionuclide releases and methodology recommended by the Environmental Protection Agency. See Chapter 7 for detail.

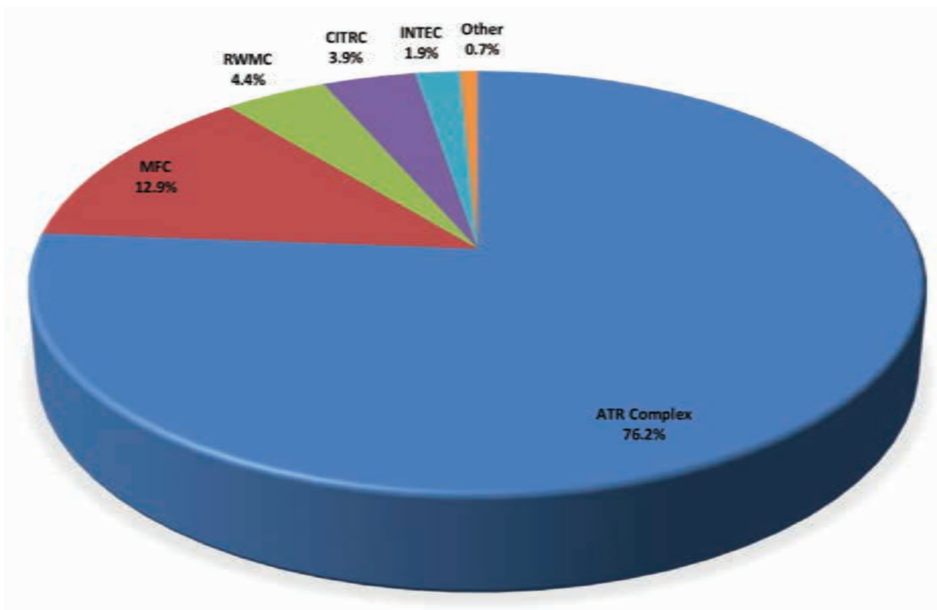


Figure 3-3. Percent Contributions in Ci, by Facility, to Total INL Site Airborne Radiological Releases (2018).

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.

- ***RWMC Emissions Sources (4.37% of total INL Site source term)*** – Emissions at RWMC 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 transuranic waste and mixed low-level waste prior to shipment to offsite 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 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. Data from 15 emission sources (both point and diffuse) at RWMC were reported in the 2018 NESHAP Report for Radionuclides (DOE-ID 2019), 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 (EPA)-approved ambient air monitoring program, which has been in place since 2008.

Radiological emissions at RWMC are primarily due to treatment of contaminated air removed from the vadose zone and releases of tritium and carbon-14 (^{14}C) associated with buried beryllium blocks. Releases of transuranic radionuclides, including americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239 (^{239}Pu), plutonium-240 (^{240}Pu), and plutonium-241 (^{241}Pu) have declined in recent years as waste exhumation and processing activities slow down.

- ***Critical Infrastructure Test Range Complex (CITRC) Emissions Sources (3.91% of total INL Site source term)*** – Emission increases from CITRC are the result of new and increased activity from National and Homeland Security missions. Activities at CITRC include program and project testing for critical infrastructure resilience, nonproliferation, wireless test bed operations, power line and grid, unmanned aerial vehicles, accelerator testing, explosives detection, and training radiological counter-terrorism emergency response. Most of the increased activity is from krypton-85.

- ***INTEC Emissions Sources (1.90% of total INL Site source term)*** – Radiological air emissions from INTEC are primarily associated with sources exhausted through the Main Stack (CPP-708), 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. Other releases are associated with waste disposal in the landfill and evaporation pond operations at ICDF, which is located outside the fenced boundary of INTEC; and the Three Mile Island Unit 2 Independent Spent Fuel Storage Installation (CPP-1774). 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.

- ***Test Area North Emissions Sources (0.63% of total INL Site source term)*** – The main emissions sources at Test Area North are the Specific Manufacturing Capability project, the New Pump and Treat Facility, and the nearby Northern Test Range of the Radiological Response Training Range. Radiological air emissions from the Specific Manufacturing Capability project are associated with processing of depleted uranium. Potential emissions are uranium isotopes. Low levels of strontium-90 (^{90}Sr) and tritium are present in the treated water from the New Pump and Treat Facility and are released to the atmosphere by the treatment process. Emissions from Radiological Response Training Range are the result of training activities such as contamination control, site characterization, and field sampling techniques for response to radiological incidents using mostly short-lived radioactive materials.

- ***Central Facilities Area (CFA) Emissions Sources (0.034% 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.

The estimated radionuclide releases (Ci/yr) from INL Site facilities, shown in Table 3-2, were used to calculate the dose to the hypothetical MEI member of the public, who is assumed to reside near the INL Site perimeter. The estimated dose to the MEI in Calendar Year 2018 was 0.0102 mrem/yr (0.102 µSv/yr). Potential radiation doses to the public are discussed in more detail in Chapter 7 of this report. Five radionuclides (cesium-137 [^{137}Cs], tritium, argon-41, ^{90}Sr, and iodine-129]) contributed to 87% of the MEI dose with the remaining 13% due primarily to ^{14}C and cobalt-60 (^{60}Co).

3.3 Ambient Air Monitoring

Ambient air monitoring is conducted on and off the INL Site to identify regional and historical trends, to detect accidental and unplanned releases, and to determine if air concentrations are below 10 percent of derived concentration standards (DCSs) established by DOE for inhaled air (DOE 2011). Each radionuclide-specific DCS corresponds to a dose of 100 mrem for continuous exposure during the year. The Clean Air Act NESHAP standard is 10 mrem per year (or 10% of 100 mrem per year).

3.3.1 Ambient Air Monitoring System Design

Figure 3-2 shows the regional and INL Site routine air monitoring locations. A total of 37 low-volume air samplers, one high-volume air sampler, eight atmospheric moisture samplers, and four precipitation samplers operated in the network in 2018 (Table 3-3).

Historically, air samplers were positioned near INL Site facilities or sources of contamination, in predominant downwind directions from sources of radionuclide air emissions, at potential offsite receptor population centers, and at background locations. In 2015, the network was evaluated quantitatively, using atmospheric transport modeling and frequency of detection methods (Rood, Sondrup, and Ritter 2016). A Lagrangian Puff air dispersion model (CALPUFF) with three years of meteorological data was used to model atmospheric transport of radionuclides released from six major facilities and predict air concentrations at each sampler location for a given release time and duration. Frequency of detection is defined as the fraction of events that result in a detection at either a single sampler or network. The frequency of detection methodology allowed for evaluation of short-term releases that included effects of short-term variability in meteorological conditions. Results showed the detection frequency was over 97.5% for the entire network considering all sources and radionuclides. Network intensity results (the fraction of samplers in the network that have a positive detection for a given event) ranged from 3.75% to 62.7%. Evaluation of individual samplers indicated some samplers were poorly located and added little to the overall effectiveness of the network.

Tritium is present in air moisture due to natural production in the atmosphere and is also released by INL Site facilities (Table 3-2). Historical NESHAP data show that most tritium is released from the ATR Complex and INTEC. Tritium enters the environment as tritiated water and behaves like water in the environment. The air monitoring network evaluation described in the previous paragraph was also used to locate atmospheric moisture samplers. The Experimental Field Station (EFS) and Van Buren Boulevard samplers are located onsite and appear to be in or near the highest projected air dispersion concentrations. Atomic City and Howe are communities that are downwind of INL Site operations and/or are situated in areas of maximum projected offsite concentrations and close to the INL Site boundary. Idaho Falls and Craters of the Moon are good offsite locations for measuring background concentrations because they do not appear to be impacted by modeled dispersion of tritium. Thus, one or two atmospheric moisture samplers are currently placed at each of the six locations: Atomic City, Craters of the Moon, EFS (two samplers), Howe, Idaho Falls (two samplers), and Van Buren Boulevard. Although there are more particulate air monitoring stations, additional atmospheric moisture and precipitation monitoring stations are not warranted. This is because the calculated dose for INL Site releases is less than 0.1 mrem, which is the recommended DOE limit for routine surveillance (DOE 2015).

Historical tritium concentrations in precipitation and atmospheric moisture samples collected by the ESER contractor during the 10-year period from 2008 through 2017 were compared statistically, and results indicate that there are no differences between data sets. For this reason, ESER precipitation samplers were placed at the same locations as the ESER atmospheric moisture samplers (Atomic City, EFS, Howe, and Idaho Falls). In addition, Idaho Falls can be easily and readily accessed by ESER personnel after a precipitation event. The EPA has a precipitation collector in Idaho Falls and subsamples are collected for the ESER program.

Table 3-3. INL Site Ambient Air Monitoring Summary (2018).

Medium Sampled	Type of Analysis	Frequency	Number of Locations: Onsite INL[a]	Onsite ESER[b]	Onsite *Total*	Offsite INL[a]	Offsite ESER[b]	Offsite *Total*	Minimum Detectable Concentration (MDC)
Air (low volume)	Gross alpha	Weekly	16	3	**19**	5	13	**18**	1×10^{-15} µCi/mL
	Gross beta	Weekly	16	3	**19**	5	13	**18**	2×10^{-15} µCi/mL
	Specific gamma[c]	Quarterly	16	3	**19**	5	13	**18**	2×10^{-16} µCi/mL
	Plutonium-238	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5×10^{-18} µCi/mL
	Plutonium-239/240	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5×10^{-18} µCi/mL
	Americium-241	Quarterly	16	2	**18**	5	4-5	**9-10**	4.6×10^{-18} µCi/mL
	Strontium-90	Quarterly	16	2	**18**	5	4-5	**9-10**	3.4×10^{-17} µCi/mL
	Iodine-131	Weekly	16	3	**19**	5	13	**18**	1.5×10^{-15} µCi/mL
	Total particulates	Weekly	–	3	**3**	–	13	**13**	10 µg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	–	–	1	**1**	1×10^{-15} µCi/mL
	Gamma scan	Continuous	–	–	–	–	1	**1**	Not applicable
	Specific gamma[c]	Annually[e]	–	–	–	–	1	**1**	1×10^{-14} µCi/mL
	Isotopic U and Pu	Every 4 yrs	–	–	–	–	1	**1**	2×10^{-18} µCi/mL
Air (atmospheric moisture)[f]	Tritium	3–6/quarter	2	1	**3**	2	3	**5**	2×10^{-13} µCi/mL (air)
Air (precipitation)[g]	Tritium	Monthly	–	0	**0**	–	1	**1**	88 pCi/L
		Weekly	–	1	**1**	–	3	**3**	

a. Low volume 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 Blvd. In addition, there are two rotating duplicate samplers for QA. In 2018, they were at RWMC 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; RWMC = Radioactive Waste Management Complex; SMC = Specific Manufacturing Capability). This table does not include high volume "event" monitoring by the INL contractor (see Section 3.3.1).

b. The ESER contractor operates low volume samplers on the INL Site at Main Gate, EFS, and Van Buren Blvd. Offsite locations include Arco, Atomic City, Blackfoot, Blue Dome, Craters of the Moon, Dubois, Federal Aviation Administration (FAA) Tower, Howe, Idaho Falls, Jackson (WY), Monteview, Mud Lake, and Sugar City. In addition, there are two rotating duplicate samplers for quality assurance. In 2018, these were placed at Atomic City and Blue Dome.

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

d. The 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. 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.

f. Atmospheric moisture samples are collected onsite at EFS by ESER and INL, and at Van Buren Boulevard by INL. Samples are collected offsite at Atomic City by ESER, at Craters of the Moon by INL, at Howe by ESER, and at Idaho Falls by ESER and INL.

g. Precipitation samples are currently collected onsite at EFS. Samples are collected offsite at Atomic City, Howe, and Idaho Falls (also used as the EPA RadNet precipitation location).

To support emergency response, the INL contractor maintains 16 high volume event air samplers at NOAA weather towers (Figure 3-4). These event monitors are only turned on as needed for sampling when an event occurs, such as a range fire or unplanned release.

3.3.2 Air Particulate, Radioiodine, and Tritium Sampling Methods

3.3.2.1 Air Particulates and Radioiodine

Filters are collected weekly by the INL and ESER contractors from a network of low-volume air samplers (Table 3-3). At each low-volume air sampler, a pump pulls air (about 57 L/min [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm particulate 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 gross beta activity. Gross alpha and gross 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 gross beta radioactivity in air samples is dominated by the presence of naturally

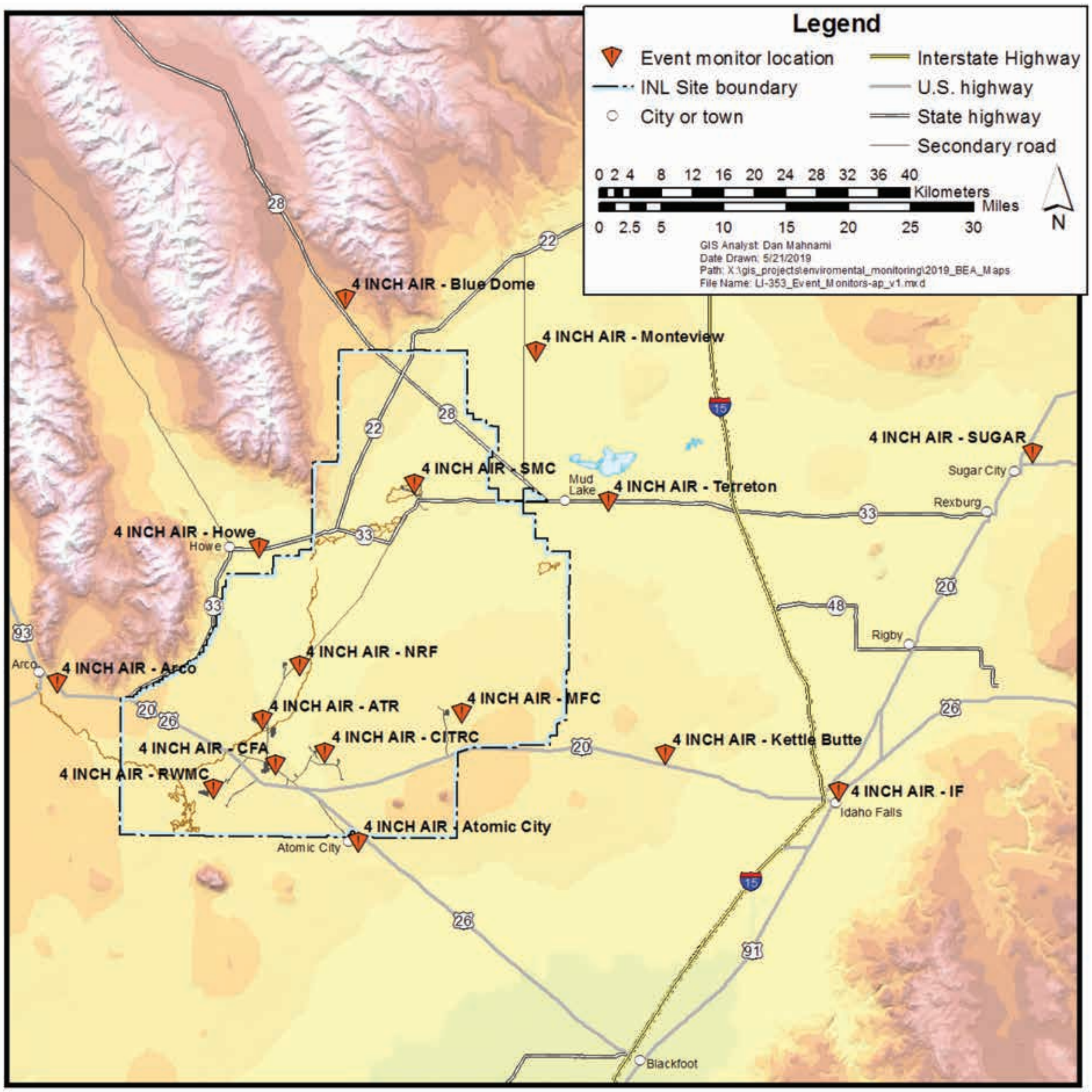


Figure 3-4. Locations of INL Contractor High-volume Event Monitors at NOAA Weather Stations.

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 gross 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 for each location 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 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 site releases or to resuspension of surface soil particles contaminated by INL Site activities or global fallout. ESER samples are analyzed on a rotating basis – each quarter six or seven composites are selected for alpha spectrometry and six or seven composites are selected for beta spectrometry.

3.3.2.2 Radioiodine

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.

3.3.2.3 Tritium

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the EFS and Van Buren Boulevard and off the INL Site at Atomic City, Howe, and Idaho Falls. 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.

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

3.3.3 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,100 charcoal cartridges (blanks and duplicates) in 2018. There were no statistically positive measurements of ^{131}I. During 2018, the ESER contractor analyzed 1,040 cartridges (including blanks and duplicate samples), usually in batches of 10 cartridges, looking specifically for ^{131}I. Analyses of cartridges found no detectable ^{131}I.

Gross Activity – Gross alpha and gross 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 gross 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., onsite, 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 conducted by INL and ESER contractors are summarized in Tables 3-4 and 3-5. (Note: the ESER contractor collects 52 weekly samples per year, whereas the INL contractor collects 51 samples per year – 50 times weekly and once biweekly over the Christmas holiday.) Results are further discussed below.

Table 3-4. Median Annual Gross Alpha Concentrations in Ambient Air Samples Collected in 2018.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median Concentration ($\times 10^{-15}$ µCi/mL)
ESER Contractor				
Distant	Blackfoot	52	0.10 – 3.1	1.2
	Craters of the Moon	52	-0.05 – 3.7	1.1
	Dubois	52	0.14 – 3.5	1.2
	Idaho Falls	52	-0.09 – 4.2	1.8
	Jackson	52	0.16 – 4.2	1.2
	Sugar City	52	-0.03 – 4.1	1.1
			Distant Median:	1.2
Boundary	Arco	52	0.21 – 3.3	1.1
	Atomic City	52	-0.32 – 3.3	1.2
	Blue Dome	52	-0.17 – 3.0	1.0
	FAA Tower	52	0.12 – 3.4	1.2
	Howe	52	0.30 – 3.4	1.6
	Monteview	51	0.11 – 3.1	1.3
	Mud Lake	52	0.18 – 3.2	1.5
			Boundary Median:	1.3
INL Site	EFS	52	0.09 – 3.0	1.0
	Main Gate	52	0.26 – 3.4	1.2
	Van Buren	51	-0.25 – 3.4	1.1
			INL Site Median:	1.1
INL Contractor				
Distant	Blackfoot	51	-0.21 – 5.1	1.3
	Craters of the Moon	50	-0.24 – 5.1	1.1
	Idaho Falls	51	0.08 – 5.7	1.4
	IRC[d]	51	-0.48 – 5.8	1.3
	Sugar City	51	0.11 – 5.6	1.3
			Distant Median:	1.3
INL Site	RHLLW	51	-0.21 – 3.9	1.2
	ATR Complex (NE corner)	49	-0.4 – 5.3	1.2
	Highway 26 Rest Area	51	-0.62 – 6.2	1.1
	CFA	51	-0.90 – 3.8	1.4
	EBR-I	51	-0.09 – 4.8	1.4
	EFS	48	-0.15 – 6.3	1.3
	Gate 4	50	-0.09 – 5.4	1.4
	INTEC (NE corner)	51	-0.52 – 7.6	1.3
	INTEC (west side)	51	-0.51 – 5.8	1.3
	MFC (North)	51	-0.18 – 5.4	1.1
	MFC (South)	51	-0.43 – 3.8	1.3
	NRF	51	-0.41 – 4.9	1.4
	RWMC	51	0.05 – 4.3	1.3
	RWMC (South)	51	-0.64 – 4.6	1.2
	SMC	48	-0.16 – 5.4	1.2
	Van Buren Boulevard	51	-0.40 – 5.1	1.2
			INL Site Median:	1.3

a. ATR = Advanced Test Reactor, 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, RHLLW = Remote Handled Low-Level Waste, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability. See Figure 3-2 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 made for quality assurance purposes, 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. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

Table 3-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2018.

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)
		ESER Contractor		
Distant	Blackfoot	52	1.1 – 4.2	2.4
	Craters of the Moon	52	0.99 – 4.2	2.3
	Dubois	52	1.0 – 4.0	2.4
	Idaho Falls	52	1.0 – 4.6	2.4
	Jackson	52	1.0 – 4.7	2.4
	Sugar City	52	0.98 – 5.1	2.3
			Distant Median:	2.4
Boundary	Arco	52	1.0 – 4.8	2.4
	Atomic City	52	1.2 – 5.6	2.5
	Blue Dome	52	1.1 – 4.4	2.3
	FAA Tower	52	1.1 – 4.8	2.5
	Howe	52	0.99 – 4.7	2.5
	Monteview	51	1.0 – 4.3	2.5
	Mud Lake	52	1.1 – 5.6	2.6
			Boundary Median:	2.4
INL Site	EFS	52	1.0 – 5.4	2.4
	Main Gate	52	1.2 – 5.4	2.5
	Van Buren	51	1.5 – 5.7	2.5
			INL Site Median:	2.5
		INL Contractor		
Distant	Blackfoot	51	0.95 – 4.6	2.2
	Craters of the Moon	50	0.94 – 4.7	2.1
	Idaho Falls	51	0.98 – 5.0	2.4
	IRC[d]	51	0.52 – 4.5	2.2
	Sugar City	51	0.95 – 4.4	2.2
			Distant Median:	2.2
INL Site	RHLLW	51	1.0 – 4.4	2.5
	ATR Complex (NE corner)	49	0.61 – 4.7	2.4
	Highway 26 Rest Area	51	1.1 – 4.8	2.4
	CFA	51	1.1 – 5.1	2.4
	EBR-I	51	1.1 – 4.9	2.5
	EFS	48	0.86 – 5.7	2.3
	Gate 4	50	0.54 – 5.2	2.6
	INTEC (NE corner)	51	0.72 – 4.6	2.3
	INTEC (west side)	51	0.89 – 4.8	2.3
	MFC (North)	51	1.1 – 4.3	2.2
	MFC (South)	51	1.2 – 4.3	2.3
	NRF	51	1.1 – 5.0	2.5
	RWMC	51	1.2 – 4.8	2.4
	RWMC (South)	51	0.85 – 4.9	2.4
	SMC	48	0.98 – 4.9	2.2
	Van Buren Boulevard	51	1.1 – 4.8	2.1
			INL Site Median:	2.3

a. ATR = Advanced Test Reactor, 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, RHLLW = Remote Handled Low-Level Waste, 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 made for quality assurance purposes, 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. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

- ***Gross Alpha.*** Gross alpha concentrations measured on a weekly basis in individual air samples ranged from a low of $(-0.9 \pm 1.1) \times 10^{-15}$ µCi/mL collected by the INL contractor at the CFA on June 27, 2018, to a high of $(7.6 \pm 2) \times 10^{-15}$ µCi/mL collected by the INL contractor at INTEC on May 30, 2018 (Table 3-4). The maximum result measured at INTEC was lower than the maximum concentration (12.0×10^{-15} µCi/ mL) reported in previous Annual Site Environmental Reports from 2008–2017. The past measurement was attributed to mechanical disturbance of previously contaminated roadbed materials.

The median annual gross alpha concentrations were typical of previous measurements. The maximum result is less than the 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, although unrealistically, be applied to gross alpha activity.

- ***Gross Beta.*** Weekly gross beta concentrations measured in air samples ranged from a low of $(5.2 \pm 1.3) \times 10^{-15}$ µCi/mL at INL Research Center (IRC), collected by the INL contractor on March 7, 2018, to a high of $(5.67 \pm 0.10) \times 10^{-14}$ µCi/mL (collected by the ESER contractor at Van Buren on November 21, 2018 (Table 3-5). All results were below the maximum concentration of 1.3×10^{-13} µCi/mL reported in previous Annual Site Environmental Reports (2008–2017). 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 usually 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 2018, the most prominent inversion periods occurred in January, November, and December. 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.

> ***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.

- ***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. For these analyses, uncensored analytical results (i.e., values less than their analysis-specific minimum detectable concentrations) were included. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2018. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2018 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 $2.33 \pm 0.3 \times 10^{-14}$ µCi/mL, respectively) showed equivalence at one sigma uncertainty and are attributable to natural data variation.

Specific Radionuclides – Of the 96 INL contractor quarterly samples composited in 2018, ^{241}Am was detected in five composite samples. One was from RWMC in the third quarter and four were during the second quarter from MFC, ATR Complex, Remote Handled Low-level Waste, and Van Buren Boulevard. Americium-241 was detected in two of the 26 quarterly composites collected by the ESER contractor in 2018 (Table 3-6). The highest concentration $(4.5 \pm 0.42) \times 10^{-17}$ µCi/mL was measured in the sample collected by the ESER contractor at Van Buren Boulevard during the second quarter. The results were well below the DCS for ^{241}Am in air $(4.1 \times 10^{-14}$ µCi/mL). The maximum result was the second highest concentration reported for the past decade (2008-2017). The highest ^{241}Am result $(1.47 \pm 0.12) \times 10^{-16}$ µCi/mL was measured at Van Buren Boulevard in the second quarter of 2009 at a concentration more than three times greater than the highest 2018 concentration. It was attributed to nearby road construction which may have exposed and resuspended contaminated materials used for the old road bed. An elevated gross alpha concentration $([1.22 \pm 0.06] \times 10^{-14}$ µCi/mL) was also observed in the filter collected during the week that road construction activities were initiated (April 16-29, 2009). The gross alpha activity at Van Buren Boulevard was about six times the maximum activity observed at other locations during that week. In contrast, no elevated gross alpha results were observed during the second quarter of 2018.

Plutonium-238 was detected in one composited sample collected by the ESER contractor at Van Buren Boulevard during the second quarter of 2018. The result $(1.3 \pm 0.33) \times 10^{-17}$ µCi/mL is elevated compared concentrations observed in the last ten years (2008-2017) although several orders of magnitude below the DCS for ^{238}Pu in air $(3.7 \times 10^{-14}$ µCi/mL).

Plutonium-239/240 was detected in one of the second quarter composites collected by the INL contractor from the northeast corner of ATR Complex. Plutonium-239/240 was also detected in a quarterly composite collected at Van Buren Boulevard by the ESER contractor during the second quarter of 2018. Both concentrations were elevated compared to the highest measurement $(1.25 \text{ x } 10^{-17}$ µCi/mL) reported in previous annual reports from 2008–2017 but are two-to-three orders of

Table 3-6. Human-Made Radionuclides Detected in Ambient Air Samples Collected in 2018.

Radionuclide	Result[a] (µCi/mL)	Location	Group	Quarter Detected
Americium-241	$(9.9 \pm 1.7) \times 10^{-18}$	Atomic City[b]	Boundary	1st
	$(4.5 \pm 0.42) \times 10^{-17}$	Van Buren Boulevard[b]	INL Site	2nd
	$(1.2 \pm 0.27) \times 10^{-17}$	RHLLW[c]	INL Site	2nd
	$(9.7 \pm 2.5) \times 10^{-18}$	Van Buren Boulevard[c]	INL Site	2nd
	$(8.7 \pm 2.4) \times 10^{-18}$	MFC[c]	INL Site	2nd
	$(7.7 \pm 2.4) \times 10^{-18}$	ATR Complex[c]	INL Site	2nd
	$(1.3 \pm 0.31) \times 10^{-17}$	RWMC[c]	INL Site	3rd
Plutonium-238	$(1.3 \pm 0.33) \times 10^{-17}$	Van Buren Boulevard[b]	INL Site	2nd
Plutonium-239/240	$(1.3 \pm 0.13) \times 10^{-16}$	ATR Complex[c]	INL Site	2nd
	$(5.5 \pm 0.45) \times 10^{-17}$	Van Buren Boulevard[b]	INL Site	2nd
Strontium-90	$(5.6 \pm 0.52) \times 10^{-17}$	Arco[b]	INL Site	2nd

a. Results ± 1σ. Results shown are ≥ 3σ.
b. Samples collected by ESER contractor.
c. Samples collected by INL contractor.

magnitude below the DCS for $^{239/240}$Pu in air (3.4 x 10^{-14} µCi/mL).

Strontium-90, a beta-emitting radionuclide, was detected in one sample collected at Arco by the ESER contractor, during the second quarter. The ^{90}Sr result was far below the DCS of 2.5 × 10^{-11} µCi/mL and within concentrations measured from 2008-2017. It is most likely due to resuspension of soil contaminated with fallout from historical nuclear weapons testing.

No human-made gamma-emitting radionuclide (e.g., ^{137}Cs) was detected in any of the 144 (including eight duplicates) composited samples submitted by the ESER contractor for gamma analysis in 2018. The INL contractor also reported no detections of ^{137}Cs in any of the 96 quarterly composited samples analyzed.

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.

Most of the alpha-emitting radionuclides (^{238}Pu, $^{239/240}$Pu, and ^{241}Am) were detected during the second quarter. This was also one of the infrequent times ^{241}Am and plutonium isotopes have been detected together in an ESER contractor composite sample (all three radionuclides were detected together in a composite sample collected at Van Buren Boulevard in 2007). Thorough examination of quality assurance and control data, including analytical results from blanks and performance evaluation samples, does not suggest inadvertent contamination of the filter in the field or laboratory. Differences in analytical laboratories and methods, and requested detection limits between the contractors causes some variability in sample results. In addition to INL Site sources, the radionuclides detected are ubiquitous in the environment due to atmospheric nuclear weapons testing conducted by several nations in the 20th century and have been detected in samples collected on and around the INL Site in previous years at concentrations consistent with background levels. Plutonium isotopes and ^{241}Am are known to occur in soils and wastes at the Subsurface Disposal Area (SDA). SDA soils are contaminated from past flooding (in 1962 and 1969) of pits and trenches containing transuranic waste originating from the Rocky Flats Plant. The Van Buren Gate location is also situated in the predominant downwind direction from the RWMC. During the second quarter of 2018, routine facility operations and maintenance activities took place on the INL Site, including soil movement and road maintenance, which may result in resuspension of radioactive particulates. The ARP V event occurred in April 2018 (discussed below) but there is no definitive evidence of radiological releases associated with the event. Given the low concentrations and types of radionuclides detected, it is not possible to identify a specific source for the alpha-emitting radionuclides detected during the second quarter of 2018.

The concentrations of all specific radionuclides detected during 2018 were very low and do not pose any risk to the public or the environment.

High-volume Event Monitoring Results – On the night of April 11, 2018, there was an incident in the ARP V facility, WMF-1617, at the RWMC (RPT-1659). This incident resulted in a thermal event and subsequent energetic release of radioactive material from four 55-gal drums to a work area normally accessible to facility workers. There were no workers in the facility at the time. There was no detected release to the environment. The retrieval enclosures in ARP V (WMF-1617) are large tension membrane buildings erected over specified exhumation areas to limit the spread of contamination and provide protection from the weather. They are actively ventilated with high-efficiency particulate air filtration systems. In response to the event, the INL contractor activated high-volume event monitors at ATR Complex, Arco, Atomic City, CFA, Howe, Idaho Falls, Naval Reactors Facility, CITRC, RWMC, and Kettle Butte. The 4-in. filter samples were sent to an offsite laboratory and analyzed for gross alpha and beta radioactivity, ^{241}Am, uranium isotopes, plutonium isotopes, and ^{90}Sr. The laboratory reported no detections of ^{241}Am, ^{90}Sr, or plutonium isotopes. The laboratory reported gross alpha and beta radioactivity at concentrations consistent with background levels in 2-in. routine ambient air samples collected by the INL contractor (as discussed above in this section). Isotopes of uranium were detected at concentrations consistent with those in air filter composites collected by the ICP contractor (see Section 3.4.2) and indicate the activity is most likely naturally occurring.

3.3.4 Atmospheric Moisture Monitoring Results

During 2018, the ESER contractor collected 52 atmospheric moisture samples at four locations. Table 3-7 presents the percentage of samples that contained detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in 35 ESER samples, with a high of $(17.5 \pm 1.56) \times 10^{-13}$ $\mu Ci/mL_{air}$ at EFS on August 8, 2018. The highest concentration of tritium detected in an atmospheric moisture sample collected since 2008 was 34×10^{-13} $\mu Ci/mL_{air}$ at Atomic City in 2009. The highest observed tritium concentration in a 2018 sample collected by the ESER contractor is far below the DCS for tritium in air (as water vapor) of 2.1×10^{-7} $\mu Ci/mL_{air}$ (see Table A-2 of Appendix A).

In 2018, the INL contractor collected 33 atmospheric moisture samples on the INL Site at EFS and Van Buren Boulevard and off the INL Site at Idaho Falls and Craters of the Moon (Table 3-7). The INL contractor results were similar to those measured in samples collected by the ESER contractor. Tritium was detected in approximately 9% of the field samples collected. The maximum detected concentration measured was 13.8×10^{-13} $\mu Ci/mL_{air}$ at EFS on October 31, 2018. Tritium was also reported as present in one of four blank samples (collected on September 25, 2018) at a concentration of 11.9×10^{-13} $\mu Ci/mL_{air}$. These results are well below the DCS for tritium, as vapor, in air (2.1×10^{-7} $\mu Ci/mL$) and below the maximum (1.1×10^{-12} $\mu Ci/mL_{air}$) measured in 2010. Fewer detections were observed among INL samples than among ESER samples most likely because ESER samples were counted longer, resulting in lower detection levels.

The source of tritium measured in atmospheric moisture samples collected on and around the INL Site is probably of cosmogenic origin (see Section 3.3.5). Tritium releases from non-fugitive sources, such as the ATR, are highly localized and although might be detected immediately adjacent to the facility are unlikely to be detected at current air monitoring stations because of atmospheric dispersion.

3.3.5 Precipitation Monitoring Results

Tritium exists in the global atmosphere primarily from nuclear weapons testing and from natural production in the upper atmosphere by the interaction of galactic cosmic rays with nitrogen and can be detected in precipitation. Since the Nuclear Test Ban Treaty in 1963, the level of tritium measured in precipitation has been steadily decreasing due to radioactive decay and dilution in the world oceans. The International Atomic Energy Agency has participated in surveying tritium composition in precipitation around the globe since 1961 (www-naweb.iaea.org/napc/ih/IHS_resources_gnip.html). Long-term data suggest that tritium levels in precipitation are close to their pre-nuclear test values (Cauquoin et al. 2015). The tritium measured in precipitation at the INL Site is thus most likely cosmogenic in origin and not from weapons testing.

The ESER contractor collects precipitation samples weekly, when available, at Atomic City, EFS, and Howe. Precipitation is collected monthly at Idaho Falls for the EPA RadNet monitoring (https://www.epa.gov/radnet) and a subsample is taken for the ESER contractor for analysis.

A total of 72 precipitation samples were collected during 2018 from the four sites. Tritium was detected in 51 samples, and detectable results ranged from 25 pCi/L at EFS during December to 299 pCi/L at Idaho Falls during May. Most detections were near the approximate detection level of 88 pCi/L. Table 3-8 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 range (-62.1 – 413 pCi/L) measured from 2009–2018, as reported in the previous annual reports.

The results were also comparable with tritium concentrations reported by EPA for precipitation during the 10-year period from 2002–2011 (measurements were discontinued after 2011), based on a query of available data (https://iaspub.epa.gov/enviro/erams_query_v2.simple_query). Concentrations reported by EPA for Idaho Falls during that period ranged from 0-1720 pCi/L and averaged 35.1 pCi/L.

Annual tritium concentrations in atmospheric moisture and precipitation have no discernable statistical distribution, so nonparametric statistical methods were used to assess both sets of data (see *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, a supplement to this annual report.) To summarize the results, box plots were constructed of annual tritium concentrations measured in atmospheric moisture (as water) and precipitation samples collected by the ESER contractor for the past 10 years (Figure 3-5). The results appear to be similar for each year. A statistical comparison of both sets of data (using the nonparametric Wilcoxon Matched Pairs Test) shows that there are no differences between median annual tritium concentrations measured in atmospheric moisture and in precipitation samples. Because low levels of tritium exist in the environment at all times as a result of cosmic ray

Table 3-7. Tritium Concentrations[a] in Atmospheric Moisture Samples Collected On and Off the INL Site in 2018.

ESER Contractor				
	Atomic City	**EFS**	**Howe**	**Idaho Falls**
Number of samples	12	12	12	16
Number of detections	6	11	8	10
Detection percentage	50%	92%	75%	63%
Concentration range (×10^{-13} µCi/mL$_{air}$)[b]	-8.8 ± 1.6 – 17.4 ± 1.5	1.6 ± 0.8 – 17.5 ± 1.6	-2.4 ± 1.3 – 15.1 ± 2.2	-0.9 ± 1.4 – 17.4 ± 2.2
Mean concentration (×10^{-13} µCi/mL$_{air}$)[b]	4.8	9.0	6.2	6.3
Median concentration (×10^{-13} µCi/mL$_{air}$)	4.2	7.3	5.6	5.0
Mean detection level (×10^{-13} µCi/mL$_{air}$)	4.5	4.0	5.6	5.2
INL Contractor				
	Craters of the Moon	**EFS**	**Idaho Falls**	**Van Buren Boulevard**
Number of samples	6	9	9	9
Number of detections	0	3	0	0
Detection percentage	0%	33%	0%	0%
Concentration range (×10^{-13} µCi/mL$_{air}$)[b]	-1.3 ± 1.1 – 4.7 ± 2.1	2.3 ± 1.8 – 13.8 ± 3.9	-4.1 ± 6.7 – 21 ± 6.9	-0.3 ± 3.2 – 12.4 ± 3
Mean concentration (×10^{-13} µCi/mL$_{air}$)[b]	2.6	8.8	4.2	5.3
Median concentration (×10^{-13} µCi/mL$_{air}$)	3.6	9.5	3.7	5.2
Mean detection level (×10^{-13} µCi/mL$_{air}$)	7.7	11.6	14.6	10.4

a. Results ± 1σ.

b. All measurements, including negative results, 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.

reactions with water molecules in the upper atmosphere and because tritium concentrations do not appear to differ between precipitation and atmospheric moisture samples, the source of tritium measured in precipitation and atmospheric moisture is most likely of natural origin and not from INL Site releases.

Table 3-8. Tritium Concentrations in Precipitation Samples Collected by the ESER Contractor in 2018.[a,b]

	Atomic City	Experimental Field Station	Howe	Idaho Falls
Number of samples	22	19	20	11
Number of detections	15	16	13	7
Detection percentage	68%	84%	65%	64%
Concentration range (pCi/L)	31.6 ± 24.1 – 267 ± 25.5	24.7 ± 24.1 – 238 ± 24.8	37.2 ± 23.3 – 221 ± 25.7	46.1 ± 24.3 – 299 ± 25.2
Mean concentration (pCi/L)	109	139	117	107
Median concentration (pCi/L)	98	169	119	77
Mean detection level (pCi/L)	88	88	88	88

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.

3.3.6 Suspended Particulates Monitoring Results

In 2018, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99% efficient for collection of particles greater than 0.3 µm in diameter. That is, they collect the total particulate load greater than 0.3 µm in diameter.

In general, particulate concentrations were highest during the period from the end of June through mid-September. This was most likely influenced by smoke from regional wildfires observed at all locations from the end of July through the first week of September, as well as from agricultural activities off the INL Site that resulted in increased dust loads.

The particulate concentrations of all locations (excluding Jackson, which was not affected by agricultural activities or wildfires near the INL Site) were determined to be log-normally distributed. The geometric mean of these measurements during 2018 was therefore calculated to be 14.3 µg/m^3.

3.4 Waste Management Environmental Surveillance Air Monitoring

3.4.1 Gross Activity

The ICP Core contractor conducts environmental surveillance in and around waste management facilities to comply with DOE O 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 2018 (Figure 3-6). Samples were also collected at a control location at Howe, Idaho (Figure 3-2), 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. Due to a lightning strike on May 12, 2018, which affected power distribution to the monitoring station, there was an interruption in sampling at SDA 4.3A until the monitor could be relocated approximately 30 m (100 ft) east of the previous location (SDA 4.3B). Sampling resumed at the new location on June 21, 2018. Gross alpha and gross beta activity were determined on all suspended particulate samples. Table 3-9 shows the median annual and range of gross alpha concentrations at each location. Gross alpha concentrations ranged from a low of (0.99 ± 0.30) × 10^{-15} µCi/mL collected at location HOWE 400.4 on March 15, 2018, to a high of (14.3 ± 2.04) × 10^{-15} µCi/mL at location SDA 11.3 on August 15, 2018.

Table 3-10 shows the annual median and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of (0.61 ± 0.15) × 10^{-14} µCi/mL at location SDA 4.3A on January 15, 2018, to a

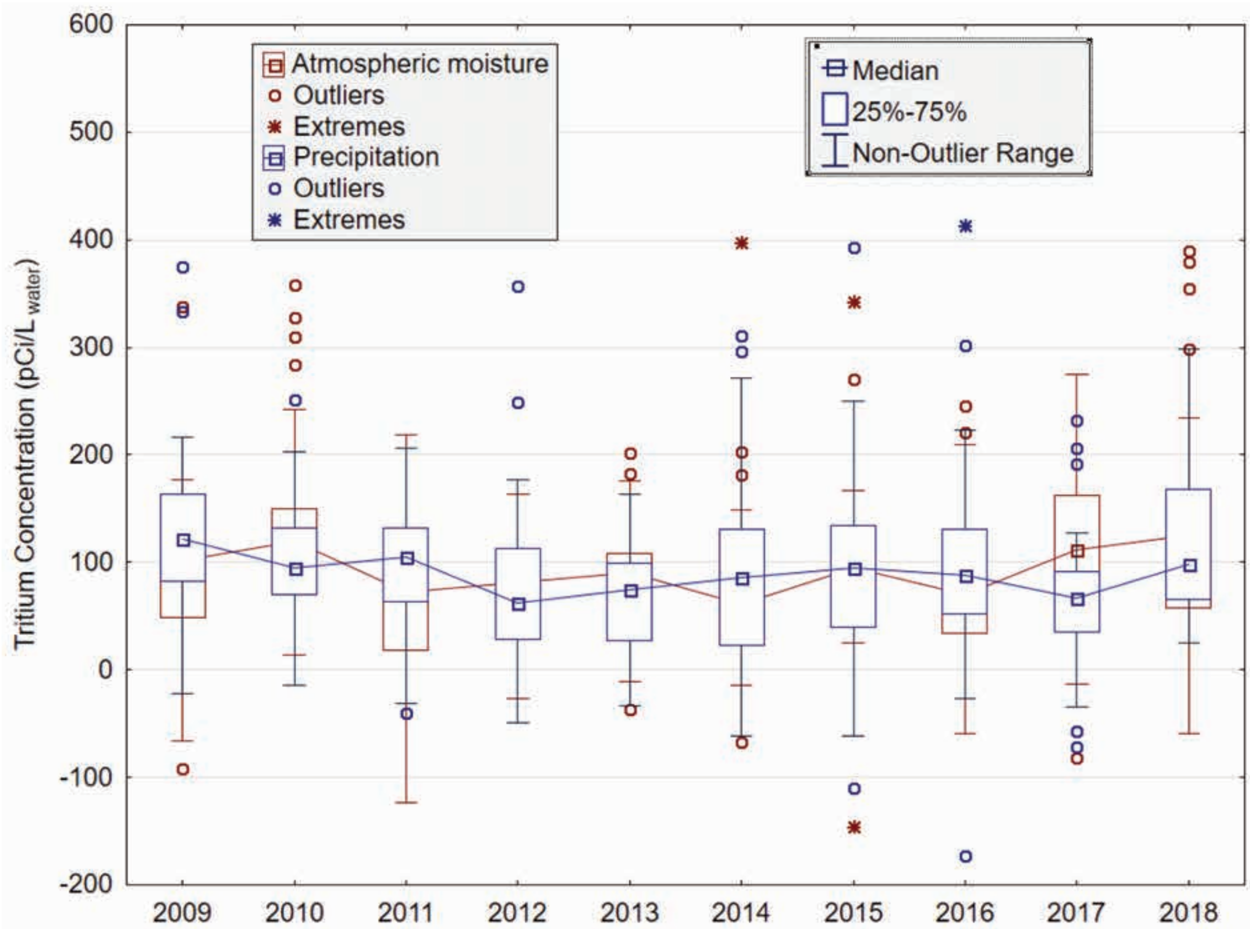


Figure 3-5. Box Plots of Tritium Concentrations Measured in Atmospheric Moisture and in Precipitation from 2009–2018.

high of (9.35 ± 0.91) x 10^{-14} µCi/mL at location SDA 9.3 on November 29, 2018.

Figure 3-7 compares gross alpha and gross beta sample results from 2012 through 2018 to 10% of the most restrictive DCS values ($^{239/240}$Pu for gross alpha, ^{90}Sr for gross beta) established by DOE for inhaled air (DOE 2011). The results for the SDA and ICDF are well below their respective DCS values.

3.4.2 Specific Radionuclides

Air filters collected by the ICP Core contractor are composited in a laboratory and analyzed for human-made, gamma-emitting radionuclides and specific alpha- and beta-emitting radionuclides. Gamma spectroscopy methods are performed monthly and radiochemical methods are performed quarterly.

In 2018, 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.

Table 3-11 shows human-made specific radionuclides detected at the SDA in 2018. None were detected at ICDF in 2018. These detections are consistent with levels measured in air at the SDA in previous years. All detections were three to four orders of magnitude below the DCS stipulated in DOE (2011), as shown in Figure 3-8, and statistically false positives at the 95% confidence error are possible. In addition to the human-made, gamma-emitting radionuclides discussed above, the ICP Core contractor also monitors for uranium. While not enumerated in Table 3-11, detections of uranium nuclides occur routinely at concentrations that suggest a natural origin. An error occurred in the schedule for specific radionuclides analysis. ICP Core Sample and Analysis Management personnel determined this error was due to deficiencies in the training of new employees at the analytical laboratory. The mistake made in composit-

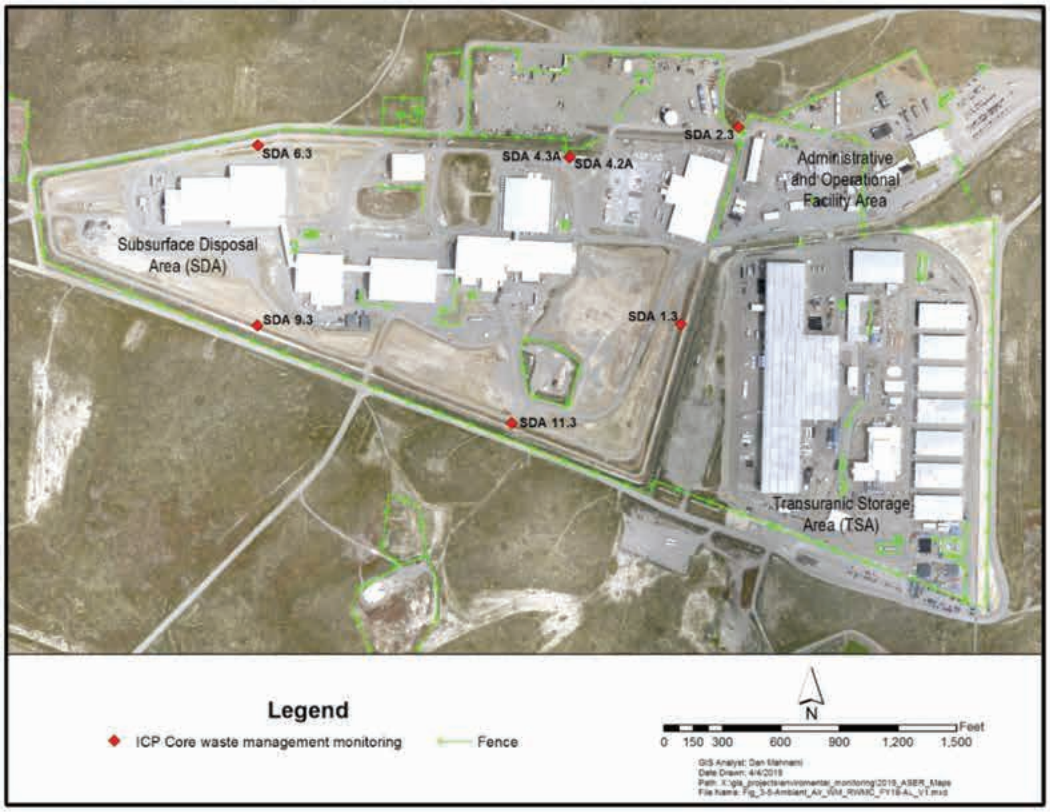


Figure 3-6. Locations of ICP Core Contractor Low-volume Air Samplers at Waste Management Areas (SDA [top] and ICDF [bottom]).

Table 3-9. Median Annual Gross Alpha Concentration in Air Samples Collected at Waste Management Sites in 2018.

Group	Location	No. of Samples Collected	Range of Concentrations (× 10^{-15} µCi/mL)	Annual Median (× 10^{-15} µCi/mL)
Subsurface Disposal Area	SDA 1.3	24	1.06 - 8.26	2.76
	SDA 2.3	24	1.08 - 11.9	2.37
	SDA 4.3A/B	19	1.57 - 6.87	3.26
	SDA 6.3	20	1.23 - 8.87	2.87
	SDA 9.3	24	1.14 - 13.2	2.52
	SDA 11.3	24	1.28 - 14.3	2.65
Idaho CERCLA Disposal Facility	INT 100.3	24	1.36 - 12.3	2.80
Boundary	HOWE 400.4	23	0.99 - 12.4	2.39

a. Results ± 1σ.

Table 3-10. Median Annual Gross Beta Concentration in Air Samples Collected at Waste Management Sites in 2018.

Group	Location	No. of Samples Collected	Range of Concentrations (× 10^{-14} µCi/mL)	Annual Median (× 10^{-14} µCi/mL)
Subsurface Disposal Area	SDA 1.3	24	1.71 - 5.26	2.91
	SDA 2.3	24	0.87 - 5.13	2.70
	SDA 4.3A/B	19	0.61 - 5.38	2.91
	SDA 6.3	20	1.45 - 4.43	3.01
	SDA 9.3	24	1.60 - 9.35	2.80
	SDA 11.3	24	1.83 - 8.34	2.98
Idaho CERCLA Disposal Facility	INT 100.3	24	1.69 - 5.06	3.10
Boundary	HOWE 400.4	23	1.52 - 5.11	2.71

a. Results ± 1σ.

ing the samples, from the final three quarters of 2018, for analysis was one of several issues resulting in non-conformance reports (NCR) during the same period. The vast majority of the NCRs were related to the need for additional training of new employees or retraining of employees in new positions at the laboratory. There have been no issues resulting in NCRs from the time of the retraining conducted by the laboratory, which indicates that it has been effective. Therefore, no corrective actions were required by the ICP Core contractor. The ICP Core contractor will continue to closely monitor radionuclides to identify trends.

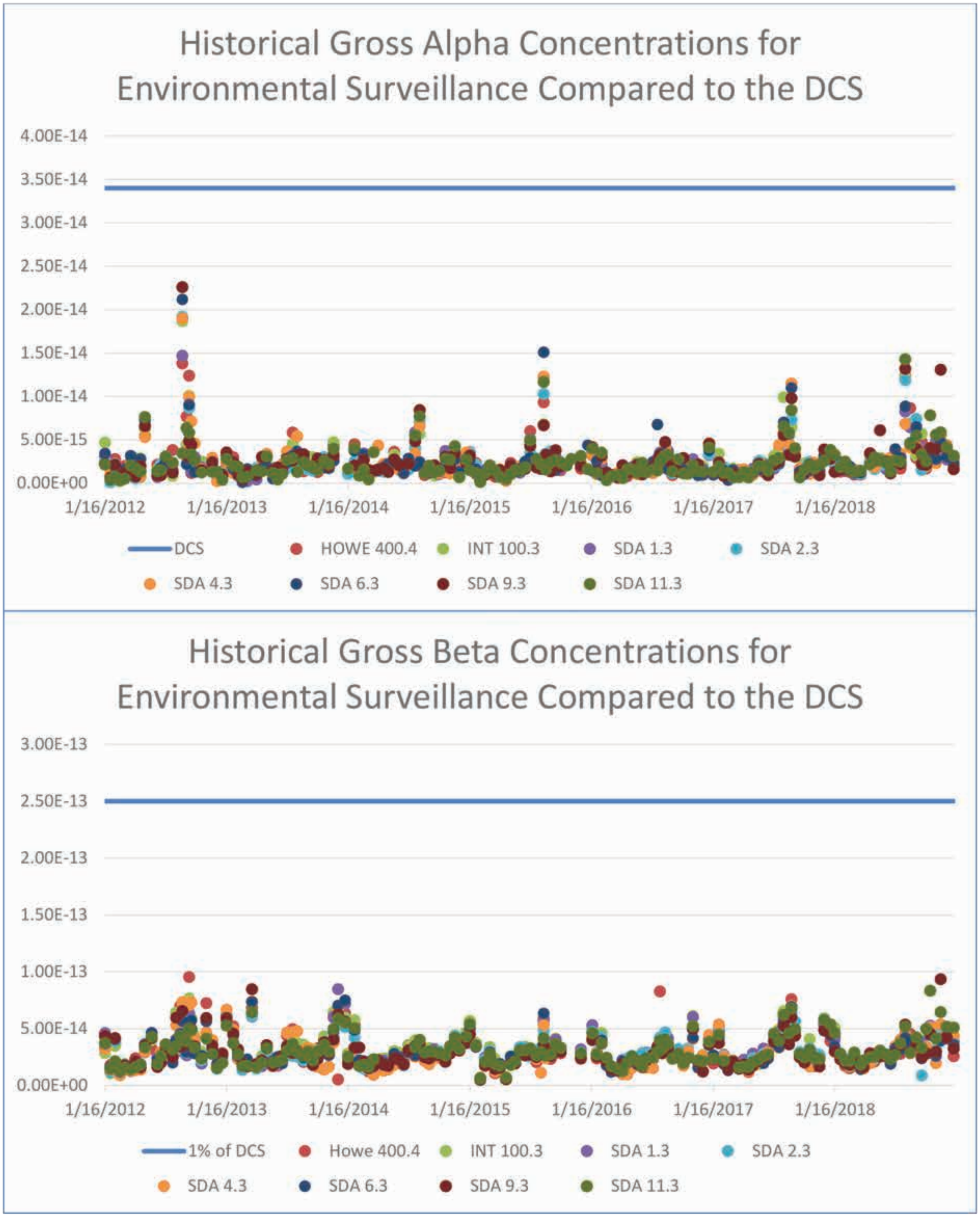


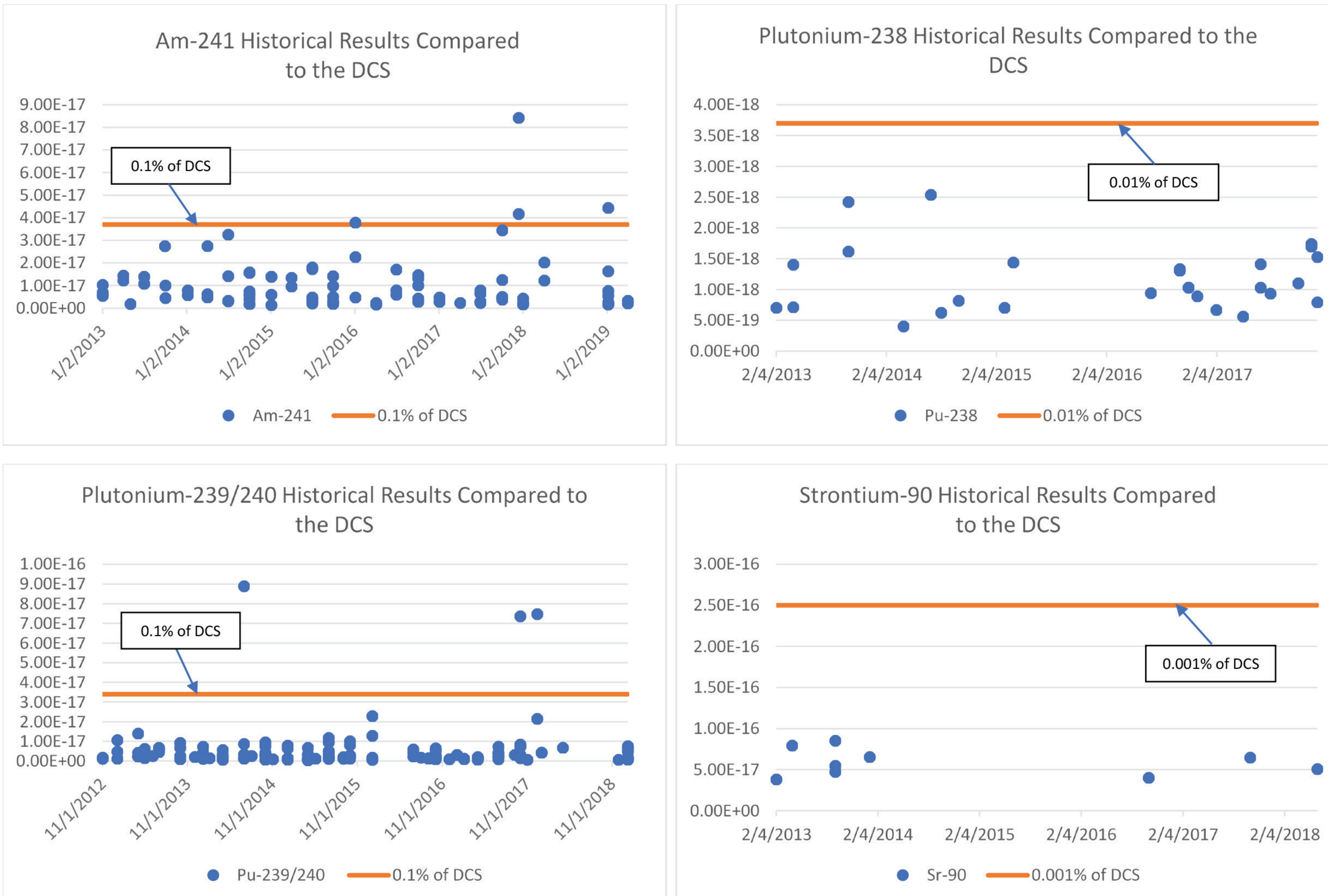
Figure 3-7. Gross Alpha and Gross Beta Results from Waste Management Site Air Samples Compared to Their Respective Derived Concentration Standards.

Table 3-11. Human-made Radionuclides Detected in Air Samples Collected at Waste Management Sites in 2018.[a]

Radionuclide	Location	Result (µCi/mL)	Uncertainty (1 Sigma)	Period Detected
Am-241	SDA 4.2A	2.03E-17	2.03E-18	1/2/2018 – 4/3/2018
Am-241	SDA 4.3A	1.22E-17	2.39E-18	
Pu-239/240	SDA 4.2A	6.88E-18	1.30E-18	
Am-241	SDA 4.2A	4.31E-17	9.59E-18	4/3/2018 – 4/12/2018[b]
Am-241	SDA 4.3A	2.61E-17	7.24E-18	
Am-241	SDA 1.3	2.44E-18	4.07E-19	4/12/2018 – 1/7/2019[c]
Am-241	SDA 2.3	7.72E-18	9.13E-19	
Am-241	SDA 4.2B	4.44E-17	4.00E-18	
Am-241	SDA 4.3B	1.62E-17	1.92E-18	
Am-241	SDA 6.3	1.60E-18	3.83E-19	
Am-241	SDA 9.3	5.41E-18	7.71E-19	
Am-241	SDA 11.3	1.80E-18	4.71E-19	
Pu-239/240	SDA 1.3	1.07E-18	3.21E-19	
Pu-239/240	SDA 2.3	4.88E-18	1.05E-18	
Pu-239/240	SDA 4.2B	7.55E-18	1.37E-18	
Pu-239/240	SDA 4.3B	6.05E-18	1.26E-18	
Pu-239/240	SDA 6.3	1.27E-18	4.12E-19	
Pu-239/240	SDA 9.3	6.71E-18	1.20E-18	
Pu-239/240	SDA 11.3	1.77E-18	4.42E-19	

a. Results ± 1σ. Results shown are ≥ 3σ.
b. Samples were taken on April 12, 2018, following the drum over pressurization event that occurred in the ARP V facility on April 11, 2018.
c. The laboratory mistakenly composited all samples for this period rather than report by calendar quarter as agreed under contract with the laboratory.

Figure 3-8. Specific Human-made Radionuclide Detections (µCi/mL) from SDA Air Samples Compared to Various Fractions of Their Respective Derived Concentration Standards.



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Big Lost River Diversion

Rock Pigeon
Columba livia

4. Environmental Monitoring Programs: Liquid Effluent Monitoring

2018

Wastewater discharged to land surfaces and evaporation ponds at the 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 2018 by the Idaho National Laboratory (INL) contractor and the Idaho Cleanup Project (ICP) Core contractor for compliance with permit requirements and applicable regulatory standards established to protect human health and the environment.

During 2018, permitted facilities were: Advanced Test Reactor (ATR) Complex Cold Waste Pond; C; Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds; and Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond. These facilities were sampled for parameters required by their facility-specific permits. No permit requirements were exceeded in 2018.

Additional liquid effluent and groundwater monitoring was performed in 2018 at ATR, INTEC, and MFC to comply with Idaho groundwater primary constituent standards, as well as, environmental protection objectives of the U.S. Department of Energy (DOE). All parameters were below applicable health-based standards in 2018.

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 did not exceed DOE Derived Concentration Standards.

4. 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. Groundwater sampling related to wastewater and direct discharges is also conducted as part of these programs.

Table 4-1 presents the requirements for 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.

4.1 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 Rules" (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 2019a, 2019b; INL 2018a, 2018b, 2018c, 2018d) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2018, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 4-2):

- Advanced Test Reactor (ATR) Complex Cold Waste Ponds (Section 4.1.1)

Common Nighthawk
Chordeiles minor

Table 4-1. Liquid Effluent Monitoring at the INL Site.

Area/Facility[a]	Monitoring Requirements		
	Idaho Wastewater Reuse Permit[b]	DOE O 458.1[c] Liquid Effluent Monitoring	DOE O 435.1[d] Surface Runoff Surveillance
INL Contractor			
ATR Complex Cold Waste Ponds	•	•	
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, 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 U.S. Department of Energy (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 O 458.1 and provides Derived Concentration Standards as reference values to control effluent releases from DOE facilities.

d. The objective of DOE O 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 O 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 4.1.2)
- Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond (Section 4.1.3).

Additional effluent constituents are monitored at these facilities to comply with environmental protection objectives of DOE O 458.1 and are discussed in Section 4.2. Surface water monitoring at the Radioactive Waste Management Complex is presented in Section 4.3.

4.1.1 Advanced Test Reactor Complex Cold Waste Pond

Description. The Cold Waste Ponds (CWP) are 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 4-1). The CWP were excavated in 1982. Each pond 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 38.69 ML (10.22 MG).

Table 4-2. 2018 Status of Wastewater Reuse Permits.

Facility[a]	Permit Status at End of 2018	Explanation
ATR Complex Cold Waste Pond	Permit issued	DEQ[b] issued Permit I-161-02 on November 20, 2014, with a minor modification issued March 7, 2017. The permit expires on November 19, 2019. A permit application was submitted May 15, 2019, to DEQ.
INTEC New Percolation Ponds	Permit issued	DEQ issued Permit M-130-06 on June 1, 2017. The permit expires on June 1, 2024.
MFC Industrial Waste Pond and Industrial Waste Ditch	Permit issued	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. DEQ issued Permit I-160-02 on January 26, 2017, with a minor modification issued March 7, 2017.

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

b. DEQ = Idaho Department of Environmental Quality

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 issued a minor modification to the permit to clarify data delivery on March 7, 2017. The permit expires on November 19, 2019.

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 206 mg/L in the January 2018 sample to 1,230 mg/L in the June 2018 sample. Sulfate ranged from a minimum of 22 mg/L in the November 2018 sample to a maximum of 671 mg/L in the June 2018 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.

The CWP permit also specifies maximum annual and 5-year average hydraulic loading rates of 300 MG/yr and 375 MG/yr, respectively. As shown in Table C-2, the 2018 flow of 201.04 MG did not exceed either of these requirements.

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 4-1). For 2018, none of the constituents exceeded their respective primary or secondary constituent standards and are presented in Table C-3a and Table C-3b. The metals concentrations continue to remain at low levels.

4.1.2 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

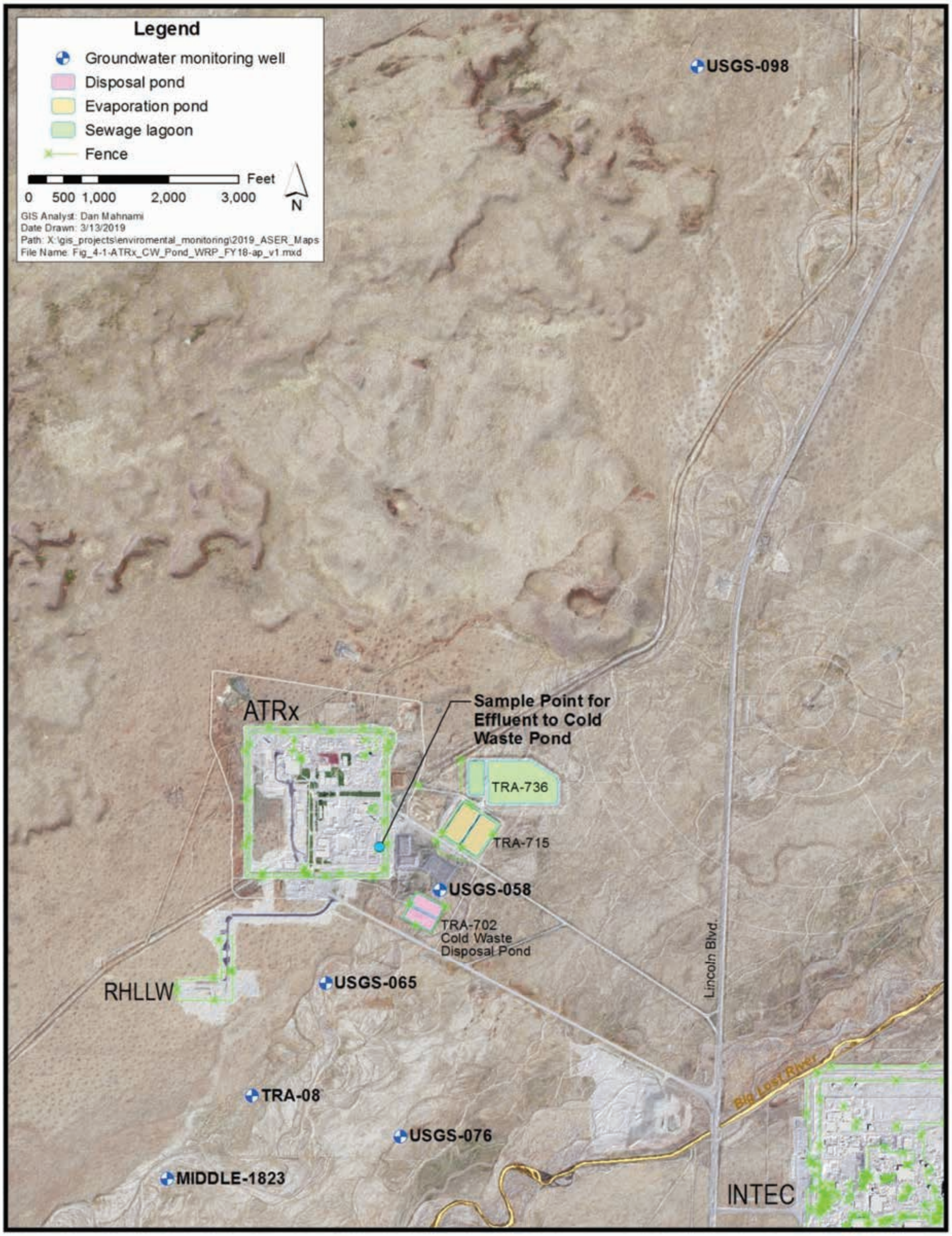

Figure 4-1. Permit Monitoring Locations for the ATR Complex Cold Waste Pond.

surficial alluvium and surrounded by bermed alluvial material (Figure 4-2). Each pond is 93 m x 93 m (305 ft x 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 11.36 Ml (3 MG) per day.

The INTEC New Percolation Ponds receive discharge of only 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/nonradiological 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 is treated by natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) in four lagoons. 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 were permitted by DEQ to operate as a reuse facility under Reuse Permit M-130-06 (DEQ 2017).

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 4-3). As required by the permit, all samples are collected as 24-hour composites, except pH, fecal coliform, 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 2018 reporting year monitoring results for CPP-769, CPP-773, and CPP-797 are provided in the 2018 Wastewater Reuse Report (ICP 2019a), and the 2018 calendar year monitoring results are summarized in Tables C-4, C-5, and C-6.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table C-7, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2018.

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 4-2.

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 Rules."

Table C-8 shows the 2018 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-9 presents similar information for the perched water wells.

Tables C-8 and C-9 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 2018.

4.1.3 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 1078.84 ML (285 MG) at a maximum water depth of 3.96 m (13 ft) (Figure 4-4). The pond receives industrial wastewater from the Industrial Waste Pipeline, storm water runoff from the nearby areas, and industrial wastewater from the Industrial Waste Ditch (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.

Reuse Permit I-160-02 issued January 26, 2017, with minor modification effective March 7, 2017, eliminated maximum concentration limits for total suspended solids and total nitrogen. The new permit also updated the constituents required for effluent and groundwater monitoring and frequency of recording flow data.

Plans for the MFC West Campus Utility Corridor were submitted to DEQ on August 1, 2018, and approved

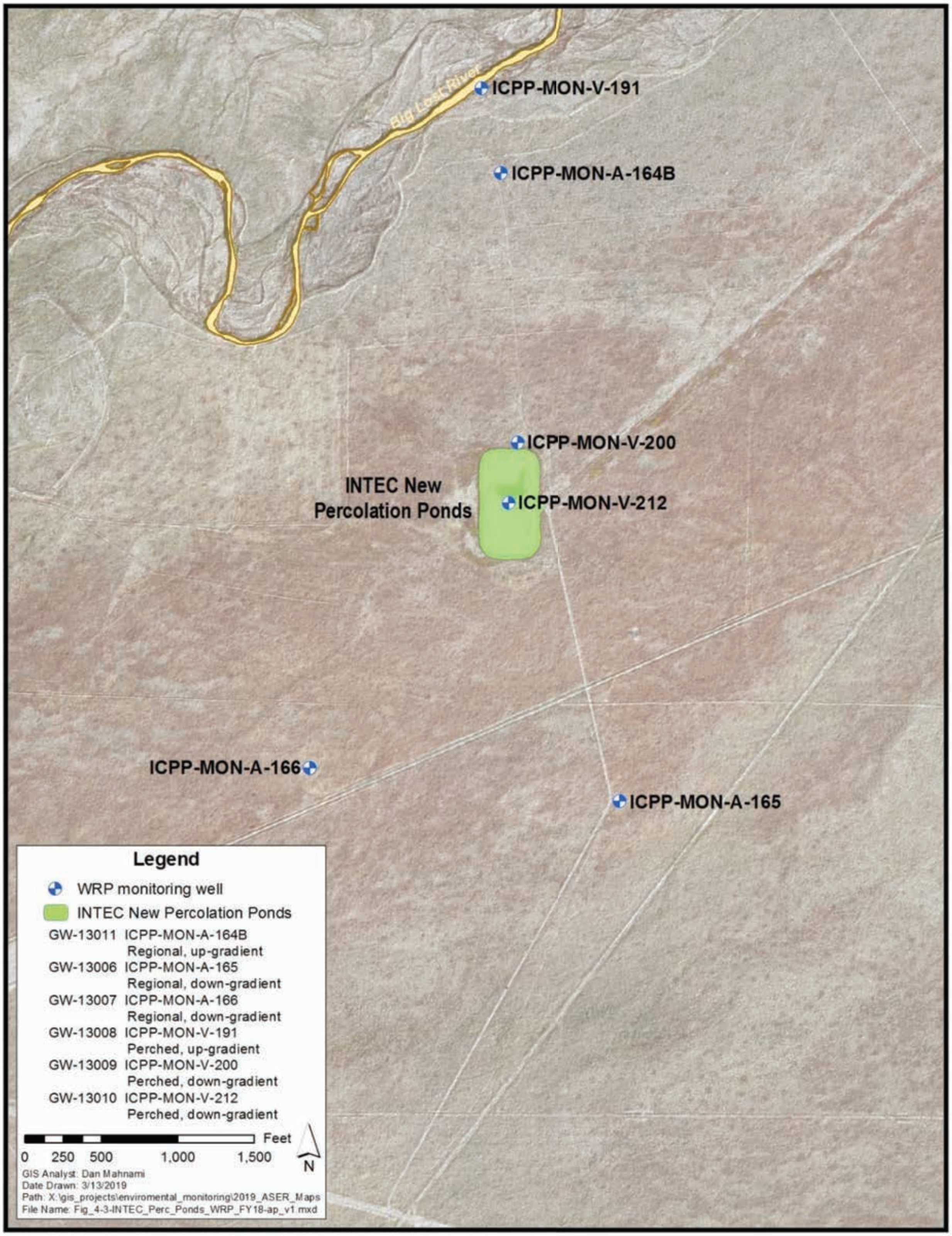

Figure 4-2. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds.

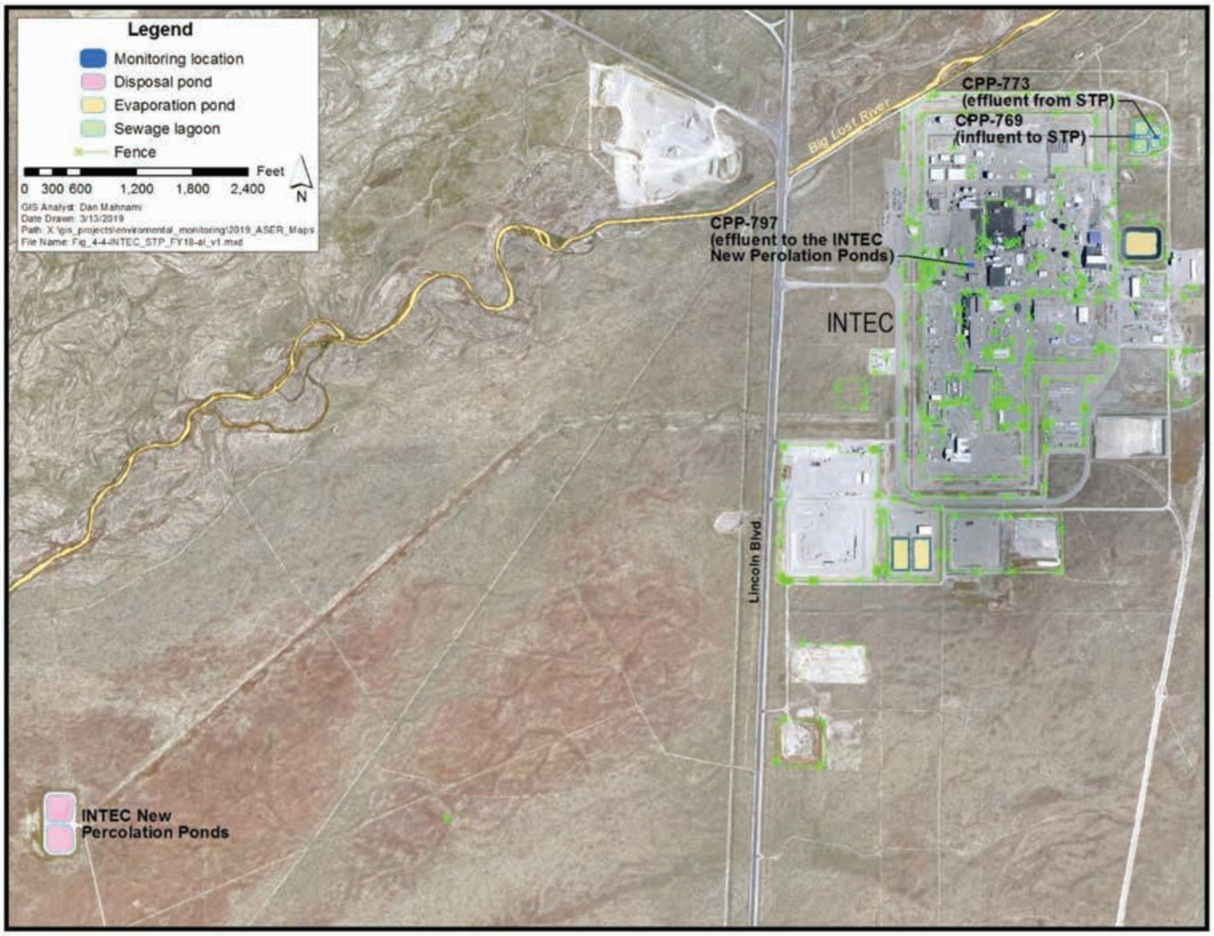

Figure 4-3. INTEC Wastewater Monitoring for Wastewater Reuse Permit.

on August 29, 2018. This project will reroute the industrial wastewater currently discharged into the Ditch C from the Industrial Waste Water Underground Pipe into a new section of underground pipe that will connect to the existing Industrial Waste Pipeline. Excavation for the project began in October 2018 and is ongoing.

Wastewater Monitoring Results for the Wastewater Reuse Permit. The new reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline and quarterly sampling of the discharge to Ditch C from the Industrial Waste Water Underground Pipe. As stated above, monthly concentration limits for total suspended solids and total nitrogen have been eliminated. 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. The reuse permit requires groundwater monitoring in April/May and September/October at one upgradient well and two downgradient wells (Figure 4-4).

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

4.2 Liquid Effluent Surveillance Monitoring

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

4.2.1 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

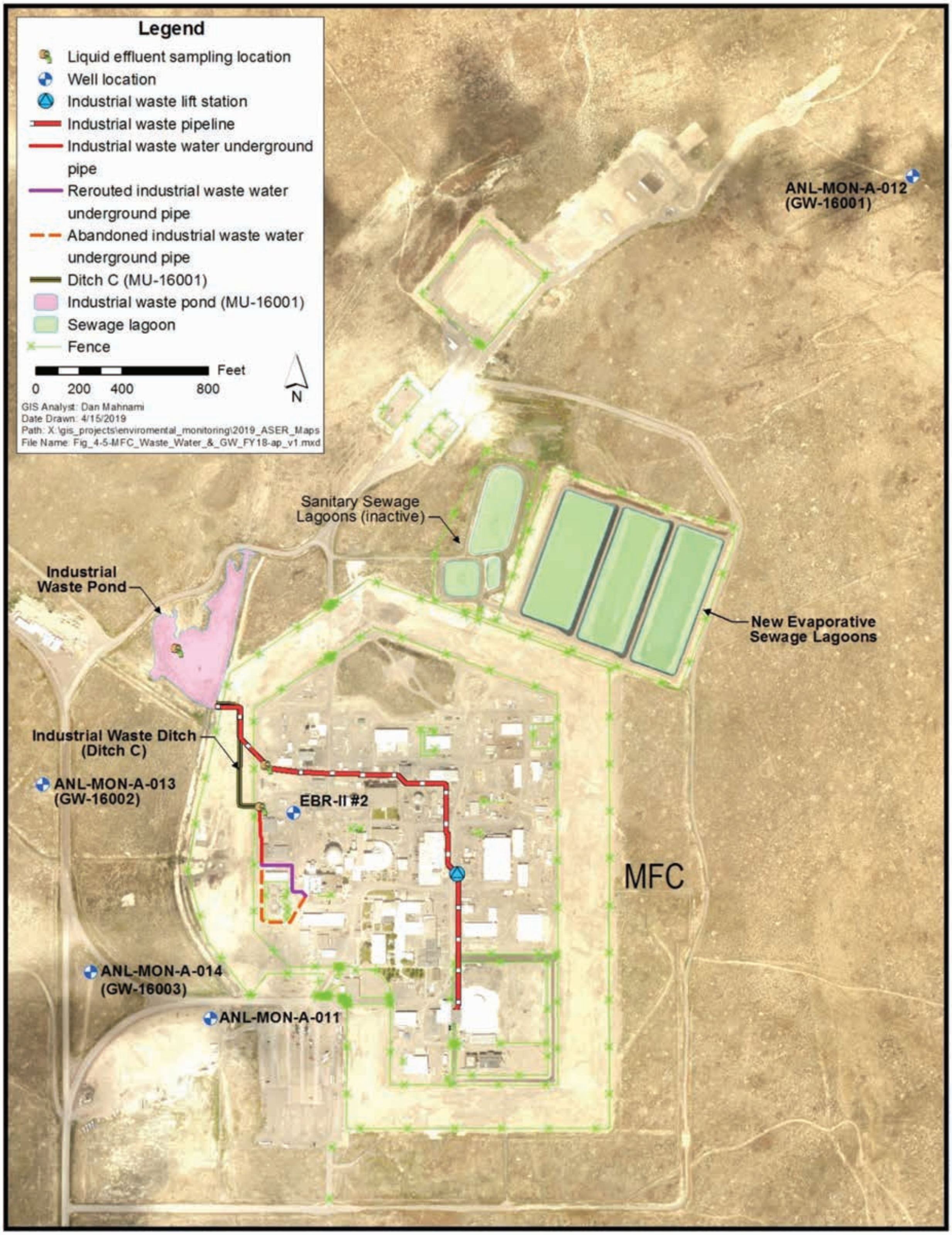

Figure 4-4. Wastewater and Groundwater Sampling Locations MFC.

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.

4.2.2 Idaho Nuclear Technology and Engineering Center

In addition to the permit-required monitoring summarized in Section 4.1.3, surveillance monitoring was conducted at CPP-773 (effluent from STP), CPP-797 (effluent to 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.

Twenty-four-hour composite samples were collected from the CPP-773 effluent in March 2018 and September 2018 and analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-15, neither gross alpha nor total strontium was detected in any of these samples. Gross beta was detected in both the March 2018 sample (9.09 pCi/L) and the September 2018 sample (24.5 pCi/L). Gamma emitter potassium-40 was detected in the March 2018 sample (48.1 pCi/L). These detections were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

Twenty-four-hour flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. Each monthly composite sample was 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 activity was detected in any of the samples collected at CPP-797 in 2018. Gross alpha was detected in four of the 12 samples, and gross beta was detected in all 12 samples collected in 2018. These detections were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

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 2018 and September 2018 and analyzed for gross alpha and gross beta. As shown in Table C-16, gross alpha was detected in aquifer Well ICPP-MON-A-165 (2.66 pCi/L and 2.79 pCi/L), aquifer Well ICPP-MON-A-166 (2.52 pCi/L), and perched water Well ICPP-MON-V-212 (3.25 pCi/L). Gross beta was detected in three of the four monitoring wells in April 2018 and all four monitoring wells in September 2018.

4.2.3 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium (Figure 4-4). Annual samples are collected and analyzed for selected isotopes of americium, iron, strontium, plutonium, and uranium. Gross alpha, gross beta and uranium isotopes were detected in 2018 (Table C-17) and are below applicable derived concentration standards found in Table A-2.

4.3 Waste Management Surveillance Surface Water Sampling

Radionuclides could be transported outside RWMC boundaries via surface water runoff. Surface water runs off the 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.

Additionally, water sheet flows across asphalt surfaces and infiltrates around/under door seals at Waste Management Facility (WMF)-636 at the Advanced Mixed Waste Treatment Project. The resulting surface water inflow accumulates in the WMF-636 Fire Water Catch Tanks (Tanks A, B, C, and D). If the level of surface water in the Fire Water Catch Tanks reaches a predetermined level, the water is pumped into aboveground holding tanks, where it can be sampled, prior to discharge into the drainage canal surrounding the SDA.

In compliance with DOE O 435.1, the ICP Core contractor collects surface water runoff samples at the RWMC SDA from the location shown in Figure 4-5. The WMF-636 Fire Water Catch Tanks are also shown in Figure 4-5. 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 from the SDA Lift Station were collected semiannually during 2018.

Table 4-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made

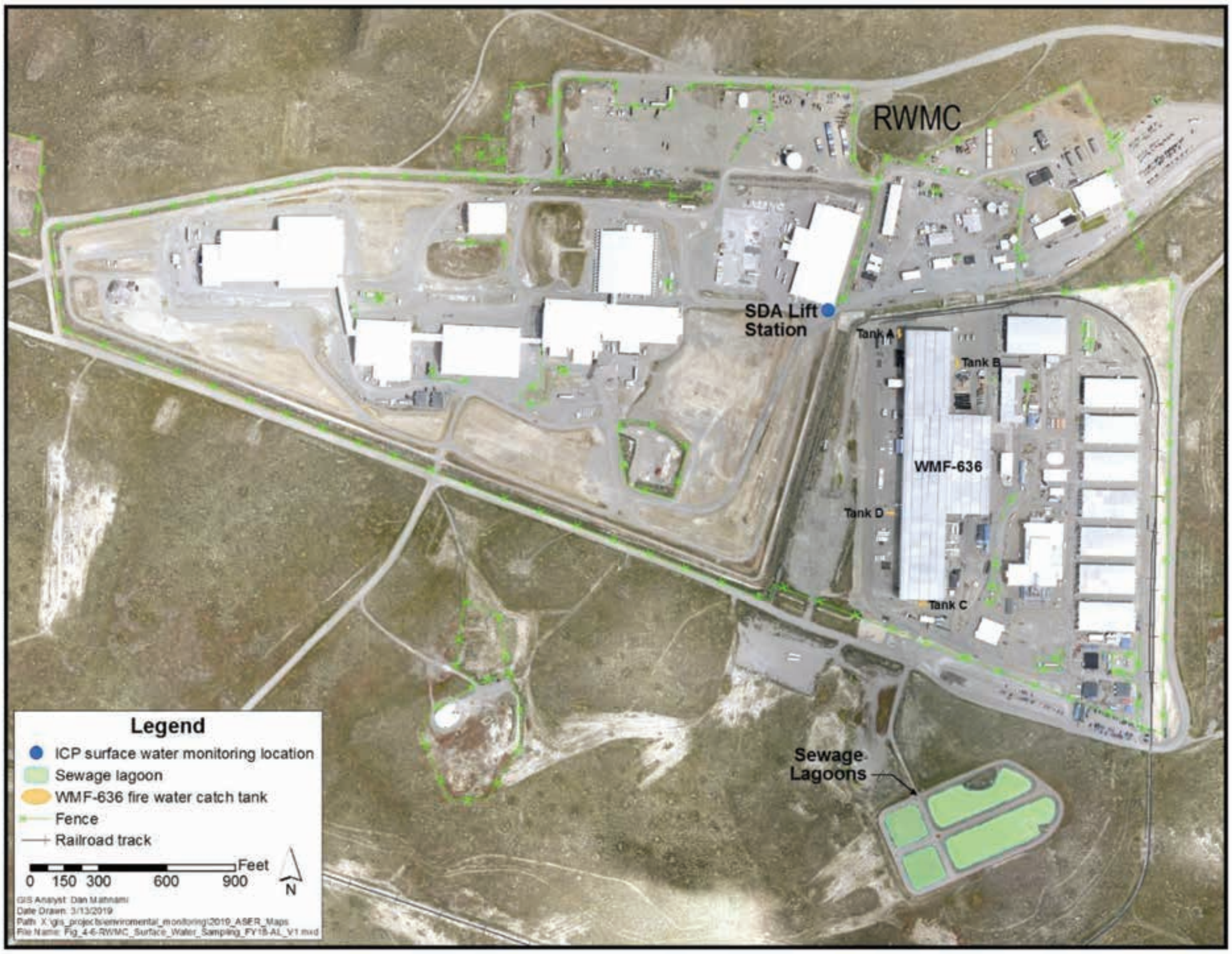

Figure 4-5. Surface Water Sampling Location at the RWMC SDA.

gamma-emitting radionuclides were detected. The americium-241, plutonium-239/240, and strontium-90 concentrations are elevated in comparison to those reported in previous years, but they are well below DOE Derived Concentration Standards (DOE 2011).

The ICP Core contractor will sample twice during 2019, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation.

Table 4-3. Radionuclides Detected in Surface Water Runoff at the RWMC SDA (2018).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	15.5 ± 1.19	9.12
Plutonium-238	19.9 ± 1.55	13.27
Plutonium-239/240	15.3 ± 1.19	10.93
Strontium-90	194 ± 22.8	17.64

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

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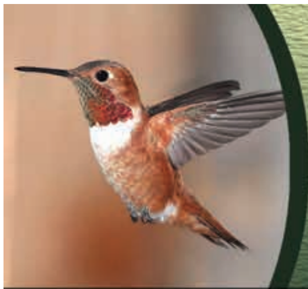
East and Middle Butte

Photo Credit: Peggy Scherbinske



Rufous Hummingbird
Selasphorus rufus

5. Environmental Monitoring Programs: Eastern Snake River Plain Aquifer

2018

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 2018, USGS sampled 27 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds (VOCs).Ten purgeable organic compounds were detected in at least one well. Most of the detected 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 Radioactive Waste Management Complex. This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Tetrachloromethane (trichloroethene) shows a similar decreasing trend through time at wells south of the RWMC was also detected above the MCL at a well at Test Area North where there is a known groundwater plume containing this contaminant being treated.

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 – 4 and WAG 9 in 2018.

There are 12 drinking water systems on the INL Site. All contaminant concentrations measured in drinking water systems in 2018 were below regulatory limits. 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 ingesting radionuclides in water was calculated. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2018 was 0.134 mrem (1.34 µSv). This value is below the EPA standard of 4 mrem/yr (40 µSv/yr) for public drinking water systems.

Drinking water and springs were sampled by the Environmental Surveillance, Education, and Research contractor in the vicinity of the INL Site and analyzed for gross alpha and gross beta activity and tritium. Some locations were co-sampled with the state of Idaho Department of Environmental Quality INL Oversight Program. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases.

5. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain aquifer serves as the primary source of 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 5-1); 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

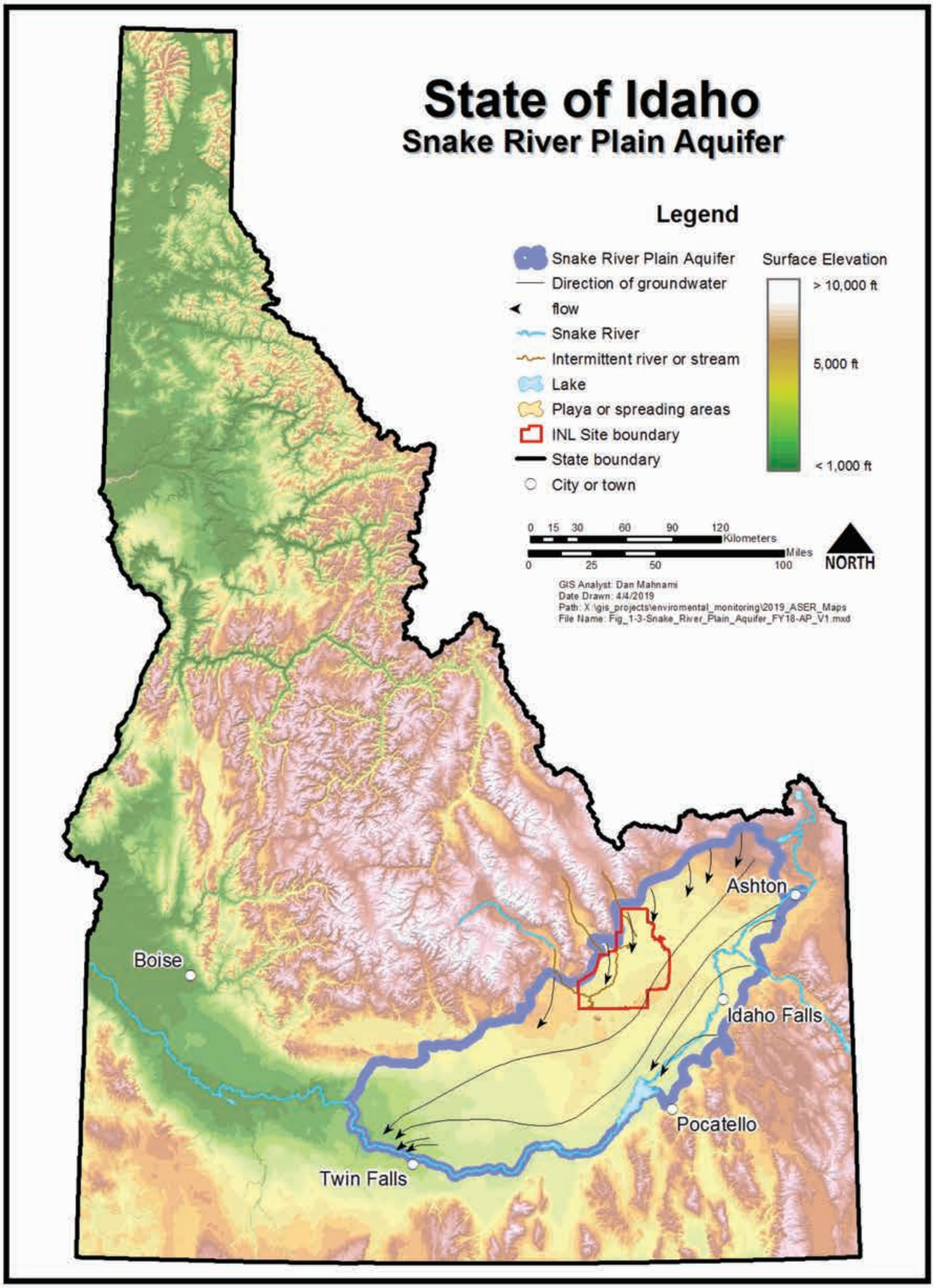


Figure 5-1. The Eastern Snake River Plain Aquifer and Direction of Groundwater Flow.

- 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 Derived Concentration Standards for ingestion of water (DOE 2011).

5.1 Summary of Monitoring Programs

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

- 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 groundwater 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 5-2) and at locations throughout the eastern Snake River Plain.

Table 5-1 summarizes the USGS routine groundwater surveillance program. In 2018, USGS personnel collected and analyzed over 1,000 samples for radionuclides and inorganic constituents, including trace elements, and 38 samples for purgeable organic compounds. USGS INL Project Office personnel also published four documents covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Chapter 9.

- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site (Figure 5-3) for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and Radioactive Waste Management Complex (RWMC). In 2018, the ICP Core contractor monitored groundwater at Test Area North (TAN), Advanced Test Reactor (ATR) Complex, INTEC, and Central Facilities Area (CFA) (WAGs 1, 2, 3, and 4, respectively). In 2018, groundwater monitoring was not performed at wells near the RWMC, which is discussed further in Section 5.5.7. Table 5-2 summarizes the routine monitoring for the ICP Core contractor drinking water program. The ICP Core contractor collected and analyzed 119 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, disinfection byproducts, and volatile organic compounds (VOCs) in 2018.
- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9) ATR Complex, and Remote Handled Low-Level Waste facility (RHLLW) 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 5-3 summarizes the routine groundwater and drinking water program. In 2018, the INL contractor sampled and analyzed 199 groundwater and 333 drinking water samples, which included 43 non-routine and 23 performance samples for varying constituents including radionuclides, inorganic compounds, and VOCs. Compared to previous years, the number of groundwater samples seems to have decreased, however the number of constituents analyzed did not change significantly. The number of sampling locations actually increased due to additional sampling requirements from RHLLW. The reduction is due to increased efficiency and strategic handling allowing more constituents to be analyzed from a particular sample.
- 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

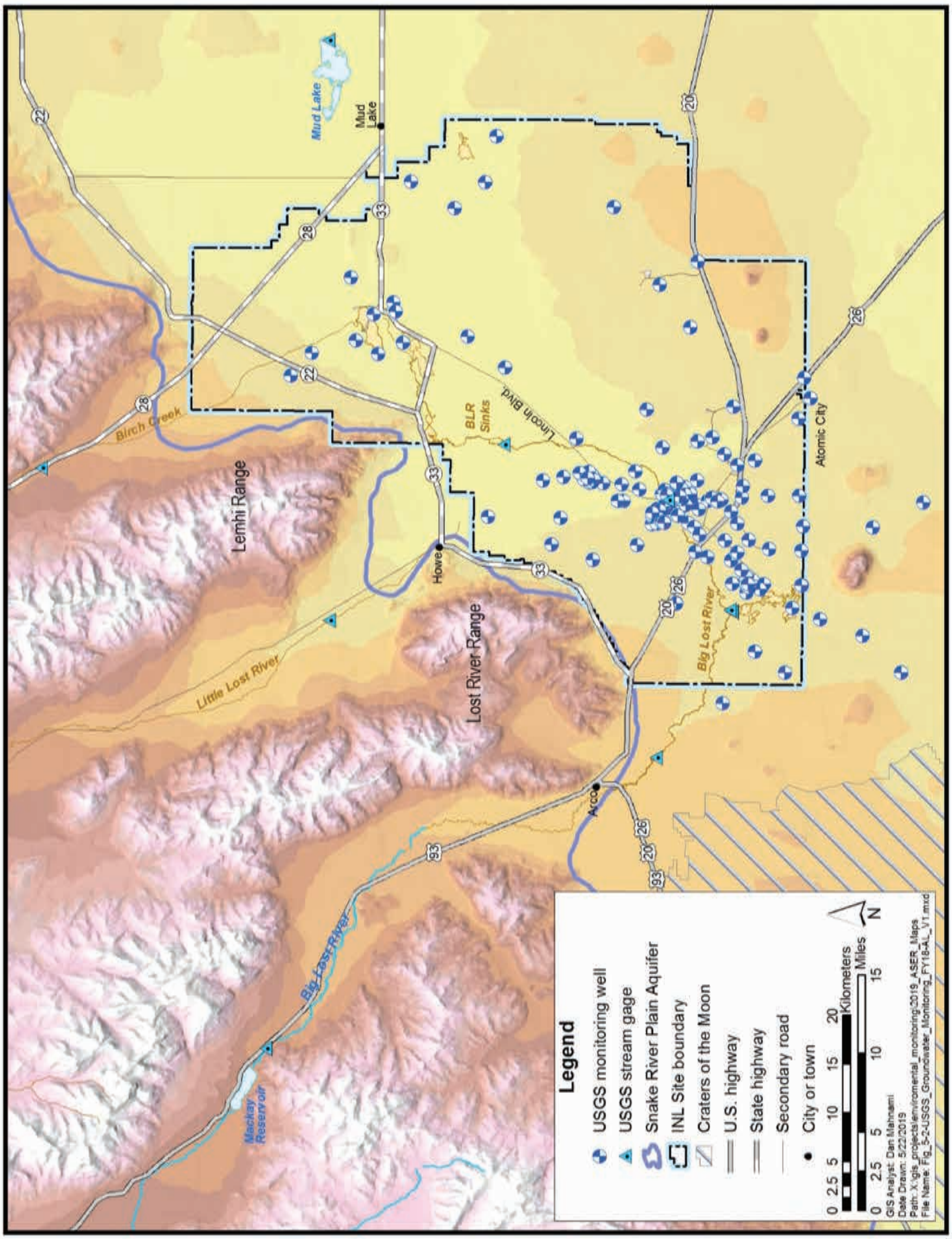


Figure 5-2. USGS Groundwater Monitoring Locations On and Off the INL Site.

Table 5-1. USGS Monitoring Program Summary (2018).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or Activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	54	53	4	4	8 pCi/L
Gross beta	54	53	4	4	3.5 pCi/L
Tritium	147	141	7	7	200 pCi/L
Gamma-ray spectrometry	55	52	—[b]	—	—[c]
Strontium-90	85	81	—[b]	—	2 pCi/L
Americium-241	12	12	—[b]	—	0.03 pCi/L
Plutonium isotopes	12	12	—[b]	—	0.02 pCi/L
Iodine-129	14	14	—[b]	—	<1 pCi/L
Specific conductance	147	141	7	7	Not applicable
Sodium ion	141	134	—[b]	—	0.1 mg/L
Chloride ion	147	141	7	7	0.02 mg/L
Nitrates (as nitrogen)	120	115	—[b]	—	0.04 mg/L
Fluoride	4	4	—[b]	—	0.01 mg/L
Sulfate	130	123	—[b]	—	0.02 mg/L
Chromium (dissolved)	77	74	—[b]	—	0.6 mg/L
Purgeable organic compounds[d]	27	38	—[b]	—	Varies
Mercury	11	11	—[b]	—	0.005 µg/L
Trace elements	13	13	—[b]	—	Varies

a. Number of samples does not include 12 replicates and four blanks collected in 2018. Number of samples was different from the number of sites because one site for volatile organic compounds is sampled monthly, and seven sites that had pump problems or were dry were not sampled. Number of sites does not include 20 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.

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 5-4. In 2018, the ESER contractor sampled and analyzed 26 surface and drinking water samples. An additional 24 samples were collected on the Big Lost River.

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 *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2019).

5.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, including

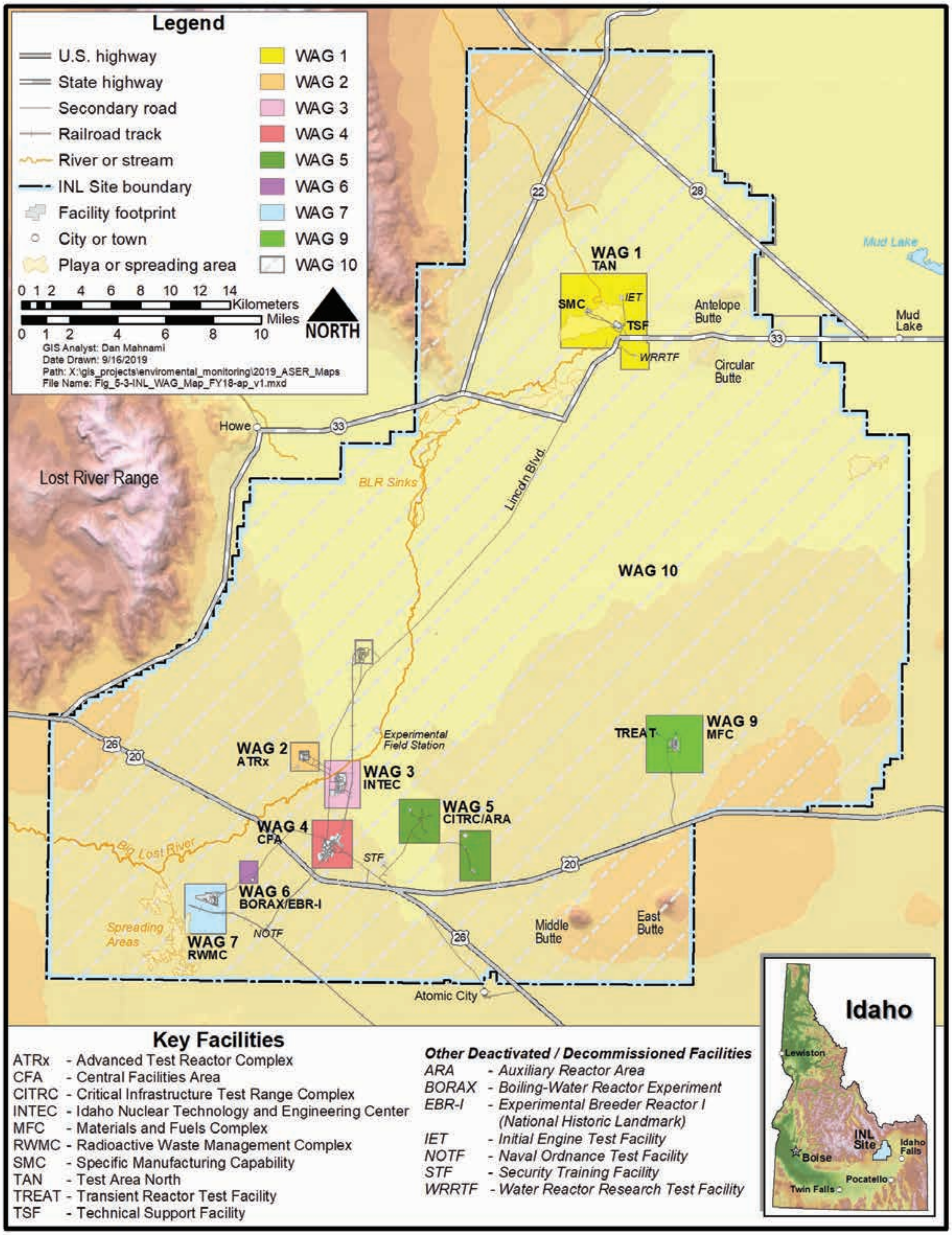


Figure 5-3. Map of the INL Site Showing Locations of Facilities and Corresponding WAGs.

Table 5-2. ICP Core Contractor Drinking Water Program Summary (2018).

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	4 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)
Radium-226/-228	2 every 9 years	5 pCi/L
Strontium-90	4 annually	8 pCi/L
Total trihalomethanes	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium	2 every 9 years	30 µg/L
Volatile organic compounds	1 quarterly	Varies

Table 5-3. INL Contractor Drinking Water Program Summary (2018).

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]	11 annually	10 mg/L (as nitrogen)
Microbes[c]	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
Total trihalomethanes[e]	1 annual	0.08 mg/L
Haloacetic acids[e]	1 annual	0.06 mg/L
Lead/Copper[e]	30 triennially	0.015/1.3 mg/L

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.
e. Total trihalomethanes, haloacetic acids, and lead/copper are only sampled at ATR-Complex, CFA, MFC, and TAN/CTF water systems.

Table 5-4. Environmental Surveillance, Education, and Research Program Surface and Drinking Water Summary (2018).

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,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 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 (when flowing) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at the Experimental Field Station, 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.
c. One sample is also collected offsite at Birch Creek as a control for the Big Lost River, when it is flowing.

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 ICP Core and 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.
- The USGS Data Management Program involves putting all data in the National Water Information System, which is available online at https://waterdata.usgs.gov/id/nwis/nwis.

5.3 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 the 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 5-4 (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.

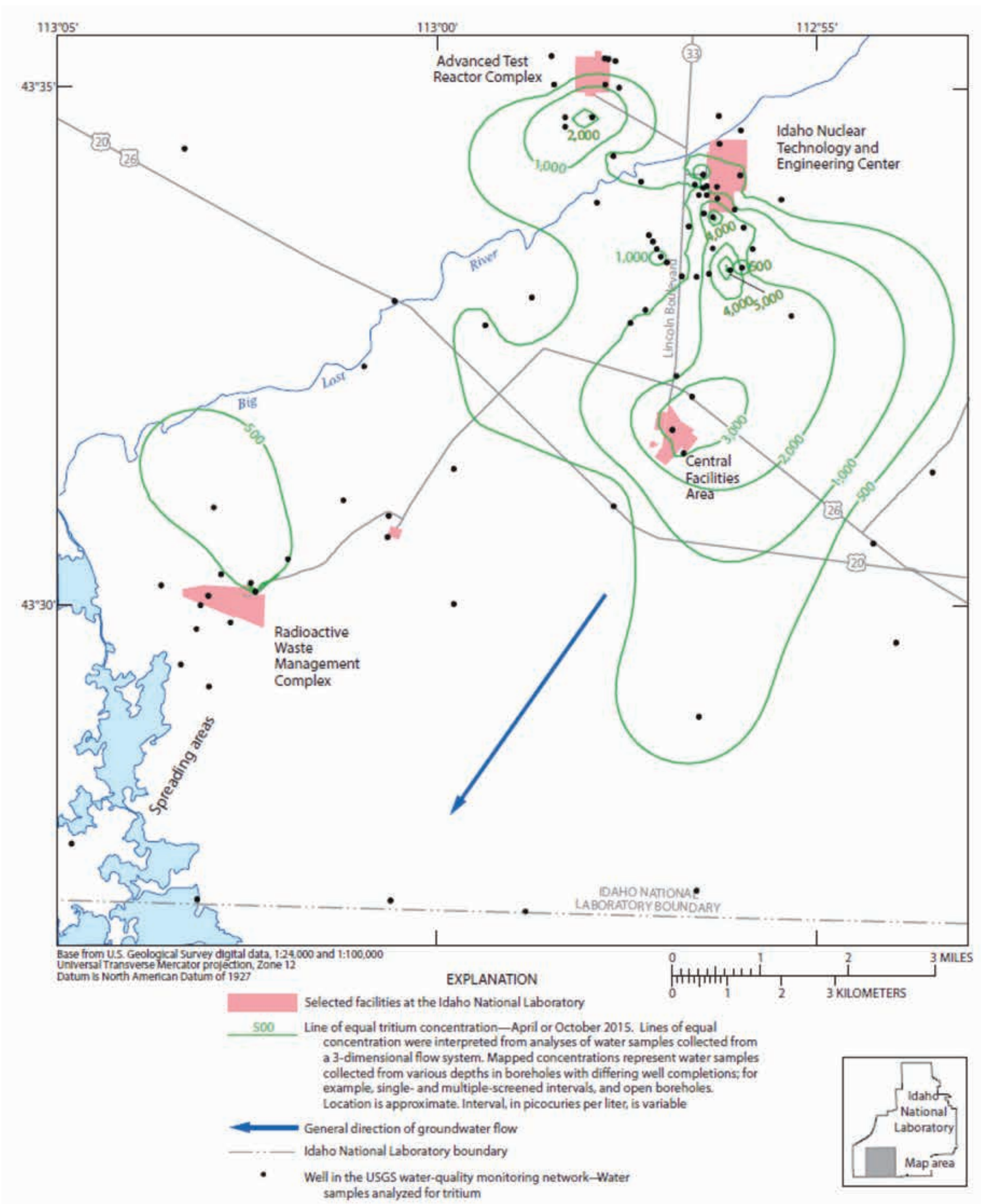


Figure 5-4. Distribution of Tritium (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

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 5-5). 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 decreased from 2,150 ± 80 pCi/L in 2017 to 1,930 ± 80 pCi/L in 2018; the tritium concentration in USGS-114, south of INTEC, decreased from 5,410 ± 120 pCi/L in 2017 to 5,100 ± 190 in 2018.

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 12.33 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 5-6 (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 2018. 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.

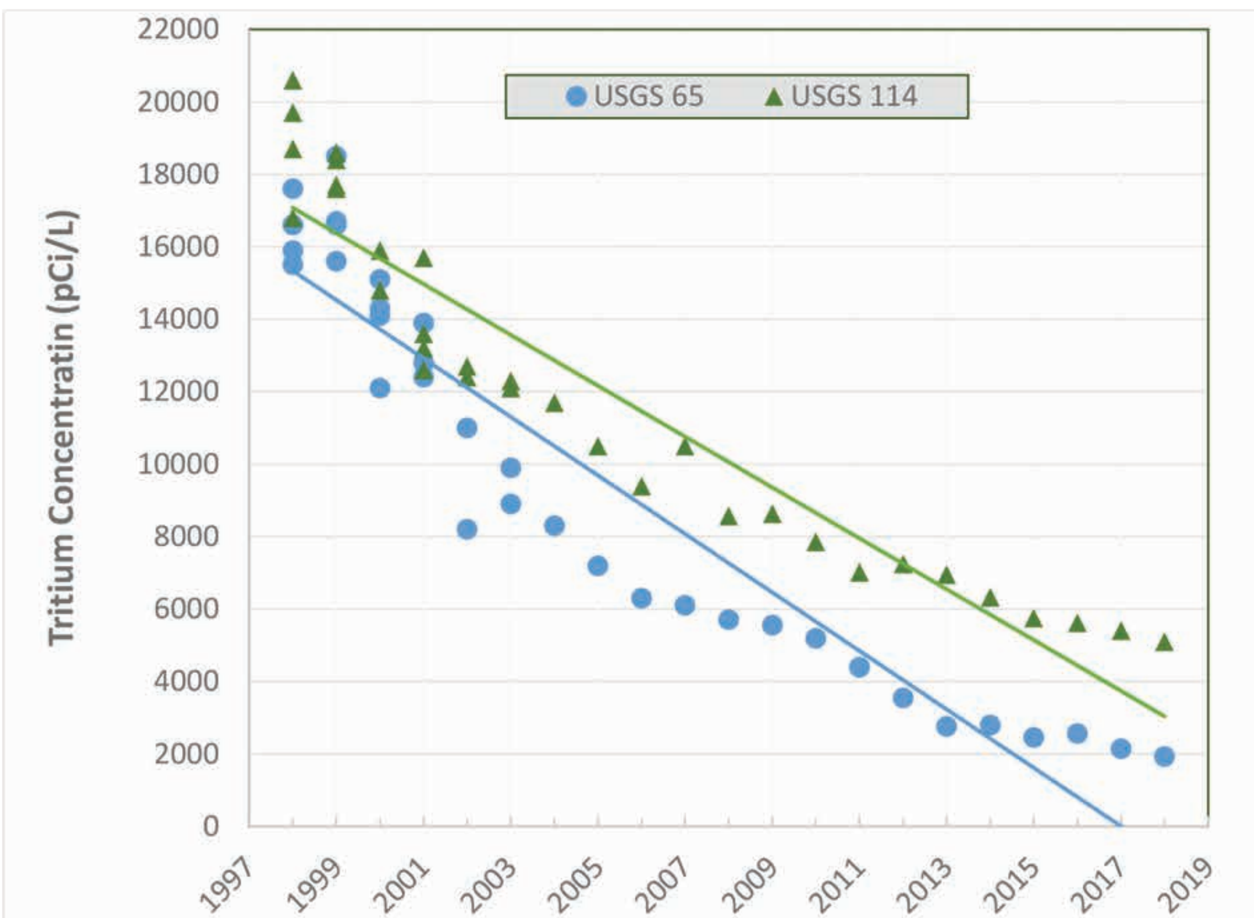


Figure 5-5. Long-term Trend of Tritium in Wells USGS-065 and -114 (1998–2018).

The ^{90}Sr trend over the past 20 years (1998–2018) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 5-7. 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

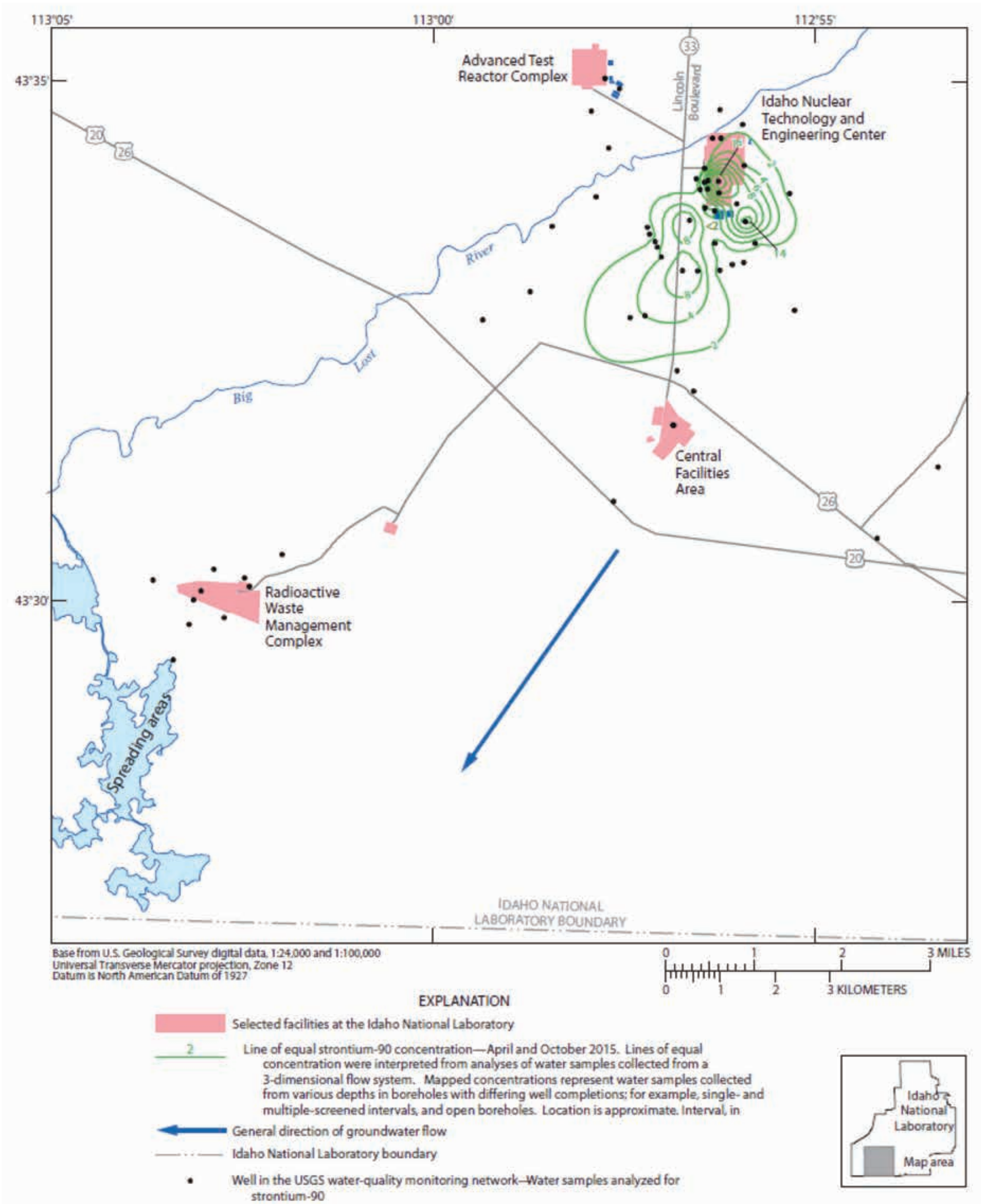


Figure 5-6. Distribution of ^{90}Sr (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

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 5-1). Results for wells sampled in 2018 are available at https://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 radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.1 ± 0.7 to 1,010 ± 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, 2007, 2011, and 2012 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009, 2013). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2017 and collected additional samples in the spring of 2018. Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, 2011–2012, and 2017-2018 decreased from 1.15 pCi/L in 1990–1991 to 0.168 pCi/L in 2017–2018. The maximum concentration in 2011 was 1.02 ± 0.04 pCi/L in a monitoring well

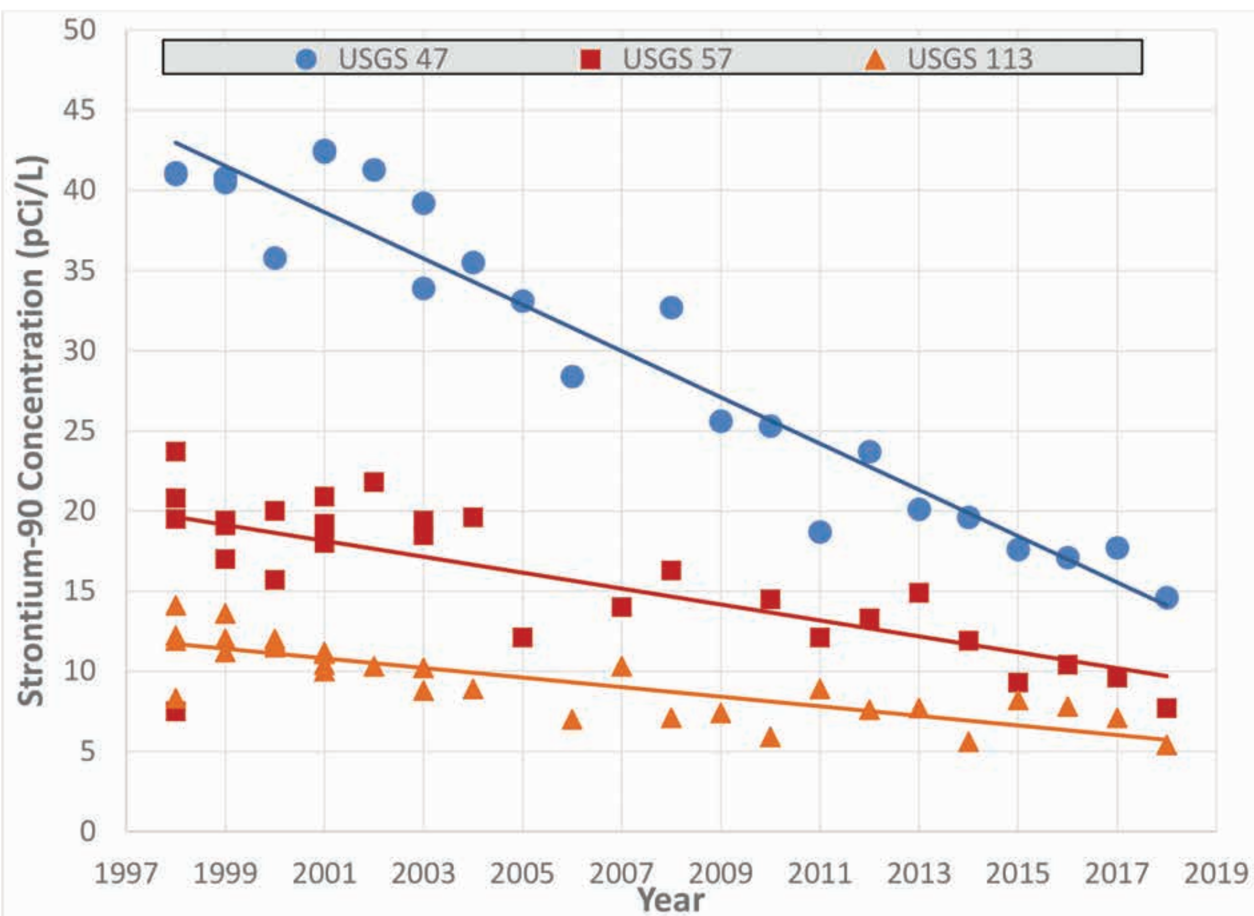


Figure 5-7. Long-term Trend of ^{90}Sr in Wells USGS-047, -057, and -113 (1998–2018).

southeast of INTEC—the drinking water standard for [129]I is 1 pCi/L. The concentration in that same well in 2017 decreased to 0.877 ± 0.032 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 published date), are shown in Figure 5-8 (Bartholomay 2013).

5.4 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 5-1). 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

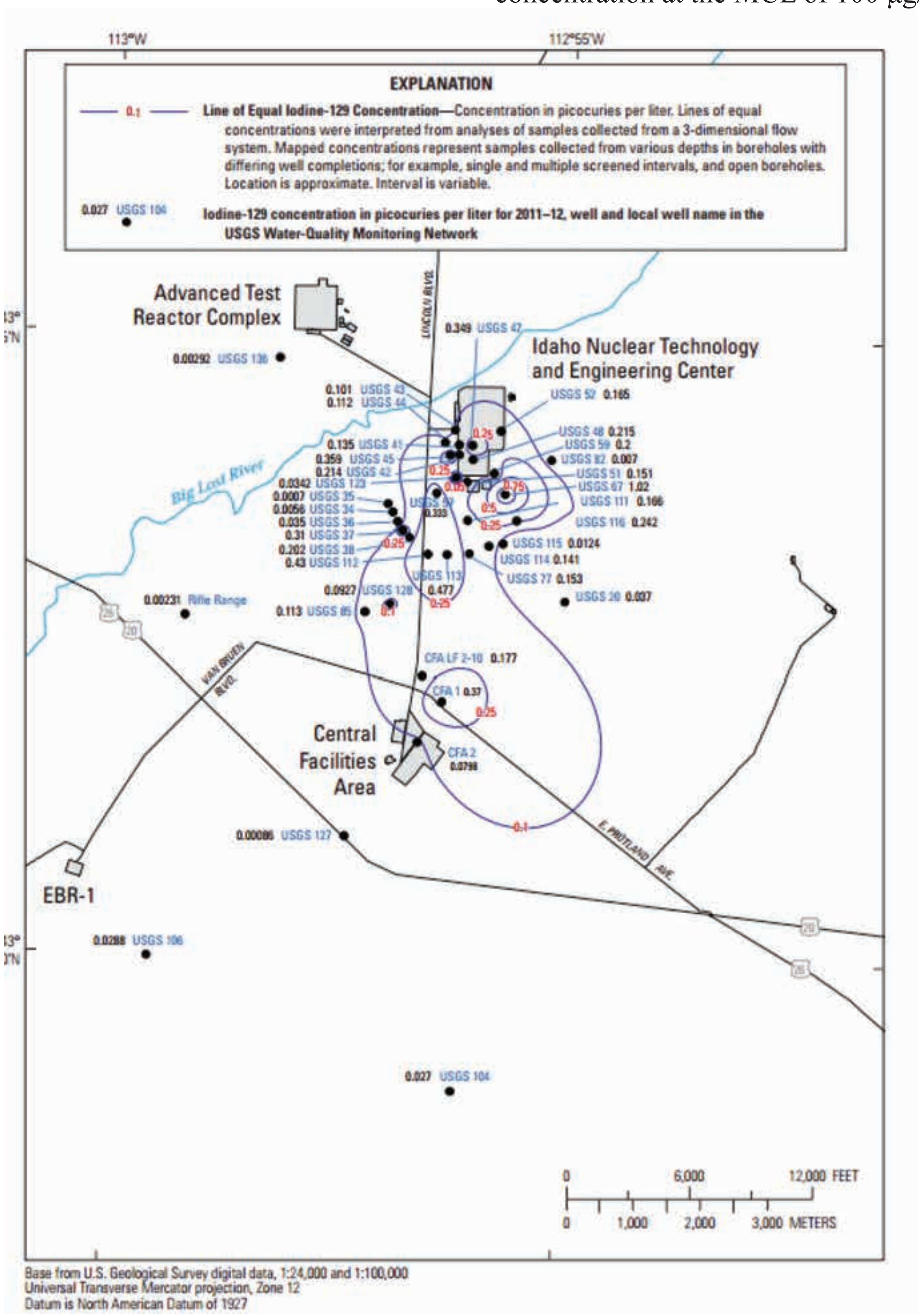


Figure 5-8. Distribution of [129]I in the Eastern Snake River Plain Aquifer on the INL Site in 2011–2012 (from Bartholomay 2013).

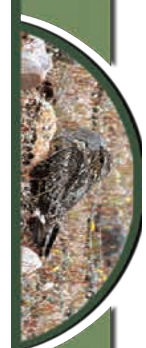


Table 5-5. Purgeable Organic Compounds in Annual USGS Groundwater Well Samples (2018).

Constituent[a]	GIN 2	RWMC-M7S	TAN-2271	USGS-65	USGS-77	USGS-87	USGS-88	USGS-89	USGS-119	USGS-120
1,1-Dichloroethane	<0.1	<0.1	0.269	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
cis-1,2-Dichoroethene[b] (µg/L)	0.106	<0.1	1.68	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
trans-1,2-Dichloroethene[b]	<0.1	<0.1	94.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tetrachloromethane (µg/L) (MCL = 5)[a]	<0.2	3.39	<0.2	<0.2	<0.2	3.49	0.779	<0.2	0.341	3.11
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.66	<0.1	<0.1
Trichloromethane (µg/L) (MCL = 80)	0.105	0.747	<0.1	0.119	<0.1	0.303	0.37	<0.1	<0.1	0.88
1,1,1-Trichloroethane (µg/L) (PCS = 200)[c]	<0.1	0.241	<0.1	<0.1	<0.1	0.133	<0.1	<0.1	<0.1	0.192
Tetrachloroethene[b] (µg/L) (MCL = 5)	1.91	0.303	<0.1	<0.1	<0.1	0.175	<0.1	<0.1	<0.1	0.138
Trichloroethene[b] (µg/L) (PCS = 5)	8.86	2.12	2.74	<0.1	<0.1	1.1	0.494	<0.1	<0.1	1.63
Vinyl chloride	<0.2	<0.2	0.862	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

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

b. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11

(Davis et al. 2013), but its concentration has been below the MCL since 2016 and has been 76.0 µg/L in 2018; 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 in all wells during 2015 (Bartholomay et al. 2017).

VOCs are present in water from the eastern Snake River Plain aquifer because of historical waste disposal practices at the INL Site. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. The USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2018. Samples from 27 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 5-5).

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 2018, and concentrations exceeded the MCL of 5 µg/L during 9 of the 12 months (Table 5-6).

Concentrations have routinely exceeded the MCL for tetrachloromethane in drinking water (5 µg/L) at RWMC since 1998. (Note: VOCs are removed from the production well water prior to human consumption—see Section 5.6.4.) Trend test results for tetrachloromethane 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

Table 5-6. Purgeable Organic Compounds in Monthly Production Well Samples at the RWMC (2018).

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL = 5)[a]	4.76	5.63	5.84	4.88	5.61	6.04	5.82	5.84	5.41	5.45	4.95	5.85
Trichloromethane (µg/L) (MCL = 80)[b]	1.52	1.57	1.71	1.58	1.71	1.62	1.49	1.64	1.7	1.8	1.78	1.89
Tetrachloroethene[c] (µg/L) (PCS = 5)[d]	0.392	0.364	0.39	0.333	0.363	0.369	0.403	0.424	0.354	0.327	0.447	0.428
1,1,1-Trichloroethane (µg/L) (PCS = 200)	0.269	0.308	0.308	0.28	0.297	0.303	0.291	0.332	0.288	0.287	0.261	0.323
Trichloroethene[c] (µg/L) (PCS = 5)	3.9	3.44	3.65	3.04	3.71	3.42	3.59	3.83	3.96	3.81	4.27	4.05

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. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.
d. PCS = primary constituent standard values from IDAPA 58.01.11

well. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

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).

Trichloroethylene (trichloroethene) (TCE) exceeded the MCL of 5 µg/L from one sample collected from Well GIN 2 at TAN (Table 5-5). There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 5.5.1.

5.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2018

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 5-3. 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 https://ar.icp.doe.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

5.5.1 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 VOC 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 VOC 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 (near Well TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated solvents (principally TCE). The hot spot concentration was defined using TCE data from 1997 (Figure 5-9) 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. Currently, the ISB rebound test has been split into two components: 1) an ISB rebound test for the area near the former injection Well TSF-05 and 2) ISB activities to treat the TCE source affecting Well TAN-28.

In 2018, an ISB rebound test was in progress for the area near the former injection Well TSF-05. Anaerobic conditions created by ISB were still present in the hot spot area, and TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2019a).

Data from Wells TAN-28 and TAN-1860 indicated that there was an untreated source in the aquifer. To treat the TCE source responsible for elevated TCE concentrations in Wells TAN-28 and TAN-1860, ISB injections began first into Well TAN-2272. However, the data indicated that the injections into Well TAN-2272 were not having a significant impact on the suspected TCE source. Consequently, a decision was made to change the ISB injection well to Well TAN-37 and ISB injections began into this well in April 2018. Three ISB injections were made during 2018 with one injection into Well TAN-2272 and two injections into Well TAN-37.

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 2018 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone (1,000–20,000 µg/L) are based on data collected in 1997, before remedial actions started (Figure 5-9), and do not reflect current concentrations. In 2018, only one well, Well TAN-28, was near 1,000 µg/L. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 near the New Pump and Treat Facility are used as indicators of TCE concentrations migrating past the New Pump and Treat Facility extraction wells into the distal zone. In 2018, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 19.3 to 40.1 µg/L.

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

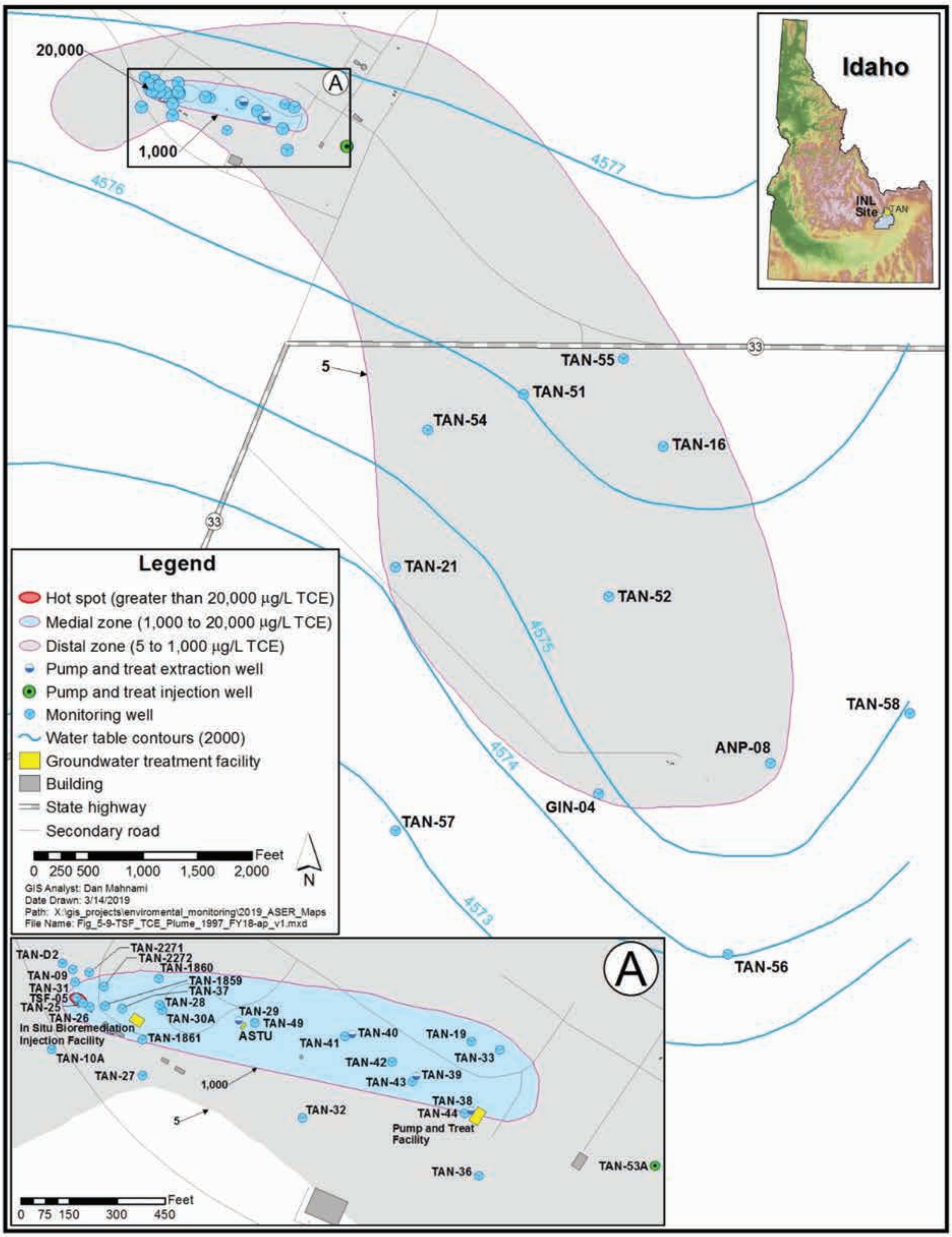


Figure 5-9. Trichloroethylene (trichloroethene) Plume at TAN in 1997.

defined by 1997 TCE concentrations (Figure 5-9). 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 2018 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 will meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that plume expansion is currently within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring – In addition to the VOC plume, ^{90}Sr, ^{137}Cs, tritium, and ^{234}U are listed as contaminants of concern in the Record of Decision Amendment (DOE-ID 2001). 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 enhanced mobility from elevated concentrations of competing cations (calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer. The elevated cation concentrations are due to ISB activities to treat VOCs. Strontium-90 and ^{137}Cs trends are mostly trending lower. The trends will continue to 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. All results for tritium are below the MCL of 20,000 pCi/L with the highest tritium result of 2,070 pCi/L at Well TAN-25. Sampling will be conducted for ^{234}U after ISB conditions dissipate, because ISB conditions suppress uranium concentrations.

5.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells at WAG 2, ATR Complex, during 2018 (Figure 5-10). Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (target analyte is cobalt-60), tritium, and chromium (filtered). The data for the October 2018 sampling event will be included in the Fiscal Year 2019 Annual Report for WAG 2. The October 2018 sampling data are summarized in Table 5-7.

No analyte occurred above its MCL. The highest chromium concentration occurred in Well USGS-065 at 71.9 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well TRA-07 was also elevated at 70.7 µg/L. The chromium concentrations decreased in both TRA-07 and USGS-065 from the previous year and the chromium concentrations in both wells are in long-term declining 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 4,260 pCi/L in Well TRA-07. In the past, Well TRA-08 had detections of ^{90}Sr, but since October 2010, ^{90}Sr has been below detection limits.

Table 5-7. WAG 2 Aquifer Groundwater Quality Summary for 2018.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	4	71.9	1.17	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	34	4,260	ND	0

a. MCL = maximum contaminant level
b. Background concentrations are for western tributary water for the eastern Snake River Plain aquifer from Bartholomay and Hall (2016).
c. ND = not detected

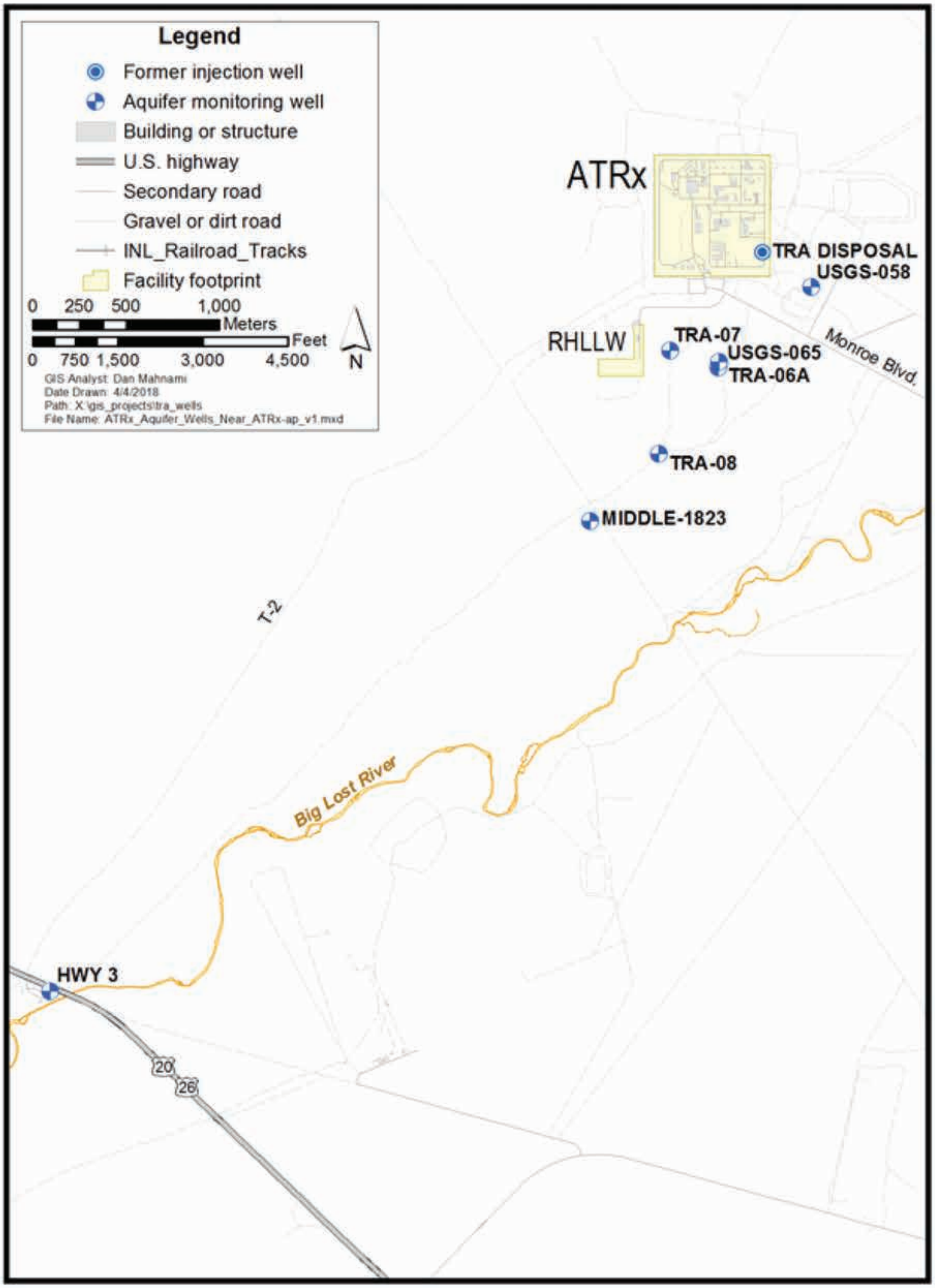


Figure 5-10. Locations of WAG 2 Aquifer Monitoring Wells.

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 2018 eastern Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Water levels in the vicinity of ATR Complex rose approximately 0.47 m (1.65 ft) on average from September 2017 to October 2018.

5.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 13 eastern Snake River Plain aquifer monitoring wells during 2018 (Figure 5-11). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2018 Annual Report (DOE-ID 2019b). Table 5-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90 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. Strontium-90 concentrations remained above the MCL (8 pCi/L) at four of the well locations sampled. During 2018, the highest ^{90}Sr level in eastern Snake River Plain aquifer groundwater was at monitoring Well USGS-047 (17.6 ± 1.62 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.

In contrast to past sampling events, ^{99}Tc was not detected above the MCL (900 pCi/L). During 2018, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at Well ICPP-2021-AQ (889 ± 50.8 pCi/L), located south 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 (10.6 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 concentrations were below drinking water MCLs at all Snake River Plain aquifer monitoring locations. Iodine-129 was detected at three locations with highest level at Well USGS 067 (0.978 ± 0.23 pCi/L). These detections are not consistent with previous years' sampling results. Re-analysis of samples could not be performed due to insufficient sample volume. As in the previous reporting period, ^{129}I was not detected in any other Snake River Plain aquifer wells.

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 ICPP-2021-AQ, southeast of the Tank Farm (2,070 ± 233 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 (^{238}U) was detected at all eastern Snake River Plain aquifer well locations, with the highest concentration at Well ICPP-MON-A-230 (1.22 ± 0.195 pCi/L). Similarly, uranium-234 (^{234}U) also was detected in all groundwater samples, with the greatest concentrations of 2.22 ± 0.287 pCi/L at Well ICPP-MON-A-230. Uranium-234 is the daughter product (from alpha decay) of the long-lived, naturally occurring ^{238}U. The slightly higher uranium concentrations at Well ICPP-MON-A-230 are attributed to impacts from previous releases at the Tank Farm. 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 (^{235}U) was detected in six groundwater samples. An evaluation of uranium in groundwater near RWMC indicates that eastern Snake River Plain aquifer background ^{235}U activities are generally less than 0.15 pCi/L (95% upper tolerance limit). Reported ^{235}U concentrations in groundwater at INTEC have historically

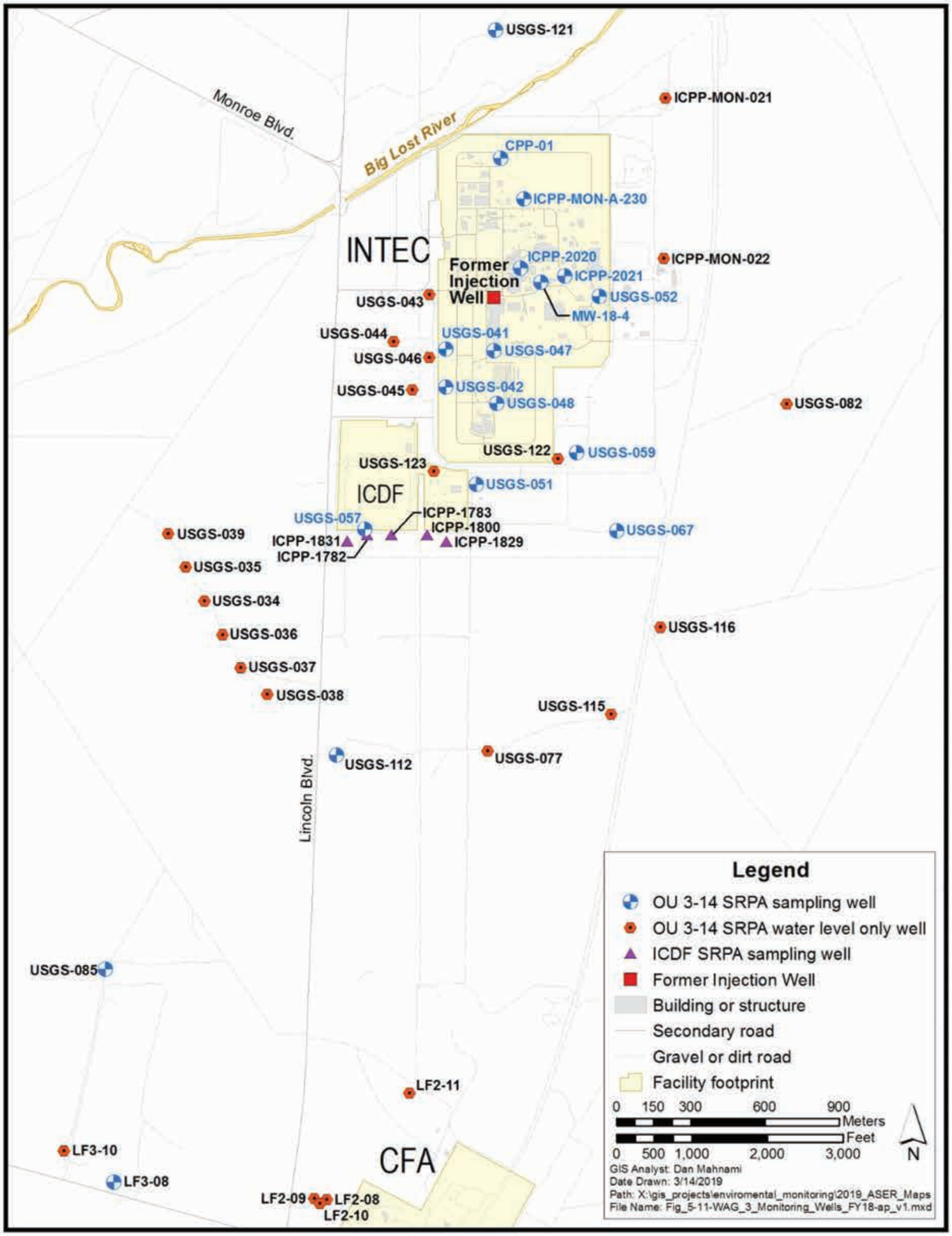


Figure 5-11. Locations of WAG 3 Monitoring Wells.

Table 5-8. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (Fiscal Year 2018).

Constituent	EPA MCL[a]	Units	Snake River Plain Aquifer Groundwater – May 2018 Maximum Reported Value	Number of Results[b]	Results >MCL[b]
Gross alpha	15	pCi/L	5.24 ± 1.46	13	0
Gross beta	NA[c]	pCi/L	409 ± 8.69	13	NA
Cesium-137	200	pCi/L	ND[d]	13	0
Strontium-90	8	pCi/L	**17.6 ± 1.62**[e]	13	4
Technetium-99	900	pCi/L	889 ± 50.8	13	0
Iodine-129	1	pCi/L	0.978 ± 0.23	13	0
Tritium	20,000	pCi/L	2,070 ± 233	13	0
Plutonium-238	15	pCi/L	ND	13	0
Plutonium-239/240	15	pCi/L	ND	13	0
Uranium-233/234	NA[f]	pCi/L	2.22 ± 0.287	13	NA
Uranium-235	NA[f]	pCi/L	0.239 ± 0.0919 J[g]	13	NA
Uranium-238	NA[f]	pCi/L	1.22 ± 0.195	13	NA
Bicarbonate	NA	mg/L	154	13	NA
Calcium	NA	mg/L	62.8	13	NA
Chloride	250[h]	mg/L	77.4	13	0
Magnesium	NA	mg/L	19.6	13	NA
Nitrate/Nitrite (as N)	10	mg/L	**10.6**	13	1
Potassium	NA	mg/L	4.16	13	NA
Sodium	NA	mg/L	26	13	NA
Sulfate	250[h]	mg/L	35.5	13	0
Total dissolved solids	500[h]	mg/L	389	13	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level
b. Does not include field duplicates.
c. NA = not applicable
d. ND = constituent not detected in sample
e. **Bold** values exceed MCL.
f. Not applicable because values are reported in pCi/L. EPA MCL is reported in mass units (µg/L).
g. J = estimated concentration
h. Secondary (aesthetic) MCL.

been slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

5.5.4 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, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2018). Four wells south of CFA were sampled for nitrate, sulfate, and chloride to monitor a nitrate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 5-12. Analytes detected in groundwater are compared to regulatory levels in Table 5-9. A complete list of the groundwater sampling results is contained in the *Central Facilities Area Landfills I, II, and III Annual Monitoring Report – Fiscal Year 2018* (DOE-ID 2019c).

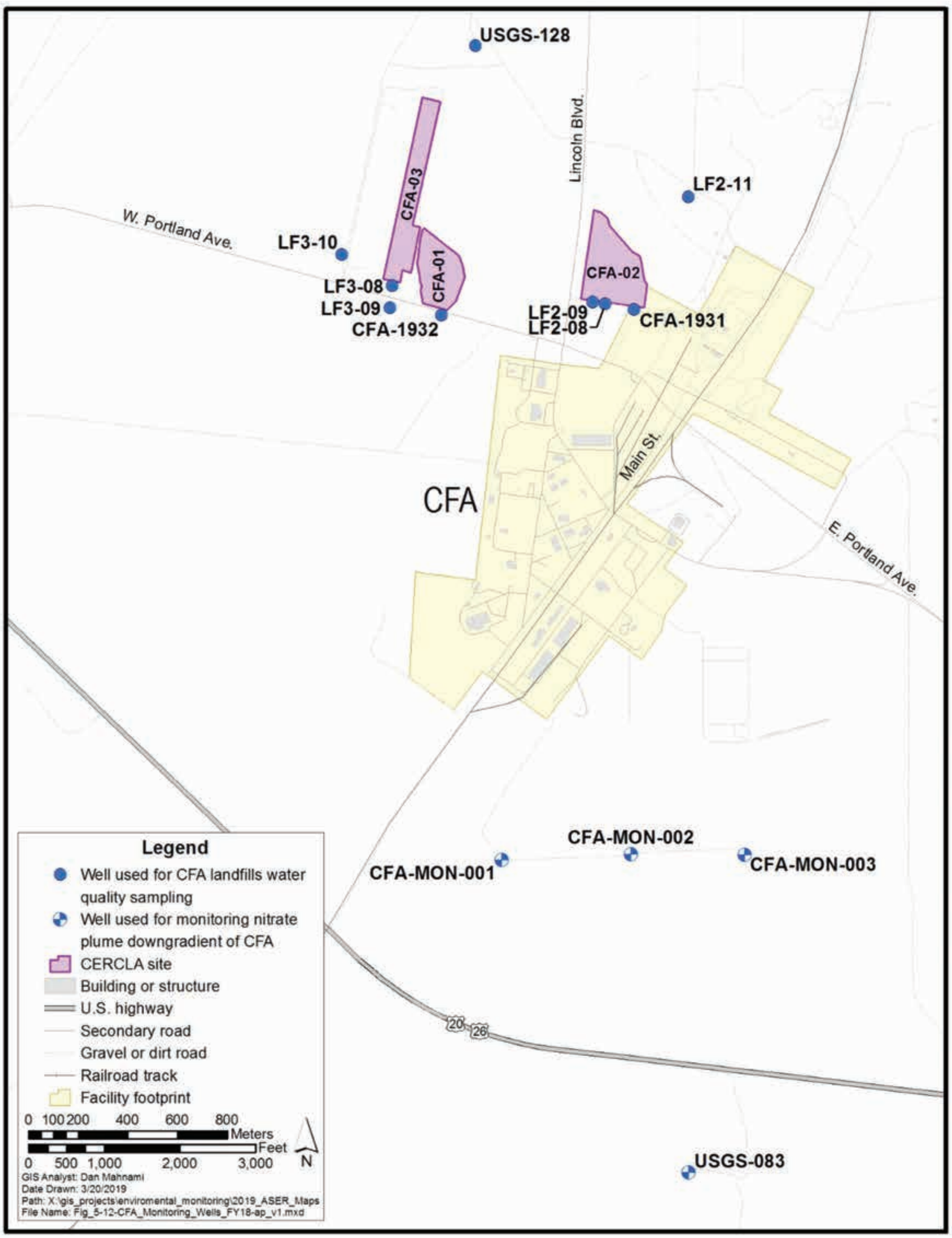


Figure 5-12. Locations of WAG 4/CFA Monitoring Wells.

Table 5-9. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2018).

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]	69.5	0
Sulfate (mg/L)	*250*	31.3	0
Nitrate/nitrite (mg-N/L)	10	**13.9**[d]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	62.6	0
Sulfate (mg/L)	*250*	40.0	0
Nitrate/nitrite (mg-N/L)	10	2.3	0
Common Cations			
Calcium (µg/L)	None	55,800	NA[e]
Magnesium (µg/L)	None	20,600	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*	ND	0
Arsenic (µg/L)	10	3.45	0
Barium (µg/L)	2,000	97.1	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	27.5	0
Copper (µg/L)	*1,300/1,000*	1.86	0
Iron (µg/L)	*300*	146	0
Lead (µg/L)	15	ND	0
Manganese (µg/L)	50	9.67	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	30.2	NA
Selenium (µg/L)	50	2.83	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	6.85	NA
Zinc (µg/L)	*5,000*	71.5	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	100	0.79	0
Cyclohexane	None	0.56	NA
Toluene	1,000	0.45	0
Naphthalene	None	1.39	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

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 decreased in 2018 to 13.9 mg/L-N. The nitrate concentration at Well CFA-MON-A-002 is consistent with a decreasing trend that has been in place since 2006.

The nitrate concentration of 7.61 mg/L-N in Well CFA-MON-A-003 is below the MCL and has dropped below its historic range of 8 to 11 mg/L-N. The decline in nitrate suggests that a downward trend is present, but additional data are needed to confirm the trend.

In 2018, no laboratory analyte exceeded an EPA MCL for the CFA Landfill monitoring and no laboratory analyte exceeded secondary maximum contaminant levels (SMCLs).

Water level measurements taken in the CFA area increased an average of 2.19 ft from August 2017 to August 2018. A water level contour map based on August 2018 water levels was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2019c).

5.5.5 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). In the Explanation of Significant Differences following the 2010 to 2014 five-year review (DOE-ID 2016a), Operable Unit 5-12 was dropped from the list of operable units requiring a five-year review and will no longer be included in this report.

5.5.6 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 5.5.9.

5.5.7 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples were not collected from monitoring wells near RWMC in 2018. In the past, this sampling activity, conducted in accordance with the Operable Unit 7-13/14 Field Sampling Plan (Forbes and Holdren 2014), occurred annually in November. Because of adverse weather conditions causing safety and equipment issues, this sampling activity was moved to May for Fiscal Year 2019 and moving forward, with agency concurrence. Discussion of the WAG 7 groundwater samples collected in May 2019 will be included in the 2019 Site Environmental Report.

5.5.8 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, anions, cations, and other water quality parameters, as surveillance monitoring under the WAG 9 Record of Decision (Figure 5-13; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 5-10. Overall, the data show no discernable impacts from activities at the MFC.

5.5.9 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2016b), groundwater samples are collected every two years at the locations shown on Figure 5-14. In 2018, groundwater sampling was not performed for WAG 10. Groundwater samples for WAG 10 will be collected in 2019.

5.6 Onsite Drinking Water Sampling

The INL and ICP Core contractor monitors 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 be monitored at least once every three years. Parameters with SMCLs 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. Contractors 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 EBR-I,

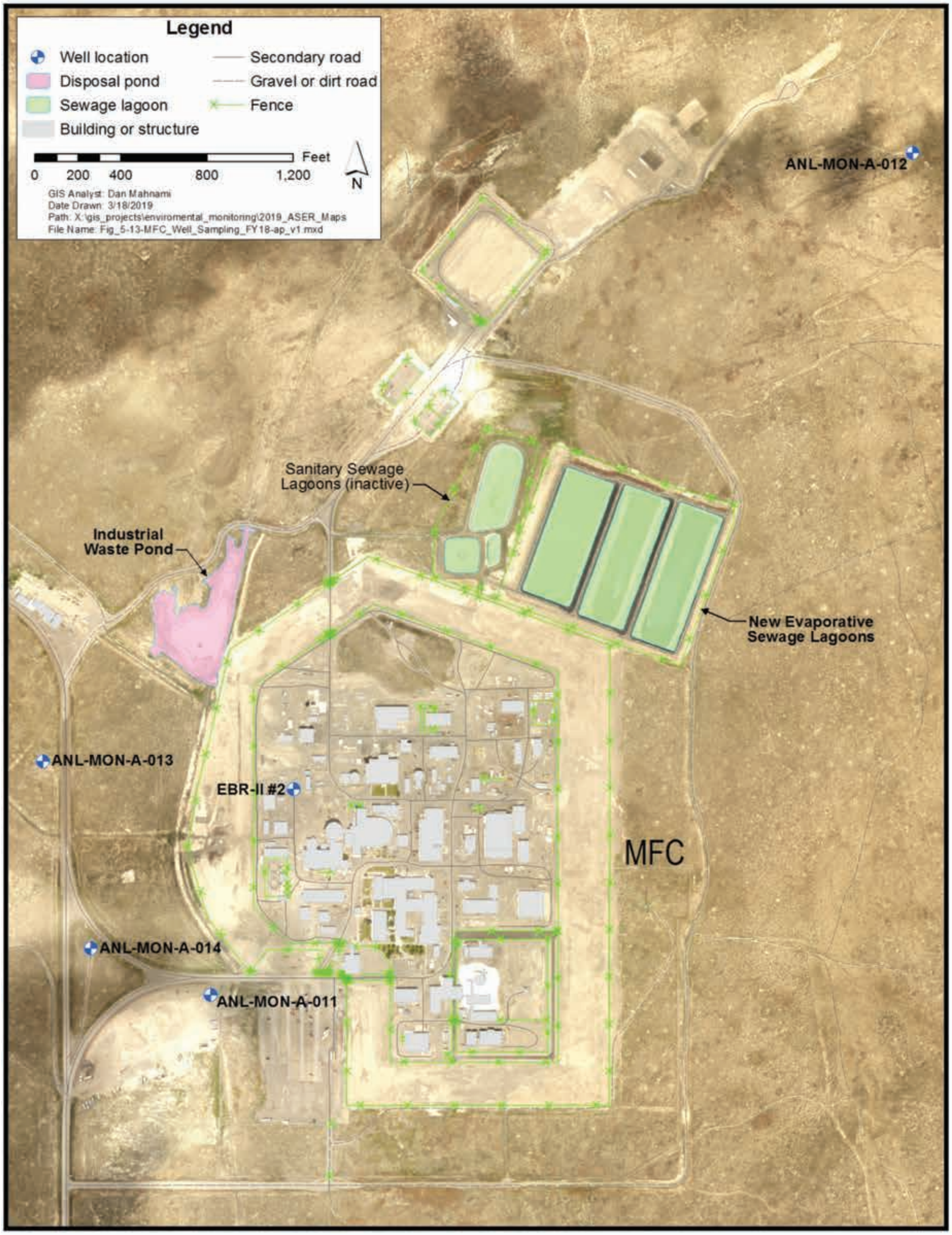


Figure 5-13. Locations of WAG 9 Wells Sampled in 2018.

Table 5-10. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2018).

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:	4/24/2018	9/25/2018	4/23/2018	9/25/2018	4/24/2018	9/25/2018	4/24/2018	9/25/2018	4/25/2018	9/26/2018	
Radionuclides[c]											
Gross alpha(pCi/L)	1.33 ± 0.354[d]	ND[e]	ND (1.29 ± 0.358)	0.924 ± 0.304	1.61 ± 0.382	1.77 ± 0.526	ND	ND	2.8 ± 0.441	ND	15 pCi/L
Gross beta (pCi/L)	3.54 ± 0.356	2.3 ± 0.22	4.09 ± 0.325 (2.85 ± 0.31)	2.84 ± 0.249	3.54 ± 0.375	3.05 ± 0.328	3.17 ± 0.397	4.54 ± 0.361	3.81 ± 0.362	3.64 ± 0.347	4 mrem/yr
Uranium-233/234 (pCi/L)	1.63 ± 0.219	1.60 ± 0.225	1.27 ± 0.164 (1.42 ± 0.183)	1.96 ± 0.237	1.38 ± 0.187	1.31 ± 0.193	1.42 ± 0.184	1.41 ± 0.196	1.98 ± 0.23	1.07 ± 0.163	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.853 ± 0.145	0.494 ± 0.116	0.05 ± 0.0942 (0.0651 ± 0.114)	0.71 ± 0.126	0.489 ± 0.103	0.468 ± 0.107	0.615 ± 0.112	0.666 ± 0.127	0.915 ± 0.138	0.719 ± 0.128	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND (ND)	ND	ND	ND	ND	ND	0.294 ± 0.0791	ND	NE[f]
Metals[g]											
Arsenic (mg/L)	0.00219	0.002U	0.00219 (0.00209)	0.002U	0.00212	0.002U	0.00229	0.002U	0.00219	0.002U	0.05
Barium (mg/L)	0.0358	0.037	0.0399 (0.0388)	0.039	0.0363	0.0392	0.0373	0.0359	0.0379	0.0376	2
Calcium (mg/L)	34.8	37.7	34.8 (37.5)	39.5	37.5	38.1	34.1	39.0	36.2	39.0	NE[f]
Chromium (mg/L)	0.003U	0.003U	0.003U (0.003U)	0.003U	0.00364	0.003U	0.003U	0.003U	0.003U	0.003U	0.01
Copper (mg/L)	0.00049	0.000675	0.000724 (0.000486)	0.000352	0.000807	0.000576	0.000662	0.000464	0.00311	0.00537	1.3
Iron (mg/L)	0.0398	0.0612	0.03U (0.03U)	0.03U	0.150	0.0576	0.03U	0.03U	0.03U	0.03U	0.3
Lead (mg/L)	0.0005U	0.0005U	0.0005U (0.0005U)	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.00132	0.00186	0.015
Magnesium (mg/L)	10.9	12.1	10.7 (11.3)	12.1	12.1	12.5	10.7	12.5	11.4	12.6	NE

Table 5-10. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2018). (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]
Sample Date:	4/24/2018	9/25/2018	4/23/2018	9/25/2018	4/24/2018	9/25/2018	4/24/2018	9/25/2018	4/25/2018	9/26/2018	
Manganese (mg/L)	0.001U	0.001U	0.001U (0.001U)	0.001U	0.00395	0.00128	0.001U	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.0006U	0.000848	0.00074 (0.000801)	0.000609	0.00201	0.000764	0.0006U	0.0006U	0.00813	0.0103	NE
Potassium (mg/L)	3.21	3.23	3.54 (3.38)	3.31	3.27	3.21	34.1	29.9	33.5	31.4	NE
Sodium (mg/L)	15.9	16.7	15.6 (16.6)	17.2	17.8	17.9	15.6	17.3	16.6	17.2	NE
Vanadium (mg/L)	0.00456	0.0033U	0.0048 (0.00473)	0.0033U	0.00551	0.0033U	0.00496	0.0033U	0.00483	0.0033U	NE
Zinc (mg/L)	0.0033U	0.00372	0.0033U (0.0033U)	0.0063	0.0033U	0.0033U	0.0033U	0.0033U	0.0269	0.0252	5
Anions											
Chloride (mg/L)	16.7	17.1	16.6J (16.4J)	16.6	18.2	19.7	17.7	16.4	17.7	17.1	250
Nitrate-as nitrogen (mg/L)	2.31	2.43	2.23 (2.23)	2.33	2.23	2.33	2.26	2.35	2.31	2.38	10
Phosphorus (mg/L)	0.0423J	0.024J	0.0429J (0.0391J)	0.0255J	0.0447J	0.0156U	0.0424J	0.0199U	0.0411J	0.0141U	NE
Sulfate (mg/L)	18.7J	18.6J	18.3J (18.1J)	17.8	18.7J	19.8J	19.1J	18.7J	18.9	19J	250
Water Quality Parameters											
Alkalinity (mg/L)	140	145	137 (139)	141	143	139	137	142	135	140	NE
Bicarbonate alkalinity (mg/L)	140	145	137 (139)	141	143	139	137	142	135	140	NE
Total dissolved solids (mg/L)	199	227	196 (180)	216	197	233	184	216	191	230	500

a. EBR-II = Experimental Breeder Reactor II, but also known as well ANL 2
b. PCS = primary constituent standard; SCS = secondary constituent standard
c. Result ± 1s
d. Results in parentheses are field duplicate.
e. ND = not detected; J = estimated concentration; U = not detected at the concentration shown
f. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
g. Metals reported as non-filtered unless noted

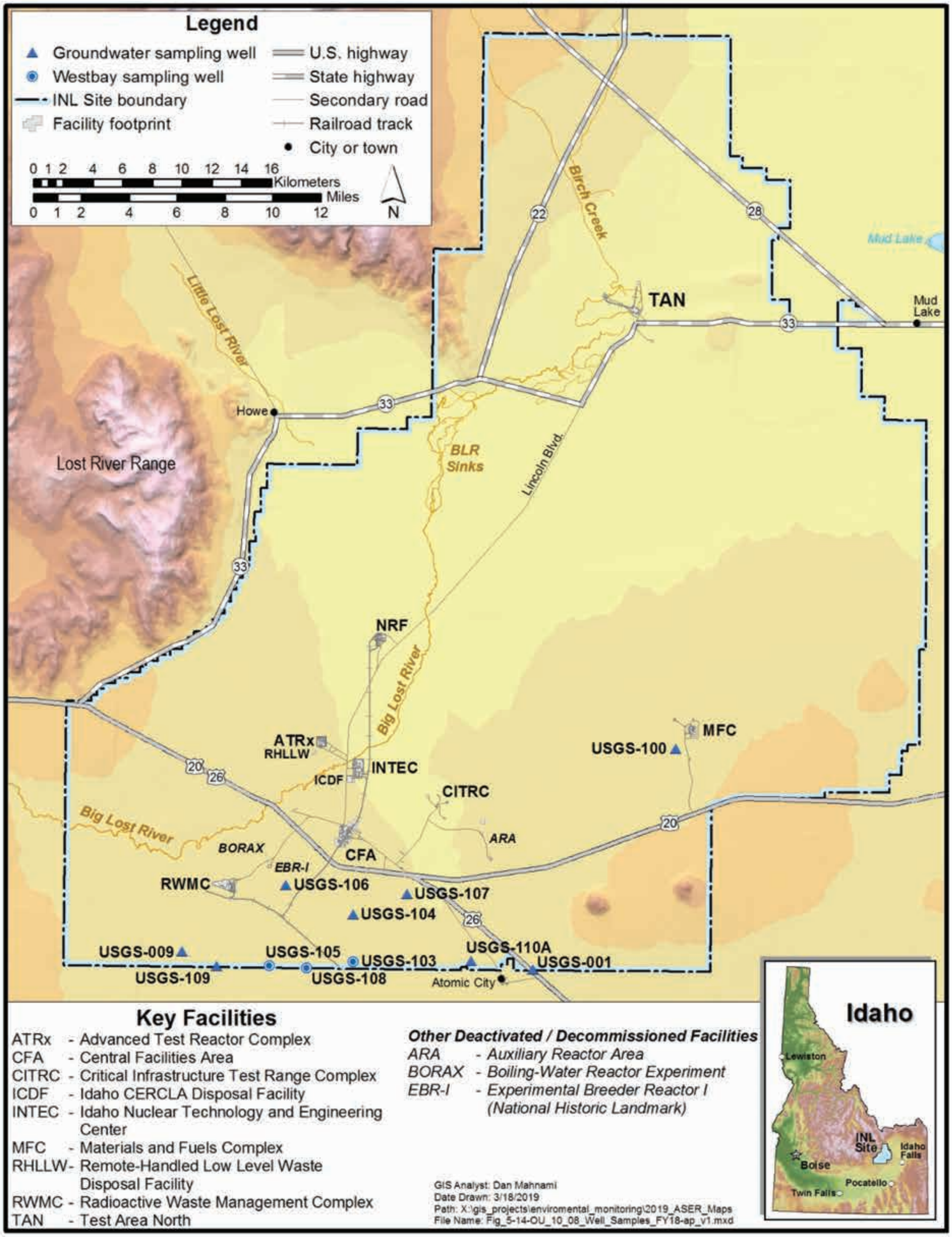


Figure 5-14. Well Locations Sampled for Operable Unit 10-08.

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.

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.

5.6.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2018, the INL contractor collected 267 routine samples and 23 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 43 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 10-1. Table 5-11 summarizes monitoring results for 2018. The quality control program associated with these data is discussed in Section 10.3.2.4.

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 2.97 mg/L at CFA and 2.16 mg/L at MFC. Samples for total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at ATR-Complex, MFC, and TAN/CTF. Also, VOCs were collected at TAN/TSF.

5.6.2 Central Facilities Area

The Central Facilities Area (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 5-15) 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 10-1. Quality control is discussed in Section 10.3.2.4.

Prior to 2008, 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 2018, Well CFA #1 was used to supply approximately 61% of drinking water at CFA. Well CFA #2 was used to supply approximately 39% 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 2018 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)

Table 5-11. Summary of INL Site Drinking Water Results (2018).

Constituent	MCL	ATR Complex	CFA	CITRC	EBR-I	GUN RANGE	MAIN GATE	MFC	TAN CTF	TAN TSF
Gross Alpha[a]	15 pCi/L	ND-4.47	ND-4.07	ND-4.84	ND[b]	ND-3.87	ND	2.33-2.96	ND-1.31	ND-1.50
Gross Beta[a]	50 pCi/L screening or 4 mrem/yr	ND-2.02	5.98-6.25	2.81-3.32	ND-3.49	2.88-3.25	2.82-3.66	3.78-3.53	3.22-10.4	2.94-3.49
Tritium[a]	20,000 pCi/L	ND	2,710-2,900	ND	ND	307-419	ND	ND	ND	ND
Iodine-129[c]	1 pCi/L	–	ND	–	–	–	–	–	–	–
Nitrate	10 mg/L	1.07	2.97	1.27	ND	1.14	ND	2.16	1.08	1.03
TTHMs	80 ppb	ND	3.7	NA[d]	NA	NA	NA	4.1-5.5	1.1	NA
HAA5s	60 ppb	39	ND	NA	NA	NA	NA	ND	ND	NA
VOCs	5 ppb for most VOCs	NA	NA	NA	NA	NA	NA	NA	NA	ND

a. Range of results (minimum – maximum) presented.
b. ND = not detected
c. Iodine-129 is only sampled at the CFA water system.
d. NA = not applicable

$TConc_w$ = 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:

$TConc_w$ = 2,587 pCi/L (average concentration in water in CFA distribution system for 2018)

Ing_w = 730 L/yr (calculated from Table 3 in DOE [2011])

$EDC_T = 7.14 \times 10^{-8}$ 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 2018, as calculated from samples taken from the CFA distribution system, was 0.134 mrem (1.34 µSv). This value is below the EPA standard of 4 mrem/yr (40 µSv)for public drinking water systems.

5.6.3 Idaho Nuclear Technology and Engineering Center

Drinking water for Idaho Nuclear Technology and Engineering Center (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 2018, 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 10-1. Results are presented in Tables 5-12 and 5-13 and are discussed in the following paragraphs.

Four compliance samples and 81 surveillance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for

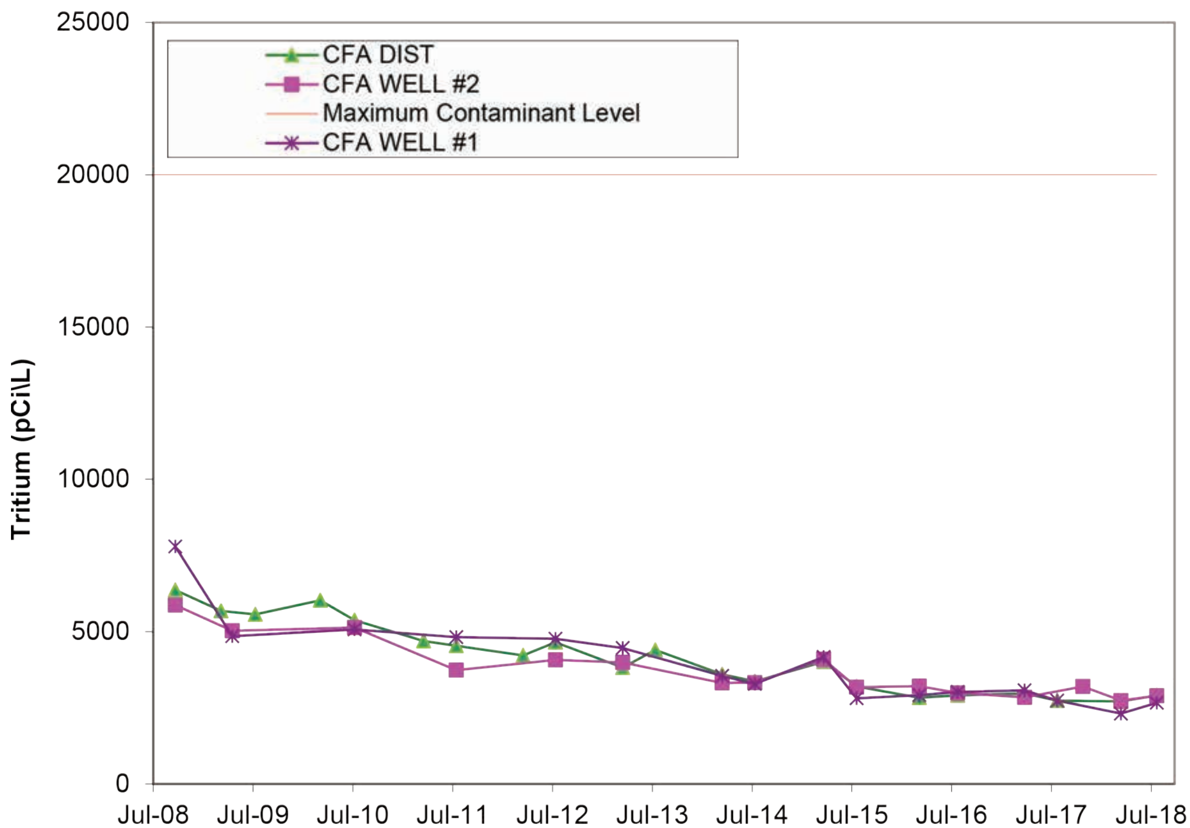


Figure 5-15. Tritium Concentrations in CFA Wells and Distribution System (2008–2018).

Table 5-12. 2018 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	0.0042 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 5-13. 2018 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	52	4 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	52	4 per month	Absent	Absent	See 40 CFR 141.63(c)
Gross alpha	2	2 per year	ND[b]	NA[c]	15 pCi/L
Gross beta	2	2 per year	2.82 pCi/L	2.80 – 2.84 pCi/L	50 pCi/L screening level or 4 mrem/yr
Strontium-90	1	1 per year	ND	NA	8 pCi/L
Tritium	1	1 per year	ND	NA	20,000 pCi/L

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

total coliform and *Escherichia coli* (E. coli) per Standard Method 9223B. The results for all samples were reported as absent.

One compliance sample was collected at Well CPP-614 on June 28, 2018, 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.

One compliance sample was collected at Well CPP-1666 on August 14, 2018, and analyzed for TTHM by EPA Method 524.2. The result was 0.0042 mg/L, which is below the TTHM MCL of 0.080 mg/L.

One compliance sample was collected at CPP-1666 on August 14, 2018, and analyzed for HAA5 by EPA Method 552.2. HAA5 was not detected (<0.002 mg/L) in the sample. The MCL for HAA5 is 0.060 mg/L.

A surveillance sample was collected at CPP-614 on February 19, 2018, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross beta was detected at 2.84 pCi/L, below its screening level of 50 pCi/L. Gross alpha, tritium, and ^{90}Sr were reported as non-detects. Another surveillance sample was collected at CPP-614 on August 28, 2018, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected at 2.8 pCi/L, below its screening level of 50 pCi/L.

5.6.4 Radioactive Waste Management Complex

The Radioactive Waste Management Center (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 2018, 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 10-1. Results are presented in Tables 5-14 and 5-15 and are discussed in the following paragraphs.

Four compliance samples and 29 surveillance samples were collected from various buildings, comfort stations, and a potable water tank at RWMC 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 WMF-604 on June 28, 2018, and analyzed for nitrate by EPA Method 353.2. The result was 1 mg/L, below the nitrate MCL of 10 mg/L.

One compliance sample was collected at WMF-678 on September 18, 2018, and analyzed for TTHM by EPA Method 524.2. The result was 0.005 mg/L, which is below the TTHM MCL of 0.080 mg/L.

One compliance sample was collected at WMF-678 on September 18, 2018, and analyzed for HAA5 by EPA Method 552.2. HAA5 was not detected (<0.002 mg/L) in the sample. The MCL for HAA5 is 0.060 mg/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 April 25, 2018, July 25, 2018, and October 31, 2018 samples. Total xylenes were detected in the January 24, 2018, sample (0.0007 mg/L), which is 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. Other than total xylenes, no other VOCs were detected in any of these 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 these four samples. Carbon tetrachloride was detected in all four samples and ranged in concentration from 0.0053 mg/L to 0.006 mg/L. Trichloroethylene (trichloroethene) was also detected in all four samples and ranged in concentration from 0.002 mg/L to 0.0031 mg/L. No other VOCs were detected in any of the samples.

Two separate surveillance samples were collected at WMF-604 on February 19, 2018, and August 28, 2018, respectively, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected in both samples, at 3.77 pCi/L and 4.6 pCi/L, each below the screening level of 50 pCi/L. A surveillance sample was collected at WMF-604 on February 19, 2018, and analyzed for ^{90}Sr and tritium. Only tritium was detected at 705 pCi/L, below its MCL of 20,000 pCi/L.

5.7 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to fewer 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 5-16 illustrates the trichloroethylene concentrations in both Well TSF #2 (2008-2018) and the distri-

Table 5-14. 2018 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)
Total trihalomethanes	1	1 per year	0.005 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	<0.002 mg/L	NA	0.06 mg/L
Xylenes (total)	4	1 per quarter	0.0007 mg/L	ND to 0.0007 mg/L	10 mg/L

a MCL = maximum contaminant level
b NA = not applicable

Table 5-15. 2018 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	29	1 to 2 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	29	1 to 2 per month	Absent	Absent	See 40 CFR 141.63(c)
Volatile organic compounds	4	1 per quarter	0.006 mg/L	ND[b] to 0.006 mg/L	0.002 – 10 mg/L[c]
Gross alpha	2	2 per year	ND	NA[d]	15 pCi/L
Gross beta	2	2 per year	4.19 pCi/L	3.77 to 4.6 pCi/L	50 pCi/L screening level or 4 mrem
Strontium-90	1	1 per year	ND	NA	8 pCi/L
Tritium	1	1 per year	705 pCi/L	NA	20,000 pCi/L

a. MCL = maximum contaminant level
b. ND = not detected
c. This range of MCLs encompasses the 21 organic contaminants listed in 40 CFR 141.61(a). The 0.006 mg/L result was for carbon tetrachloride and the sample was collected from the RWMC Production Well at WMF-603 on October 31, 2018. 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.
d. NA = not applicable

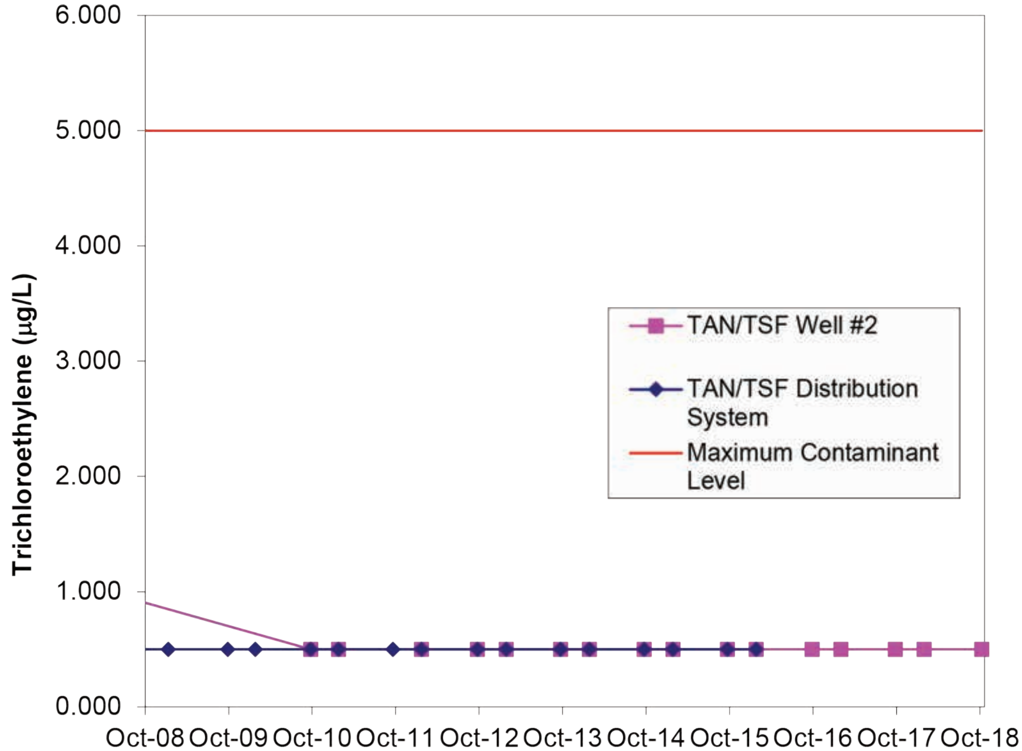


Figure 5-16. Trichloroethylene Concentrations in TAN/TSF Drinking Water Well and Distribution System (2008–2018).

bution system (2008-2015). Sampling of the distribution system was discontinued in 2015 and is only sampled on a contingency basis if there a detection at Well TSF #2. Contingency sampling did not occur in 2018. The mean trichloroethylene concentration in Well TSF #2, as summarized in Table 5-16, was <0.5 ug/L.

5.8 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 2018. 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 2018. 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 contractor results are shown in Table 5-17. 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 3σ) in one of nine samples collected in May 2018 (Craters of the Moon) and in four of nine samples collected in November 2018 (Atomic City, Craters of the Moon, Howe, and Minidoka) at just above the minimum detectable concentration. Neither of the bottled water (control) samples had detectable concentrations of gross alpha activity. The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 2.3 ± 0.47 pCi/L, measured at Howe in November.

Gross beta activity was detected statistically in all but three drinking water samples collected by the ESER contractor. Gross beta activity was not detected in the bottled water samples (controls) or in the November Howe sample. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 4.9 ± 0.46 pCi/L, measured at the Minidoka well in May. 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 Re-

Table 5-16. Trichloroethylene Concentrations at TAN/TSF Well #2 and Distribution System (2018).

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)[c]	0	-	-	-	5.0

a. MCL = maximum contaminant level (see Table A-4)
b. NA = not applicable. Maximum contaminant level applies to the distribution system only.
c. TAN/TSF Distribution (610) is only sampled if there is a detection at TAN/TSF Well #2 (612).

ports was 7.83 ± 0.61 pCi/L (Atomic City in spring of 2011).

Tritium was statistically detected in two of the drinking water samples collected in 2018 (Idaho Falls and Minidoka). The maximum result measured was 209 ± 25 pCi/L. The results were generally within historical measurements and well below the EPA MCL of 20,000 pCi/L. The maximum tritium level was slightly greater than that measured since 2010 (169 ± 24.8 pCi/L at Rest Area in spring of 2017).

5.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2017 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 5-17). ESER contractor results are shown in Table 5-18.

Gross alpha activity was detected in one sample collected at Hagerman in May (0.92 ± 0.30 pCi/L). This is the highest measurement made at this location since 2010. For comparison, the maximum concentration measured since 2010 in all springs was 3.7 ± 0.68 pCi/L at Clear Springs in 2017.

Gross beta activity was detected in all surface water samples. The highest result (7.7 ± 0.69 pCi/L) was measured at Alpheus Springs in November. 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.

Tritium was detected in two of the six surface water samples collected by the ESER contractor. One was at Buhl in May (78 ± 24 pCi/L) and the second at Twin Falls in November (82 ± 25 pCi/L). 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 5-17). The river then mixes with other water in the eastern Snake River Plain aquifer. Water in the aquifer then emerges about 160 km (100 miles) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls.

Normally the river bed is dry because of upstream irrigation and rapid infiltration into desert soil and underlying basalt. The river rarely flows onto the INL Site. However, there was enough water in the river for ESER personnel to sample it on the INL Site in 2017 and in 2018. Samples were collected during the months of April and June, and analyzed for gross alpha, gross beta, gamma-emitting radionuclides, and tritium. There was little or no flow due to upstream irrigation during the rest of the summer and fall. There are no federal or state standards for surface water, so the results were compared with EPA MCLs (Table 5-19). None of the results exceeded these limits. The 2018 gross alpha results are similar to those reported for 2017; however, the maximum result (3.6 pCi/L) reported for 2018 is slightly higher than the maximum result (3.3) reported for 2017.

Table 5-17. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2018.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring	***Fall***	***EPA MCL[b]***
Atomic City	0.42 ± 0.31	1.29 ± 0.36	15 pCi/L
Control (bottled water)[c]	-0.28 ± 0.16	0.27 ± 0.19	15 pCi/L
Craters of the Moon	1.2 ± 0.30	1.5 ± 0.32	15 pCi/L
Howe	0.93 ± 0.34	2.3 ± 0.47	15 pCi/L
Idaho Falls	0.33 ± 0.40	0.58 ± 0.48	15 pCi/L
Minidoka	1.0 ± 0.42	1.2 ± 0.39	15 pCi/L
Mud Lake (Well #2)	0.15 ± 0.25	0.19 ± 0.23	15 pCi/L
Rest Area (Highway 20/26)	0.82 ± 0.30	0.72 ± 0.30	15 pCi/L
Shoshone	0.55 ± 0.33	0.85 ± 0.34	15 pCi/L
Gross Beta			
	Spring	***Fall***	***EPA MCL***
Atomic City	3.9 ± 0.44	4.0 ± 0.44	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	0.59 ± 0.34	-0.03 ± 0.34	4 mrem/yr (50 pCi/L)
Craters of the Moon	2.4 ± 0.41	1.2 ± 0.39	4 mrem/yr (50 pCi/L)
Howe	1.9 ± 0.40	0.80 ± 0.44	4 mrem/yr (50 pCi/L)
Idaho Falls	3.8 ± 0.45	2.7 ± 0.46	4 mrem/yr (50 pCi/L)
Minidoka	4.9 ± 0.46	3.5 ± 0.44	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.3 ± 0.42	1.5 ± 0.40	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	2.8 ± 0.41	1.3 ± 0.41	4 mrem/yr (50 pCi/L)
Shoshone	3.0 ± 0.42	1.9 ± 0.42	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	***Fall***	***EPA MCL***
Atomic City	66 ± 23	-73 ± 24	20,000 pCi/L
Control (bottled water)	54 ± 23	53 ± 24	20,000 pCi/L
Craters of the Moon	48 ± 23	-8.1 ± 25	20,000 pCi/L
Howe	53 ± 23	3.6 ± 25.	20,000 pCi/L
Idaho Falls	103 ± 24	-11 ± 25	20,000 pCi/L
Minidoka	209 ± 25	-53 ± 24	20,000 pCi/L
Mud Lake (Well #2)	35 ± 23	40 ± 25	20,000 pCi/L
Rest Area (Highway 20/26)	60 ± 23	34 ± 25	20,000 pCi/L
Shoshone	54 ± 23	18 ± 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. Water bottled in Ammon, Idaho.
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.

The 2018 gross beta results are like those reported for 2017; however, the maximum result (9.1 pCi/L) reported for 2018 is higher than the maximum result reported for 2017. All 2018 tritium results are within the range of values reported for 2017. The maximum tritium concentration reported for 2017 was 163 pCi/L). No human-made gamma-emitting radionuclides (e.g., ^{137}Cs) were detected so they are not included in Table 5-19.

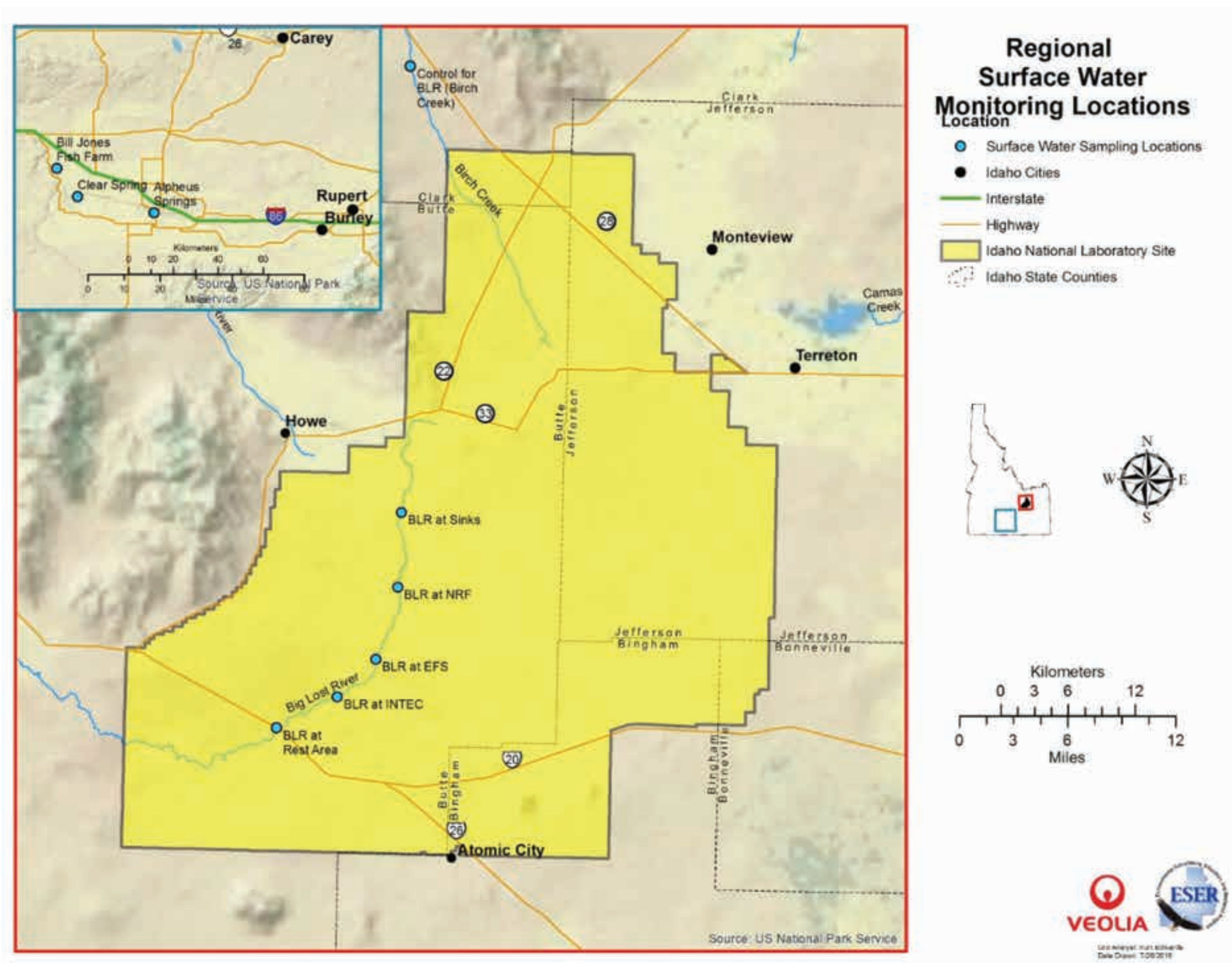


Figure 5-17. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 5-18. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2018.

Location	Sample Results (pCi/L)[a]		
	Gross Alpha		
	Spring[b]	***Fall***[b]	***EPA MCL***[c]
Alpheus Springs-Twin Falls	0.80 ± 0.40	0.10 ± 0.04	15 pCi/L
Clear Springs-Buhl	0.88 ± 0.39	0.41 ± 0.40	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.92 ± 0.30	0.59 ± 0.33	15 pCi/L
	Gross Beta		
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	6.8 ± 0.48	7.7 ± 0.69	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	4.6 ± 0.46	3.6 ± 0.45	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	3.6 ± 0.42	2.1 ± 0.41	4 mrem/yr (50 pCi/L)
	Tritium		
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	37 ± 23	82 ± 25	20,000 pCi/L
Clear Springs-Buhl	78 ± 24	-7.1 ± 24	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	58 ± 23	-23 ± 23.6	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 22, 2918, and on November 6, 2018.
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.

Table 5-19. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected Along the Big Lost River by the ESER Contractor in 2018.

Location	Sample Results (pCi/L)[a]		
	Gross Alpha		
	April	***June***	***EPA MCL***[b]
Rest Area	1.1 ± 0.42	2.4 ± 0.42	15 pCi/L
INTEC	1.4 ± 0.45	3.6 ± 0.51	15 pCi/L
Experimental Field Station (EFS)	-9.8 ± 0.71	3.6 ± 0.52	15 pCi/L
Naval Reactors Facility (NRF)	2.6 ± 0.50	2.4 ± 0.42	15 pCi/L
Big Lost River (BLR) Sinks	0.62 ± 0.40	1.5 ± 0.33	15 pCi/L
Birch Creek (control)	1.5 ± 0.47	0.98 ± 0.36	15 pCi/L
	Gross Beta		
	April	***June***	***EPA MCL***
Rest Area	2.3 ± 0.46	6.4 ± 0.48	4 mrem/yr (50 pCi/L)[c]
INTEC	3.0 ± 0.47	9.1 ± 0.52	4 mrem/yr (50 pCi/L)
EFS	2.8 ± 0.48	9.1 ± 0.53	4 mrem/yr (50 pCi/L)
NRF	3.6 ± 0.51	6.8 ± 0.48	4 mrem/yr (50 pCi/L)
BLR Sinks	3.9 ± 0.41	4.5 ± 0.44	4 mrem/yr (50 pCi/L)
Birch Creek (control)	0.49 ± 0.45	0.19 ± 0.41	4 mrem/yr (50 pCi/L)
	Tritium		
	April	***June***	***EPA MCL***
Rest Area	136 ± 31	119 ± 24	20,000 pCi/L
INTEC	68 ± 30	98 ± 24	20,000 pCi/L
EFS	86 ± 31	62 ± 23	20,000 pCi/L
NRF	108 ± 31	64 ± 23	20,000 pCi/L
BLR Sinks	91 ± 30	99 ± 24	20,000 pCi/L
Birch Creek (control)	117 ± 30	76 ± 24	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s 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.= Environmental Protection Agency; MCL = maximum contaminant level

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Common Nighthawk
Chordeiles minor

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Western Kingbird
Tyrannus verticalis

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

2018

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 2018. 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 (^{90}Sr) and cesium-137 (^{137}Cs). 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 two big game (elk) road-killed animals sampled in 2018. Four human-made radionuclides (cobalt-60 [^{60}Co], zinc-65 [^{65}Zn], ^{90}Sr, and ^{137}Cs) were detected in some tissue samples of waterfowl collected on ponds in the vicinity of the Advanced Test Reactor Complex at the INL Site. The source of these radionuclides was most likely the radioactive wastewater evaporation pond, which can be accessed by waterfowl, but not the public.

Bat carcasses have been collected on the INL Site since the summer of 2015. Bats collected during 2017 and 2018 were composited each year by area and analyzed for radionuclides in 2018. Seven human-made radionuclides (^{60}Co, ^{90}Sr, ^{137}Cs, ^{65}Zn, europium-152 [^{152}Eu], plutonium-238, and plutonium-239/240 [$^{239/240}$Pu]) were detected in at least one of the eight sample groups in 2017 and 2018. While ^{137}Cs and ^{90}Sr may be of fallout origin, ^{60}Co, ^{65}Zn and ^{152}Eu may indicate that the bats have visited radioactive effluents ponds on the INL Site. Plutonium isotopes could originate in soils contaminated by global fallout or by radioactive waste.

Soil samples were collected off the INL Site in 2018 as part of a biennial sampling plan. Samples were collected at 12 locations. The detected radionuclides are products of historical above-ground nuclear weapons testing and show expected temporal patterns in averaged concentrations. Cesium-137 shows a decreasing trend in concentration over time consistent with its 30-year half-life. Although ^{90}Sr has approximately the same half-life as ^{137}Cs, it has decreased at a greater rate, possibly reflecting greater mobility in the environment. Plutonium-239/240 persists in the environment due to long half-lives. Americium-241 seems to be increasing in concentration since the late 1970's as a result of the ingrowth from the decay of plutonium-241.

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 124 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.

6. 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 2018. 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

Common Nighthawk
Chordeiles minor

Table 6-1. 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)**	**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 Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility
c. RWMC = Radioactive Waste Management Complex

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 6-1). 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 6-1).

6.1 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 3-1). Figure 6-1 shows the locations where agricultural products were collected in 2018.

6.1.1 Sampling Design for Agricultural Products

Agriculture products could become contaminated by radionuclides released from INL Site facilities which are transported offsite by wind and deposited in soil and on plant surfaces. This is important, since approximately 45% of the land surrounding the INL Site is used for agriculture (DOE-ID 1995). In addition, many residents maintain home gardens that could be impacted by INL Site releases. Animals could also eat contaminated crops and soil and in turn transfer radionuclides to humans through consumption of meat and milk.

Agricultural product sampling began in the vicinity of the INL Site in the 1960s with milk and wheat as part of the routine environmental surveillance program. Currently the program focuses on milk, lettuces, alfalfa, potatoes and grains.

As specified in the *DOE Handbook Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015), representative samples of the pathway-significant agricultural products grown within 16 km (10 miles) of the site should be collected and analyzed for radionuclides potentially present from site operations. These samples should be collected in at least

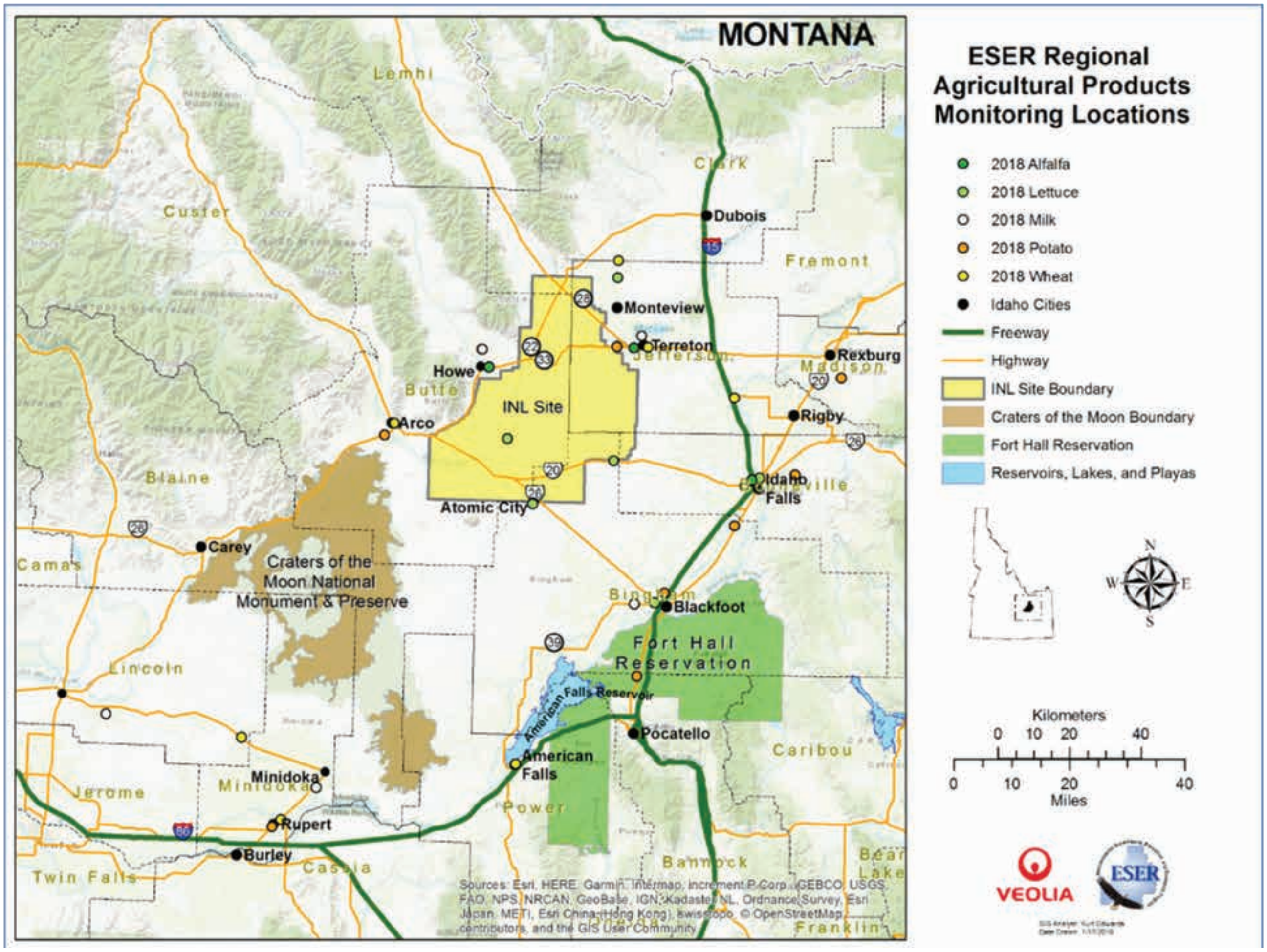

Figure 6-1. Locations of Agricultural Product Samples Collected (2018).

two locations: the place of expected maximum radionuclide concentrations and a "background" location unlikely to be affected by radionuclides released from the site.

Sample design was primarily guided by wind direction and frequencies and farming practices. Air dispersion modeling, using CALPUFF and INL Site meteorological data measured from 2006 through 2008, was performed to develop data quality objectives for radiological air surveillance for the INL Site using methodology documented in Rood and Sondrup (2014). The same methodology was used to discern deposition patterns. The dispersion and deposition patterns resulting from these sources reflect the southwest/northeast wind patterns typical of the INL Site. The maximum offsite deposition was modeled to be located between the southwest INL Site boundary and Big Southern Butte. Because there are no agricultural activities in this region, sampling is focused on other agricultural areas west and northeast of the INL Site. In addition, the sampling design considers locations of interest to the public, as well as those of historical interest, which is why some samples are collected at extended distances from the INL Site.

6.1.2 Methods

Fresh produce and milk are purchased from local farmers when available. In addition, lettuce is grown by the ESER program in areas that have no commercial or private producers.

6.1.3 Milk Results

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows, then to milk, which is then ingested by humans. During 2018, the ESER contractor collected 163 milk samples (including duplicates and controls) at various locations off the INL Site (Figure 6-1) and from commercially available milk from outside the state of Idaho (the control). The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk

Common Nighthawk
Chordeiles minor

samples were collected weekly from dairies in Idaho Falls and Terreton, as well as monthly at other locations around the INL Site. The Blackfoot dairy is unique because milk is collected from goats. Goat's milk is of particular interest because it may contain higher concentrations of radioiodine than that found in cow's milk due to the ability of the goat to transfer iodine from forage to milk more efficiently than cows (IAEA 2010).

All milk samples were analyzed for gamma-emitting radionuclides, including (^{131}I) and cesium-137 (^{137}Cs), as well as for strontium-90 (^{90}Sr). During the second and fourth quarters, samples from each of the seven locations, with the exception of Blackfoot, were analyzed for ^{90}Sr and tritium during the fourth quarter. The family-run goat dairy at that location did not have enough sample for ^{90}Sr analysis at that time.

Iodine is an essential nutrient and is readily assimilated by cows or goats 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 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. The ingestion of milk pathway is the main route of internal iodine-131 (^{131}I) exposure for people. 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. Most of the ^{131}I released in 2018 was from the Materials and Fuels Complex (approximately 88.8 mCi). None was detected in air samples collected at or beyond the INL Site boundary (see Chapter 3). Iodine-131 was also not detected in any milk sample collected during 2018.

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 2018.

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 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 three of the 13 milk samples analyzed. It was not detected in the two control samples from outside the state. Detectable concentrations ranged from 0.14 ± 0.05 pCi/L at Howe to 0.21 ± 0.05 pCi/L at Blackfoot (Table 6-2). These levels were 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 from 2007 through 2016, ranged from 0 to 0.54 pCi/L (EPA 2017). In general, the number of detections and concentrations of ^{90}Sr have steadily decreased since 2013. This is consistent with the observation that ^{90}Sr concentrations in soil are decreasing due to radioactive decay and other factors (see Section 6.3). The maximum concentration detected in the past 10 years was 2.37 ± 0.29 pCi/L, measured at Fort Hall in November 2013.

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 (0.21 ± 0.05 pCi/L) is approximately 0.02% of the DCS for drinking water.

Tritium, with a half-life of about 12 years, 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 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 six of 14 milk samples analyzed (Table 6-2). Concentrations varied from -34 ± 31 Ci/L in a sample from Howe in May to 171 ± 30 pCi/L in the Mini-

Table 6-2. Strontium and Tritium Concentrations[a] in Milk Samples Collected Off the INL Site in 2018.

Strontium-90 (pCi/L)		
Location	**May 2018**	**November 2018**
Blackfoot	0.21 ± 0.05	NS[c]
Dietrich	0.16 ± 0.05	0.05 ± 0.04
Howe	0.14 ± 0.05	-0.06[b] ± 0.04
Idaho Falls	0.10 ± 0.05	-0.03 ± 0.04
Minidoka	0.05 ± 0.05	0.009 ± 0.04
Terreton	0.11 ± 0.04	-0.04 ± 0.04
AVERAGE	0.14	-0.01
Control (Colorado)	0.04 ± 0.05	-0.18 ± 0.04
Tritium (pCi/L)		
Location	**May 2018**	**November 2018**
Blackfoot	164 ± 30	42 ± 24
Dietrich	134 ± 30	88 ± 25
Howe	-34 ± 31	20 ± 24
Idaho Falls	151 ± 30	36 ± 24
Minidoka	171 ± 30	42 ± 24
Terreton	136 ± 30	25 ± 24
AVERAGE	105	42
Control (Colorado)	12 ± 33	36 ± 25

a. 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.
c. NS = no sample. The Blackfoot sample is collected from a small goat farm. There was insufficient sample collected in November for radiochemical analysis.

doka sample in May. 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 0.01% of the DCS.

6.1.4 Lettuce

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 3-1). Uptake of radionuclides by plants may occur through root uptake from soil and/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 6-1). The number and locations of gardens have changed from year to year depending on whether or not vegetables were available. Home gardens have generally been replaced with portable lettuce planters (Figure 6-2) 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 and potting mix, sown with lettuce seed, and self-watered through a reservoir.

Figure 6-2. Portable Lettuce Planter.

Six lettuce samples were collected from portable planters at Atomic City, the Experimental Field Station (EFS), the Federal Aviation Administration Tower, Howe, Idaho Falls, and Monteview. In 2018, 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. A duplicate sample was collected at Idaho Falls. In addition to the portable samplers, a sample was obtained from a farm in Blackfoot and a control sample was purchased at the grocery store from an out-of-state location (Oregon).

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was detected (at the 3s level) in the lettuce sample collected at EFS. Table 6-3 shows the average and range of all measurements (including those below detection levels) from 2018. The maximum ^{90}Sr concentration of 154 ± 24 pCi/kg, measured in the lettuce sample collected from EFS, is within the range of concentrations detected in the past ten years. It is 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 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, Colsher, and Thompson 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, tends to form compounds that are comparatively soluble. These factors could help explain why ^{90}Sr was detected in lettuce and ^{137}Cs was not.

6.1.5 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2018 the ESER contractor collected grain samples at nine locations from areas surrounding the INL Site (Figure 6-1), and an additional duplicate sample was collected from Rupert. A control sample was purchased from outside the state of Idaho. The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made radionuclides were found in any samples. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990).

6.1.6 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 potatoes are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were col-

Table 6-3. Cesium and Strontium Concentrations[a] in Lettuce Samples Collected On and Off the INL Site in 2018.

Strontium-90 (pCi/kg)	
Location	**July 2018**
Atomic City	33.3 ± 19.4
Blackfoot	54.3 ± 20.8
EFS	154.0 ± 23.5
FAA Tower	44.7 ± 20.0
Howe	30.9 ± 19.4
Idaho Falls	55.6 ± 20
Monteview	0.89 ± 17.5
AVERAGE	20.0
Control (Clackamas OR)[b]	-37.6[c] ± 14.9
Cesium-137 (pCi/kg)	
Location	**July 2018**
Atomic City	60.8 ± 69.0
Blackfoot	31.6 ± 84.8
EFS	32.2 ± 73.2
FAA Tower	109.0 ± 84.7
Howe	14.6 ± 90.7
Idaho Falls	57.8 ± 82.2
Monteview	82.7 ± 86.7
AVERAGE	151.0
Control (Clackamas OR)	-118.0 ± 86.5

a. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected.
b. The control was collected at grocery store in August.
c. A negative result indicates that the measurement was less than the laboratory background measurement.

lected by the ESER contractor at eight locations in the vicinity of the INL Site (Figure 6-1) and obtained from one location outside eastern Idaho. None of the ten potato samples (including a duplicate) collected during 2018 contained a detectable concentration of any human-made radionuclides. Potatoes, like grain, are generally less efficient at removing radioactive elements from soil than leafy vegetables such as lettuce.

6.1.7 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. A sample of alfalfa was collected in June from locations in the Mud Lake/Terreton area, Howe, and Idaho Falls. Mud Lake/Terreton is the agricultural area where the highest potential offsite air concentration was calculated using an air dispersion model (see Figure 7-6). (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 samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made, gamma-emitting radionuclides were found, but ^{90}Sr was detected in the sample collected at Idaho Falls (135 ± 24.8) pCi/kg, the highest concentration measured since alfalfa collection began in 2010. The concentrations found ranged from -36.7 to 135.0 pCi/kg. This is more similar to the range found in lettuce, a leafy vegetable, than in wheat and potatoes.

Common Nighthawk
Chordeiles minor

6.1.8 Big Game Animals

Muscle samples were collected by the ESER contractor from two elk. Two thyroid samples were also obtained. No liver samples could be collected. 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 sample.

6.1.9 Waterfowl

Waterfowl are collected each year by the ESER contractor at ponds on the INL Site and at a location off the INL Site. Four waterfowl collected from wastewater ponds located at the Advanced Test Reactor (ATR) Complex plus two control waterfowl collected from Roberts were analyzed for gamma-emitting radionuclides, ^{90}Sr, and actinides (americium-241 [^{241}Am], plutonium-238 [^{238}Pu], and plutonium-239/240 [$^{239/240}$Pu]). These radionuclides were selected because they have historically been measured in liquid effluents from some INL Site facilities. Each sample was divided into the following three sub-samples: 1) edible tissue (muscle, gizzard, heart, and liver), 2) external portion (feathers, feet, and head), and 3) all remaining tissue.

A total of four human-made radionuclides were detected in edible, exterior, and remainder subsamples from the ducks collected at the ATR Complex ponds. These were cobalt-60 (^{60}Co), zinc-65 (^{65}Zn), ^{90}Sr, and ^{137}Cs. A Green-winged Teal, collected from the sewage lagoons at ATR Complex had three of these radionuclides in edible tissue (Table 6-4). Cobalt-60 was also detected in the edible tissue of another Green-winged Teal collected at the same location. The two Buffleheads had radionuclides

Table 6-4. Radionuclide concentrations Detected in Waterfowl Collected in 2018.

Radionuclides Detected in Waterfowl Tissue (pCi/kg dry weight)				
Location	**Species**	**Portion**	**Radionuclide**	**Concentration**
ATR Complex Ponds	Green-winged Teal	Edible	^{60}Co	963 ± 17
			^{65}Zn	2,120 ± 119
			^{137}Cs	579 ± 38
		Exterior	^{60}Co	612 ± 36
			^{90}Sr	42 ± 4
			^{65}Zn	1330 ± 92
			^{137}Cs	264 ± 22
		Remainder	^{60}Co	982 ± 14
			^{65}Zn	3030 ± 159
			^{90}Sr	326 ± 10
			^{137}Cs	453 ± 29
	Green-winged Teal	Edible	^{60}Co	19 ± 5
		Exterior	^{60}Co	18 ± 5
		Remainder	^{60}Co	129 ± 8
			^{65}Zn	169 ± 21
			^{90}Sr	15 ± 8
	Bufflehead	Remainder	^{90}Sr	16 ± 4
	Bufflehead	Exterior	^{60}Co	109 ± 9
			^{90}Sr	62 ± 5

in the exterior and remainder portions. No human-made radionuclides were detected in the control ducks.

Because more human-made radionuclides were found in ducks from the ATR Complex than other locations and at higher levels, it is assumed that the evaporation pond associated with this facility is the source of these radionuclides. The ducks were not taken directly from the two-celled Hypalon™-lined radioactive wastewater evaporation pond, but rather from an adjacent sewage lagoon. However, the ducks probably also spent time at the evaporation pond. Concentrations of the detected radionuclides in waterfowl collected at the ATR Complex were for the most part lower than those collected in 2017, with the exception of ^{65}Zn. Zinc-65 was detected in only one duck collected in 2017 and at a much lower concentration (190 ± 29 pCi/kg). The hypothetical dose to a hunter who eats a contaminated duck from the ATR Complex ponds is estimated in Chapter 7.

6.1.10 Bats

Bat carcasses have been collected on the INL Site since the summer of 2015. Bats are typically desiccated when received and generally weigh about a few grams each. The samples collected in 2017 and 2018 were analyzed in 2018 for gamma-emitting radionuclides, for specific alpha-emitting radionuclides (plutonium isotopes and americium-241), and for ^{90}Sr (a beta-emitting radionuclide).

The bat carcasses were divided and composited by area with the exception of the RWMC in 2018. Only one bat was collected from that area and consequently the detection level for the 2018 RWMC bat was higher than for the composited samples. Before reporting, results were converted from ashed weight concentrations to dry weight concentrations.

The bat analysis results are summarized in Table 6-5. The following gamma-emitting radionuclides were detected in at least one sample during 2017 and 2018:

Table 6-5. Radionuclide Concentrations Measured in Bats Collected in 2017 and 2018.

Bat Tissue Concentrations (pCi/g dry weight)			
2017			
Radionuclide	***Minimum***[a]	***Maximum***[b]	***Number of Detections***[c]
^{241}Am	ND[d]	ND	0
^{137}Cs	0.13 ± 0.02	70.8 ± 0.32	3
^{60}Co	0.27 ± 0.03	110.0 ± 0.50	2
^{152}Eu	1.29 ± 0.21	1.29 ± 0.21	1
^{238}Pu	0.012 ± 0.004	0.018 ± 0.003	3
^{239}Pu	0.069 ± 0.006	0.069 ± 0.006	1
^{90}Sr	39.5 ± 0.17	39.5 ± 0.17	1
^{65}Zn	9.88 ± 0.68	9.88 ± 0.68	1
2018			
Radionuclide	***Minimum***	***Maximum***	***Number of Detections***
^{241}Am	ND	ND	0
^{137}Cs	1.87 ± 0.15	19.3 ± 0.44	2
^{60}Co	12.1 ± 0.32	96.7 ± 0.94	3
^{238}Pu	ND	ND	0
^{239}Pu	ND	ND	0
^{90}Sr	1.84 ± 0.08	26.9 ± 0.20	3
^{65}Zn	5.34 ± 0.35	31.0 ± 1.10	2

a. Minimum detected concentration
b. Maximum detected concentration
c. Out of 4 composites analyzed
d. ND = not detected

^{60}Co, ^{65}Zn, ^{90}Sr, and ^{137}Cs. Cesium-137 is fairly ubiquitous in the environment because of fallout from historical nuclear weapons tests. Strontium-90 is another fallout radionuclide. Cobalt-60 and ^{65}Zn, which are fission products, may indicate that the bats visited radioactive effluent ponds on the INL Site, such as at the ATR-C ponds. Europium-152 (^{152}Eu), a fission product, was detected in one composite sample in 2017 and may also indicate that bats use radioactive effluent ponds on the INL Site. Plutonium-238 (^{238}Pu) and plutonium-239/240 ($^{239/240}$Pu), which are present in radioactive waste as well as in the environment from past weapons testing, were detected in some samples collected in 2017 but not in any sample collected in 2018. The potential doses received by bats are discussed in Chapter 7.

6.2 Soil Sampling

In the early 1970s, the DOE Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface soils (0–5 and 5–10 cm deep) on and around the INL Site. At that time, RESL established extensive onsite soil sampling grids outside facilities. Offsite locations were also established by RESL during this process to serve as background sites. RESL analyzed all samples (onsite and offsite) for gamma-emitting radionuclides with a subset onsite analyzed for ^{90}Sr, ^{241}Am, and isotopes of plutonium. In addition, all soil from the surface component (0–5 cm) of the offsite samples was analyzed for ^{90}Sr and alpha emitting-radionuclides (^{241}Am and isotopes of plutonium).

Between 1970 and 1978, RESL extensively sampled the onsite grids outside INL Site facilities and then reduced the onsite sampling frequency to a seven-year rotation that ended in 1990 with sampling at the Test Reactor Area (now known as the Advanced Test Reactor Complex). Surface soils were sampled at distant and boundary locations off the INL Site annually from 1970 to 1975, and the collection interval for offsite soils was extended to every two years starting in 1978.

The INL contractor currently completes soil sampling on a five-year rotation at the INL Site to evaluate long term accumulation trends and to estimate environmental radionuclide inventories. Data from previous years of soil sampling and analysis on the INL Site show slowly declining concentrations of short-lived radionuclides of human origin (e.g., ^{137}Cs), with no evidence of detectable concentrations depositing onto surface soil from ongoing INL Site releases, as discussed in INL (2016). Soil was not sampled by the INL contractor in 2018.

The ESER contractor collects soil samples in offsite locations first established by RESL every two years (in even-numbered years). Results to date indicate that the source of detected radionuclides in soil 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 2018.

6.2.1 Soil Sampling Design

The basis for the current INL contractor soil sampling design is defined in the Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site (INL 2016), which is discussed in the 2017 Annual Site Environmental Report. Soil was not sampled by the INL contractor in 2018.

6.2.2 Offsite Soil Sampling Results

Above-ground nuclear weapons testing resulted in many radionuclides being distributed throughout the world via atmospheric deposition. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{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.,^{238}Pu $^{239/240}$Pu, and ^{241}Am). Soil samples are collected by the ESER contractor in the region outside the INL Site (Figure 6-3) 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 2018. Soil sampling locations are shown in Figure 6-3. Surface soil samples (0 - 5 cm) were analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium isotopes. Subsurface soil samples (collected from 5-10 cm) were analyzed for gamma-emitting radionuclides (^{137}Cs) to confirm that the fallout radionuclide inventory remains primarily in the top 5-cm layer of the soil profile. This verifies that the majority of radionuclide activity can be determined by sampling down to the first five centimeters of soil.

Cesium-137 was above the detection limit in all the samples collected. Results for this radionuclide from 1978 to 2018 are presented in Figure 6-4. Above-ground nuclear weapons testing has been extremely limited since 1975, and no tests have occurred since 1980, so no ^{137}Cs have been deposited on soil from sources outside the INL Site in that time. It would be expected that the concentra-

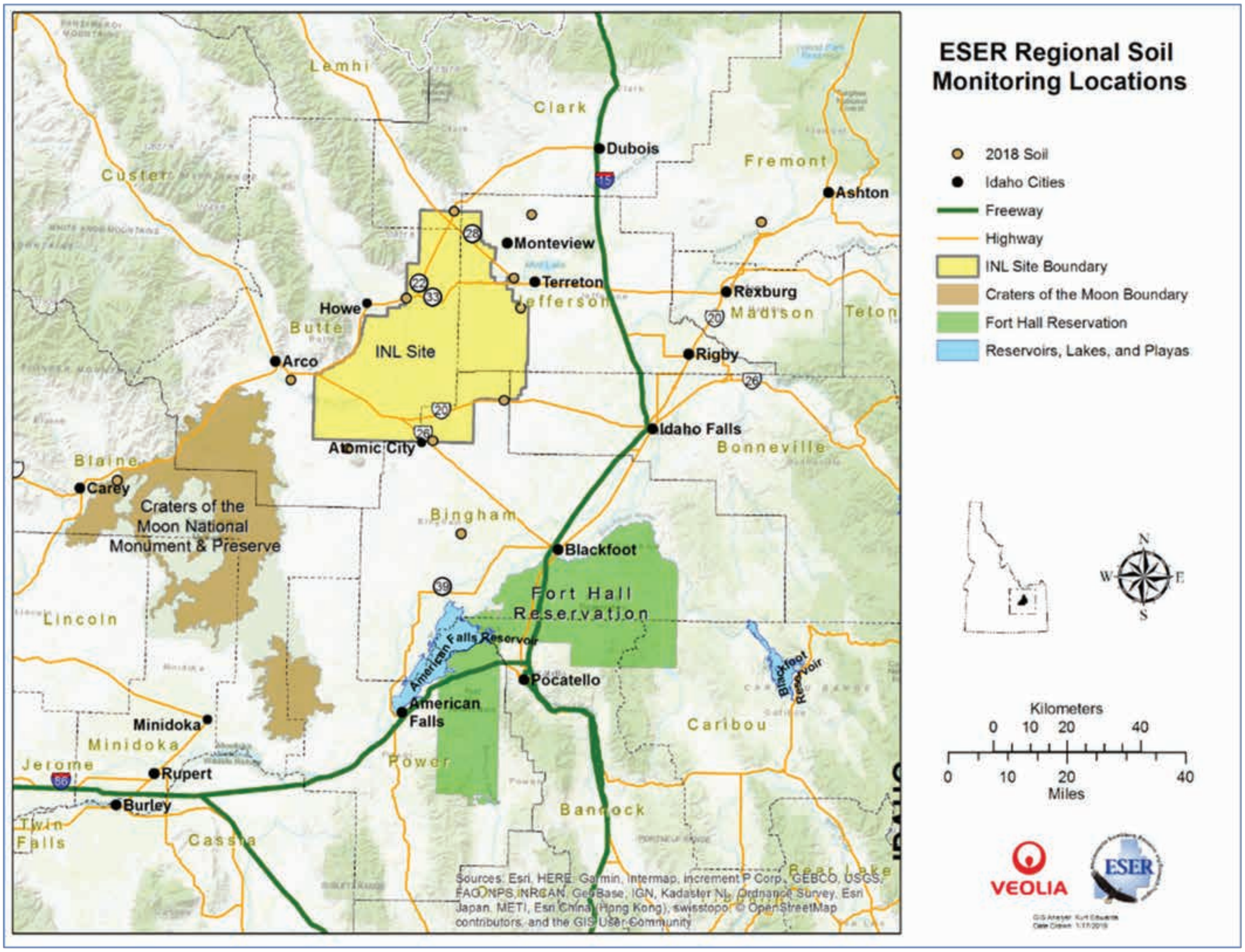

Figure 6-3. Soil Sampling Locations (2018).

tions would decrease over time from the levels measured in 1978 at a rate consistent with their approximate 30-year half-life, unless the INL Site was having an impact. Figure 6-4 shows that ^{137}Cs follows the expected decay line closely.

Strontium-90, another fallout radionuclide, was detected above 3s in one surface soil sample and above 2s in three other samples at levels within historical measurements. Current results are typically below detection levels and it is thus apparent that ^{90}Sr is becoming more undetectable in surface soil. Mean annual (geometric) concentrations of ^{90}Sr in surface over time appear to decrease at a rate which exceeds that projected for radioactive decay (Figure 6-5). Strontium-90 is more mobile than ^{137}Cs in alkaline soils and the accelerated decrease may be due to other processes in the soil, such as movement into lower depths or uptake by plants. No accumulation of either ^{137}Cs or ^{90}Sr on surface soil is indicated as a result of operations at the INL Site.

Transuranic radionuclides (including isotopes of plutonium) are present in our environment as a result of global fallout from above-ground nuclear weapon tests. Until 1979 the integrated deposition in the north temperate zone (40-50° latitude) was estimated for ^{238}Pu (1.5 Bq/m² [0.04 nCi/m²]); $^{239/240}$Pu (58 Bq/m² [1.6 nCi/m²]); ^{241}Pu (730 Bq/m² [19.73 nCi/m²]) and ^{241}Am (25 Bq/m² [0.68 nCi/m²]) (Bunzl, Henrichs and Kracke 1987). Measurements of ^{238}Pu, $^{239/240}$Pu, and ^{241}Am made by the DOE RESL during the same period are shown in Table 6-6. The estimated fallout lies within the 95% confidence in-

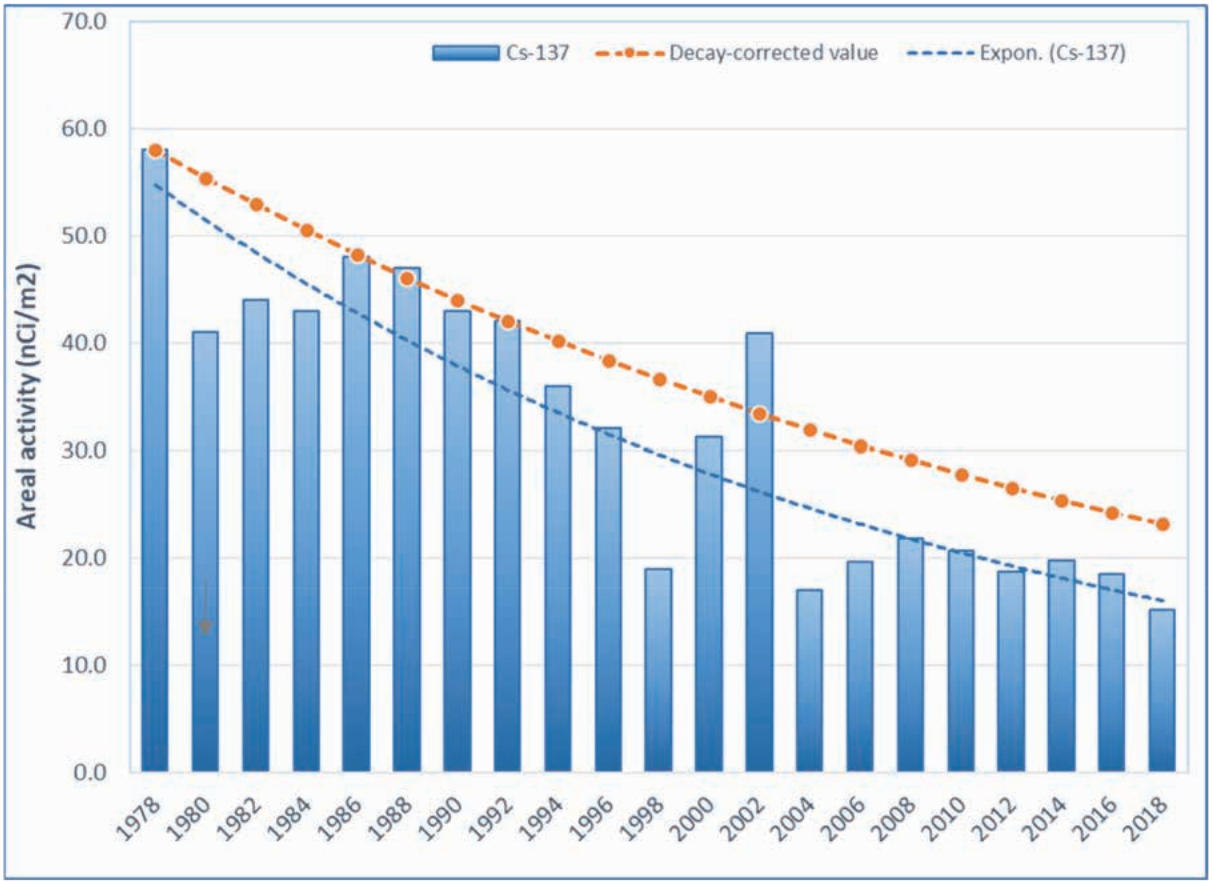

Figure 6-4. Mean (Geometric) Areal Activities of ^{137}Cs in Surface (0–5 cm [0–2.5 in.]) Soils Off the INL Site (1978–2018). *Decay-corrected values assume an initial mean areal activity measured in 1978 and a half-life of 30.17 years. The decreasing trend in the mean activity in soil samples was determined to be exponential (r^2=0.79).*

tervals reported for ^{238}Pu (both years) and $^{239/240}Pu$ (1978). The concentrations of ^{241}Am measured in surface soils in 1978 and 1980 are about half of the fallout concentrations estimated for 1979.

Based on the estimated fallout presented in Table 6-6, ^{238}Pu would not be expected to be detected very often in the environment. Not surprisingly, no particular trend in ^{238}Pu has been observed over time by the ESER program because it is infrequently detected (about 10% of the time since 2008). In addition, the half-life of ^{238}Pu is 87.7 years so about 25% of the original activity has decayed since 1978. Plutonium-238 was detected above 3s in only one ESER sample (9.49 ± 2.74 pCi/kg or 0.61 nCi/m²) collected at Mud Lake South.

Plutonium-239 and -240 have long half-lives (24,100 years and 6,561 years, respectively) and thus these fallout radionuclides persist in the environment. Six of the 13 samples analyzed in 2018 had detectable concentrations (greater than 3s) of $^{239/240}Pu$. The highest result (46.40 ± 7.50 pCi/kg or 1.54 nCi/m²) is slightly higher than would be expected from estimated fallout (1.16 nCi/m²), as shown in Table 6-6, but well within historical measurements (Figure 6-6).

No statistical trend is discernible, most likely because of several factors. These include:

- heterogeneous nature of soils (variation of particle size and soil chemistry) and consequently of radionuclide concentrations across the area sampled
- nonuniform redistribution of contaminated soil via deposition and resuspension resulting from differences in wind, vegetation cover and topography
- use of multiple laboratories, which have different procedures and detection limits, over the past four decades
- small subsample analyzed. Radiochemical analyses of soil samples involve the consumption of a small subsample (typically only 5 g) which represents

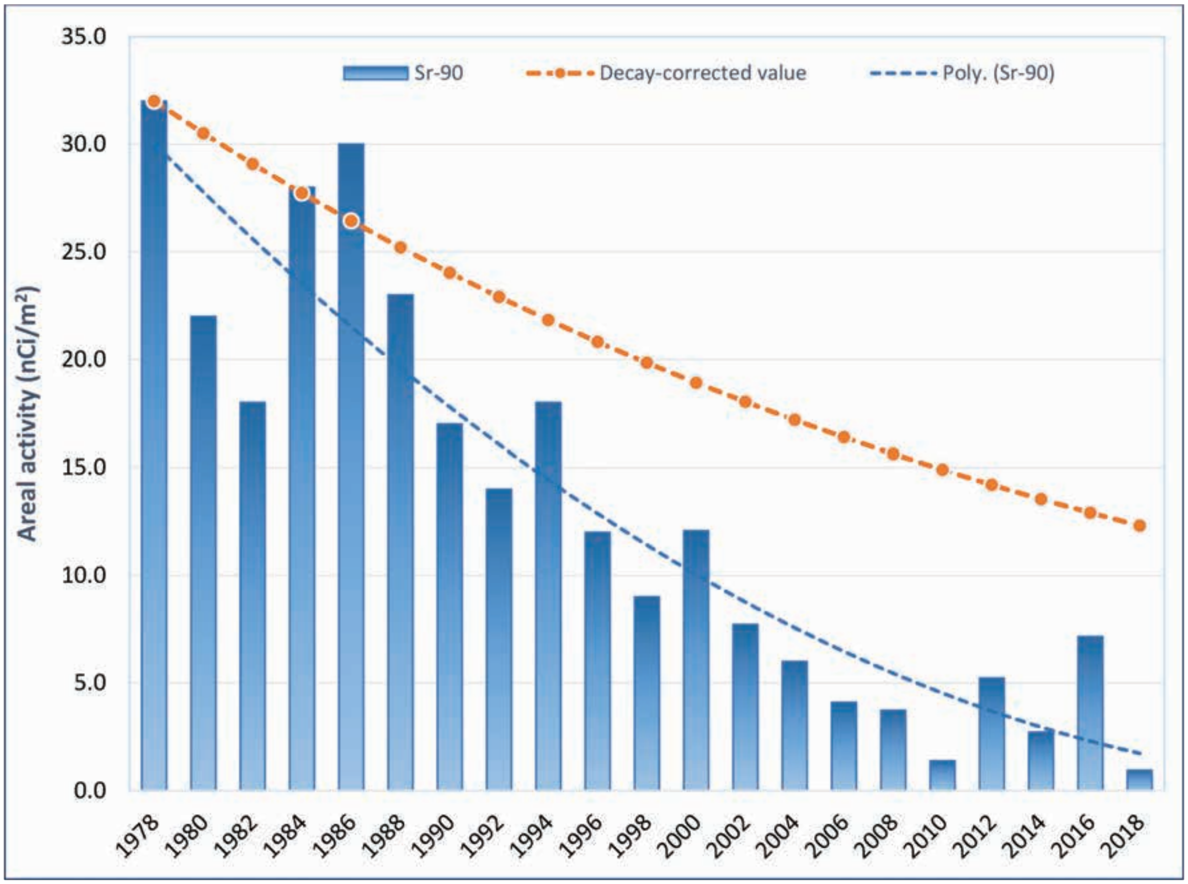

Figure 6-5. Mean (Geometric) Areal Activities of ^{90}Sr in Surface (0–5 cm [0–2.5 in.]) Soils Off the INL Site (1978–2018). *All results above zero were included in the calculation of the geometric mean. Decay-corrected values assume an initial mean areal activity measured in 1978 and a half-life of 28.8 years. The decreasing trend in the mean activity in soil samples was determined to be a second order polynomial (r^2=0.85).*

about 0.25% of the original sample weight. Although the sample is dried and sieved (< 35 mesh or 0.5 mm), the subsample is not homogeneous and not necessarily representative of the entire sample collected. [Note: Gamma analyses, on the other hand, can be performed on a much large sample size (~500 g)].

No particular trend is indicated in the graph of $^{239/240}Pu$ concentrations over time in Figure 6-6. This is consistent with the long half-life of the radionuclide, but the graph also does not indicate any accumulation over time.

Americium-241 is not produced directly in nuclear explosions but is the decay product of the fallout alpha-emitter ^{241}Pu (half-life 14.4 y). For this reason, the ^{241}Am activity in the environment is expected to increase as ^{241}Pu decays. Americium-241 was detected (>3σ) in only three of the 13 samples collected in 2018. The highest result (34.10 ± 8.61 pCi/kg or 2.25 nCi/m²), collected from Mud Lake North, is about 93% higher than expected from that projected from estimated fallout (Figure 6-7). Soil concentrations in samples collected by ESER appear to show an increasing trend with time, although no statistically significant trend was evident.

6.2.3 Onsite Soil Sampling Results

Onsite soils were not collected in 2018.

6.3 Direct Radiation

6.3.1 Sampling Design

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 approximately 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

Table 6-6. Radionuclides in Offsite Surface Soils[a] (1978 and 1980).

		Geometric Average[b]		Detection Limit		Estimated Fallout (1979)[c]
Radionuclide	**Year**	**pCi/kg**	**nCi/m²**	**pCi/kg**	**nCi/m²**	**(nCi/m²)**
Pu-238	1978	1.0 ×/÷ 1.9	0.06 ×/÷ 1.9	2	0.2	0.04
	1980	0.7 ×/÷ 1.3	0.05 ×/÷ 1.3	2	0.2	
Pu-239/240	1978	18.0 ×/÷ 1.4	1.09 ×/÷ 1.7	4	0.3	1.57
	1980	10.0 ×/÷ 1.7	0.63 ×/÷ 1.3	4	0.3	
Am-241	1978	6.2 ×/÷ 1.4	0.38 ×/÷ 1.3	4	0.3	0.68
	1980	3.0 ×/÷ 1.3	0.20 ×/÷ 1.4	4	0.3	

a. Ten soil samples collected each year to a depth of 5 cm.
b. Geometric average ×/÷ 2 standard geometric deviations of the mean. This represents the 95% confidence interval for the mean (DOE-ID 1981).
c. From Bunzl et al. 1987.

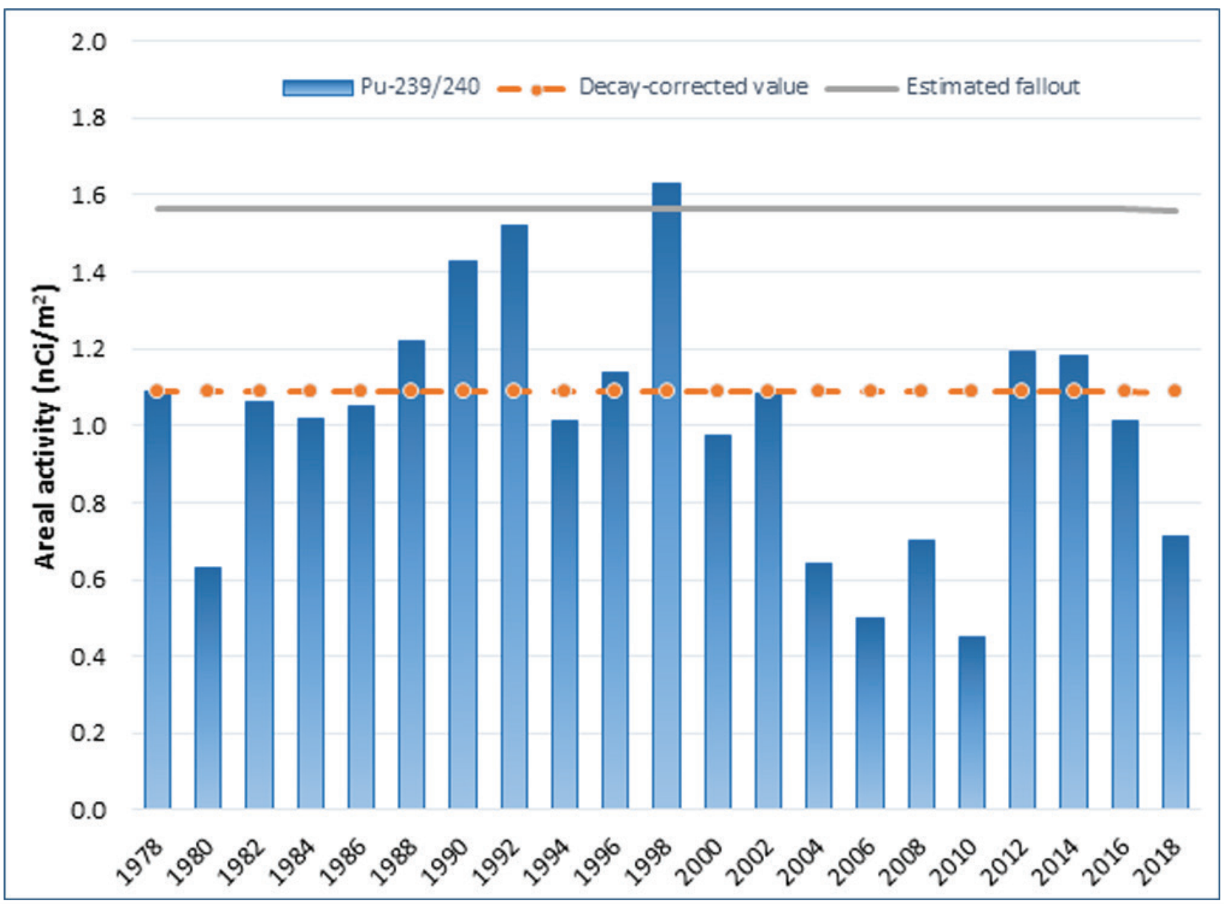

Figure 6-6. Mean (Geometric) areal activities of $^{239/240}$Pu in surface (0–5 cm [0–2.5 in.]) soils off the INL Site (1978–2018). *All results above zero were included in the calculation of the geometric mean. No statistically significant trend in the mean activity in soil samples could be determined. The fallout concentration was estimated from Bunzl et al. 1987.*

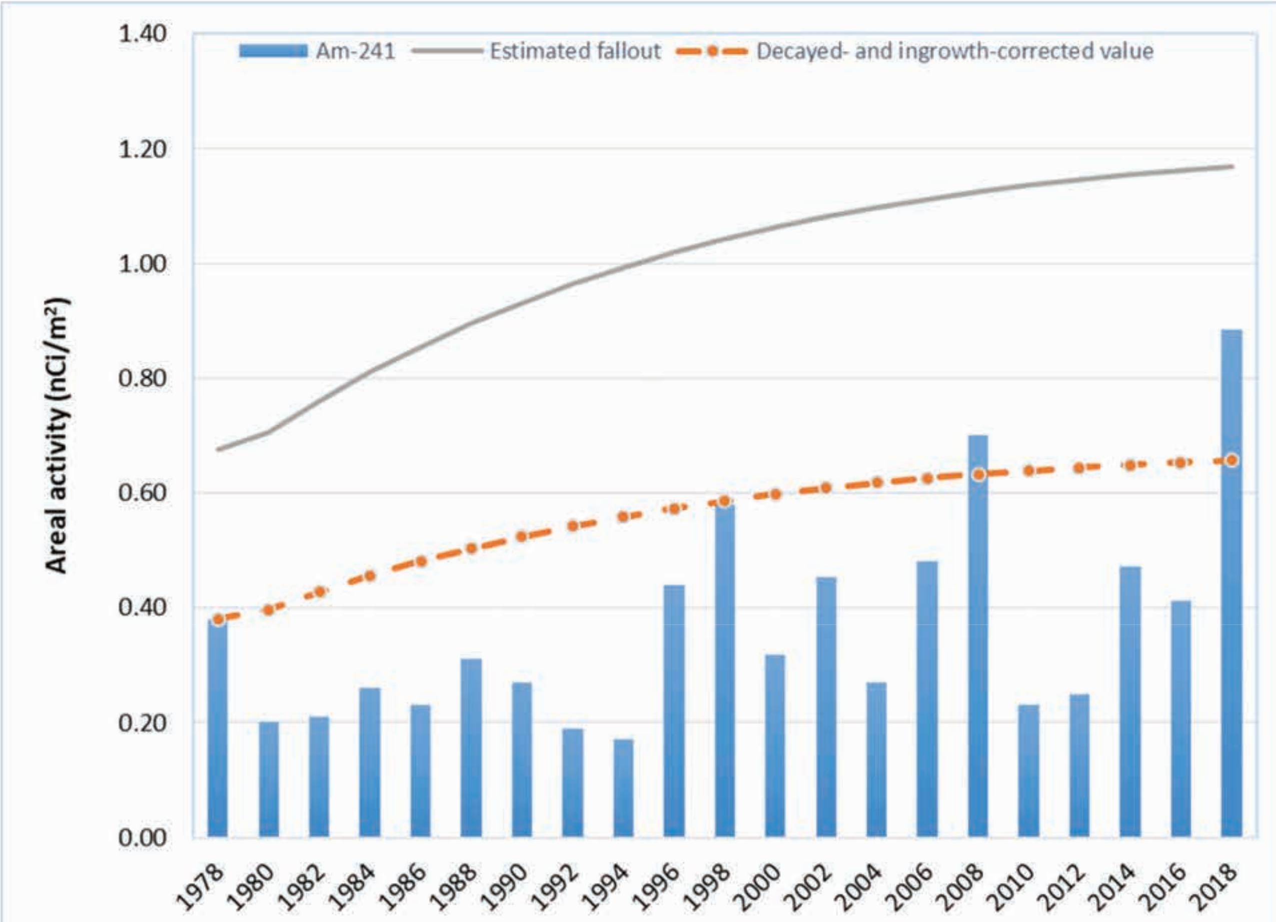

Figure 6-7. Mean (Geometric) Areal Activities of ^{241}Am in Surface (0–5 cm [0–2.5 in.]) Soils Off the INL Site (1978–2018). *The projected fallout concentrations assumes the initial fallout areal concentration reported in Bunzl et al (1987) plus the decay of ^{241}Pu to ^{241}Am. Results above zero were included in the calculation of the geometric mean. Decay-corrected values assume an initial mean areal activity measured in 1978 and a half-life of 432.2 years for ^{241}Am and 14.4 years for ^{241}Pu. No statistically significant trend in the mean activity in soil samples could be determined.*

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.

ESER TLDs were analyzed by the Idaho Cleanup Project contractor through 2015, after which they no longer performed that task. In 2017, the Idaho State University Environmental Assessment Laboratory (EAL) assumed responsibility for the ESER TLD monitoring effort with the transfer of the TLD analytical equipment to the ISU radiological science laboratory. The EAL spent 2017 bringing the TLD reader into service, including acquiring and installing software to operate the reader. The reader was calibrated using known exposures of TLDs irradiated by the DOE Radiological and Sciences Laboratory. In 2018, the ESER contractor TLDs were collected and read by EAL.

Dosimeter locations are shown in Figure 6-8. The sampling periods for 2018 were from November 2017–April 2018 and May 2018–October 2018.

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.

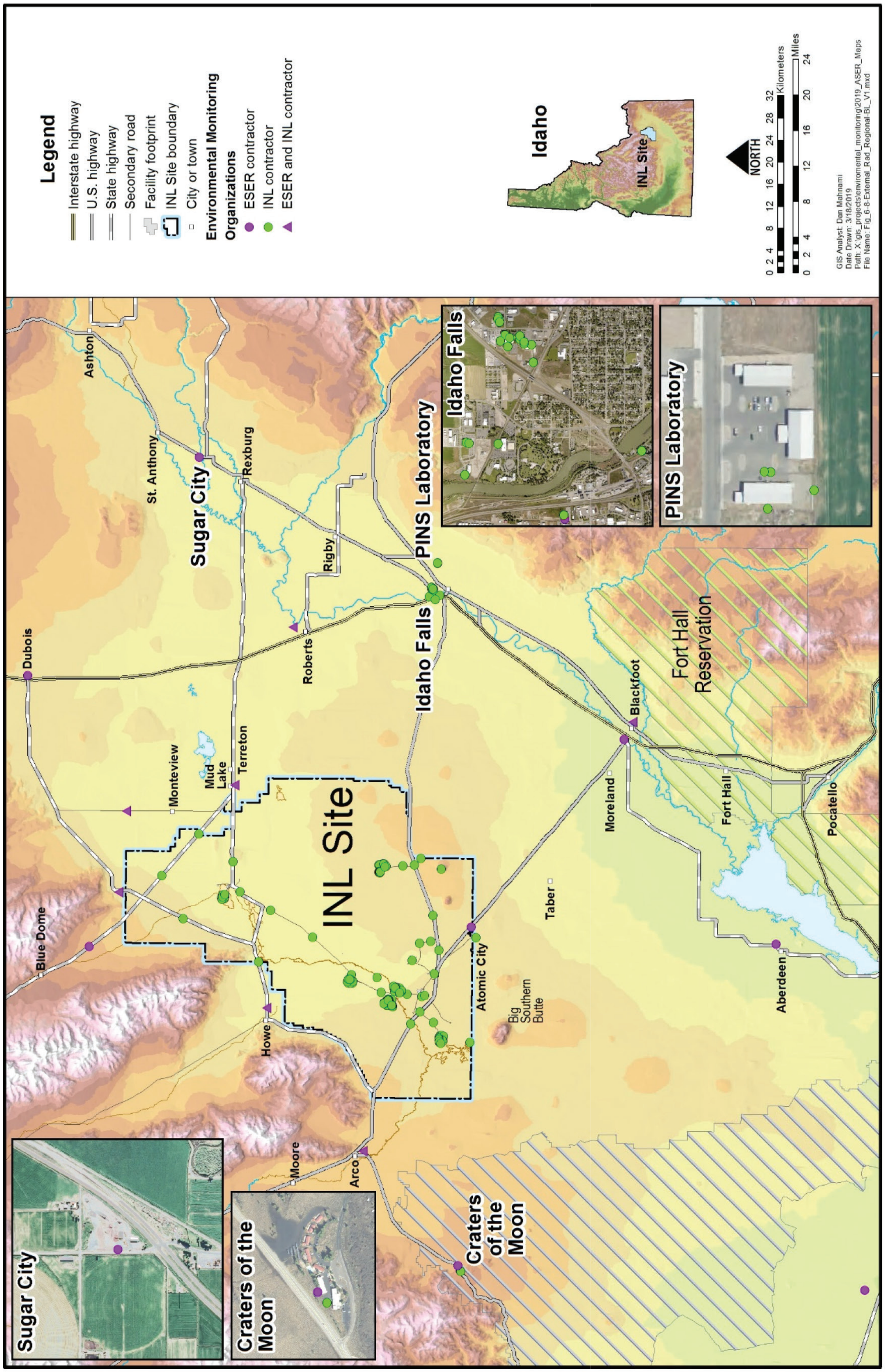

Figure 6-8. Regional Direct Radiation Monitoring Locations (2018).

6.3.2 Methods

TLDs are deployed in the field in May and then replaced in November. The dosimeters are sent to the EAL for analysis.

OSLDs are also placed in the field for six months at the same locations as the TLDs, and then returned to the manufacturer for analysis. Transit control dosimeters are shipped with the field dosimeters 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 five 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).

6.3.3 Results

The ESER and INL contractor OSLD data measured at common locations around the INL Site in 2018 are shown in Table 6-7. Using OSLD data collected by both the ESER and INL contractors, the mean annual ambient dose was estimated at 125 mrem (1250 uSv) for boundary and 124 mrem (1,240 uSv) for distant locations. The mean annual ambient dose for all locations combined is 124 mrem (1,240 uSv).

The 2018 direct radiation results and locations collected by the INL contractor at sitewide and regional locations are provided in Appendix D. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2018 reported values for field locations were primarily below the historic background six-month UTL. Table 6-8 shows the locations that exceeded the specific six-month UTL. Neutron monitoring is conducted around buildings in Idaho Falls with sources that may emit or generate neutron radiation. In Idaho Falls, these buildings include the IF-675 PINS Laboratory, the IF-670 Bonneville County Technology Center, and the IF-638 Physics Laboratory. Neutron dosimeters are also placed at INL Research Center along the south perimeter fence and at the Idaho Falls background location (O-10). The background level for neutron dose is zero and the current 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 neutron dose measured is considered present due to sources inside the building. All neutron dosimeters collected in 2018 were reported as “M” (dose equivalents below the minimum measurable quantity of 10 mrem).

The 2018 ESER TLD data are shown in Figure 6-9. The TLD results demonstrate a strong linear relationship ($r^2 = 0.91$) with the 2018 ESER OSLD results, indicating a good correlation (Figure 6-9). The two dosimetry systems do not measure the same radiological quantity. The TLD system is calibrated to measure the quantity, exposure¸ expressed in units of Roentgen. The OSLD system is calibrated to measure the quantity, *ambient dose equivalent (H*(10))*, expressed in units of rem. However, they appear to have respond in a similar fashion to penetrating radiation fields in the field. More TLDs will be deployed in 2019 in order to gain additional insight and increase confidence in the data.

Table 6-9 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 1976–1993, as summarized by Jessmore, Lopez, and Haney (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,

Table 6-7. Annual Environmental Radiation Doses Using OSLDs at All Offsite Locations (2014–2018).

Location	2014		2015		2016		2017		2018	
	ESER[a]	INL[b] Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER[c]	INL Contractor
Distant										
Aberdeen	112	NA[d]	119	NA	117	NA	120	NA	123	NA
Blackfoot	[e]	NA	114	NA	118	NA	112	NA	NA	NA
Craters of the Moon	109	124	115	125	113	118	116	125	118	132
Dubois	95	NA	90	NA	103	NA	98	NA	103	NA
Idaho Falls	103	119	113	124	122	113	110	119	118	126
IF-IDA	NA	NA	NA	109	NA	106	NA	106	NA	119
Jackson	89	NA	[f]	NA	[f]	NA	[f]	NA	109	NA
Minidoka	104	NA	99	NA	99	NA	102	NA	109	NA
Mountain View[g]	104	111	102	114	107	115	102	110	110	125
Rexburg/Sugar City[h]	147	121	134	NA	151	NA	141	NA	151	NA
Roberts[i]	118	140	117	135	132	122	119	124	130	145
Mean	109	123	109	116	118	115	113	117	119	129
Boundary										
Arco	117	127	113	125	114	121	111	122	122	134
Atomic City	113	123	119	117	122	128	117	122	122	132
Birch Creek Hydro[j]	101	108	98	108	108	107	93	94	110	119
Blue Dome	84	NA	95	NA	103	NA	94	NA	106	NA
Howe	104	116	105	[k]	111	101	109	115	119	129
Monteview	102	117	106	117	115	124	110	133	119	130
Mud Lake	122	129	63	135	132	129	117	131	132	143
Mean	106	120	111	112	115	118	107	120	119	131

a. ESER = Environmental Surveillance, Education, and Research Program.
b. INL = Idaho National Laboratory.

Table 6-8. Dosimetry Locations Above the Six-month Background Upper Tolerance Limit (2018).

Location	May 2018 Sample Result (mrem)	Nov. 2018 Sample Result (mrem)	Background Level UTL[a] (mrem)
ANL O-16	*	83.7	80.42
ANL O-21[b]	82.6	90.3	80.42
ANL O-22[b]	*	86.6	80.42
ANL O-23[b]	83	90.8	80.42
Blackfoot O-9	62.9	*	61.81
ICPP O-14[b]	*	128.4	102
ICPP O-15	114.9	163.2	102
ICPP O-20[b]	249.2	267.4	102
ICPP O-27[b]	148	214.3	102
ICPP O-28[b]	124.2	199.8	102
ICPP O-30[b]	200.7	191.3	102
ICPP TreeFarm O-1[b]	109.1	131.6	102
ICPP TreeFarm O-4[b]	141.5	136.6	102
IF-638W O-4[b]	69.9	*	68.02
Main Gate O-1[b]	75.5	*	74.53
Monteview O-4	*	67	65.74
RRL5 O-1[b]	*	91	80.42
RWMC O-13A	88.4	99.1	85.78
RWMC O-41	*	142	131.3
RWMC O-9A	90.1	90.3	85.78
TRA O-19[b]	98	*	96.39

a. The UTL is the value such that 95 percent of all the doses in the area are less than that value with 95 percent confidence. That is, only 5 percent of the doses should exceed the UTL.

b. Location has not been sampled long enough (years) to be included in the six-month UTL calculation. The comparison value is from the facility UTL or other nearby locations.

* Sample did not exceed the UTL for the collection period.

and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose that Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2018, 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 2018 was estimated to be 126 mrem/yr. This is approximately similar to the 124 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 2018.

The component of background dose that varies the most is inhaled radionuclides. According to the NCRP, the major contributor of effective dose received by a

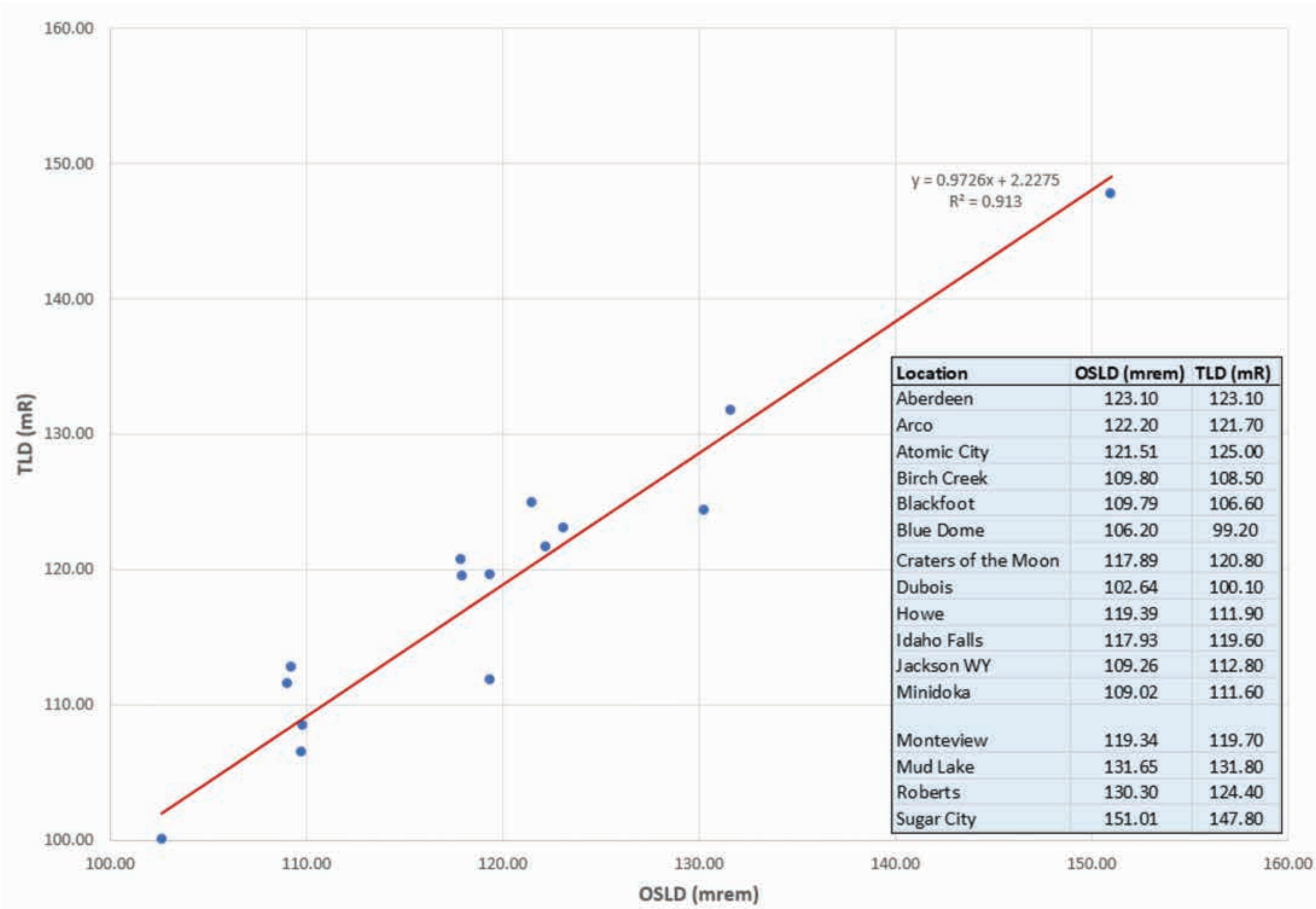

Figure 6-9. Comparison of TLD Versus OSLD Results Measured by ESER.

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 6-9 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).

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 6-9). This value was used in Table 7-5 to calculate background radiation dose to the population living within 50 mi of INL Site facilities.

6.4 Waste Management Surveillance Sampling

For compliance with DOE O 435.1, "Radioactive Waste Management" (2011), vegetation and soil are sampled at RWMC, and direct surface radiation is measured at RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility.

Table 6-9. Calculated Effective Dose from Natural Background Sources (2018).

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	124
Internal Irradiation (Primarily Ingestion)[e]		
Potassium-40	15	NM[f]
Thorium-232 and uranium-238	13	NM
Others (carbon-14 and rubidium-87)	1	NM
Internal Irradiation (Primarily Inhalation)[d]		
Radon-222 (radon) and its short-lived decay products	212	NM
Radon-220 (thoron) and its short-lived decay products	16	NM
Total	383	NM

a. Calculated from the average annual external exposure at all offsite locations (ESER and INL) measured using OSLDs (see Table 6-7).
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.
f. NM = not measured.

6.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, historically, vegetation was 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 (Figure 6-10). Russian thistle was collected in even-numbered years. Crested wheatgrass and rabbitbrush were collected in odd numbered years. In 2018, the ICP contractor made a decision, using guidance from DOE-HDBK-1216-2015 (DOE 2015), to discontinue further biota sampling activities. This decision was based on an evaluation of biota sample data trends, which concluded that vegetation is not considered a major mode of radionuclide transport through the environment surrounding the SDA at RWMC.

6.4.2 Soil Sampling at the Radioactive Waste Management Complex

Waste Management surveillance soil sampling has been conducted triennially at the SDA at RWMC since 1994. The last triennial soil sampling event was conducted in 2015. In 2017, the results of soil sampling from 1994–2015 were reviewed for each constituent of interest and compared to their respective environmental concentration guide, which were established in 1986 in *Development of Criteria for the Release of Idaho National Engineering Laboratory Sites Following Decontamination and Decommissioning* (EGG-2400). All results were well below their environmental concentration guide.

The footprint at RWMC has changed drastically since this soil sampling began. The area where soil sampling has been performed at the SDA at RWMC is now

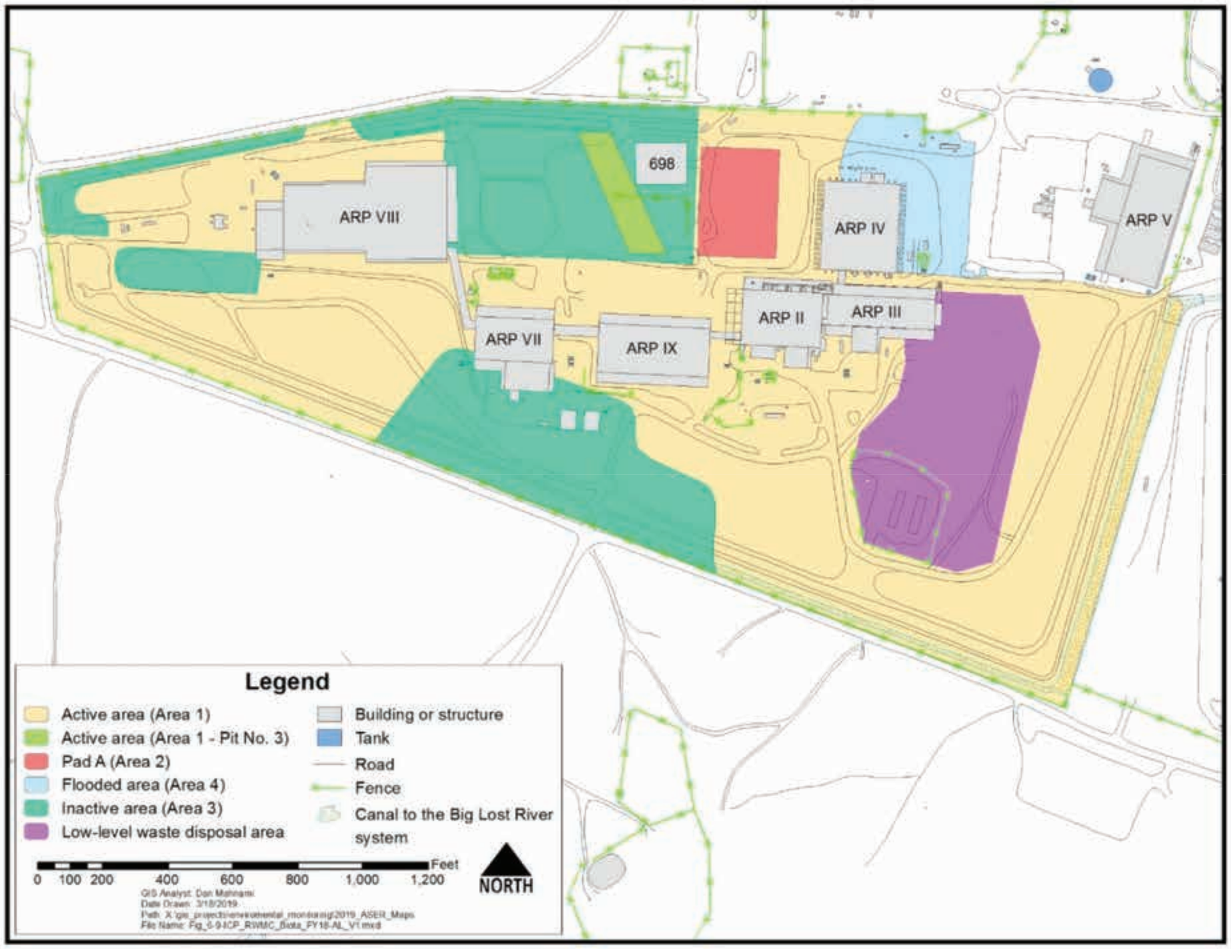

Figure 6-10. Historical Vegetation Sampling Areas at the RWMC.

a heavily disturbed area. Structures cover a majority of the area and fill has been brought in where subsidence has occurred. Gravel has been applied for road base. The DOE Handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015) states, "Except where the purpose of soil sampling dictates otherwise, every effort should be made to avoid tilled or disturbed areas and locations near buildings when selecting soil sampling locations."

In 2017, a decision was made to discontinue soil monitoring based on several factors: 1) the limited availability of undisturbed soils; and 2) sufficient historical data had been collected to satisfy the characterization objectives, as well as the conclusion that planned activities in the SDA do not have a potential to change surface soil contaminant concentrations prior to installation of the surface cover over the entire SDA under the CERCLA program.

6.4.3 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 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 (Radiation Solutions, Inc., Model RS-701) was used to conduct this year's soil surface radiation (gross gamma) surveys to detect trends in measured levels of surface radiation. The RS-701 system consists of two sodium iodide (NaI) scintillator gamma detectors, housed in two separate metal cabinets, and a Trimble global positioning system receiver, mounted on a rack attached to the front bumper of a four-wheel drive vehicle. The detectors are approximately 24 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 field vehicle. The GPRS system software displays the gross gamma counts and spectral second-by-second data from the detectors, along with the corresponding 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 field vehicle is driven 5 mph (7 ft/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 2018, in comparison to previous years.

Figure 6-11 shows a map of the area that was surveyed at RWMC in 2018. 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 2018 results 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 measure-

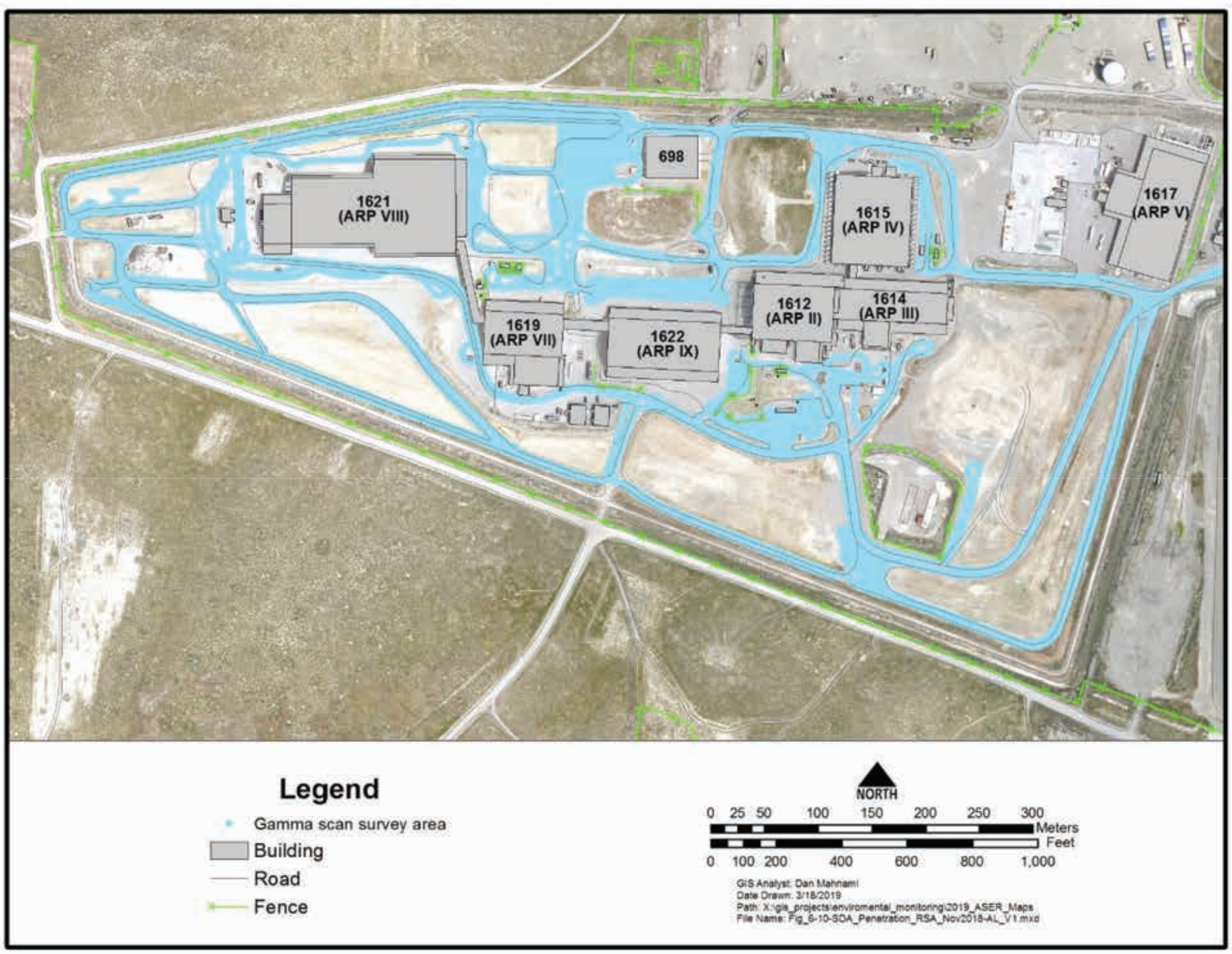

Figure 6-11. SDA Surface Radiation Survey Area (2018).

ments from the buried waste in pits and trenches are more visible. Average background values near or around areas that were radiometrically scanned were generally at or below 4000 counts per second. Most of the 2018 RWMC gross gamma radiation measurements were at background levels. The 2018 maximum gross gamma radiation measurement on the SDA was 92,572 counts per second, as compared to the 2017 measurement of 11,706 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 6-12. 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 2017). In 2018, the readings were either at background levels or slightly above background levels (approximately 3,580 counts/second), which is expected until the facility is closed and capped.

6.5 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 2002) 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 re-

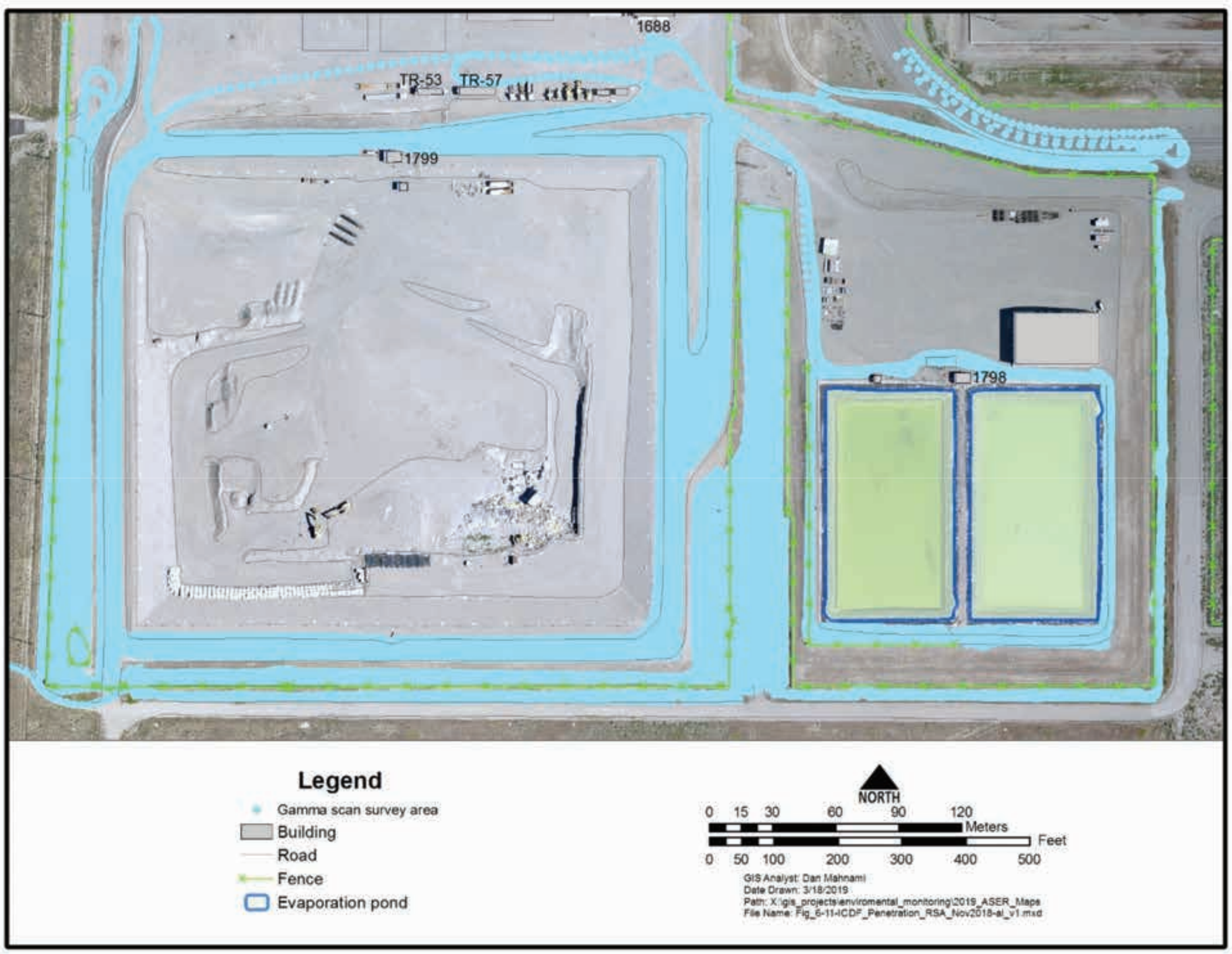

Figure 6-12. Idaho CERCLA Disposal Facility Surface Radiation Survey Area (2018).

quired, the regulatory agencies requested additional analysis using the latest ecological risk assessments. Refined ecological risks were presented in a summary report (VanHorn 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 by VanHorn (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.

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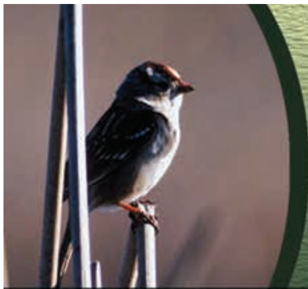


White-crowned Sparrow
Zonotrichia leucophrys

7. Dose to the Public and Biota

2018

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 2018, as determined by this program, was 0.010 mrem (0.10 µSv), well below the applicable standard of 10 mrem (100 µSv) per year. A maximum potential dose from ingestion was also estimated using the highest radionuclide concentrations in the edible tissue of waterfowl collected at Advanced Test Reactor ponds in 2018. The maximum potential dose to an individual who consumes the duck was calculated to be 0.016 mrem (0.16 µSv). The total dose (via air and ingestion) estimated to be received by the MEI during 2018 was thus 0.026 mrem (0.26 µSv). 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 337,643 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 2018, the estimated potential population dose was 7.45 x 10^{-3} person-rem (7.45 x 10^{-5} person-Sv). This dose is approximately 0.000008 percent of that expected from exposure to natural background radiation of 129,317 person-rem (1,293 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 addition, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds were used to estimate internal doses to the waterfowl. These calculations indicate that the potential doses to waterfowl do not exceed the DOE limits for biota.

No unplanned releases were detected from the INL Site in 2018, therefore, no doses were associated with unplanned releases.

7. DOSE TO THE PUBLIC AND BIOTA

U.S. Department of Energy (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 DOE. In addition to requiring environmental monitoring to ensure compliance with the order, DOE O 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* (DOE 2002). The Standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

Title 40 Code of Federal Regulations (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 U.S. Environmental Protection Agency (EPA) approved computer models.

Common Nighthawk
Chordeiles minor

This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2018 environmental monitoring measurements or calculated emissions.

7.1 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 3-1).

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 and waterfowl harvested from INL Site wastewater ponds 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.

7.2 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 or could potentially be released by the facilities. The 2018 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2019) reported potential radionuclide releases from 68 source locations at the INL Site. However, many of the sources resulted in doses that were insignificant and many sources are located relatively close together such that the sampling network response from a release would be the same for all nearby sources. Therefore, insignificant sources were not explicitly modeled and some sources were consolidated with nearby sources. Four large operating stacks were modeled explicitly and included the Advanced Test Reactor (ATR) main stack (TRA-770), the Materials Test Reactor main stack (TRA-710), the Idaho Nuclear Technology and Engineering Center (INTEC) main stack (CPP-708), and the Experimental Breeder Reactor-II main stack (MFC-764). All other releases within a facility were assigned as ground-level releases from a single location within the facility. These other releases include other non-fugitive releases from ducts and vents and fugitive releases from ponds, soil, or other sources. Figure 7-1 shows the location of all sources modeled in the dose assessment. Releases from the Radiological Response Training Range–Northern Test Range (RRTR-NTR) and Test Area North–Technical Support Facility (TAN-TSF) were assumed collocated with releases from Specific Manufacturing Capability (SMC). Releases from the Transient Reactor Test (TREAT) Facility were assumed collocated with releases from Materials and Fuels Complex (MFC).

The radionuclides and source terms used in the dose calculations are presented in Table 3-2 and summarized in Table 7-1. The category of noble gases comprised the largest emission quantity, but only contributed slightly to the dose, except for argon-41 (^{41}Ar), which had a more significant contribution. Radionuclides that were categorized as noble gases tend to have short half-lives and are not typically incorporated into the food supply. Radionuclides that contributed the most to the overall estimated dose were cesium-137 (^{137}Cs), tritium (^{3}H), ^{41}Ar, strontium-90 (^{90}Sr), iodine-129 (^{129}I), carbon-14 (^{14}C), and cobalt-60 (^{60}Co). These radionuclides 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 NESHAP regulations.*** The Clean Air Act Assessment Package-1988 computer model, PC (CAP88-PC) Version 4 (EPA 2013), was used to predict the maximum concentration and dose at offsite receptor locations. The receptor location with the highest estimated dose is the MEI location.
- ***The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility.*** For this calculation, the HYbrid Single-Particle Lagrangian Integrated Trajectory

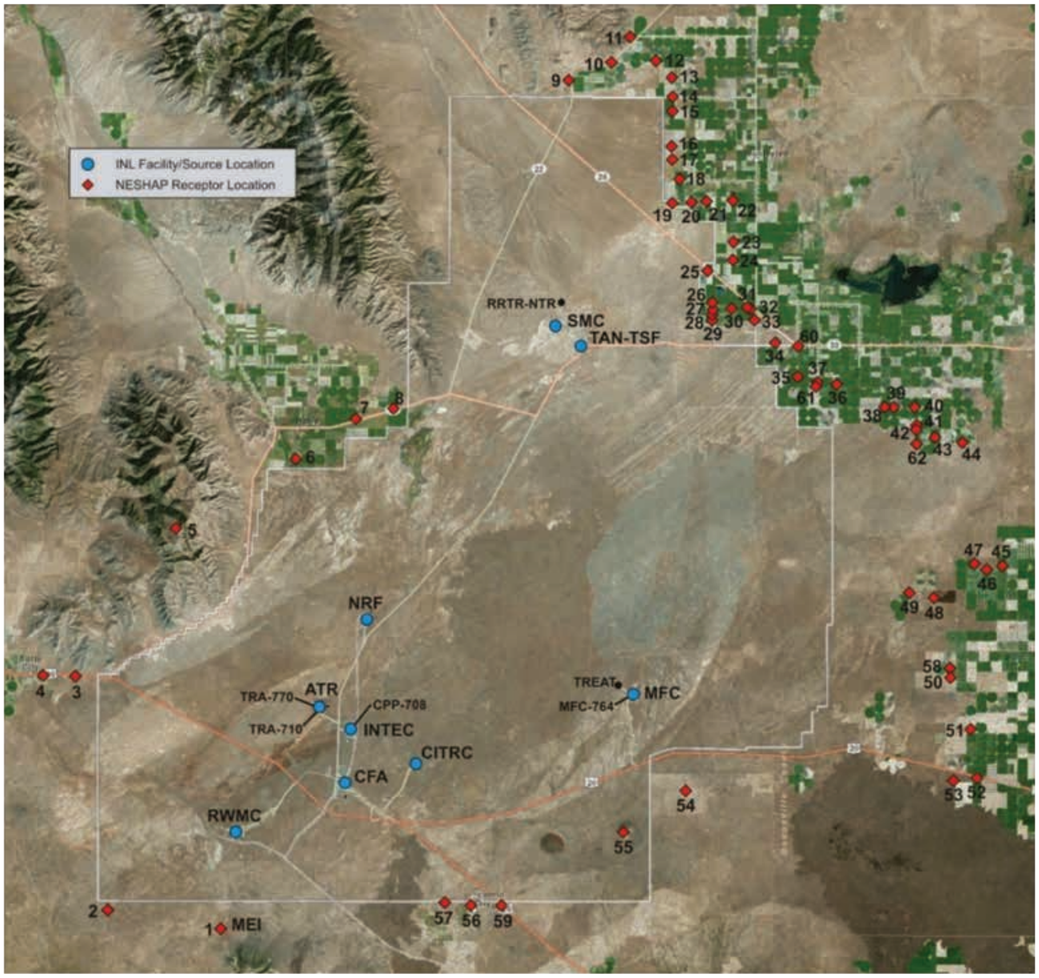


Figure 7-1. INL Site Major Facility Airborne Source Locations.
TRA-770, TRA-710, CPP-708, and MFC-764 were modeled as stack releases. The remaining sources were modeled as ground-level releases. Releases from RRTR-NTR and TAN-TSF were assumed collocated with releases from SMC. Releases from TREAT were assumed collocated with releases from MFC. Sixty-two specific receptor locations, including the MEI, modeled by CAP88-PC are also shown.

(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 2019), using dispersion and deposition factors calculated by HYSPLIT in order to comply with DOE O 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 3-1). The CAP88-PC computer model uses dose and risk tables developed by the EPA. Population dose calculations were made using: 1) the HYSPLIT model to calculate dispersion and deposition factors, the methods described in Rood (2019), 2) DOE effective dose coefficients for inhaled radionuclides (DOE 2011), 3) EPA dose conversion factors for ingested radionuclides (EPA 2002), and 4) EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (EPA 2002).

7.2.1 Maximally Exposed Individual Dose

The EPA NESHAP regulation requires demonstrating that radionuclides other than radon released to air from

Table 7-1. Summary of Radionuclide Composition of INL Site Airborne Effluents (2018).

	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	2.45E+02	1.50E-08	8.79E+02	2.74E-01	1.85E-02	3.70E-02	2.18E-02	1.34E-08	8.46E-06	2.46E-05	3.12E-10
CFA	5.09E-01	3.86E-10	1.72E-04	5.20E-06	4.80E-03	3.80E-10	1.26E-10	5.95E-09	1.11E-10	1.60E-08	7.83E-12
CITRC	-	5.70E+01	-	1.41E-12	7.50E-01	1.13E-05	-	4.00E-05	-	-	-
INTEC	2.58E+01	2.25E+00	-	-	1.72E-03	1.57E-03	4.92E-06	3.84E-07	1.00E-06	9.03E-07	
MFC	3.74E-01	4.44E-02	1.82E+02	7.36E+00	7.05E-02	8.88E-02	2.02E-06	3.54E-07	3.92E-07	8.16E-09	7.50E-12
NRF	2.20E-02	2.10E-01	-	-	7.80E-01	5.19E-05	4.70E-05	-	2.70E-06	-	-
RWMC	6.44E+01	-	-	-	1.12E-01	-	1.30E-08	1.65E-06	8.88E-05	2.15E-05	1.79E-11
TAN	3.26E-02	1.37E-05	2.01E-05	2.32E+00	6.96E+00	-	1.02E-06	5.57E-10	-	-	-
Total	**3.36E+02**	**5.95E+01**	**1.06E+03**	**9.95E+00**	**8.69E+00**	**1.27E-01**	**2.18E-02**	**4.24E-05**	**1.01E-04**	**4.70E-05**	**3.45E-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 and Radiological Response Training Range-Southern Test Range); 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 2018 = ^{39}Ar and ^{85}Kr (^{39}Ar release is negligible).

d. Noble gases ($T_{1/2}$ < 40 days) released in 2018 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{89}Kr, ^{90}Kr, ^{91}Kr, ^{92}Kr, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, ^{137}Xe and ^{138}Xe, ^{139}Xe, ^{140}Xe.

e. Fission products and activation products ($T_{1/2}$ < 3 hours) released in 2018 = ^{109m}Ag, ^{110}Ag, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{80}Br, ^{83}Br, ^{38}Cl, ^{60m}Co, ^{138}Cs, ^{139}Cs, ^{140}Cs, ^{68}Ga, ^{142}La, ^{56}Mn, ^{97}Nb, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, ^{90}Rb, ^{91}Rb, ^{92}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{81}Se, ^{81m}Se, ^{129}Te, ^{131}Te, and ^{91m}Y.

f. Fission products and activation products ($T_{1/2}$ > 3 hours) released in 2018 = ^{108m}Ag, ^{110m}Ag, ^{111}Ag, ^{112}Ag, ^{77}As, ^{133}Ba, ^{140}Ba, ^{10}Be, ^{210}Bi, ^{210m}Bi, ^{80m}Br, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{113m}Cd, ^{115}Cd, ^{115}mCd, ^{139}Ce, ^{141}Ce, ^{143}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{135}Cs, ^{136}Cs, ^{137}Cs, ^{166}Dy, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{157}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{72}Ga, ^{153}Gd, ^{159}Gd,^{68}Ge, ^{71}Ge, ^{175}Hf, ^{178m}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{115m}In, ^{192}Ir, ^{40}K, ^{42}K, ^{43}K, ^{140}La, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{95m}Nb, ^{96}Nb, ^{147}Nd, ^{59}Ni, ^{63}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{210}Pb, ^{109}Pd, ^{147}Pm, ^{148}Pm, ^{148m}Pm, ^{149}Pm, ^{151}Pm, ^{143}Pr, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{105}Rh, ^{103}Ru, ^{106}Ru, ^{35}S, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{126}Sb, ^{127}Sb, ^{46}Sc, ^{32}Si, ^{151}Sm, ^{113}Sn, ^{119m}Sn, ^{121}Sn, ^{123}Sn, ^{125}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{160}Tb, ^{161}Tb, ^{99}Tc, ^{99m}Tc, ^{123m}Te, ^{125m}Te, ^{127}Te, ^{127m}Te, ^{129m}Te, ^{131m}Te, ^{132}Te, ^{204}Tl, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{93}Y, ^{65}Zn, ^{72}Zn, ^{93}Zr, ^{95}Zr and ^{97}Zr.

g. Radioiodine released in 2018 = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I.

h. Radiostrontium released in 2018 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr.

i. Uranium isotopes released in 2018 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U and ^{238}U.

any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H). EPA requires the use of an approved computer model such as CAP88-PC to demonstrate compliance with 40 CFR 61, Subpart H. 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).

The dose to the MEI from INL Site airborne releases of radionuclides was calculated to demonstrate compliance with NESHAP and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2018 INL Report for Radionuclides* (DOE-ID 2019). 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 Frenchmans Cabin, located 2.26 km (1.4 mi) 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 0.0102 mrem (0.102 µSv) was calculated for a hypothetical person living at Frenchmans Cabin during 2018.

Figure 7-2 compares the maximum individual doses calculated for 2009–2018. All 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, Subpart H. The highest dose estimated was in 2009.

Although noble gases were the radionuclides released in the largest quantities, they represented relatively smaller fractions of the cumulative dose from all pathways (affecting immersion only) largely because of their short half-lives and exclusion from the food supply. For example, about 61% of the total activity released was ^{41}Ar (Table 3-2), yet ^{41}Ar resulted in approximately 15.9% of the estimated MEI dose. In contrast, radionuclides typically associated with airborne particulates, such as ^{60}Co, ^{137}Cs, ^{129}I, and ^{90}Sr, comprised only a small fraction (less than 0.01 percent) of the total amount of radionuclides reported to be released (Table 3-2) yet resulted in approximately 53.2% of the estimated dose (Figure 7-3). The potential dose from ingesting or inhal-

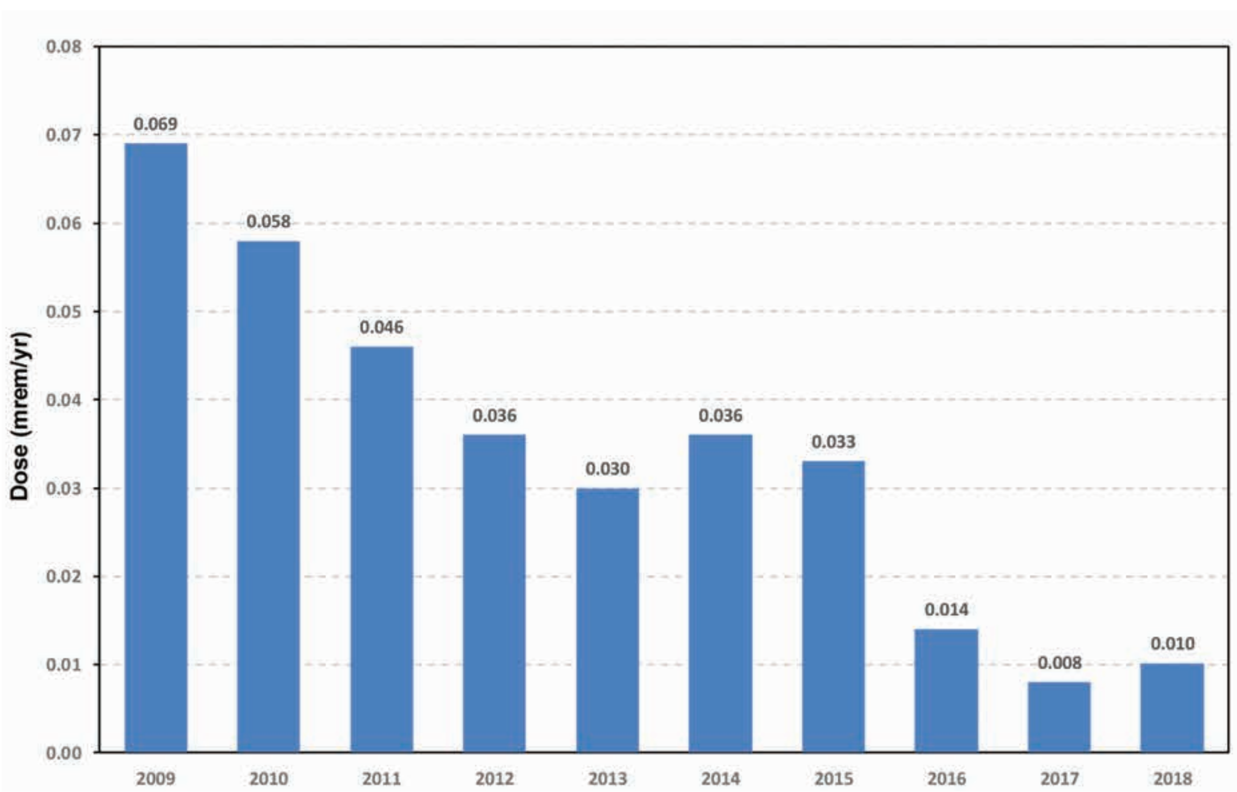


Figure 7-2. MEI Dose from INL Site Airborne Releases Estimated for 2009–2018.

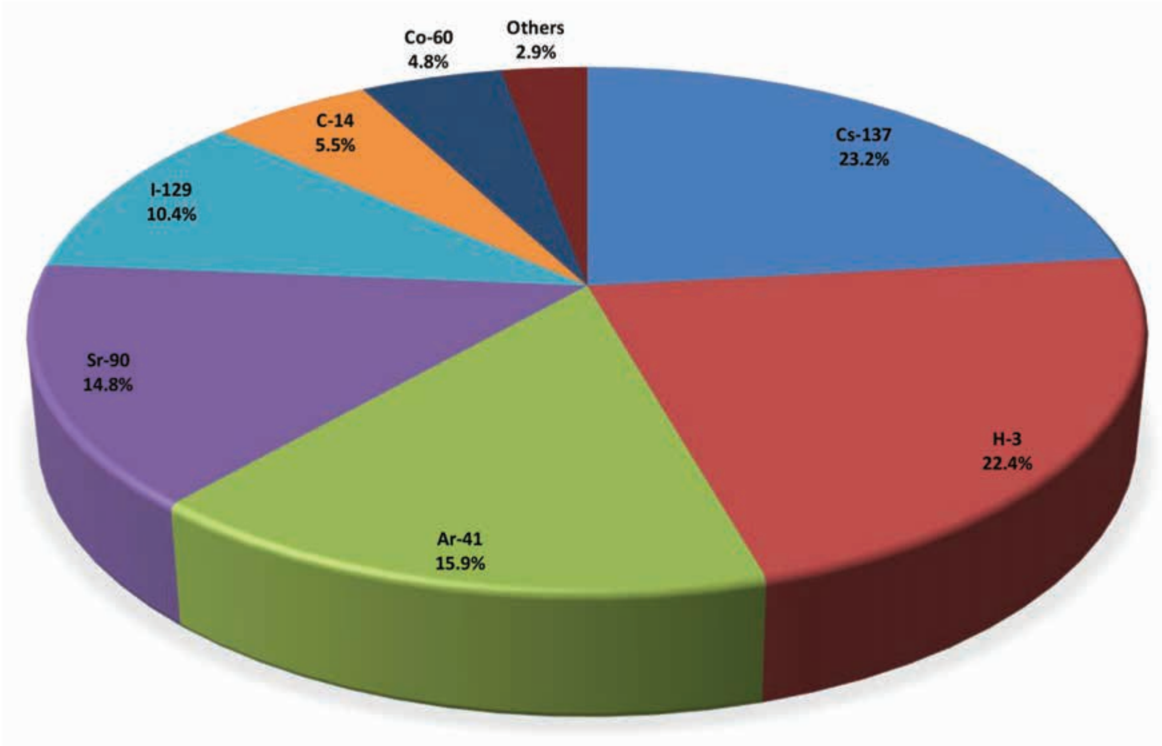


Figure 7-3. Radionuclides Contributing to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2018).

ing ^{90}Sr is higher than that for other particulate radionuclides because it is relatively long-lived (half-life = 29 years) and in the body it acts similar to calcium as it accumulates long term in bone tissue. While in the body, ^{90}Sr continues to expose the surrounding tissues to beta radiation. Tritium represented about 23% of the total activity released and contributed approximately 22% of the calculated dose to the MEI in 2018. 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 7-4) were identified during preparation of the annual NESHAP report (DOE-ID 2019) as follows:

- About 23% of the dose can be accounted for from ^{137}Cs due mostly to new conditions and activities at the Radiochemistry Laboratory located at MFC.
- The dose from tritium emissions, which accounted for approximately 22% of the total dose to the MEI, results mainly from non-fugitive (i.e., point source) releases from the ATR main stack (TRA-770) and the INTEC main stack (CPP-708); and fugitive (i.e., nonpoint source) releases from beryllium blocks at the Radioactive Waste Management Complex (RWMC) and from the Warm Waste Evaporation Pond (TRA-715-001) at the ATR Complex.
- Airborne emissions of ^{41}Ar were primarily the result of operation of the Advanced Test Reactor at the ATR Complex and accounted for 15.9% of the total MEI dose.
- The major source of ^{90}Sr resulting in dose to the MEI was from the Warm Waste Evaporation Pond at the ATR Complex. Strontium-90 accounts for 14.8% of the total MEI dose.
- Iodine-129 releases accounted for 10.4% of the total MEI dose and were primarily from the INTEC main stack (CPP-708).

The ATR complex continued to be the largest contributor to dose at over 50% contribution followed by MFC at 18.7%, RWMC at 11.5%, and INTEC at 11.3%.

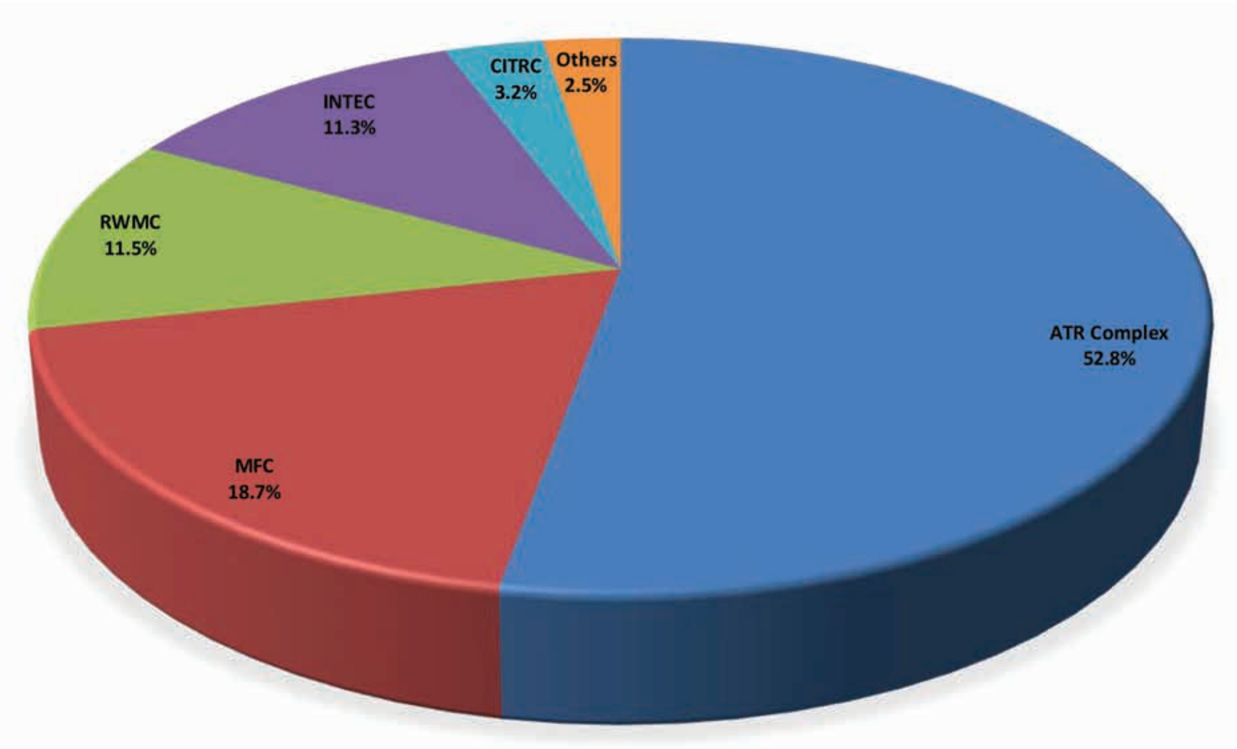


Figure 7-4. Percent Contributions, by Facility, to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2018).

7.2.2 Eighty Kilometer (50 Mile) Population Dose

Total effective population dose from airborne releases was calculated using air dispersion modeling performed by the National Oceanic and Atmospheric Administration (NOAA) Idaho Falls Office using their HYSPLIT model (Stein et al. 2015; Draxler et al. 2013), and the Dose Multi-Media (DOSEMM) v190429 (Rood 2019) dose assessment model. The HYSPLIT model and its capabilities are described on the NOAA Air Resources Laboratory website (https://www.arl.noaa.gov/hysplit/hysplit/).

The objective of these calculations was to provide a grid of total effective dose across a model domain that encompasses an 80-km (50-mi) radius from any INL Site source (Figure 7-5). In addition to INL Site sources, releases from the Idaho Falls facilities located at the INL Research Center (IRC) within the Idaho Falls city limits were also included. These data were then used with geographical information system software to compute population dose.

The radionuclide source term for facilities that contributed significantly to the annual dose were the same as those used by the CAP88-PC (EPA 2013) modeling performed for the annual NESHAP report (DOE-ID 2019). These sources and radionuclides were included in the HYSPLIT/DOSEMM modeling. Radionuclide-facilities that yielded greater than 0.1% of the total dose at the location of the MEI were selected to be run. The MEI was the receptor south of the INL Site referred to as Frenchmans Cabin. For Idaho Falls facilities, radionuclides that result in a dose greater than 1% of the total dose at the MEI in Idaho Falls were included. The radionuclide source terms used for the modeling are shown in Tables 7-2 and 7-3.

During 2018, the NOAA Air Resources Laboratory – Field Research Division 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 2018 together with regional topography. The model predicted dispersion and deposition resulting from releases from each facility at each of 17,877 grid points projected on and

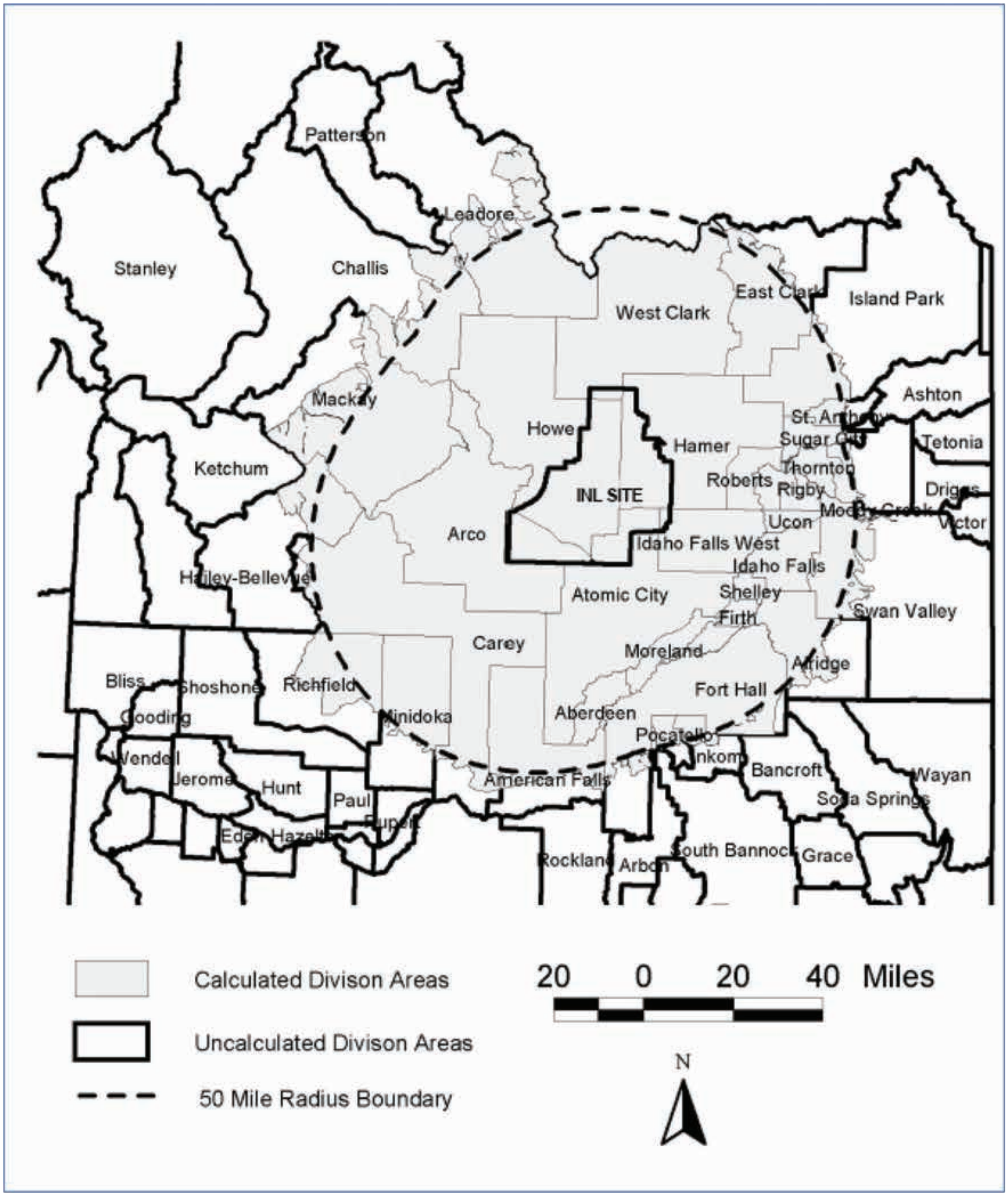


Figure 7-5. Region within 80 kilometers (50 miles) of INL Site Facilities.
Census Divisions used in the 50-mile population dose calculation are shown.

around the INL Site. The Cartesian grid was designed to encompass the region within 80 km (50 mi) of INL Site facilities (Figure 7-5). 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 17,877 grid nodes across the model domain. These values were converted to dispersion and deposition factors for use in DOSEMM (Rood 2019).

Table 7-2. Radionuclide Source Term (Ci yr–1) for Radionuclide-facility Combinations that Contributed Greater than 0.1% of the Total Dose for INL Site Facilities[a] (2018).

Radionuclide[b]	CITRC	INTEC	INTEC-MS	MFC	NRF	RTC	RTC-ATR	RTC-MTR	RWMC	RRTR	Total ($Ci\ yr^{-1}$)
Am-241		9.03E-07	2.66E-13	2.09E-11		2.20E-05	8.73E-08		2.14E-05		4.44E-05
Ar-41				6.61E+01		5.40E-05	8.38E+02			1.95E-05	9.04E+02
Br-82						1.63E-10				4.39E+00	4.39E+00
C-14	7.50E-01	1.67E-03		1.98E-03	7.80E-01	6.33E-11		1.35E-14	1.12E-01		1.65E+00
Co-60		1.29E-06		1.97E-12	2.00E-07	8.93E-03	1.09E-06	6.74E-10	1.23E-12		8.94E-03
Cs-137		3.56E-05	5.99E-10	6.18E-02	5.90E-05	5.82E-03	4.30E-05	5.70E-11	5.87E-13		6.78E-02
H-3		1.96E-01	2.56E+01	3.74E-01	2.20E-02	8.49E+01	1.48E+02	1.23E+01	6.44E+01		3.36E+02
I-129	1.13E-05	7.84E-05	1.49E-03	4.60E-05	4.80E-05	1.08E-07					1.67E-03
Kr-88				7.78E+00		2.21E-03					7.78E+00
Pu-238		5.89E-08	5.74E-12	2.95E-10		4.06E-14			1.24E-05		1.25E-05
Pu-239		4.25E-07	9.81E-14	3.61E-07	2.70E-06	8.46E-06			3.06E-05		4.26E-05
Pu-240		9.03E-08	8.83E-14	1.18E-11		1.29E-14			7.01E-06		7.10E-06
Sr-90		4.92E-06	5.49E-10	1.95E-06	4.70E-05	2.18E-02	8.19E-08		1.30E-08		2.19E-02
Xe-138				1.32E+01		1.18E-04	1.94E+01				3.26E+01

a. 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)

b. Am = americium, Ar = Argon, Br = bromine, C = carbon, Co = Cobalt, Cs = cesium, H-3 = tritium, I = iodine, Kr = krypton, Pu = plutonium, Sr = strontium, Xe =xenon

Table 7-3. Radionuclide Source Term (Ci yr–1) for Radionuclides that Contributed Greater than 1% of the Total Dose for INL In-town Facilities (2018).

Radionuclide[a]	Annual Release (Ci yr^{-1})
Ac-227	5.93E-09
Am-241	1.03E-07
Am-243	1.04E-09
Ba-133	4.37E-07
Co-60	1.72E-08
Cs-134	5.99E-08
Cs-137	2.77E-07
Eu-152	5.24E-08
Eu-154	9.74E-08
I-125	1.00E-06
I-131	3.53E-07
Np-237	6.48E-09
Pa-231	1.15E-09
Pu-238	8.02E-08
Pu-239	1.32E-07
Ra-226	7.54E-08
Sr-90	7.56E-08
U-232	3.27E-08
U-233	1.64E-07
U-238	1.88E-08
Xe-133	3.60E-01
Zn-65	1.01E-07

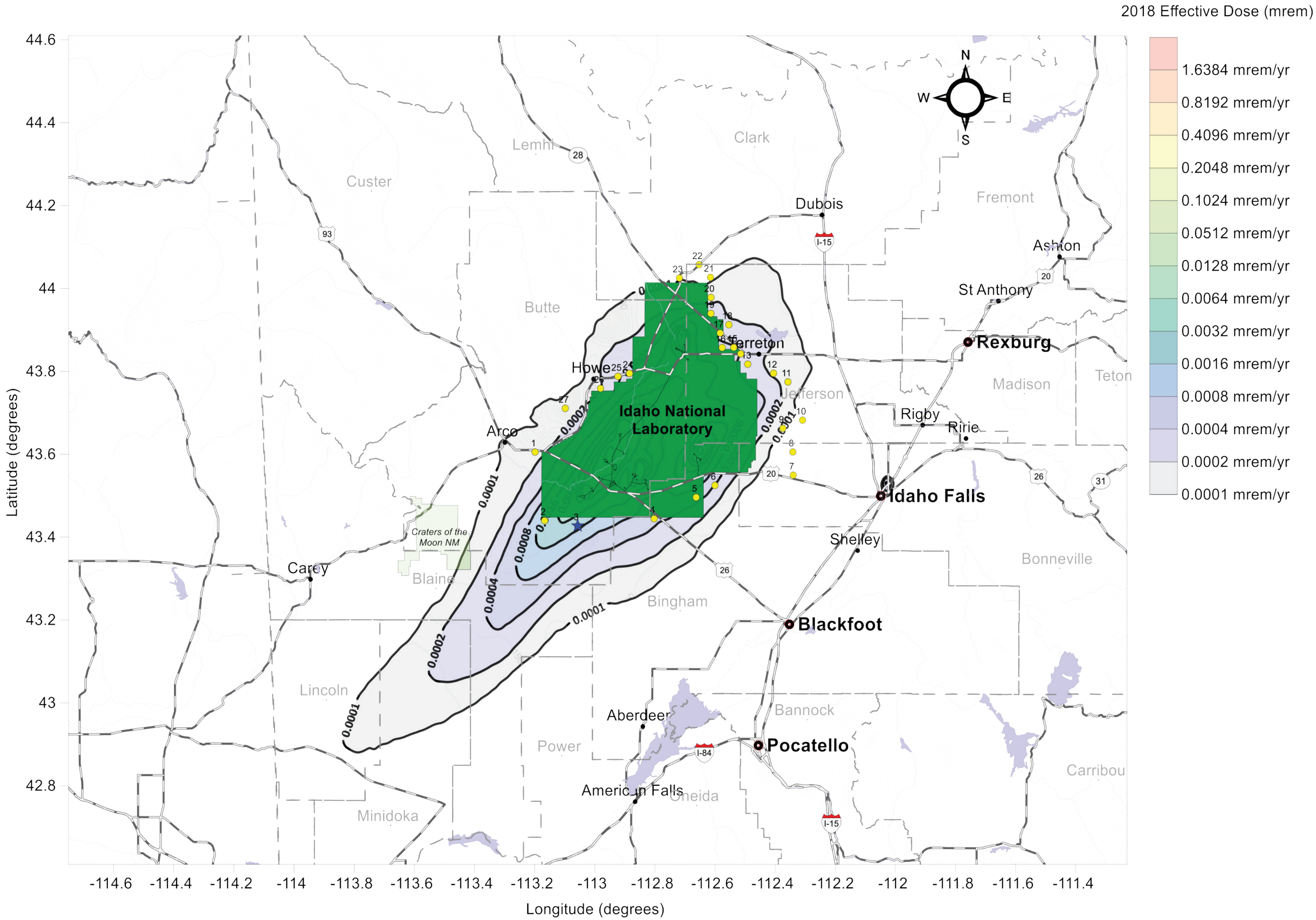
a. Ac = actinium, Am = americium, Ba = barium, Co = cobalt, Cs = cesium, Eu = europium, I = iodine, Np =neptunium, Pa = protactinium, Pu = plutonium, Ra = radium, Sr = strontium, U = uranium, Xe = xenon, Zn = zinc

The dispersion factor, often referred to as the X/Q value (concentration divided by source), was calculated by dividing the concentration in air (Ci/m^3) by the unit release rate (1 Ci/s) resulting in dispersion factor units of s/m3. 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.

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 (2019).

Figure 7-6 displays the summation of all doses calculated from the modeling of all releases from all facilities (including INL in-town facilities) as isopleths, ranging in

Figure 7-6. Effective Dose (mrem) Isopleth Map with Boundary Receptor Locations Displayed (2018).
The 27 boundary receptor locations are depicted as yellow circles. The maximum receptor dose is projected at Frenchmans Cabin (depicted as a blue star south of the INL southern boundary.)



value from 0.0001 to 0.03 mrem (0.001 to 0.3 µSv). The highest dose to an INL Site boundary receptor was estimated to be 0.01 mrem at Frenchman's Cabin (Receptor location #1). Frenchmans Cabin is also the location of the MEI used for the NESHAP dose assessment in 2018, which reported an estimated dose of 0.01 mrem (0.1 µSv) to the MEI (see Section 7.2.1). The lowest dose (0.00007 mrem [0.0007 µSv]) was estimated at Receptor location #7, located almost due east of INL Site along highway 20.

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 2018. The next step involved the use of the Geographic Information System. The grid and dose values from DOSEMM were imported into the Geographic Information System project established and maintained by the Environmental Surveillance, Education, and Research program. 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 7-5. These doses were then summed over all census divisions to result in the 80-km (50-mi) population dose (Table 7-4). The estimated potential population dose was 7.46 x 10^{-3} person-rem (7.46 x 10^{-5} person-Sv) to a population of approximately 337,643. When compared with the approximate population dose of 129,317 person-rem (1,293 person-Sv) estimated to be received from natural background radiation (Table 7-5), this represents an increase of about 0.000008 percent. The largest collective dose was in the Idaho Falls census division due its large population size and the inclusion of the dose from in-town facilities.

The estimated population dose for 2018 is slightly less than that calculated for 2017 (1.06 x 10^{-2} person-rem).

7.3 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 MFC, and game animals that may reside on or migrate through the INL Site.

7.3.1 Waterfowl

The maximum potential dose of 0.016 mrem (0.16 µSv) calculated for an individual consuming contaminated waterfowl based on 2018 sample results is lower than the dose estimated for 2017 (0.046 mrem [0.46 µSv]). As in the past, the 2018 samples were not collected directly from the warm wastewater evaporation ponds at the ATR Complex but from sewage lagoons adjacent to them. However, the waterfowl probably resided at all the ponds while they were in the area. A new Hypalon™ liner was installed in the west evaporation pond in 2016 .

7.3.2 Big Game Animals

A study on the INL Site from 1972–1976 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. This dose 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 2018, neither of the two game animals collected (both elk) 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, Markham, and White 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.

7.4 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 on the INL Site along the southern boundary (Mann and Cecil 1990; Bartholomay, Hopkins, and Maimer 2015). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration from all wells on the INL Site (5,100 ± 190 pCi/L) in 2018 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

Table 7-4. Dose to Population within 80 km (50 miles) of INL Site Facilities (2018).

Census County Division[a,b]	Population[c]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,635	5.23E-05	5.23E-07
Alridge	583	1.08E-06	1.08E-08
American Falls	9,410	2.95E-04	2.95E-06
Arbon (part)	30	9.89E-08	9.89E-10
Arco	2,661	1.49E-03	1.49E-05
Atomic City (division)	2,692	1.09E-03	1.09E-05
Blackfoot	15,974	8.88E-05	8.88E-07
Carey (part)	1,094	1.11E-04	1.11E-06
East Clark	83	2.10E-06	2.10E-08
East Madison (part)	303	1.45E-06	1.45E-08
Firth	3,282	1.53E-05	1.53E-07
Fort Hall (part)	4,584	1.70E-05	1.70E-07
Hailey-Bellevue (part)	6	5.60E-08	5.60E-10
Hamer	2,361	7.87E-04	7.87E-06
Howe	390	6.12E-04	6.12E-06
Idaho Falls	112,013	1.66E-03	1.66E-05
Idaho Falls, west	1,687	7.41E-05	7.41E-07
Inkom (part)	659	1.38E-06	1.38E-08
Island Park (part)	98	1.57E-06	1.57E-08
Leadore (part)	6	9.68E-08	9.68E-10
Lewisville-Menan	4,378	6.07E-05	6.07E-07
Mackay (part)	1,274	1.55E-05	1.55E-07
Moreland	10,822	1.01E-04	1.01E-06
Pocatello	68,793	2.11E-04	2.11E-06
Rexburg	30,969	2.49E-04	2.49E-06
Rigby	21,692	1.84E-04	1.84E-06
Ririe	2,085	6.97E-06	6.97E-08
Roberts	1,655	3.84E-05	3.84E-07
Shelley	9,103	5.52E-05	5.52E-07
South Bannock (part)	334	9.55E-07	9.55E-09
St. Anthony (part)	2,689	2.59E-05	2.59E-07
Sugar City	7,731	8.80E-05	8.80E-07
Swan Valley (part)	6,890	1.19E-05	1.19E-07
Ucon	6,833	8.21E-05	8.21E-07
West Clark	844	3.35E-05	3.35E-07
Total	**337,643**	7.46E-03	7.46E-05

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 2018 values based on 2010 Census Report for Idaho.

Table 7-5. Contribution to Estimated Annual Dose from INL Site Facilities to a Maximally Exposed Individual by Pathway (2018).

Pathway	Annual Dose to Maximally Exposed Individual (mrem)	(µSv)	Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	0.01	0.1	0.01	0.0075	0.000075	337,643	129,317
Waterfowl	0.016	0.16	NA[c]	NA	NA	NA	NA
Big game animals	-[d]	-[d]	NA	NA	NA	NA	NA
Total pathways	**0.026**	**0.26**	**0.026**	**0.0075**	**0.000075**	**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 background dose was estimated to be 383 mrem or 0.383 rem in 2018 (Table 6-9). The background population dose is calculated by multiplying the individual background dose by the population within 80 km (50 mi) of the INL Site.

c. NA = Not applicable

d. No radionuclides were detected in 2018 so no dose was calculated.

from these wells would hypothetically receive a dose of approximately 1 mrem (10.0 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.

7.5 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).

In 2018, 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.

7.6 Dose to the Public from All Pathways

DOE O 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 2018, 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 (see Figure 7-6), would receive a calculated dose from INL Site airborne releases reported for 2018 (Section 7.2.1) and from consuming a duck contaminated at the ATR Complex wastewater ponds (Section 7.3.1). No dose was calculated from eating big game animals in 2018 (Section 7.3.2).

The dose estimate for an offsite MEI is presented in Table 7-5. The total dose was conservatively estimated to be 0.026 mrem (0.26 µSv) for 2018. The total dose calculated to be received by the hypothetical MEI for 2018 represents about 0.01 percent of the dose expected to be received from background radiation (383 mrem [3.8 mSv], as shown in Table 6-8) 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 expected to result in acute health effects.

The dose received by the entire population within 80 km (50 mi) of INL Site facilities was calculated to be 7.5 x 10^{-3} person-rem (7.5 x 10^{-5} person-Sv) (Table 7-5). This is approximately 0.000002 percent of the dose (129,317 person-rem, [1,293 person-Sv]) expected from exposure to natural background radiation in the region.

7.7 Dose to the Public from Operations on the INL Research and Education Campus (REC)

Facilities in the City of Idaho Falls that reported potential radionuclide emissions for inclusion in the 2018 NESHAP report include the INL Research Center (IRC) Laboratory (IF-603), DOE RESL (IF-683), and the National Security Laboratory (IF-611). These facilities are located contiguously at the IRC, part of the Research and Education Campus (REC) on the north side of the City of Idaho Falls. Though programs and operations at the IRC are affiliated with the INL, the IRC is located within the city limits of Idaho Falls and is not contiguous with the INL Site, the nearest boundary of which is approximately 35 km (22 mi) west of Idaho Falls. For this reason, the 2018 INL NESHAP evaluation (DOE-ID 2019) includes a dose calculation to a member of the public that is separate from the INL Site MEI. (Note: the REC source term was, however, included in the population dose calculation reported in Section 7.2.2.) The IRC MEI for calendar year 2018 is approximately 110 meters south-southeast of the RESL. The effective dose equivalent to the MEI was conservatively calculated, using CAP88-PC, to be 0.006 mrem/yr (0.06 μSv/yr), which is 0.06 percent of the 10-mrem/yr federal standard.

7.8 Dose to Biota

7.8.1 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, and biological elimination rates) can be modified to represent site- and organism-specific characteristics. The kinetic model 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.

7.8.2 Terrestrial Evaluation

The division of the INL Site into evaluation areas based on potential soil contamination and habitat types is of particular importance for the terrestrial evaluation portion of the 2018 biota dose assessment. 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, Lopez, and Haney 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 1-4 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 7-6). The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, 2015, and 2017 (soil samples were not collected on the INL Site in 2016 and 2018).

Using the maximum radionuclide concentrations for all locations in Table 7-6, 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 were for the MFC Industrial Waste Pond (Table C-17). The results for uranium-233/234 ($^{233/234}U$) and uranium-238 in Table C-17, 1.26 pCi/L and 1.07 pCi/ respectively, were thus used to represent surface water concentrations. When $^{233/234}U$ was reported, it was assumed that the radionuclide present was ^{233}U.

The combined sum of fractions was less than one for both terrestrial animals (0.21) and plants (0.002) and passed the general screening test (Table 7-7). 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.

Tissue data from bats collected at or near INL facilities were also available (Table 6-5). Concentrations of radionuclides in tissue were input into the RESRAD-Biota computer model at the Level 3 step to calculate the internal dose to bats. The results of the dose evaluation to bats using radionuclide concentrations measured in tissue are shown in Table 7-8. The maximum dose received by bats at the INL Site was estimated to be 0.0044 rad/d (0.044 mGy/d) in 2017 and 0.00253 rad/d (0.025 mGy/d) in 2018. The calculated doses are well below the standard of 1 rad/d (10 mGy/d). Based on these results, members of the bat population at the INL Site receive an absorbed dose that is within the DOE standard established for protection of terrestrial animals.

7.8.3 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 2018 calculations. The results shown in Table 7-9 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 (1.11×10^{-3}) and riparian animals (3.28×10^{-3}).

Tissue data from waterfowl collected on the ATR Complex ponds in 2018 were also available (Table 6-4). Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Table 6-4. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 7-10. The estimated dose to waterfowl was calculated by RESRAD-Biota to be 4.73×10^{-4} rad/d (4.73×10^{-3} mGy/d). This dose is significantly less than the standard of 1 rad/d (10 mGy/d). Based on these results, there is no evidence that impounded water at the INL Site is harming aquatic biota.

Table 7-6. Concentrations of Radionuclides in INL Site Soils, by Area.

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b]	
		Minimum	Maximum
ATR Complex	Cesium-137	2.0×10^{-1}	6.1×10^{-1}
	Strontium-90	------[c]	5.8×10^{-2}
	Plutonium-238	5.9×10^{-3}	4.3×10^{-2}
	Plutonium-239/240	1.7×10^{-2}	2.2×10^{-2}
ARA/CITRC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	3.0
	Strontium-90	2.1×10^{-1}	3.7×10^{-1}
	Plutonium-238	------	3.9×10^{-3}
	Plutonium-239/240	1.3×10^{-2}	1.8×10^{-2}
	Americium-241	5.5×10^{-3}	8.5×10^{-3}
EFS	Cesium-137	1.5×10^{-1}	6.8×10^{-1}
MFC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	4.9×10^{-1}
	Cobalt-60	------	5.0×10^{-2}
	Plutonium-239/240	1.5×10^{-2}	2.9×10^{-2}
	Americium-241	4.3×10^{-3}	1.2×10^{-2}
INTEC	Cesium-134	------	8.0×10^{-2}
	Cesium-137	3.0×10^{-2}	3.5
	Strontium-90	4.9×10^{-1}	7.1×10^{-1}
	Plutonium-238	2.5×10^{-2}	4.3×10^{-2}
	Plutonium-239/240	1.1×10^{-2}	2.9×10^{-2}
	Americium-241	6.1×10^{-3}	8.1×10^{-3}
Rest Area	Cesium-137	1.4×10^{-2}	4.5×10^{-2}
	Plutonium 239/240	------	2.4×10^{-2}
NRF	Cesium-134	------	6.0×10^{-2}
	Cesium-137	------	3.3×10^{-1}
	Plutonium-239/240	5.7×10^{-3}	1.6×10^{-2}
	Americium-241	4.3×10^{-3}	9.7×10^{-3}
RWMC	Cesium-134	3.0×10^{-2}	9.0×10^{-2}
	Cesium-137	6.5×10^{-2}	6.0×10^{-1}
	Srontium-90	1.0×10^{-1}	3.5×10^{-1}
	Plutonium-238	2.2×10^{-3}	1.5×10^{-2}
	Plutonium-239/240	1.9×10^{-2}	9.5×10^{-1}
	Americium-241[d]	4.7×10^{-2}	6.2×10^{-1}
TAN/SMC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.1×10^{-1}	3.1
	Plutonium-239/240	1.3×10^{-2}	1.7×10^{-2}
	Americium-241	3.2×10^{-3}	5.7×10^{-3}
All	**Cesium-134**	3.0×10^{-2}	9.0×10^{-2}
	Cesium-137	1.4×10^{-2}	3.5
	Cobalt-60	------	5.0×10^{-2}
	Strontium-90	1.0×10^{-2}	7.1×10^{-1}
	Plutonium-238	2.2×10^{-3}	4.3×10^{-2}
	Plutonium-239/240	5.7×10^{-3}	9.5×10^{-1}
	Americium-241[d]	3.2×10^{-3}	6.2×10^{-1}

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CITRC = Critical Infrastructure Test Range Complex; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear

Table 7-6. Concentrations of Radionuclides in INL Site Soils, by Area. (cont.)

Technology and Engineering Center; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability. See Figure 7-1.

b. Legend:

a.	Results measured in 2013-2014 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.	Results measured by laboratory analyses of soil samples collected in 2015.
f.	Results measured by laboratory analyses of soil samples collected in 2017.

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.

7.9 Doses from Unplanned Releases

No unplanned radioactive releases were detected from the INL Site in 2018. As such, no doses were associated with unplanned releases during 2018.

Table 7-7. RESRAD-Biota Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site.

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	0.62	3.89E+03	1.59E-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	0.09	1.13E+01	7.97E-03
Cesium-137	0	5.99E+05	0.00E+00	3.5	2.08E+01	1.69E-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	1.26	4.01E+05	3.14E-06	0	4.83E+03	0.00E+00
Uranium-238	1.07	4.06E+05	2.64E-06	0	1.58E+03	0.00E+00
Summed	–	–	**5.78E-06**	–	–	**2.09E-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	0.62	2.15E+04	2.88E-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	0.09	1.09E+03	8.28E-05
Cesium-137	0	4.93E+07	0.00E+00	3.5	2.21E+03	1.59E-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	1.26	1.06E+10	1.19E-10	0	5.23E+04	0.00E+00
Uranium-238	1.07	4.28E+07	2.50E-08	0	1.57E+04	0.00E+00
Summed	–	–	**2.51E-08**	–	–	**1.98E-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 7-8. RESRAD Biota Assessment (Level 3 Analysis) of Terrestrial Ecosystems on the INL Site Using Measured Bat Tissue Data (2017-2018)[a].

Bat Dose (rad/d)					
2017					
Nuclide	***Water[b]***	***Soil[b]***	***Sediment***	***Tissue[c]***	***Summed***
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	9.64E-04	9.64E-04
Cesium-137	0.00E+00	0.00E+00	0.00E+00	9.31E-04	9.31E-04
Europium-152	0.00E+00	0.00E+00	0.00E+00	1.04E-05	1.04E-05
Plutonium-238	0.00E+00	0.00E+00	0.00E+00	1.03E-04	1.03E-04
Plutonium-239/240	0.00E+00	0.00E+00	0.00E+00	3.69E-04	3.69E-04
Strontium-90	0.00E+00	0.00E+00	0.00E+00	2.04E-03	2.04E-03
Zinc-65[d]	0.00E+00	0.00E+00	0.00E+00	1.33E-05	1.33E-05
Total	0.00E+00	0.00E+00	0.00E+00	**4.43E-03**	**4.43E-03**
2018					
Nuclide	***Water[b]***	***Soil[b]***	***Sediment***	***Tissue[c]***	***Summed***
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	8.47E-04	8.47E-04
Cesium-137	0.00E+00	0.00E+00	0.00E+00	2.54E-04	2.54E-03
Strontium-90	0.00E+00	0.00E+00	0.00E+00	1.39E-03	1.39E-03
Zinc-65	0.00E+00	0.00E+00	0.00E+00	4.16E-05	4.16E-05
Total	0.00E+00	0.00E+00	0.00E+00	**2.53E-03**	**2.53E-03**

a. Bat carcasses collected during 2017 and 2018 were analyzed in 2018.
b. External doses to bats from radionuclides in soil and water were assumed to be negligible.
c. Calculated using maximum concentrations measured in bat tissues for the year of interest.
d. The half-life of ^{65}Zn is 244.06 days. For this reason, the concentration measured in composited tissue is probably lower (by as much two times) than the original concentrations in the live bats.

Table 7-9. RESRAD-Biota Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2018).

Aquatic Animal						
	Water			Sediment		
Nuclide	**Concentration (pCi/L)**	**BCG[a] (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Uranium-233	1.26	2.00E+02	6.31E-03	0.063	1.06E+07	5.95E-09
Uranium-238	1.07	2.23E+02	4.79E-03	0.0535	4.28E+04	1.25E-07
Summed	–	–	**1.11E-03**	–	–	**6.81E-07**
Riparian Animal						
	Water			Sediment		
Nuclide	**Concentration (pCi/L)**	**BCG (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Uranium-233	1.26	6.76E+02	1.86E-03	0.063	5.28E+03	1.19E-05
Uranium-238	1.07	7.56E+02	1.42E-03	0.0535	2.49E+03	2.15E-05
Summed	–	–	**3.28E-03**	–	–	**3.34E-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.

Table 7-10. RESRAD Biota Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2018).

Waterfowl Dose (rad/d)					
Nuclide	**Water[a]**	**Soil[b]**	**Sediment**	**Tissue[c]**	**Summed**
Americium-241	0.00E+00	4.37E-06	0.00E+00	0.00E+00	4.37E-06
Cesium-134	0.00E+00	5.37E-06	0.00E+00	0.00E+00	5.37E-06
Cesium-137	0.00E+00	7.58E-05	0.00E+00	9.00E-06	7.58E-05
Cobalt-60	0.00E+00	4.97E-06	0.00E+00	3.72E-06	3.72E-06
Plutonium-238	0.00E+00	1.76E-10	0.00E+00	0.00E+00	1.76E-10
Plutonium-239	0.00E+00	1.94E-09	0.00E+00	0.00E+00	1.94E-09
Strontium-90	0.00E+00	5.14E-07	0.00E+00	0.00E+00	5.14E-07
Zinc-65	0.00E+00	0.00E+00	0.00E+00	1.53E-05	1.53E-05
Uranium-233	1.87E-04	NA	2.19E-10	NA	1.87E-04
Uranium-238	1.40E-04	NA	6.99E-08	NA	1.40E-04
Total	3.25E-04	8.71E-05	2.51E-06	3.26E-05	4.73E-04

a. Only uranium isotopes were measured in the Material and Fuels Complex Industrial Waste Pond. Hence, doses were not calculated for other radionuclides in water and sediment.
b. External doses to waterfowl were calculated using soil concentrations. Maximum concentrations of radionuclides measured in soil at the INL Site were used (Table 7-6). Note: NA=uranium isotopes were not analyzed for in soil.
c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Table 6-4. Note: NA=uranium isotopes were not analyzed for in tissue samples.

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Brewer's Sparrow
Spizella breweri

8. 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 2018, Sage-grouse, Raven, midwinter eagle, breeding bird, and bat surveys were conducted on the INL Site and are highlighted as follows:

Sage-grouse monitoring and research has been conducted on the INL Site for over 30 years and show that the populations are decreasing. When Sage-grouse were petitioned for listing under the Endangered Species Act, DOE-ID recognized the need to reduce impacts to existing and future mission activities. In 2014, DOE-ID entered into a Candidate Conservation Agreement (CCA) with the U.S. Fish and Wildlife Service (USFWS) to identify threats to the species and its habitat and develop conservation measures and objectives to avoid or minimize threats to Sage-grouse. The CCA established a population trigger based on the 2011 male Sage-grouse lek attendance on 27 active leks. If male lek attendance falls below this threshold, a response by USFWS and DOE-ID would be initiated. Environmental Surveillance, Education, and Research (ESER) biologists continue to conduct surveys of Sage-grouse leks along routes established by the Idaho Department of Fish and Game, as well as at other leks on the INL Site.

Ravens are known to prey on Sage-grouse eggs and chicks. Raven and raven-nest observations have had a positive trend over the past 30 years. DOE-ID provides funding, when available, to support collaborators with research aimed at developing methods for deterring raven nesting on utility structures.

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.

The North American Breeding Bird Survey was developed in the 1960s by the U.S. Fish and Wildlife Service along with the Canadian Wildlife Service to document trends in bird populations. The U.S. Geological Survey manages the program in North America, which currently consists of over 4,100 routes with approximately 3,000 of these sampled annually. The INL Site has five U.S. Geological Survey Breeding Bird Survey routes, established in 1985, and eight additional routes which border INL Site facilities.

Research has been conducted on bats 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 by ESER in 2012. In addition, monitoring of hibernating bat populations is conducted biennially.

8. MONITORING WILDLIFE POPULATIONS

The Environmental Surveillance, Education and Research (ESER) contractor has historically collected data on several key groups of wildlife that occupy the Idaho National Laboratory (INL) Site, including Greater Sage-grouse (*Centrocercus urophasianus*), 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) documents and enables DOE-ID officials to make informed decisions for project planning and to maintain up-to-date information on po-

Common Nighthawk
Chordeiles minor

tentially 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 (1918)
- Migratory Bird Treaty Act Special Purpose Permit with U.S. Fish and Wildlife Service (FWS) calendar year 2018)
- Bald and Golden Eagle Protection Act (1940)
- Memorandum of Understanding between the U.S. Department of Energy and the 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 INL Site (DOE-ID and FWS 2014)
- Executive Order 11514 (1970); Protection and Enhancement of Environmental Quality—(Created in furtherance of the purpose and policy of NEPA, 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 (INL 2011)

The following sections summarize the results from wildlife surveys conducted by the ESER contractor on the INL Site during 2018.

8.1 Sage-grouse

Populations of Greater Sage-grouse (hereafter, 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 broad expanses of sagebrush (*Artemisia* spp.). Sagebrush lands have been greatly altered during the past 150 years and are currently at risk from a variety of pressures (Knick et al. 2003, Connelly et al. 2004). Not only are healthy stands of sagebrush necessary year-round for Sage-grouse to survive, 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 and the USFWS entered into a CCA to conserve Sage-grouse and its habitat on the INL Site (DOE-ID and USFWS 2014). This voluntary agreement established a Sage-grouse Conservation Area (SGCA) (Figure 8-1), and DOE-ID committed to deprioritize the SGCA when planning infrastructure development and to establish mechanisms for reducing human disturbance of breeding and nesting Sage-grouse. To guard against Sage-grouse declines outside the natural range of variation, the CCA established a population trigger based on 2011 numbers. If tripped, a predetermined response by both agencies would be initiated. To trip the trigger, the three-year running average of peak male attendance, summed across 27 leks (i.e., traditional breeding sites) within the SGCA, must fall below 253 males, representing a 20% decrease from the 2011 baseline of 316 males.

Each spring, ESER biologists repeatedly visit all Sage-grouse leks on the INL Site to count males that have congregated to display and breed. The number of males observed during peak attendance is a useful indicator of the size of the local breeding population. As such, these data provide needed information to monitor the population trigger, and also allow ESER to track breeding population trends and maintain accurate records of active lek locations. Biologists also survey sites where Sage-grouse have been observed displaying in the past, which are no longer used as display grounds (i.e., inactive leks).

Lek data are analyzed in three ways to address CCA and other DOE-ID needs: as lek routes, as baseline leks for the population trigger, and as inactive leks that are revisited approximately once every five years. Leks in close proximity that can be visited on the same day and in the same order are surveyed as lek routes. Currently, six lek routes exist on the INL Site (Figure 8-1). Three (Tractor Flats, Lower Birch Creek, and Radioactive Waste Management Complex [RWMC]) were established by the Idaho Department of Fish and Game (IDFG) and have been surveyed annually for over 20 years. Three others (Frenchmans Cabin, West T-3, and T-9) were established and surveyed as formal routes for the first time in 2017. Lek route data are used to estimate a long-term breeding population trend on the INL Site (Jenni and Hartzler 1978, Connelly et al. 2003, Garton et al. 2011). A second grouping of lek data involves the twenty-seven leks within the SGCA that were used to establish a threshold for the population trigger. These SGCA baseline leks are visited multiple times

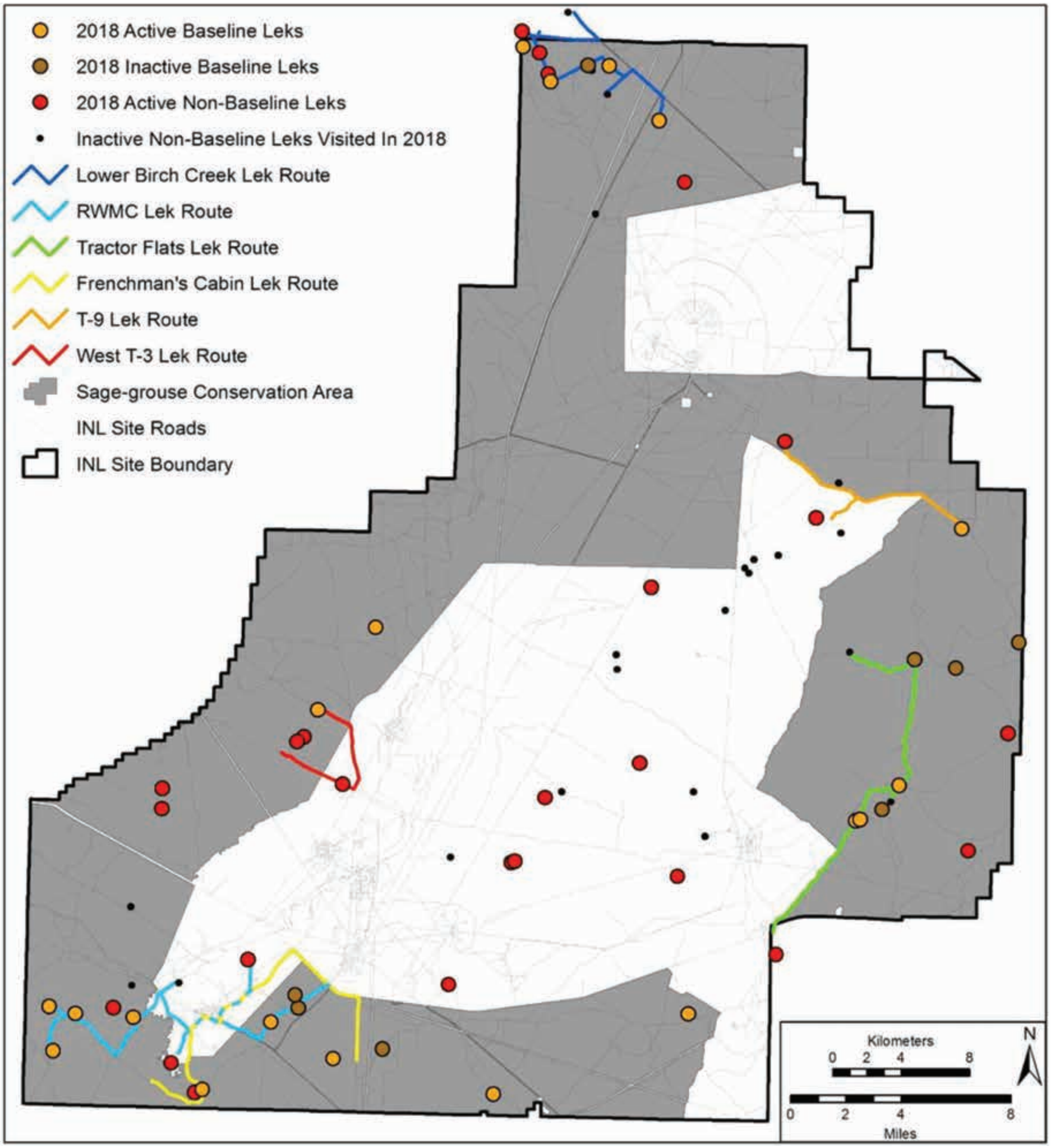

Figure 8-1. An Overview of Greater Sage-grouse Leks Surveyed on the Idaho National Laboratory Site in 2018. *Lek activity designations (active vs. inactive) refer to lek statuses when surveys commenced in March 2018.*

each year, but some are visited singly, and others are included in a lek route. Peak attendance at these leks are summed and compared to the population trigger threshold. The third group of lek data includes a rotating subset of inactive leks that have not been visited for at least five years and active leks that are neither baseline leks nor assigned to lek routes. In conjunction with data from lek routes and SGCA baseline leks, these non-route data assist ESER in maintaining an accurate count of active leks on the INL Site and verifying if old leks have been reoccupied.

The following paragraphs present results from each type of lek survey for 2018. For greater detail about methods, analyses, and results, see Shurtliff et al. (2019).

Lek Routes

Each of the six lek routes were surveyed 5–7 times ($\bar{x}$ = 6.2 surveys, SD=1.0). On IDFG routes, the number of males per lek surveyed (MPLS) was lower than the past two years (Figure 8-2). On the Tractor Flats route, the 2018 MPLS was 11% lower than 2017 and 35% lower than 2016 (Figure 8-3). On the Lower Birch Creek route, the 2018 MPLS was 24% lower than 2017 and 25% lower than 2016 (Figure 8-3). On the RWMC route, the 2018 MPLS was 5% lower than 2017 and 20% lower than 2016 (Figure 8-3). The RWMC route experienced a 16% drop in absolute numbers of males from 2017 to 2018, however one less lek was surveyed in 2018 which lessened the average decline of males per lek. All three IDFG lek routes had similar or slightly higher MPLS values resulting in a three year average of 164% of the trigger threshold (Shurtliff et al. 2019).

The 2018 MPLS values for the three new lek routes compare to 2017 values as follows: Frenchmans Cabin route dropped 22%, West T-3 route dropped 4%, and T-9 route increased 9%. Although the number of leks surveyed on each of these routes was the same as 2017, additional 2018 surveys of West T-3 and T-9, may have captured peak male attendance that 2017 efforts may have missed due to logistical constraints (Shurtliff et al. 2019). The greater survey effort in 2018 for West T-3 and T-9 routes may explain why the West T-3 route had the lowest documented MPLS decline and the T-9 route had the only recorded MPLS increase among the six routes.

SGCA Baseline Leks:

Each baseline lek was surveyed 2–7 times ($\bar{x}$ = 5.5 surveys, SD=1.7; Figure 8-1) in 2018. The sum of peak male attendance across the baseline leks was 365, an 11% decrease from 2017. Despite this decrease in peak counts, which followed a 13% decrease last year (Shurtliff et al. 2018), the three-year (2016–2018) running average of peak male attendance on baseline leks increased 2.5% over the 2017 running average, to 416 males (Figure 8-2). The three-year average is now 64% greater than the trigger threshold of 253 males and has been stable or has increased in each of the past five years. That trend will likely shift downward next year as the three-year running average loses a high-count year (2016).

Other Non-route Leks

Twenty-seven additional active leks were surveyed (i.e., non-baseline leks) 3–8 times ($\bar{x}$ = 5.3 surveys, SD=1.5, Figure 8-1). Average peak male attendance was 9.6 males per lek (range: 0–25 males, SD=7.9), down from 12.1 males per lek in 2017.

Fifteen inactive leks were surveyed two times each that were neither baseline leks nor part of lek routes. These leks were included as part of the ESER effort to resurvey each inactive lek approximately once every five years. Observations of male Sage-grouse were not recorded at any of the leks, so each will retain its inactive status.

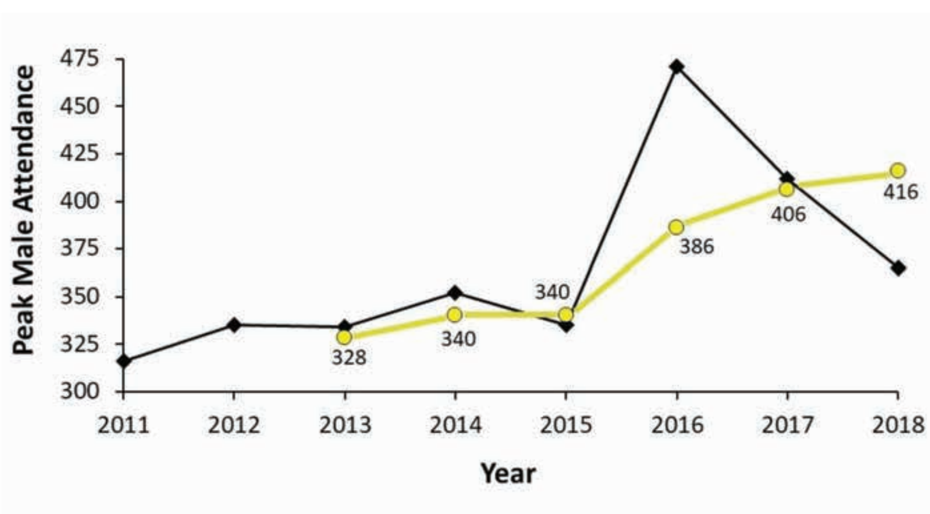

Figure 8-2. Peak Male Attendance of Greater Sage-grouse from 2011–2018 on the 27 Baseline Leks in the Sage-Grouse Conservation Area Associated with the Population Trigger. *Black diamonds represent annually summed peak male attendance values for each lek, and yellow circles (values displayed) represent the three-year running average.*

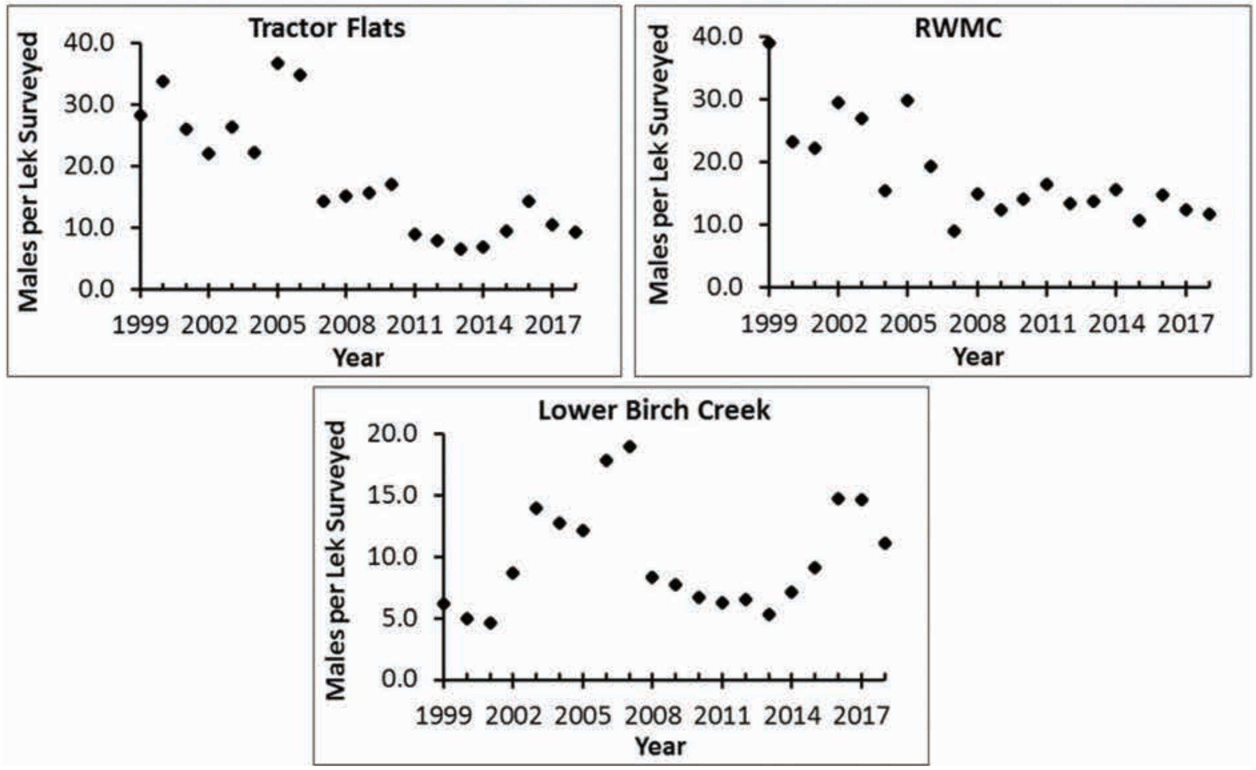

Figure 8-3. Mean Number of Males Per Lek Surveyed During Peak Male Attendance on Three Idaho Department of Fish and Game Lek Routes from 1999–2018 on the Idaho National Laboratory Site.
The number of leks surveyed each year increased over the displayed time period as follows: Tractor Flats (4–8 leks), Radioactive Waste Management Complex (RWMC; 2–9 leks), and Lower Birch Creek (6–9 leks).

Summary of Known Active Leks and of Changes in Lek Classification

Before the 2018 field season, 45 leks were designated active on or near the INL Site, including two just outside the Site boundaries that are part of the IDFG survey routes. Following the 2018 field season, ESER downgraded two active route leks to inactive status and upgraded two inactive route leks to active status (Figure 8-4; for a description of criteria used to determine lek activity, see Whiting et al. 2014, Shurtliff et al. 2015). The program also reclassified an active lek to inactive status. This lek was not in the SGCA, nor was it assigned to a lek route. Thus, there was a net loss of one active lek, and the total number of known active leks on or near the INL Site is currently 44.

8.2 Raven Nest Surveys

The Common Raven (*Corvus corax*) is a native bird that adapts well to human disturbance and land development, and is adept at utilizing resultant food, water, and nest-site subsidies. Ravens prey on Sage-grouse eggs and chicks and consequently may directly impact Sage-grouse, which DOE-ID is striving to conserve in partnership with other federal, state, and private stakeholders. Raven observations during annual breeding bird surveys on the INL Site have steadily increased over the past 30 years (ESER, unpublished data), mirroring trends across western North America (Sauer et al. 2014).

In the CCA for Greater Sage-grouse, DOE-ID has committed to provide funding, when available, to support collaborators with research aimed at developing methods for deterring raven nesting on utility structures (Conservation Measure 10; DOE and USFWS 2014). Later, this scope broadened into a commitment from DOE-ID to work with INL contractors and others to opportunistically reduce raven nesting on any anthropogenic structure, including power lines, towers and structures at facilities. The DOE-ID continues to recognize the value of research that would improve its ability to deter Raven nesting on power lines, but it also recognizes that some Raven nesting on towers and at facilities could be deterred by simple methods employed at appropriate times. Hence, DOE-ID now encourages ESER to collaborate with contractors and the National Oceanic and Atmo-

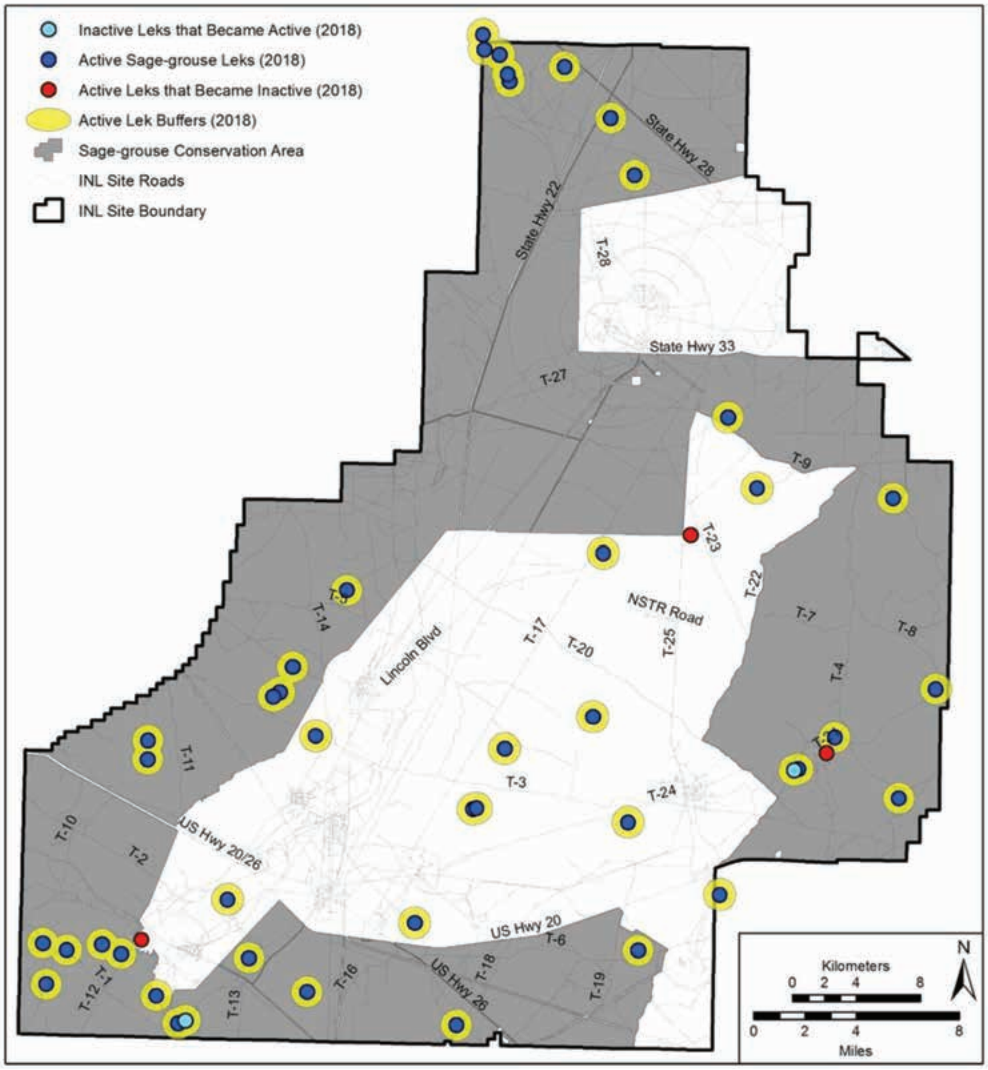

Figure 8-4. Locations of 44 Active Leks and Three Leks Reclassified as Inactive (Red) On or Near the Idaho National Laboratory Site. *The two leks reclassified as active (light blue) were within 500 m of other active leks.*

spheric Administration (NOAA), to seek opportunities to reduce the suitability of any human structures most likely to be used for nesting.

In support of the original CCA conservation measure to develop effective nest deterrents, and the recently expanded scope, ESER established and continues to operate an annual Raven nest monitoring program. Under this monitoring program, nearly all infrastructure on the INL Site are monitored during April and May when Ravens typically build nests and care for eggs and chicks. The purpose of the task is three-fold: (1) to determine how many Raven nests are built on INL Site infrastructure and to track annual trends; (2) to identify structures and stretches of power line favored by Ravens for nesting, which may be candidates for retrofitting; and (3) to allow ESER to evaluate the effectiveness of deterrents after they are installed.

Between April 2 and June 1, 2018, all power lines were systematically surveyed (transmission lines = 231 km [143 mi], distribution lines = 37 km [23 mi] – see Howe et al. [2014] for a description of power line dimensions and attributes), towers, raptor nesting platforms and facilities on the INL Site that had been surveyed the previous year (Shurtliff et al. 2018), following methods described elsewhere (Shurtliff et al. 2015). All power line segments were surveyed four times, with each survey being separated by at least 14 days. Facilities, towers, and other infrastructure were surveyed at least twice, primarily in April. If a nest was seen on a structure, but its activity level could not be confirmed, the nest was revisited again before the next formal survey commenced. As a result, nests that remained unconfirmed throughout the nesting season were visited twice as often as nests with confirmed activity. This level of effort increased our confidence at the end of the season that remaining unconfirmed nests had not been occupied by Ravens during the breeding season.

In 2018, ESER observed 43 active Raven nests on man-made structures or in trees associated with facilities (this is an adjusted total, after considering observations of nests likely built after a first nest fell to the ground – see Shurtliff et al. 2019). Thirty-one of the 43 nests (72%) were on power line structures, all of which were transmission structures or lattice structures used for cyber-security testing (i.e., none were on single-pole distribution structures). Fourteen nests on power line structures (45%) were inside or bordering the SGCA.

Biologists surveyed 12 facilities and recorded eight nests at seven of them (Table 8-1). Two nests located at a single facility included one nest inside the fence of the Materials and Fuels Complex and one nest on the nearby Transient Reactor Test Facility. During 2018, Ravens nested at the same facilities as in 2017, with three exceptions. No Raven nests were observed at the Critical Infrastructure Test Range Complex this year, nor at the Sheep Station, as already noted. However, for the first time since surveys began, a Raven nest was documented at the Materials and Fuels Complex (Shurtliff et al., 2018, 2019).

In addition to facilities, Ravens maintained nests on two cellular phone towers located near the INL Site boundary and on two meteorological towers operated by NOAA (Figure 8-5).

The adjusted number of active Raven nests recorded on the INL Site was 5% higher in 2018, compared to 2017, and is nearly identical to the peak number observed in 2016 (Figure 8-6). One caveat is that the number of Raven nests reported last year may have been slightly overestimated. In 2017, ESER reported three Raven nests at the U.S. Sheep Experiment Station (Sheep Station; Shurtliff et al. 2018); however, investigators now believe some if not all three nests were occupied by American Crows (*Corvus brachyrhynchos*; see Shurtliff et al. 2019). If the three nests were mistakenly attributed to Ravens, the 2017 total would have been 38 Raven nests. Thus, the 2018 Raven nest count would be 13% higher than in 2017. Regardless of whether the Sheep Station nests were occupied by American crows or Ravens, results suggest that the number of Raven nests on anthropogenic substrates has been stable on the INL Site for at least the past three years. If Ravens indeed occupied fewer nests in 2017 than were reported, the current conclusion of a stable trend would extend to the past four years.

DOE-ID does not own any of the weather monitoring or cellular service towers occupied by Ravens in 2018, and therefore it cannot make a unilateral decision to install nest deterrents. ESER continues to work with NOAA to improve the placement of hardware cloth on two towers which have been used for nesting for several years. Hardware cloth installed by NOAA technicians last year did not adequately cover the most likely nesting sites on the towers, but NOAA intends to add more hardware cloth at the end of 2018.

Conservation Measure 10 in the CCA specifically identifies utility structures as the target for nest deterrent experiments because most Raven nests on anthropogenic structures are on power transmission structures (DOE and USFWS 2014). Since the CCA was signed however, several factors have reduced the priority of this conservation measure relative to other ongoing or potential actions that can or could be taken to address threats to Sage-grouse (Shurtliff et al. 2019). Furthermore, most power line sections that support Raven nests are outside the SGCA—the primary area of focus for the conservation of Sage-grouse. No known studies in similar sagebrush steppe habitat have determined the territory size of breeding Ravens; also, it is not known if there is any study in similar habitat that documents how far nesting Ravens will travel to forage. Thus, it is not known whether the majority of Ravens on power lines forage in the SGCA. Understanding Raven foraging behavior may be a more important priority than installing nest deterrents because the latter would be a much greater cost and could potentially be unnecessary if most nest-tending Ravens don't forage in the SGCA.

8.3 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 estab-

Table 8-1. Facilities Surveyed for Raven Nests in 2018.

Facility	# Times Surveyed	Days Between Surveys[a]	Active Raven Nest Confirmed	Substrate Supporting Active Nest
Advanced Mixed Waste Treatment Project/Radioactive Waste Management Complex	2	14 & 15[b]	Yes	Building Platform
Central Facilities Area Main Gate	2	14	Yes	Building Platform
Critical Infrastructure Test Range Complex	2	17	No	N/A
Experimental Breeder Reactor I	2	14	Yes	Building Platform
U.S. Sheep Experiment Station	2	19	No	N/A
Idaho Nuclear Technology and Engineering Center	2	15	Yes	Effluent Stack
Materials and Fuel Complex/ Transient Reactor Test Facility	2	14	Yes (2 nests)	Building Platform
Naval Reactors Facility (NRF)	2[c]	16	Yes	Ornamental Tree
Specific Manufacturing Capability/Test Area North	2	22	Yes	Building Platform
Advanced Test Reactor Complex	2	14	No	N/A
Central Facilities Area	2	15	No	N/A
Highway Department	2	19	No	N/A

a. The number of days between surveys is indicated, although individual nests with unconfirmed activity statuses were sometimes revisited more frequently.
b. Due to scheduling constraints, surveys are not always conducted at the two facilities that adjoin each other on the same day.
c. Environmental Surveillance, Education, and Research personnel are restricted from entering the NRF. Therefore, several years ago an NRF representative was trained, and reports to ESER two times each season on Raven nest observations.

lished 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 portions 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 seen 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 9, 2018, ESER biologists completed surveys along both traditional driving routes on the INL Site. Observers documented 11 species and recorded a total of 369 birds on both routes (Figure 8-7). This is 2.25 times the 18-year median of 163.5 birds.

Common Raven observations remain high with 218 recorded during the 2018 survey (Figure 8-8). Rough-legged Hawk observations remained consistent for a third year (n = 128 in 2016; n = 76 in 2017; n = 120 in 2018) after four years of counts ranging from 15 to 22 (mean of 18.8 over period 2012–2015). Golden eagle observations (n = 6) were lower this year from the previous two years (Figure 8-8).

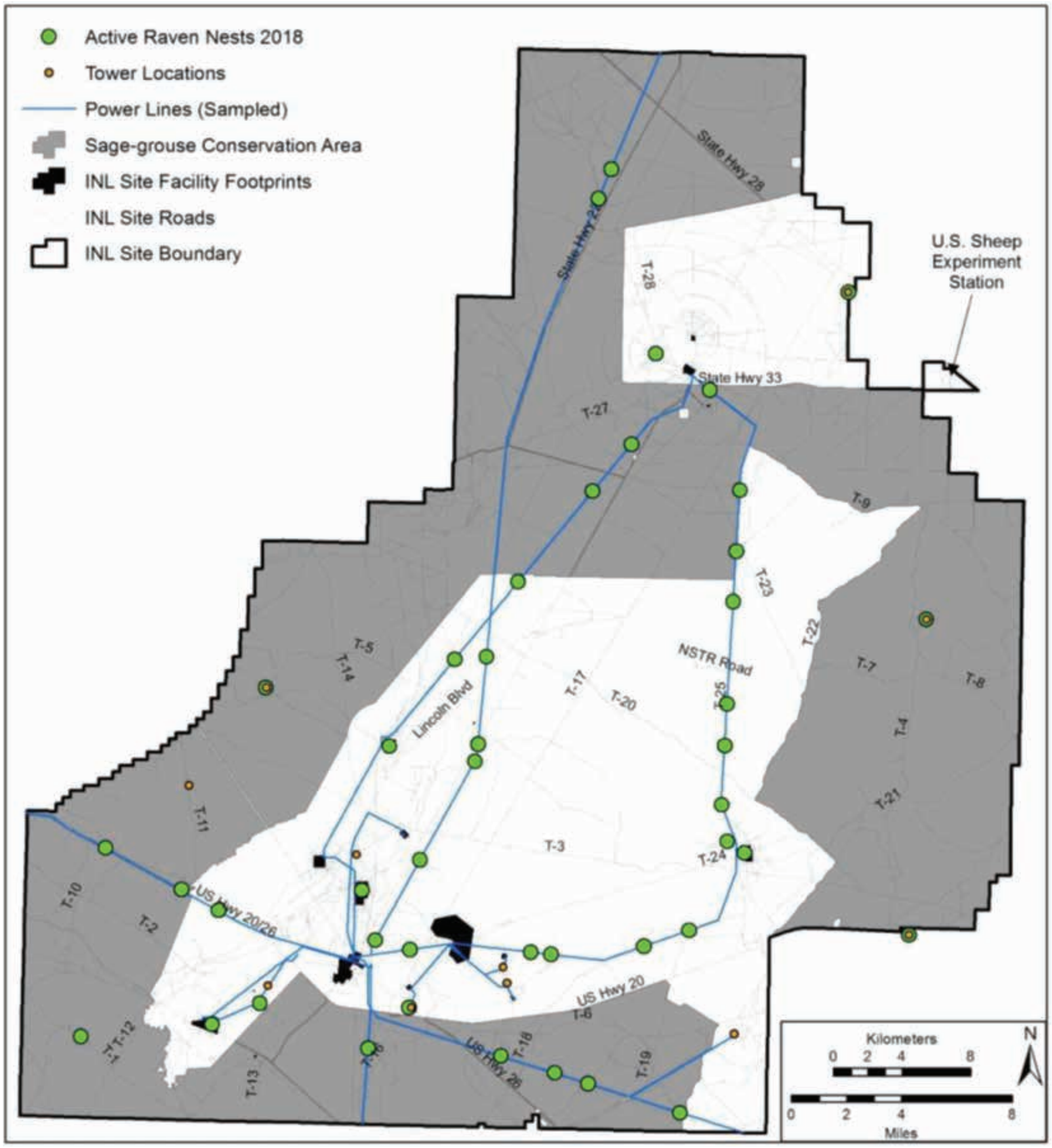

Figure 8-5. Results of 2018 Raven Nest Survey. *Raven nests displayed represent adjusted nest locations (n = 43).*

The importance of the mid-winter Bald 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.

8.4 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

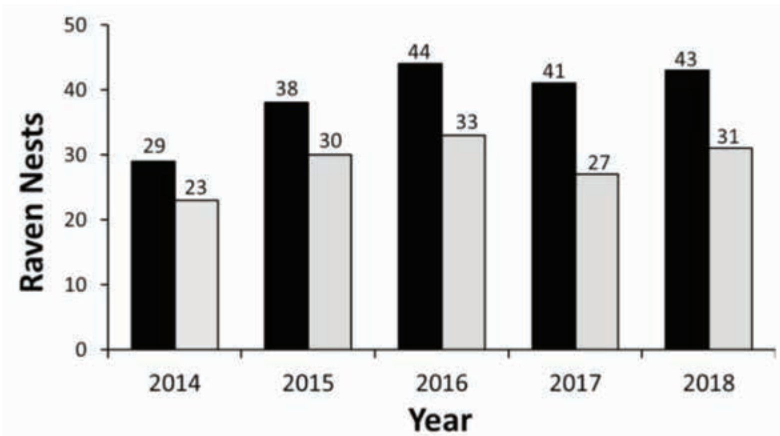

Figure 8-6. Adjusted Number of Common Raven Nests Observed on Idaho National Laboratory Site Infrastructure. *Black bars represent total nest counts and gray bars represent nests on power lines. Total nest count in 2017 may have been overestimated by two or three nests (see above).*

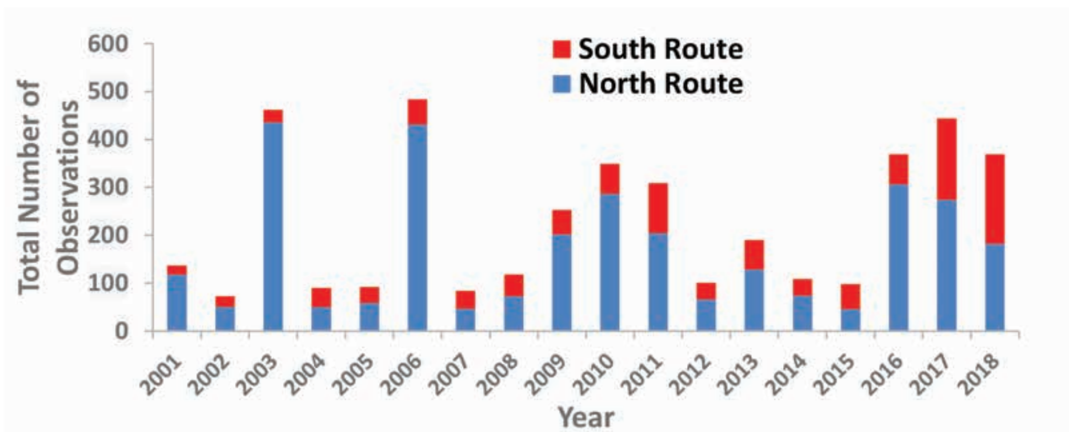

Figure 8-7. Total Number of Observations Separated by Survey Route, During the Mid-winter Bald Eagle Surveys Since 2001.

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 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 8-9). Data from remote routes contribute to the USGS continent-wide analyses of bird trends, and 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 Site activities cause measurable impacts on abundance and diversity of native birds.

Surveys were conducted along the 13 remote and facility routes in June and early July of 2018 and documented a total of 2,840 individuals from 53 bird species (Bybee et al., 2019). The six most numerous birds across all routes were Horned Lark (*Eremophila alpestris*, *n*

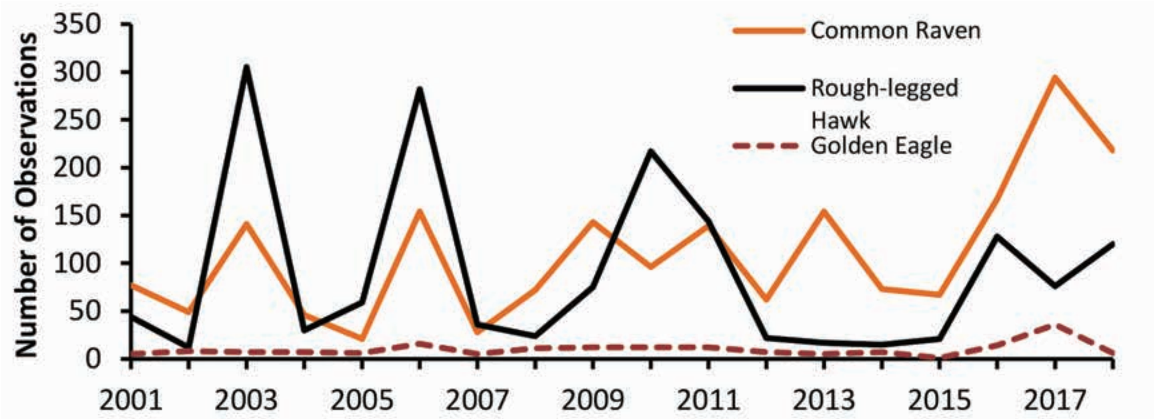

Figure 8-8. Trends of the Three Species Most Commonly Observed During Annual Midwinter Eagle Surveys. *Data were pooled from both northern and southern routes.*

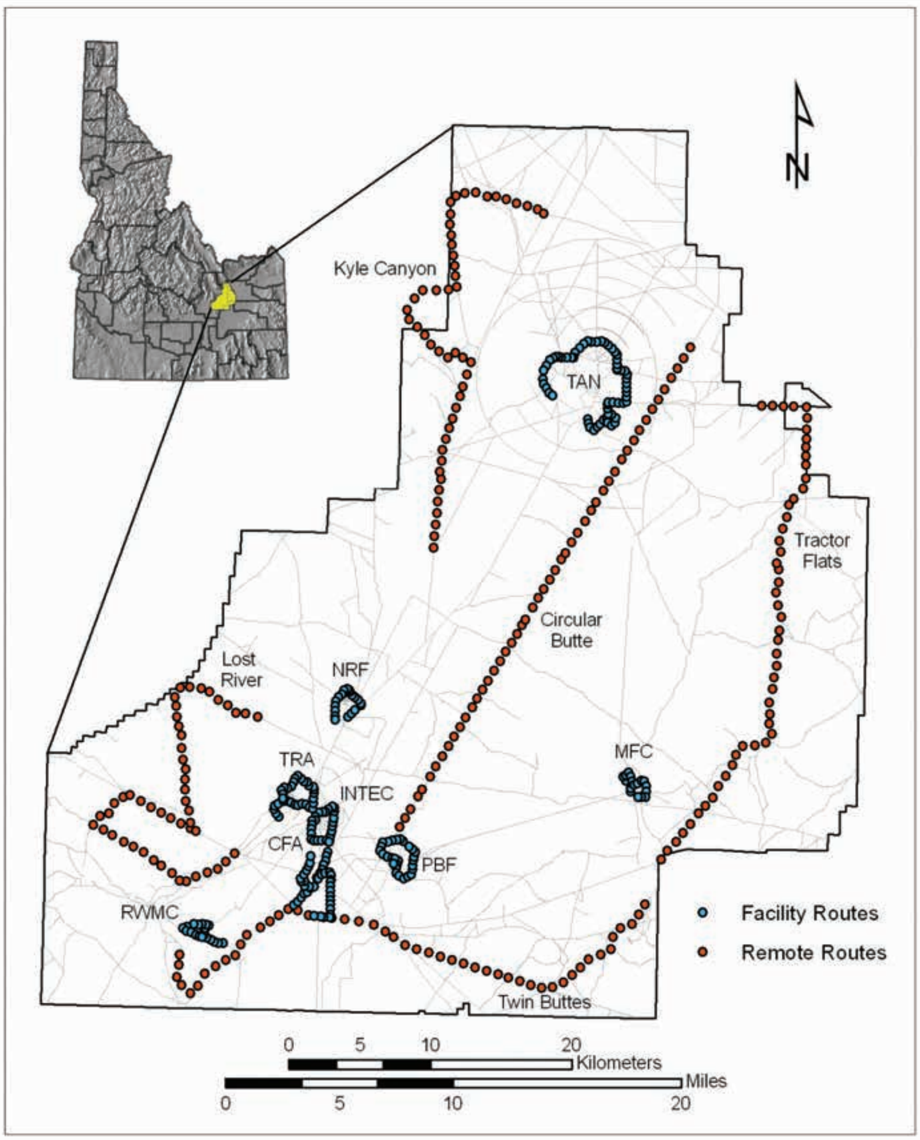

Figure 8-9. Breeding Bird Survey Routes on the INL Site.

= 873), Western Meadowlark (*Sturnella neglecta*, *n* = 481), Sage Thrasher (*Oreoscoptes montanus*, *n* = 376), Brewer's Sparrow (*Spizella breweri*, *n* = 184), and Sagebrush Sparrow (*Artemisiospiza nevadensis*, *n* = 201). These five species comprised >74% of all observations, and with the exception of the Sagebrush Sparrow, 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 24 of the 32 years of INL Site BBS (in the other years they were among the seven most abundant species).

Species observed during the 2018 BBS that are considered by the IDFG as "Species of Greatest Conservation Need" included the Sage Thrasher, Sagebrush Sparrow, Franklin's Gull (*Larus pipixcan*, *n* = 50), Common Nighthawk (*Chordeiles minor*, *n* = 26), Ferruginous Hawk (*Buteo regalis*, *n* = 7), Grasshopper Sparrow (*Ammodramus savannarum*, *n* = 7), Burrowing Owl (*Athene cunicularia*, *n* = 3), and Long-billed Curlew (*Numenius americanus*, *n* = 5).

Three of the six most numerous birds on the INL Site 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* = 376), followed by Sagebrush Sparrow (*n* = 201) and Brewer's Sparrow (*n* = 184). The Sagebrush Sparrow and Brewer's Sparrow continue to be observed at near historically lows on the INL Site. For the past eight 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 (Figure 8-10). The decline in sagebrush obligate species is attributed to the loss of sagebrush habitat from large fires on the INL Site in 2010 and 2011.

Conversely, Common Raven observations continue to increase (which also may be driven by wildfires). The number of Common Ravens observed continue to increase and with the exception of 2010 when a large single flock was observed, in 2018 was higher than any other year (*n* = 167; Figure 8-11). The combination of loss of sagebrush-dominated communities and increased predators, such as the Common Raven which raid nests of sagebrush obligates, may affect the growth potential of some species, especially Sage-grouse, which is a conservation concern for DOE-ID.

8.5 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

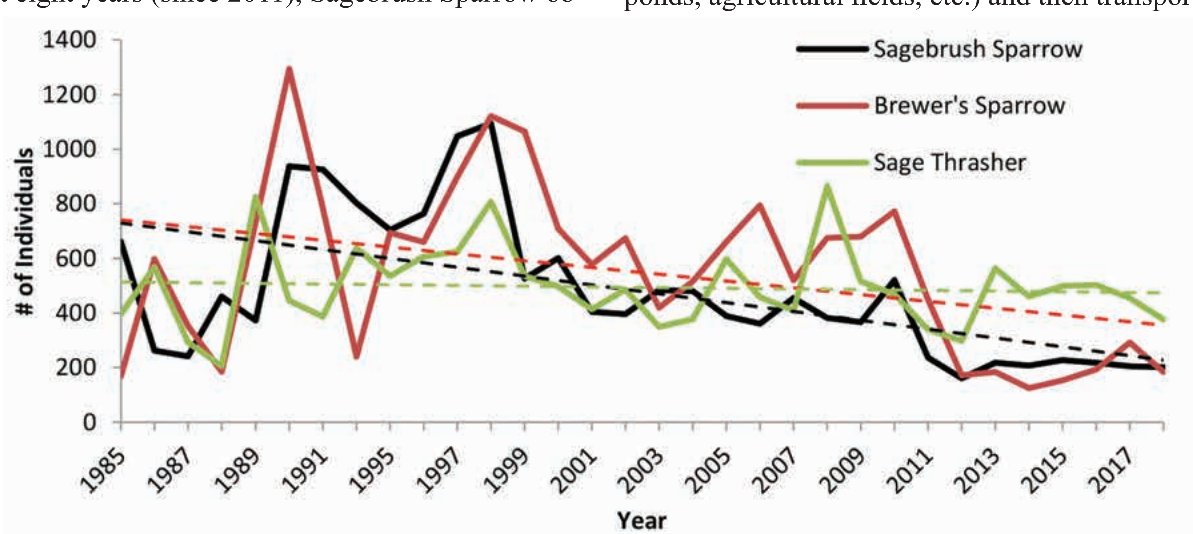

Figure 8-10. Trends of Three Sagebrush Obligates Recorded During Breeding Bird Surveys Since 1985.
Surveys were not conducted in 1992 and 1993.

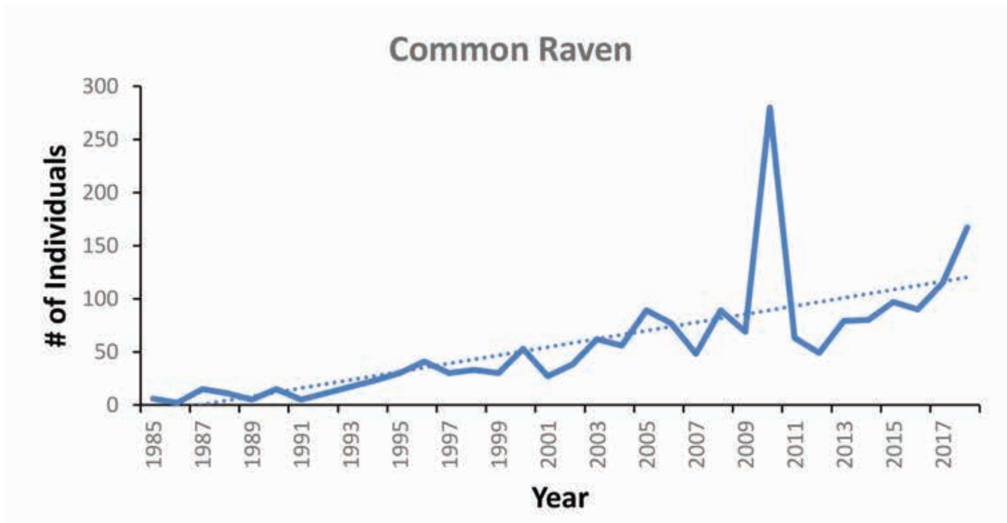

Figure 8-11. Trend of Ravens Observed During Breeding Bird Surveys Since 1985.
Surveys were not conducted in 1992 and 1993.

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. 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%. 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 organism was identified in a Silver-haired Bat (*Lasionycteris noctivagans*) from the same area. Since that time WNS or the disease-causing organism has been detected in the western states of South Dakota, Wyoming, North Dakota, and California. New species affected include Long-legged Myotis (*Myotis volans*), Western Long-eared Myotis (*Myotis evotis*), Western Small-footed Myotis (*Myotis ciliolabrum*), and Yuma Myotis (*Myotis yumanensis*), all species that occur at the INL Site. 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. Dur-

ing that time, four theses (Haymond 1998, Doering 1996, Wackenhut 1990, Bosworth 1994), three reports, and one publication (Genter 1986) 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 (Keller 1985), eleven of those species are confirmed to occupy the INL Site during some part of the year (Table 8-2). All eleven of these species may be detected at the INL Site in appropriate habitats throughout 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 8-2). 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 8-2). 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 8-2).

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 2018, 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 8-12). Preliminary analysis of a pilot data set was initiated in 2015 and continued in 2018 (Figure 8-13). Over 730 thousand ultrasonic files were collected during the 2018 monitoring season; more than 306,000 of these files were recorded at facilities, the rest at caves and other remote sites. 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 (*Myotis ciliolabrum*) was the most commonly detected bat at all surveyed features. Little Brown Bats (*Myotis lucifugus*) are more commonly detected at facilities than at cave sites.

Most identified bat species were detected at all features (both facilities and caves). One exception, Townsend's Big-eared Bat (*Corynorhinus townsendii*), 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. Small numbers of Townsend's Big-eared Bat (*Corynorhinus townsendii*) files have been recorded every survey year at two facilities (Materials and Fuels Complex and RWMC). These facilities are nearer to areas of the INL Site where typical Townsend's Big-Eared Bat (*Corynorhinus townsendii*) roost habitat (e.g., exposed rock outcrops, caves and cave-like features) is most common. Tree bats (Hoary Bats [*Lasiurus cinereus*] and Silver-haired Bats [*Lasionycteris noctivagans*]) 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, U.S. Forest Service, 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. Surveys were conducted for three years, but because so few bats were recorded, it was determined in 2018 that surveys would only be conducted on one route (Lincoln road) once monthly May-September.

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 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

Table 8-2. Bat Species and the Season 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,b] (*Eptesicus fuscus*)	Site-wide; buildings, caves, and lava tubes; year-round	Yes	Yes
Hoary Bat[a,c] (*Lasiurus cinereus*)	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	Yes	Potentially
Red Bat (*Lasiurus blossevillii* or *L. borealis*)[d]	Unknown; possible autumn migrant or vagrant; not considered an Idaho state species[e]	No	Yes
Silver-haired Bat (*Lasionycteris noctivagans*)	Patchy; riparian and junipers; summer resident at facilities and autumn migrant	Yes	Yes
Townsend's Big-eared Bat[a,b] (*Corynorhinus townsendii*)	Caves, lava tubes and rocky areas; year-round	Yes	Potentially
Fringed Myotis[d] (*Myotis thysanodes*)	Unknown; caves and lava tubes; single high-certainty acoustic detection only	Potentially	Yes
Brazilian Free-tailed Bat (*Tadarida brasiliensis*)	Unknown; single, dead specimen found at TAN; not considered an 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	Yes	Potentially
Western Small-footed Myotis[a,b] (*Myotis ciliolabrum*)	Site-wide; buildings, caves, and lava tubes; year-round	Yes	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. Detected acoustically only, possible vagrant.

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. INL Site caves are scheduled to be counted during even year winters. 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

Figure 8-12. 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.)*

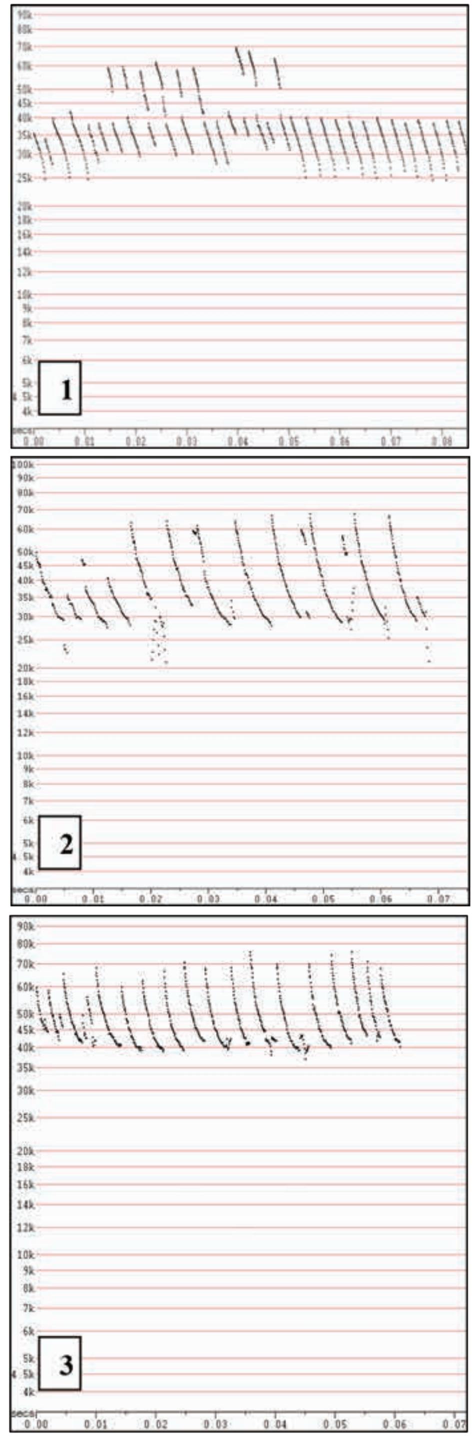

Figure 8-13. Sonograms (Frequency Versus Time Plots) of Bat Echolocation Calls of Three Species of Bats Recorded by AnaBat Detectors (1 = Townsend's big-eared bat, 2 = big brown bat, 3 = western small-footed myotis) from Caves on the INL Site.

highest and most stable. Caves were scheduled to be counted again during the winter of 2016–2017; however, numerous instance of severe winter weather and impassible travel conditions resulted in a decision to cancel 2016–2017 surveys. Subsequently, hibernaculum surveys were conducted during the 2017–2018 season. 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. For this reason, bat counts are typically counted during February and early March of survey winters. All internal surveys are conducted consistent with OP-8, ESER Cave Protection and Access procedure, and an approved INL Site cave entry permit. The latest FWS decontamination protocol to avoid the spread of WNS is carefully followed.

To date, Townsend's Big-eared Bat (*Corynorhinus townsendii*) is the most commonly counted over-wintering bat species, with western Small-footed Myotis (*Myotis ciliolabrum*) being the second most common, but with far fewer numbers. A total of 487 Townsend's Big-eared Bats (*Corynorhinus townsendii*) and 51 Western Small-footed Myotis (*Myotis ciliolabrum*) were counted during 2017-2018 winter counts. Historically over-wintering Big Brown Bats (*Eptesicus fuscus*) 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

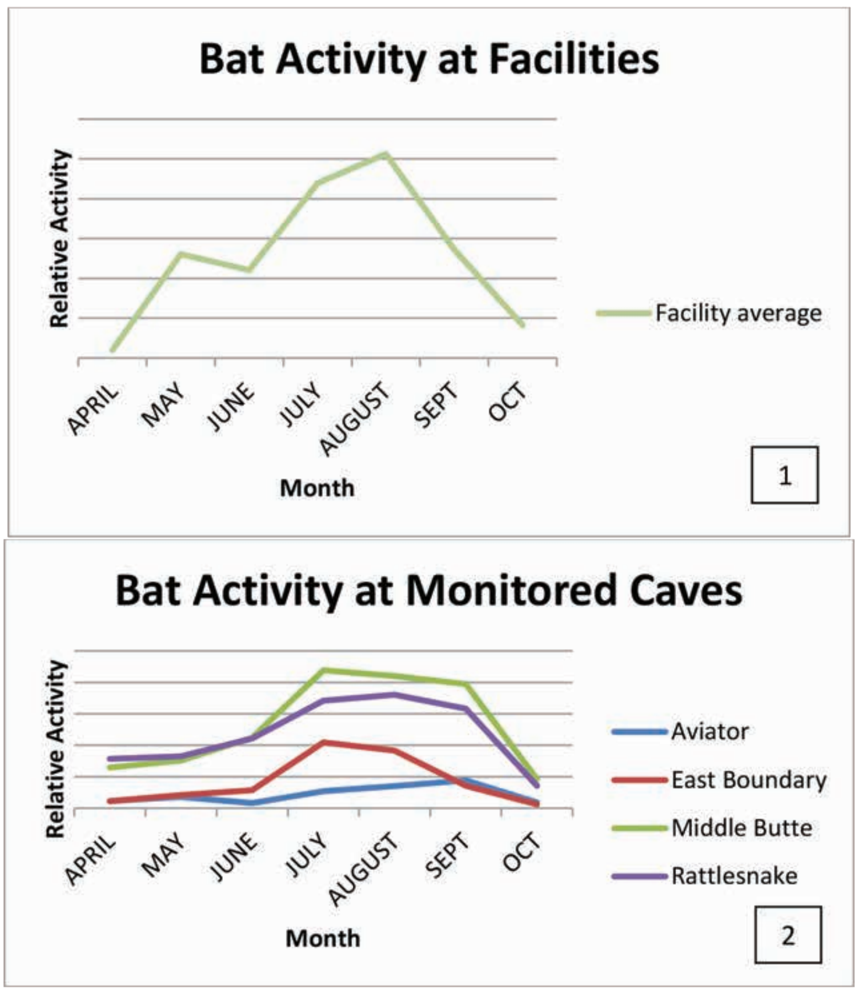

Figure 8-14. Average Relative Levels of Bat Activity Across the Summer Activity Season (April–October) for Acoustic Monitors Deployed at Facilities (1) and Caves (2). *May and August activity peaks at facilities indicate a good deal of transient use as bats migrate back and forth between summer and winter habitats. High activity throughout summer months at caves indicate these areas are important summer activity centers for resident bats.*

of activity across seasons with clear differences between developed and natural areas (Figure 8-14). 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% 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 8-14 reveal good levels of summer activity at both developed and natural sites. May and August peaks at facilities reveal transient use at facilities 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).

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Black Rosy-Finch
Leucosticte atrata

9. Environmental Research at the Idaho National Laboratory Site

2018

Ecological monitoring and research at the Idaho National Laboratory Site in 2018 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 2018 including analysis and reporting of data collected across the INL Site using the Long-term Vegetation (LTV) transects and associated permanent plots from 1950 through 2016. The LTV project allows researchers to observe long-term vegetation changes and the potential impacts of these changes across the INL Site. Progress also continued on an update to the INL Site vegetation mapping effort. In 2108, accuracy assessment data were collected, completing the third step in a three-part process. The map and accompanying technical report will be finalized and published in 2019.

Sagebrush habitat monitoring and conservation measures to support the CCA were addressed by two tasks in 2018. 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 restoration continued in 2018 and seedling survivorship assessments of shrubs planted in 2017 were completed.

During 2018, two ecological research project were conducted on the Idaho National Environmental Research Park; continued studies of ants and ant guests at the INL Site and behavioral ecology of pregnant Great Basin Rattlesnakes. 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. Four reports were published in 2018 by the Idaho National Laboratory Project Office.

9. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological monitoring and research performed at the Idaho National Laboratory (INL) (Sections 9.1 through 9.4) by ESER and research conducted on the eastern Snake River Plain and eastern Snake River Plain aquifer by the United States Geological Survey (Section 9.5) during 2018.

9.1 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*; 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 U.S. Department of Energy (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 last conducted in 2016 and an INL Site Vegetation Map update was initiated in 2017.

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 currently two habitat monitoring tasks, one to assess annual habitat condition and one to document habitat distribution across the INL Site. The habitat distribution task is completed periodically, based on available imagery, and was not conducted in 2018. There is also a task associated with habitat restoration. This task supports the CCA and is a conservation measure that includes planting sagebrush seedlings to hasten the return of viable habitat in burned areas and monitoring previously planted areas for survivorship.

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 restricted public access. Universities typically provide their own funding and the Environmental Surveillance, Education, and Research (ESER) Program facilitates researcher 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 involves tracking rattlesnake movements through gestation and dispersal of young.

9.2 Vegetation Communities and Sensitive Plant Species

9.2.1 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 et al. 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 9-1) 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 regular basis, about once every five years. Eighty-nine LTV plots are still accessible, and most have now been sampled consistently 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 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 (Figure 9-1). Soil disturbance associated with fighting wildland fires and disturbance associated with general increases in the use of remote back country areas are notable throughout the Intermountain West. Concurrently, many of the hottest and driest years during the 60-year weather record occurred during the past decade. All of these factors contribute to increasing stress on native plant communities and potentially set

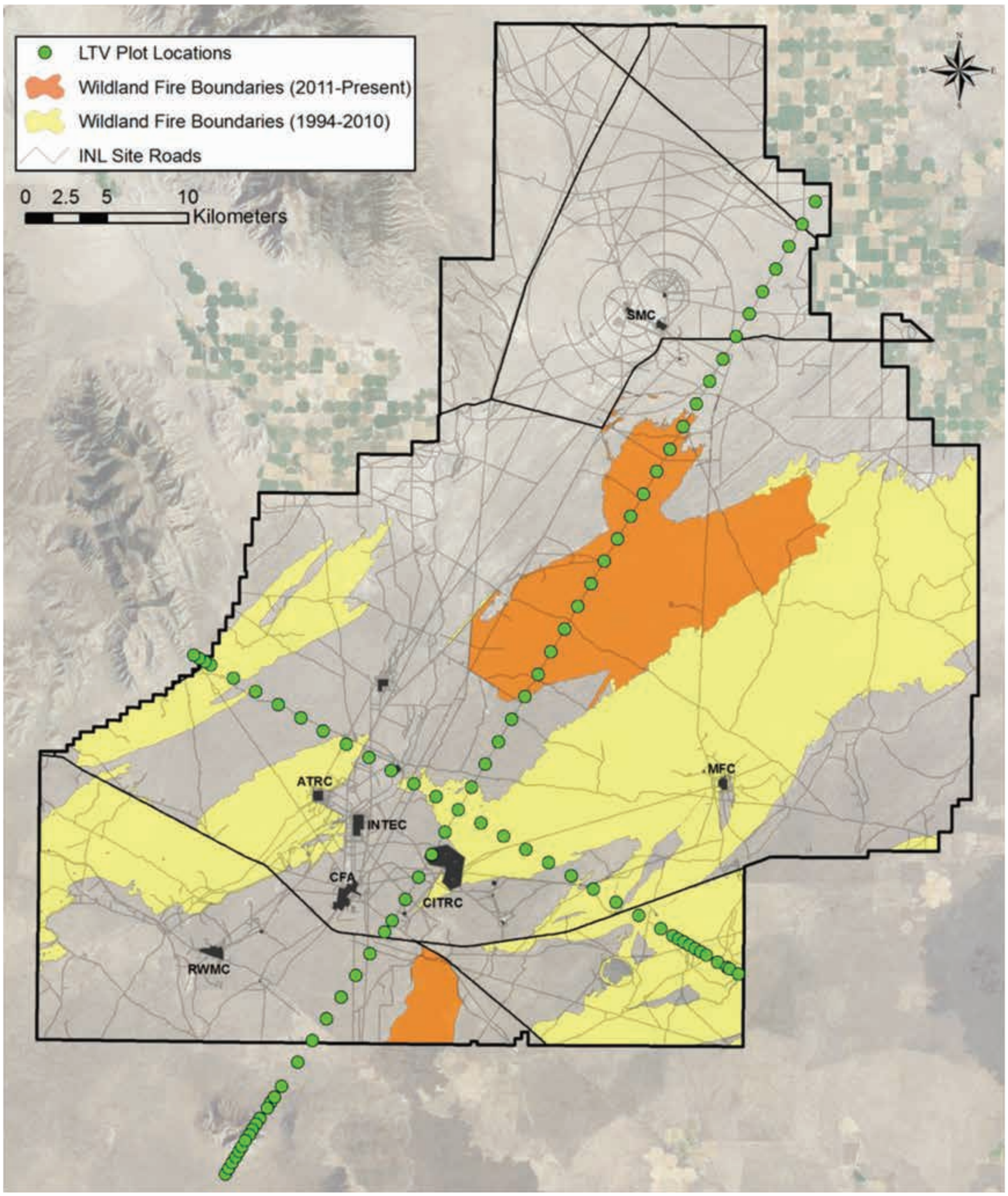

Figure 9-1. Long-term Vegetation Transects and Permanent Plot Locations on the INL Site.
Wildland fires depicted are from 1994-2016.

Common Nighthawk
Chordeiles minor

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. Data were analyzed using one- and two-way ANOVAs and repeated measures designs were used when possible (Zar 1999). Significance was determined at $\alpha = 0.05$ and the Holm-Sidak method (Sidak 1967) was used for multiple comparisons. Updates to analyses characterizing trends in native species abundance and community composition were addressed using both point- and line-interception cover data on the core plots. Analyses of non-native annual species' distribution and abundance patterns from 1950 through the current study period were conducted using density/frequency data on all the LTV plots that were sampled during each of ten sample periods in which all available plots were sampled.

Notable changes between the 2011 and 2016 sample periods include decreases in shrub cover, particularly big sagebrush (*Artemisia tridentata*); increases in native grass cover; and declines in the densities of introduced annual grasses and forbs. In terms of long-term trends, big sagebrush cover is at its lowest point in the 66-year history of the data set and native, perennial grasses are near the upper end of their historical range of variability (Figure 9-2). Although the abundance of introduced annuals has declined between the most recent two sampling efforts, introduced annuals remain much more abundant than native annuals across the LTV plots. Introduced annuals have also been exhibiting fluctuations with greater magnitudes of change from one sample period to the next over the past two decades when compared with earlier sample periods (Figure 9-3). Coincidentally, annual precipitation was below average for four of the five years prior to the 2016 sample period and the seasonal timing of precipitation has shifted away from wet spring periods to elevated precipitation in late-summer and fall over the past five to ten years (see Forman and Hafla 2018 for complete description of precipitation patterns).

Declines in big sagebrush cover are due to direct losses from wildland fire and possibly from reduced germination and establishment because of below average spring precipitation on the INL Site over the past decade. Changes in the seasonality of precipitation are likely also affecting the abundance of introduced annuals, especially with respect to the magnitude of change from one sample period to the next. Increased pressure from non-native species, including annuals like cheatgrass (*Bromus tectorum*) and perennials like crested wheatgrass (*Agropyron cristatum*), will undoubtedly persist over the next few decades. Some of the more recent changes in vegetation distribution and structure on the LTV plots may suggest the beginning of a shift to INL Site plant communities that are less resilient than they have been in the past. As sagebrush steppe management across the West faces increasing challenges, the LTV will continue to provide useful insight to local scientists and regional researchers alike.

A technical report summarizing the results of the LTV project through 2016 was completed in 2018 and is available on the ESER website (http://www.idahoeser.com/PDF/2016LTVReport.pdf).

9.2.2 INL Site Vegetation Map Update

The most recent vegetation map for the INL Site was based on vegetation classification data sampled across the Site and a time-series of digital imagery used to produce manual map delineations (Shive et al. 2011). This dataset represented a substantial improvement over previous maps of the INL Site in terms of resolution, accuracy, and statistical rigor. Since its completion, the vegetation map has been used extensively to support inventory and monitoring of ecological resources on the INL Site. Several of the monitoring and adaptive management tasks outlined in the CCA for Greater Sage-grouse (DOE-ID and FWS 2014), including assessment of the status of habitat distribution, require an accurate vegetation map. The vegetation map is also instrumental for identifying and prioritizing potential habitat for other sensitive species, identifying restoration and/or weed control opportunities, and characterizing affected environments for NEPA analyses. Over the past decade, the vegetation map has become one of ESER's most important datasets and is used to support nearly every other ecologically based task.

Because the vegetation map is integral to the ESER Program, it is important to update the map periodically to ensure that both the vegetation classes identified on the INL Site and the mapped boundaries of those classes remain accurate. There have been many changes in vegetation distribution and composition since the map was

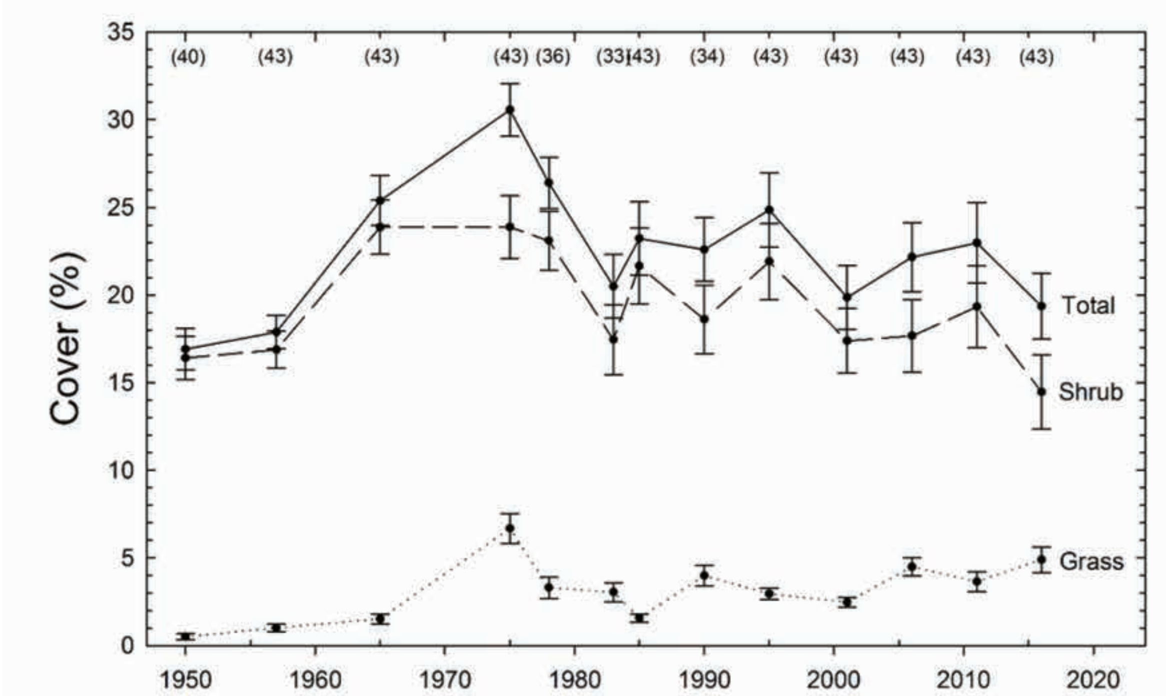

Figure 9-2. Trends in Shrub Cover, Native Perennial Grass Cover, and Total Combined Perennial Grass and Shrub Cover from 1950 to 2016 for the Core Subset of Plots on the Long-term Vegetation Project at the INL Site. *Data were collected using line-interception methods and are represented here as means ± 1 SE. Numbers in parentheses at the top of the frame indicate the number of plots for which data were available in each sample year.*

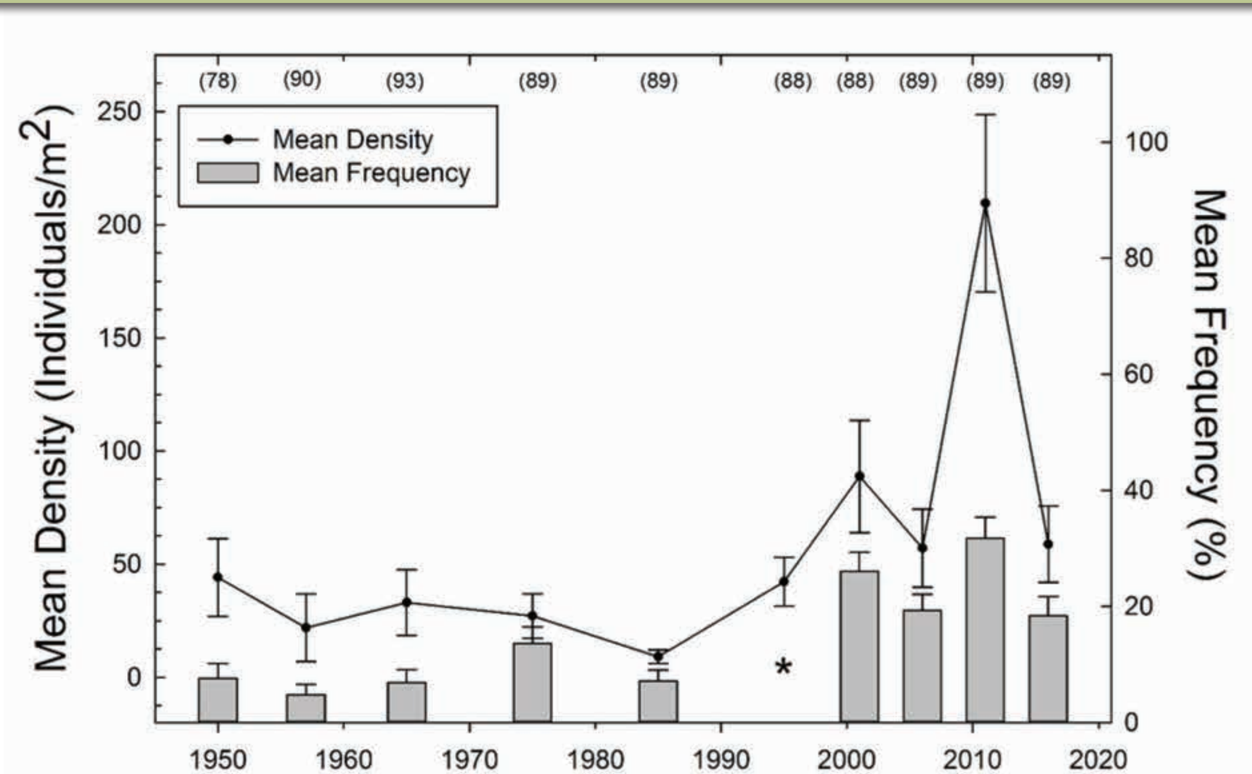

Figure 9-3. Density and Frequency Trends for Bromus tectorum on the Long-term Vegetation Project Permanent Plots at the INL Site from 1950 to 2016.
*Data are means ± 1 SE. *Frequency data are missing from the 1995 data archives.*


Common Nighthawk
Chordeiles minor

completed. The most spatially discrete changes were caused by four, relatively large wildland fires that burned approximately 52,820 ha (130,521 acres), representing approximately 23% of the INL Site from 2010–2012. More gradual changes in plant community composition, like increases in the abundance and distribution of non-native annual grasses and forbs, have also been occurring over the past decade. These changes will affect the way vegetation classes are defined and mapped across the INL Site and will be an important consideration for all ESER tasks that utilize the vegetation map.

A comprehensive update to the current map was initiated in 2017 and involves three steps; 1) plant community classification to define vegetation classes, 2) map delineations of those classes, and 3) accuracy assessment of the map. The plant community classification was completed in 2018 and the results were used to generate a list of current vegetation classes for the INL Site. A total of 16 unique vegetation classes resulted from the statistical classification. The draft map delineations were also completed in 2018, and plots were sampled to collect data for an accuracy assessment of the updated map.

Upon completion of the plant community classification, a dichotomous key to INL Site vegetation classes was developed using constancy and mean cover values for each class. Because specific ranges of cover values are difficult to estimate rapidly in the field, dichotomies in the key were driven by relative abundance concepts like; "dominant," "co-dominant," "abundant," "common," and "rare." While these concepts facilitate efficient data collection, they necessarily oversimplify the range of variability present in most plant communities. The dichotomous key was used to assign vegetation classes to accuracy assessment plots sampled during the independent map validation data collection. The key will also be used to support rapid vegetation characterization for NEPA assessments.

The 2017 Idaho National Agricultural Imaging Program color-infrared multispectral imagery was used as the primary base map layer for manual map delineations. The 2015 Idaho National Agricultural Imaging Program imagery was also utilized in regions where water was present in the 2017 imagery and obscured the ground. To assist with the vegetation class delineations, two vegetation indices (i.e., the Normalized Difference Vegetation Index and the Soil-adjusted Vegetation Index), as well as a statistical texture layer (i.e., 3 x 3 Range), were calculated from the base map imagery. Ancillary GIS data layers (e.g., digital elevation model) were also used during the image delineation process to help identify vegetation class patterns on the landscape.

The limitations of applying automated image classification methods in a semi-arid sagebrush steppe environment were identified during previous mapping experiences on the INL Site; therefore, polygons were mapped using manual photo interpretation of digital imagery directly within a GIS. The map delineations were produced through manual interpretation and digitizing at a 1:6,000 mapping scale using a suite of GIS editing tools. To capture the fine-scale details of five non-vegetation classes (e.g., paved roads and borrow sources) and one agricultural class, those classes were digitized at approximately a 1:2,000 mapping scale.

After reviewing the vegetation class list resulting from statistical classification, it was apparent that several vegetation classes were unlikely to be recognizable in multispectral imagery. Consequently, there were two sets of the original 16 vegetation classes that were combined into a single map class resulting in a total of 14 map classes. Each of the delineated polygons were assigned to one of the 14 map classes (Table 9-1)or to one of the five non-vegetation classes.

Once the map delineations were completed, spatial topology was implemented to perform the final Quality Assurance/Quality Control of the map polygons. Topology rules test whether polygons erroneously overlap one another or have small gaps between adjacent polygons that should share a common edge. Mapping errors were manually edited and corrected, and then topology validation was rerun to verify all geometric errors were resolved.

The updated INL Site vegetation map contains 7,637 polygons, of which 7,265 (95.1%) represent vegetation classes. The remaining 372 (4.9%) polygons were assigned to non-vegetation special classes that accounted for only 30.3 km^2 (7,478.8 acres) of the total mapped area (Table 9-1). The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class contained the largest amount of total area mapped with 851.2 km^2 (210,330.9 acres). The second largest class mapped was the combined Green Rabbitbrush/Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland class with 570.8 km^2 (141,035 acres). The three largest map classes cover 73.2% of the vegetated area on the INL Site, suggesting the majority of vegetation communities are dominated by big sagebrush or species most com-

Table 9-1. Vegetation Map Class Summary for the INL Site. *The two map classes denoted with an asterisk represent degraded vegetation communities that were assigned the most closely related map class, but generally contain an abundance of non-native species not well-represented in the dichotomous key.*

Map Class Name	Total Area (acres)	Total Area (km^2)	# of Polygons	Mean Area (acres)
(1) Green Rabbitbrush / Sandberg Bluegrass – Bluebunch Wheatgrass Shrub Grassland	39388.16	159.40	51	772.32
(2) Cheatgrass Ruderal Grassland	22832.95	92.40	1436	15.90
(3/5) Green Rabbitbrush / Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland	141034.94	570.75	1058	133.30
(4) Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland	33021.23	133.63	115	287.14
(6) Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland	210330.09	851.18	2387	88.11
(7) Crested Wheatgrass Ruderal Grassland	23924.96	96.82	102	234.56
(8) Big Sagebrush Shrubland	59529.83	240.91	891	66.81
(9) Western Wheatgrass Grassland	7742.69	31.33	377	20.54
(9*) Western Wheatgrass Grassland (Degraded)	454.96	1.84	1	454.96
(10) (Basin Wildrye) – Mixed Mustards Infrequently Inundated Playa/Streambed	3337.61	13.51	49	68.11
(10*) (Basin Wildrye) – Mixed Mustards Infrequently Inundated Playa/Streambed (Degraded)	513.79	2.08	1	513.79
(11) Juniper Woodland	5832.08	23.60	385	15.15
(12/14) Indian Ricegrass Grassland and Gardner's Saltbush (Winterfat) Shrubland	6021.63	24.37	250	24.09
(13) Shadscale Saltbush – Winterfat Shrubland	4824.05	19.52	14	344.58
(15) Black Sagebrush Shrubland	1209.83	4.90	145	8.34
(16) Low Sagebrush Shrubland	1517.94	6.14	3	505.98

monly associated with post-fire communities where big sagebrush was previously present.

The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class also had the greatest number of map polygons with 2,388 and an average polygon area of 0.36 km^2 (88.1 acres). The class containing the second largest number of polygons was the Cheatgrass Ruderal Grassland class with 1,435 polygons. However, the mean area of Cheatgrass Ruderal Grassland class was much smaller at 0.06 km^2 (15.9 acres) and many of the polygons mapped were isolated individual patches rather than larger contiguous areas.

Initially, 400 random plot locations were selected, and they were stratified across each map class to support the accuracy assessment of the vegetation map. Some of the randomly selected points were dropped during field data collection for a variety of reasons, such as access issues from impassable roads. Around the midpoint of the field season current sample sizes were considered and additional random points for rare classes were generated to help achieve minimum sample size requirements, and to expand the distribution and number of plots located within recently burned areas. Random points were dropped for some abundant classes mid-season as those classes had already been adequately sampled.

Field crews used the dichotomous field key to assign a vegetation class at each plot location and were also given the opportunity to select a second vegetation class and note when the field key did not perform well at the plot. ESER staff, including plant ecologists and a natural resource specialist, reviewed all the plots where the field key did not work well to determine whether those data should be discarded from the dataset. The internal review resulted in a total of 453 validation plots (Figure 9-4) that will be used to support the accuracy assessment of the final vegetation map.

In 2019, a standard error matrix will be used to calculate map accuracy metrics including user's and producer's accuracy, overall accuracy and the Kappa statistic. The mapping results will be summarized, and a final technical report will be published to document the vegetation map update and make the spatial data available to support ongoing ESER natural resource and monitoring projects.

9.3 Sagebrush Habitat Monitoring and Restoration

9.3.1 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. In addition to healthy stands of sagebrush, sage-grouse also require a diverse understory

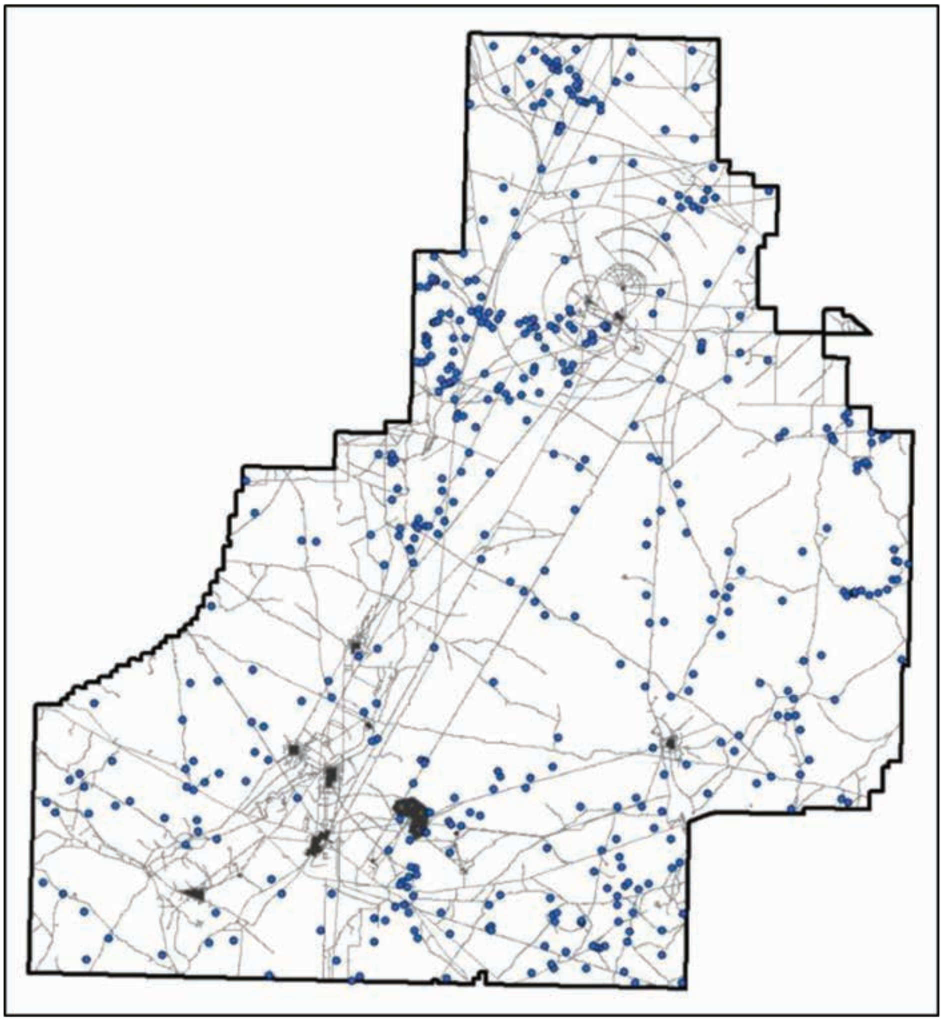

Figure 9-4. Vegetation Map Accuracy Assessment Plot Locations Sampled During the Summer of 2018 on the INL Site.

of native forbs and grasses which provide protection from predators and supply high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011).

The CCA between the DOE-ID and the FWS (2014) outlines a monitoring task to support ongoing assessment of sage-grouse habitat condition. Habitat condition monitoring data have been 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 plants). Although the surveys were not 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 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. The annual plots are split into two groups. The first group consists of 48 plots located in areas currently mapped as sagebrush habitat. The second group contains 27 plots located in recovering habitat where sagebrush has been lost due to wildland fires. To increase sample size and to address potential habitat threats, specifically fire and livestock use, an additional 150 plots were added and are sampled on a rotational basis. Rotational plots are divided into three sets of 50 plots that are each sampled once over a five-year cycle. Plots are sampled for vegetation cover, height by species, sagebrush density, and sagebrush juvenile frequency. In 2018, data were collected on 75 annual and 50 rotational plots between June and August (Figure 9-5). Results from annual plots were summarized and results were compared to a site-specific baseline from previous years and to regional habitat guidelines (Connelly et al. 2000).

From 2013 through 2017, biologists compared local monitoring results to regional sage-grouse habitat guidelines (Connelly et al. 2000) to evaluate the status of sagebrush habitat on the INL Site. However, experts highly recommend the development of site-specific standards to evaluate the status of local habitat conditions (Connelly et al. 2000, Connelly et al. 2011). Beginning in 2018, enough locally collected data were available to begin developing a site-specific standard. Local habitat condition values (referred to hereafter as local means) were developed utilizing vegetation data from 2013 to 2017 on the 75 annual plots. These values establish a local standard against which to better compare current sagebrush habitat conditions on the INL Site. Because this local standard was new in 2018, the local means were compared to regional guidelines (Connelly et al. 2000) and 2018 results were interpreted within the context of the new local means.

Overall, the newly developed local means do not differ drastically from general guidelines (Connelly et al. 2000 Table 3; Table 9-2a) for nesting and brood rearing sagebrush habitat. Local means for sagebrush cover and height are also within the recommended range from regional guidelines (10-25%, 30 - 80 cm, respectively), local means for herbaceous cover are slightly lower than recommended in regional guidance (≥ 15%), and herbaceous height is near the lower end of the generally recommended range (> 18 cm). Relative to regional habitat guidelines, these site-specific departures do not appear to be the result of poor ecological condition, but rather the effect of soils and climate on the local ecosystem (Forman et al. 2013).

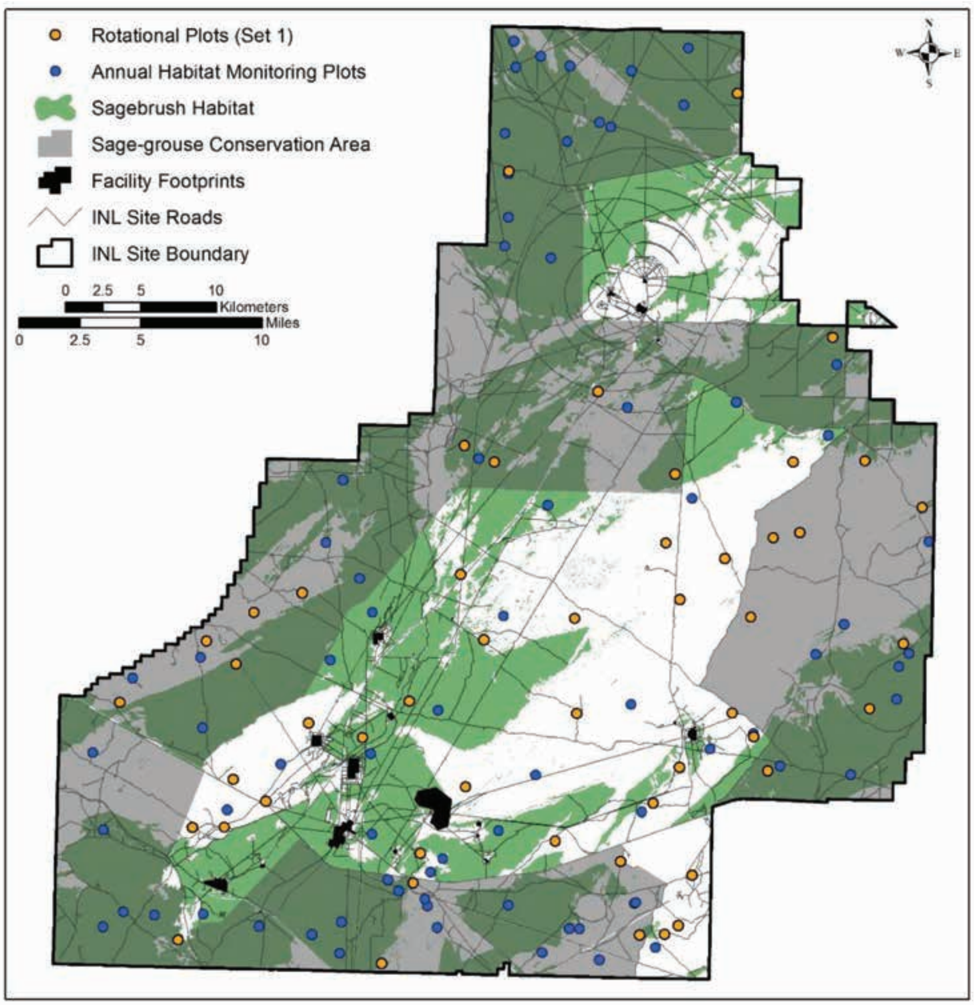

Figure 9-5. Sage-grouse Habitat Condition Monitoring Plots Sampled in 2018 on the INL Site Displays Both Annual and Set 1 of the Rotational Plots.

Common Nighthawk
Chordeiles minor

In 2018, sagebrush habitat plot data were compared to the local means (Table 9-2b, Table 9-2a). Total absolute cover on sagebrush habitat plots was about 70% and just under half was from shrubs (Shurtliff et al. 2019). Most of the shrub component was from sagebrush, and mean cover in 2018 was slightly higher than the local means. Perennial grass/forb cover and height were substantially higher in 2018, by 11% and 11 cm, when compared to the local means. Perennial herbaceous cover and height have been increasing since 2014 and both remain near the upper end of their range of variability (Shurtliff at al. 2019). Sagebrush density was lower in 2018 than the local mean (Table 9-2a, Table 9-2b), but it is within the recorded range of variability from the 2013-2017 habitat condition monitoring data.

Plots from recovering burned areas were also compared to the local means (Table 9-2a, Table 9-2b). Total absolute cover on recovering burned areas was about 80% in 2018 and nearly half of that cover was from introduced annual grasses, namely cheatgrass. About 25% of the 2018 vegetative cover on recovering burned plots is from perennial grasses and forbs and the remaining 25% is from green rabbitbrush (*Chrysothamnus viscidiflorus*). Perennial grass/forb cover in 2018 are comparable to local means. Sagebrush density remains very low in recovering burned plots when compared to current habitat plots, but 2018 densities are consistent with local means.

Herbaceous functional groups have been highly influenced by precipitation in 2018 and throughout the duration of this monitoring effort. In 2018, total annual precipitation was above average and May precipitation was three times the monthly average, with a total 103 mm. Over the past decade, weather patterns have been highly

Table 9-2a. Average Local Habitat Condition Values (Local Means) of Selected Vegetation Measurements for Evaluating the Condition of Sagebrush Habitat Monitoring Plots and Non-sagebrush Monitoring Plots on the INL Site. *Local means were generated from 2013-2017 data.*

Local Means	Mean Cover (%)	Mean Height (cm)	Mean Density (individuals/m^2)
Sagebrush Habitat Plots			
Sagebrush	21.27	47.81	5.19
Perennial Grass/Forbs	10.26	20.70	
Non-sagebrush Plots			
Sagebrush	0.22	33.54	0.07
Perennial Grass/Forbs	19.97	29.77	

Table 9-2b. Summary of Selected Vegetation Measurements for Evaluating the Condition of Sagebrush Habitat Monitoring Plots and Non-sagebrush Monitoring Plots on the INL Site in 2018.

2018	Mean Cover (%)	Mean Height (cm)	Mean Density (individuals/m^2)
Sagebrush Habitat Plots (n = 48)			
Sagebrush	23.65	47.59	3.55
Perennial Grass/Forbs	21.21	31.90	
Non-sagebrush Plots (n = 27)			
Sagebrush	0.27	48.91	0.07
Perennial Grass/Forbs	24.97	38.51	

variable with some of the driest years on record and substantial departures from historical patterns of seasonality. These short-term precipitation patterns would certainly favor some plant species and functional groups over others. Cover from perennial herbaceous species, as well as cover from cheatgrass and all annual forbs was probably uncharacteristically low in 2013 and 2014 (Shurtliff et al. 2015) and was much higher than it would likely be under normal conditions in 2015–2018 due to the anomalous precipitation patterns in those years (Shurtliff et al. 2019).

A monitoring report containing the full results of the habitat condition monitoring project through 2018 is available on the ESER website (http://www.idahoeser.com/LandManagement/PDFs/2018 percent20CCA percent20Full percent20Report_Final_01-30-2019.pdf).

9.3.2 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 fire fighting activities by taking steps to accelerate 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 recurring 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, and again in 2018, sagebrush seeds were collected from a representative sample of stands across the INL Site. Every year, seeds are germinated and grown in greenhouses in 10-in^3 conetainers, and each fall the seedlings are planted into a selected priority restoration area, or an area that meets most of the criteria and is readily accessible. Seedlings are 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. In 2017 and again in 2018, sagebrush seedlings were planted at a location within the Jefferson Fire (Figure 9-6).

Although DOE committed to growing and planting at least 5,000 seedlings every year, the seedlings planted have increased every year since 2015 (Figure 9-7). In 2018, approximately 9,000 seedlings were planted on 20.2 ha (49.8 acres) and the locations of 1530 (~17%) seedlings were marked for future monitoring. In addition to the 9,000 seedlings planted with DOE funding, an Office of Species Conservation (OSC) grant allowed ESER to plant an additional 15,625 seedlings on 39.1 ha (96.7 acres; Figure 9-6), and 300 (1.9%) of those were marked for future monitoring. There were no seedlings planted to mitigate potential sagebrush loss by contractor project activities in 2018. Over the past four years, a total of 42,000 seedlings have been planted from all funding sources (Figure 9-7). Sagebrush restoration has now been addressed on a total 135.5 hectares (334.9 acres).

To assess one-year survivorship of seedlings planted in 2017, 597 sagebrush seedlings were revisited in August 2018. Of the 597 revisited seedlings, 316 (53%) were healthy, 33 (6%) were stressed, 67 (11%) were dead, and 181 (30%) were missing. Assuming the missing seedlings were dead, a total of 59% of the seedlings survived the first year. For comparison in 2017, 497 seedlings planted in 2016 were revisited and 240 (48%) were healthy, 66 (13%) were stressed, 26 (5%) were dead, and 165 (33%) were missing. Therefore, the one-year survivorship for seedlings planted in 2016 was 62%.

Precipitation patterns from fall 2017 to fall 2018 were characteristic of a good recruitment year. Although the winter was fairly dry, March through May were uncharacteristically wet, which would have been ideal for early spring growth precipitation for the seedlings. The summer growing season was slightly below average (Shurtliff et al. 2019). Despite the lack of moisture during summer, most of the plants relocated were labeled as being healthy. Young sagebrush plants experience the highest mortality during the first year (Dettweiler-Robinson et al. 2013). In a review of 24 projects where containerized sagebrush seedlings were planted and survivorship was measured after one year (Dettweiler-Robinson et al. 2013), researchers reported first year survival of stock ranged from 14% to 94% (median = 59%, weighted average=57%). Thus, sagebrush establishment following every planting on the INL Site thus far was at or higher than average, even when the non-located plants are considered dead.

A monitoring report containing the full results of the sagebrush habitat restoration project through 2018 is available on the ESER website (http://www.idahoeser.com/LandManagement/PDFs/2018 percent20CCA percent20Full percent20Report_Final_01-30-2019.pdf).

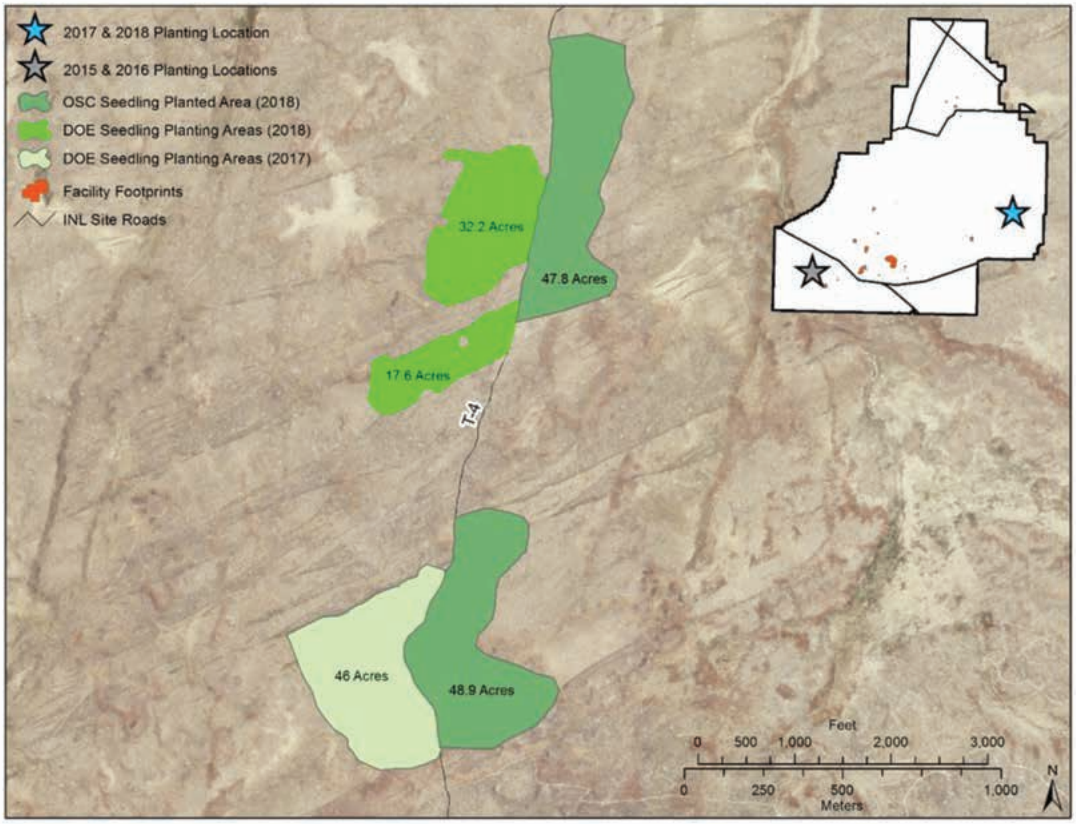

Figure 9-6. Areas Planted with Big Sagebrush Seedlings in 2018 and in 2017. *The stars on the inset map shows the general location of all plantings.*

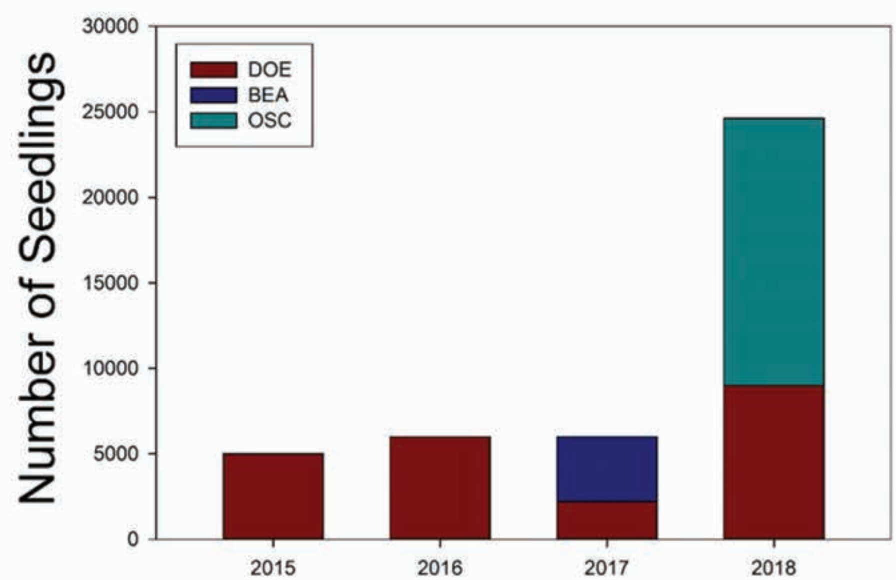

Figure 9-7. Funding Sources for Sagebrush Restoration Efforts on the INL Site from 2015-2018.

9.4 Ecological Research at the Idaho National Environmental Research Park

9.4.1 Studies of Ants and Ant Guests at the INL Site

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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.

Figure 9-8. 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.

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 9-8). 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.

Some limited fieldwork was completed in 2018 and 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.

9.4.2 Studies of Great Basin Rattlesnakes on the INL Site: Behavioral Ecology of Pregnant Snakes

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The Great Basin Rattlesnake, *Crotalus oreganus lutosus*, is arguably the most abundant snake species on the INL site. And, because of research conducted by the Idaho Herpetological Laboratory at Idaho State University over the past three decades, the ecology of this snake is well documented. *Crotalus o. lutosus* form aggregations of sometimes several hundred individuals for overwintering underground. During their activity season, *C. o. lutosus* make a lengthy migration away from and back to the overwintering site. The migratory routes taken are used for foraging, finding mates, and gestation by pregnant snakes. One component of this activity we know relatively little about is, what are the defining attributes of gestation sites chosen by pregnant snakes and if, and how, naïve newborn rattlesnakes born during the summer return to communal overwintering sites.

In 2018, a project was initiated on the INL site to locate gestation sites used by pregnant *C. o. lutosus* and to conduct a preliminary radio telemetry of a few individuals and their corresponding offspring. Results indicate that pregnant snakes utilize rocky outcrops or large individual rocks for gestation. Eighteen different gestation sites were discovered in the southeastern portion of the INL site. Physical attributes (e.g., length, width, thickness, etc.) of these gestation rocks and nearby random rocks were measured and suggests that gravid females are not randomly choosing rocks for gestation but rather selecting rocks with certain attributes that may make them suitable for gestating young. In 2019, these gestation rocks and additional gestation rocks to be located will be measured for their thermal properties to test if pregnant snakes may be choosing rocks that maintain specific temperature ranges. Thermoregulation at appropriate temperatures is a leading hypothesis regarding the selection of gestation sites by pregnant snakes. After the 2019 field season a manuscript will be prepared describing rock selection by gestating *C. o. lutosus* on the INL.

Within two weeks following the birth of newborns, post-parturient female snakes moved away from gestation rocks. In several cases, the newborn snakes left the rock as well. These females did not move toward the overwintering site but rather selected sites with rodent activity to apparently forage. This behavior would negate the hypothesis that newborns are returning to native overwintering sites by following pheromone trails of their mother. Additionally, no newborn snakes were observed near the foraging mothers. Three different patterns of newborn movement behavior were observed. If birth occurred near (within a few meters) the overwintering site, then newborns would easily move to the communal area. If birth occurred distant (e.g., >50 m) to the overwintering site, newborns would typically make movement forays away from the gestation rock. Some of these newborns would return and apparently overwinter near or at the gestation rock. Others would not return to the gestation rock area and would evidently have to seek alternative sites for overwintering. This work was preliminary and requires further research to better understand newborn movement behavior.

Two additional observations from 2018 are noteworthy. One suggests that the American Badger, *Taxidea taxus,* may be a primary predator of gestating *C. o. lutosus* and their newborns. Three of the 18 gestation rocks showed evidence of soil excavation consistent with *T. taxus* digging, and at two of those rocks the occupying female had been killed. This suggests *T. taxus* may be able to specifically target gestation sites for foraging. Second, is that during rain events *C. o. lutosus* would exhibit rain-gathering behavior. During two rain events, multiple *C. o. lutosus* were observed to expose themselves to the rain and form a tight round coil so that water pooled between adjacent body coils. The snakes would then drink the pooled water. The second observation occurred on 5 October 2018 at a snake overwintering site containing snakes that had returned for the winter. In addition to the eight *C. o. lutosus* observed drinking, eight gopher snakes (*Pituophis catenifer*) emerged from underground or from under rocks to drink pooled water. Such unified behavior suggests that the drinking of free water during sporadic rain events is significant for snakes within the Snake River Plain and the INL site.

Acknowledgments

I thank William Doering (Univ. of Idaho undergraduate student) and Derek Schleicher (Craters of the Moon student intern) for assistance in the field with snakes. Kristin Kaser and Jeremy Shive, both with Veolia, helped me with vegetation sampling and GIS, respectively.

9.5 U.S. Geological Survey 2018 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.

Four reports were published by the USGS INL Project Office in 2018. The abstracts of these studies and the publication information associated with each study are presented below.

9.5.1 Updated procedures for using drill cores and cuttings at the Lithologic Core Storage Library, Idaho National Laboratory, Idaho (Hodges, M. K. V. et al., 2018)

In 1990, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy Idaho Operations Office, established the Lithologic Core Storage Library at the Idaho National Laboratory (INL). The facility was established to consolidate, catalog, and permanently store nonradioactive drill cores and cuttings from subsurface investigations conducted at the INL, and to provide a location for researchers to examine, sample, and test these materials.

The facility is open by appointment to researchers for examination, sampling, and testing of cores and cuttings. This report describes the facility and cores and cuttings stored at the facility. Descriptions of cores and cuttings include the corehole names, corehole locations, and depth intervals available.

Most cores and cuttings stored at the facility were drilled at or near the INL, on the eastern Snake River Plain; however, two cores drilled on the western Snake River Plain are stored for comparative studies. Basalt, rhyolite, sedimentary interbeds, and surficial sediments compose most cores and cuttings, most of which are continuous from land surface to their total depth. The deepest continuously drilled core stored at the facility was drilled to 5,000 feet below land surface. This report describes procedures and researchers' responsibilities for access to the facility and for examination, sampling, and return of materials.

9.5.2 Geochemistry of groundwater in the eastern Snake River Plain aquifer, Idaho National Laboratory and vicinity, eastern Idaho (Rattray, G. W. 2018)

Nuclear research activities at the U.S. Department of Energy (DOE) Idaho National Laboratory (INL) in eastern Idaho produced radiochemical and chemical wastes that were discharged to the subsurface, resulting in detectable concentrations of some waste constituents in the

eastern Snake River Plain (ESRP) aquifer. These waste constituents may pose risks to the water quality of the aquifer. In order to understand these risks to water quality the U.S. Geological Survey, in cooperation with the DOE, conducted a study of groundwater geochemistry to improve the understanding of hydrologic and chemical processes in the ESRP aquifer at and near the INL and to understand how these processes affect waste constituents in the aquifer.

Geochemistry data were used to identify sources of recharge, mixing of water, and directions of groundwater flow in the ESRP aquifer at the INL. The geochemistry data were analyzed from 167 sample sites at and near the INL. The sites included 150 groundwater, 13 surface-water, and 4 geothermal-water sites. The data were collected between 1952 and 2012, although most data collected at the INL were collected from 1989 to 1996. Water samples were analyzed for all or most of the following: field parameters, dissolved gases, major ions, dissolved metals, isotope ratios, and environmental tracers.

Sources of recharge identified at the INL were regional groundwater, groundwater from the Little Lost River (LLR) and Birch Creek (BC) valleys, groundwater from the Lost River Range, geothermal water, and surface water from the Big Lost River (BLR), LLR, and BC. Recharge from the BLR that may have occurred during the last glacial epoch, or paleorecharge, may be present at several wells in the southwestern part of the INL. Mixing of water at the INL primarily included mixing of surface water with groundwater from the tributary valleys and mixing of geothermal water with regional groundwater. Additionally, a zone of mixing between tributary valley water and regional groundwater, trending southwesterly, extended from near the northeastern boundary of the INL to the southern boundary of the INL. Groundwater flow directions for regional groundwater were southwesterly, and flow directions for tributary groundwater were southeasterly upon entering the ESRP, but eventually began to flow southwesterly in a direction parallel with regional groundwater.

Several discrepancies were identified from comparison of sources of recharge determined from geochemistry data and backward particle tracking with a groundwater-flow model. Some discrepancies observed in the particle tracking results included representation of recharge from BC near the north INL boundary, groundwater from the BC valley not extending far enough south, regional groundwater that extends too far west in the southern part of the INL, and no representation of recharge from geothermal water in model layer 1 or recharge from the BLR in the southwestern part of the INL.

9.5.3 Localized late Miocene flexure near the western margin of the eastern Snake River Plain, Idaho constrained by regional correlation of Snake River-type rhyolites and kinematic analysis of small-displacement faults (Schusler, K. L., 2018)

The eastern Snake River Plain (ESRP) aquifer is contained within the northeast trending volcanic province known as the ESRP. The majority of the ESRP aquifer flows through rubble zones between basalt layers. In the western Idaho National Laboratory (INL), the base of the ESRP aquifer is likely defined by the contact between subsurface Snake River-type rhyolites and overlying basalts. Near the western margin of the ESRP, basalts are thought to thin, and the subsurface geology and geometry of the basalt-rhyolite contact there are poorly constrained.

A recently drilled rhyolite in borehole USGS 142 is tentatively correlated to the Walcott Tuff B in borehole WO-2. Another rhyolite, exposed at the surface southeast of Arco, Idaho, dips 20 degrees south toward the ESRP, and is tentatively correlated to the uppermost Picabo-aged rhyolite found in borehole INEL-1. These correlations suggest that the tilts of surface and subsurface rhyolites must shallow toward their correlative units from the margin to the center of the ESRP; the tilts of subsurface rhyolites are localized near the margin of the ESRP and northern Basin and Range.

This research also involved a kinematic analysis of northeast-striking, small-offset faults due east of Arco, Idaho as a basis for inferring the tectonic evolution of the western margin of the ESRP. Northeast-striking faults record nearly pure dip-slip offset and a northwest-southeast extension direction. In addition, faults proximal to the ESRP record a northwest-plunging extension direction, whereas faults distal to the ESRP record a shallowly southeast-plunging extension direction. These observations suggest that the northeast-striking faults likely formed as a result of early stages of flexure from the subsidence of the ESRP and were later rotated similarly to Mesozoic fold-hinges.

9.5.4. Completion summary for borehole TAN-2312 at Test Area North, Idaho National Laboratory, Idaho (Twining, B. V., et al., 2018)

In 2017, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, drilled and constructed borehole TAN-2312 for stratigraphic framework analyses and long-term groundwater monitoring of the eastern Snake River Plain aquifer at the Idaho National Laboratory in southeast Idaho. The location of borehole TAN-2312 was selected because it was downgradient from TAN and believed to be the outer extent of waste plumes originating from the TAN facility. Borehole TAN-2312 initially was cored to collect continuous geologic data, and then re-drilled to complete construction as a monitor well. The final construction for borehole TAN-2312 required 16- and 10-inch diameter carbon-steel well casing to 37 and 228 feet below land surface (ft BLS), respectively, and 9.9-inch. diameter open-hole completion below the casing to 522 ft BLS. Depth to water is measured near 244 ft BLS. Following construction and data collection, a temporary submersible pump and water-level access line were placed near 340 ft BLS to allow for aquifer testing, for collecting periodic water samples, and for measuring water levels.

Borehole TAN-2312 was cored continuously, starting at the first basalt contact (about 37 ft BLS) to a depth of 568 ft BLS. Not including surface sediment (0–37 ft), recovery of basalt and sediment core at borehole TAN-2312 was about 93%; however, core recovery from 170 to 568 ft BLS was 100%. Based on visual inspection of core and geophysical data, basalt examined from 37 to 568 ft BLS consists of about 32 basalt flows that range from approximately 3 to 87 ft in thickness and 4 sediment layers with a combined thickness of approximately 76 ft. About 2 ft of total sediment was described for the saturated zone, observed from 244 to 568 ft BLS, near 296 and 481 ft BLS. Sediment described for the saturated zone were composed of fine-grained sand and silt with a lesser amount of clay. Basalt texture for borehole TAN-2312 generally was described as aphanitic, phaneritic, and porphyritic. Basalt flows varied from highly fractured to dense with high to low vesiculation.

Geophysical and borehole video logs were collected after core drilling and after final construction at borehole TAN-2312. Geophysical logs were examined synergistically with available core material to suggest zones where groundwater flow was anticipated. Natural gamma log measurements were used to assess sediment layer thickness and location. Neutron and gamma-gamma source logs were used to identify fractured areas for aquifer testing. Acoustic televiewer logs, fluid logs, and electromagnetic flow meter results were used to identify fractures and assess groundwater movement when compared against neutron measurements. Furthermore, gyroscopic deviation measurements were used to measure horizontal and vertical displacement for borehole TAN-2312.

After construction of borehole TAN-2312, a single-well aquifer test was completed September 27, 2017, to provide estimates of transmissivity and hydraulic conductivity. Estimates for transmissivity and hydraulic conductivity were 1.51×102 feet squared per day and 0.23 feet per day, respectively. During the 220-minute aquifer test, well TAN-2312 had about 23 ft of measured drawdown at sustained pumping rate of 27.2 gallons per minute. The transmissivity and hydraulic conductivity estimates for well TAN-2312 were lower than the values determined from previous aquifer tests in other wells near Test Area North.

Water samples were analyzed for cations, anions, metals, nutrients, volatile organic compounds, stable isotopes, and radionuclides. Water samples for most of the inorganic constituents showed concentrations near background levels for eastern regional groundwater. Water samples for stable isotopes of oxygen, hydrogen, and sulfur indicated some possible influence of irrigation on the water quality. The volatile organic compound data indicated that this well had some minor influence by wastewater disposal practices at Test Area North.

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Common Nighthawk
Chordeiles minor

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Lost River Sinks

Western Tanager
Piranga ludoviciana

10. Quality Assurance of Environmental Monitoring Programs

2018

10. QUALITY ASSURANCE OF ENVIRONMENTAL MONITORING PROGRAMS

Quality assurance (QA) consists of planned and systematic activities that give confidence in effluent monitoring and environmental surveillance program results (NCRP 2012). Environmental monitoring programs should provide data of known quality for the assessments and decisions being made. This chapter describes specific measures taken to ensure adequate data quality and summarizes performance.

10.1 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 O 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.

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.

10.2 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 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 measurement, 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 10-1 and are discussed below. Summaries of program-specific QC data are presented in Section 10.3. Documentation of the QA programs is provided in Section 10.4.

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

10.2.1 Planning

Environmental monitoring activities are conducted by a variety of organizations including:

- Idaho National Laboratory
- Idaho Cleanup Project (ICP) Core
- Environmental Surveillance, Education, and Research (ESER) Program
- U.S. Geological Survey (USGS)
- National Oceanic and Atmospheric Administration (NOAA)

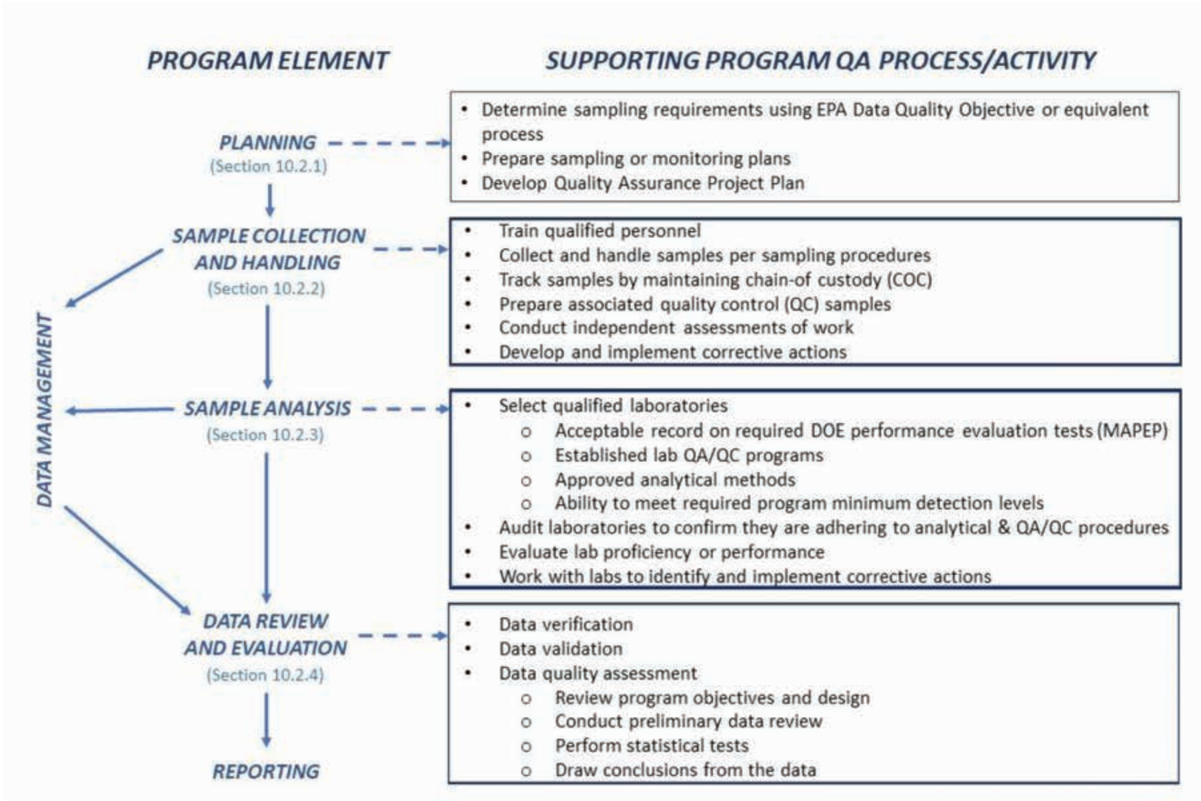

Figure 10-1. Flow of Environmental Monitoring Program Elements and Associated QA Processes and Activities.

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 and Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update. The *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014) and the *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2012) summarizes the various programs at the INL Site, including 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

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.

A QA Project Plan 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 QA Project Plan.

10.2.2 Sample Collection and Handling

Strict adherence to program procedures is an implicit foundation of QA. In 2018, 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 10.2.3).

10.2.3 Sample Analysis

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 10-1.

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.

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 10.3.1. Continued acceptable performance in programs such as but not limited to MAPEP is required to remain as the contracted laboratory. Laboratories are audited for their adherence to QA/QC procedures and specific requirements outlined in their contract agreements. Programs exist to help contract holders conduct

Table 10-1. 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	Radiological
ICP Core Liquid Effluent Monitoring Program	Intermountain Analytical Service – EnviroChem	Microbiological
	GEL Laboratories, LLC	Inorganic and radiological
ICP Core Groundwater Monitoring Program	Intermountain Analytical Service – EnviroChem	Microbiological
	GEL Laboratories, LLC	Inorganic, organic, and radiological
INL Drinking Water Program	GEL Laboratories, LLC	Inorganic and 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	Inorganic and radiological
INL Environmental Surveillance Program	ALS Laboratory Group	Radiological
	Environmental Services In Situ Gamma Laboratory	^{131}I
	Landauer, Inc.	Penetrating radiation (optically stimulated luminescent and neutron dosimeters)
Environmental Surveillance, Education, and Research Program	Environmental Assessments Laboratory (EAL) at Idaho State University (ISU)	Gross radionuclide analyses (gross alpha and gross beta), optically stimulated luminescent dosimetry, liquid scintillation counting (tritium), and gamma spectrometry
	GEL Laboratories, LLC	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$) and gamma spectrometry.

Table 10-1. Analytical Laboratories Used by INL Site Contractors and USGS Environmental Monitoring Programs. (cont.)

Contractor and Program	Laboratory	Type of Analysis
U.S. Geological Survey (USGS)	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

and assess a laboratory's ongoing performance. Requirements for participation in specific programs are at the discretion of the contract holder. One program, the Department of Energy Consolidated Audit Program-Accreditation Program (DOECAP-AP), accredits laboratories in meeting requirements outlined in the Quality System Manual (QSM). The QSM was developed by technical experts and contract holders throughout the DOE system. Examples of QSM requirements include:

- personnel training and qualification
- detailed analytical procedures
- calibration of instrumentation
- participation in an inter-comparison program
- use of blind controls
- analysis of calibration standards

Any issues identified during the accreditation process requires corrective action plans for audit findings and are closed when the third-party accrediting body 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. A known quantity of material, radionuclides, or nonradioactive substances are incorporated into a sample in order to evaluate the laboratory's ability to detect. These samples are typically traceable to National Institute of Standards and Technology (NIST) requirements. Samples are submitted to the laboratory with regular field samples using the same labeling and sample numbering system, or they can be submitted by a third party directly to evaluate the performance of the laboratory. The MAPEP is an example of this (see Section 10.3.1). The

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).

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.

10.2.4 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.

10.3 Quality Control Results for 2018

Results of the QC measurements for specific DOE contracted environmental programs in 2018 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. MAPEP proficiency is no longer required for DOECAP-AP accreditation.

10.3.1 Mixed Analyte Performance Evaluation Program Proficiency Tests

The MAPEP is administered by DOE's Radiological and Environmental Sciences Laboratory (RESL). The 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. The RESL maintains the following accreditation certifications through the American Association for Laboratory 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 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 Radiological Traceability Program, 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 38 was distributed in March 2018, and Series 39 was distributed in August 2018. 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%
- W = Result acceptable with warning, 20% < bias < 30%
- N = Result not acceptable, bias > 30%
- 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 2.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% bias], ^{238}Pu in soil test 14 "-N" [-43% 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%], ^{137}Cs in soil test 14 "+N" [+45%]).
- Consistent bias, either positive or negative, at the "Warning" level (greater than ± 20% 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%], ^{90}Sr in air filter test 14 "+W" [+28%]).
- 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%], ^{241}Am in soil test 13 "+W" [+24%], ^{241}Am in soil test 14 "-N" [-38%]).
- 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 2018, each radiological laboratory used by the INL, ICP Core, and ESER contractors participated in the 2018 MAPEP Series 38 (March 2018) and 39 (August 2018). The laboratories of interest evaluated were ALS-Fort Collins (ALS-FC), 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-FC is located in Fort Collins, Colorado. The INL and ICP Core contractors used ALS-FC for their surveillance programs. The isotopic analytes of common interest to the INL and ICP Core surveillance programs include: ^{90}Sr, ^{241}Am, ^{238}Pu, and plutonium-239/240 ($^{239/240}$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, cobalt-60 (^{60}Co), cesium-134 (^{134}Cs), cesium-137 (^{137}Cs), europium-152 (^{152}Eu), and antimony-125 (^{125}Sb). The same isotopic analytes and gamma-emitting radionuclides were analyzed for surface water and vegetation samples collected by the ICP Core contractor.

For MAPEP Series 38 and 39, all analytes of interest in air filters were acceptable. All analytes of interest in vegetation were also acceptable for MAPEP Series 38 and 39. All analytes of interest in water were acceptable except for radium-226 in MAPEP Series 38, which received an "N" flag. For MAPEP Series 39, tritium (^{3}H) and radium-226 received a "W" flag. The MAPEP results for these INL and ICP Core programs reported by ALS-FC do not demonstrate any issues of concern for the 2018 air data. The programs will continue to monitor the MAPEP results to determine if any trends warrant further action.

Idaho State University Environmental Assessment Laboratory. The ISU-EAL is located in Pocatello, Idaho. The ESER contractor uses ISU-EAL to analyze samples for the following analytes of interest: ^{3}H, gross alpha and gross beta, and multiple gamma spectrometry radioisotopes.

All analytes of interest were acceptable for MAPEP Series 38 and 39. The MAPEP results do not demonstrate any issues of concern for the 2018 data reported by ISU-EAL. The ESER contractor will continue to monitor the MAPEP results to determine 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 ESER Program started using GEL for their 2018 sampling analyses. Analytes of interest are ^{241}Am, ^{238}Pu, $^{239/240}$Pu and ^{90}Sr in air filters, waterfowl, soil, and bats (including gamma spectrometry) and ^{90}Sr only in milk and produce (lettuce, alfalfa, wheat, and potatoes) samples.

All other analytes of interest for media of concern were "A" (Acceptable) for both Series 38 and 39. The MAPEP results for INL, ICP Core, and ESER programs reported by GEL do not demonstrate any issues of concern for the 2018 data.

10.3.2 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 2018 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%) samples should be collected and analyzed.

10.3.2.1 Liquid Effluent and Groundwater Monitoring Program Quality Control Data

INL Contractor

The INL contractor Liquid Effluent Monitoring Program (LEMP) and Groundwater Monitoring Program (GWMP) have specific QA/QC objectives for analytical data. Table 10-2 presents a summary of 2018 LEMP, GWMP, and Drinking Water Program (DWP) QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness is to collect 100% of all required compliance samples. In 2018 these goals were met.

Precision – Field Duplicates. Field duplicates are collected annually at each sample location, or 10% of the total samples collected, in order to assess measurement uncertainty and variability caused by sample heterogeneity and collection methods. In 2018, field duplicates were

Table 10-2. 2018 INL Liquid Effluent Monitoring Program, Groundwater Monitoring Program, and Drinking Water Program QA/QC Criteria and Performance.

Liquid Effluent Monitoring Program	Criterion	2018 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		
	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 Program	**Criterion**	**2018 Performance**
	Completeness	
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	98% (58/59)
Surveillance Samples Collected and Successfully Analyzed	90%	99% (206/208)
	Precision	
Field Duplicates	90%	100%
Field Blanks	90%	100%
	Accuracy	
Liquid Effluent Monitoring Program	**Criterion**	**2018 Performance**
Performance Evaluation Samples Note: 23 out of 98 samples were QA/QC.	90%	100%

collected at the Advanced Test Reactor Complex Cold Waste Pond, USGS-098, Materials and Fuels Complex Industrial Waste Pipeline, Ditch C, 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 the RPD from field duplicates be less than or equal to 35% for 90% of the analyses. In 2018, 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 Core 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 10-3 presents a summary of 2018 QC criteria and performance results.

Completeness – Collection and Analysis. The ICP Core LEMP goal for completeness was to collect and successfully analyze 100% of all permit-required compliance samples. This goal was met in 2018. The permit required a total of 276 parameters to be collected and analyzed during the year. All 276 sample parameters were collected, submitted for analysis, and successfully analyzed. The results are provided in the 2018 Wastewater Reuse Report (ICP 2019) and summarized in Tables C-4, C-5, and C-6.

The goal for completeness was to collect and successfully analyze 90% of the LEMP surveillance samples. This goal was exceeded in 2018, because 100% of the samples were collected and analyzed. A total of 350 sample parameters were collected, and 350 parameters were successfully analyzed. The summary results are provided in Table C-15.

Precision – Field Duplicate Samples. To quantify measurement uncertainty from field activities, an annual nonradiological field duplicate sample was collected at CPP-797 on March 14, 2018, 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% or less for 90% of the parameters analyzed. One-hundred percent of the results had an RPD of less than or equal to 35%. This is a marked improvement from last year's value.

An annual radiological field duplicate sample was collected at CPP-797 on November 1, 2018, 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% of the parameters. Of the 25 parameters analyzed, only gross beta and gross alpha had two statistically positive results. The mean difference was calculated to be 1.96, which was less than 3.

Accuracy – Performance Evaluation Samples. During 2018, performance evaluation samples were submitted to the laboratory with routine wastewater monitoring samples on December 13, 2018. Seventy-nine percent of the results were within their QC performance acceptance limits, which was less than the program goal of 90%. ICP Core will continue to work with the analytical laboratories to improve this value.

Introduction of Contamination – Field Blank Samples. A field blank was collected on September 5, 2018. A total of five parameters were analyzed, and none of the parameters were detected.

Decontamination – Equipment Rinsate Samples. Equipment rinsate samples are collected annually and are used to evaluate the effectiveness of equipment decontamination. On June 13, 2018, a sample carboy associated with CPP-797 was decontaminated by the Idaho Nuclear Technology and Engineering Center licensed wastewater operators. After decontamination, deionized water was added to the carboy, and the rinsate samples were collected by LEMP personnel. A total of 10 parameters were analyzed, and none of the parameters were detected.

Table 10-3. 2018 ICP Core Liquid Effluent Monitoring Program, Wastewater Reuse Permit Groundwater Monitoring Program, and Drinking Water Program QA/QC Goals and Performance.

ICP Core Liquid Effluent Monitoring Program	Criterion	2018 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%
Equipment rinsates	90%	100%
Field blanks	90%	100%
Accuracy		
Performance evaluation samples	90%	79%
ICP Core WRP Groundwater Monitoring Program	**Criterion**	**2018 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%
Equipment rinsates	90%	85%
Field blanks	90%	100%
Accuracy		
Performance evaluation samples	90%	92%
ICP Core Drinking Water Monitoring Program	**Criterion**	**2018 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%

WRP = Wastewater Reuse Permit

10.3.2.2 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 laboratory performance evaluation samples. Table 10-3 presents a summary of 2018 WRP GWMP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze

100% of all required compliance samples. This goal was met in 2018. A total of 176 sample parameters were collected and submitted for analysis, and 176 parameters were successfully analyzed. The results are provided in Tables C-8 and C-9 and summarized in the 2018 Wastewater Reuse Report (ICP 2019).

The goal for completeness was to collect and successfully analyze 90% of the WRP GWMP surveillance samples. This goal was exceeded in 2018. Sixteen parameters, or 100%, were collected and successfully analyzed. The results are provided in Table C-16.

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% or less for 90% of the parameters analyzed. Field duplicate samples were collected from Well ICPP-MON-V-200 on April 10, 2018, and from Well ICPP-MON-A-166 on September 26, 2018. One-hundred percent of the results had an RPD of less than or equal to 35%. This is an improvement from last year's value.

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 10, 2018, and from Well ICPP-MON-A-166 on September 26, 2018. 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% 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 three.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory in April 2018. Ninety-two percent of the performance evaluation sample results were within their QC performance acceptance limits.

Introduction of Contaminants – Field Blank Samples. Field blanks were collected on April 11, 2018, and analyzed for the permit-specific metals and radiological parameters. All the parameters tested were not detected.

Introduction of Contaminants – Equipment Rinsate Samples. Equipment rinsates were collected on April 11, 2018, and analyzed for the permit-specific parameters. A total of 13 parameters were analyzed, and 11 of these parameters were not detected in the samples. Total dissolved solids and conductivity were detected above their respective detection/reporting limits in the sample. Since these parameters are typically found in water, the analytical detections do not negatively impact data usability.

10.3.2.3 Idaho Cleanup Project Contractor Groundwater Monitoring Quality Control Data

QA/QC samples and results for Waste Area Groups (WAG) 1, WAG 3, and WAG 4 are discussed in the annual reports for Fiscal Year 2017 (DOE-ID 2018a, 2018b, 2018c) and for WAG 2 in the Fiscal Year 2018 report (DOE-ID 2018d). QA/QC samples for WAG 7 were not collected in 2018, as discussed in Section 5.5.7.

10.3.2.4 Drinking Water Program Quality Control Data

INL Contractor

The INL contractor Drinking Water Program (DWP) 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% of the surveillance and 100% 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% of the surveillance, and 100% of the compliance samples must be successfully collected on an annual basis and reported according to the specified procedures. This criteria was not met due to one compliance sample not being reported because of suspected bottle contamination. Data was evaluated, and the quality of the other samples was not affected; thus, no further corrective action was needed.

Precision – Field Duplicates. DWP goals are established for precision of less than or equal to 35% for 90% of the analyses. The DWP 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%. Results reported as nondetect are not used in the RPD calculation.

For 2018, the DWP reported 31 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 Core Contractor

The ICP Core 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 10-3 presents a summary of 2018 DWP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze 100% of all required compliance samples. This goal was met in 2018. A total of 132 parameters were collected and submitted for analysis, and 132 parameters were successfully analyzed. For the DWP surveillance samples, the goal for completeness was to collect and successfully analyze 90% of the samples. This goal was exceeded in 2018. A total of 268 parameters were collected and 100% of these parameters were successfully analyzed.

Precision – Field Duplicates. Field duplicate samples were collected on August 14, 2018 (disinfection byproducts), and October 31, 2018 (volatile organic compounds). The RPD determined from field duplicate samples should be 35% or less for 90% of the parameters analyzed. One-hundred percent of the results had an RPD of less than or equal to 35%.

A radiological field duplicate sample was collected from WMF-604 on February 19, 2018, and analyzed for ^{3}H. The mean difference was calculated to be 0.5, which was less than three. On August 28, 2018, a radiological field duplicate sample was collected from CPP-614 and analyzed for gross alpha and gross beta. Neither parameter had two statistically positive results.

Accuracy – Performance Evaluation Samples. Accuracy of results was assessed using the laboratory's control samples, initial and continuing calibration samples, and matrix spikes. No laboratory issues were identified from the performance of these QA/QC samples.

Introduction of Contaminants – Field Blank Samples. A field blank was prepared as part of the January 25, 2018 (volatile organic compounds), sampling event. One-hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90%.

Introduction of Contaminants – Trip Blank Samples. Trip blanks were prepared as part of the following sampling events: January 25, 2018 (volatile organic compounds); April 25, 2018 (volatile organic compounds); July 25, 2018 (volatile organic compounds); and October 31, 2018 (volatile organic compounds). One-hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90%.

10.3.2.5 Environmental Surveillance, Education, and Research Program Quality Control Data

Table 10-4 presents a summary of 2018 ESER QC analysis results.

Completeness – Collection and Analysis. The ESER contractor met its completeness goals of greater than 98% in 2018. Three air samples were considered invalid because insufficient volumes were collected due to power interruptions (i.e., blown fuse and/or tripped breaker). Two optically stimulated luminescent dosimeters (OSLD) and two thermoluminescent dosimeter (TLD) samples were considered invalid because they were lost from a construction event in the area. All other samples were collected and analyzed as planned.

Table 10-4. 2018 ESER Surveillance Program Quality Assurance Elements.

QC Program Element 2018	Criterion	Performance[a]
Completeness		
Surveillance Samples Successfully Completed	100%	99.7%
Submitted Surveillance Samples Successfully Analyzed	100%	100%
Accuracy		
Blind Spike Program		
Idaho State University - Environmental Assessment Lab (EAL)[b]	90%	100%
General Engineering Laboratory - (GEL)[c]	90%	82.4%
Precision		
Field Duplicates		
EAL	Differences within 3 standard deviations (3σ) or within ± 20 percent RPD	100%
GEL		95.7%
Field Blanks		
EAL	± 3σ of Zero	94.7%
GEL		94.1%

a. Sample matrices include: water (drinking, surface, and precipitation), air filter, milk, soil, TLD/OSLD, vegetation (grain, alfalfa, potato, lettuce), and waterfowl. Big game (deer, elk, pronghorn) 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 spectrometry (i.e. ^{137}Cs, and ^{131}I), tritium, gross alpha, and gross beta.

c. GEL - ESER requested analysis: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu, gamma spectrometry (bats only).

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 (Atomic City and Blue Dome) 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 100% and the GEL in 95.7% of all environmental samples collected during 2018, 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 the RESL, as described in Section 10.3.1, for soil, wheat, air particulate filter, milk, and water samples. All the acceptance criteria are for three-sigma limits and ± 30% 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 eight double blind spike sample sets to the ISU-EAL laboratory during the 2018 calendar year for gamma spectrometry and liquid scintillation analysis. The following matrices were spiked for the 2018 year: water, air particulate filters, milk, soil, wheat, potato, lettuce, and alfalfa. The ISU-EAL submitted sample results for 49 individual analytes that had recovery analysis completed by the RESL; 49 had an Agreement of "YES". This was a 100% (i.e., 49/49 x 100) performance in the ESER double blind spike program.

The ESER Program sent five double blind spike sample sets to the GEL laboratory during the 2018 calendar year for radiochemical analysis. The following matrices were spiked for the 2018 year: water, air particulate filters, milk, soil, lettuce, potato, and wheat. The GEL submitted sample results for 17 individual analytes that had recovery analysis completed by the RESL; 14 had an Agreement of "YES." This was 82.4% (i.e., 14/17 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 2018, the ISU-EAL attained over 94.7% performance of blanks within one to three standard deviations of zero; the GEL had a 94.1% performance of blanks with the above stated criterion.

10.3.2.6 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 inter-comparison 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 10-5).

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 1,100 planned air samples, six were invalid because of power interruptions (i.e., blown fuses and/ or tripped breakers), inaccessibility due to weather, and insufficient volumes. Of the 392 planned dosimeter badges, two OSLDs and five neutron badges were considered invalid because they were lost or damaged in the field. All other dosimeters were collected and analyzed as planned for completeness of 98%.

Precision – Collocated Samples. To allow for data comparisons, the Environmental Surveillance Program rotates two replicate air samplers that are placed adjacent to regular samplers and that were at Radioactive Waste Management Complex and Idaho Nuclear Technology and Engineering Center (INTEC) locations in 2018. 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% of the mean difference values were less than the goal of three.

Introduction of Contaminants – Media Blanks. In 2018, the majority of the media blanks were within two standard deviations of zero for air. See Table 10-5 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 spectrometry and radiochemistry. During 2018 for the four samples spiked with gamma emitters (i.e., ^{60}Co, ^{134}Cs, ^{137}Cs, manganese-54 [^{54}Mn], zinc-65 [^{65}Zn]) and radionuclides requiring radiochemistry (i.e., ^{241}Am, ^{90}Sr, ^{238}Pu, and $^{239/240}$Pu), the results were in agreement with the known activity, until the fourth quarter. In the fourth quarter the gamma spectrometry results were in agreement, but the radiochemistry results (^{241}Am, ^{90}Sr, ^{238}Pu) were biased low and not in agreement with the known activities.

10.3.2.7 ICP Core Environmental Surveillance for Waste Management Quality Control Data

Table 10-6 summarizes the 2018 ICP Core Environmental Surveillance Program for Waste Management QC analysis results.

Table 10-5. 2018 BEA Environmental Surveillance Program QA Elements.

QC Program Element - 2018	Criterion	Performance
Completeness		
Samples Collected		
Air	90%	99%
Samples Analyzed		
Air	90%	100%
Accuracy		
Performance Evaluation Samples		
Air[a]	Ideally 100%	99%
Precision		
Field Replicates/Duplicates		
Air	MD[b] < 3	
Gross Beta (weekly)	Ideally 100%	99%
Gamma Spec[c] (Quarterly)	Ideally 100%	100%
Laboratory Control Sample		
Air	LCS percent Recovery ± 25%	100%
Media Blanks		
Air	Ideally 100% within 2σ of zero	99%

a. Includes all results for gamma spectrometry and isotopic analysis.
b. Mean difference.
c. As ^7Be.

Completeness. The ICP Core Environmental Surveillance Program for Waste Management completeness goal, which includes samples collected and samples analyzed, is 90%. The collection of air samples was 95.8% in 2018. For gross alpha and gross beta analysis, 11 days of sampling in a two-week period is required. During the month of 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. The samples were still collected and used for gamma spectrometry and isotopic analysis. Also, a few monitors were out for repairs during several collection periods. Surface water samples collected was 100%. Overall sample collection for all media was 95.9%.

Precision – Field Duplicate/Replicate Samples. To measure precision of duplicates/replicates, results are compared using the RPD or the standard deviation criterion (Equation 1); the RPD is acceptable if it is within 20%. For air sampling, a replicate air sampler is set adjacent to a regular sampler. For ambient air, an overall average performance rate of 93.1% was achieved.

$$|R_1 - R_2| \leq 3(s_1^2+s_2^2)^{1/2} \qquad (1)$$

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 collected semiannually. In 2018, a field duplicate was taken during the second quarter sampling. When comparing results of the regular sample and the duplicate sample, precision was 92.8%.

Table 10-6. 2018 ICP Core Environmental Surveillance Program QA Elements.

QC Program Element - 2018	Criterion	Performance[a]
Completeness		
Surveillance samples successfully completed	90%	95.9%
Surveillance samples successfully analyzed	90%	100%
Accuracy		
Blind Spike Program[b]		
ALS Environmental Laboratory – Fort Collins (ALS)	90%	83.0%
Precision		
Field Replicates/Duplicates		
Differences within 3 standard deviations (3σ)	MD[b] > 3	93.1%
Laboratory Control Sample		
All media	Laboratory control sample percent recovery ±25%	100%
Field Blanks		
Air and surface water	Ideally 100% within 2s	81.1%

a. Sample matrices include: air filter and surface water.
b. Requested analyses—gamma spectrometry and isotopic.

The overall precision result for all media sampled was 93.1%.

Accuracy. The ICP Core contractor submitted air and surface water blind spike samples to ALS Laboratory Group for analysis in 2018 to check laboratory accuracy. These samples were prepared at the RESL as described in Section 10.3.1. All air blind spike samples showed 100% satisfactory agreement (within ± 30% of the known value and within three-sigma) for all constituents of concern. For water, blind spike samples showed unsatisfactory agreement for all constituents of concern except for ^{90}Sr (Sample #102611-01) and uranium-238 (Sample #102612-01). For ^{241}Am, ^{238}Pu, and ^{239}Pu, results either did not agree or were "Acceptable with Warning" showing a low bias. The ICP Core contractor is currently investigating the cause of the low bias of the 2018 PE samples for surface water runoff.

Laboratory Inter-comparison QA Programs. ALS Laboratory Group participated in a variety of inter-comparison 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. The laboratory met the performance objectives specified by these two inter-comparison QA programs.

Laboratory Control Samples. All laboratory control sample recoveries were within their acceptance range of ± 25% 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 2018, 81.2% 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}Pu and uranium-234 were detected in the batch blank. In the third quarter, ^{238}Pu was detected.

Positive 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 second 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 2017 and updated as needed, 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 April 2018, the ICP Core QA program performed a triennial surveillance on the air sampling program. No findings were noted. There was an issue with the agreement of analytical results and known values in the 2017 PE samples; however, the laboratory identified the cause (incorrect labeling in the laboratory) and implemented corrective actions (retraining staff) to ensure the problem would not be repeated.

10.3.2.8 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, Maimer, and Wehnke 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, Maimer, and Wehnke 2014). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams, Bartholomay, and Campbell (1998), Bartholomay and Twining (2010), Rattray (2012), Davis, Bartholomay, and Rattray (2013), Rattray (2014); and Bartholomay et. al, (2017). During 2018, the USGS collected 15 replicate samples, five field blank samples, two equipment blank samples, two spike samples, one source solution blank, and one trip blank sample. Evaluation of results will be summarized in future USGS reports.

10.4 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 10-7, Table 10-8, and Table 10-9, respectively.

10.4.1 Idaho National Laboratory Contractor

The INL contractor integrates applicable quality assurance requirements 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 10-7).

10.4.2 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).

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 10-8).

10.4.3 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

Table 10-7. 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-8550, Environmental Support and Services Monitoring Services Surveillance Plan 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-330, Groundwater Monitoring for the Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit LI-148, Portable PH/Conductivity Meter Operating Instructions LI-849, Groundwater Monitoring at the Remote-Handled Low-Level Waste Disposal Facility LI-859, Sampling Vadose Zone Water at the Remote Handled Low-Level Waste Disposal Facility
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
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 Assembly 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

Table 10-7. INL Environmental Program Documentation. (cont.)

Document/Media Type	Document No.[a] and Title
	LI-357, Collecting and Preparing Environmental Dosimetry
	LI-459, Surface Radiation Surveys Using Global Positioning Radiometric Scanner
	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. 5, Battelle Energy Alliance Statement of Work for Analytical Services
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

sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in PLN-5231, "Quality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System," and PLN-5778, "Quality Assurance Project Plan for the RCE and ICE NESHAP Stack Monitoring System."

10.4.4 Environmental Surveillance, Education, and Research Program

The ESER Program QA documentation (Table 10-9) 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 O 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 provides requirements, responsibilities, and authority for implementing the ESER Quality Assurance Project Plan 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.

Table 10-8. 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 Hydrolab 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-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

Table 10-8. ICP Core Environmental Program Documentation. (cont.)

Document/ Media Type	Document No.[a] and Title
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

a. GDE = guide
MCP = management control procedure
PLN = plan
PRD = program requirements document
SPR = sampling procedure
TPR = technical procedure.

10.4.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Water-Quality Activities and Water-Level Measurements (Bartholomay, Maimer, and Wehnke 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 meets 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).

10.4.6 National Oceanic and Atmospheric Administration

The *NOAA Quality Program Plan, NOAA Air Resources Laboratory Field Research Division* (NOAA-ARLFRD 1993) addresses the requirements of DOE O 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 2015. Unscheduled service also is performed promptly whenever a sensor malfunctions.

10.5 Duplicate Sampling among Organizations

The ESER contractor, INL contractor, and the Department of Environmental Quality-INL Oversight Program (DEQ-IOP) collects air samples at four common sampling locations: 1) the distant locations of Craters of the Moon National Monument, 2) Idaho Falls, 3) on the INL Site at the Experimental Field Station, and 4) Van Buren Boulevard Gate. The DEQ-IOP Annual Report for 2018 has not been issued at this time. Results for 2017 are compared in the DEQ-IOP Annual Report (http://www.deq.idaho.gov/inl-oversight/monitoring/reports/).

Table 10-9. ESER Program Documentation.

Document/ Media Type	Document No.[a] and Title
Program Description	DOE/ID-11088 Revision 4, Idaho National Laboratory Site Environmental Monitoring Plan
Quality Procedures	VFS-ID-ESER-PROC-047_Preparation, Review, and Approval of ESER Procedures VFS-ID-ESER-PROC-048_Document Control VFS-ID-ESER-PROC-067 Information Management VFS-ID-ESER-PROC-068 Assessments VFS-ID-ESER-PROC-069 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	VFS-ID-ESER-PROC-024_Low-Volume Air Sampler VFS-ID-ESER-PROC-026_EPA High-Volume Air Sampling VFS-ID-ESER-PROC-029_Precipitation Sampling VFS-ID-ESER-PROC-045_Atmospheric Moisture Sampling VFS-ID-ESER-PROC-027_Environmental Radiation Measurement VFS-ID-ESER-PROC-039_Jackson WY Low-Volume Air Sampler VFS-ID-ESER-PROC-036_Drinking and Surface Water Sampling VFS-ID-ESER-PROC-028_Soil Sampling VFS-ID-ESER-PROC-050_Milk Sampling VFS-ID-ESER-PROC-057_Lettuce Sampling VFS-ID-ESER-PROC-038_Grain Sampling VFS-ID-ESER-PROC-055_Potato Sampling VFS-ID-ESER-PROC-035_Large Game Animal VFS-ID-ESER-PROC-049_Waterfowl Sampling VFS-ID-ESER-PROC-054_Alfalfa Sampling VFS-ID-ESER-PROC-056_Calibration of INL Offsite Environmental Surveillance Program Equipment VFS-ID-ESER-PROC-043_Sample Handling, Custody, Delivery for Analysis VFS-ID-ESER-PROC-025_ESER Environmental Surveillance Data Preparation VFS-ID-ESER-PROC-042_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
QIP = Quality Implementation Plan
QMP = Quality Management Plan

Common Nighthawk
Chordeiles minor

DEQ-IOP 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-IOP 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-IOP has placed several electret ionization chambers at locations monitored by DOE contractors, using TLDs and OSLDs. Comparisons of results may be found in the 2017 DEQ-IOP Annual Report.

The DEQ-IOP 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-IOP Annual Report for 2017.

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40 CFR 61, 2019, Appendix B, “Test Methods, Method 114, Test Methods for Measuring Radionuclide Emissions from Stationary Sources,” *Code of Federal Regulations*, Office of the Federal Register; available electronically at https://www.ecfr.gov/cgi-bin/text-idx?SID=1724f1c1459afe2593f049ee3b7c85ae&mc=true&node=sp40.10.61.b&rgn=div6 last visited July 8, 2019.

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Barn Swallow
Hirundo rustica

Appendix A. Environmental Statues 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, 2019, "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; https://ecfr.io/Title-36/pt36.1.79, last visited September 9, 2019.
- 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; https://ecfr.io/Title-36/cfr800_main, last visited September 9, 2019.
- 40 CFR 50, 2019, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.2.50, last visited September 9, 2019.
- 40 CFR 61, 2019, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.10.61, last visited September 9, 2019.
- 40 CFR 61, Subpart H, 2019, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.10.61#sp40.10.61.h, last visited September 9, 2019.
- 40 CFR 112, 2019, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/cfr112_main, last visited September 9, 2019.
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- 40 CFR 141, 2019, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.25.141, last visited September 9, 2019.
- 40 CFR 142, 2019, "National Primary Drinking Water Regulations Implementation," *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.25.142, last visited September 9, 2019.
- 40 CFR 143, 2019, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.25.143, last visited September 9, 2019.
- 40 CFR 260, 2019, "Hazardous Waste Management System: General," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.28 260, last visited September 9, 2019.
- 40 CFR 261, 2019, "Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.28.261, last visited September 9, 2019.
- 40 CFR 262, 2019, "Standards Applicable to Generators of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.28.262, last visited September 9, 2019.
- 40 CFR 263, 2019, "Standards Applicable to Transporters of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-40/pt40.28.263, last visited September 9, 2019.
- 40 CFR 264, 2019, "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; https://ecfr.io/Title-40/pt40.28.264, last visited September 9, 2019.

- 40 CFR 265, 2019, "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; https://ecfr.io/Title-40/pt40.28.265, last visited September 9, 2019.
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- 50 CFR 450–453, 2019, "Endangered Species Exemption Process," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register; https://ecfr.io/Title-50/pt50.11.450, last visited September 9, 2019.
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- 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, 2019, “Rules for the Control of Air Pollution in Idaho,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580101.pdf, last visited September 9, 2019.
- IDAPA 58.01.02, 2019, “Water Quality Standards,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580102.pdf, last visited September 9, 2019.
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- IDAPA 58.01.06, 2019, “Solid Waste Management Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580106.pdf, last visited September 9, 2019.
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- IDAPA 58.01.11, 2019, “Ground Water Quality Rule,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580111.pdf, last visited September 9, 2019.
- IDAPA 58.01.15, 2019, “Rules Governing the Cleaning of Septic Tanks,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current58/580115.pdf, last visited September 9, 2019.
- IDAPA 58.01.16, 2019, “Wastewater Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580116.pdf, last visited September 9, 2019.
- IDAPA 58.01.17, 2019, “Recycled Water Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580117.pdf, last visited September 9, 2019.

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 O 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 (2019) and the Idaho groundwater quality values from IDAPA 58.01.11 (2019).

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

Radiation Standard	Effective Dose Equivalent (mrem/yr)	Effective Dose Equivalent (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]	1.0×10^{-10}	3.3×10^{-7}
Tritium (tritiated water)	2.1×10^{-7}	1.9×10^{-3}	Iodine-131[f]	4.1×10^{-10}	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]	2.0×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	—	Iodine-135[f]	9.7×10^{-9}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[e]	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[e]	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[e]	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[e]	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[e]	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 O 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	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.

Big Lost River

Appendix B. Cultural Resource Reviews Performed at the INL Site

The Idaho National Laboratory (INL) Cultural Resource Management Office (CRMO) resides within U.S. Department of Energy - Idaho Operations Office's (DOE-ID) INL Management and Operations Contractor, Battelle Energy Alliance. Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the *INL Cultural Resource Management Pla*n (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 Battelle Energy Alliance and other INL Site contractors and in company procedures that guide work completion.

B.1 INL Section 106 Project Reviews

Cultural resource identification and evaluation studies in fiscal year (FY) 2018 included archaeological field surveys related to INL Site project activities as well as broader research goals, archival and historic research, routine monitoring of sensitive resources and ground disturbance associated with active INL Site projects, and meaningful interaction with members of the Shoshone-Bannock Tribes and public stakeholders who value the largely undisturbed legacy of human history and prehistory that is preserved at the INL Site. The totals reported in this section are derived from surveys related to INL Site project reviews.

In FY 2018, 29 INL Site project reviews were completed to assess potential impacts to archaeological resources per the general requirements of Section 106 of the National Historic Preservation Act. Field investigations were completed for 16 of these proposed projects and 342 acres were intensively surveyed for cultural resources. Table B-1 provides a summary of the cultural resource reviews performed in 2018.

Reporting for FY 2018 INL Site Cultural Resource Management (CRM) projects consisted largely of recommendations tailored to specific projects and any archaeological resources that required consideration, all delivered in official e-mail notes that became part of the projects' National Environmental Policy Act-driven Environmental Checklists and permanent records. Several project-specific reports or plans were also prepared.

The INL Cultural Resource Management Plan defines architectural historic properties as buildings, structures, and objects that are eligible for listing on the National Register of Historic Places (NRHP). The historic property management approach includes property categories under which architectural properties are defined as eligible for listing on the NRHP. The four architectural property categories are (INL Cultural Resource Management Plan 2016: pg. 160):

- ***Signature Properties:*** A term used by U.S. Department of Energy-Headquarters, Signature Properties represent the most historically important properties across the complex and/or properties that are viewed as having tourism potential. These properties are documented through Historic American Buildings Survey (HABS), Historic American Engineering Record (HAER), or Historic American Landscape Survey reports, or NRHP nomination packets, regardless of their ultimate disposition.
- ***Category 1 Properties:*** Key individual INL properties (generally reactor buildings) that, through periodic reviews, may be reclassified as Signature Properties.
- ***Category 2 Properties:*** INL properties, which are contributing to the historic context and landscape, and which are directly associated with Signature or Category 1 properties.
- ***Category 3 Properties:*** INL properties, which are contributing to the historic context and landscape, but which are not directly associated with Signature or Category 1 properties.

When an effect on a historic architectural property will be adverse and avoidance or reuse is infeasible, mitigation to minimize the adverse effect is necessary. Based on the relative importance of the affected property, as defined by the property category, mitigation includes varying types of documentation and potentially other activities (DOE-ID 2016).

Fifty-six projects were identified for cultural resource review for potential effects to historic architectural properties in FY 2018 (Table B-2). Most of these proj-

Table B-1. FY 2018 Projects for Archaeological Properties.

CRMO Project No.	Project Title	Associated Documentation	Survey Required	Project Area (acres)	Number of Historic Properties	Recommendations and Mitigation	Idaho SHPO Consult
BEA-18-02	ATR Complex Potable Water Well	EC INL-18-057	No	5	0	No Effect	N/A
BEA-18-03	Wireless Test Bed Tower	EC INL-18-060	Yes	7	0	No Effect	N/A
BEA-18-04	Drinking Water Well Signs	EC INL-17-127	Yes	2	0	No Effect	N/A
BEA-18-06	PBF Exercises	EC INL-15-101	No	N/A[a]	N/A	No Effect	N/A
BEA-18-07	SMC Warehouse	EC INL-17-002	Yes	9	0	No Effect	N/A
BEA-18-08	NRF Spent Fuel Expansion	NRF EIS-0453	Yes	22	2	No Adverse Effect	Yes
BEA-18-09	Sandia Weapons Storage Enclosures	EC INL-17-126	No	N/A	N/A	No Effect	N/A
BEA-18-11	USGS Wells	EC INL-18-013	Yes	1	0	No Effect	N/A
BEA-18-12	VTR Seismic Studies	EC INL-18-014	Yes	1	0	No Effect	N/A
BEA-18-13	Power Line Testing	EC INL-13-017, Rev. 5	No	0	0	No Effect	N/A
BEA-18-16	NHS Wireless Testing	EC INL-15-031, Rev. 3	No	0	0	No Effect	N/A
BEA-18-17	T-28 North Gravel Pit Berm	—	Yes	42	0	No Effect	N/A
BEA-18-18	CFA Landfill	EC INL-16-036	Yes	35	0	No Effect	N/A
BEA-18-19	Maintaining INL Unpaved Roads	EC INL-18-029	No	0	0	No Effect	N/A
BEA-18-22	SMC Temporary Trailer	EC INL-18-047	No	0	0	No Effect	N/A
BEA-18-23	HFTB Gravel	EC INL-15-149, Rev. 2	No	0	0	No Effect	N/A
BEA-18-24	Fluor Road Blading	INL/LTD-12-27685	Yes	5	0	No Effect	N/A
BEA-18-25	CFA Live Fire Range Shoothouse	EC INL-17-077	Yes	1	1	No Adverse Effect	N/A
BEA-18-26	Iona Hill Land Transfer	DOE Revocation of Withdrawal	Yes	40	0	No Effect	N/A
BEA-18-27	PBF-612 Maintenance	EC INL-18-054	No	1	0	No Effect	N/A
BEA-18-28	Communication Tests	EC INL-18-060	No	0	0	No Effect	N/A
BEA-18-29	West Bay Well Rehabilitation	FLUOR M1392EC	No	0	0	No Effect	N/A
BEA-18-30	Adams Blvd Source Sampling	FLUOR M1391EC	No	0	0	No Effect	N/A
BEA-18-31	ATR Air Leak	EC INL-18-075	No	0	0	No Effect	N/A

Table B-1. FY 2018 Projects for Archaeological Properties. (cont.)

CRMO Project No.	Project Title	Associated Documentation	Survey Required	Project Area (acres)	Number of Historic Properties	Recommendations and Mitigation	Idaho SHPO Consult
BEA-18-33	SMC Parking Lot Improvements	EC INL-18-079	Yes	68	0	No Effect	N/A
BEA-18-34	SMR Seismic Station	EC INL-18-095	Yes	1	0	No Effect	N/A
BEA-18-36	Crater Butte Fence	EC INL-18-104	Yes	1	0	No Effect	N/A
BEA-18-38	TAN Fire and Potable Line Replacement	EC INL-18-073	Yes	62	0	No Effect	N/A
BEA-18-39	Obsidian Test Pad	EC INL-18-110	Yes	45	0	No Effect	N/A

a. N/A = not applicable

ects involved exempt activities including routine maintenance, replacement-in-kind, safety systems, and internal reconfiguration of active laboratories.

Two of these projects completed required mitigation:

- ***BEA 18 H031* -** Install Floor Tile in TRA 616; Category 3 property type mitigation, in the form of digital photography and completion of an Idaho Historic Sites Inventory form.
- ***BEA 18 H054*** – 2018 CFA Excess Facilities Deactivation and Demolition; Category 2 property type mitigation, in the form of large format photography as part of a Historic American Landscape Survey.

B.2 INL Section 110 Research

In 2018, INL cultural resource investigations were also conducted to further DOE-ID obligations under Section 110 of the National Historic Preservation Act. These efforts were designed to develop a broad understanding of regional Native American and Euroamerican land use patterns, as well as assist in formulating historic contexts as per the *INL Cultural Resource Management Plan* (DOE-ID 2016). In 2018, there were two active Section 110 research designs to address archaeological context on the INL. These designs focus on (1) Lake Terreton and terminal Pleistocene and early Holocene archaeological record of the Pioneer Basin, and (2) trade and transport of southern Idaho volcanic glass sources.

In 2018, roughly 100 acres were intensively inventoried and five archaeological sites were recorded as part of the Lake Terreton research design. With permission of private landowners, as well as BLM, CRMO staff have so far gathered source samples from Timber Butte, Brown's Bench, Big Southern Butte, Coal Banks, Cannonball Mountain, Malad, and Lake Walcott (Figure B-1). Preliminary results from sources gathered in 2018 indicate that significant differences exist between volcanic glass sources utilized during the terminal Pleistocene and early Holocene, and those represented in Holocene assemblages. This suggests that land use patterns in the region may have changed during the onset of the Holocene to correspond with shifts in available resources and an expanding seasonal round.

B.3 Cultural Resource Monitoring

The INL CRMO conducts yearly cultural resource monitoring that includes many sensitive archaeological, historic architectural and tribal resources. Results of all monitoring and formal impact investigations are summarized in INL/EXT 19 52647, Idaho National Laboratory Cultural Resource Management Annual Report for Fiscal Year 2018. This report is available through the DOE-ID Cultural Resource Coordinator or the INL Cultural Resource Management Office. Reports containing restricted data on site locations are not available to the public.

Table B-2. FY 2018 Projects for Historic Built Environment.

CRMO Project No.	Project Title	Property Type(s)
BEA-18-H002	Install Fabric Covered Boards in Main Office Area, TRA-653	Category 3
BEA-18-H003	Install Lockers in TRA-620	Category 3
BEA-18-H004	Install Equipment Storage Cabinets in ATR/TRA-671	Category 3
BEA-18-H005	Remodel of TRA-652 ATR Document Control Storage Room to Office Spaces	Category 3
BEA-18-H007	Remove PCS Snubbers 670 MS 4 5 6 7 and 8	Category 1
BEA-18-H009	Replace MFC-768 Cooling Water Pumps	Category 3
BEA-18-H010	TRA-670 Install Receptacles in RCR for Wind Station and Foreman Work Station	Category 1
BEA-18-H011	Hang White Board in 652	Category 3
BEA-18-H013	Remove Old Phone Lines/Cable Trays in Electric Shop Office (TRA-653)	Category 3
BEA-18-H015	IF-685 (Energy Systems Laboratory) Bay D100 Modifications	Not Eligible
BEA-18-H016	Fab and Install Gas Bottle Rack in the 2nd Basement	Category 1
BEA-18-H017	Fab and Install Gas Bottle Rack in the 2nd Basement	Category 3
BEA-18-H018	FPR Model Acquisition (for INL archives)	Not Eligible
BEA-18-H019	TRA-653 Conference Room Computer Drops	Category 3
BEA-18-H020	ATR Complex, CFA, EBR-I, and MFC Miscellaneous Concrete Replacement	Various
BEA-18-H021	670-E-118 & 670-E119 Relay and Meter Replacement	Category 1
BEA-18-H023	Removal of HVA-206 and HVA-207 in TRA-653	Category 3
BEA-18-H027	Install Conduit and Cable Tray for Server Racks in RDAS; Install Server Racks in RDAS Room	Category 1
BEA-18-H028	Replace Water Lines in TRA-620	Category 3
BEA-18-H029	MFC West Campus Utility Corridor	Various
BEA-18-H030	1A Primary Cubicle Oxygen Sensors	Category 1
BEA-18-H031	Install Floor Tile in TRA-616	Category 3
BEA-18-H032	Replace Carpet in Room 151 of Building 652 (TRA-652)	Category 3
BEA-18-H034	Install Ice and Water Machine and Install New Water Fountain in ATR (TRA-670)	Category 1
BEA-18-H037	Hanging 50th Banner, Photo, and Plaques (ATR/TRA-670)	Category 1
BEA-18-H038	Idaho National Laboratory (INL) Research and Education Campus (REC) Integrated Priorities List	Various
BEA-18-H042	Advanced Test Reactor (ATR) Digital Radiation Monitoring System (DRMS) Replacement Project	Category 1
BEA-18-H043	Replace Radiochemistry Glovebox System located in B-137 (MFC-752/AL)	Category 3, Exempt
BEA-18-H044	Installation of Exhaust on Orion XT Smoke Detector	Category 3
BEA-18-H046	Big Lost River, South Canal	Linear Resource

Table B-2. FY 2018 Projects for Historic Built Environment. (cont.)

CRMO Project No.	Project Title	Property Type(s)
BEA-18-H048	Replace Lights in 2C Secondary Cubicle (TRA-670)	Category 1
BEA-18-H049	Research and Development Activities at In-Town Locations (Overarching)	Various
BEA-18-H050	Upgrade 120 V Electrical in 670 Room 208 (TRA-670/ATR)	Category 1
BEA-18-H051	Paint and Carpet Upstairs Room in 609 (TRA-609)	Category 3
BEA-18-H052	Materials and Fuels Complex Analytical Laboratory Equipment Installation	Category 3
BEA-18-H054	2018 CFA Excess Facilities Deactivation and Demolition	Category 2
BEA-18-H055	Hang Corkboard in TRA-652 Room 117	Category 3
BEA-18-H056	Install Monitor in TRA-608, Room 102	Category 3
BEA-18-H057	Advanced Test Reactor Complex Xeriscaping	Category 1
BEA-18-H058	Installation of Milli-Q Deionizer	Category 1
BEA-18-H061	EBR-I Fuel Rod Hole Repair	Signature
BEA-18-H062	2018 Campus Improvement Projects at the Materials and Fuels Complex (MFC)	Category 3
BEA-18-H063	2018 Campus Improvement Projects at the Materials and Fuels Complex (MFC)–MFC-752AL Exterior Insulation and Finishing System (EIFS) Installation (AL-200)	Category 3
BEA-18-H064	Terra Power Metallic Fuels and Materials Research and Development	Category 3
BEA-18-H065	Replace 13.8 kV Electrical Cable at MFC	Category 3
BEA-18-H066	PBF-622 Fiber Optic Cable Installation	Not Eligible
BEA-18-H067	Equipment Relocation, TRA-653 to TRA-1626	Category 3
BEA-18-H068	TV for Sean O'Kelly	Category 3
BEA-18-H069	Install White Board in 608 Break Room (TRA-608)	Category 3

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, INL employees, and stakeholders such as the Idaho State Historic Preservation Office, 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-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.

INL hosted nine cultural resource tours in 2018. Of the nine tours, eight tours included three public tours in commemoration of the Idaho Archaeology and Historic Preservation Month; three INL employee and intern appreciation tours; a tour for Senator Risch's congressional staff visiting INL; and a coordinated tour for DOE ID, DOE Headquarters staff, and the Shoshone Bannock Tribes. These tours included visits to a variety of Native American and Euroamerican archaeological sites within the INL boundaries.

Nicholas Holmer, a CRMO archaeologist, gave a presentation on archaeology to high school students at Emerson Alternative High School in Idaho Falls, Idaho, during District 91's 2018 Career Fair, and Reese Cook of the CRMO gave an overview of archaeology to elementary students in the Gilbert School District in Phoenix, Arizona.

The CRMO began discussions with the Museum of Idaho (MOI) on the up-coming Way Out West Exhibit, scheduled to open in 2020. Through 2019, the CRMO, BEA, DOE ID, and the Shoshone Bannock Tribes will coordinate with the MOI to provide interpretive material for this exhibit, which focuses on the history of southeastern Idaho.

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 2017). 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 Heritage Tribal Office, DOE-ID, and the INL CRMO meets on a bimonthly basis.

REFERENCES

DOE-ID, 2016, *Idaho National Laboratory Cultural Resource Management Plan*, DOE/ID-10997, Rev 6, February 2016.

DOE-ID, 2017, *Agreement-in-Principle (between the Shoshone-Bannock Tribes and the U.S. Department of Energy)*, September 2017.

DOE-ID, 2018, *Idaho National Laboratory Cultural Resource Management Annual Report for Fiscal Year 2018*, INL/EXT 19 52647, TBD 2019.

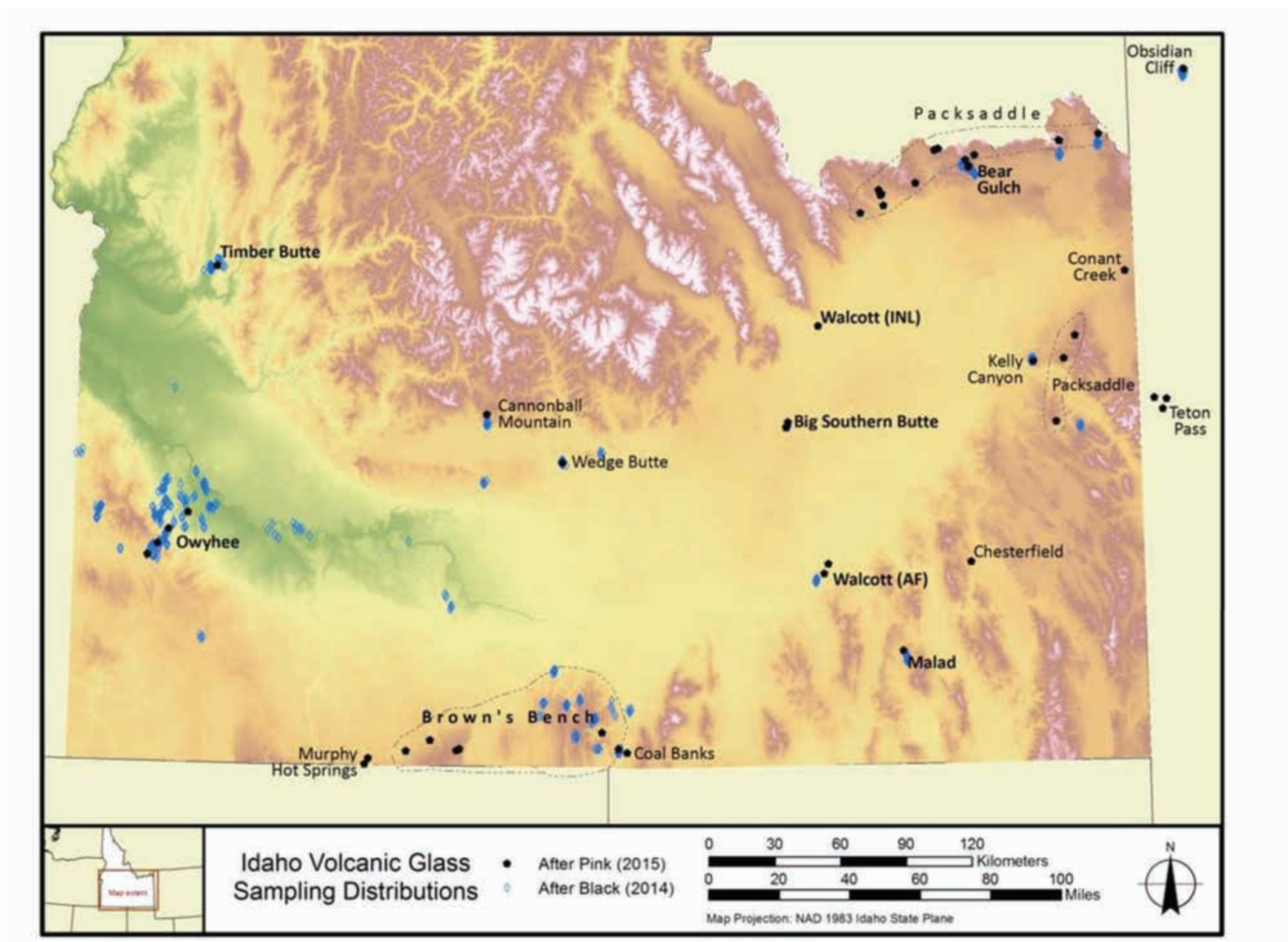


Figure B-1. Southern Idaho Volcanic Glass Sample Distribution.

Table C-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Permit-Required Monitoring Results (2018).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.54	7.41	7.02
Conductivity (µS/cm)	368	1,513	562
Aluminum, filtered (mg/L)	0.0193U[b]	0.0193U	0.0193U
Chloride (mg/L)	9.20	46.5	22.8
Chromium, filtered (mg/L)	0.00326	0.0145	0.00607
Chromium, total (mg/L)	0.0027	0.00154	0.0062
Iron, filtered (mg/L)	0.033U	0.170	0.0479
Manganese, filtered (mg/L)	0.001U	0.0039	0.0016
Nitrate + nitrite as nitrogen (mg/L)	0.863	4.02	1.16
Nitrogen, total kjeldahl nitrogen (TKN) (mg/L)	-0.25	0.908	0.0999
Nitrogen, Total (mg/L)[c]	0.863	4.928	1.2599
Solids, total dissolved (mg/L)	206	1,270	349.5
Sulfate (mg/L)	22	671	93

a. Duplicate samples were collected in August 2018 and the results for the duplicate samples are not included in the statistical 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. Hydraulic Loading Rates for the Advanced Test Reactor Complex Cold Waste Pond.

	Yearly Total Flow
2018 flow	201.04 MG[a]
Annual permit limit	375 MG
5-yr moving annual average permit limit	300 MG

a. MG = million gallons

Table C-3a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2018).

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard[a] PCS/SCS
Sample Date:	*4/16/18*	*9/20/18*	*4/18/18*	*9/24/18*	*4/17/18*	*9/24/18*	*4/17/18*	*9/20/18*	*4/17/18*	*9/20/18*	
Water table depth (ft) bls[b]	427.60	427.30	475.26	475.29	483.15	483.28	489.01	489.11	492.86	493.00	NA[c]
Water table elevation (ft)[d]	4461.61	4461.91	4453.31	4453.28	4450.06	4449.93	4450.05	4449.95	4450.01	4449.87	NA
Borehole correction factor (ft)[e]	2.53	2.53	NA	NA	NA	NA	0.63	0.63	NA	NA	NA
Nitrite + nitrate as nitrogen (mg/L)	1.02	0.987J[f] (0.990J)[g]	1.39	1.32J	0.965	0.915J	0.975	0.951J	0.965	0.923J	10 (PCS)
Total kjeldahl nitrogen (mg/L)	0.178U[h]	-0.0117U (0.0284U)	0.160U	0.0139U	0.141U	0.013U	0.138U	0.798J	0.128U	0.0769J	NA
Total nitrogen[i] (mg/L)	1.20	<1.02 (<1.02)	1.55	1.33	1.11	0.93	1.11	1.75	1.09	1.00	NA
pH (s.u.)	7.61	6.70	7.74	7.60	8.08	7.72	7.45	7.75	7.71	7.45	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	382	534	606	588	432	419	446	414	436	416	NA
Chloride (mg/L)	13.6J	13.1 (12.6)	17J	17.9	12J	11.6	10.6J	11	9.69J	10.4	250 (SCS)
Sulfate (mg/L)	22	21 (20.3)	150	140	35	33.4	46.9	45.9	30.7	31.8	250 (SCS)
Total dissolved solids (mg/L)	240	223 (247)	439	423	264	240	286	261	257	240	500 (SCS)
Aluminum, filtered (mg/L)	0.0193U	0.0193U (0.0193U)	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0343	0.2 (SCS)
Chromium[j], total (mg/L)	0.00778	0.00697 (0.00687)	0.0776	0.0773	0.0124	0.0113	0.0242	0.022	0.00917	0.0099	0.1 (PCS)
Chromium[j], filtered (mg/L)	0.00678	0.00643 (0.00643)	0.0768	0.0752	0.0119	0.0114	0.0215	0.0225	0.00936	0.01	0.1 (PCS)
Iron, filtered	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)

Table C-3a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2018). (cont.)

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard[a] PCS/SCS
Sample Date:	*4/16/18*	*9/20/18*	*4/18/18*	*9/24/18*	*4/17/18*	*9/24/18*	*4/17/18*	*9/20/18*	*4/17/18*	*9/20/18*	
(mg/L)		(0.03U)									
Manganese, filtered (mg/L)	0.001UJ	0.001U (0.001U)	0.001UJ	0.001U	0.001UJ[k]	0.001U	0.001UJ	0.001U	0.00136J	0.00321J	0.05 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

b. bls = below land surface

c. NA = not applicable

d. Water table elevation above mean sea level (ft). Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

e. The borehole correction factors were determined from gyroscopic surveys conducted by USGS in order to reconcile discrepancies in water level measurements.

f. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

g. Results shown in parenthesis are from the field duplicate samples.

h. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit but the value is not more than 5 times the highest positive amount in any laboratory blank and is U qualified as a result of data validation.

i. Total nitrogen is calculated as the sum of the total Kjeldahl nitrogen (TKN) and nitrite +nitrate as nitrogen. For results reported as a negative value, the method detection limit (MDL) of 0.033 mg/L replaced the result for calculation purpose and the product was reported as a less than (<) number. For positive results reported below the instrument detection limit, the MDL was used in the total nitrogen calculation and the product was reported as a less than (<). Results were rounded to the nearest hundredth.

j. PCS for chromium does not apply under this permit.

k. UJ flag indicates the sample was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

Table C-3b. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2018).

Well Name	USGS-058[a] (GW-016107)		
Sample Date:	***4/18/18***	***9/24/18***	**Standard (PCS/SCS)[b]**
Water table depth (ft) bgs[c]	471.20	471.22	NA[d]
Water table elevation (ft)[e]	4450.69	4450.67	NA
Borehole correction factor (ft)[f]	NA	NA	NA
Total dissolved solids (mg/L)	276	261	500(SCS)
Sulfate (mg/L)	35.5	32.2	250(SCS)

a. Reuse permit only requires water table elevation, water table depth, total dissolved solids and sulfate reported for USGS-058.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

c. bgs = below ground surface

d. NA = not applicable

e. Water table elevation above mean sea level (ft). Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

f. NR indicates the parameter is not required by the Reuse Permit. The borehole correction factors were determined from gyroscopic surveys conducted by USGS in order to reconcile discrepancies in water level measurements.

Table C-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2018).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	9.11	605	160
Nitrate + nitrite, as nitrogen (mg/L)	-0.0174U[a]	0.149	0.0260
Total kjeldahl nitrogen (mg/L)	23.2	133	60.2
Total phosphorus (mg/L)	2.73	24.2	7.45
Total suspended solids (mg/L)	43.0	493	147

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table C-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2018).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	3.29U[a]	59.3	18.7
Nitrate + nitrite, as nitrogen (mg/L)	0.0483	8.26	2.82
pH (standard units)[b]	7.10	8.88	7.93
Total coliform (MPN/100 mL)[b]	74.3	>2,419	1,653
Total kjeldahl nitrogen (mg/L)	5.52	74.4	23.5
Total phosphorus (mg/L)	1.94	7.48	4.91
Total suspended solids (mg/L)	1.80	64.0	21.1

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.

MPN = most probable number

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2018).

Parameter	Minimum	Maximum	Mean
Chloride (mg/L)	11.3	17.2	13.7
Chromium (mg/L)	0.00217	0.00538U[a]	0.00418
Coliform, fecal (MPN/100 mL)[b]	<1	6	1.58
Coliform, total (MPN/100 mL)[b]	12.0	866	202
Fluoride (mg/L)	0.172	0.251	0.210
Manganese, total (mg/L)	0.002U	0.002U	0.002U
Nitrate + nitrite, as nitrogen (mg/L)	0.772	2.31	1.30
pH (standard units)[b]	7.80	8.64	8.33
Selenium (mg/L)	0.002U	0.002U	0.002U
Total dissolved solids (mg/L)	180	264	218
Total phosphorus (mg/L)	0.628	1.04	0.765

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.

Table C-7. Hydraulic Loading Rates for the INTEC New Percolation Ponds.

	Maximum Daily Flow	Yearly Total Flow
2018 flow	847,400 gallons	201 MG[a]
Permit limit	3,000,000 gallons	1,095 MG

a. MG = million gallons

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2018).

Parameter	ICPP-MON-A-165 (GW-13006)		ICPP-MON-A-166 (GW-13007)		ICPP-MON-A-164B (GW-13011)		Standard PCS/SCS[a]
Sample Date:	*4/11/2018*	*9/26/2018*	*4/11/2018*	*9/26/2018*	*4/10/2018*	*9/25/2018*	
Water table depth (ft bls)[b]	503.01	500.25	510.14	510.78	502.97	502.71	NA[c]
Water table elevation (ft above mean sea level)[d]	4,449.90	4,452.66	4,449.40	4,448.76	4,449.20	4,449.46	NA
Chloride (mg/L)	33.1	32.9	14.3	14.2	9.60	9.50	250
Chromium (mg/L)	0.0141	0.0113	0.00631	0.00500	0.0123	0.0112	0.1
Coliform, fecal (MPN[e]/100 mL)	<1	<1	<1	<1	<1	<1	<1 CFU[f]/100 ml
Coliform, total (MPN/100 mL)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1 CFU/100 ml[g]
Dissolved oxygen (mg/L)	6.36	6.64	4.92	4.31	5.97	5.90	NA
Electrical conductivity (µmhos/cm)	457	454	333	318	406	392	NA
Fluoride (mg/L)	0.196	0.252	0.246	0.331	0.224	0.207	4
Manganese, dissolved (mg/L)[h]	NR[i]	NR	NR	NR	NR	NR	0.05
Manganese, total (mg/L)	0.001U[j]	0.001U	0.0142	0.0242	0.001U	0.001U	0.05
Nitrate / nitrite, as nitrogen (mg/L)	1.05	1.09	0.282	0.286	0.898	0.882	10
pH (standard units)	7.97	7.96	7.85	8.00	7.78	8.16	6.5–8.5
Selenium (mg/L)	0.00174[j]	0.0015U	0.0015U	0.0015U	0.00278[j]	0.0015U	0.05
Temperature (°F)	54.86	54.68	53.98	53.85	55.65	55.69	NA
Total dissolved solids (mg/L)	280	254	224	197	264	233	500
Total phosphorus (mg/L)	0.0192U	0.0263[k]	0.0270[k]	0.0254[k]	0.0170U	0.022[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. bls = below land surface
c. NA = not applicable
d. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
e. MPN = most probable number
f. CFU = colony forming unit
g. 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.
h. The results of dissolved concentrations of this parameter are used for SCS compliance determinations.
i. NR = not required, since the analytical result for total manganese did not exceed the standard in IDAPA 58.01.11.200.01.d for manganese of 0.05 mg/L.
j. U flag indicates the result was reported as below the detection/reporting limit.
k. The parameter was positively detected, but the reported value is an estimate.

Table C-9. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2018).

Parameter	ICPP-MON-V-191 (GW-13008)		ICPP-MON-V-200 (GW-13009)		ICPP-MON-V-212 (GW-13010)		Standard PCS/SCS[a]
Sample date:	***4/11/2018***	***9/25/2018***	***4/10/2018***	***9/25/2018***	***4/10/2018***	***9/25/2018***	
Depth to water (ft bls)[b]	105.37	Dry[c]	111.47	112.06	236.17	236.15	NA[d]
Water table elevation (ft above mean sea level)[e]	4842.59		4841.50	4840.91	4722.33	4722.35	NA
Chloride (mg/L)	3.33		21.9	14.7	30.7	29.6	250
Chromium (mg/L)	0.00539		0.00600	0.00531	0.0161	0.0117	0.1
Coliform, fecal (MPN[f]/100 mL)	<1		<1	<1	<1	<1	<1 CFU[g]/100 mL
Coliform, total (MPN/100 mL)	<1.0		<1.0	<1.0	<1.0	<1.0	1 CFU/100 mL[h]
Dissolved oxygen (mg/L)	7.93		5.92	5.76	4.96	6.70	NA
Electrical conductivity (µmhos/cm)	293		418	392	447	431	NA
Fluoride (mg/L)	0.183		0.259	0.286	0.305	0.273	4
Manganese, dissolved (mg/L)[i]	NR[j]		NR	NR	NR	NR	0.05
Manganese, total (mg/L)	0.0016		0.001U[k]	0.001U	0.00271	0.00279	0.05
Nitrate / nitrite, as nitrogen (mg/L)	0.112		2.09	1.66	1.46	1.46	10
pH (standard units)	8.13		7.53	7.97	8.46	7.85	6.5–8.5
Selenium (mg/L)	0.0015U		0.0017[l]	0.0015U	0.0028[l]	0.0015U	0.05
Temperature (°F)	41.38		61.49	61.25	61.36	66.96	NA
Total dissolved solids (mg/L)	183		260	224	280	251	500
Total phosphorus (mg/L)	0.026[l]		0.310	0.345	0.00492U	0.396	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. bls = below land surface
c. ICPP-MON-V-191 was dry in September 2018.
d. NA = not applicable
e. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
f. MPN = most probable number
g. CFU = colony forming units
h. 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.
i. The results of dissolved concentrations of this parameter are used for SCS compliance determinations.
j. NR = not required since the analytical result for total manganese did not exceed the standard in IDAPA 58.01.11.200.01.d for manganese of 0.05 mg/L.
k. U flag indicates the result was reported as below the detection/reporting limit.
l. The parameter was positively detected, but the reported value is an estimate.

Table C-10. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2018).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.63	7.21	8.44
Conductivity ((µS/cm)	412	447	557
Nitrate + nitrite as nitrogen (mg-N/L)	2.25	3.47	2.56
Iron (mg/L)	0.03U[b]	0.241	0.0694
Iron, filtered(mg/L)	0.03U	0.03U	0.03U
Manganese (mg/L)	0.002U	0.00318	0.002U
Manganese, filtered (mg/L)	0.002U	0.00297	0.002U
Total dissolved solids (mg/L)	164	337	257

a. Duplicate samples were collected in July and the results for the duplicate samples are included in the data summary.
b. U qualifier indicates the result was below the detection limit.

Table C-11. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2018).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	7.40	8.16	7.88
Conductivity ((µS/cm)	872	1,179	944
Nitrate + nitrite as nitrogen (mg-N/L)	5.75	6.94	5.85
Iron (mg/L)	0.03U[b]	0.159	0.0547
Iron, filtered (mg/L)	0.03U	0.0878	0.03U
Manganese (mg/L)	0.002U	0.0117	0.002U
Manganese, filtered (mg/L)	0.002U	0.00321	0.002U
Total dissolved solids (mg/L)	544	607	567

a. Duplicate samples were collected in May and the results for the duplicate samples are included in the data summary.
b. U qualifier indicates the result was below the detection limit.

Table C-12. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2018).

Well Name	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		
Sample Date:	***4/23/2018***	***9/25/2018***	***4/24/2018***	***09/25/2018***	***4/24/2018***	***9/25/2018***	PCS/SCS[a]
Water table depth (ft bls)[b]	658.47	659.99	646.91	648.33	646.05	647.53	NA[c]
Water table elevation (ft above mean sea level)[d]	4474.23	4472.71	4473.46	4472.04	4472.03	4470.55	NA
Temperature (°F)	54.86	53.78	52.88	55.58	51.98	58.10	NA
pH (s.u)	7.68	7.26	7.58	7.17	7.59	7.55	6.5 to 8.5 (SCS)
Conductivity (µmhos/cm)	388 (376)	370	409	380	378	371	NA
Nitrite + nitrate as N (mg/L)	2.30 (2.18)	2.49	2.20	2.49	2.28	2.54	NA
Nitrate nitrogen (mg/L)[e]	2.23 (2.23)	2.33	2.23	2.33	2.26	2.35	10 (PCS)
Total dissolved solids (mg/L)	196 (180)	216	197	233	184	216	500 (SCS)
Iron, total (mg/L)	0.03U[f] (0.03U)	0.03U	0.150	0.0576	0.03U	0.03U	0.3 (SCS)
Iron, filtered (mg/L)	0.03U (0.03U)	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)
Manganese, total (mg/L)	0.001U (0.001U)	0.001U	0.00395	0.00128	0.001U	0.001U	0.05 (SCS)
Manganese, filtered (mg/L)	0.001U (0.001U)	0.001U	0.001U	0.001U	0.001U	0.001U	0.05 (SCS)

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) from IDAPA 58.01.11 (Ground Water Quality Rule).
b. bls = below land surface
c. NA = Not applicable.
d. Elevations are given in the National Geodetic Vertical Datum of 1929.
e. Constituent analyzed in response to comments from the 2016 annual report (John 2017).
f. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit but the value is not more than 5 times the highest positive amount in any laboratory blank and is U qualified as a result of data validation.

Table C-13. Advanced Test Reactor Complex Cold Waste Ponds Surveillance Monitoring Results (2018).

Parameter	Minimum	Maximum
Gross alpha (pCi/L ± 1σ)	0.691 ± 1.02U[a]	5.01 ± 1.26
Gross beta (pCi/L ± 1σ)	0.798 ± 0.376	7.65 ± 1.17
pH (standard units)[b]	6.54	7.41
Potassium-40 (pCi/L ± 1σ)	-19.1 ± 10.6	35.3 ± 8.86

a. U qualifier indicates the result was below the detection limit.
b. Median pH was 7.02.

Spiny Hopsage (*Grayia spinosa*)

Table C-14. Radioactivity Detected in Surveillance Groundwater Samples Collected at the Advanced Test Reactor Complex (2018).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-098	4/16/2018	Gross Alpha	1.62 (±0.438)[a]
		Gross Beta	1.82 (±0.416)
		Tritium	ND[b]
	09/20/2018	Gross Alpha	ND [1.22 (±0.342)][c]
		Gross Beta	2.96 (±0.487) [4.1 (±0.385)]
		Tritium	ND
USGS-065	04/18/2018	Gross Alpha	2.38 (±0.449)
		Gross Beta	2.89 (±0.331)
		Tritium	1,770 (±211)
	09/24/2018	Gross Alpha	2.19 (±0.612)
		Gross Beta	2.89 (±0.325)
		Tritium	1,620 (±194)
TRA-08	04/17/2018	Gross Alpha	1.93 (±0.504)
		Gross Beta	2.08 (±0.358)
		Tritium	990 (±139)
	09/20/2018	Gross Alpha	1.5 (±0.393)
		Gross Beta	2.33 (±0.273)
		Tritium	766 (±122)
USGS-076	04/17/2018	Gross Alpha	ND
		Gross Beta	ND
		Tritium	481 (±103)
	09/24/2018	Gross Alpha	1.37 (±0.452)
		Gross Beta	2.13 (±0.383)
		Tritium	427 (±98.3)
Middle-1823	04/17/2018	Gross Alpha	ND
		Gross Beta	2.56 (±0.368)
		Tritium	505 (±103)
	9/20/2018	Gross Alpha	ND
		Gross Beta	2.33 (±0.485)
		Tritium	475 (±101)
USGS-058	04/18/2018	Gross Alpha	ND
		Gross Beta	ND
		Tritium	548 (±105)
	09/24/2018	Gross Alpha	1.71 (±0.381)
		Gross Beta	1.51 (±0.315)
		Tritium	455 (±100)

a. One sigma uncertainty shown in parentheses.
b. ND = not detected
c. Analytical result from field duplicate sample collected on September 20, 2018, from Well USGS-098. Results shown in brackets.

Table C-15. Liquid Effluent Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2018).

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 2018	48.1 (±17.3)J[c,d]	ND[e]	9.09 (±1.20)	ND
September 2018	ND	ND	24.5 (±1.07)	ND
Effluent to INTEC New Percolation Ponds (CPP-797)				
January 2018	ND	ND	4.09 (±0.88)	ND
February 2018	ND	2.33 (±0.95)J	5.15 (±0.99)	ND
March 2018	ND	ND	5.78 (±0.94)	ND
April 2018	ND	ND	8.38 (±1.05)	ND
May 2018	ND	ND	8.12 (±0.97)	ND
June 2018	ND	ND	14.2 (±1.48)	ND
July 2018	ND	5.01 (±1.37)	9.51 (±1.30)	ND
August 2018	ND	ND	10.8 (±1.01)J	ND
September 2018	ND	ND	12.10 (±1.29)	ND
October 2018	ND	2.31 (±0.88)J	10.00 (±1.27)	ND
November 2018	ND	3.37 (±1.03)	9.84 (±0.89)	ND
December 2018	ND	ND	10.2 (±1.15)	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. J flag indicates the associated value is an estimate.
d. Positive detection for potassium-40.
e. 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 (2018).

Monitoring Well	Sample Date	Gross Alpha[a] (pCi/L)	Gross Beta[a] (pCi/L)
ICPP-MON-A-165	4/11/2018	2.66 (±0.98)J[c]	4.83 (±086)
	9/26/2018	2.79 (±1.03)J	2.57 (±0.67)
ICPP-MON-A-166	4/11/2018	2.52 (±0.89)J	ND[b]
	9/26/2018	ND	2.96 (±0.83)
ICPP-MON-V-200	4/10/2018	ND	6.05 (±0.82)
	9/25/2018	ND	5.37 (±0.95)
ICPP-MON-V-212	4/10/2018	3.25 (±1.02)	10.9 (±1.04)
	9/25/2018	ND	7.38 (±1.10)

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.
c. J flag indicates the associated value is an estimate.

Table C-17. Radiological Monitoring Results for Materials and Fuels Complex Industrial Waste Pond (2018).[a]

Parameter[b] (pCi/L)	Minimum	Maximum	DCS[c] (pCi/L)
Gross alpha	0.369 ± 0.75U[d]	2.94 ± 1.03	NA[e]
Gross beta	4.13 ± 0.536	11.9 ± 1.38	NA
Uranium-238[f]	1.07 ± 0.156	1.07 ± 0.156	750
Uranium-233/234[f,g]	1.26 ± 0.175	1.26 ± 0.175	660

a. Detected results are shown along with the reported 1 σ uncertainty.
b. Only parameters with at least one detected result are shown.
c. DCS = DOE Derived Concentration Standard for ingested water.
d. U qualifier indicates the result was below the detection limit.
e. NA = Not applicable.
f. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.
g. DCS for Uranium-233 is shown because it is more conservative than that for Uranium-234.

INL Site Looking Towards the Lost River Range.

Appendix D. Onsite Dosimeter Measurements and Locations

Location	mrem[a]	
	Nov. 2017 – April 2018	May 2018 – Oct. 2018
ARA I&II O-1	73	72
PBF SPERT O-1	73	75

a. Millirem (mrem) in ambient dose equivalent.

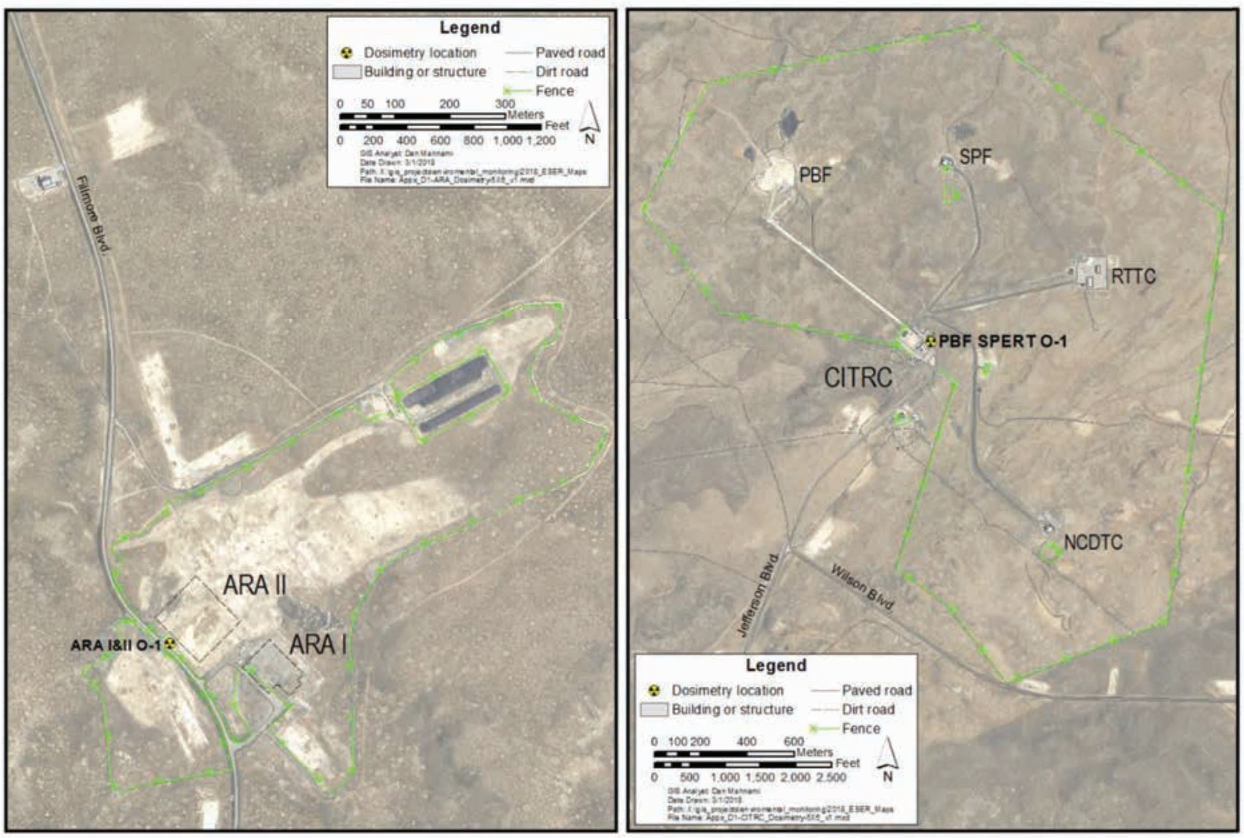


Figure D-1. Environmental Radiation Measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2018).

	mrem[a]			mrem[a]	
Location	Nov. 2017 – April 2018	May 2018– Oct. 2018	Location	Nov. 2017– April 2018	May 2018 – Oct. 2018
RHLLW O-1	72	71	TRA O-14	78	74
RHLLW O-2	72	64	TRA O-15	70	73
RHLLW O-3	67	67	TRA O-16	79	81
RHLLW O-4	79	lost	TRA O-17	79	82
RHLLW O-5	72	68	TRA O-18	75	76
RHLLW O-6	72	68	TRA O-19	98	91
TRA O-1	74	80	TRA O-20	83	80
TRA O-6	74	75	TRA O-21	89	83
TRA O-7	67	76	TRA O-22	77	76
TRA O-8	79	86	TRA O-23	72	80
TRA O-9	85	80	TRA O-24	75	76
TRA O-10	90	88	TRA O-25	79	72
TRA O-11	82	85	TRA O-26	69	80
TRA O-12	79	81	TRA O-27	78	73
TRA O-13	76	81	TRA O-28	75	73

a. Millirem (mrem) in ambient dose equivalent.

Figure D-2. Environmental Radiation Measurements at Advanced Test Reactor Complex (ATRx) and Remote-handled Low-level Waste Disposal Facility (RHLLW) (2018).

Location	mrem[a]	
	Nov. 2017 – April 2018	May 2018 – Oct. 2018
CFA O-1	77	77
LincolnBlvd O-1	72	74

a. Millirem (mrem) in ambient dose equivalent.

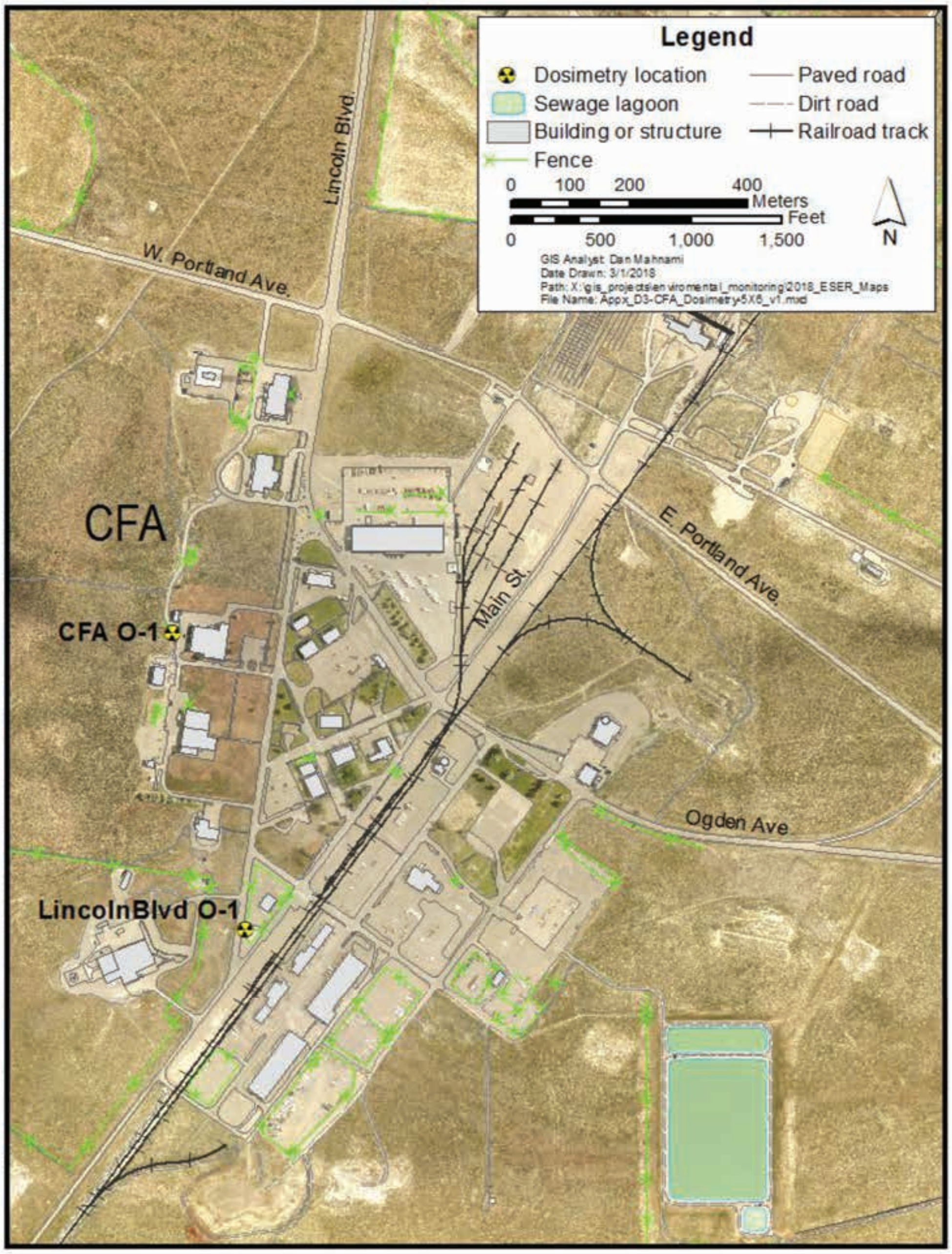


Figure D-3. Environmental Radiation Measurements at Central Facilities Area (CFA) and Lincoln Boulevard (2018).

Location	mrem[a]		Location	mrem[a]	
	Nov. 2017 – April 2018	May 2018 – Oct. 2018		Nov. 2017 – April 2018	May 2018– Oct. 2018
ICPP O-9	89	90	ICPP O-26	86	75
ICPP O-14	102	108	ICPP O-27	148	214
ICPP O-15	115	163	ICPP O-28	124	200
ICPP O-17	78	78	ICPP O-30	201	191
ICPP O-19	80	91	TreeFarm O-1	109	132
ICPP O-20	249	267	TreeFarm O-2	87	91
ICPP O-21	96	91	TreeFarm O-3	91	95
ICPP O-22	92	100	TreeFarm O-4	142	137
ICPP O-25	77	86			

a. Millirem (mrem) in ambient dose equivalent.

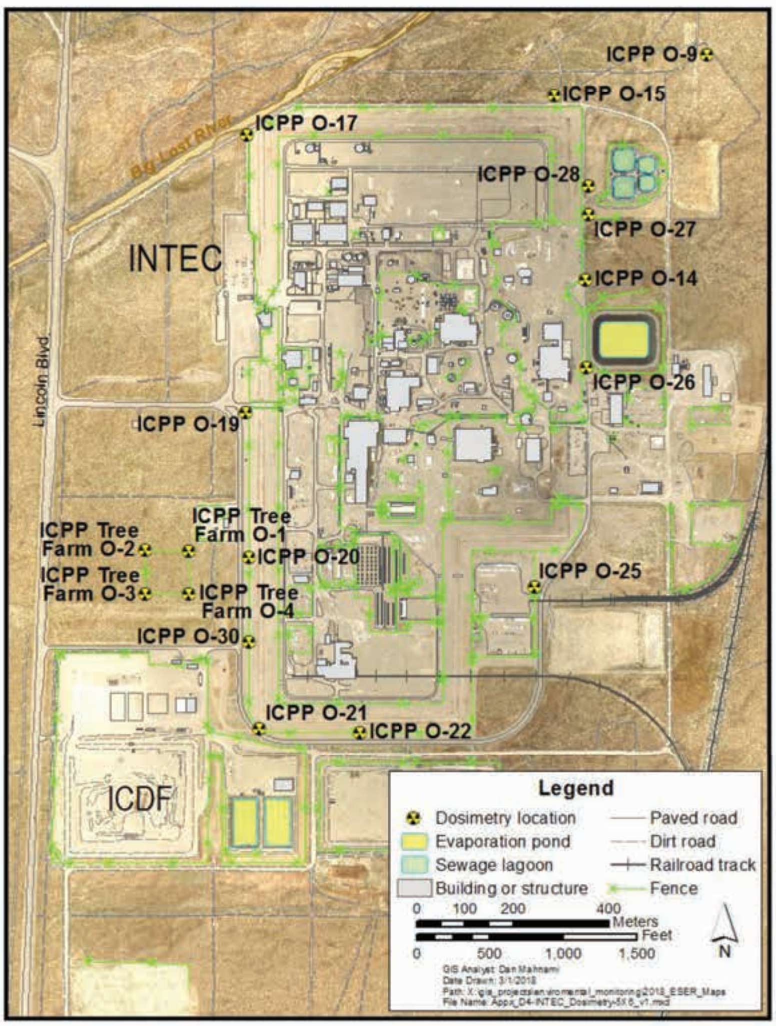


Figure D-4. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2018).

	mrem[a]			mrem[a]	
Location	Nov. 2017 – April 2018	May 2018– Oct. 2018	Location	Nov. 2017 – April 2018	May 2018 – Oct. 2018
IF-603N O-1	56	60	IF-670N O-31	64	56
IF-603E O-2	54	54	IF-670E O-32	56	54
IF-603S O-3	56	58	IF-670S O-33	63	56
IF-603W O-4	63	62	IF-670D O-34	61	55
IF-627 O-30	62	62	IF-670W O-35	69	64
IF-638N O-1	61	59	IF-689 O-7	57	64
IF-638E O-2	51	55	IF-689 O-8	59	61
IF-638S O-3	59	59	IRC O-39	64	62
IF-638W O-4	70	66			

a. Millirem (mrem) in ambient dose equivalent.

Figure D-5. Environmental Radiation Measurements at INL Research Center Complex (IRC) (2018).

Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018	Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018
ANL O-7	63	75	ANL O-24	63	68
ANL O-8	68	64	ANL O-25	75	77
ANL O-12	62	60	ANL O-26	80	80
ANL O-14	70	66	TREAT O-1	72	63
ANL O-15	73	76	TREAT O-2	68	63
ANL O-16	80	84	TREAT O-3	66	lost
ANL O-18	69	71	TREAT O-4	77	74
ANL O-19	72	69	TREAT O-5	67	74
ANL O-20	75	80	TREAT O-6	74	71
ANL O-21	83	90	TREAT O-7	65	73
ANL O-22	80	87	TREAT O-8	65	68
ANL O-23	83	91			

a. Millirem (mrem) in ambient dose equivalent.

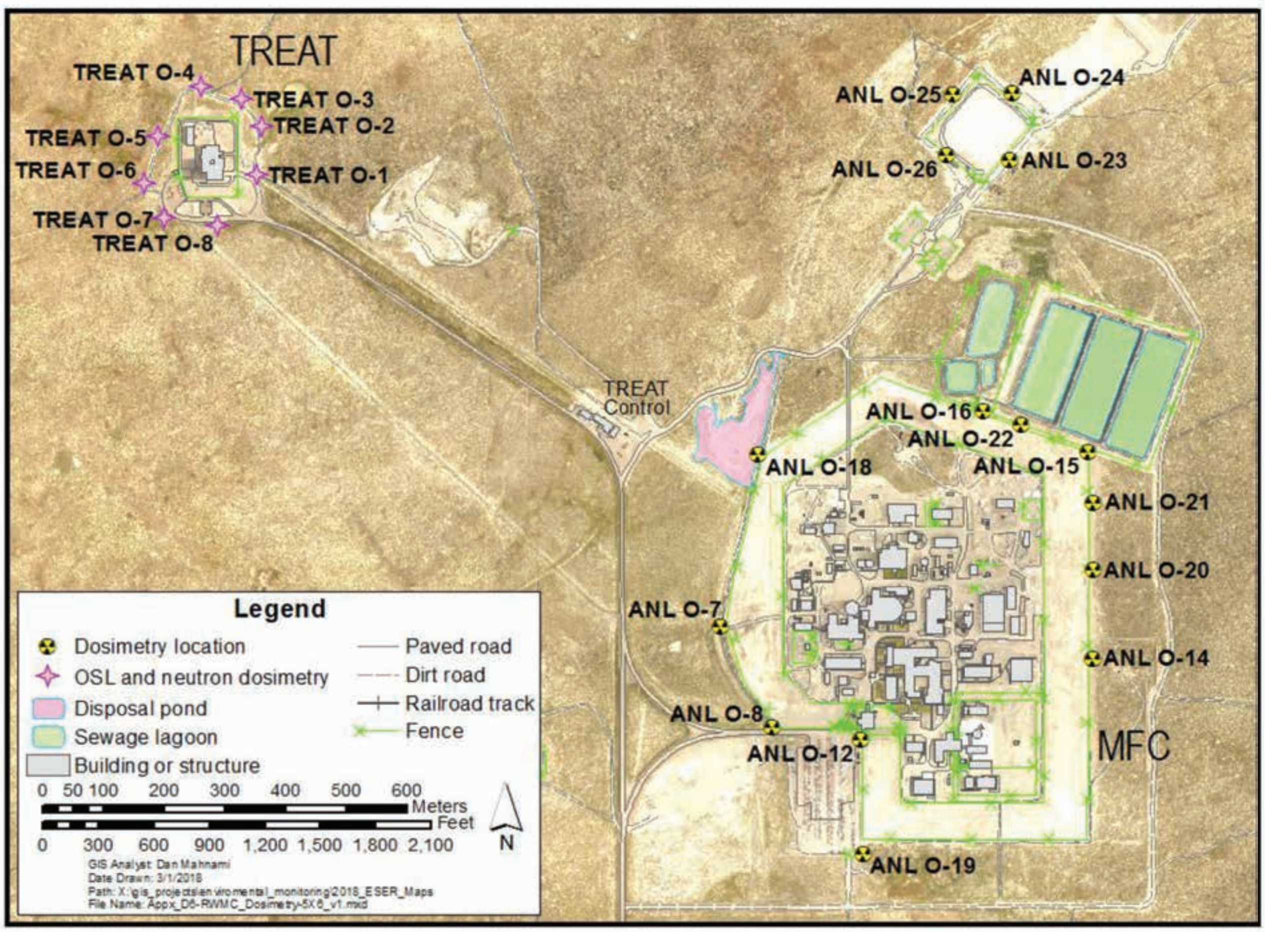


Figure D-6. Environmental Radiation Measurements at Materials and Fuels Complex (MFC) and Transient Reactor Test (TREAT) Facility (2018).

Location	Exposure[a] Nov. 2017 – April 2018	Exposure[a] May 2018 – Oct. 2018	Location	Exposure[a] Nov. 2017 – April 2018	Exposure[a] May 2018 – Oct. 2018
NRF O-11	73	77	NRF O-21	68	71
NRF O-16	70	72	NRF O-22	70	74
NRF O-18	70	73	NRF O-23	70	68
NRF O-19	76	73	NRF O-24	72	75
NRF O-20	74	75			

a. Millirem (mrem) in ambient dose equivalent.

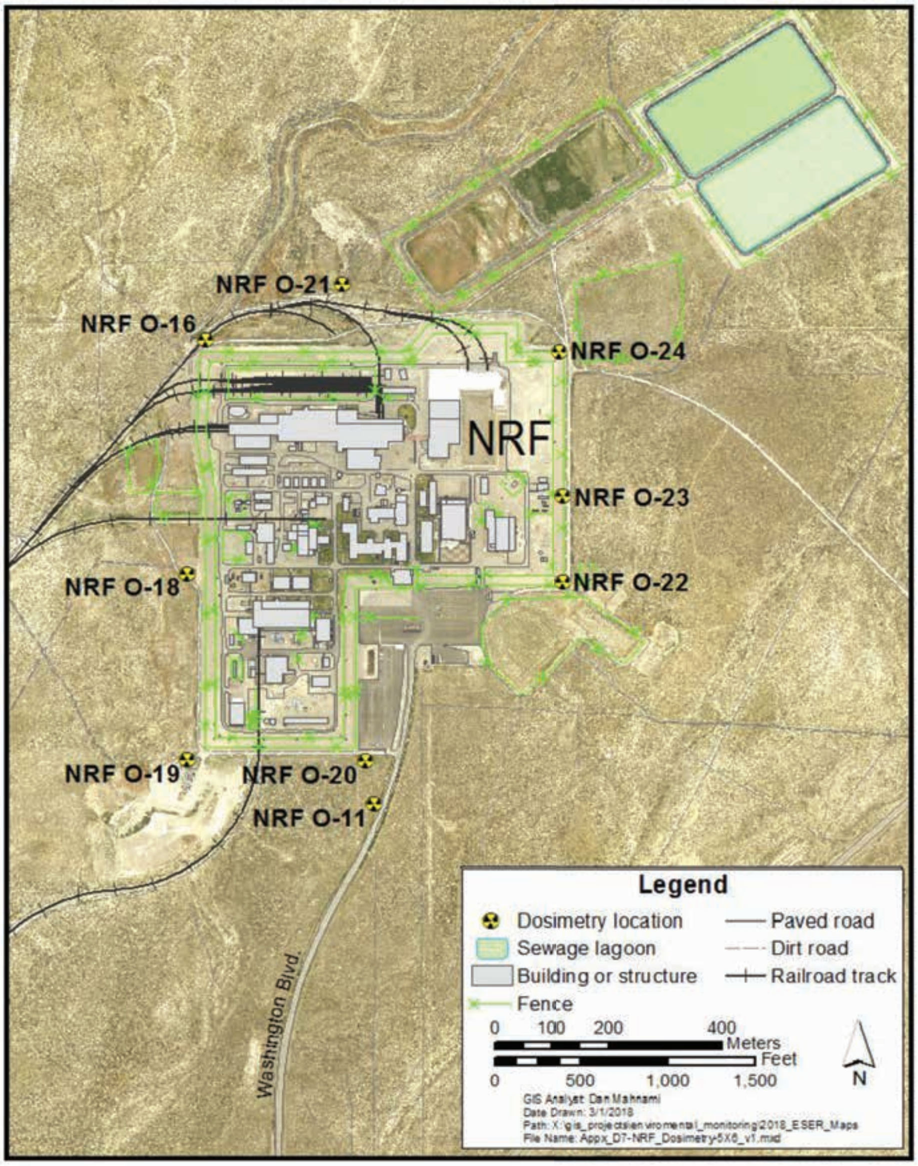


Figure D-7. Environmental Radiation Measurements at Naval Reactors Facility (NRF) (2018).

Location	mrem[a]	
	Nov. 2017 – April 2018	May 2018 – Oct. 2018
IF-675E O-31	58	57
IF-675D O-33	58	55
IF-675S O-34	58	60
IF-675W O-35	60	56

a. Millirem (mrem) in ambient dose equivalent.

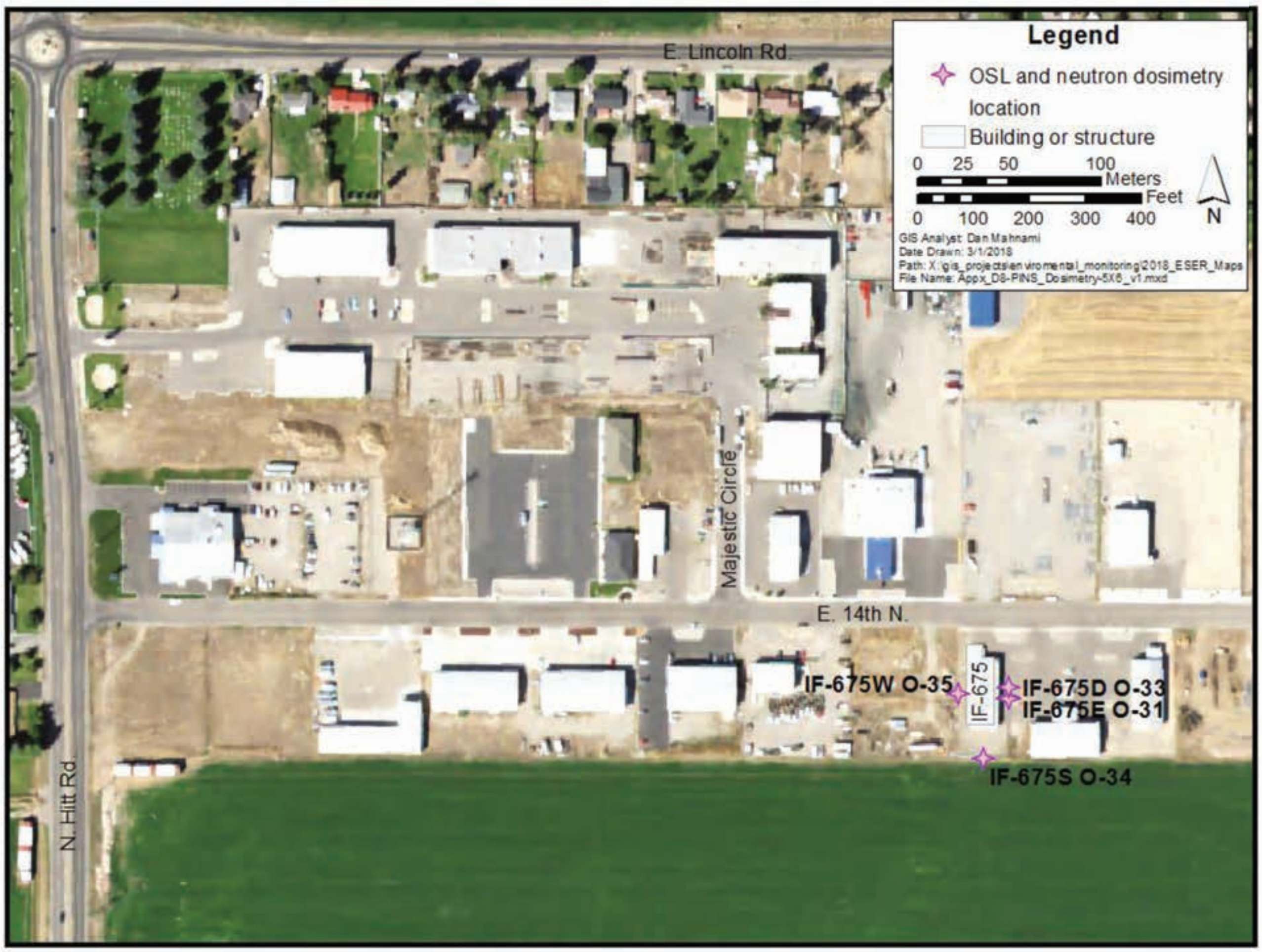


Figure D-8. Environmental Radiation Measurements at IF-675 Portable Isotopic Neutron Spectroscopy (PINS) Laboratory (2018).

Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018	Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018
RWMC O-3A	66	73	RWMC O-25A	69	76
RWMC O-5A	68	69	RWMC O-27A	67	74
RWMC O-7A	65	68	RWMC O-29A	68	73
RWMC O-9A	90	90	RWMC O-39	76	82
RWMC O-11A	72	77	RWMC O-41	128	142
RWMC O-13A	88	99	RWMC O-43	74	78
RWMC O-19A	69	73	RWMC O-46	69	74
RWMC O-21A	75	78	RWMC O-47	70	72
RWMC O-23A	71	75			

a. Millirem (mrem) in ambient dose equivalent.

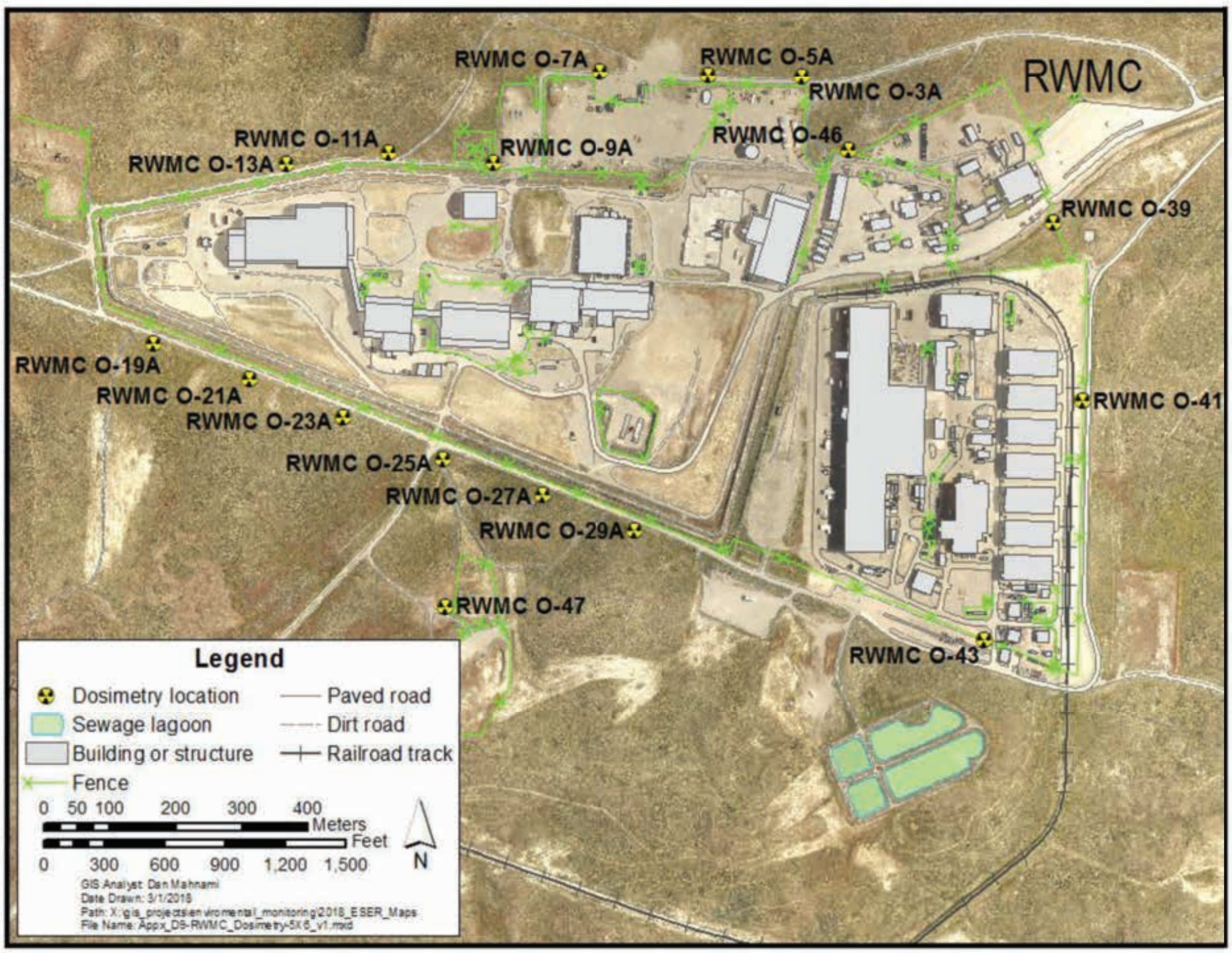


Figure D-9. Environmental Radiation Measurements at Radioactive Waste Management Complex (RWMC) (2018).

Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018	Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018
TAN LOFT O-6	70	73	TAN LOFT O-10	74	70
TAN LOFT O-7	79	73	TAN LOFT O-11	73	72
TAN LOFT O-8	60	60	TAN LOFT O-12	68	69
TAN LOFT O-9	57	56	TAN LOFT O-13	76	76

a. Millirem (mrem) in ambient dose equivalent.

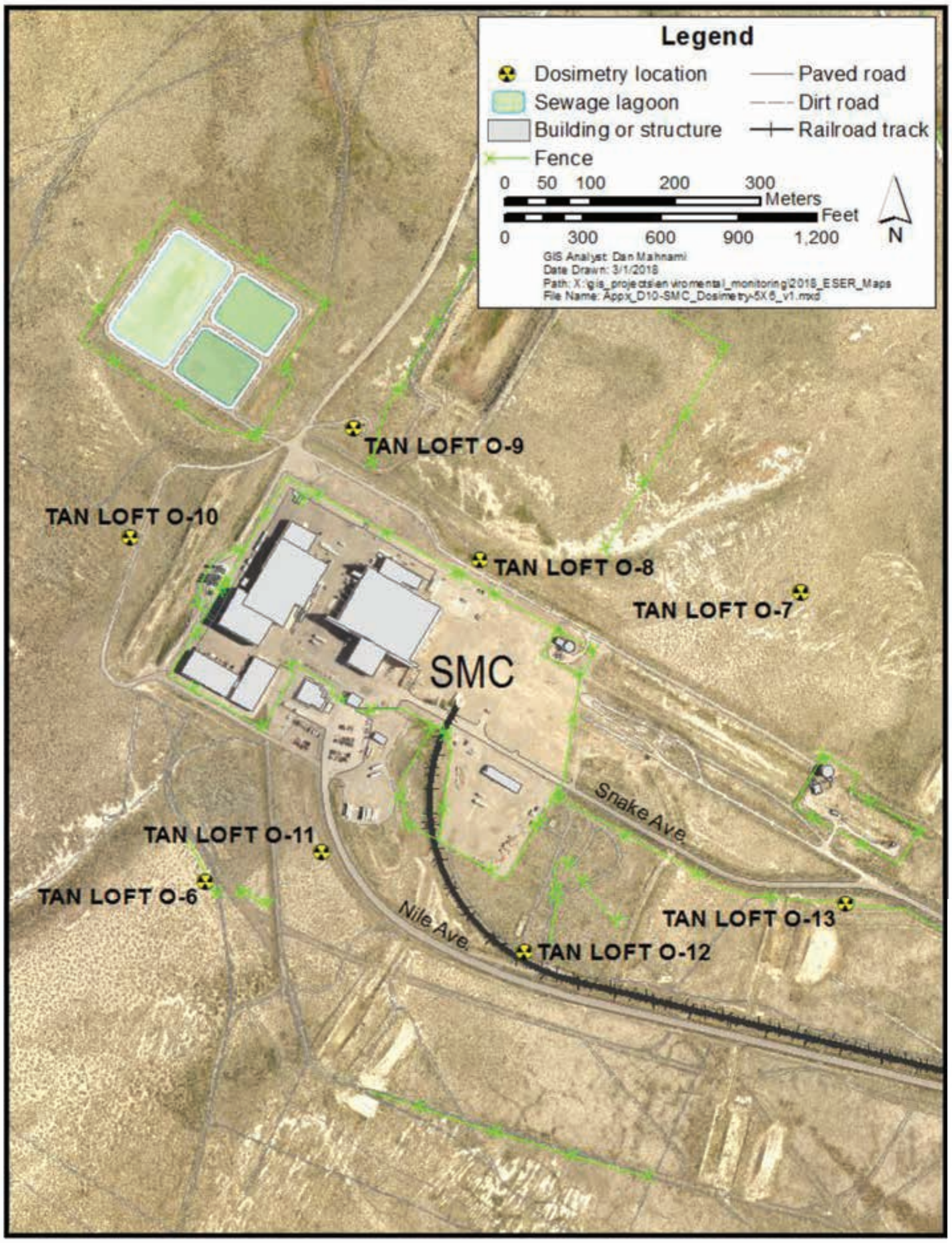


Figure D-10. Environmental Radiation Measurements at Specific Manufacturing Capability (SMC) (2018).

Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018	Location	mrem[a] Nov. 2017 – April 2018	mrem[a] May 2018 – Oct. 2018
EBR1 O-1	59	59	Hwy33 T17 O-3	67	64
EFS O-1	72	67	LincolnBlvd O-3	76	78
Gate4 O-1	71	63	LincolnBlvd O-5	81	77
Haul E O-1	68	74	LincolnBlvd O-9	73	78
Haul W O-2	72	79	LincolnBlvd O-15	77	73
Hwy20 Mile O-266	70	66	LincolnBlvd O-25	67	67
Hwy20 Mile O-270	71	68	Main Gate O-1	76	74
Hwy20 Mile O-276	71	67	Rest O-1	70	73
Hwy22 T28 O-1	63	59	VANB O-1	74	73
Hwy28 N2300 O-2	59	62			

a. Millirem (mrem) in ambient dose equivalent.

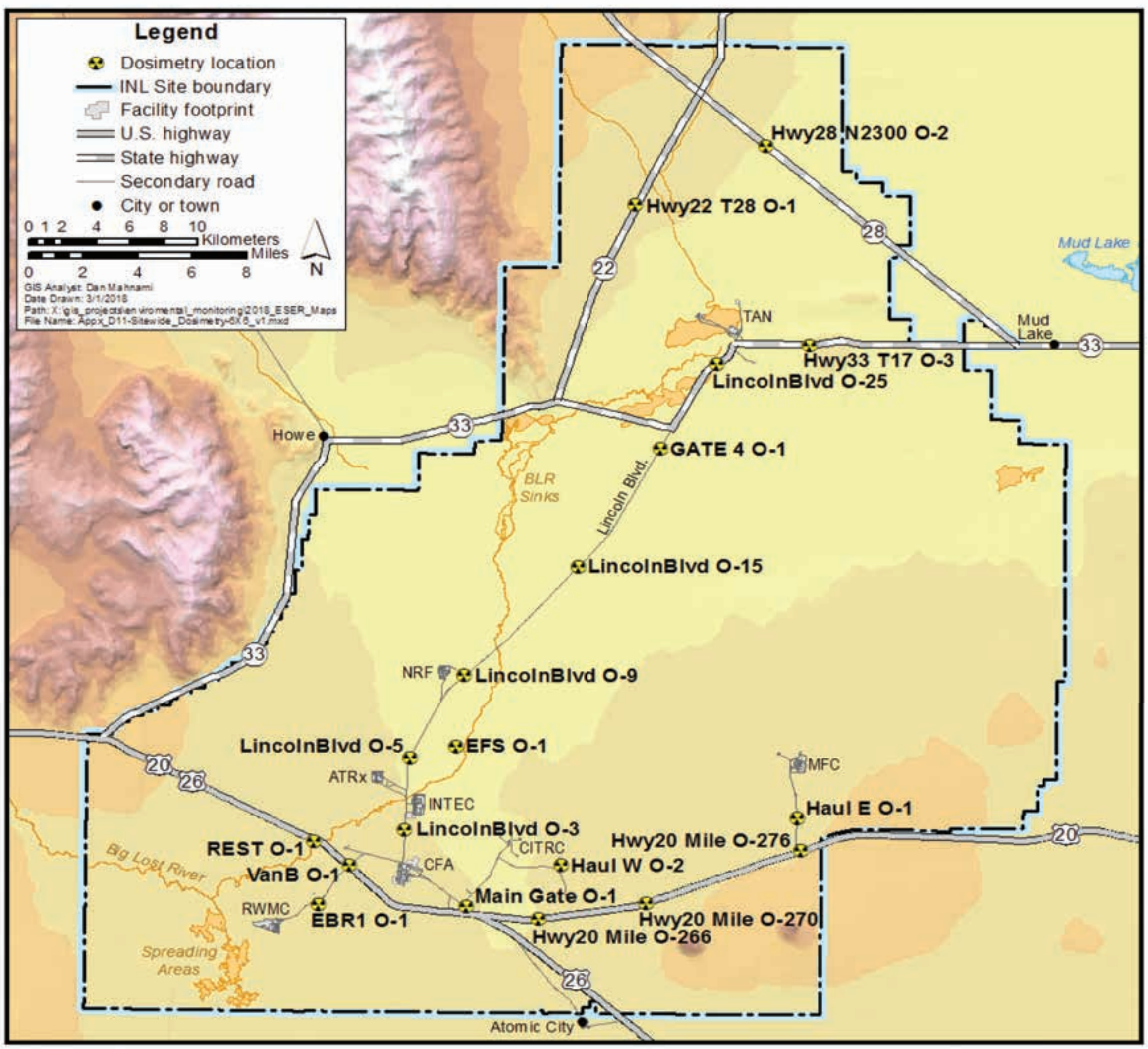


Figure D-11. Environmental Radiation Measurements at Sitewide Locations (2018).

	mrem[a]			mrem[a]	
Location	Nov. 2017– April 2018	May 2018 – Oct. 2018	Location	Nov. 2017– April 2018	May 2018 – Oct. 2018
Arco O-1	66	68	Mud Lake O-5	73	70
Atomic City O-2	66	66	Reno Ranch O-6	61	58
Blackfoot O-9	63	62	RobNOAA	64	81
Craters O-7	64	69	RRL3 O-1	64	60
Howe O-3	67	62	RRL5 0-1	73	91
Idaho Falls O-10	63	63	RRL6 O-1	71	65
IF-IDA O-38	60	59	RRL17 O-1	65	62
Monteview O-4	63	67	RRL24 O-1	58	57

a. Millirem (mrem) in ambient dose equivalent.

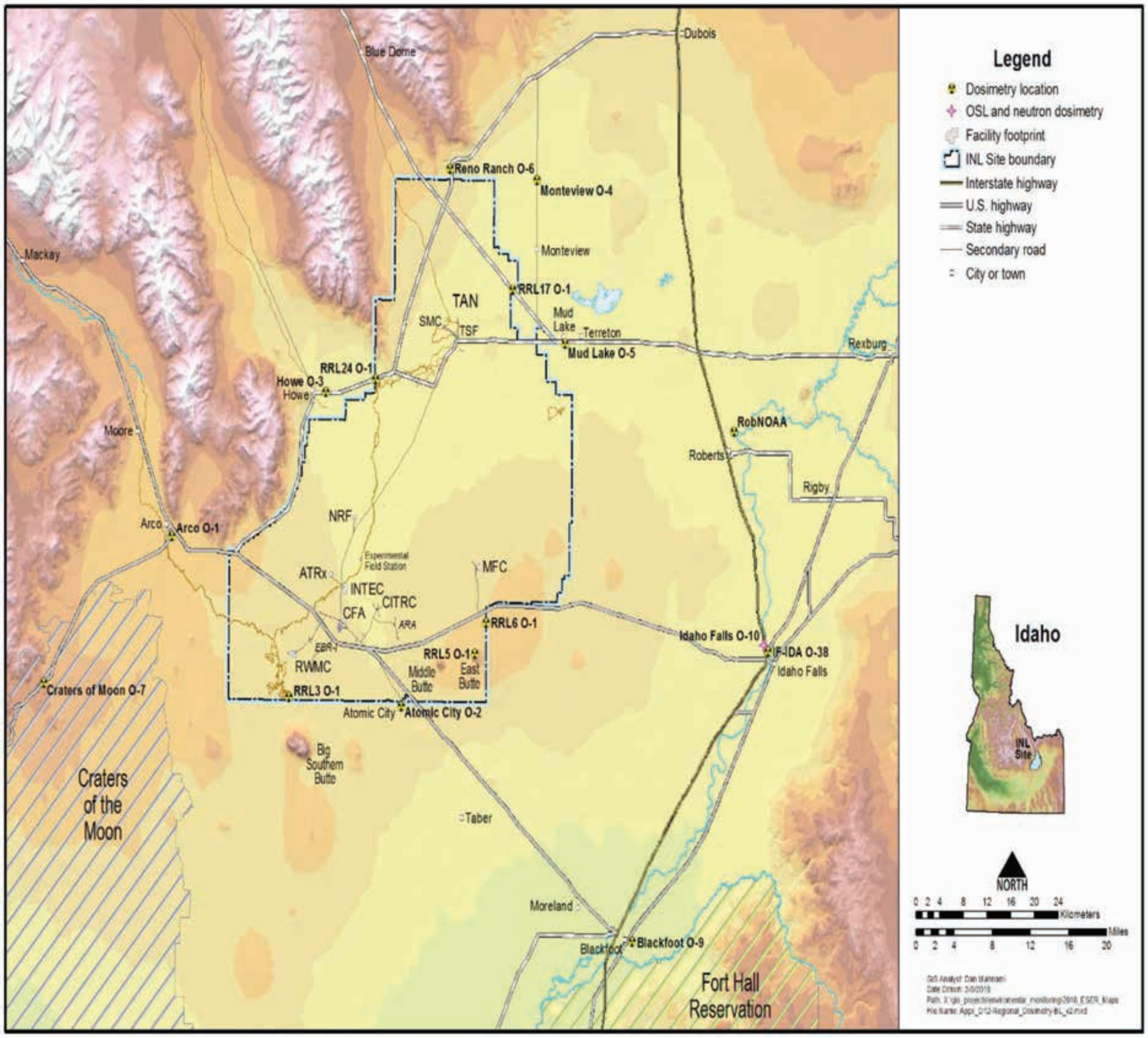


Figure D-12. Environmental Radiation Measurements at Regional Locations (2018).

Location	mrem[a]	
	Nov. 2017 – April 2018	May 2018 – Oct. 2018
IF-616N O-36	77	64
IF-665W O-37	65	69

a. Millirem (mrem) in ambient dose equivalent.

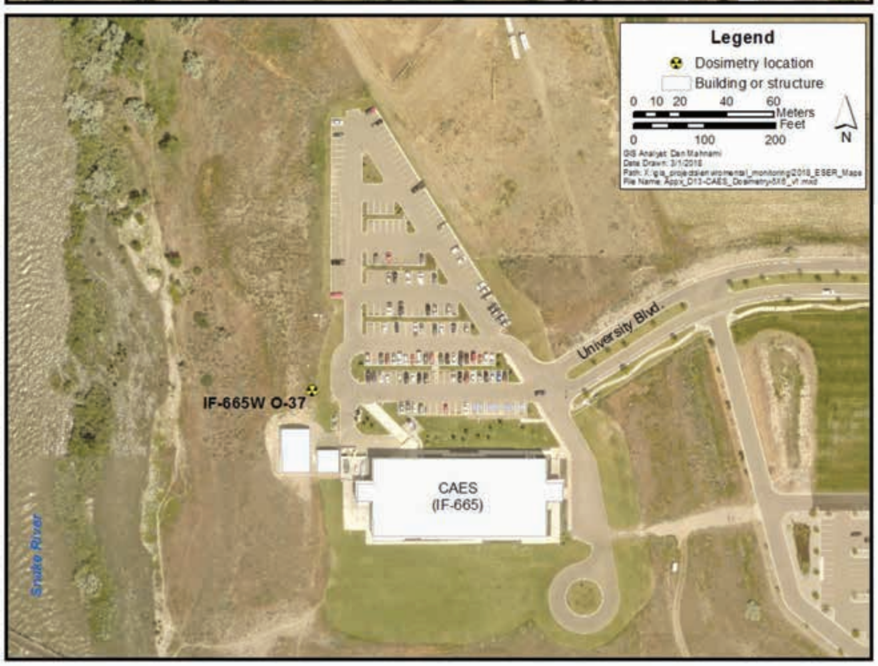
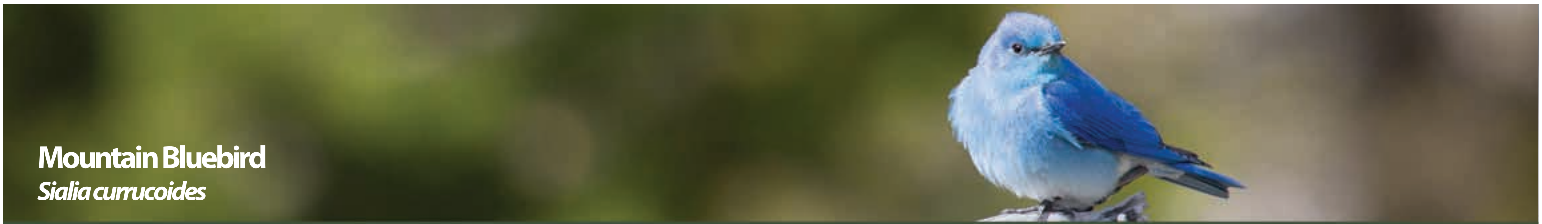


Figure D-13. Environmental Radiation Measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2018).

Desert Cottontail
(Sylvilagus audubonii)



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.

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 × 1010 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). DOE O 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 dispersion 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 (H_T): 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 substance: A substance listed in the appendices to 40 CFR 355, "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of above-ground 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 (corrosivity, reactivity, ignitability, 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 by which water on the ground surface enters the 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% 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:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

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% (one sigma), 95.4% (two sigma), or 99.7% (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 an average of 25 persons less than six months per year. These systems are typically campgrounds or highway rest stops.

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 to wet conditions that cannot adapt to an absence of flooding. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

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