Calendar Year 2019

Idaho National Laboratory

Site Environmental Report

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Idaho National Laboratory Site Environmental Report Calendar Year 2019

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

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TO OUR READERS

The Idaho National Laboratory Site Environmental Report for Calendar Year 2019 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, 2019. 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/2019/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 Veolia Nuclear Solutions Federal Services 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 Environmental Surveillance, Education and Research Program website are:

- INL (https://www.inl.gov/)

- Idaho Cleanup Project Core (https://fluor-idaho.com/default.aspx#about

- 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)

- Environmental Surveillance, Education and Research Program (http://www.idahoeser.com/)

Included in the chapter headings of this report are photographs, as well as common and scientific names of birds and flora native to the INL Site.

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

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

environmental cleanup of the legacy wastes generated from World War II-era conventional weapons testing, government-owned reactors, and spent fuel reprocessing. The overarching aim of the project is to reduce risks to workers and production facilities, the public, and the environment and to protect the Snake River Plain aquifer.

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/2019/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 2019 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; Idaho Nuclear Technology and Engineering Center (INTEC); Materials and Fuels Complex (MFC); Naval Reactors Facility; Radioactive Waste Management Complex (RWMC); and Test Area North (TAN), which includes the Specific Manufacturing Capability. 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

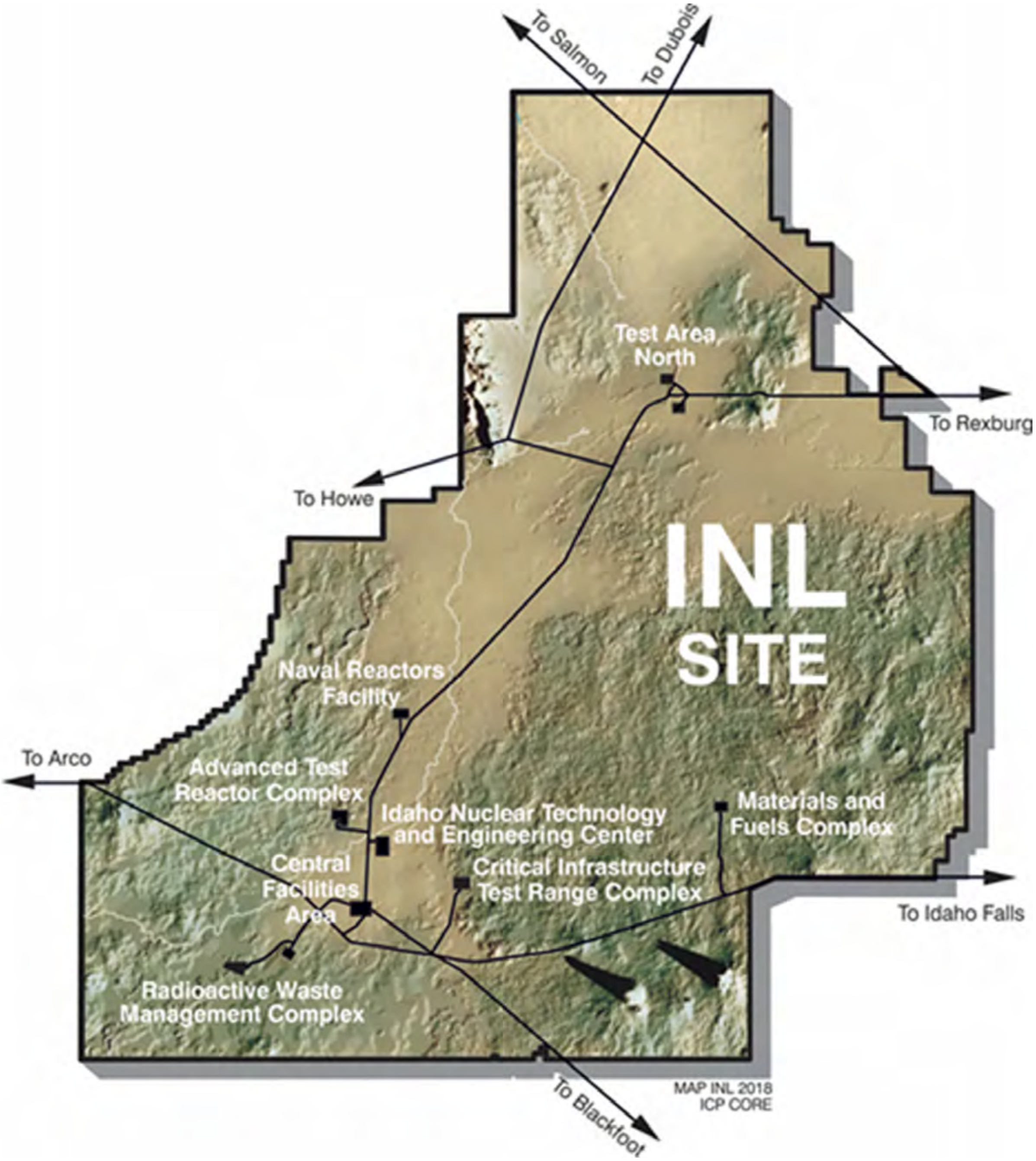


Figure ES-2. Idaho National Laboratory Site Facilities.

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.

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. The ATR provides unique irradiation capabilities for nuclear technology research and development.
Central Facilities Area	INL	INL support for the operation of other INL Site facilities and management responsibility for the balance of the INL outside of facility boundaries.
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. Location of the Integrated Waste Treatment Unit, a first-of-a-kind, 53,000-square-foot facility, that will treat 900,000 gallons of liquid radioactive and hazardous waste that has been stored underground storage tanks.
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, Idaho, 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.

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 2019, all institutional controls and operational and maintenance requirements were maintained, and active remediation continued on WAGs 1, 3, 7, and 10.

Radiation Dose to the Public and Biota from INL Site Releases

Humans, plants, and animals potentially receive radiation doses from various INL Site operations. The DOE sets dose limits for the public and biota to ensure that exposure to radiation from site operations are not a health concern. Potential radiological doses to the public from INL Site operations were calculated to determine compliance with pertinent regulations and limits (Table ES-2). The calculated dose to the maximally exposed individual in 2019 from the air pathway was 0.056 mrem (0.56 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 determined by the air dispersion model. This person is assumed to live at a location east of INL's east entrance and south of Highway 20. For comparison, the dose from natural background radiation was estimated in 2019 to be 382 mrem (3,820 µSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 342,761 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.048 person-rem (0.00048 person-Sv), below that

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2019).

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	0.056	0.56	0.056	0.048	0.00048	342,761	130,935
Waterfowl	0.004	0.04	NA[c]	NA	NA	NA	NA
Big game animals	-[d]	-[d]	NA	NA	NA	NA	NA
Total pathways	**0.06**	**0.6**	**0.06**	**0.048**	**0.00048**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.

b. The individual dose from background radiation was estimated to be 382 mrem (3.8 mSv) in 2019 (Table 7-8).

c. NA = Not applicable

d. No road-killed big game animals were available for collection in 2019, so no dose was calculated.

expected from exposure to background radiation (130,935 person-rem or 1,309 person-Sv). The 50-mi population dose calculated for 2019 is higher than that calculated for 2018 (0.0075 person-rem or 0.000075 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 0.004 mrem (0.04 µSv). There were no big game animals sampled in 2019. Because there were no big game animals sampled in 2019, there were no radionuclies detected; hence no dose was calculated for 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 0.06 mrem (0.6 µSv) in 2019. This is 0.06 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 (5,041 pCi/L) via drinking water from these wells would receive a dose of approximately 0.3 mrem (0.003 mSv) in one year. This is an unrealistic pathway to humans because there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for tritium (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 2019, the dose was conservatively estimated to be 0.01 mrem (0.1 µSv), which is 0.1 percent of the 10-mrem/yr federal standard.

Doses were also evaluated for nonhuman biota at the INL Site using a graded approach. 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 1,611 curies (5.96×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2019. 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 2019, the INL contractor monitored ambient air at 16 locations on the INL Site and at six 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

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 2019*.	2.2.1 4.2 8.2.1
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 preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment.	The INL Site maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions does not present risk to the public, workers, or environment. Environmental monitoring plans are well documented, and the results are published in the annual INL Site Environmental Report.	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/40 CFR 300	The Comprehensive Environmental Response, Compensation and Liability Act provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning) of inactive hazardous waste disposal sites. The	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.	2.1.1
EPA/40 CFR 109-140	Clean Water Act establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two Clean Water Act permits as applicable or needed- the National Pollution Discharge Elimination System permits and Storm Water Discharge Permits for construction activity.	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 routinely sampled and analyzed 12 drinking water systems in 2019 as required by the state of Idaho and EPA.	2.3.2 6.6
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 May of 2019. Alleged instances of noncompliance were resolved.	2.1.2

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. 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 two stations on and two stations off the INL Site in 2019. 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 ESER were below DOE standards. Tritium measured in these samples is most likely the result of natural production in the atmosphere and remants of nuclear weapons testing and not the result of INL Site effluent releases.

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 an industrial waste ditch and waste pond at MFC. 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 2019, 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. The INL and ICP Core contractors monitored 11 drinking water systems at the INL Site in 2019. (The NRF contractor monitors an additional drinking water system, the results of which are reported separately by NRF.) 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 2019. The dose, 0.131 mrem (1.31 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. Gross beta and radium-226 were detected in 2019 samples. 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 2019, 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 30 groundwater monitoring wells and one perched well sampled at the INL Site in 2019. 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 2019. 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 17 aquifer monitoring wells at and near INTEC (WAG 3) during 2019. 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 landfill were monitored in 2019 for metals (filtered), volatile organic compounds, and anions (nitrate, chloride, fluoride, and sulfate). No laboratory analyte exceeded an EPA maximum contaminant level for the CFA landfill monitoring. Iron was the only analyte for CFA landfill monitoring which exceeded a secondary maximum contaminant level. Nitrate continued to exceed the EPA maximum contaminant level (MCL) in one well in the plume south of the CFA in 2019, and overall the data show a downward trend since 2006.

Groundwater samples were collected from monitoring wells near the RWMC (WAG 7) in May 2019 and analyzed for radionuclides, inorganic constituents, and VOCs. No analytes were detected above the MCLs in samples collected from the aquifer in May 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 (as part of WAG 10) were sampled and analyzed for VOCs, anions, gross alpha, gross beta and tritium in 2019. None of the analytes exceeded the EPA MCLs or secondary MCLs.

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 2019. 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 a low level in a milk sample collected regionally.

No big game animals were available in 2019. Cobalt-60, ^{65}Zn, ^{90}Sr, ^{137}Cs, and ^{238}Pu were detected in tissues of waterfowl collected near the ATR Complex ponds indicating that they accessed the contaminated ponds.

Cobalt-60, ^{65}Zn, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239/240}$Pu were detected in some composited bat samples indicating that bats may have visited radioactive wastewater ponds, such as those at the ATR Complex.

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 2019 included sage-grouse lek surveys, raven nest surveys, mid-winter raptor, corvid and shrike surveys, and breeding bird surveys. During 2019, operation and monitoring of permanent bat monitoring stations continued at the INL Site.

Forty-four sage-grouse leks were classified as active on or near the INL Site prior to the 2019 field season. After the field season, reclassification resulted in a net loss of four active leks. The total number of known active leks at or near the INL Site is currently 40.

The total number of active raven nests recorded on the INL Site was 33 percent lower in 2019, compared to 2018 with a total of 29 observed. Twenty-one of the 29 nests were located on powerline structures and seven located within facility boundaries, and four on towers.

The 2019 midwinter raptor, corvid, and shrike count on the INL Site recorded higher golden eagle observations (14) than in 2018 (6), a slight increase in rough-legged hawk observed, and the number of ravens fell slightly from the previous two years.

The 2019 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 sage-brush-dominated communities during large wildfires since 2000.

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 2019, ecological research and monitoring projects conducted through the ESER program included completion of a comprehensive INL Site vegetation map and technical report with supporting documentation, and annual sagebrush habitat monitoring and sagebrush restoration.

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 accuracy assessment of the updated map was completed in 2019 along with a technical report summarizing the results of the project.

Two sagebrush habitat monitoring and restoration tasks were ongoing in 2019. Sagebrush habitat monitoring was completed on 119 of the 125 plots due to plots being affected by the Sheep Fire. Over the past six years sagebrush cover has been stable, however, cheatgrass cover decreased from 37% in 2018 to 27% in 2019. The only sagebrush habitat lost, due to the Sheep Fire within the Sage-Grouse Conservation Area were 2.3 ha (5.7 acres) of unburned patches of sagebrush that remained in the footprint of the 2010 Jefferson Fire boundary and 10,401.7 ha (25,703.1 acres) of sagebrush habitat outside the Sage-Grouse Conservation Area. Sagebrush restoration efforts included planting approximately 10,000 seedlings at a location in the northwest corner of the Jefferson Fire. One-year survivorship monitoring of seedlings planted in 2018 indicated a minimum survivorship of 66 percent.

The land within the INL Site's borders became DOE's second NERP 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 three ecological research projects ongoing through the Idaho NERP, one includes documenting ants and associated arthropods on the INL Site, one involves tracking rattlesnake movements through gestation and dispersal of young, and one addresses sage-grouse movements and habitat use through nesting and brood-rearing seasons.

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 2019, the USGS published three 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 2019. 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 2019 were addressed with the laboratories and have been or are being resolved.

HELPFUL INFORMATION

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

What is Radiation?

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

X-Rays and Gamma-Rays. X-rays and gamma-rays are photons that have very short wave-lengths 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

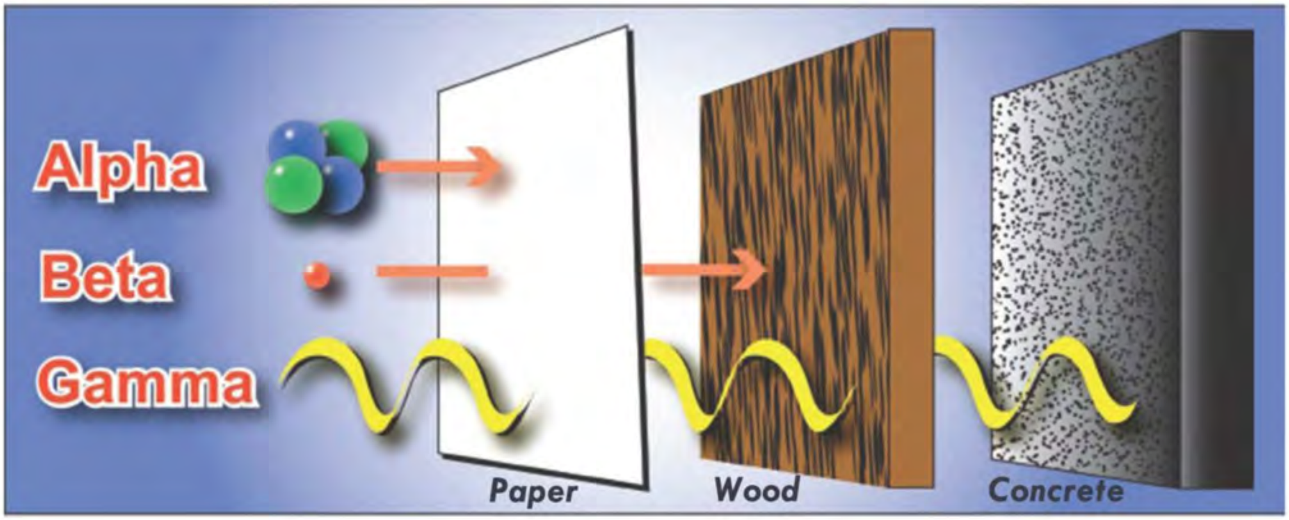


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

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

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 x 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 x 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 x 10^5 yr
^{141}Ce	Cerium-141	32.508 d	^{40}K	Potassium-40	1.251 x 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 x 10^5 yr
^{129}I	Iodine-129	1.57 x 10^7 yr	^{232}Th	Thorium-232	1.405 x 10^{10} yr
^{131}I	Iodine-131	8.0207 d	^{233}U	Uranium-233	1.592 x 10^5 yr
^{55}Fe	Iron-55	2.737 yr	^{234}U	Uranium-234	2.455 x 10^5 yr
^{59}Fe	Iron-59	44.495 d	^{235}U	Uranium-235	7.04 x 10^8 yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468 x 10^9 yr
^{87}Kr	Krypton-87	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

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 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.

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 Ci). The curie is based on the disintegration rate occurring in 1 gram of the radionuclide radium-226, which is 37 billion (3.7×10^{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

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

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)

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 partialbody 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 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.

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.

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/kg) 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

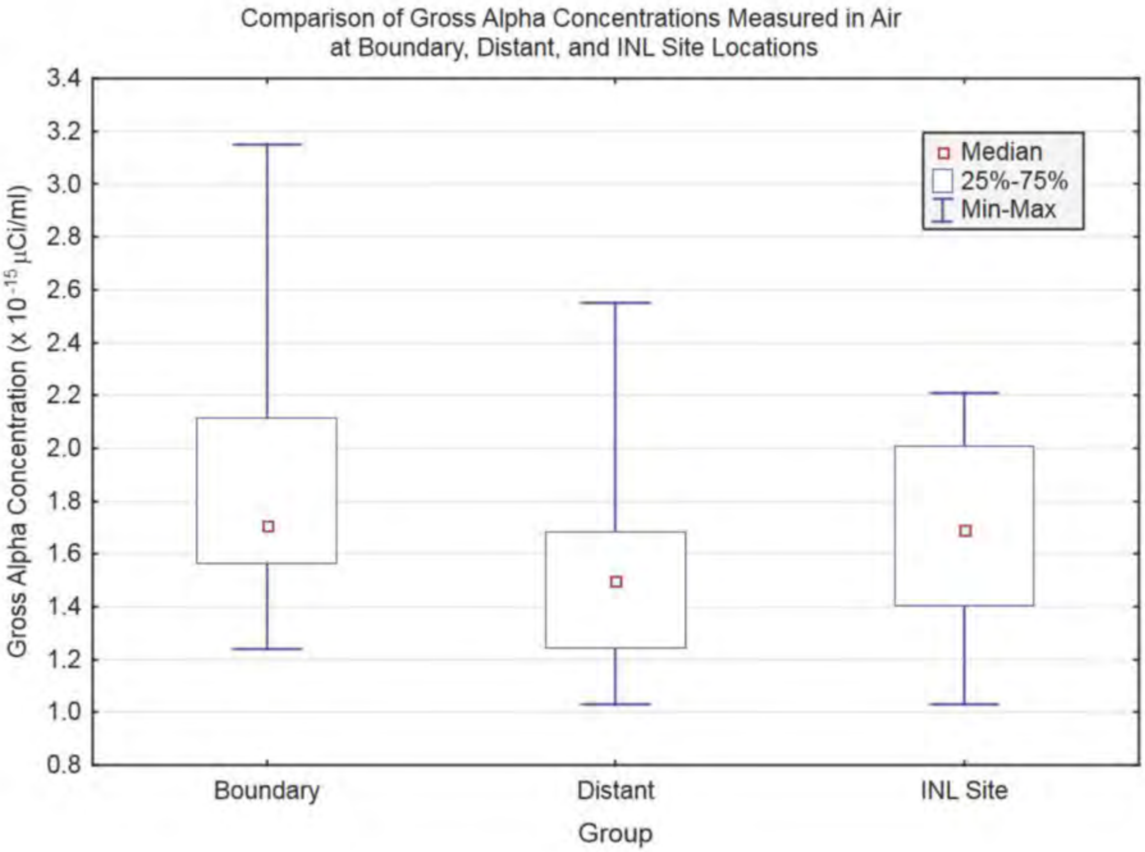


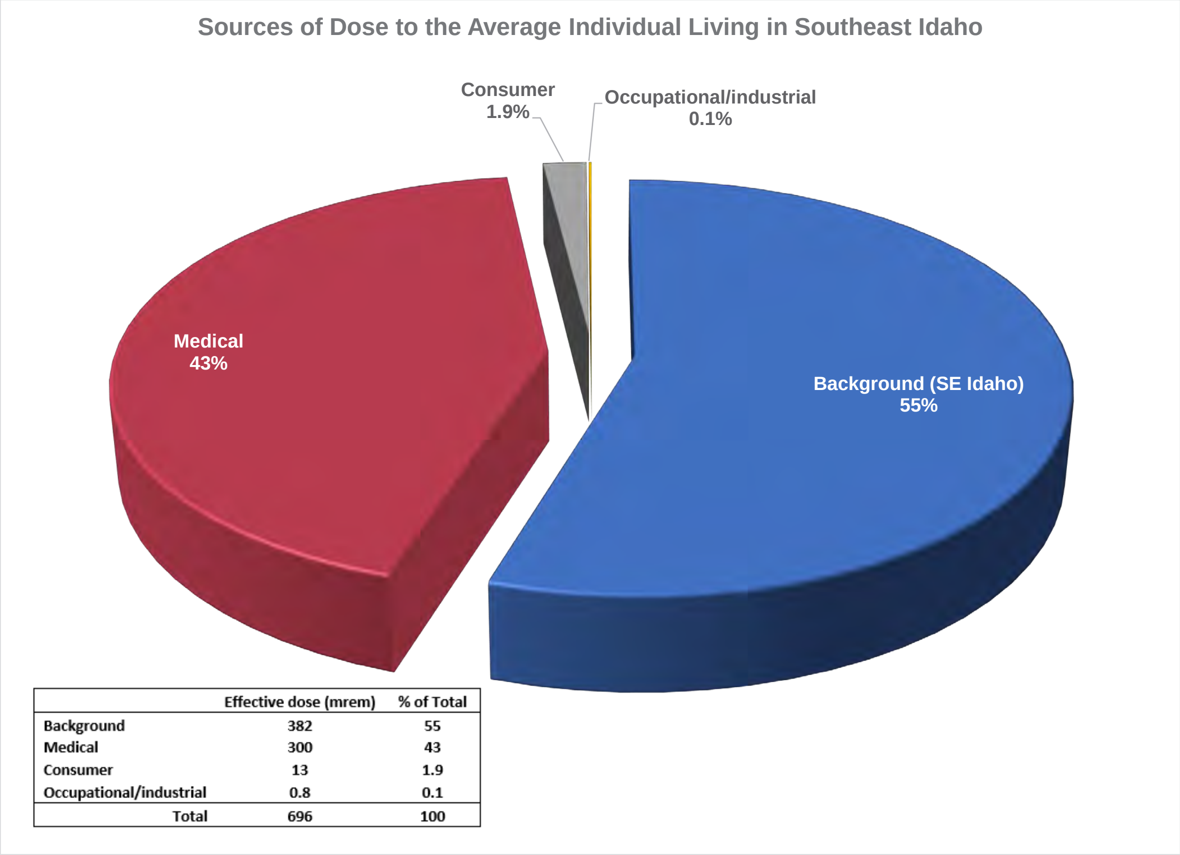
Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results with a Box Plot. The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile, and 75 percent of the measurements are less than the 75th percentile.

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 south-east 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 7-8 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 2010 through 2019. 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 three wells collected by USGS for 21 years (1999–2019). The results are plotted by year.

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



	Effective dose (mrem)	% of Total
Background	382	55
Medical	300	43
Consumer	13	1.9
Occupational/industrial	0.8	0.1
Total	696	100

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

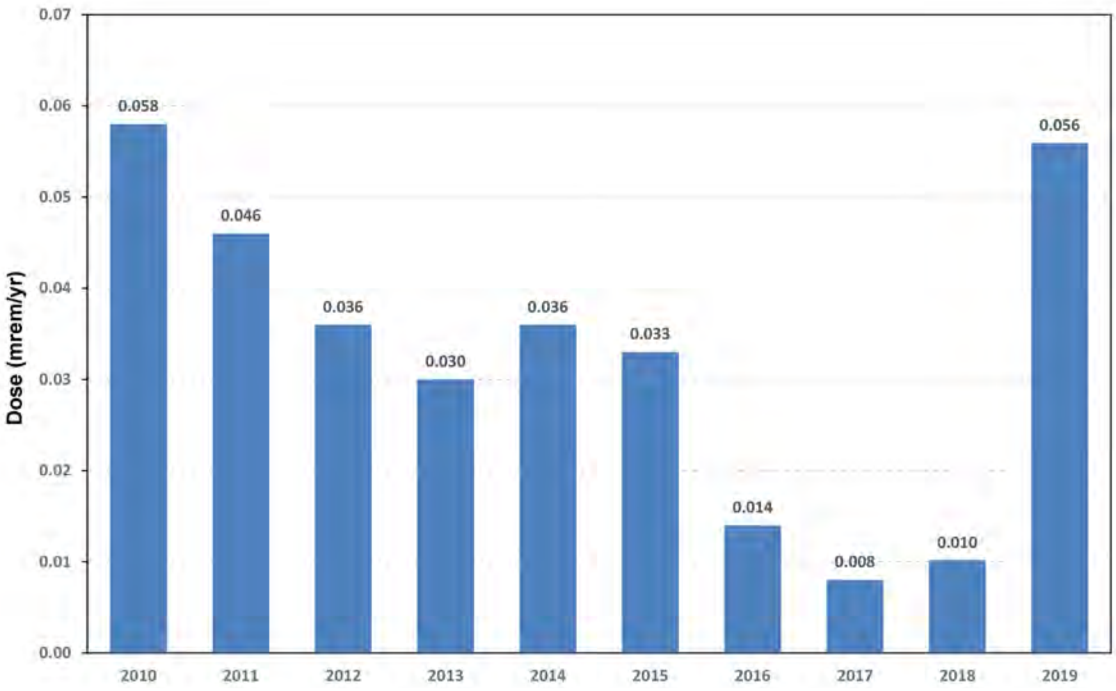


Figure HI-4. Data Plotted Using a Column Chart.

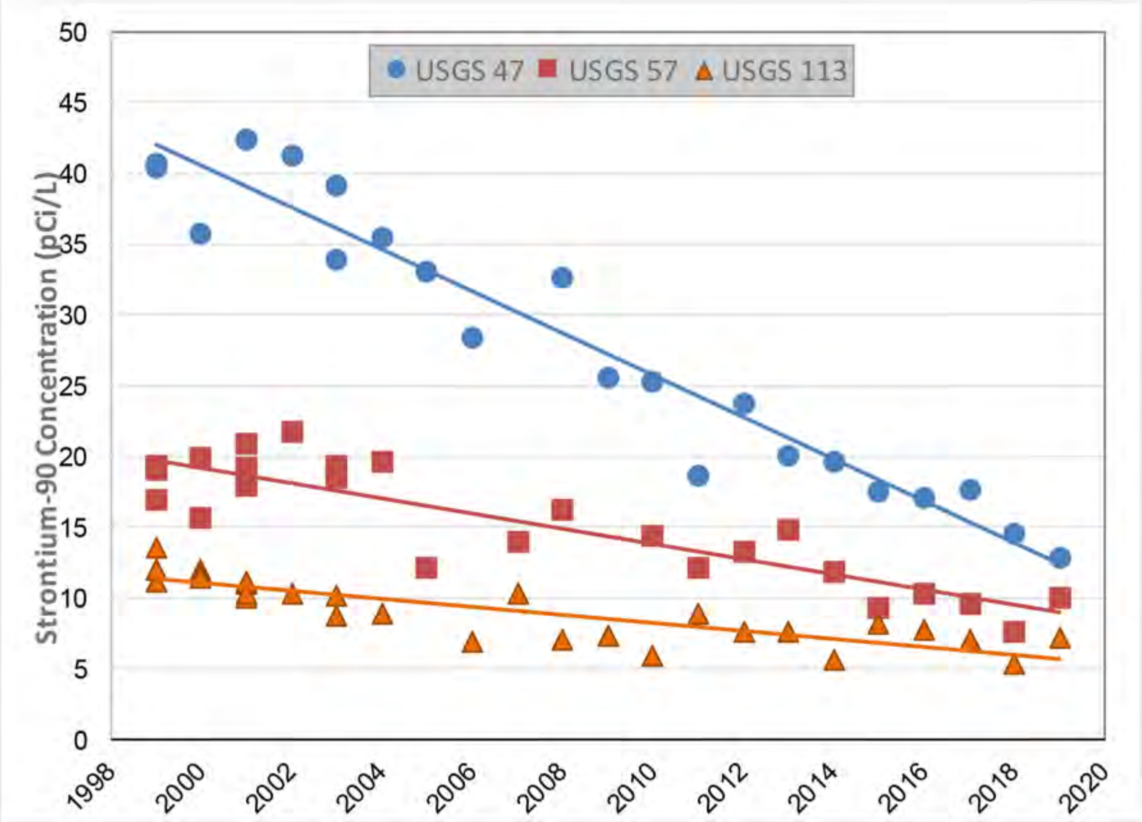


Figure HI-5. Data Plotted Using a Linear Plot.

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:

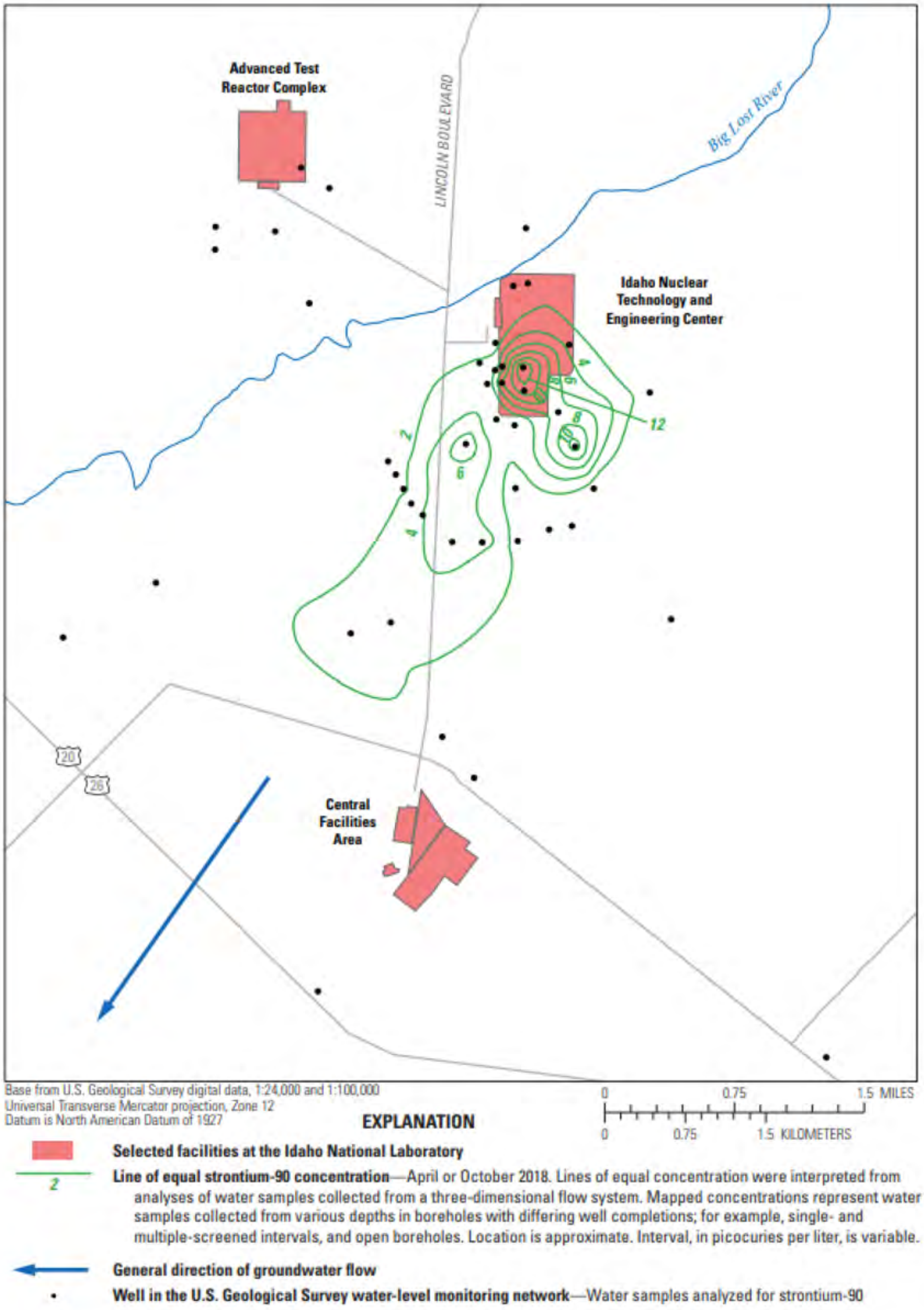
- Comparison of results collected at different locations. For example, measurements made at Idaho National Laboratory (INL) Site locations are compared with those made at locations near the boundary of the INL Site and distant from the INL Site to find differences that may indicate an impact (Figure 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 from 2010 to 2019. Figure HI-6 illustrates a clear spatial pattern of radionuclide concentrations in groundwater decreasing with distance from the source.

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

What Is Background Radiation?

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



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

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.

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 2019 to receive an average dose of about 382 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 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

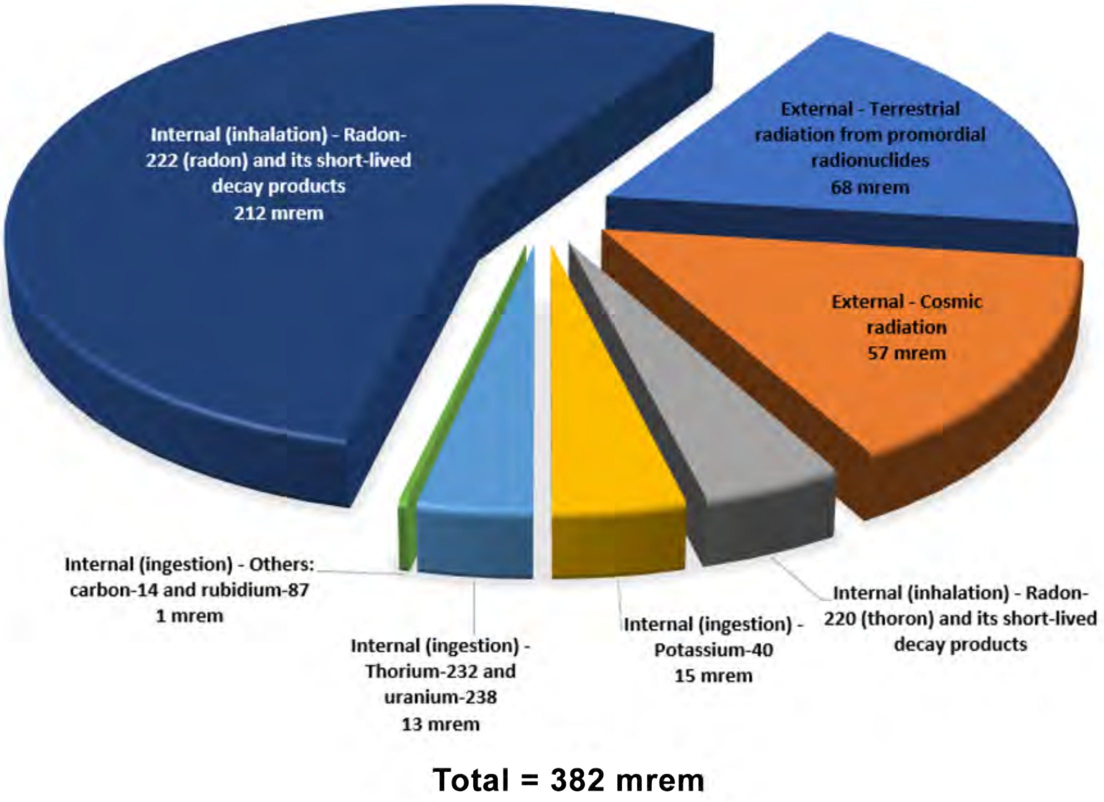


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2019).

generally higher at midlatitudes 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 (68 mrem/yr or 0.68 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).

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

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

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°. 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 5.8×10^{-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 382 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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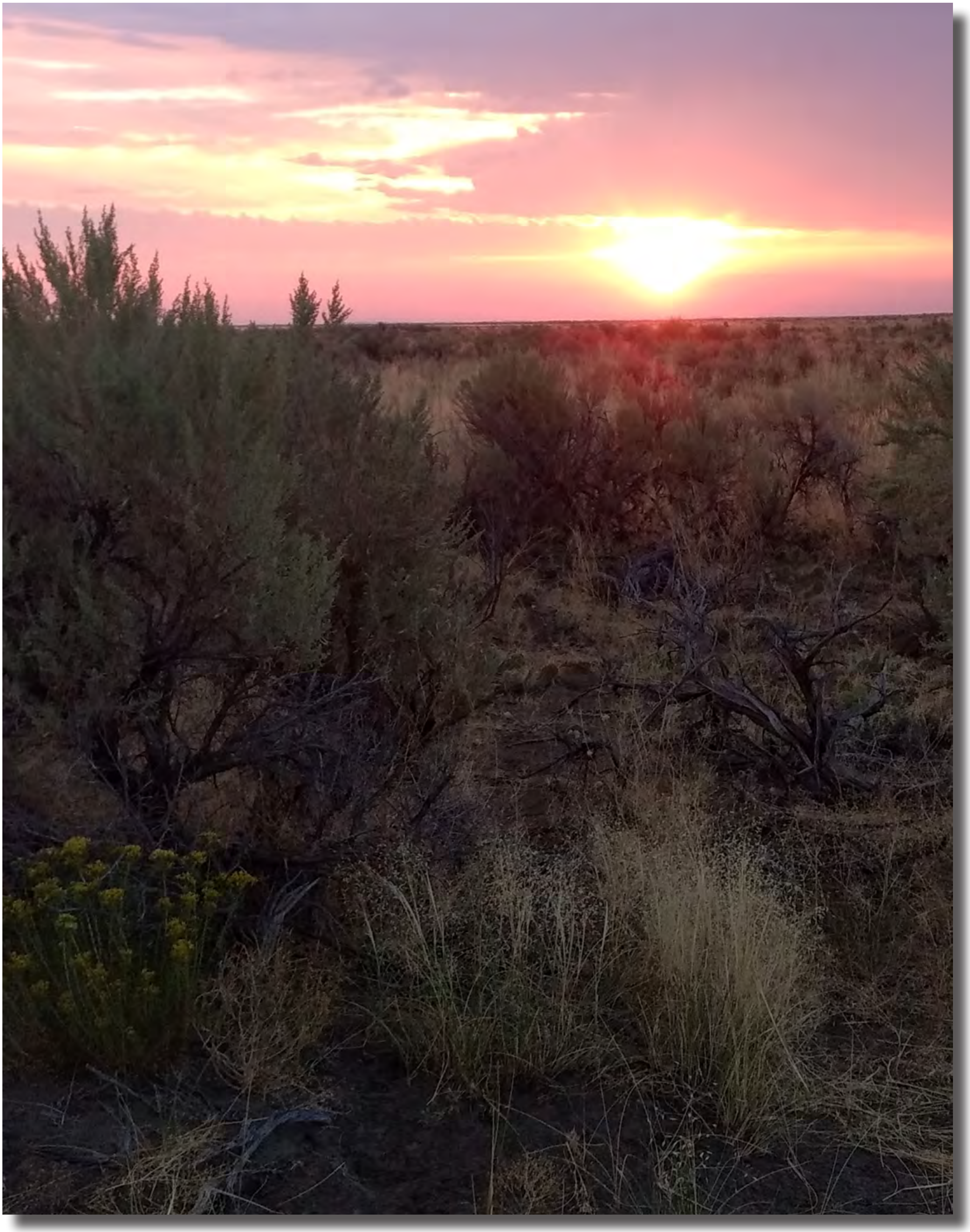
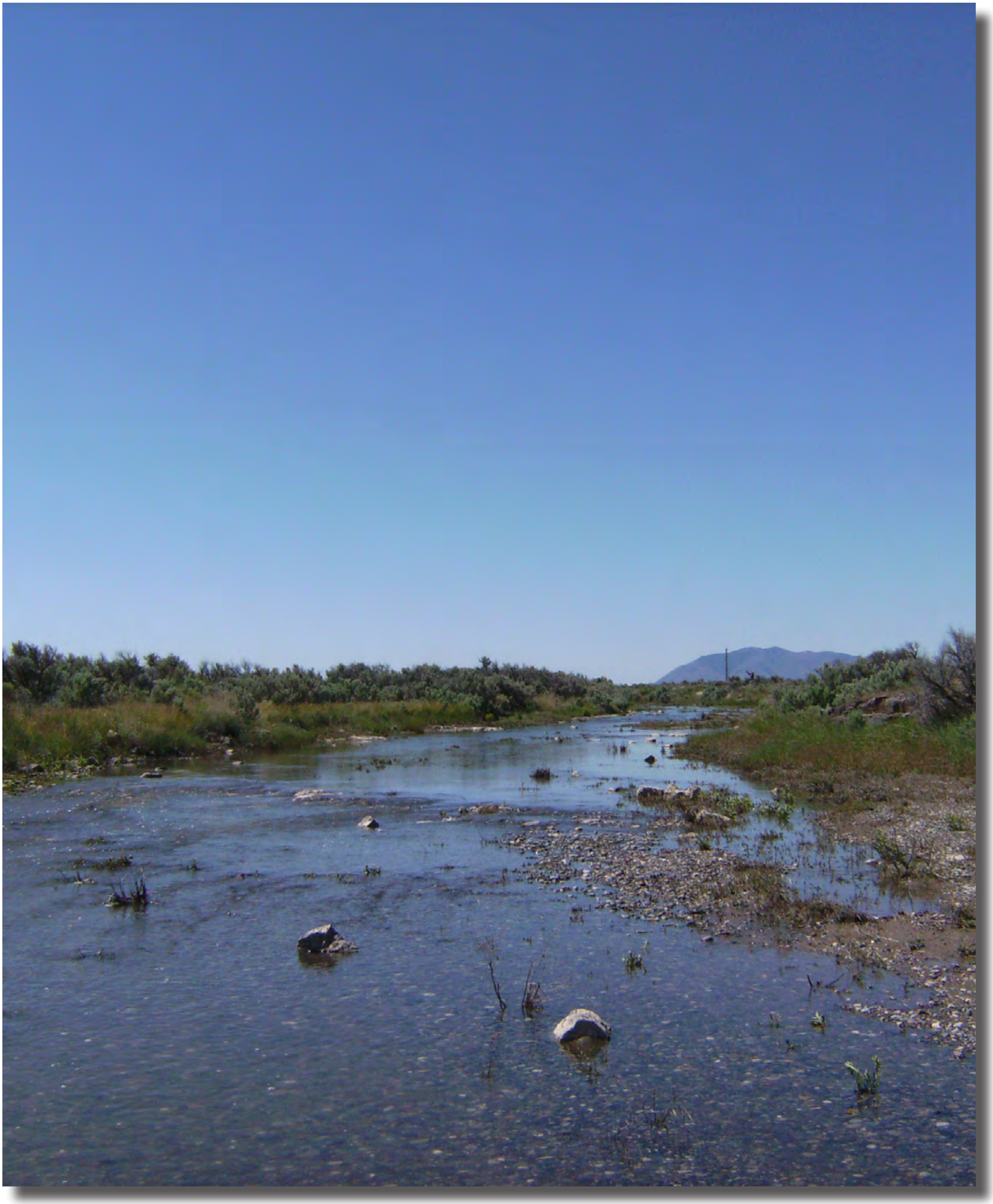


ACRONYMS

AFV	alternative fuel vehicle
ALARA	As Low As Reasonably Achievable
ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ARP	Accelerated Retrieval Project
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
BBS	breeding bird survey
C&D	construction and demolition
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	U.S. Department of Energy
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOSEMM	dose multi-media
DQO	data quality objective
DWP	Drinking Water Program
ECM	energy conservation measures
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
EPEAT	Electronic Product Environmental Assessment Tool
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
ESPC	Energy Savings Performance Contract
ESRP	Eastern Snake River Plain
EUI	energy-use intensity
FAA	Federal Aviation Administration
FFA/CO	Federal Facility Agreement and Consent Order
FWS	U.S. Fish and Wildlife Service

FY	fiscal year
GEL	GEL Laboratories, LLC
GHG	greenhouse gas
GP	Guiding Principles
GPRS	Global Positioning Radiometric Scanner
GWMP	Groundwater Monitoring Program
HAA5	haloacetic acids
HVAC	heating, ventilating, and air conditioning
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
ILA	industrial, landscaping, and agricultural
IM	Information Management
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRC	INL Research Center
ISB	in situ bioremediation
ISA	Idaho Settlement Agreement
ISO	International Organization for Standardization
ISU-EAL	Idaho State University – Environmental Assessment Laboratory
IUPAC	International Union of Pure and Applied Chemistry
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
NAREL	National Analytical Radiation Environmental Laboratory
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
NM	not measured
NRF	Naval Reactors Facility

NS	no sample
O&M	Operations & Maintenance
OSLD	optically stimulated luminescence dosimeter
PBC	polychlorinated biphenyls
PCS	primary constituent standard
PE	performance evaluation
PLN	plan
PUE	power utilization effectiveness
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
RI/FS	Remedial Investigation/Feasibility Study
RHLLW	Remote Handled Low-level Waste Disposal Facility
RMA	Rocky Mountain Adventure
ROD	Record of Decision
RPD	relative percent difference
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
TRU	transuranic
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TREAT	Transient Reactor Test Facility
TTHM	total trihalomethanes
UESC	Utility Energy Services Contract
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
VNSFS	Veolia Nuclear Solutions Federal Services
VOC	volatile organic compound
WAG	waste area group
WFMC	Wildland Fire Management Committee
WIPP	Waste Isolation Pilot Plant
WMF	Waste Management Facility
WNS	white-nose syndrome
WRP	Wastewater Reuse Permit
YOY	year over year



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

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1. INTRODUCTION


Silvery lupine
(*Lupinus argenteus*)

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.

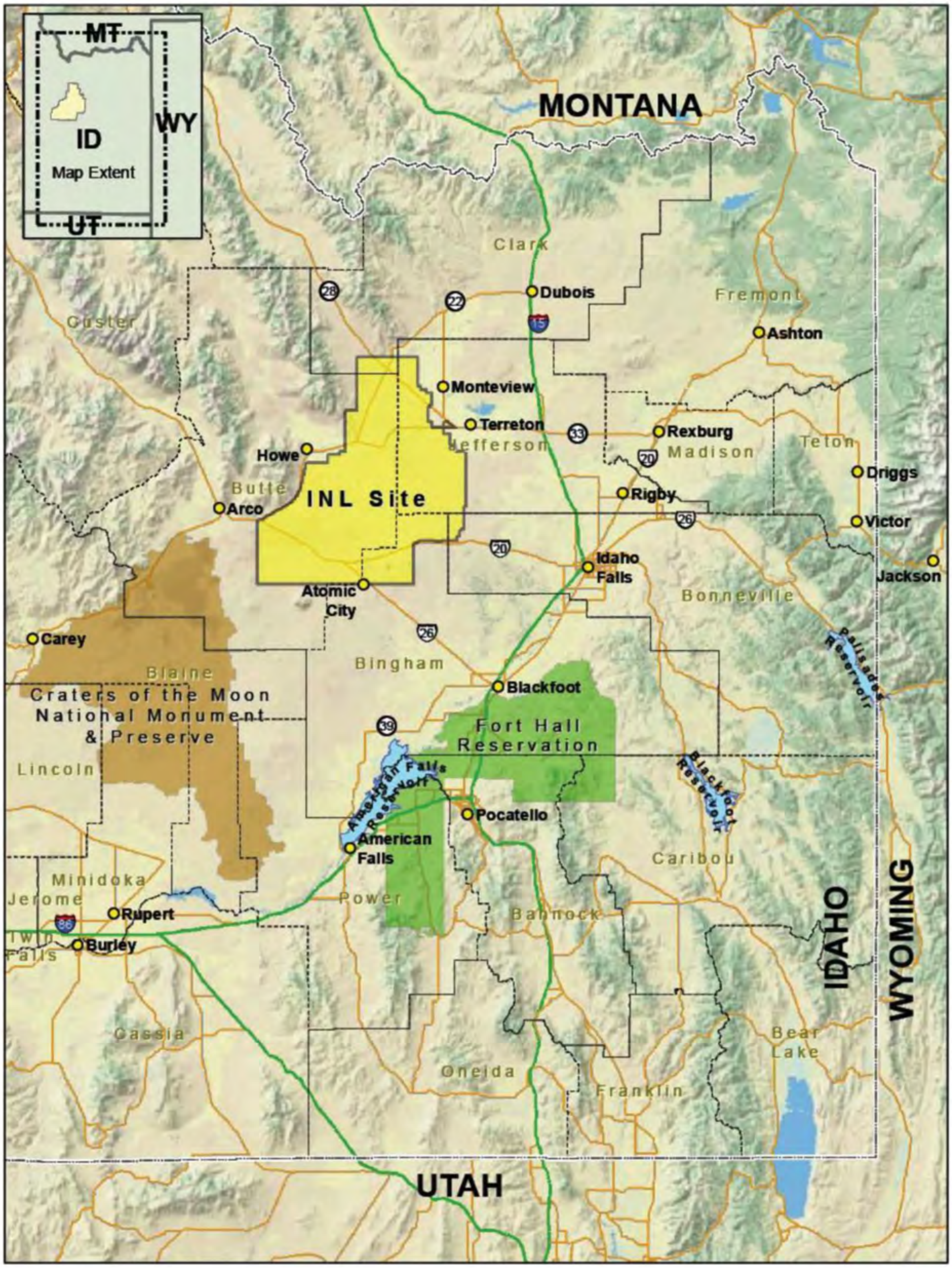

Figure 1-1. Location of the Idaho National Laboratory Site.

The INL Site is also home to many kinds of animals. 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 riverbed 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 part of 2019 and fill the Big Lost River Sinks (Figure 1-2). River samples were collected during 2017-2019 after being dry from 2013-2016.

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 used as a gunnery range, known then as the Naval Proving Ground.

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

The U.S. Army Air Corps also trained bomber crews out of the Pocatello Airbase and used the area as a bombing range.

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

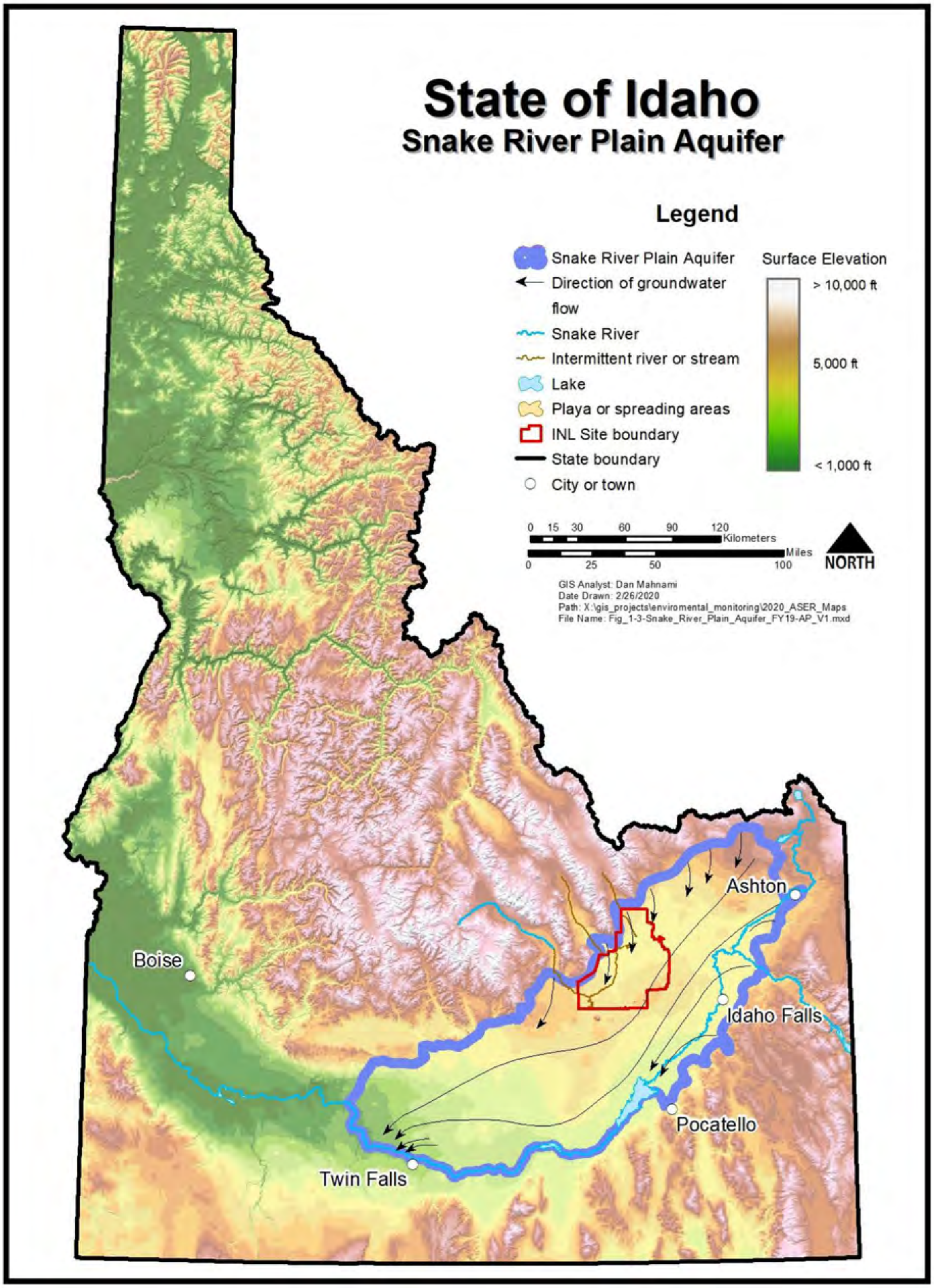

Figure 1-3. INL Site Relation to the Eastern Snake River Plain Aquifer.

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 342,761. Over half of this estimated population (184,440) resides in the census divisions of Idaho Falls (116,010) and northern Pocatello (68,430). Another 31,799 are projected to live in the Rexburg census division. Approximately 22,485 are estimated to reside in the Rigby census division and 16,142 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.

Most of the 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 approximately 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

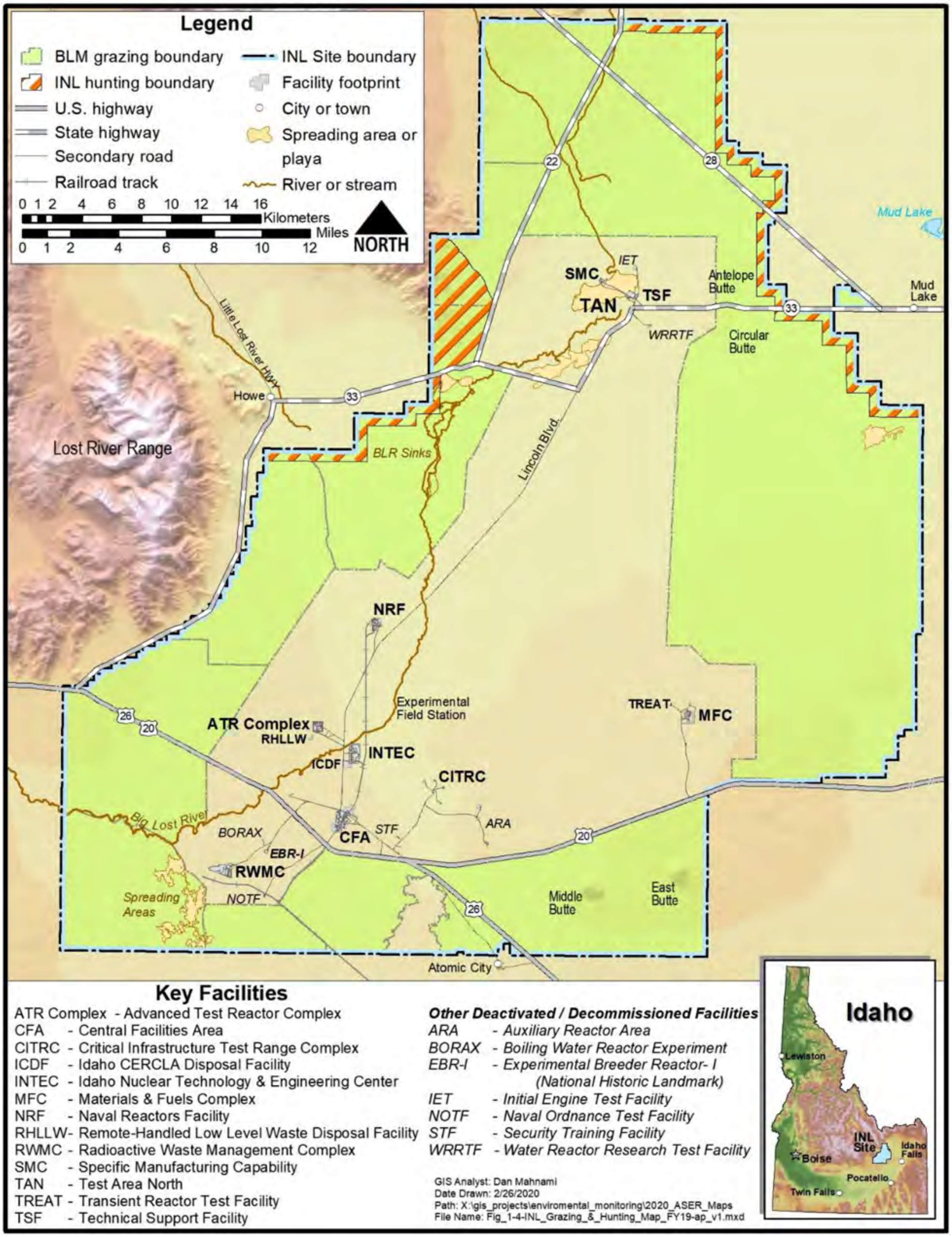

Figure 1-4. Location of the Idaho National Laboratory Site, Showing Facilities.

the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2020).

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 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 its 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. Board members comprise a variety of backgrounds and viewpoints, 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 quarterly, 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.

The 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 2019, ESER created and presented educational programs to over 16,000 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 (Figure 1-5), STEM Day at the Zoo, the Idaho Falls Water Festival, water festivals in Mackay and Shelley, and three Bat Nights at the Idaho Falls Zoo.

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 three 2-day workshops for Idaho State University credit: 1) Contrast: Idaho Mountains and Deserts, 2) Wonderful Wetlands, and 3) Water of the West (river and stream habitats).

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

Figure 1-5. Wild and Scenic Rivers Day at the Conant Valley Boat Dock. Organized by Idaho Bureau of Land Management.

Figure 1-6. Exotics and Natives in Idaho Teacher Workshop. Organized by the ESER Program and the Idaho Falls Zoo.

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 2019, 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 1-6).

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.

The theme for the 2019 Rocky Mountain Adventure was Water in our World. 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 theme for the 2019 High Adventure Camp was Real World Gaming, which got participants outside to explore the REAL elements of video and board games.

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 2019 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 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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2. ENVIRONMENTAL COMPLIANCE SUMMARY


Spiny hopsage (*Grayia spinosa*)

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 was one reportable environmental releases at the INL Site during Calendar Year 2019. In 2019, 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 2019 include:

- Environmental restoration continued in 2019 at four active waste area groups. Six waste area groups 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 state of Idaho Department of Environmental Quality (DEQ) performed an unannounced Resource Conservation and Recovery Act inspection in May 2019. DEQ issued a Warning Letter for six apparent violations of the INL Hazardous Waste Management Act/Resource Conservation and Recovery Act partial Permits. Actions taken by DOE and the INL Site contractors were sufficient to resolve the alleged instances of noncompliance.
- DOE-ID worked on three environmental assessments in 2019 in compliance with the National Environmental Policy Act. The Environmental Assessment for the Expansion of Capabilities at the National Security Test Range and Radiological Response Training Range at the Idaho National Laboratory was completed. Development of the Environmental Assessment for the Expansion of Capabilities at Idaho National Laboratory Power Grid Test Bed was completed in 2019 and resulted in a Finding of No Significant Impact. DOE-ID also began preparation of the Versatile Test Reactor Environmental Impact Statement.
- The FFA/CO requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. In 2019, two transuranic INL Site Treatment Plan milestones and one Calcine Disposition Project milestone were not met due to unanticipated characterization requirements and waste technical complexities. The DEQ approved extensions for the transuranic milestones but favors no change for the Calcine Disposition Project. 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 2019 is 60,013 m^3 (78,494 yd^3).
- The Integrated Waste Treatment Unit, designed to process liquid waste stored at the Idaho Nuclear Technology and Engineering Center by the end of 2012, has still delayed startup due to various technical problems.
- In 2019, approximately 1,494 m^3 (1,954 yd^3) of mixed low-level waste and 1,161 m^3 (1,519 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 47.91 m^3 (62.66 yd^3) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area (SDA) in 2019.
- The Idaho DEQ has authority to implement the Clean Air Act. In 2019, the state conducted two 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. Twelve active drinking water systems at INL Site facilities were sampled according to these regulations and were well below regulatory limits for drinking water.

- The Idaho DEQ issues waste-water reuse permits in accordance with state of Idaho rules. All systems at the INL Site were operated in compliance with all permit requirements during 2019.
- The Emergency Planning and Community Right-to-Know Act 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 had one reportable release during 2019. Approximately 105 gallons of diesel fuel leaked from a trenching machine. Eighty gallons of free product was recovered, and approximately 25 gallons was absorbed into the soil. The DEQ was notified and the contaminated soil was shoveled and containerized and disposed of through the INL waste management organization.

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 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.

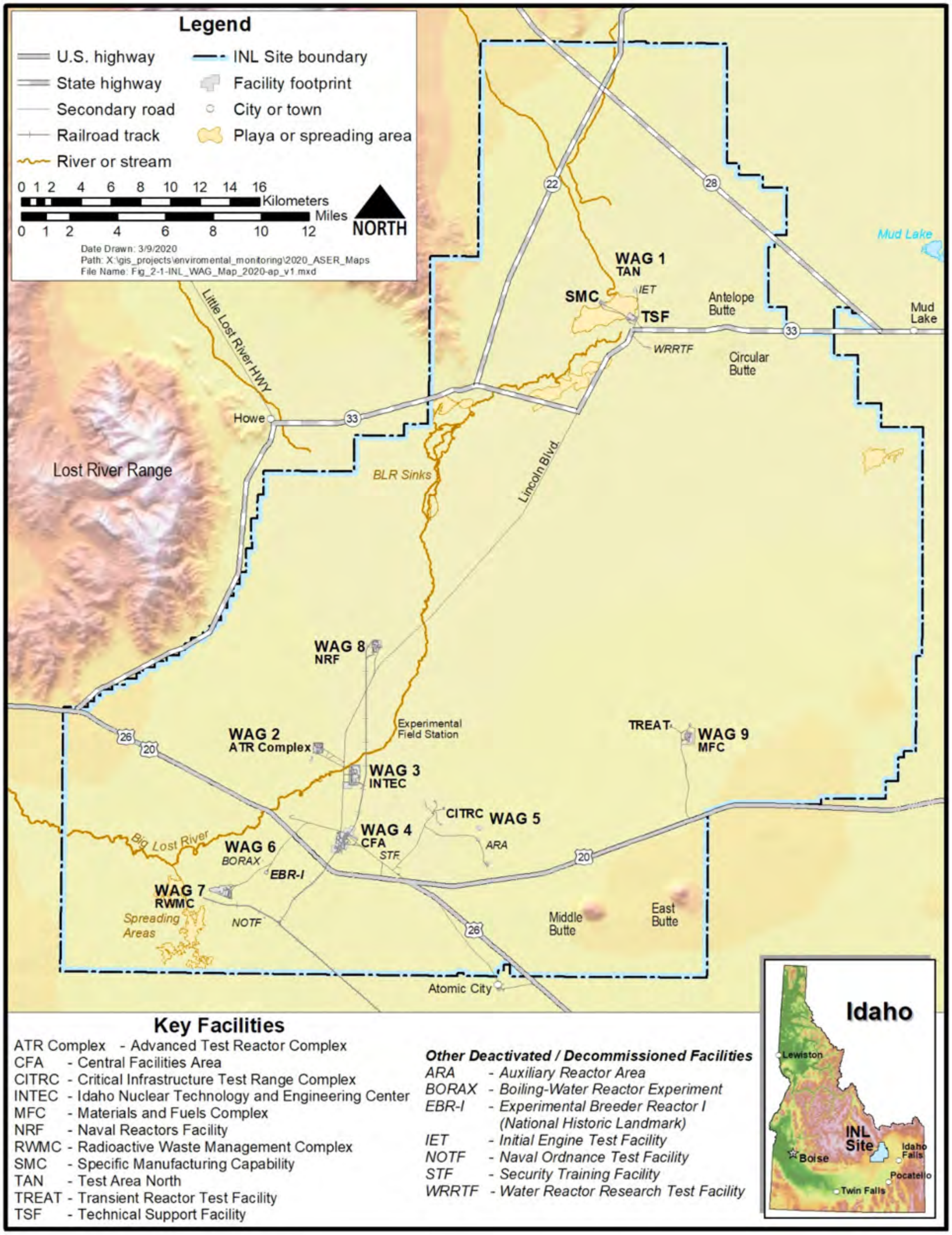

Figure 2-1. Map of INL Site Showing Facilities and Corresponding WAGs.

Table 2-1. 2019 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 2019. 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 2019.
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 Department of Environmental Quality (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 2019. 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 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 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

Table 2-1. 2019 Status of Active WAGs Cleanup (continued).

Waste Area Group	Facility	Status
		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 2019, 9,396 m^3 (12,290 yd^3) of targeted waste has been retrieved and packaged from a combined area of 2.08 hectares (5.13 acres). In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of continued vapor-vacuum extraction and treatment of solvent vapors from the subsurface, in-situ grouting of specified waste forms containing mobile contaminants (completed 2010), constructing an evapotranspiration surface barrier over the entire landfill, and long-term management and control following construction. Construction will be complete by 2028.
10	10-04 INL Site-wide Miscellaneous Sites and Comprehensive RI/FS	Operable Unit 10-04 addresses long-term stewardship functions—ICs and O&M for sites that do not qualify for Unlimited Use/Unrestricted Exposure—and explosive hazards associated with historical military operations on the INL Site. All ICs and O&M requirements were maintained in 2019, under the Site-wide IC/O&M Plan. A CERCLA 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. Another five-year review will be completed during 2020.
	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 2019 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

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 2019 Idaho Hazardous Waste Generator Annual Report on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remaining in storage. The Biennial Report required by sections 3002 and 3004 of the RCRA was also submitted for 2019.

RCRA Closure Plan. There were no closure activities completed in 2019.

RCRA Inspection. For Fiscal Year (FY) 2019, the state of Idaho DEQ performed an unannounced RCRA inspection May 6th through 9th 2019. On November 24, 2019, DEQ issued a Warning Letter for six apparent violations of the INL Hazardous Waste Management Act/RCRA partial Permits. On December 31, 2019, DEQ issued a letter to DOE, Fluor Idaho and Battelle Energy Alliance, indicating the actions taken described in the written responses to the Warning Letters received by DEQ December 17, 2019, and December 5, 2019, respectively, are sufficient to resolve the alleged instances of non-compliance identified in the November 24, 2019, Warning Letter.

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 Idaho Nuclear Technology and Engineering Center (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 31, 2018, to March 30, 2019. 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 2019, DOE-ID completed the preparation of the *Environmental Assessment for Expanding Capabilities at the Power Grid Test Bed at Idaho National Laboratory* (DOE/EA-2097) and the *Environmental Assessment for Expanding Capabilities at the National Security Test Range and the Radiological Response Training Range at Idaho National Laboratory* (DOE/EA-2063), both resulting in a Finding of No Significant Impact. DOE-ID also began preparation of the Versatile Test Reactor Environmental Impact Statement. A Notice of Intent was published in the Federal Register (81 FR 38021) on August 5, 2019, which commenced a 30-day public scoping period. The draft Environmental Impact Statement is expected in 2020 with a final Environmental Impact Statement planned for 2021.

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 (PCBs). For example, PCB 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. During 2019, DOE-ID and responsible contractor staff engaged successfully with EPA Region 10 TSCA Program staff to derive compliant strategies and processes to address several PCB waste management issues. Full compliance to the TSCA PCB regulations has been rigorously maintained.

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 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 2019, two transuranic (TRU) waste Site Treatment Plan milestones and one Calcine Disposition Project milestone were not met. DEQ was notified that due to unanticipated characterization requirements and waste technical complexities, the Original Volume Transuranic Contaminated Waste (Contact-Handled Waste) Treatment Milestone (excluding treatment of sludge waste) and the shipment of the remaining volume of Original Volume TRU Reclassified as Mixed Low Level Waste Shipment Milestone would not be achieved. Subsequently, the DEQ approved extensions for the TRU milestones. Additionally, on September 30, 2019, DOE requested an extension to the Table 5-1 Calcine Disposition Project Milestones. DEQ responded to that request, stating that the state of Idaho favors no change at this time.

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 (STP) and the ISA required 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 m^3 (85,016 yd^3). This milestone was not achieved, however revised STP milestones were agreed upon with the Department of Environmental Quality and an Addendum to the Idaho Settlement Agreement was signed on November 6, 2019 to address the milestone.

In February 2014, the shipment of transuranic waste was curtailed due to the suspension of the Waste Isolation Pilot Plant (WIPP) operations in Carlsbad, New Mexico. In April of 2017, shipments resumed to WIPP.

In FY 2019, there were 194 shipments of TRU contaminated waste to the WIPP. At the end of FY 2019, the INL was approved to ship four waste streams to WIPP. Due to outages and other issues at WIPP, the number of shipments per week have recently decreased to three to four (down from six to eight).

DOE-ID has succeeded in the treatment of 90% of the Original Volume Transuranic Contaminated non-sludge waste (i.e., debris and associated waste inventory) during FY 2019. Relatively small volumes of miscellaneous debris waste streams remain to be treated.

As of September 30, 2019, a total of 61,322 m^3 (80,206 yd^3) of original volume TRU-contaminated waste has been processed.

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 2019, 194 shipments of the transuranic waste were shipped to WIPP, for a total of 549 m^3 (718 yd^3). The ISA includes a requirement to ship an annual three-year running average of 2,000 m^3 (2,616 yd^3) of that waste out of the state. The annual three-year running average of ISA transuranic waste shipped out of Idaho over the past three years was 2,007 m^3 (2,625 yd^3). Through December 2019, the cumulative volume of the transuranic waste shipped out of Idaho is 60,013 m^3 (78,494 yd^3).

The Idaho Cleanup Project (ICP) Core manages and operates several projects to facilitate the disposition of radioactive waste as required by the ISA and Site Treatment Plan. The Advanced Mixed Waste Treatment Project performs retrieval, characterization, treatment, packaging, and shipment of transuranic waste currently stored at the INL Site. Most of the waste processed at the

Advanced Mixed Waste Treatment 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 several 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 2019, approximately 1,494 m³ (1,954 yd³) of mixed low-level waste and 1,161 m³ (1,519 yd³) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 47.91 m³ (62.66 yd³) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area (SDA) in 2019 (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

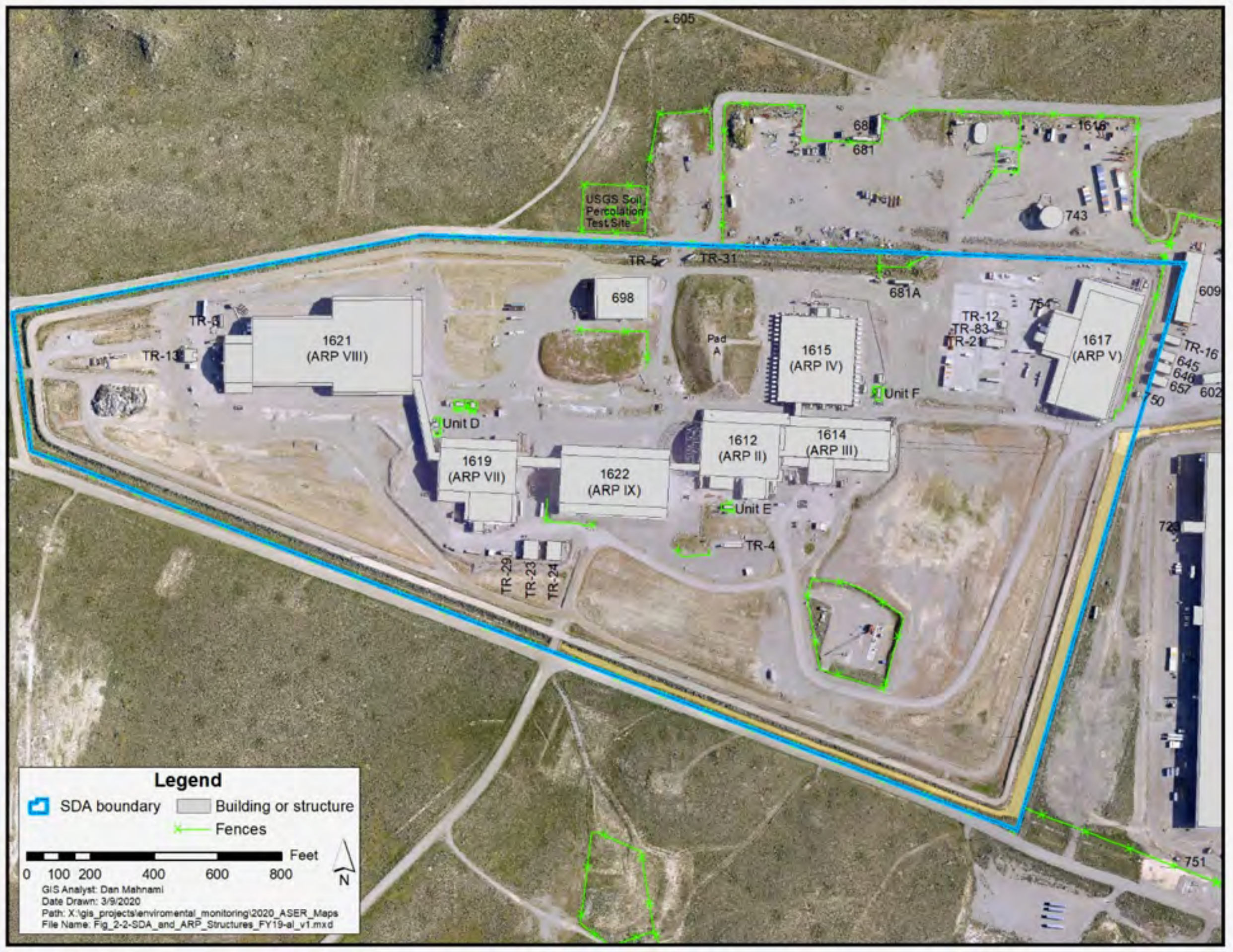

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2019).

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 Core contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility, and the INL contractor at the Advanced Test Reactor Complex and Materials and Fuels Complex.

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 2019, the Department of Environmental Quality (DEQ) conducted two onsite regulatory inspections, which covered compliance for facility-specific Permits to Construct and the INL Permit to Construct Facility Emissions Cap. The inspections concluded that the facilities were operating in compliance with permit conditions and requirements. (Table 2-2)

Table 2-2. Environmental Permits for the INL Site (2019).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	2
Synthetic Minor	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 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 National Pollutant Discharge Elimination System program. The DEQ program, called the Idaho Pollutant Discharge Elimination System is being implemented in a phased approach. DEQ assumed responsibility over Publicly Owned Treatment Works 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 Idaho Pollutant Discharge Elimination System permit program to set pretreatment standards for nondomestic discharges to Publicly Owned Treatment Works. This program is set out in Title 8, Chapter 1 of the Municipal Code of the city of Idaho Falls. The INL Research Center is the only INL Site facility that is required to have an Industrial Wastewater Acceptance permit. The Industrial Wastewater Acceptance permit contains special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements and effluent concentration limits for specific parameters. All discharges in 2019 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. Eleven are monitored by the INL and ICP contractors. The remaining system is monitored by the NRF contractor. All INL Site public water systems sample their drinking water as required by the state of Idaho. There were no drinking water requirements exceedances for any of the INL public water systems during 2019. Chapter 6 contains details on drinking water monitoring.

2.3.3 State of Idaho Wastewater Reuse Permits

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

- Advanced Test Reactor Complex Cold Waste Ponds
- INTEC New Percolation Ponds
- Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond.

These systems were operated in compliance with all permit requirements during 2019. Chapter 5 contains details on wastewater reuse monitoring.

2.4 Other Environmental Statutes

2.4.1 Endangered Species Act

The Endangered Species Act (ESA):

- Provides a means whereby the ecosystems endangered, and threatened species depend on may be conserved
- Provides a program to 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 10). 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 9.

2.4.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits taking any migratory bird, or any part, nest, or egg of any such bird, without authorization from the U.S. Department of the Interior. Permits may be issued for scientific collecting, banding and marking, falconry, raptor propagation, depredation, import, export, taxidermy, waterfowl sale and disposal, and special purposes. DOE-ID has a Special Purpose Permit for limited nest relocation and destruction and the associated take of migratory birds if 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).

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 7.

2.4.3 Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) is Title III of the 1986 Superfund Amendments and Reauthorization Act to CERCLA. EPCRA is intended to help local emergency response agencies better prepare for potential chemical emergencies and to inform the public of the presence of toxic chemicals in their communities. The INL Site's compliance with key EPCRA provisions is summarized in the following subsections and in Table 2-3.

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 2019.

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 2019, the chemical inventory report included 69 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 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 chromium, lead, naphthalene, nickel, nitric acid, and nitrate compounds to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – INL had one reportable release during 2019. About 105 gallons of diesel fuel leaked from a trenching machine. Eighty gallons of free product was recovered, and approximately 25 gallons was absorbed into the soil. The DEQ was notified and the contaminated soil was shoveled and containerized and disposed of through the INL waste management organization. The full documentation and transmittal information for this spill is maintained in the INL data management system.

2.4.4 Executive Order 11988 – Floodplain Management

Executive Order 11988 requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requests consider flood hazards

Table 2-3. INL Site EPCRA Reporting Status (2019).

EPCRA Section	Description of Reporting	2019 Status
Section 304	Extremely Hazardous Substance Release Notification	Not Required
Section 311-312	Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

and floodplain management. It is the intent of Executive Order 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA. 10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an 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).

2.4.5 Executive Order 11990 – Protection of Wetlands

Executive Order 11990 requires each federal agency to issue or amend existing regulations and procedures to ensure wetlands are protected in decision making. It is the intent of this Executive Order that federal agencies implement wetland requirements through existing procedures, such as those established to implement NEPA. The 10 CFR 1022 regulations contain DOE policy and wetland environmental review and assessment requirements through the applicable NEPA procedures. In instances where impacts of actions in wetlands are not significant enough to require the preparation of an 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 2019, no actions took place or impacted potential jurisdictional wetlands on the INL Site.

2.5 Cultural Resources Protection

INL Site cultural resources are numerous and represent at least 13,000 years of human land use in the region. As a federal agency, the U.S. Department of Energy has been directed by Congress, the U.S. president, and the American public to provide leadership in the preservation of precontact, historic, and other cultural resources on the lands it administers. This mandate to preserve cultural resources in a spirit of stewardship for the future is outlined in various federal preservation laws, regulations, and guidelines such as the National Historic Preservation Act, the Archaeological Resources Protection Act, and the National Environmental Policy Act. These resources are nonrenewable, bear valuable physical and intangible legacies, and yield important information about the past, present, and perhaps the future. There are special challenges associated with balancing the preservation of these sites with the management and ongoing operation of an active scientific laboratory. DOE-ID is committed to a cultural resource management program that accepts these challenges in a manner reflecting both the spirit and intent of the legislative mandates. DOE-ID has tasked the implementation of a cultural resource management program for the INL Site to INL's Cultural Resource Management Office (CRMO). Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. DOE-ID continues to work with the Shoshone-Bannock Tribes under the 2017 Agreement in Principle for government-to-government consultation and participation on cultural resources field surveys.

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3. ENVIRONMENTAL MANAGEMENT SYSTEM


Basalt Milkvetch (*Astragalus filipes*)

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

DOE employs the environmental management system (EMS) modeled by the International Organization for Standardization (ISO) Standard 14001 to help establish policy, objectives, and targets at the INL Site to reduce environmental impacts and increase operating efficiency through a continuing cycle of planning, implementing, evaluating, and improving processes. The two main contractors have established EMSs for their respective operations. The INL contractor and the Idaho Cleanup Project (ICP) Core contractor were last certified to the ISO 14001:2015 standard in May and October 2017.

The INL Site Sustainability program implements sustainability strategies and practices that will meet key DOE sustainability goals, including: reduce greenhouse gas emissions; reduce energy and potable water intensity; reduce fleet petroleum consumption; divert nonhazardous solid waste and construction and demolition debris; and use energy from renewable sources. The INL contractor met 98% of the EMS Objectives and Targets in 2019. The ICP Core contractor completed 65% of the EMS Objectives and Targets in 2019.

Both INL and ICP Core contractors were audited in 2019 by an external, accredited auditor and showed conformance to the ISO 14001:2015 standard. INL's EMS performance data was submitted to the Federal Facilities Environmental Stewardship & Compliance Assistance Center and received a "Green" score for the EMS performance metrics.

3. ENVIRONMENTAL MANAGEMENT SYSTEM

The framework U.S. Department of Energy (DOE) has chosen to use for Environmental Management Systems (EMSs) and sustainable practices is the International Organization for Standardization (ISO) Standard 14001:2015, "Environmental management systems – Requirements with guidance for use". The ISO 14001:2015 model uses a system of policy development, planning, implementation and operation, checking, corrective action, and management review. Ultimately, ISO 14001:2015 aims to improve performance as the management cycle repeats. The EMS must also meet the criteria of Executive Order (EO) 13834, "Efficient Federal Operations," and DOE O 436.1, "Departmental Sustainability," which require federal facilities to put into practice EMSs. Sites must maintain their EMS as being certified to or conforming with the ISO 14001:2015 standard following the accredited registrar provisions or self-declaration instructions.

Idaho National Laboratory (INL) balances research, development, and demonstration; waste management; and decontamination and decommissioning activities in support of the INL mission with the protection and preservation of human health and the environment and compliance with applicable laws, regulations, and other requirements. INL's EMS integrates environmental protection, environmental compliance, pollution prevention, and continual improvement into work planning and execution throughout work areas as a part of the Integrated Safety Management System.

INL is a combination of all operating contractors along with the DOE, Idaho Operations Office, and includes the Idaho Falls campus and the research (see Figure 3-1) and industrial complexes (INL Site) located 50 miles west of Idaho Falls. For the purposes of this report, INL consists of those facilities operated by Battelle Energy Alliance, LLC (BEA) or by Fluor Idaho, LLC. BEA and Fluor Idaho are referred to by their noted acronyms and include all facilities under their individual responsibility.

Figure 3-1. BEA's Idaho Falls Campus.

INL has been certified to meet the requirements of ISO 14001 since 2005. In 2019, INL (BEA) became the first DOE national laboratory to be certified to the Nuclear Quality Assurance Certification Program. Many elements of the Nuclear Quality Assurance-1 align with and complement, the ISO 14001:2015 standard.

BEA and Fluor Idaho have established EMSs for their respective operations and were last certified to the ISO 14001:2015 standard in May and October 2017. The EMS is audited annually to verify that it is operating as intended and in conformance with ISO 14001:2015 standards. BEA and Fluor Idaho were both audited in 2019 by an external, accredited auditor and showed conformance to the ISO 14001:2015 standard. Results from the BEA audit showed no nonconformities, seven system strengths, and two opportunities for improvement. Both opportunities for improvement have been addressed. Results from the Fluor Idaho audit showed no nonconformities, five system strengths, and two opportunities for improvement, which have been addressed. Recertification of the EMSs is required every three years, so BEA and Fluor Idaho will undergo a recertification audit in 2020 to the current standard.

3.1 Environmental Management System Structure

INL's EMS is based on a plan-do-check-act cycle that focuses on 1) environmental policy, 2) planning, 3) implementation and operation, 4) checking and corrective action, and 5) management review.

3.2 Environmental Policy

INL states its commitments to the environment through an overarching policy that is displayed to employees. The policy commits specifically to:

- Environmental protection
- Environmental compliance
- Pollution prevention
- Continual improvement.

INL employees integrate environmental requirements and pollution prevention techniques into work planning and execution to minimize the environmental impacts of their activities.

3.3 Planning

3.3.1 Environmental Aspects

INL has evaluated its activities, products, and services to identify the environmental aspects of its work activities having the potential to affect the environment, the public, or result in a noncompliance with regulatory requirements. Environmental aspects that have been identified 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.

Air Emissions. Air emissions applies to operations or activities that have the potential to generate air pollutants in the form of radionuclides, chemical and combustion emissions, fugitive dust, asbestos, and refrigerants. INL has an Environmental As Low As Reasonably Achievable (ALARA) review process per DOE O 458.1, “Radiation Protection of the Public and the Environment,” that protects the public and the environment against undue risk of radiation. The Environmental ALARA Committee evaluates activities that have the potential for radiological impacts on the environment and the public and determines the requirements for radiological emissions.

Discharging to Surface, Storm, or Groundwater. Discharging to surface water, storm water, or groundwater applies to activities that have the potential to contaminate waters of the U.S. or groundwater. INL has spill prevention and response plans in place for areas that have the potential to contaminate waters of the U.S. or groundwater.

Disturbing Cultural or Biological Resources. Cultural resource disturbance applies to activities that have the potential to adversely affect cultural resources, such as disturbing soils by grading, excavating, sampling, off-road vehicle use, or removing vegetation. It also applies to protection of sensitive cultural or biological resources from disturbance. The potential for adverse effects also applies to modifying or demolishing historical buildings or structures that are 50 years old or older. INL has a cultural resources management team that evaluates work activities at INL to minimize impact to historical buildings and cultural sites before an activity begins.

Generating and Managing Waste. Regulated, hazardous or radioactive material and waste packaging and transportation applies to activities that generate, store, treat, or dispose hazardous, radioactive, or industrial waste. INL has a Waste Management Program that integrates and dispositions containerized hazardous, radioactive, or industrial waste and gives guidance on how to minimize the amount of regulated waste generated.

Releasing Contaminants. Releasing contaminants applies to activities that may release potentially hazardous contaminants into water, soil, or other non-contaminated or previously contaminated locations. All INL employees are trained to report any release to either their Program Environmental Lead or to the Spill Notification Team. Releases are tracked to verify that they are cleaned up properly. Planned operations and research with the potential to release contaminants are evaluated to mitigate any significant environmental impacts.

Using, Reusing, and Conserving Natural Resources. Using, reusing, and recycling resources applies to activities that use or recycle resources such as water, energy, fuels, minerals, borrow material, wood or paper products, and other materials derived from natural resources. This beneficial aspect also applies to waste disposition activities, including building demolition and activities implementing sustainable practices and conserving of natural resources.

3.3.2 Environmental Objectives and Targets

INL establishes objectives based on the environmental policy, legal and other requirements, environmental aspects, INL’s Strategic Plan, and the views of its stakeholders. BEA plans, implements, monitors, and reports on these objectives and targets quarterly in management review reports and an annual Performance Evaluation and Measurement Plan. For more details, see Section 3.7. Fluor Idaho develops its objectives and targets annually and reports the status biannually to senior management through the Executive Safety Review Board.

3.4 Implementation and Operation

3.4.1 Structure and Responsibility

INL’s organizational structure establishes roles and responsibilities for environmental management within research, development, and demonstration; operations; and other support organizations within Environmental, Safety, Health and Quality.

3.4.2 Competence, Training, and Awareness

INL Training directorate conducts training analysis and designs, develops, and evaluates training. Environmental training gives personnel the opportunity to gain experience, knowledge, skills, and abilities necessary to:

- Do jobs in a safe and environmentally responsible manner
- Comply with federal, state, and local environmental laws, regulations and permits, and INL requirements and policies
- Increase awareness of environmental protection practices and pollution and prevention/waste minimization opportunities
- Take actions in an emergency.

3.4.3 Communication

INL implements comprehensive communication programs that distribute timely information to interested parties like the public, news media, regulatory agencies, and other government agencies. These programs provide communications about the environmental aspects of INL work activities, among other topics. An example of such a program is the Media and Community Relations program which distributes information to the public through public briefings, workshops, personal contacts, news releases, media tours, public tours, and news conferences. The program also coordinates tours of INL for schools, members of the public, special interest groups, and government and elected officials. Internal communications about environmental aspects is available via intranet sites, emails, posters, brochures, booklets, trainings, and personal interaction with Environmental, Safety, Health and Quality staff.

3.4.4 Operational Control

Environmental personnel evaluate each work activity at INL to determine the level of environmental review needed. Environmental personnel also apply administrative and engineering controls. Administrative controls include procedures and best management practices. Engineering controls include utilizing protective equipment and barriers to minimize or avoid impacts to the environment.

3.4.5 Document and Record Control

Environmental documents are prepared, reviewed, revised, and issued per INL standards and procedures. INL's document control system maintains the current version of documents and makes legible and dated copies available to employees.

3.5 Checking and Corrective Action

INL monitors compliance with environmental laws and regulations through the Assurance Portfolio process in the Contractor Assurance System. INL conducts assurance activities through performance metrics, observations, and assessments. Issues, trends, or improvements identified through these activities are rolled into the INL issues management database where corrective actions are assigned and tracked to completion. Examples of contractor assurance activities include monitoring progress toward environmental objectives for each organization and an internal assessment of the EMS against the ISO 14001:2015 standard. Contractor assurance activities in environmental organization are documented in a management review.

3.6 Management Review

INL's management review of the EMS occurs through a process that includes weekly, monthly, quarterly, and annual meetings, committees, and councils. Through the contractor assurance system, EMS performance trends, audit findings, objectives and targets, improvements, and risks are documented in a management review that is rolled up to senior management. Senior management evaluates the management review and recommends actions to continually improve the environmental performance.

3.7 Sustainability Goals

In 2018, EO 13834 "Efficient Federal Operations," was issued, which directs agencies to focus priorities on statutory sustainability requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. The evolving priorities for sustainability incorporated into planning for FY 2020 and beyond were considered in completing planned sustainability work at the end of FY 2019. The INL Site Sustainability Plan (DOE-ID 2019) describes the overall sustainability strategy for INL during FY 2020 and includes a status of the FY 2019 performance in the areas of greenhouse gas emission reduction, energy management, water management, waste diversion, fleet management, clean and renewable energy, green buildings, and other areas. Each sustainability goal, INL's performance status, and planned actions are detailed in Table 3-1 below.

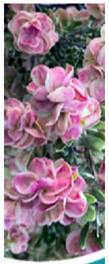

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
Energy Management				
30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2015 from a FY 2003 baseline and 1.0% year over year (YOY) thereafter.	INL energy-use intensity is 154,016 Btu/ft², a decrease of 0.2% from FY 2015 and 15.8% from FY 2003. Six light emitting diode lighting and heating, ventilating, and air conditioning (HVAC) upgrades were completed in FY 2019, providing \$33.8k (629 MWh) in energy savings at a total cost of \$329.3k.	Nine additional light emitting diode lighting upgrade projects are planned for FY 2020, providing \$36.2k (632 MWh) in energy savings at a total cost of \$265.5k. Collect and utilize building and facility energy-use data to identify buildings with the highest energy-use intensity for a focus on building energy-use improvements and performance. Ensure that monthly performance data is entered into the Environmental Protection Agency (EPA) ENERGY STAR Portfolio Manager database.	Redesign interior space to reduce energy use through daylighting and space optimization, along with sensors and control systems. Identify opportunities to transition testbed technologies to achieve energy-reduction goals.	Implement 100% of energy conservation measures (ECMs) as documented in the Dashboard projects pipeline.
Energy Independence and Security Act Section 432 continuous (4-year cycle) energy and water evaluations.	INL completed energy and water evaluations in 59 buildings in FY 2019. For the second 4-year audit cycle (June 1, 2016, through May 31, 2020), 129 audits have been completed.	Complete energy audits in 100%+ of INL covered buildings (those that constitute 75% energy use) for the second 4-year audit cycle. BEA plans to audit 30 buildings in FY 2020 and Fluor Idaho will audit an additional eight buildings in FY 2020.	Complete energy and water evaluations on at least 25% of the covered facilities annually to ensure 100% compliance by the end of the third 4-year reporting cycle (third cycle ends May 31, 2024).	Complete energy and water evaluations on at least 25% of the covered facilities annually to ensure 100% compliance by the end of the fourth 4-year reporting cycle (fourth cycle ends May 31, 2028).
Meter all individual buildings for electricity, natural gas, steam, and	INL meters 100% of its natural gas and 62.2% of its electric usage at the building level. Two additional buildings were constructed in Idaho Falls during	Two additional new BEA buildings will be complete in FY 2020 and will have advanced metering. Fluor Idaho is planning on completing the Idaho Nuclear	Install additional electric and water meters on facilities targeted for Guiding Principle compliance through FY 2025 and beyond.	Install additional electric and water meters annually as cost effective and appropriate toward a goal of 100%

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
water where cost effective and appropriate.	FY 2019. Both have advanced metering. One of the buildings (new data center) has submetering.	Technology and Engineering Center campus breaker systems modification to allow metering of the Idaho Nuclear Technology and Engineering Center buildings powered through substations and load centers by the end of January 2021.	Benchmark 100% of appropriate covered buildings where advanced meters may be installed. Installation cost for each meter is estimated at $23k.	of covered buildings metered.
Water Management				
20% potable water intensity (gal per gross square foot) reduction by FY 2015 from a FY 2007 baseline and 0.5% YOY thereafter.	INL water intensity is 134.5 gal/ft^2, a decrease of 22.7% from FY 2007. Both new buildings constructed in Idaho Falls have water metering.	Prepare and implement a water balance evaluation to identify high water use intensity processes and buildings. Develop and implement programs to educate employees and visitors about methods to minimize water use.	Implement audit-identified, low and moderate cost water conservation measures at covered facilities, including high-efficiency water technologies.	Assess the interconnections and dependencies of energy and water on INL operations, particularly resiliency's effects on water, which may impact energy use.
Non-potable freshwater consumption (gal) reduction of industrial, landscaping, and agricultural (ILA). YOY reduction; no set target.	Current Performance: N/A All water obtained by INL is obtained from the Snake River Plain Aquifer and is considered potable.	ILA water is not applicable to INL.	ILA water is not applicable to INL.	ILA water is not applicable to INL.
Waste Management				
Reduce at least 50% of non-hazardous solid waste, excluding construction and demolition debris, sent to treatment	INL generated 3,037,088.6 lb (1,377.6 MT) of non-hazardous municipal solid waste in FY 2019. In FY 2018, INL generated 2,793,918.9 lb (1,267.3 MT), resulting in an increase of municipal solid waste	Continue to educate personnel emphasizing the priority of waste reduction to reduce total waste generated from the previous year. Continue to evaluate potential outlets and expansion of recyclable waste streams. Explore glass recycle	Investigate and develop regional composting facility based on West Yellowstone pilot project. Establish memorandum of agreement with regional entities.	Secure $2.0M funding for a regional composting center.

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
and disposal facilities.	generated of 8.7% YOY. INL diverted 58.2% of its non-hazardous solid waste in FY 2019 by recycling 1,766,344 lb (801.2 MT) of materials.	partnership with the City of Idaho Falls.		
Reduce construction and demolition materials and debris sent to treatment and disposal facilities. YOY reduction; no set target.	INL generated 18,192.4 MT of construction and demolition (C&D) waste in FY 2019, compared to 30,104.7 MT in FY 2018, resulting in a reduction of 39.6% of C&D waste generated YOY. INL diverted 69.6% (27,915,818 lb or 12,662.4 MT) of its C&D waste in FY 2019.	Continue employee education, contract language inclusion and incorporate additional materials into current C&D waste diversion processes.	Work with regional industrial recycle entities and develop strategy to recycle two construction wastes streams (e.g., concrete and gypsum).	Establish regional recycle agreements with private material contributors and vendors who will accept construction debris for recycle.
Fleet Management				
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline and 2% YOY thereafter.	INL used 581,331 gasoline gallon equivalent of petroleum-based fuels in FY 2019, a 38% reduction from FY 2005. Significant progress was made through the use of renewable diesel rather than petroleum diesel in the INL bus fleet.	Efforts will continue to build and install no-idle HVAC systems on additional buses. Continue the installation of no-idle HVAC systems on additional light-duty vehicles as funding allows. Expand the rollout of renewable diesel (R99) by working to implement usage in other vehicles and equipment that run on diesel. Continue to pilot the use of electric vehicles in the fleet and the installation of supporting charging stations.	Optimize and right-size fleet composition, by reducing vehicle size, eliminating underutilized vehicles, and acquiring and locating vehicles to match local fuel infrastructure. Issue INL policy and a plan to install appropriate charging or refueling infrastructure for zero emission or plug-in hybrid vehicles. Increase acquisitions of zero emission and plug-in hybrid vehicles.	Achieve 50% petroleum consumption reduction relative to the FY 2005 baseline.
10% increase in annual alternative fuel consumption	INL used 253,848 gasoline gallon equivalent of alternative	Expanded the use of renewable diesel (R99) in other BEA vehicles	Achieve 25% alternative fuel consumption increase relative to the FY 2005 baseline.	Achieve 50% alternative fuel consumption

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	fuels in FY 2019, a 232% increase from FY 2005. This progress was maintained through an increase of 666% in the use of E85 in light-duty vehicles and the use of renewable diesel in the INL bus fleet.	and equipment that currently run on regular diesel. Determine less costly sources of R99.		increase relative to the FY 2005 baseline.
75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles (AFV).	INL acquired 57 new light-duty vehicles in FY 2019, 44 of which were AFVs or low greenhouse gas emitting vehicles, resulting in 77% of the vehicle acquisitions as AFVs or low greenhouse gas emitting vehicles.	Identify the next gasoline vehicles for replacement with AFVs, which will increase the total AFV percentage in the light-duty fleet.	Achieve 80% or greater AFV light-duty acquisitions.	Achieve 100% AFV light-duty vehicle acquisitions. Maintain 95% or greater AFV light-duty composition in the fleet.
Clean and Renewable Energy				
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30.5% of a total agency electric consumption by FY 2025 and each year thereafter.	INL procured 18,685 MWh of renewable energy certificates from Idaho Falls Power at a total cost of $31,764. This purchase of new renewable energy renewable energy certificates, in addition to the 35.5 MWh of onsite generation (solar walls, micro-grid, and small photovoltaic systems) totals 18,721 MWh (8.4%) of renewable energy for FY 2019.	Incremental increases of purchased renewable energy certificates along with onsite generation to meet a 10% goal in FY 2020 and 15% in FY 2021. Evaluate potential projects to cost effectively contribute to the annual renewable energy goal through onsite generation of at least 7.5% of the total INL electricity consumption.	Incremental increases of purchased renewable energy certificates along with onsite generation to meet a goal of: –20% in FY 2022 –25% in FY 2023 –30% in FY 2024 –30.5% in FY 2025. Implement a project that will contribute up to 7.5% of the renewable energy goal through onsite generation.	Continue to meet or exceed this goal through purchasing renewable energy certificates and generation of renewable energy from research projects onsite.
Continue to increase non-electric thermal usage. YOY increase; no set	INL has three buildings with solar transpired walls to provide make-up air preheating.	Investigate the additional use of solar water heating, make-up air preheating, or ground source heat pumps in select locations.	Evaluate or commission the underground heat exchanger for the Willow Creek Building	Work with INL's Energy Efficiency Science and Technology organization to develop

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
target but an indicator in the Office of Management and Budget scorecard.			HVAC system and optimize the efficiency and controls.	and implement one thermal storage project.
Green Buildings				
At least 15% (by count) of owned existing buildings to be compliant with the revised Guiding Principles for High Performance Sustainable Buildings by FY 2020, with annual progress thereafter.	At the end of FY 2019, 20 DOE-owned buildings were compliant with the Guiding Principles, which represents 20.4% of INL buildings greater than 10,000 gross square footage meeting the Guiding Principles.	Document Guiding Principle compliance on three additional new construction buildings in FY 2020 and two additional new construction buildings along with one existing building in FY 2021.	Document Guiding Principle compliance on one additional new construction building in FY 2024. Implement additional audit-identified, low and moderate cost ECMs at INL covered facilities that are targeted to document the Guiding Principles.	Incorporate 100% of relevant Green Building specifications into all new construction, modernization, and major renovation projects to meet the requirements Significant funding may be needed to implement the efficiency upgrades needed.
Increase regional and local planning coordination and involvement.	INL maintains excellent relationships with local community planning groups and government entities. Interactions include transportation infrastructure and maintenance, facility planning locations, traffic patterns, and future infrastructure needs.	Maintain relationships with local community planning groups and government entities. Participate in regional events promoting alternative transportation.	Advocate for and improve access to alternative commuting options (public transportation, bike paths, improved commuter access) through regional and local organizations.	Use an integrated community approach during the refurbishment and planning of future facilities and infrastructure, which is consistent with the *INL Annual Laboratory Plan Fiscal Year 2019*.
Acquisition and Procurement				
Promote sustainable acquisition and procurement to the maximum extent	INL reports indicate 94.3% of the contracts in FY 2019 contained applicable clauses.	Achieve 100% compliance. Continue to incorporate improvements to the Sustainable Acquisition Program, including procedures, policies, and enhanced	Maintain 100% compliance. Continue to incorporate improvements to the Sustainable Acquisition Program, including procedures,	Maintain 100% compliance. Continue to incorporate improvements to the Sustainable Acquisition

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
practicable, ensuring BioPreferred® and biobased provisions and clauses are included in all applicable contracts.		work processes that increase visibility, availability, and use of sustainable products.	policies, and enhanced work processes that increase visibility, availability, and use of sustainable products.	Program, including procedures, policies, and enhanced work processes that increase visibility, availability, and use of sustainable products.
Measures, Funding, and Training				
Annual targets for sustainability investment with appropriated funds and/or financed contracts to be implemented in FY 2019 and annually thereafter.	No additional Energy Savings Performance Contract (ESPC) projects were developed in FY 2019.	Develop a comprehensive project for cost effective ECMs identified by the completed energy and water audits and determine appropriate funding sources. Continue to evaluate cost effectiveness of the ENABLE ESPC program or the utility-based Utility Energy Services Contract (UESC) program.	Continue to evaluate cost effectiveness of the ENABLE ESPC program or the utility based UESC program.	Implement one ESPC ENABLE or UESC project.
Electronic Stewardship				
Purchases – 95% of eligible acquisitions each year are Electronic Product Environmental Assessment Tool (EPEAT)-registered products.	INL achieved 96.6% of eligible electronics acquisitions meeting EPEAT standards in FY 2019.	Maintain 95% compliance or better through education, primarily of the procurement staff and employee purchasers. Establish process to evaluate electronics acquisition requests to ensure that non-standard electronics are EPEAT-registered whenever possible.	Improve tracking and reporting systems for electronics stewardship requirements through life-cycle acquisition and procurement, operations and maintenance, and end-of-life management.	Maintain 95% of eligible acquisitions each year are EPEAT-registered products
Power Management – 100% of eligible PCs, laptops, and	Power management controls are in place on all eligible computer systems. At INL, 100% of eligible PCs, laptops, and	Maintain 100% compliance. Continue to focus efforts that are cost effective and the least disruptive to performers and will	100% of eligible electronics, will have power management features enabled and will be continuously measured.	100% of eligible electronics, will have power management features enabled and will

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
monitors are power-management-enabled.	monitors are power management controls.	continue work with Information Management (IM) to improve power management.		be continuously measured.
Automatic Duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	At the end of FY 2019, 100% of managed INL equipment had duplex printing enabled, where possible.	100% of eligible printers are compliant. Continue to encourage and enable duplex printing on all printers, copiers, and multifunction devices.	100% of eligible printers are compliant. Continue to encourage and enable duplex printing on all eligible printers, copiers, and multifunction devices.	100% of eligible printers are compliant. Continue to encourage and enable duplex printing on all eligible printers, copiers, and multifunction devices.
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	In FY 2019, INL recorded that 100% of electronic devices were reused or recycled.	100% of electronics are reused or recycled unless federal requirements dictate otherwise. Continue to partner with IM and Property Disposal Services to improve electronic end-of-life disposition.	100% of electronics are reused or recycled unless federal requirements dictate otherwise. Continue to partner with IM and Property Disposal Services to improve electronic end-of-life disposition.	100% of electronics are reused or recycled unless federal requirements dictate otherwise. Continue to partner with IM and Property Disposal Services to improve electronic end-of-life disposition.
Data Center Efficiency: Establish a power usage effectiveness target for new and existing data centers; discuss efforts to meet targets.	The Engineering Research Office Building High-Performance Computing Data Center (HPC) incorporated six emerging technologies that improved efficiency in FY 2019.	Finish consolidating three existing data centers into the HPC. Build out of the new Consolidated Computing Center with a power utilization effectiveness goal of 1.4 or lower.	Install and monitor advanced energy meters in all data centers and accurately quantify power utilization effectiveness.	Consolidate two data centers.
Resilience				
Discuss overall integration of resilience in	INL emergency plans and emergency plan implementing procedures were reviewed and	Continue to consider the impacts of emerging science to build resilience into DOE-ID-managed facilities,	Prioritize energy requirements to critical mission operations (in partnership with DOE	Continue to conduct progressively more detailed vulnerability

Table 3-1. Executive Summary Table of DOE Sustainability Goals from FY 2020 INL Site Sustainability Plan (DOE-ID 2019) (continued).

DOE Goal	Current Performance Status	2 Year Performance and Plans	5 Year Performance and Plans	10 Year Performance and Plans
emergency response, workforce, and operations procedures and protocols.	revised, as necessary. Operating policies and procedures were evaluated to determine whether they should be modified to consider organizational risks.	programs, and procedures. Emergency response, workplace safety and health, and the most updated scientific knowledge will be incorporated into all facets of organizational resilience, including procedures and protocols.	office of Nuclear Energy mission priorities). Pursue life-cycle cost-effective energy resilience solutions that provide the most reliable energy to critical mission operations. Review energy solutions beyond typical backup or standby generators.	assessments to identify projects that increase resilience.
Greenhouse Gases in Multiple Categories				
YOY Scope 1 and 2 greenhouse gas (GHG) emissions reduction from a FY 2008 baseline.		Refine targeted list of high value, low-cost ECMs with a focus on biggest GHG emission reduction. Pursue funding options for implementation.	Implement projects that reduce total emissions by 5% by the end of FY 2024. Reduce or minimize the quantity of toxic and hazardous chemicals acquired, used, or disposed of, particularly where such reduction will assist INL in pursuing agency greenhouse gas reduction targets.	Implement 75% of ECMs as documented in the Dashboard.
YOY Scope 3 GHG emissions reduction from a FY 2008 baseline.		Continue to encourage teleworking, video conferencing, and carpooling as effective ways to reduce the amount of air and ground travel, including employee commuting.	Achieve a YOY 2% annual reduction for 5 years for a total 10% reduction.	Achieve a total 50% reduction from baseline.

3.8 Environmental Operating Experience and Goals

The "Performance Evaluation and Measurement Plan" establishes key priorities and provides specific objectives, expected outcomes, and measures of performance for managing and operating INL. Each fiscal year, the Laboratory and the DOE Idaho National Laboratory Field Office collaborate to develop the performance objectives.

BEA completed 98% of EMS Objectives and Targets in FY 2019. Each year, Fluor Idaho develops measurable goals for environmental improvement in the Environmental Compliance Performance Index. Fluor Idaho had 10 objectives implemented by 14 targets in FY 2019; 65% of the EMS Objectives and Targets were completed.

3.9 Accomplishments, Awards, and Recognition

BEA and Fluor Idaho were both audited in 2019 by an external, accredited auditor and showed conformance to the ISO 14001:2015 standard. The result from the BEA audit were no nonconformities, seven system strengths, and two opportunities for improvement. Both opportunities for improvement have been addressed. Results from the Fluor Idaho audit showed no nonconformities, five system strengths, and two opportunities for improvement, which have been addressed.

INL's EMS performance data was submitted to the Federal Facilities Environmental Stewardship & Compliance Assistance Center and received a "Green" score for the EMS performance metrics listed below:

- Environmental aspects were identified or reevaluated using an established procedure and updated as appropriate.
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate.
- Operational controls were documented to address significant environmental aspects consistent with objectives, and targets were fully implemented.
- Environmental training procedures were established to ensure that training requirements for individual competence and responsibility were identified, carried out, monitored, tracked, recorded, and refreshed as appropriate to maintain competence.
- EMS requirements were included in all appropriate contracts, and contractors fulfilled defined roles and specified responsibilities.
- EMS audit/evaluation procedures were established, audits were conducted, and nonconformities were addressed or corrected. Senior leadership review of the EMS was conducted, and management responded to recommendations for continual improvement.

BEA also received the Four-Star EPEAT Purchaser Award from the Green Electronics Council for 2018 EPEAT purchases, recognized/awarded in 2019. EPEAT Purchaser Award winners are recognized for their purchases from five different EPEAT product categories: Computers and Displays, Imaging Equipment, Mobile Phones, Servers, and Televisions.

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4. ENVIRONMENTAL MONITORING PROGRAMS: AIR


Anderson's Larkspur (*Delphinium andersonii*)

An estimated total of 1,611 Ci (5.96 × 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 2019. The highest contributors to the total release were the Advanced Test Reactor (ATR) Complex at 77.9%, Materials and Fuel Complex at 14.6%, the Radioactive Waste Management Complex at 3.69%, the Critical Infrastructure Test Range Complex at 3.1%, Test Area North at 0.53%, and Idaho Nuclear Technology and Engineering Center at 0.079% 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 in 2019 on the INL Site, at INL Site boundary locations, and at distant communities and were analyzed for radioactivity.

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, americium-241, plutonium-239/240 ($^{239/240}$Pu), and strontium-90. 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 gamma-emitting (primarily cesium-137) and beta-emitting radionuclides (primarily strontium-90) were not detected by either the Environmental Surveillance, Education, and Research Program (ESER) or the Idaho National Laboratory contractors during 2019. Specific alpha-emitting radionuclides (americium-241, plutonium-238, and $^{239/240}$Pu) were reported by ESER in quarterly composited samples collected along the INL Site boundary during the third quarter. Americium-241 and $^{239/240}$Pu were detected at Monteview and plutonium-238 was detected at Blue Dome. The concentrations measured were just above the detection levels and well below the radionuclide-specific DCSs developed by U.S. Department of Energy to protect human health and can be attributed to resuspended soil previously contaminated by global fallout.

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 2019. 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 tritium resulting from historical global nuclear tests and natural production in the atmosphere and not INL Site releases. All measured results were below health-based regulatory limits.

4. ENVIRONMENTAL MONITORING PROGRAMS: AIR

Idaho National Laboratory (INL) Site facilities have the potential to release radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations (Figure 4-1). 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 4-1 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).

4.1 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 4.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2019 INL Report for Radionuclides* (DOE-ID 2020), 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) O 458.1, "Radiation Protection of the Public and the Environment." The INL contractor collects air

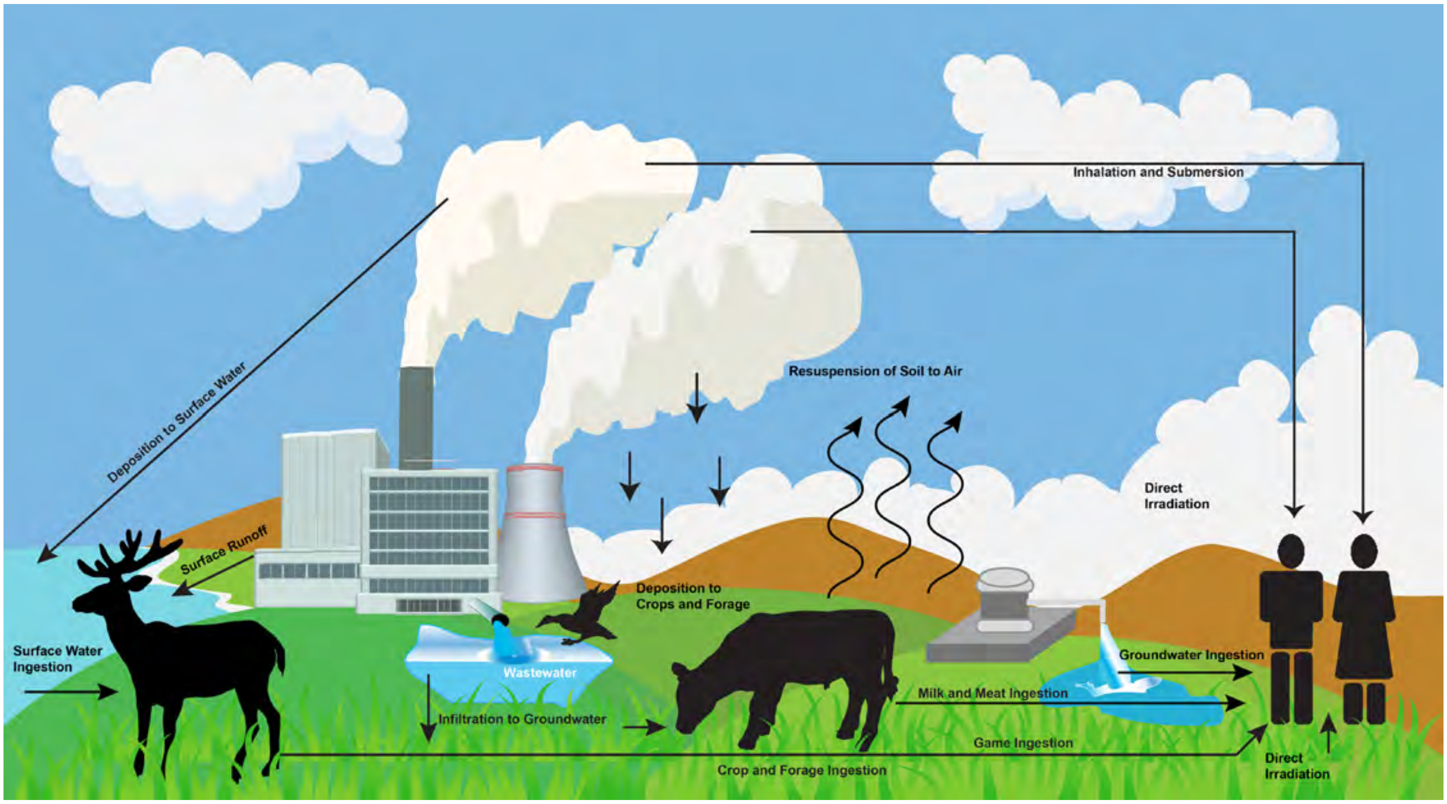
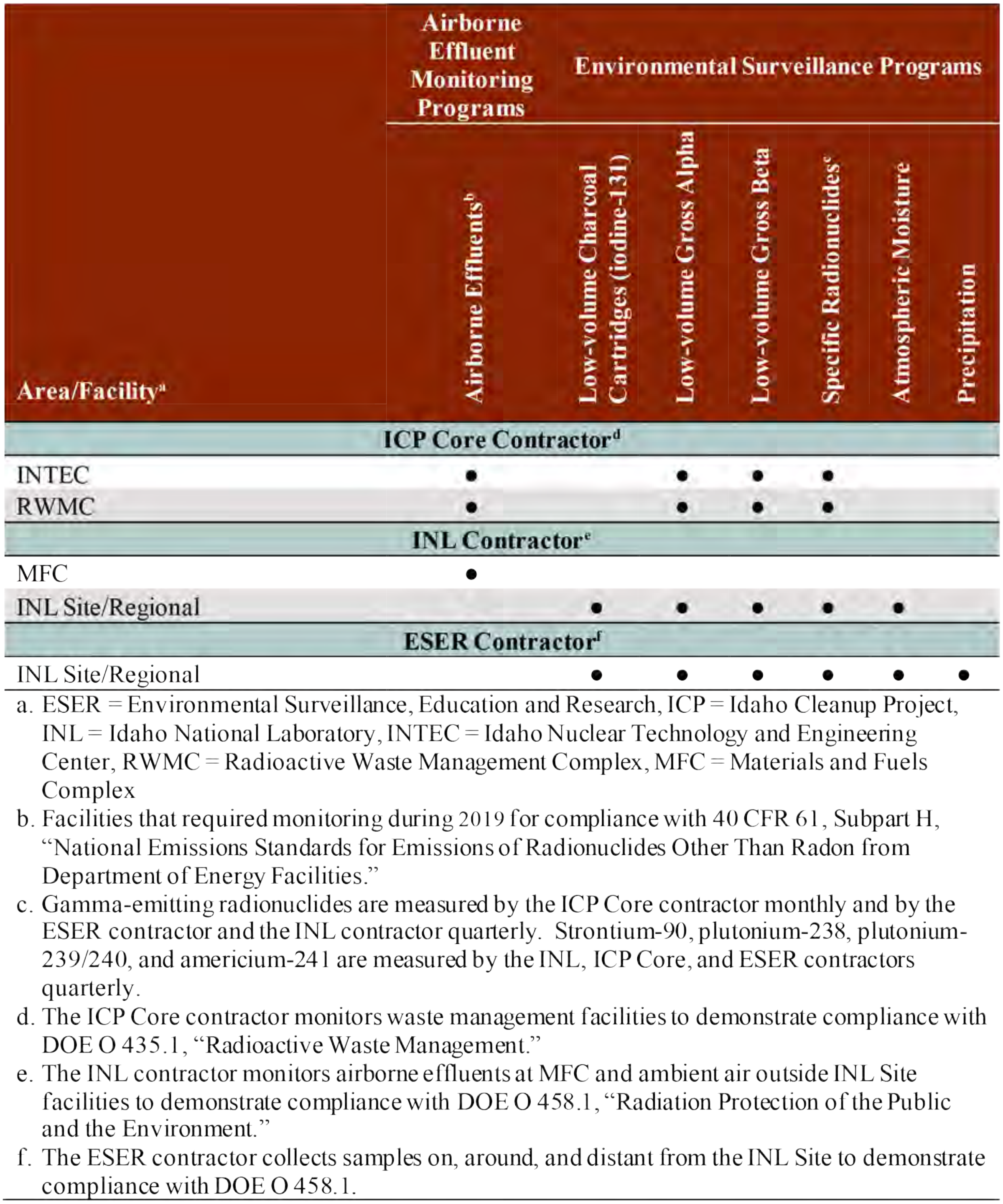


Figure 4-1. Potential Exposure Pathways to Humans from the INL Site.

Table 4-1. Radiological Air Monitoring Activities by Organization.



Area/Facility[a]	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
	Airborne Effluents[b]	Low-volume Charcoal Cartridges (iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation
ICP Core Contractor[d]							
INTEC	●		●	●	●		
RWMC	●		●	●	●		
INL Contractor[e]							
MFC	●						
INL Site/Regional		●	●	●	●	●	
ESER 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 2019 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.

samples and air moisture samples primarily on the INL Site (Figure 4-2). In 2019, the INL contractor collected approximately 1,200 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 4-2). In 2019, the ESER contractor collected approximately 1,060 air samples (including duplicate samples and blanks) for various radionuclide

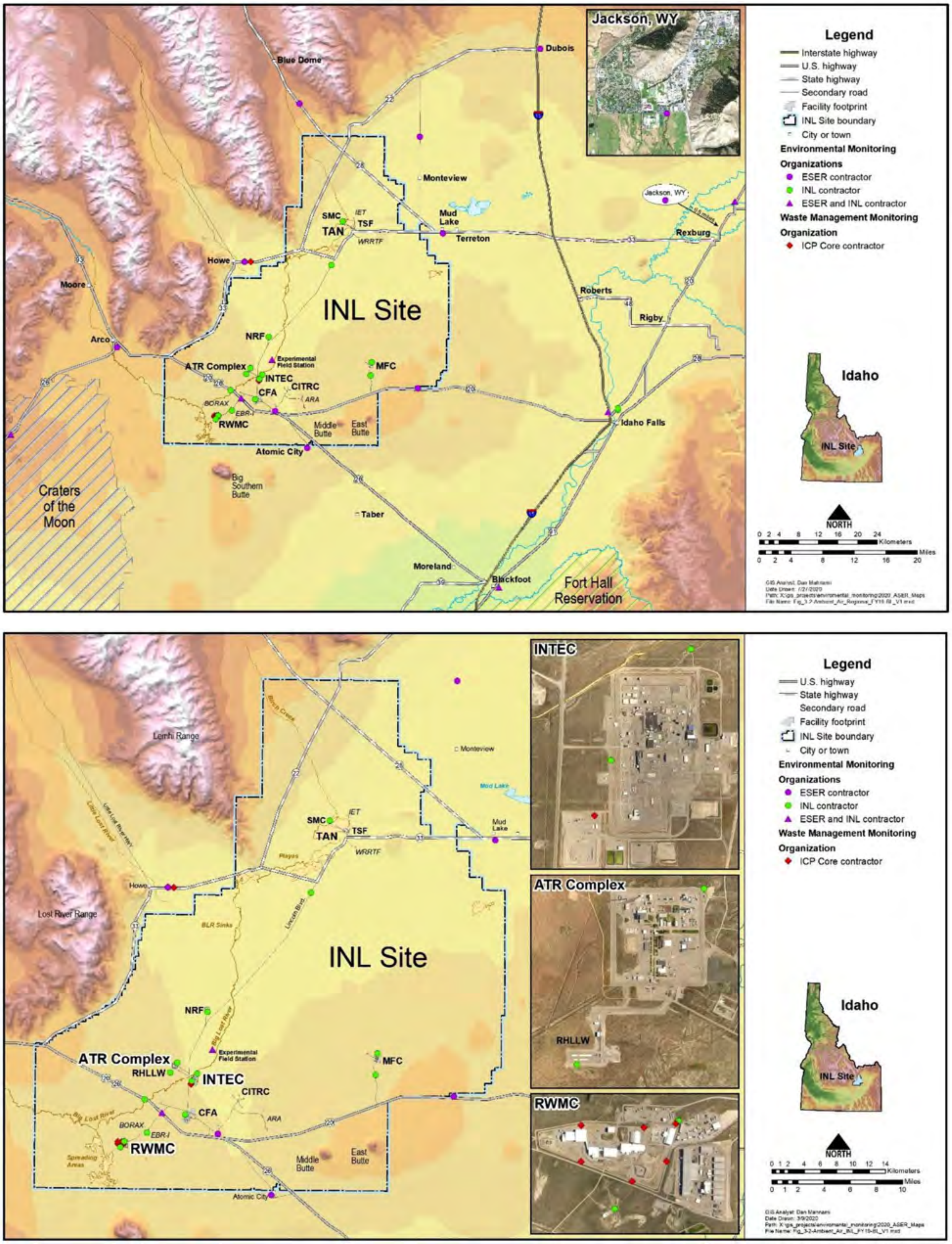


Figure 4-2. INL Site Environmental Surveillance Radiological Air Sampling Locations (regional [top] and on the INL Site [bottom]).

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

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 8 in this annual report and *Meteorological Monitoring*, a supplement to this annual report).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines airborne effluent concentrations from its regulated emission sources as required under state and federal regulations. Radiological air emissions from INL Site facilities are also used to estimate the potential dose to a hypothetical maximally exposed individual (MEI), who is a member of the public (see Chapter 8 of this report). Radiological effluents and the resulting potential dose for 2019 are reported in the NESHAP Report (DOE-ID 2020).

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 4-2. 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 2019, an estimated 1,611 Ci (5.96×10^{13} Bq) of radioactivity was released to the atmosphere from all INL Site sources. The 2019 release is 18% 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 4-3):

- ***Advanced Test Reactor (ATR) Complex Emissions Sources (77.9% 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 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 (14.6% 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

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2019).[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	2.20E-05	NS[f]	—[g]	5.68E-06	NS	—	4.42E-05	—	7.19E-05
Ar-41	109.61 m	8.03E+02	NS	—	—	8.14E+01	—	—	NS	8.84E+02
Br-82	35.30 h	NS	—	—	—	—	—	—	8.33E+00	8.33E+00
C-14	5.70E+03 y	NS	NS	7.22E-04	1.01E-04	—	5.70E-01	1.12E-01	—	6.83E-01
Cd-115m	44.6 d	—	NS	—	—	6.79E-01	—	—	—	6.79E-01
Cl-36	3.01E+05 y	—	NS	—	4.37E-07	7.19E-03	—	—	NS	7.19E-03
Cm-244	18.10 y	NS	1.46E-08	—	NS	—	—	—	—	1.46E-08
Co-60	5.2713 y	8.22E-03	NS	—	NS	NS	NS	NS	—	8.22E-03
Cs-137	30.1671 y	5.74E-03	NS	—	4.51E-05	2.61E-01	7.70E-05	NS	—	2.67E-01
Eu-152	13.537 y	8.40E-05	NS	—	NS	—	—	—	—	8.40E-05
Eu-154	8.593 y	7.17E-05	NS	—	NS	NS	—	—	—	7.17E-05
Fe-59	44.495 d	1.70E-03	NS	—	—	—	—	—	—	1.70E-03
H-3	12.32 y	3.90E+02	6.49E-01	—	1.76E-01	NS	NS	5.93E+01	NS	4.50E+02
I-129	1.57E+07 y	NS	NS	2.19E-05	7.37E-04	5.54E-04	NS	—	—	1.31E-03
I-131	8.02070 d	NS	NS	—	—	9.00E-02	NS	—	—	9.00E-02
K-42	12.360 h	NS	—	—	—	—	—	—	2.27E-01	2.27E-01
Kr-85	10.756 y	—	NS	5.00E+01	1.09E+00	NS	NS	—	NS	5.11E+01
Kr-87	76.3 m	NS	NS	—	—	1.05E+01	—	—	NS	1.05E+01
Kr-88	2.84 h	1.82E+00	NS	—	—	9.58E+00	—	—	—	1.14E+01
Pu-239	2.411E+04 y	8.46E-06	2.70E-09	—	NS	NS	2.80E-06	8.10E-06	—	1.94E-05
Pu-240	6,564 y	NS	NS	—	NS	NS	—	1.88E-06	—	1.88E-06
Sr-90	28.79 y	2.35E-02	NS	—	9.11E-06	NS	5.00E-05	NS	NS	2.36E-02
U-234	2.455E+05 y	NS	NS	—	NS	5.88E-02	—	—	NS	5.88E-02
U-235	7.04E+08 y	NS	NS	5.30E-07	NS	2.01E-03	—	NS	NS	2.01E-03
U-238	4.468E+09 y	NS	NS	4.02E-05	NS	1.29E-01	—	NS	NS	1.29E-01
Xe-135	9.14 h	1.48E+01	2.85E-03	—	—	NS	—	—	—	1.48E+01
Xe-138	14.08 m	NS	NS	—	—	1.63E+01	—	—	—	1.63E+01
Zn-65	244.06 d	NS	NS	—	NS	1.60E-01	—	—	NS	1.60E-01
	Total Ci released[h]	1.21E+03	6.52E-01	5.00E+01	1.27E+00	1.19E+02	5.70E-01	5.94E+01	8.56E+00	1.45E+03[i]
	Dose (mrem)[j]	1.23E-03	3.19E-06	3.53E-06	1.18E-05	5.37E-02	8.73E-05	5.93E-04	2.93E-04	5.59E-02

a. Radionuclide release information provided by the INL contractor.

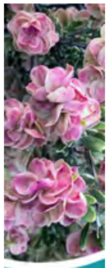


Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2019) (continued).[a]

		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

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 (includes emissions from 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 2019.

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 8-1 because Table 4-2 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 8 for detail.

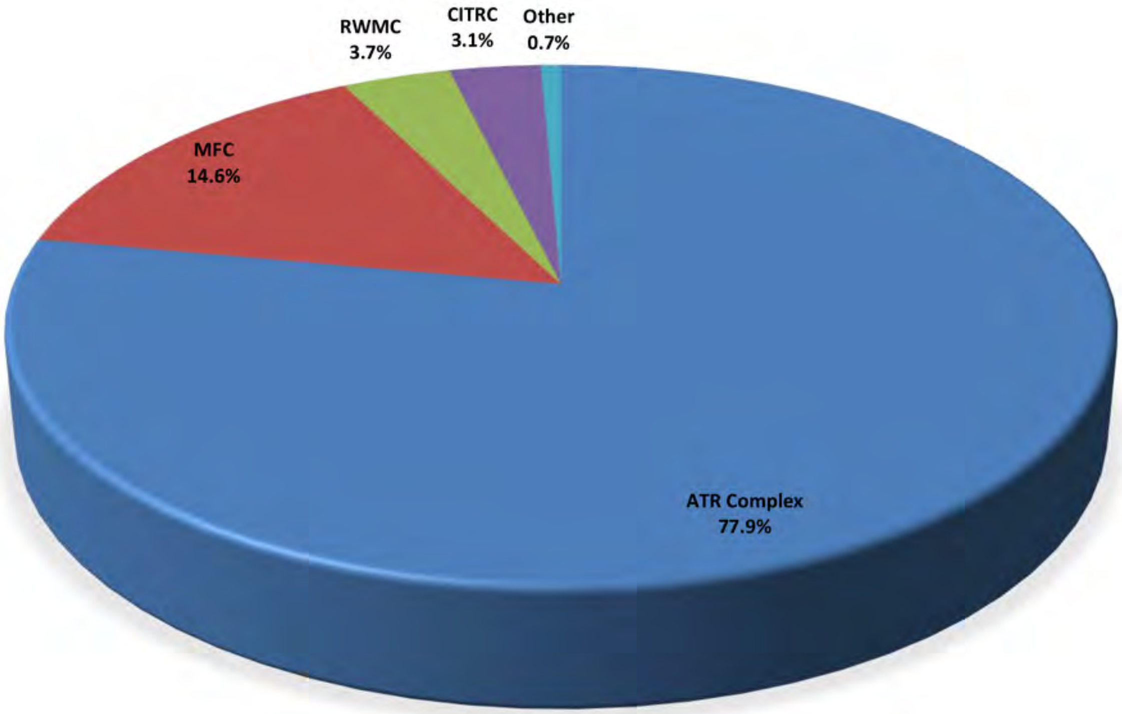


Figure 4-3. Percent Contributions in Ci, by Facility, to Total INL Site Airborne Radiological Releases (2019).

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

- ***RWMC Emissions Sources (3.69% 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 Accelerated Retrieval Projects (ARPs) VIII and IX; operation of the Resource Conservation and Recovery Act (RCRA) Sludge Repackage and Debris Repackage waste processing projects; operation of the three vapor extraction treatment units for organic contamination in the vadose zone; storage of waste within the Type II storage modules at AMWTP; storage and characterization of waste at the Drum Vent and Characterization facilities; and storage and treatment of wastes at the Transuranic Storage Area-Retrieval Enclosure (WMF-636) and the Advanced Mixed Waste Treatment Facility (WMF-676). Data from 14 emission sources (both point and diffuse) at RWMC were reported in the 2019 NESHAP Report for Radionuclides (DOE-ID 2020), of which three point sources are continuously monitored stacks. Monitoring of the radionuclide emissions from the CERCLA ARP facilities and the two RCRA facilities (WMF-1617 and WMF-1619) 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 comprised primarily of tritium and carbon-14 (^{14}C) associated with buried beryllium blocks at the Subsurface Disposal Area and removal of contaminated air from the vadose zone that is treated for volatile organic compounds. Releases of transuranic radionuclides from ARP facilities, 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 progress to completion.

- ***Critical Infrastructure Test Range Complex (CITRC) Emissions Sources (3.10% 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 (0.079% of total INL Site source term)*** – Radiological air emissions at INTEC are primarily from the operation of the ICDF landfill and ponds (located outside the fenced boundary of INTEC), and storage and containment of the Three Mile Island Unit 2 (TMI-2) core debris within the Independent Spent Fuel Storage Installation (CPP-1774), which is licensed under the Nuclear Regulatory Commission and currently managed by Spectra Tech, Inc. These sources contribute gaseous radionuclides, including tritium, iodine-129 (^{129}I), and krypton-85 (^{85}Kr), with contributions of particulate radionuclides cesium-137 (^{137}Cs) and strontium-90 (^{90}Sr) from ICDF. The INTEC Main Stack (CPP-708) is also an emission source for tritium and ^{129}I exhausted from the Tank Farm Facility where sodium-bearing radioactive waste is stored. 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 (0.53% 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 (0.041% 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 4-2, 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 2019 was 0.0559 mrem/yr (0.559 µSv/yr). Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report. Four radionuclides (cesium-137 [^{137}Cs], uranium-238 (^{238}U), uranium-234 (^{234}U), and chlorine-36 (^{36}Cl) contributed to 90% of the MEI dose.

4.3 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 regulatory standard of 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H) .

4.3.1 Ambient Air Monitoring System Design

Figure 4-2 shows the regional and INL Site routine air monitoring locations. A total of 38 low-volume air samplers, one high-volume air sampler, eight atmospheric moisture samplers, and four precipitation samplers operated in the network in 2019 (Table 4-3).

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 cen-

Table 4-3. INL Site and Regional Ambient Air Monitoring Summary (2019).

Medium Sampled	Type of Analysis	Frequency	Number of Locations						Minimum Detectable Concentration (MDC)
			Onsite			Offsite			
			INL[a]	ESER[b]	***Total***	INL[a]	ESER[b]	***Total***	
Air (low volume)	Gross alpha	Weekly	16	3	**19**	6	13	**19**	1E-15 μCi/mL
	Gross beta	Weekly	16	3	**19**	6	13	**19**	2E-15 μCi/mL
	Specific gamma[c]	Quarterly	16	3	**19**	6	13	**19**	2E-16 μCi/mL
	Plutonium-238	Quarterly	16	2	**18**	6	4-5	**10-11**	3.5E-18 μCi/mL
	Plutonium-239/240	Quarterly	16	2	**18**	6	4-5	**10-11**	3.5E-18 μCi/mL
	Americium-241	Quarterly	16	2	**18**	6	4-5	**10-11**	4.6E-18 μCi/mL
	Strontium-90	Quarterly	16	2	**18**	6	4-5	**10-11**	3.4E-17 μCi/mL
	Iodine-131	Weekly	16	3	**19**	6	13	**19**	1.5E-15 μCi/mL
	Total particulates	Weekly	–	3	**3**	–	13	**13**	10 μg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	–	–	1	**1**	1E-15 μCi/mL
	Gamma scan	Continuous	–	–	–	–	1	**1**	Not applicable
	Specific gamma[c]	Annually[e]	–	–	–	–	1	**1**	1E-14 μCi/mL
	Isotopic U and Pu	Every 4 yrs	–	–	–	–	1	**1**	2E-18 μCi/mL
Air (atmospheric moisture)[f]	Tritium	3–6/quarter	2	1	**3**	2	3	**5**	2E-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 2019, they were at CFA and INTEC. The INL contractor also samples offsite (i.e., outside INL Site boundaries) at Blackfoot, Craters of the Moon, Idaho Falls, IRC (two air samplers), 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 (two air samplers); 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 4.3.1).

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 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-realtime 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).

ters, 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. Using this information, the onsite network was optimized. In 2019, the frequency of detection method was used to evaluate the Idaho Falls facilities, with the result being an additional monitor installed at the INL Research Center (IRC).

Tritium is present in air moisture due to natural production in the atmosphere and the remnants of global fallout from historical nuclear weapons testing and is also released by INL Site facilities (Table 4-2). Historical NESHAP data show that most tritium is released from 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/yr, 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 2009 through 2018 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.

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

4.3.2 Air Particulate, Radioiodine, and Tritium Sampling Methods

4.3.2.1 Air Particulates

Filters are collected weekly by the INL and ESER contractors from a network of low-volume air samplers (Table 4-3). 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 occurring radionuclides. Gross beta radioactivity is, with rare exceptions, detected in each air filter collected. Gross alpha activity is only irregularly 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

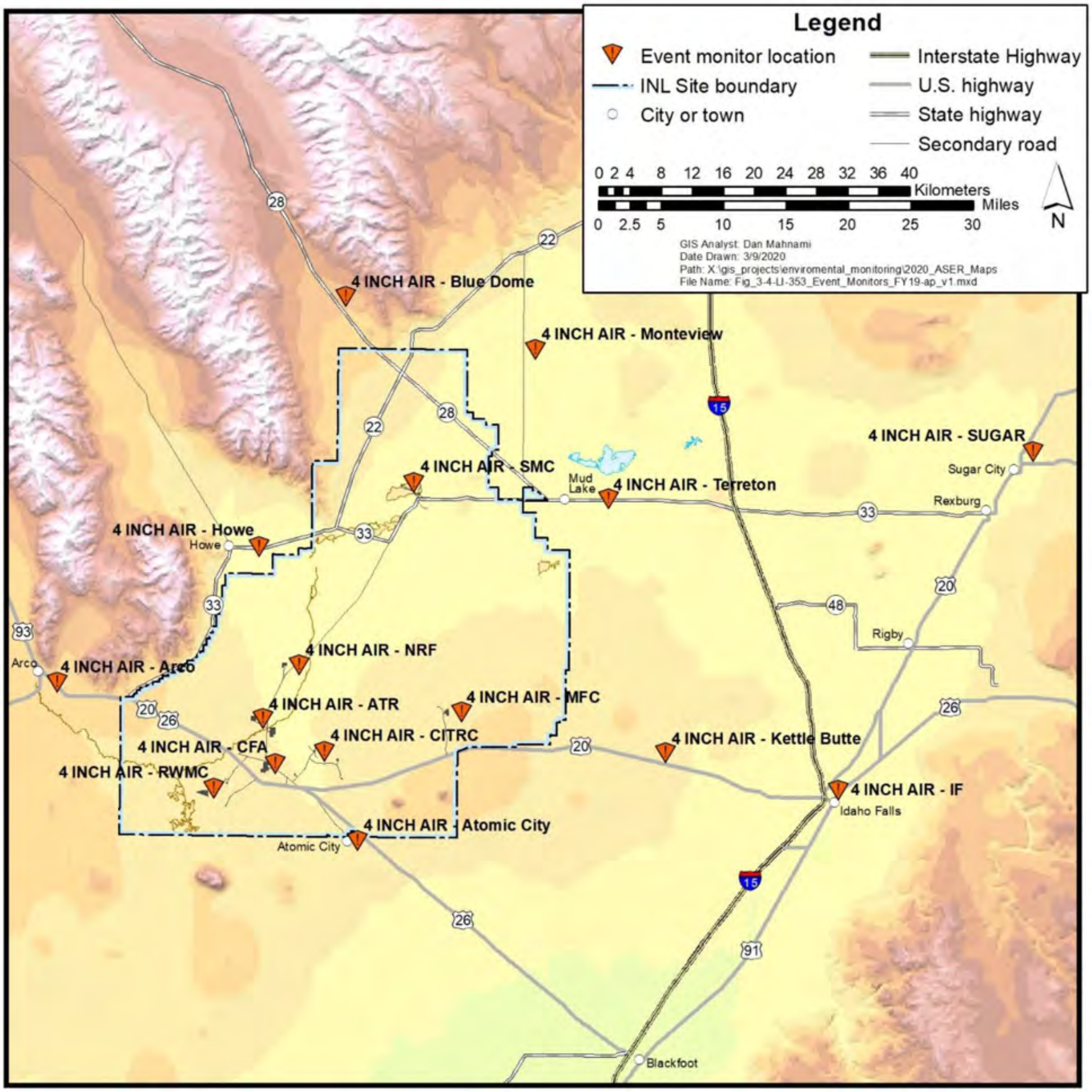


Figure 4-4. Locations of INL Contractor High-volume Event Monitors at NOAA Weather Stations.

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.

4.3.2.2 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.

4.3.2.3 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, Craters of the Moon, 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.

4.3.3 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,200 charcoal cartridges (including blanks and duplicates) in 2019. There were no statistically positive measurements of ^{131}I. During 2019, the ESER contractor analyzed approximately 1,060 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 4-4 and 4-5. Results are further discussed below.

- ***Gross Alpha.*** Gross alpha concentrations measured on a weekly basis in individual air samples ranged from a low of $(-1.3 \pm 1.7) \times 10^{-15}$ µCi/mL collected by the INL contractor at IRC (North) on December 11, 2019, to a high of $(6.9 \pm 3.0) \times 10^{-15}$ µCi/mL collected by the INL contractor at CFA on October 30, 2019 (Table 4-4). The highest detected value (i.e. greater than 3-sigma) was $(5.5 \pm 1.4) \times 10^{-15}$ µCi/mL collected by the INL contractor at INTEC on August 14, 2019 (Table 4-4). The maximum result detected at INTEC was lower than the maximum concentration (12.0×10^{-15} µCi/mL) reported in previous Annual Site Environmental Reports from 2009–2018. 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 $(5.2 \pm 2.1) \times 10^{-15}$ µCi/mL at NRF, collected by the INL contractor on December 4, 2019, to a high of $(6.5 \pm 0.7) \times 10^{-14}$ µCi/mL collected by the INL contractor at Gate 4 on December 23, 2019 (Table 4-5). The lowest detected value (i.e. greater than 3-sigma) was $(6.0 \pm 0.4) \times 10^{-15}$ µCi/mL collected by the ESER contractor at Blue Dome on December 31, 2019 (Table 4-5). All results were below the maximum concentration of 1.3×10^{-13} µCi/mL reported in previous Annual Site Environmental Reports (2009–2018). 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

Table 4-4. Median Annual Gross Alpha Concentrations in Ambient Air Samples Collected in 2019.

Group	Location[a]	No. of Samples[b]	Range of Concentrati (× 10^{-15} µCi/mL)	Annual Median Concentration (× 10^{-15} µCi/mL)
		ESER Contractor		
Distant	Blackfoot	53	0.61 – 3.0	1.3
	Craters of the Moon	51	0.19 – 1.9	1.1
	Dubois	53	0.26 – 2.3	1.1
	Idaho Falls	53	0.14 – 2.9	1.9
	Jackson	53	0.19 – 2.6	1.3
	Sugar City	53	0.38 – 2.5	1.2
			Distant Median:	1.3
Boundary	Arco	52	0.19 – 2.5	1.2
	Atomic City	52	0.08 – 2.9	1.3
	Blue Dome	53	0.10 – 2.0	0.94
	FAA Tower	53	0.30 – 2.0	1.1
	Howe	53	0.35 – 2.6	1.5
	Monteview	53	0.31 – 2.3	1.2
	Mud Lake	53	0.27 – 3.1	1.2
			Boundary Median:	1.2
INL Site	EFS	52	0.26 – 3.0	1.1
	Main Gate	52	0.18 – 3.3	1.1
	Van Buren	52	0.28 – 2.4	1.2
			INL Site Median:	1.1
		INL Contractor		
Distant	Blackfoot	52	-0.48 – 3.5	1.1
	Craters of the Moon	51	-0.41 – 2.7	0.7
	Idaho Falls	51	-0.5 – 4.1	1.2
	IRC[d]	48	-0.29 – 2.9	1.2
	IRC (North)	3[e]	-1.3 – 2.3	1.1
	Sugar City	52	-0.23 – 3.9	1.1
			Distant Median:	1.1
INL Site	RHLLW	52	-0.18 – 4.1	1.0
	ATR Complex (NE corner)	47	-0.56 – 3.4	1.4
	Highway 26 Rest Area	51	-0.18 – 3.2	1.1
	CFA	49	-0.83 – 6.9	1.2
	EBR-I	52	-0.11 – 4.2	1.0
	EFS	52	-0.07 – 5.1	1.5
	Gate 4	52	-0.26 – 4.2	1.2
	INTEC (NE corner)	52	-0.53 – 5.5	1.0
	INTEC (west side)	51	-0.4 – 2.8	1.0

Table 4-4. Median Annual Gross Alpha Concentrations in Ambient Air Samples Collected in 2019 (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-15} µCi/mL)	Annual Median Concentration (× 10^{-15} µCi/mL)
	MFC (North)	52	-0.09 – 4.3	1.0
	MFC (South)	52	-0.5 – 4.8	1.1
	NRF	50	-0.3 – 4.5	1.1
	RWMC	52	-0.2 – 3.8	1.2
	RWMC (South)	52	0.09 – 3.8	0.9
	SMC	52	-0.5 – 2.7	1.0
	Van Buren Boulevard	49	-0.35 – 3	1.1
			INL Site Median:	1.1

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 4-2 for locations on INL Site.

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

c. All measurements made by INL and ESER contractors, with the exception of duplicate measurements 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.

e. The sampler for IRC (North) was put in place late 2019 resulting in only 3 samples being collected before the end of the year.

(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 2019, 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.

- ***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

What is an inversion?

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

Table 4-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2019.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-14} µCi/mL)	Annual Median Concentration[c] (× 10^{-14} µCi/mL)
ESER Contractor				
Distant	Blackfoot	53	0.88 – 5.0	2.6
	Craters of the Moon	51	1.1 – 5.0	2.5
	Dubois	53	1.1 – 4.6	2.5
	Idaho Falls	53	1.0 – 4.8	2.6
	Jackson	53	0.93 – 5.2	2.7
	Sugar City	53	0.97 – 4.0	2.6
			Distant Median:	2.6
Boundary	Arco	52	1.0 – 6.1	2.8
	Atomic City	52	0.97 – 4.7	2.8
	Blue Dome	53	0.60 – 4.3	2.5
	FAA Tower	53	0.90 – 5.3	2.7
	Howe	53	1.2 – 4.8	2.6
	Monteview	53	1.2 – 4.6	2.5
	Mud Lake	53	1.2 – 6.3	2.7
			Boundary Median:	2.6
INL Site	EFS	52	0.94 – 6.3	2.7
	Main Gate	52	0.97 – 5.9	2.8
	Van Buren	52	1.3 – 5.7	2.9
			INL Site Median:	2.7
INL Contractor				
Distant	Blackfoot	52	0.93 – 4.49	2.3
	Craters of the Moon	51	0.93 – 4.41	2.5
	Idaho Falls	51	0.8 – 4.41	2.4
	IRC[d]	48	0.78 – 4.32	2.4
	IRC (North)	3[e]	1.73 – 4.4	2.0
	Sugar City	52	0.77 – 4.14	2.2
			Distant Median:	2.4
INL Site	RHLLW	52	0.69 – 4.65	2.5
	ATR Complex (NE corner)	47	1.31 – 4.79	2.4
	Highway 26 Rest Area	51	0.9 – 6.01	2.4
	CFA	49	1.03 – 5.1	2.5
	EBR-I	52	1.04 – 5.56	2.5
	EFS	52	0.69 – 5.08	2.3
	Gate 4	52	1.09 – 6.5	2.6
	INTEC (NE corner)	52	0.92 – 4.7	2.4
	INTEC (west side)	51	0.82 – 5.08	2.5

Table 4-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2019 (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-14} µCi/mL)	Annual Median Concentration[c] (× 10^{-14} µCi/mL)
ESER Contractor				
	MFC (North)	52	0.8 – 4.61	2.3
	MFC (South)	52	0.73 – 4.81	2.5
	NRF	50	0.52 – 5.33	2.3
	RWMC	52	0.93 – 4.76	2.4
	RWMC (South)	52	0.87 – 5.58	2.5
	SMC	52	0.96 – 4.82	2.4
	Van Buren Boulevard	49	0.88 – 4.76	2.4
			INL Site Median:	2.4

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.

e. The sampler for IRC (North) was put in place late 2019 resulting in only 3 samples being collected before the end of the year.

detectable concentrations) were included. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2019. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2019 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/Surveillance/reports.html.

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 (2.5 ± 0.3 × 10^{-14} and 2.4 ± 0.3 × 10^{-14} µCi/mL, respectively) showed equivalence at one sigma uncertainty and are attributable to natural data variation.

Specific Radionuclides – None of the 93 INL contractor quarterly samples composited in 2019 had measurable concentrations of specific radionuclides (i.e., ^{90}Sr, ^{137}Cs, plutonium isotopes, or ^{241}Am).

Strontium-90 was not detected in any sample collected by the ESER contractor. Plutonium-239/240 and ^{241}Am were detected in the sample collected by the ESER contractor from Monteview during the third quarter (Table 4-6). Plutonium-238 was also detected in the composite sampled by the ESER contractor from Blue Dome during the same quarter (Table 4-6). All results were within historical measurements made during the past ten years (2009-2018). The results were also well below the DCSs for these radionuclides in air (i.e., 4.1 × 10^{-14} µCi/mL for ^{241}Am, 3.7 × 10^{-14} µCi/mL for ^{238}Pu,

Table 4-6. Human-Made Radionuclides Detected in Ambient Air Samples Collected by the ESER Contractor in 2019.

Radionuclide	Result[a] (µCi/mL)	Location	Group	Quarter Detected
Americium-241	$(3.2 \pm 0.99) \times 10^{-18}$	Monteview	Boundary	3rd
Plutonium-238	$(3.1 \pm 0.90) \times 10^{-18}$	Blue Dome	Boundary	3rd
Plutonium-239/240	$(3.7 \pm 1.0) \times 10^{-18}$	Monteview	Boundary	3rd

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

and 3.4 x 10^{-14} µCi/mL for $^{239/240}$Pu). The source of these radionuclides is most likely global fallout. Natural ^{7}Be was detected in numerous ESER and INL contractor composite samples at concentrations consistent with past concentrations. Atmospheric ^{7}Be results from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in earth's atmosphere.

4.3.4 Atmospheric Moisture Monitoring Results

During 2019, the ESER contractor collected 53 atmospheric moisture samples at four locations. Table 4-7 presents the percentage of samples that contained detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in 36 ESER samples, with a high of $(14.7 \pm 1.8) \times 10^{-13}$ µCi/mL$_{air}$ at EFS on July 31, 2019. The highest concentration of tritium detected in an atmospheric moisture sample collected since 2009 was 34 × 10^{-13} µCi/mL$_{air}$ at Atomic City in 2009. The highest observed tritium concentration in a 2019 sample collected by the ESER contractor is far below the DCS for tritium in air (as water vapor) of 2.1 × 10^{-7} µCi/mL$_{air}$ (see Table A-2 of Appendix A).

In 2019, the INL contractor collected 34 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 4-7). Tritium was detected in 1 sample. The detected concentration measured was 6.3 × 10^{-13} µCi/mL^{air} at EFS on January 2, 2019. This result is well below the DCS for tritium, as vapor, in air (2.1 × 10^{-7} µCi/mL) and below the maximum (1.1 × 10^{-12} µCi/mL$_{air}$) measured since 2009. Fewer detections were observed in INL samples than in 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 and to some extent global fallout (see Section 4.3.5). Tritium releases from non-fugitive sources, such as 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.

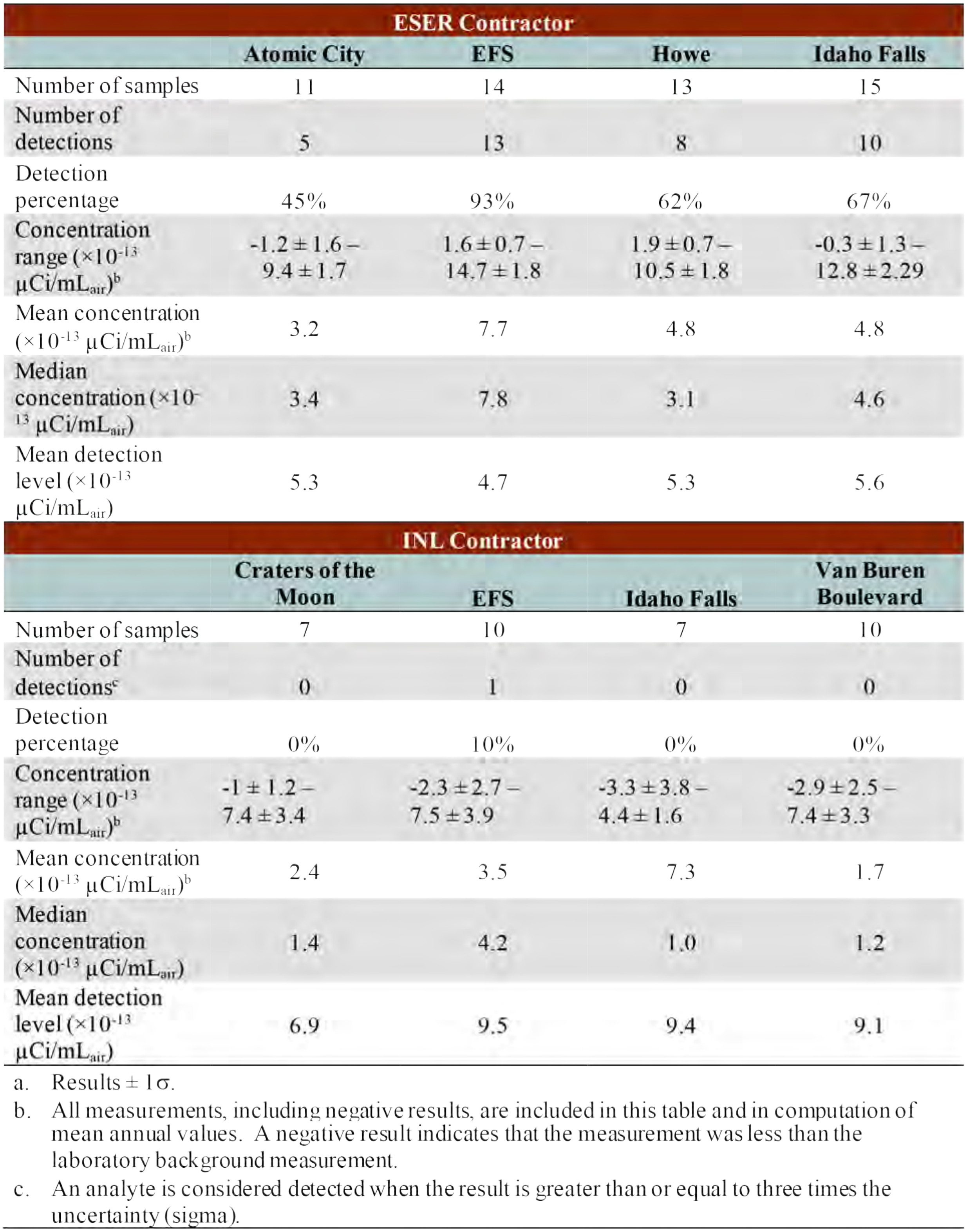
4.3.5 Precipitation Monitoring Results

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 atmospheric gases 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 by the ESER contractor for analysis.

A total of 87 precipitation samples were collected during 2019 from the four sites. Tritium was detected in 25 samples, and detectable results ranged from 73 pCi/L at Howe in June to 146 pCi/L at EFS in September. Most detections were near the approximate detection level of 90 pCi/L. Table 4-8 shows the percentage of detections, the concentration range, the mean and median concentration for each location. The highest concentration is well

Table 4-7. Tritium Concentrations[a] in Atmospheric Moisture Samples Collected on and off the INL Site in 2019.



	ESER Contractor			
	Atomic City	**EFS**	**Howe**	**Idaho Falls**
Number of samples	11	14	13	15
Number of detections	5	13	8	10
Detection percentage	45%	93%	62%	67%
Concentration range ($\times10^{-13}$ $\mu Ci/mL_{air}$)[b]	-1.2 ± 1.6 – 9.4 ± 1.7	1.6 ± 0.7 – 14.7 ± 1.8	1.9 ± 0.7 – 10.5 ± 1.8	-0.3 ± 1.3 – 12.8 ± 2.29
Mean concentration ($\times10^{-13}$ $\mu Ci/mL_{air}$)[b]	3.2	7.7	4.8	4.8
Median concentration ($\times10^{-13}$ $\mu Ci/mL_{air}$)	3.4	7.8	3.1	4.6
Mean detection level ($\times10^{-13}$ $\mu Ci/mL_{air}$)	5.3	4.7	5.3	5.6
	INL Contractor			
	Craters of the Moon	**EFS**	**Idaho Falls**	**Van Buren Boulevard**
Number of samples	7	10	7	10
Number of detections[c]	0	1	0	0
Detection percentage	0%	10%	0%	0%
Concentration range ($\times10^{-13}$ $\mu Ci/mL_{air}$)[b]	-1 ± 1.2 – 7.4 ± 3.4	-2.3 ± 2.7 – 7.5 ± 3.9	-3.3 ± 3.8 – 4.4 ± 1.6	-2.9 ± 2.5 – 7.4 ± 3.3
Mean concentration ($\times10^{-13}$ $\mu Ci/mL_{air}$)[b]	2.4	3.5	7.3	1.7
Median concentration ($\times10^{-13}$ $\mu Ci/mL_{air}$)	1.4	4.2	1.0	1.2
Mean detection level ($\times10^{-13}$ $\mu Ci/mL_{air}$)	6.9	9.5	9.4	9.1

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.

c. An analyte is considered detected when the result is greater than or equal to three times the uncertainty (sigma).

Table 4-8. Tritium Concentrations in Precipitation Samples Collected by the ESER Contractor in 2019.[a,b]

	Atomic City	Experimental Field Station	Howe	Idaho Falls
Number of samples	27	26	23	11
Number of detections	10	8	4	3
Detection percentage	37%	31%	17%	27%
Concentration range (pCi/L)	-13.0 ± 23.9 – 144 ± 25.1	-5.5 ± 24.4 – 146 ± 24.1	5.8 ± 24.8 – 98.9 ± 25.0	-2.6 ± 24.7– 127.0 ± 24.5
Mean concentration (pCi/L)	58	56	51	56
Median concentration (pCi/L)	48	50	51	52
Mean detection level (pCi/L)	90	92	92	91

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.

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 4-5). 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 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 reactions with atmospheric gases in the upper atmosphere and the decreasing influence of fallout from nuclear weapons testing in the 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 past nuclear tests, and not from INL Site releases.

4.3.6 Suspended Particulates Monitoring Results

In 2019, 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 2019 was therefore calculated to be 5.1 $\mu g/m^3$.

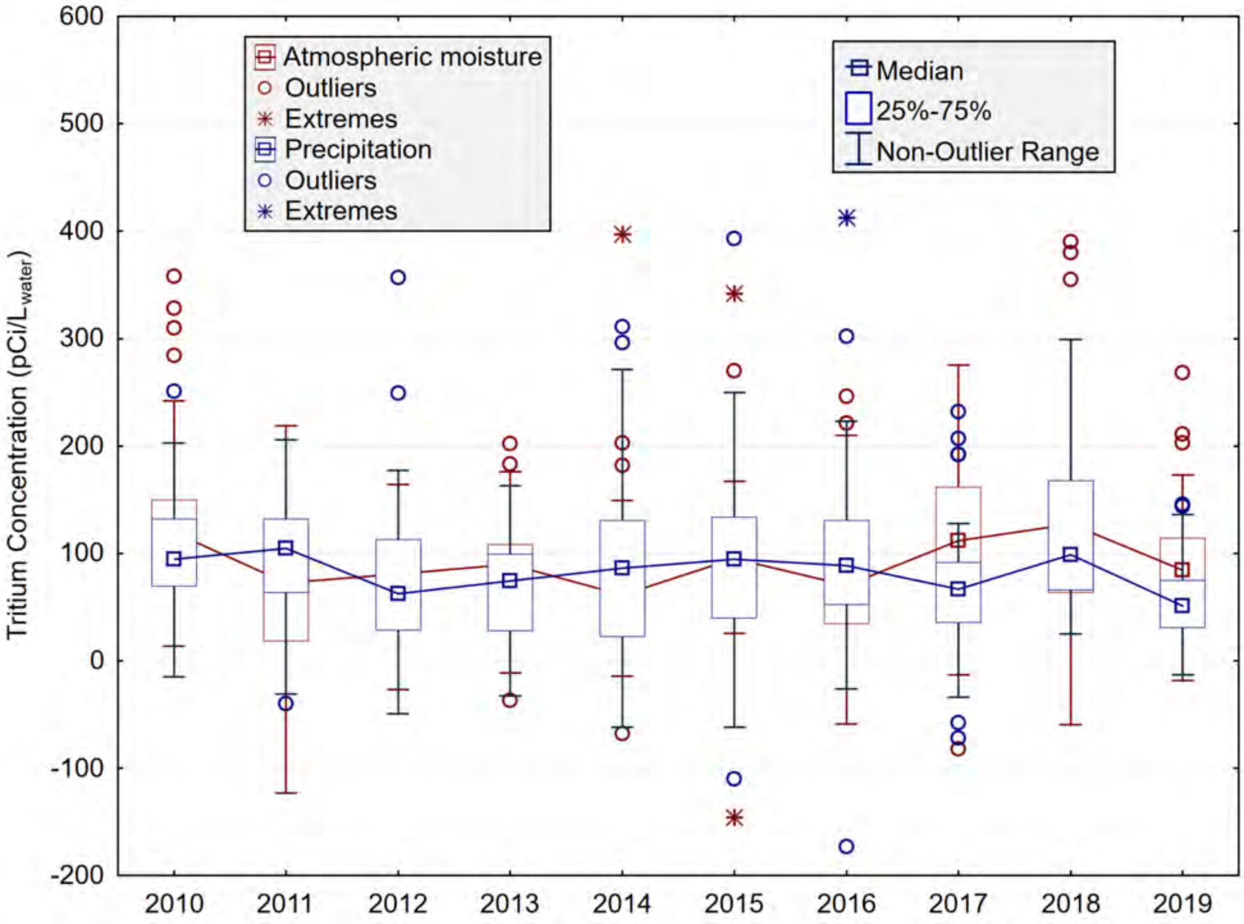


Figure 4-5. Box Plots of Tritium Concentrations Measured in Atmospheric Moisture and in Precipitation from 2010–2019.

4.4 Waste Management Environmental Surveillance Air Monitoring

4.4.1 Gross Activity

The ICP Core contractor conducts environmental surveillance in and around waste management facilities to comply with DOE 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 2019 (Figure 4-6). Samples were also collected at a control location at Howe, Idaho (Figure 4-2), to compare with the results of the SDA and ICDF.

Samples were obtained using suspended particulate monitors similar to those used by the INL and ESER contractors. The air filters are 4 in. in diameter and are changed out on the closest working day to the first and 15th of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples. Table 4-9 shows the median annual and range of gross alpha concentrations at each location. Gross alpha concentrations ranged from a low of (0.7 ± 0.2) × 10^{-15} µCi/mL collected at location SDA 11.3 on February 18, 2019, to a high of (6.83 ± 1.03) × 10^{-15} µCi/mL at location INT 100.3 on November 14, 2019.

Table 4-10 shows the annual median and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of (1.42 ± 0.14) × 10^{-14} µCi/mL at location SDA 6.3 on April 15, 2019, to a high of (1.22 ± 0.30) x 10^{-14} µCi/mL at location SDA 9.3 on February 5, 2019.

Figure 4-7 compares gross alpha and gross beta sample results from 2012 through 2019 to the most restrictive DCS values ($^{239/240}$Pu for gross alpha, ^{90}Sr for gross

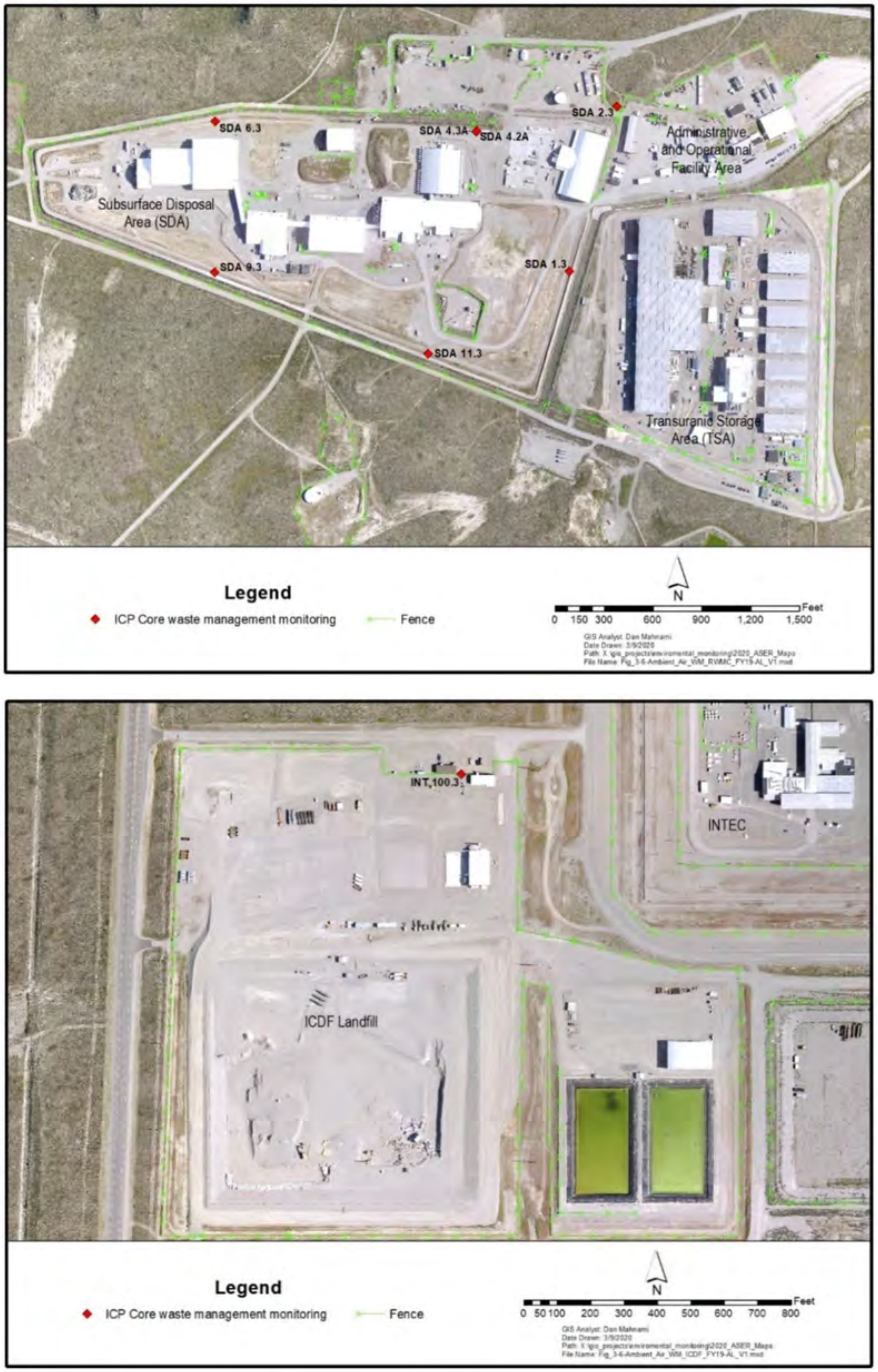
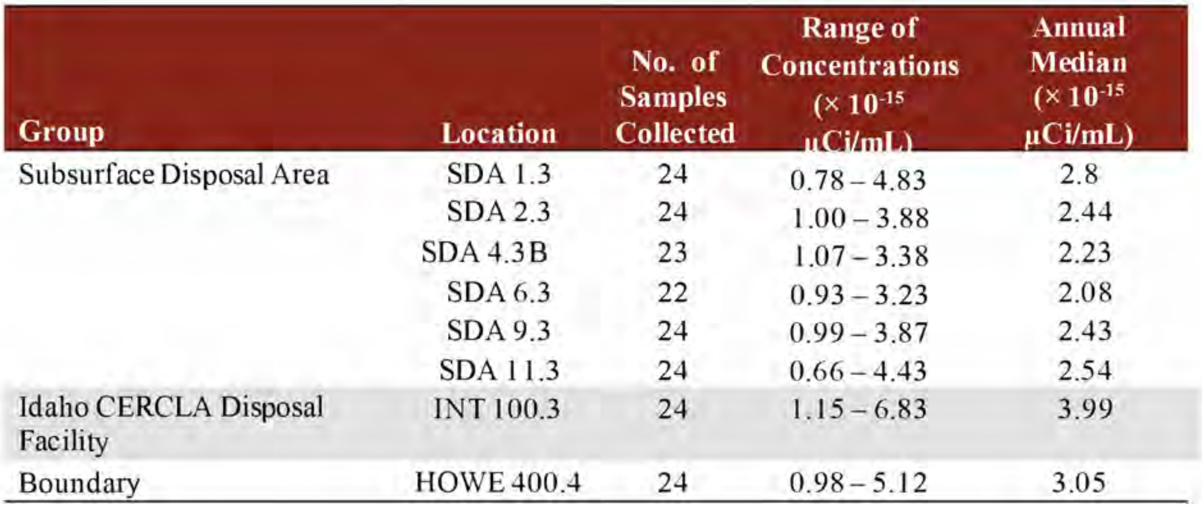


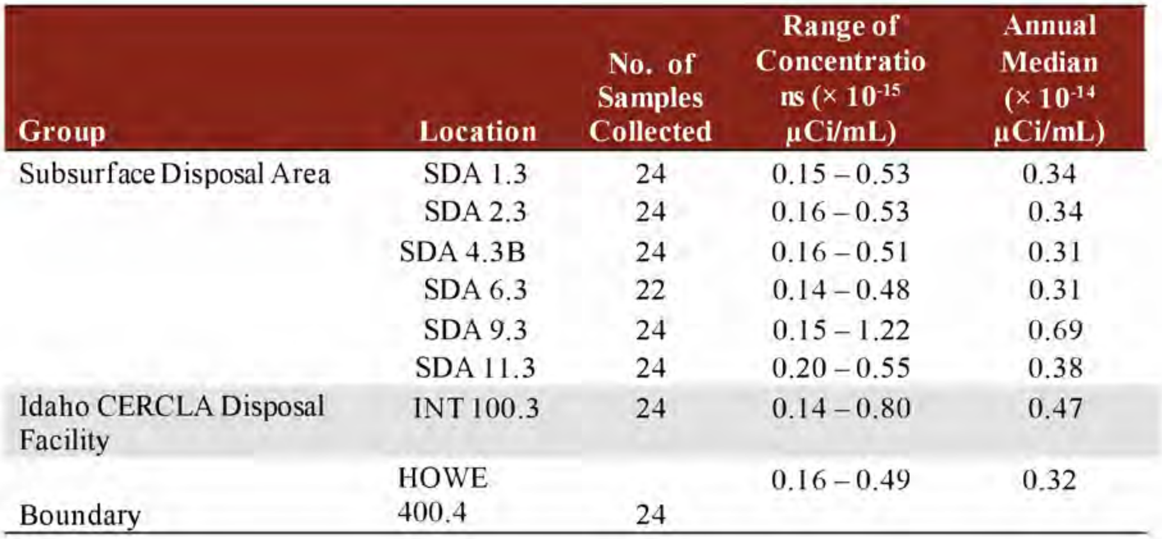
Figure 4-6. Locations of ICP Core Contractor Low-Volume Air Samplers at Waste Management Areas (SDA [top] and ICDF [bottom]).

Table 4-9. Median Annual Gross Alpha Concentration in Air Samples Collected at Waste Management Sites in 2019.



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	0.78 – 4.83	2.8
	SDA 2.3	24	1.00 – 3.88	2.44
	SDA 4.3B	23	1.07 – 3.38	2.23
	SDA 6.3	22	0.93 – 3.23	2.08
	SDA 9.3	24	0.99 – 3.87	2.43
	SDA 11.3	24	0.66 – 4.43	2.54
Idaho CERCLA Disposal Facility	INT 100.3	24	1.15 – 6.83	3.99
Boundary	HOWE 400.4	24	0.98 – 5.12	3.05

Table 4-10. Median Annual Gross Beta Concentration in Air Samples Collected at Waste Management Sites in 2019.



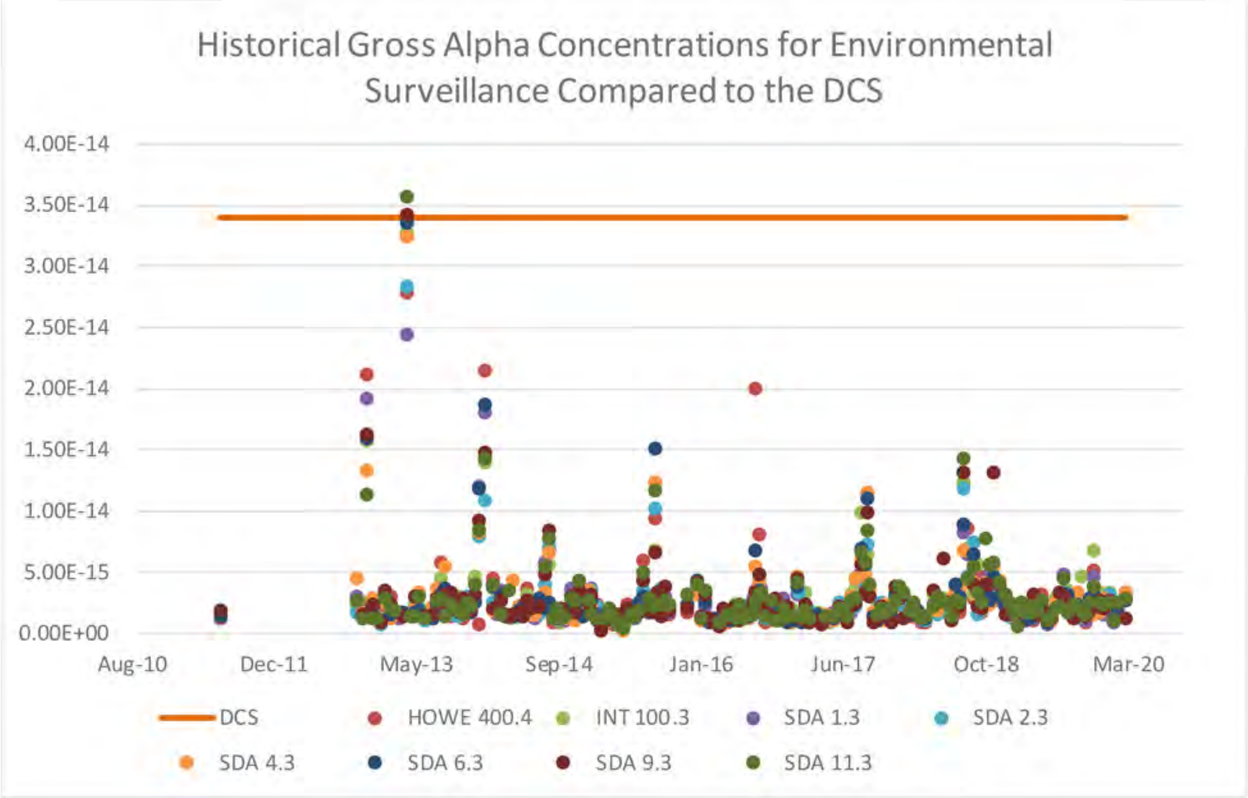
Group	Location	No. of Samples Collected	Range of Concentrations (× 10^{-15} µCi/mL)	Annual Median (× 10^{-14} µCi/mL)
Subsurface Disposal Area	SDA 1.3	24	0.15 – 0.53	0.34
	SDA 2.3	24	0.16 – 0.53	0.34
	SDA 4.3B	24	0.16 – 0.51	0.31
	SDA 6.3	22	0.14 – 0.48	0.31
	SDA 9.3	24	0.15 – 1.22	0.69
	SDA 11.3	24	0.20 – 0.55	0.38
Idaho CERCLA Disposal Facility	INT 100.3	24	0.14 – 0.80	0.47
Boundary	HOWE 400.4	24	0.16 – 0.49	0.32

beta) established by DOE for inhaled air (DOE 2011). The results for the SDA and ICDF are well below their respective DCS values.

4.4.2 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 analyses are performed monthly and radiochemical analyses are performed quarterly.

In 2019, no human-made, gamma-emitting radionuclides were detected in air samples at the ICDF at INTEC. However, human-made specific alpha- and beta-emitting radionuclides were detected at the SDA at RWMC.



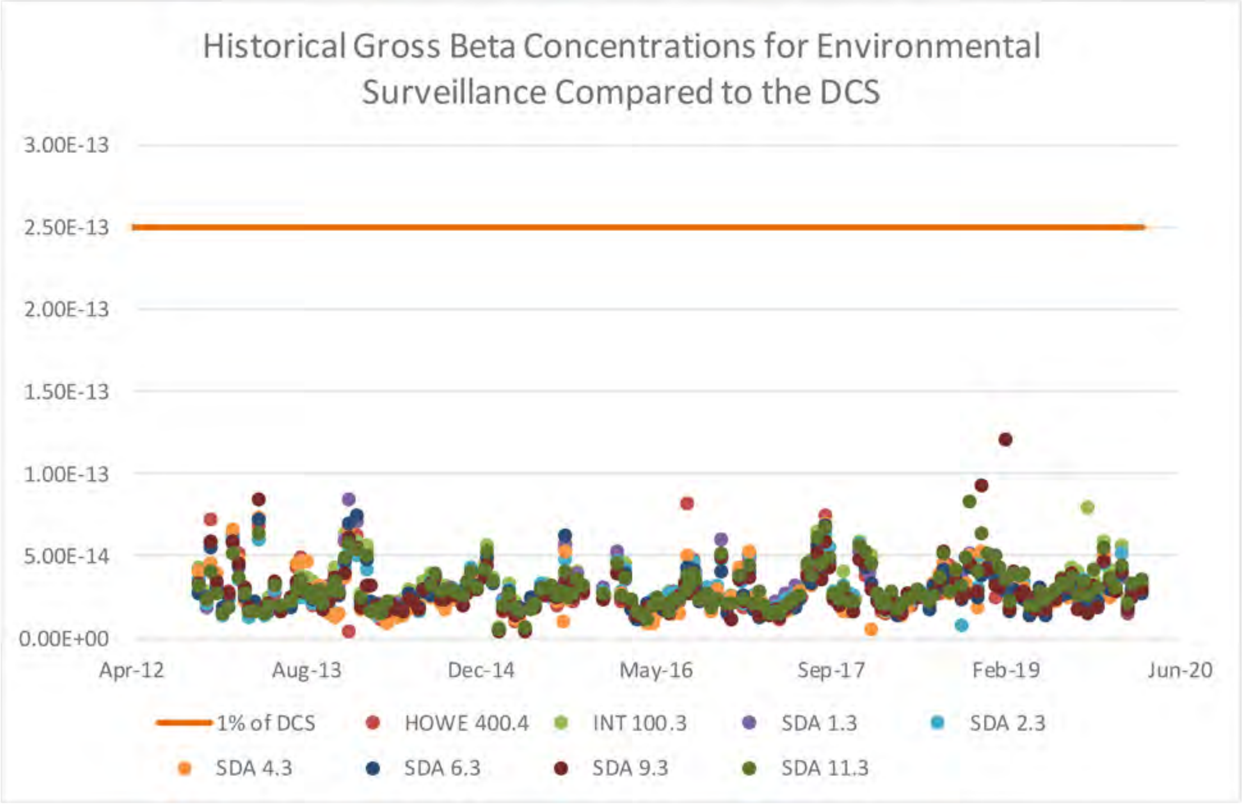


Figure 4-7. Gross Alpha and Gross Beta Results (µC/ml) from Waste Management Site Air Samples Compared to Their Respective Derived Concentration Standards.

Table 4-11 shows human-made specific radionuclides detected at the SDA in 2019. 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 4-8, and statistically false positives at the 95% confidence error are possible.

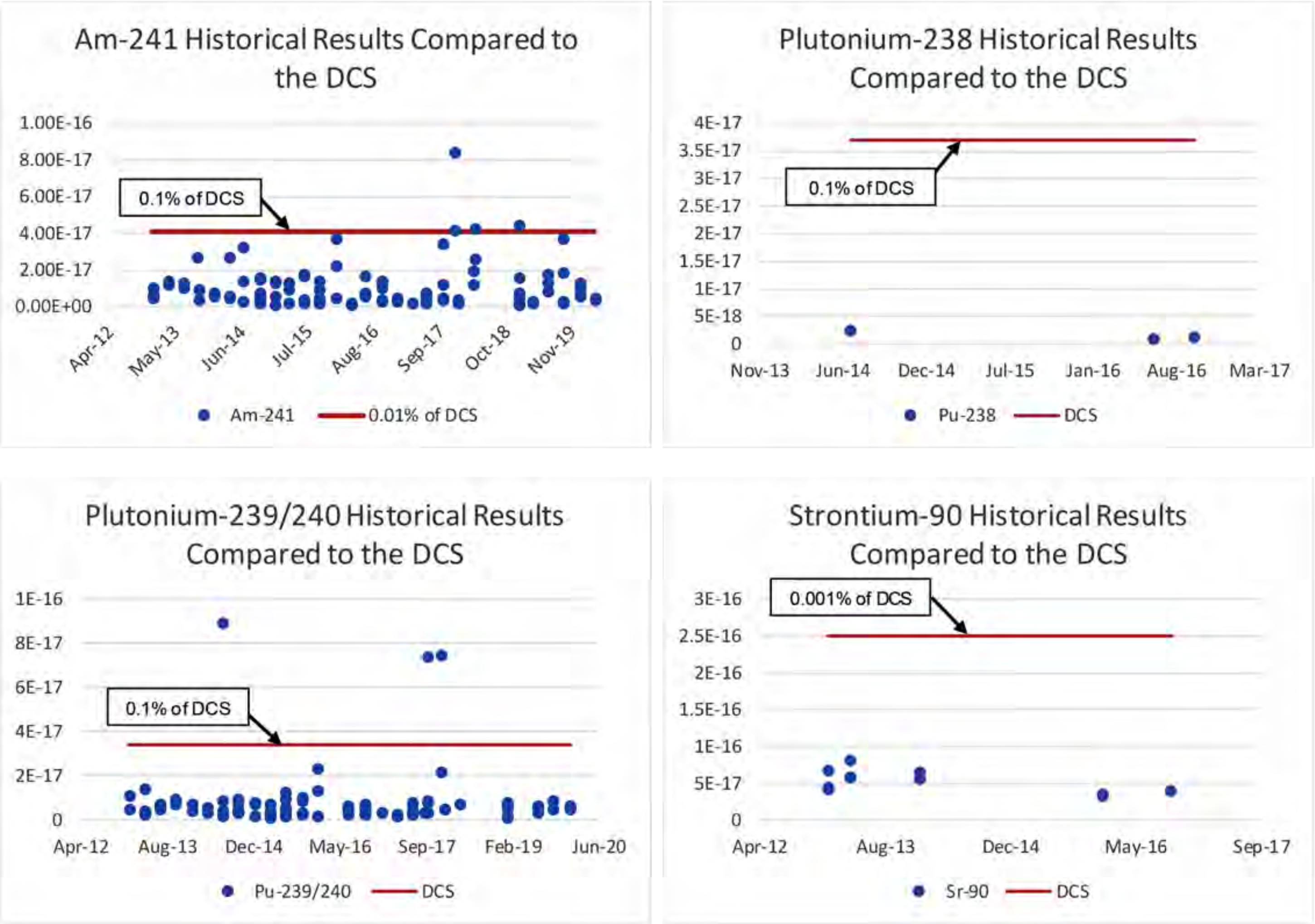
In addition to the human-made, gamma-emitting radionuclides discussed above, the ICP Core contractor also monitors for uranium. While not enumerated in Table 4-11, detections of uranium nuclides occur routinely at concentrations that suggest a natural origin.

Table 4-11. Human-made Radionuclides Detected in Air Samples Collected at Waste Management Sites in 2019.[a]

Radionuclide	Location	Result (µCi/mL)	Uncertainty (1 Sigma)	Period Detected
Am-241	SDA 4.3B	3.21E-18	6.56E-19	1/7/2019 – 4/1/2019
Am-241	SDA 2.3	8.87E-18	1.40E-18	4/1/2019 – 7/1/2019
Am-241	SDA 4.3B	1.30E-17	1.82E-18	
Pu-239/240	SDA 2.3	3.12E-18	7.43E-19	
Pu-239/240	SDA 4.3B	5.32E-18	9.69E-19	
Am-241	SDA 2.3	2.58E-18	8.35E-19	7/1/2019 – 10/1/2019
Am-241	SDA 4.3B	1.94E-17	2.37E-18	
Am-241	SDA 6.3	3.26E-18	9.56E-19	
Pu-239/240	SDA 1.3	4.70E-18	1.20E-18	
Pu-239/240	SDA 4.3B	8.23E-18	1.58E-18	
Am-241	SDA 4.3B	1.10E-17	1.52E-18	10/1/2019 – 1/6/2020
Am-241	SDA 6.3	5.73E-18	9.93E-19	
Pu-239/240	SDA 4.3B	4.31E-18	1.34E-18	
Pu-239/240	SDA 6.3	5.05E-18	1.36E-18	
Am-241	SDA 2.3	1.31E-17	1.63E-18	10/1/2019 – 1/7/2020
Pu-239/240	SDA 2.3	5.69E-18	1.30E-18	

a. Results shown are ≥ 3σ.

Figure 4-8. 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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Mud Lake ESER Sampler

5. ENVIRONMENTAL MONITORING PROGRAMS: LIQUID EFFLUENTS

Ballhead gilia (*DIpomopsis congesta*)

Wastewater discharged to land surfaces and evaporation ponds at the Idaho National Laboratory 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 2019 by the Idaho National Laboratory contractor and the Idaho Cleanup Project Core contractor for compliance with permit requirements and applicable regulatory standards established to protect human health and the environment.

During 2019, permitted facilities were: Advanced Test Reactor Complex Cold Waste Pond; Idaho Nuclear Technology and Engineering Center New Percolation Ponds; and Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond. These facilities were sampled for parameters required by their facility-specific permits. No permit requirements were exceeded in 2019.

Additional liquid effluent and groundwater monitoring was performed in 2019 at Advanced Test Reactor, Idaho Nuclear Technology and Engineering Center, and Materials and Fuels Complex to comply with environmental protection objectives of the U.S. Department of Energy. All parameters were below applicable health-based standards in 2019.

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. Additionally, water sheet flows across asphalt surfaces and infiltrates around/under door seals at Waste Management Facility-636 at the Advanced Mixed Waste Treatment Project and collects in catch tanks intended to facilitate sampling. Specific human-made gamma-emitting radionuclides were not detected in 2019. Detected concentrations of gross beta activity and radium-226 did not exceed U.S. Department of Energy Derived Concentration Standards.

5. ENVIRONMENTAL MONITORING PROGRAMS: LIQUID EFFLUENTS MONITORING

Operations at the Idaho National Laboratory (INL) Site result in the discharge of liquid effluent that may contain 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 5-1 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 B.

5.1 Wastewater and Related Groundwater Compliance Monitoring

Discharge of wastewater to the land surface is regulated by the Recycled Water Rules (IDAPA 58.01.17), Wastewater Rules (IDAPA 58.01.16) and Ground Water Quality Rule (IDAPA 58.01.11) promulgated according to the Idaho Administrative Procedure Act. Reuse permits may require monitoring of nonradioactive constituents in the influent, effluent and groundwater in accordance with the monitoring requirements specified within each permit. Some facilities may have specified radiological constituents monitored for surveillance purposes (not required by regulations). The permits may specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2020a and 2020b; INL 2019a, 2019b, 2019c, and 2019d) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

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

Area/Facility[a]	Monitoring Requirements		
	Idaho 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. RWMC=Radioactive Waste Management Complex, ATR=Advanced Test Reactor, MFC=Materials and Fuels Complex, INTEC=Idaho Nuclear Technology and Engineering Center, SDA= Subsurface Disposal Area

b. Required by permits issued according to the Idaho Department of Environmental Quality Rules, IDAPA 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.

During 2019, the INL contractor and ICP Core contractor monitored, as required by the permits, the following facilities (Table 5-2):

- Advanced Test Reactor (ATR) Complex Cold Waste Ponds (Section 5.1.1)
- Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds and Sewage Treatment Plant (STP) (Section 5.1.2)
- Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond (Section 5.1.3).

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

5.1.1 Advanced Test Reactor Complex Cold Waste Pond

Description. The Cold Waste 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

Table 5-2. 2019 Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2018	Explanation
ATR Complex Cold Waste Pond	Permit issued	DEQ issued Reuse Permit I-161-02 on November 20, 2014, with minor modifications issued March 7, 2017 and May 8, 2019. The permit expired on November 19, 2019. A permit application was submitted to DEQ May 15, 2019. DEQ issued Reuse Permit I-161-03 October 30, 2019.
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. Permit WRU-I-0160-01 (formerly LA-000160-01), Modification 1 was issued June 21, 2012. A reuse permit renewal application was submitted to DEQ in October 2014. DEQ issued Reuse Permit I-160-02 on January 26, 2017, with minor modifications issued March 7, 2017 and May 8, 2019.

(Figure 5-1). The CWPs 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).

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.

Reuse permit I-161-02 was in effect thru October 29, 2019. The new Reuse Permit I-161-03 became effective October 30, 2019. The permit specifies an annual ‘reuse year’ of November 1st thru October 31st.

Effluent Monitoring Results for the Reuse Permit. The reuse permits in effect during calendar year 2019 (I-161-02 thru October 29, 2019, and I-161-03 beginning October 30, 2019) require monthly sampling of the effluent to the CWP. The minimum, maximum, and median results of all constituents monitored are presented in Table B-1. The total dissolved solids concentration in the effluent to the CWP ranged from 203 mg/L in the April 2019 sample to 1,210 mg/L in the June 2019 sample. Sulfate ranged from a minimum of 32.2 mg/L in the May 2019 sample to a maximum of 675 mg/L in the June 2019 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.

Both CWP permits (I-161-02 and I-161-03) specify maximum annual and 5-year average hydraulic loading rates of 300 MG/yr and 375 MG/yr, respectively, based on an annual ‘reuse year’ from November 1st – October 31st. For example, the 2019 reuse year was from November 1, 2018, thru October 31, 2019. As shown in Table B-2, the annual calendar-year 2019 flow of 227.13 MG did not exceed either of these requirements.

Groundwater Monitoring Results for the Reuse Permit. Reuse Permit I-161-02 required groundwater monitoring, to measure potential impacts from the CWP, in April/May and September/October, at six groundwater wells (Figure 5-1). For 2019, none of the constituents exceeded their respective primary or secondary constituent standards and are presented in Table B-3a and Table B-3b. The metals concentrations continue to remain at low levels.

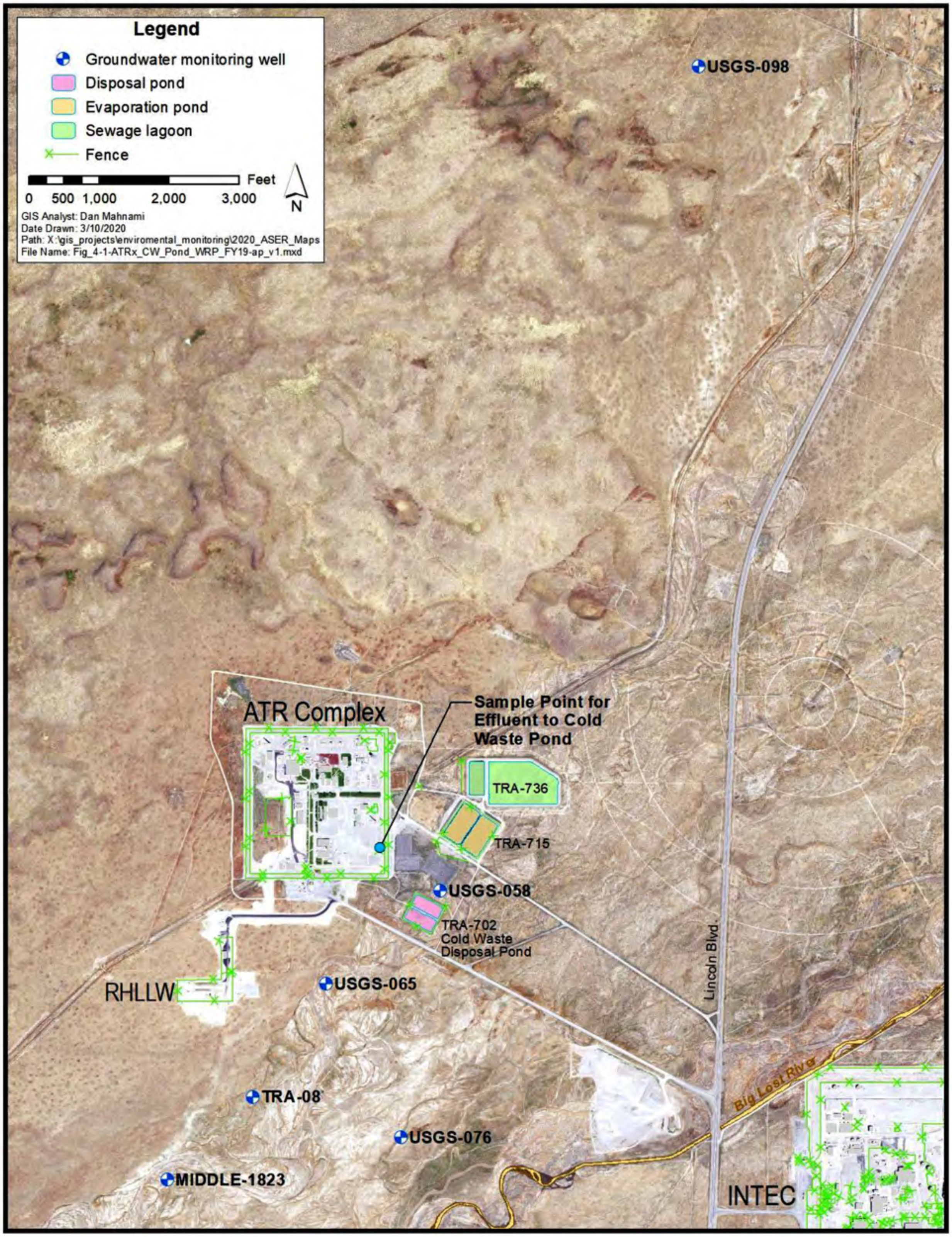

Figure 5-1. Permit Monitoring Locations for the ATR Complex Cold Waste Pond.

5.1.2 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 surficial alluvium and surrounded by bermed alluvial material (Figure 5-2). 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 Reuse Permit. Monthly samples were collected from CPP-769 (influent to STP), CPP-773 (effluent from STP), and CPP-797 (effluent to the INTEC New Percolation Ponds) (see Figure 5-3). 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 2019 reporting year monitoring results for CPP-769, CPP-773, and CPP-797 are provided in the 2019 Wastewater Reuse Report (ICP 2020a), and the 2019 calendar year monitoring results are summarized in Tables B-4, B-5, and B-6.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table B-7, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2019.

Groundwater Monitoring Results for the Reuse Permit. To measure potential impacts to groundwater from wastewater discharges to the INTEC New Percolation Ponds, the permit requires that groundwater samples be collected from six monitoring wells as shown in Figure 5-2.

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 monitoring wells are limited by primary constituent standards and secondary constituent standards, specified in IDAPA 58.01.11, "Ground Water Quality Rules."

Table B-8 shows the 2019 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 B-9 presents similar information for the perched water wells.

Tables B-8 and B-9 show all permit-required constituents associated with the aquifer and perched water monitoring wells were below their respective primary constituent standards and secondary constituent standards in 2019.

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

Description. The Materials and Fuels Complex (MFC) Industrial Waste Pond was first excavated in 1959 and has a design capacity of 1,078.84 ML (285 MG) at a maximum water depth of 3.96 m (13 ft) (Figure 5-4). 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 Wastewater Underground Pipe consists of intermittent reverse osmosis effluent and laboratory sink discharge from the MFC-768 Power Plant.

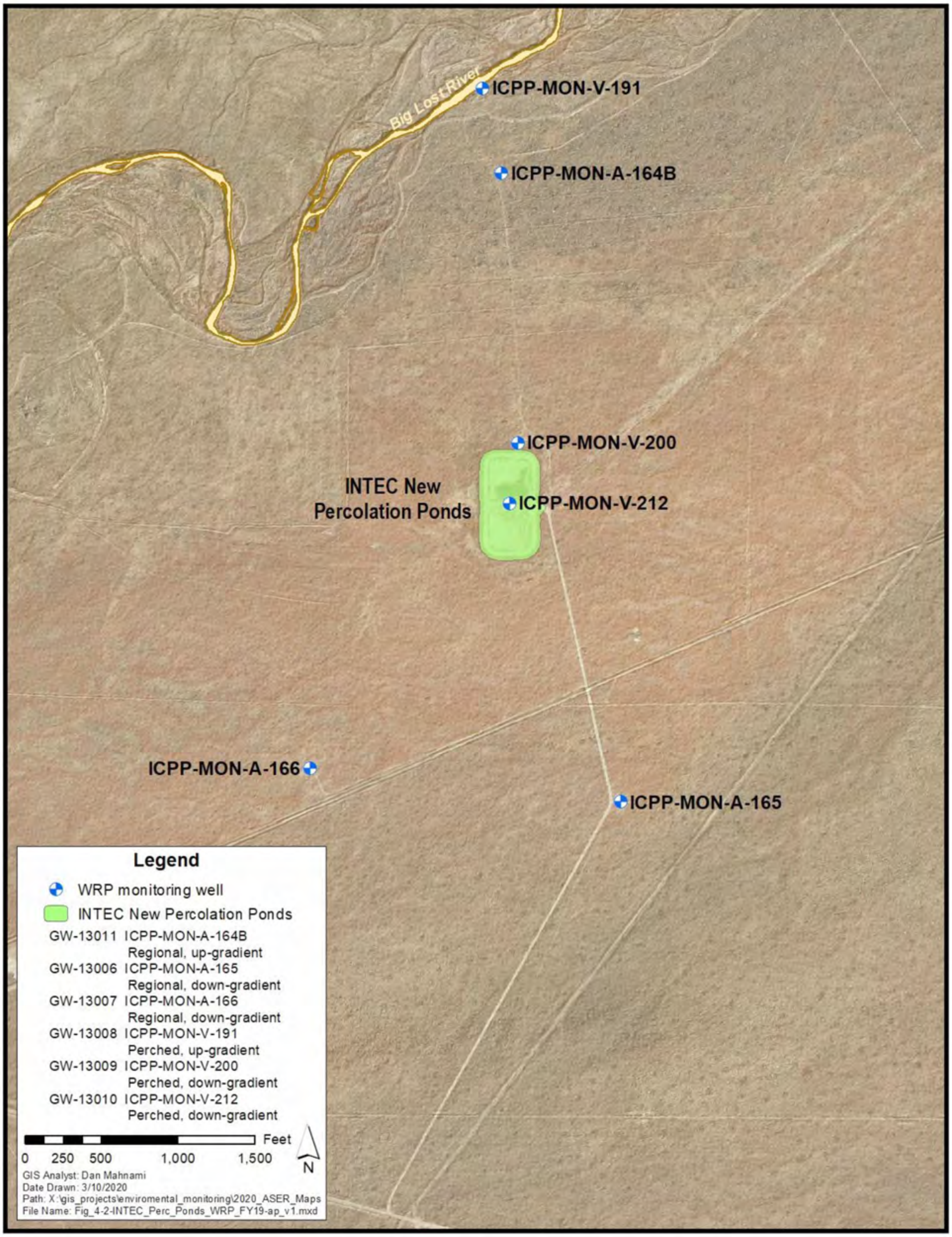

Figure 5-2. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds.

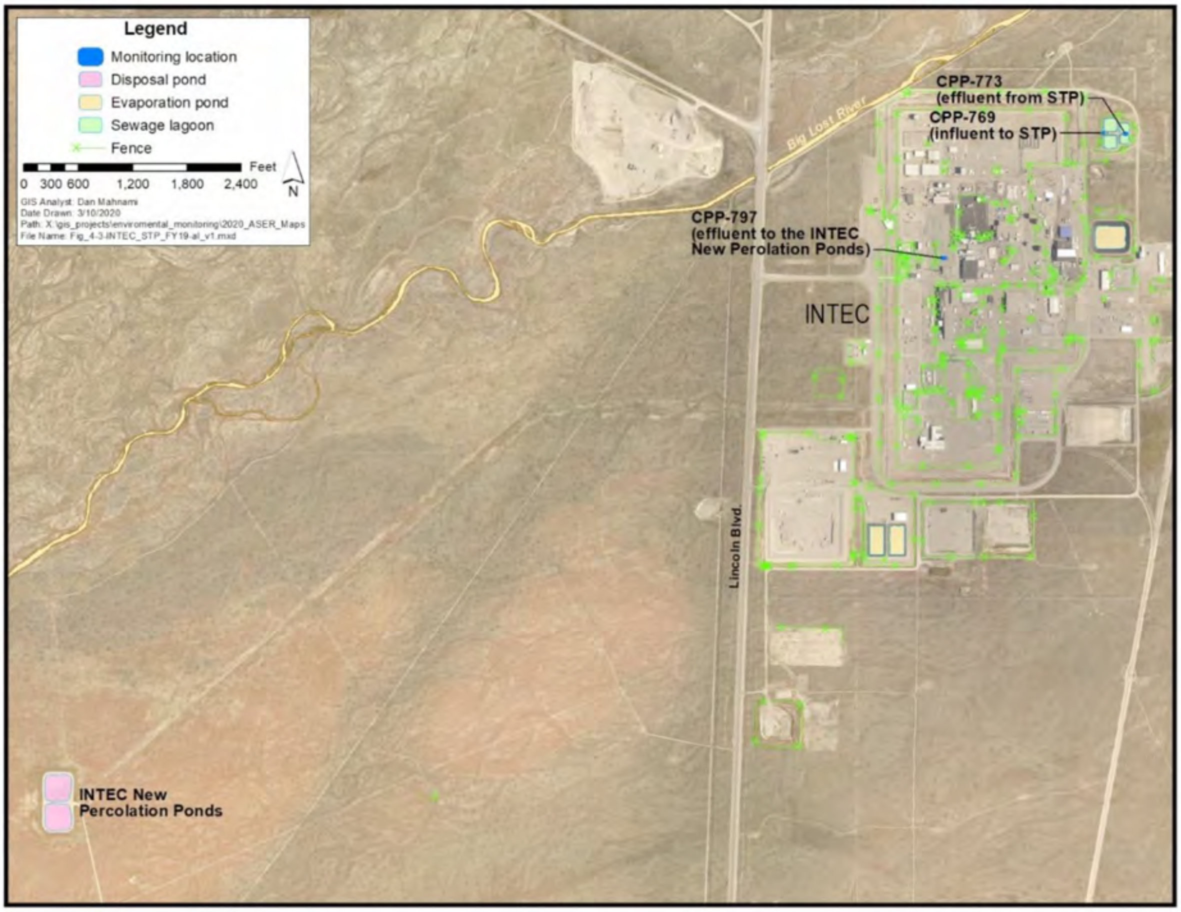

Figure 5-3. INTEC Wastewater Monitoring for Wastewater Reuse Permit.

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

Engineering plans and specifications for the MFC West Campus Utility Corridor were submitted to DEQ on August 1, 2018 and approved on August 29, 2018. This project will reroute the industrial wastewater currently discharged into the Ditch C from the Industrial Wastewater Underground Pipe into a new section of underground pipe that will connect to the existing Industrial Waste Pipeline. Excavation began in October 2018 and project completion is anticipated in 2020.

Wastewater Monitoring Results for the Reuse Permit. The reuse permit requires monthly sampling of the effluent to the pond discharged from the Industrial Waste Pipeline and quarterly sampling of the discharge to Ditch C from the Industrial Wastewater Underground Pipe. The minimum, maximum, and median results of all constituents monitored are presented in Tables B-10 and B-11.

Groundwater Monitoring Results for the Reuse Permit. The reuse permit requires groundwater monitoring in April/May and September/October at one upgradient well and two downgradient wells (Figure 5-4).

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

5.2 Liquid Effluent Surveillance Monitoring

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

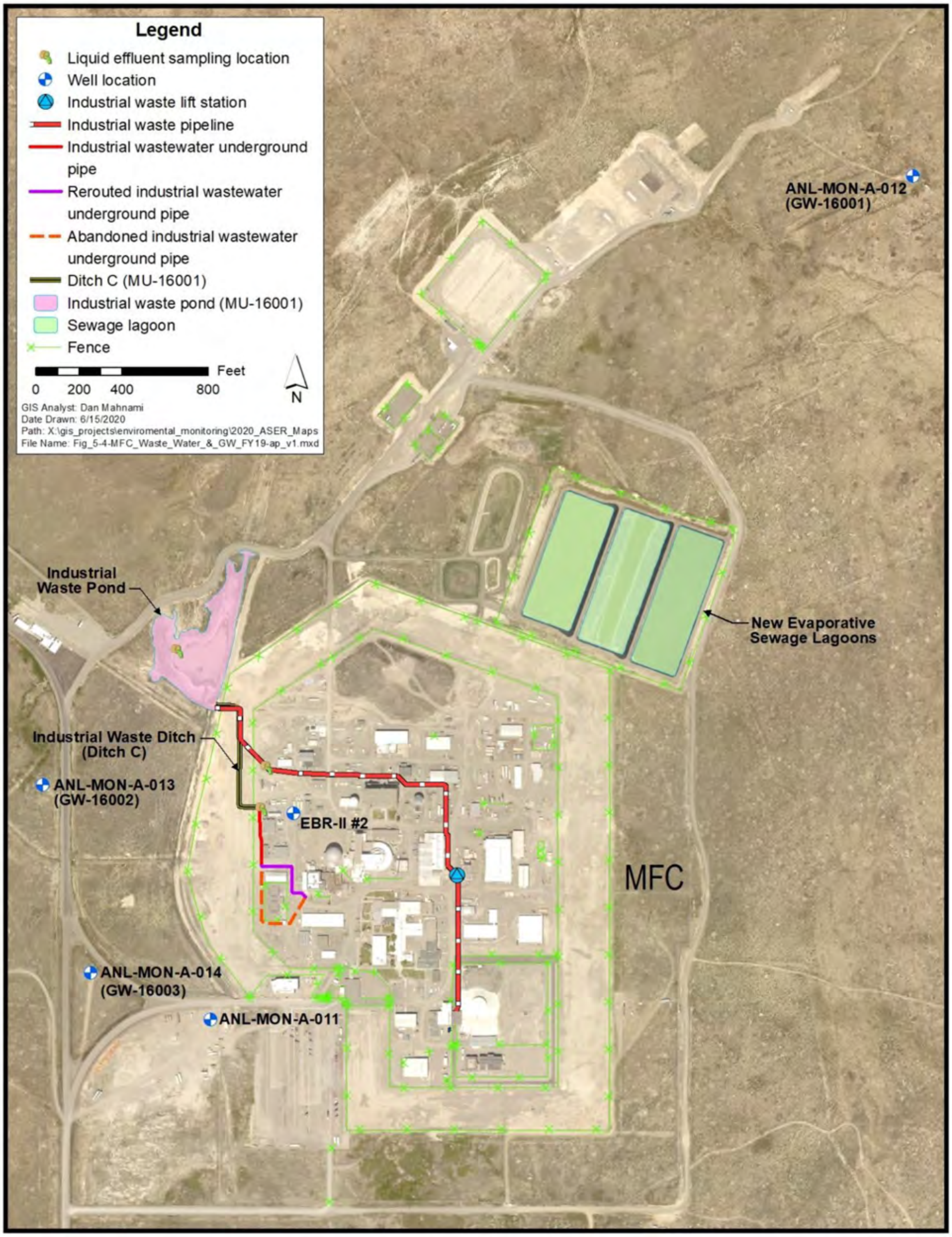

Figure 5-4. Wastewater and Groundwater Sampling Locations MFC.

5.2.1 Advanced Test Reactor Complex

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

5.2.2 Idaho Nuclear Technology and Engineering Center

In addition to the permit-required monitoring summarized in Section 5.1.3, 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 B-15 summarizes the results of radiological monitoring at CPP-773 and CPP-797, and Table B-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 April 2019 and analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table B-15, no gamma emitters were detected, and no gross alpha or total strontium was detected. Gross beta was detected at 13 pCi/L, which is 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 B-15, no gamma-emitting radionuclides or total strontium activity was detected in any of the samples collected at CPP-797 in 2019. Gross alpha was detected in four of the 12 samples, and gross beta was detected in all 12 samples collected in 2019.

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/May 2019 and September 2019 and analyzed for gross alpha and gross beta. As shown in Table B-16, gross alpha was detected in aquifer Well ICPP-MON-A-165 (1.57 pCi/L) and perched water Well ICPP-MON-V-200 (2.24 pCi/L). Gross beta was detected in three of the four monitoring wells in April/May 2019 and all four monitoring wells in September 2019.

5.2.3 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium (Figure 5-4). 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 2019 (Table B-17) and are below applicable Derived Concentration Standards found in Table A-2.

5.3 Waste Management Surveillance Surface Water Sampling

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

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 5-5. The WMF-636 Fire Water Catch Tanks are also shown in Figure 5-5. 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 not collected semiannually during 2019 due to a scheduling error. As a corrective action, this activity has been placed in the ICP Core contractor's assessment scheduling system. The system issues automated

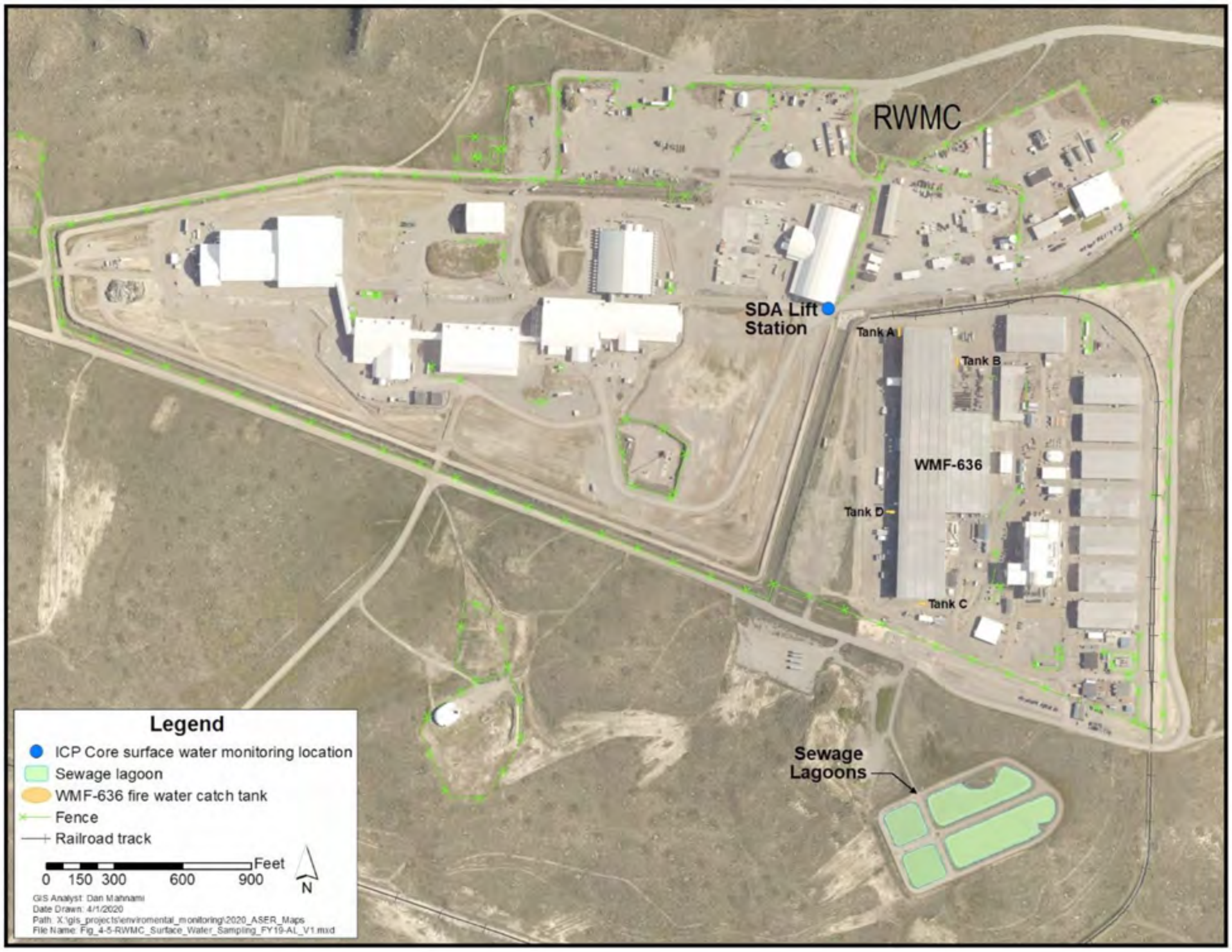

Figure 5-5. Surface Water Sampling Location at the RWMC SDA.

reminders, at predetermined intervals, to appropriate personnel who will evaluate the availability of water for sampling.

Fourteen samples were collected from the WMF-636 Fire Water Catch Tanks in 2019. These samples were analyzed for a suite of radionuclides that includes americium-241 and strontium-90. There were positive detections (3σ) of gross beta in four samples and of radium-226 in three samples taken in 2019. The maximum concentration detected for gross beta was 12.1 (±1.61) pCi/L, which is well below the 11,000-pCi/L Derived Concentration Standard for strontium-90, which was conservatively used to compare results for gross beta. The maximum concentration detected for radium-226 was 1.19 (±0.38) pCi/L, which is also well below the applicable Derived Concentration Standard (87 pCi/L).

Table 5-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The ICP Core contractor will sample from the SDA Lift Station twice during 2020, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation. The ICP Core contractor also will continue to collect samples as necessary for the discharge of accumulated water run-in contained in the WMF-636 Fire Water Catch Tanks.

Table 5-3. Radionuclides Detected in Surface Water Runoff at the RWMC SDA (2019).

Location	Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
WMF-636[c] Fire Water Catch Tanks	Gross Beta	12.1 ± 1.61	0.11
WMF-636[c] Fire Water Catch Tanks	Radium-226	1.19 ± 0.38	1.37

a. Result ±1s. Results shown are >3s.
b. See DOE-STD-1196-2011, Table A-2 (DOE 2011).
c. WMF-636 Fire Water Catch Tank samples are analyzed for Ag-108m, Ag-110m, Am-241, Ce-144, Co-58, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, Mn-54, Nb-95, Ra-226, Ru-103, Ru-106, Sb-125, Sr-90, U-235, Zn-65, and Zr-95, as well as for gross alpha and gross beta.

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6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER MONITORING

Wild Blue Flax (*Linum lewisii*)

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, 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 2019, USGS sampled 30 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds. 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. Trichloroethene 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, WAG 7, and WAG 9 in 2019.

Eleven drinking water systems were monitored on the INL Site through August 2019 by the INL and ICP contactors. In August 2019, the TAN/TSF water system was removed from service resulting in ten drinking water systems being monitored by the INL and ICP contractors. All contaminant concentrations measured in drinking water systems in 2019 were below regulatory limits. Because of the potential impacts to workers at Central Facilities Area 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 Central Facilities Area during 2019 was 0.131 mrem (1.31 µSv). This value is below the EPA standard of 4 mrem/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.

6. 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 6-1); and an ephemeral stream (the Big Lost River), which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure that:

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities

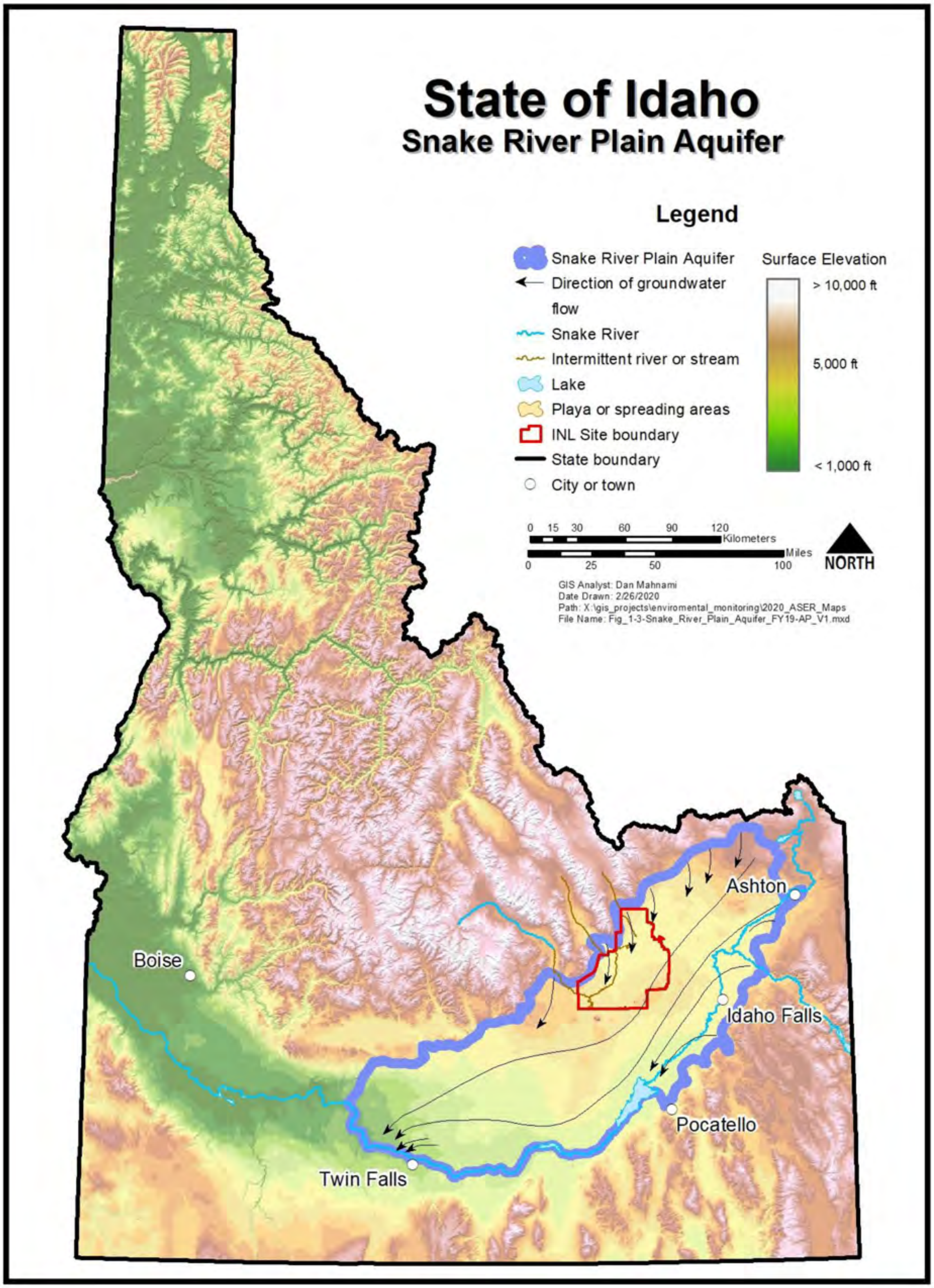


Figure 6-1. The Eastern Snake River Plain Aquifer and Direction of Groundwater Flow.

- 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 (Ground Water Quality Rule, 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).

6.1 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 6-2) and at locations throughout the eastern Snake River Plain.

  Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2019, USGS personnel collected and analyzed more than 1,200 samples for radionuclides and inorganic constituents, including trace elements, and 40 samples for purgeable organic compounds. USGS INL Project Office personnel also published three documents covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Chapter 10.
- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site (Figure 6-3) for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and Radioactive Waste Management Complex (RWMC). In 2019, the ICP Core contractor monitored groundwater at Test Area North (TAN), Advanced Test Reactor (ATR) Complex, INTEC, Central Facilities Area (CFA) and RWMC (WAGs 1, 2, 3, 4, and 7 respectively). Table 6-2 summarizes the routine monitoring for the ICP Core contractor drinking water program. The ICP Core contractor collected and analyzed 133 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, disinfection byproducts, and volatile organic compounds (VOCs) in 2019.
- 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). In 2019 the TAN/TSF water system was eliminated in August, except for the TAN Fire Station which was connected to the TAN/CTF water system. The elimination of the TAN/TSF water system included both wells, tank, and buildings. The only sampling conducted in 2019 for TAN/TSF was bacteriological until August, nitrate in May, and gross alpha/beta and tritium in March. Table 6-3 summarizes the routine groundwater and drinking water program. In 2019, the INL contractor sampled and analyzed 211 groundwater and 370 drinking water samples, which included 65 non-routine and 25 performance samples for varying constituents including radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples from around the INL Site, as well as samples from natural surface waters on and off the

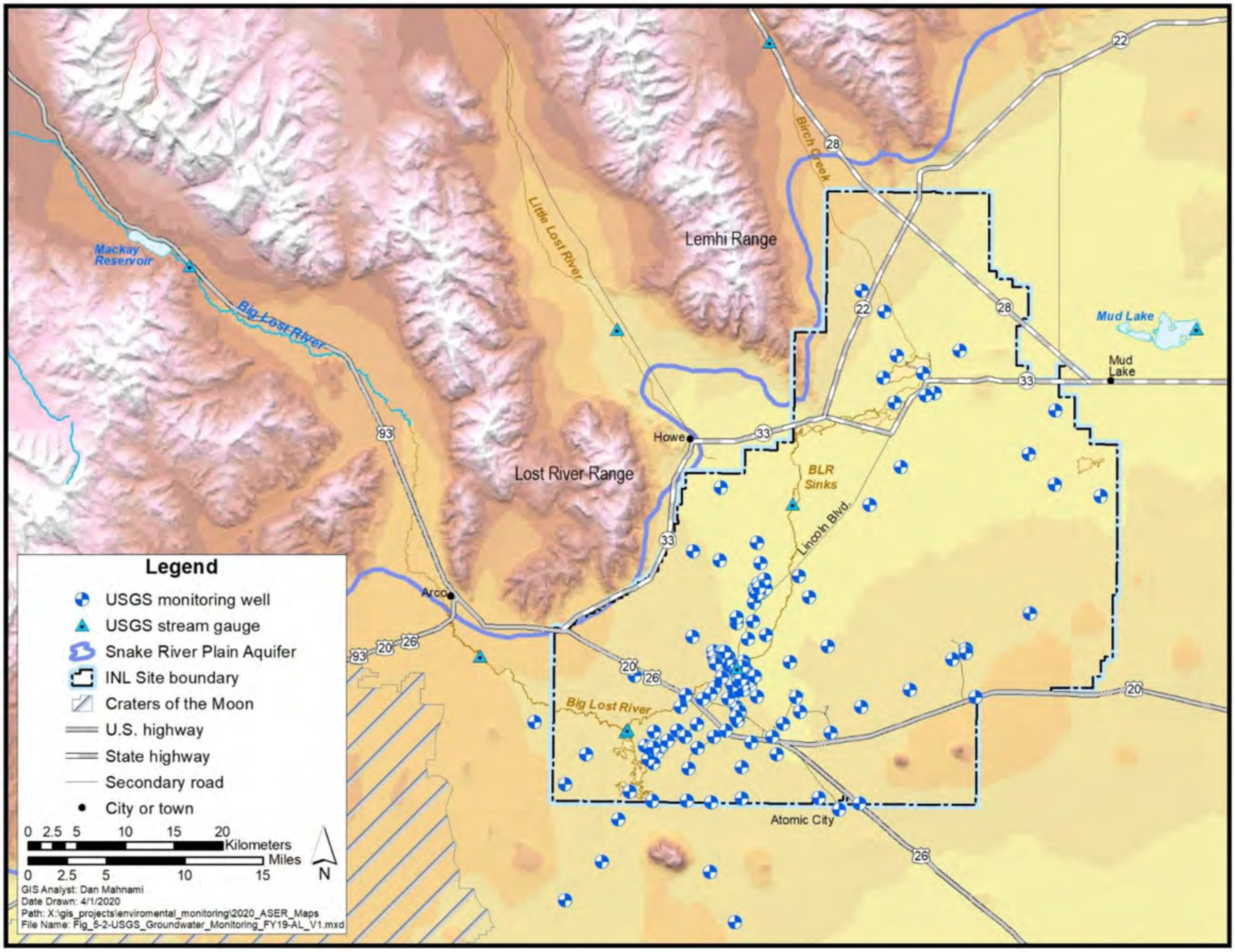


Figure 6-2. USGS Groundwater Monitoring Locations on and off the INL Site.

INL Site. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2019, the ESER contractor sampled and analyzed 26 surface and drinking water samples. An additional 24 samples were collected by ESER on the Big Lost River.

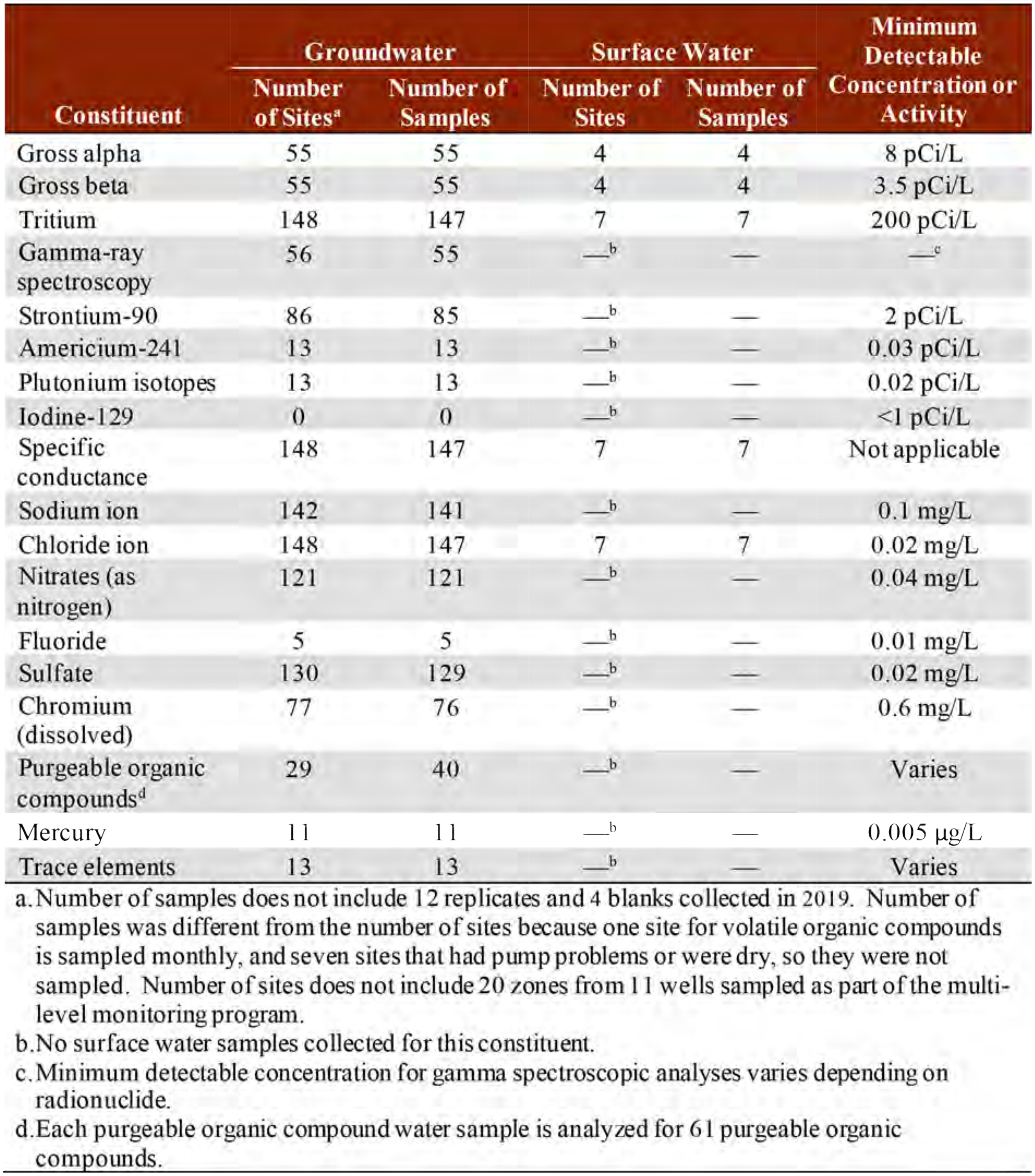
Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2019).

6.2 Hydrogeologic Data Management

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

- The Environmental Data Warehouse is the official long-term management and storage location for ICP Core and INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS. It stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.

Table 6-1. USGS Monitoring Program Summary (2019).



Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or Activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	55	55	4	4	8 pCi/L
Gross beta	55	55	4	4	3.5 pCi/L
Tritium	148	147	7	7	200 pCi/L
Gamma-ray spectroscopy	56	55	—[b]	—	—[c]
Strontium-90	86	85	—[b]	—	2 pCi/L
Americium-241	13	13	—[b]	—	0.03 pCi/L
Plutonium isotopes	13	13	—[b]	—	0.02 pCi/L
Iodine-129	0	0	—[b]	—	<1 pCi/L
Specific conductance	148	147	7	7	Not applicable
Sodium ion	142	141	—[b]	—	0.1 mg/L
Chloride ion	148	147	7	7	0.02 mg/L
Nitrates (as nitrogen)	121	121	—[b]	—	0.04 mg/L
Fluoride	5	5	—[b]	—	0.01 mg/L
Sulfate	130	129	—[b]	—	0.02 mg/L
Chromium (dissolved)	77	76	—[b]	—	0.6 mg/L
Purgeable organic compounds[d]	29	40	—[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 4 blanks collected in 2019. 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, so they 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.

- 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.

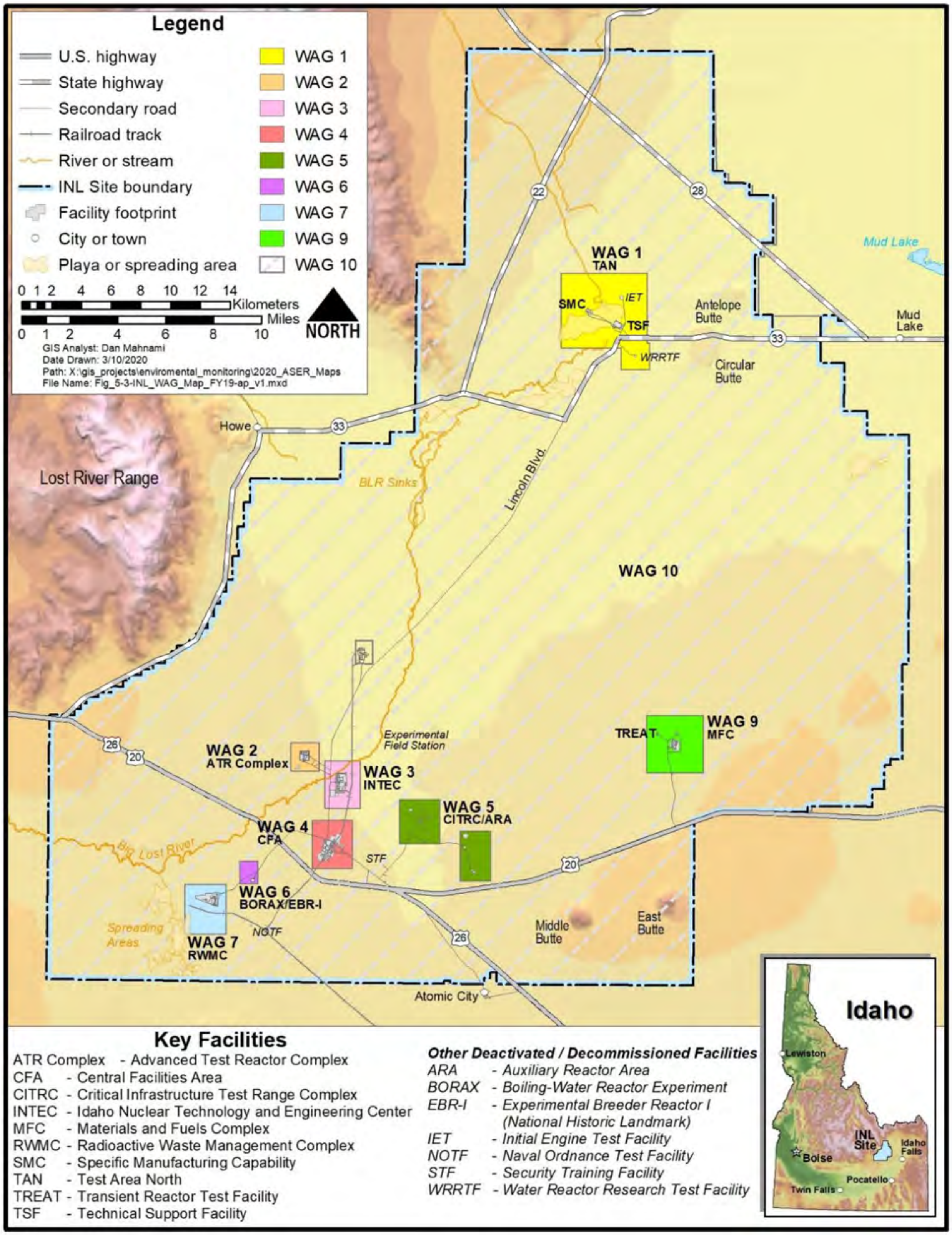
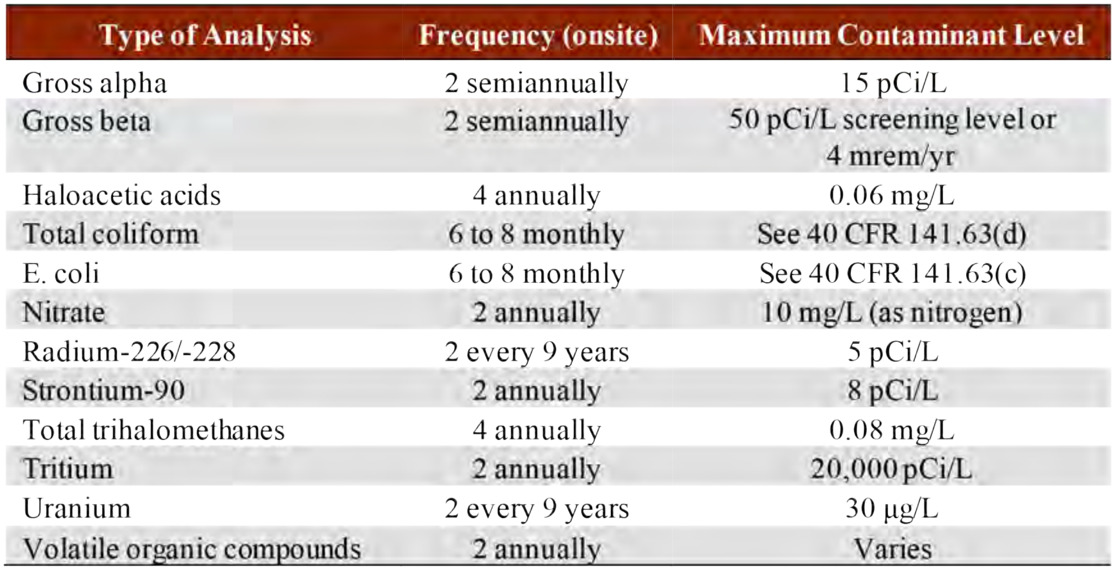


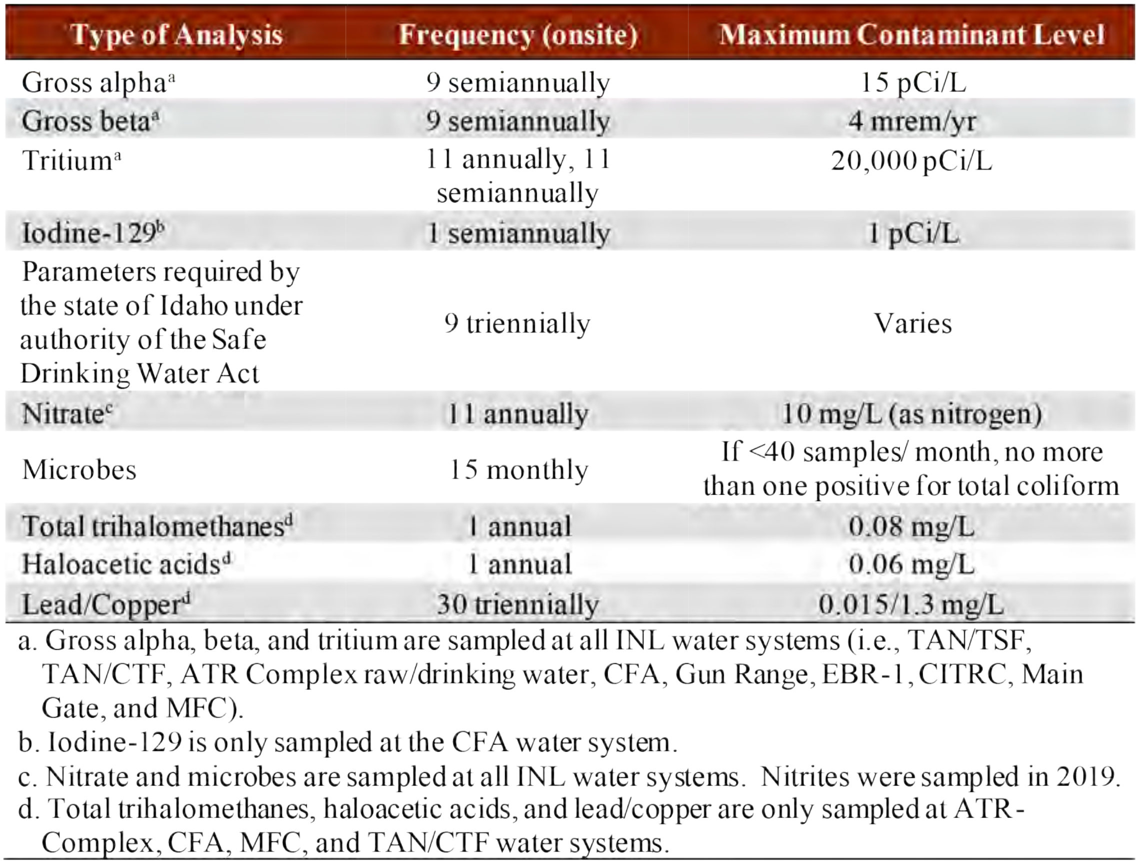
Figure 6-3. Map of the INL Site Showing Locations of Facilities and Corresponding WAGs.

Table 6-2. ICP Core Contractor Drinking Water Program Summary (2019).



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	2 annually	8 pCi/L
Total trihalomethanes	4 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium	2 every 9 years	30 µg/L
Volatile organic compounds	2 annually	Varies

Table 6-3. INL Contractor Drinking Water Program Summary (2019).



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	15 monthly	If <40 samples/ month, no more than one positive for total coliform
Total trihalomethanes[d]	1 annual	0.08 mg/L
Haloacetic acids[d]	1 annual	0.06 mg/L
Lead/Copper[d]	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. Nitrites were sampled in 2019.

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

Table 6-4. Environmental Surveillance, Education, and Research Program Surface and Drinking Water Summary (2019).

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

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

Historical 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 (2018), are shown in Figure 6-4 (Bartholomay et al. 2020). The area of contamination within the 500-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000). The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 20 years (Figure 6-5). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The tritium concentration in USGS-065 near ATR Complex decreased from 1,930 ± 80 pCi/L in 2018 to 1,610 ± 90 pCi/L in 2019; the tritium concentration in USGS-114, south of INTEC, decreased from 5,100 ± 190 in 2018 to 5,041 ± 200 pCi/L in 2019.

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

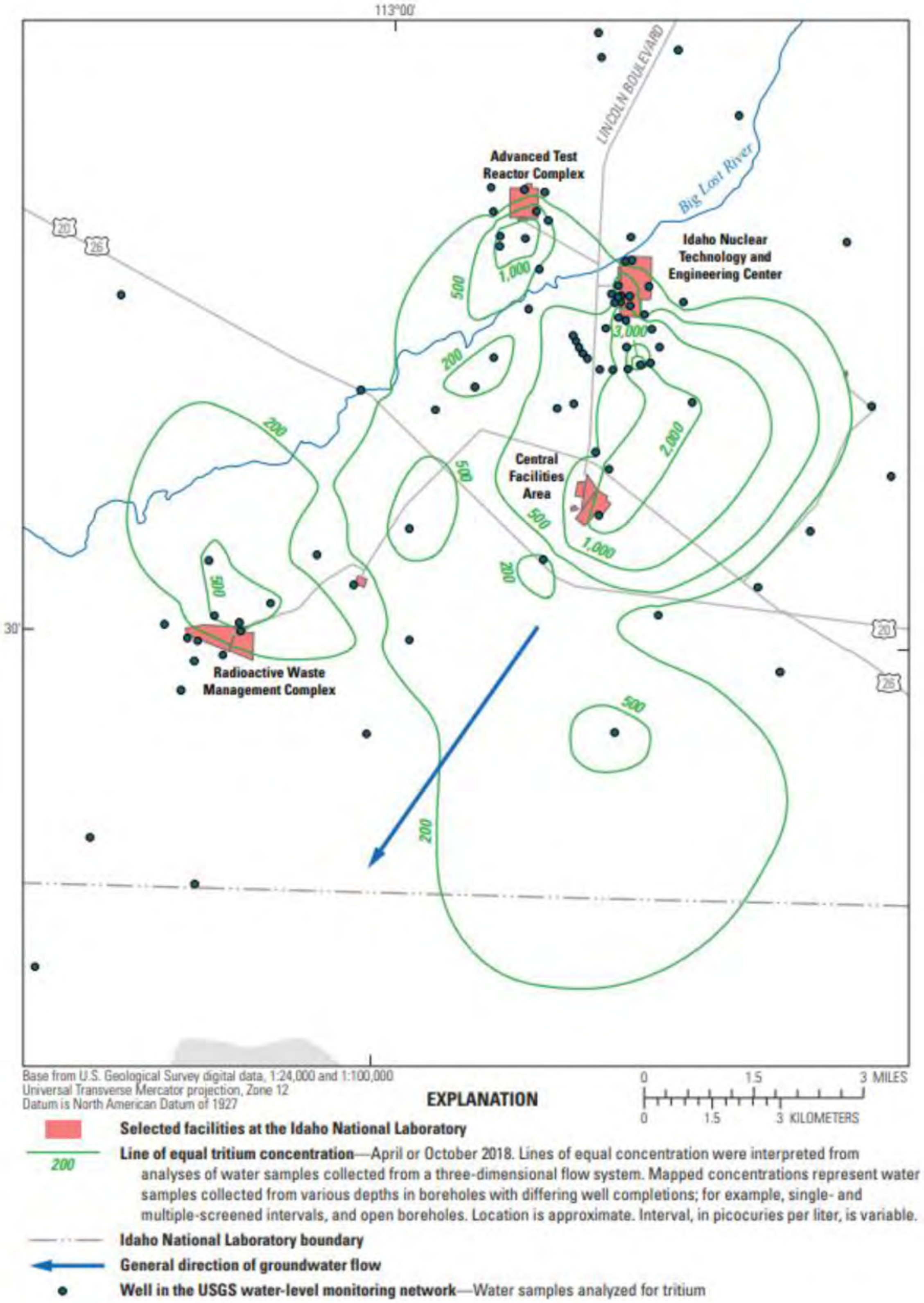


Figure 6-4. Distribution of Tritium (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

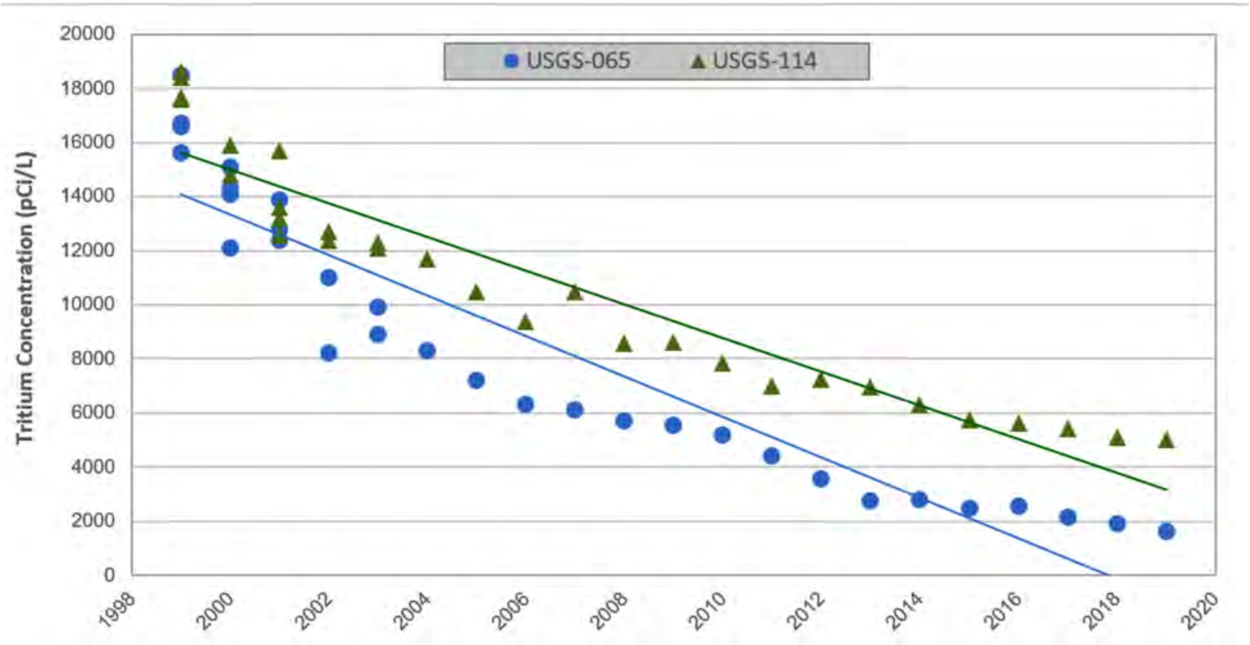


Figure 6-5. Long-term Trend of Tritium in Wells USGS-065 and -114 (1999–2019).

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 6-6 (Bartholomay et al. 2020). The contamination originates at INTEC from historical injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain aquifer near ATR Complex during 2019. All ^{90}Sr at ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (1999–2019) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes (Table 6-1). Results for wells sampled in 2019 are available at https://waterdata.usgs.gov/id/nwis/. Monitoring results for 2016–2018 are summarized in Bartholomay et al. (2019). During 2016–2018, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in one well, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all samples analyzed were less than the reporting level. In 2016–2018, reportable concentrations of gross alpha radioactivity were observed in six of the 55 wells and ranged from 6 ± 2 to 141 ± 29 pCi/L. Beta radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.4 ± 0.8 to 1,390 ± 80 pCi/L (Bartholomay et al. 2019).

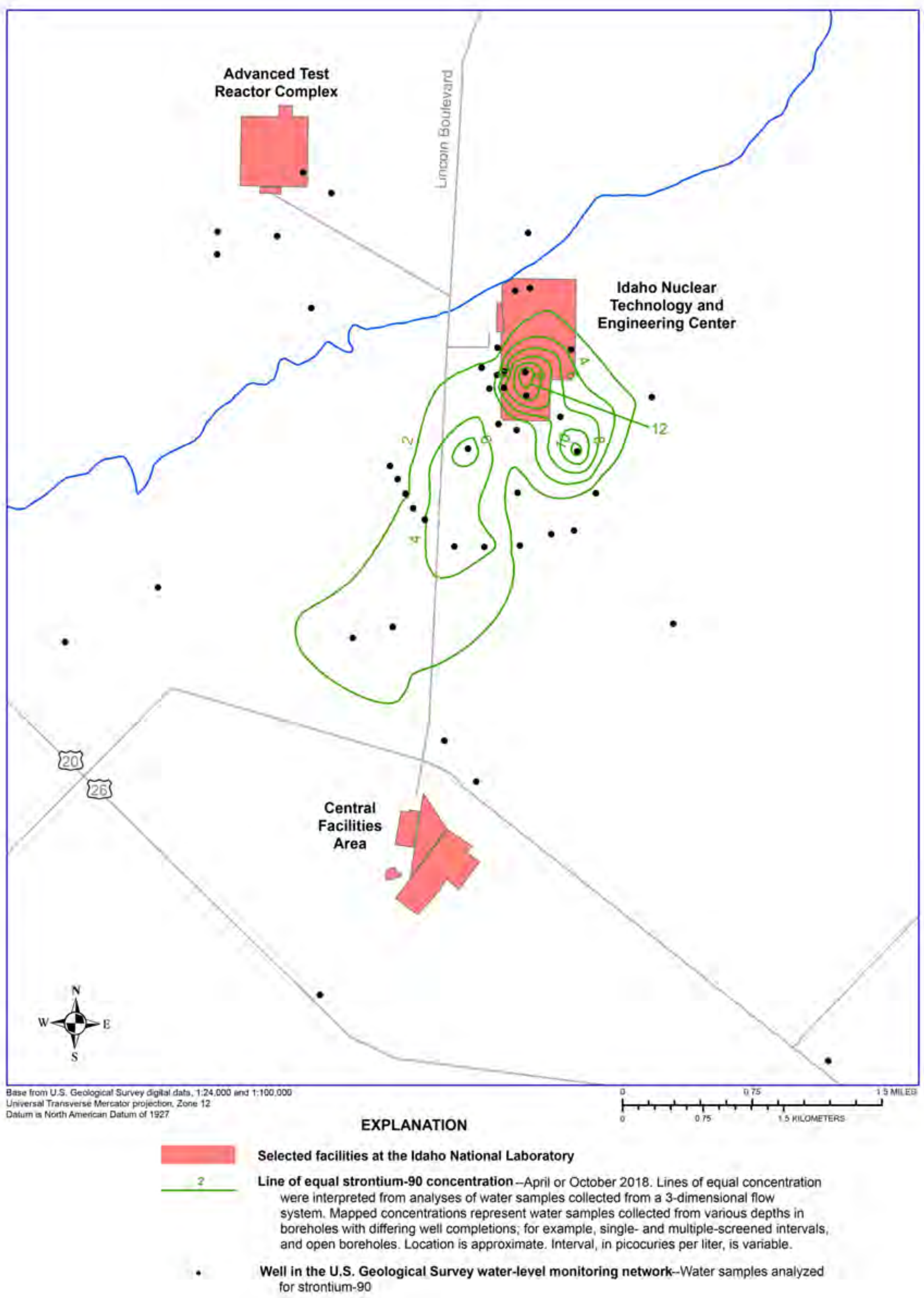


Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

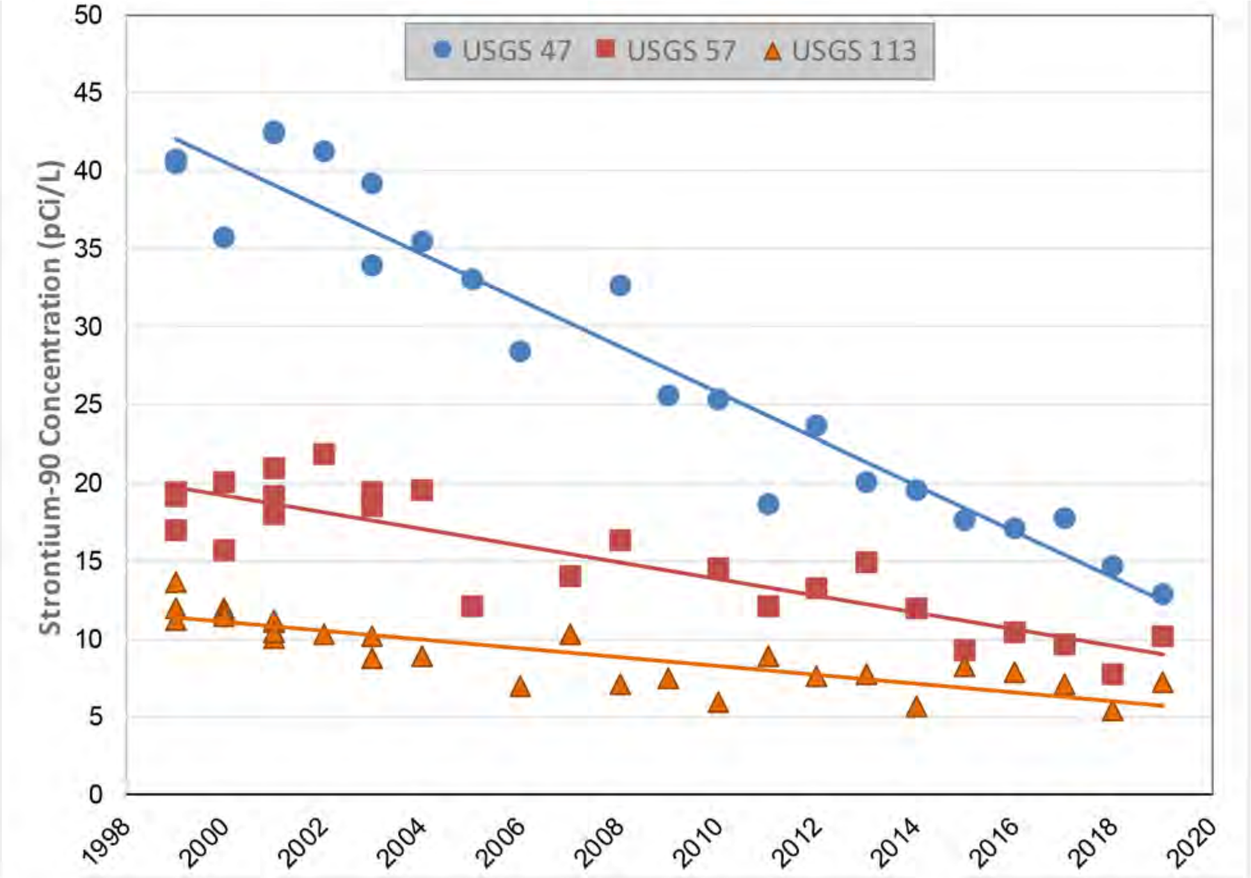


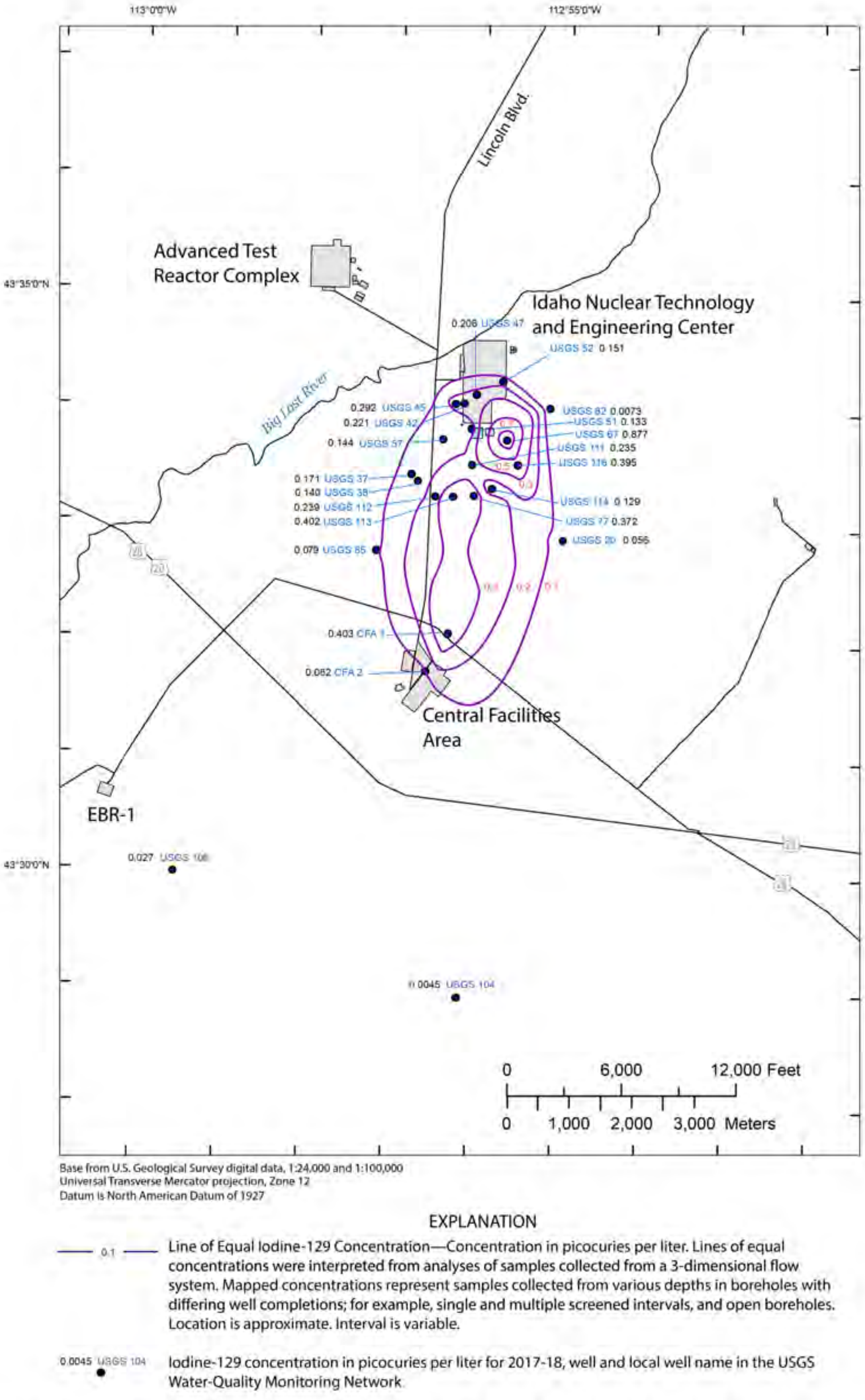
Figure 6-7. Long-term Trend of ^{90}Sr in Wells USGS-047, -057, and -113 (1999–2019).

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 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 2017–2018 USGS data (most current published date), are shown in Figure 6-8 (Maimer and Bartholomay, 2019).

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

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and selected other trace elements and purgeable organic compounds (Table 6-1). Bartholomay et al. (2020) provides a detailed discussion of results for samples collected during 2016–2018. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration has been below the MCL since then and was 76.3 µg/L in 2019; 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 2018 (Bartholomay et al. 2020).



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

EXPLANATION

Line of Equal Iodine-129 Concentration—Concentration in picocuries per liter. Lines of equal concentrations were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single and multiple screened intervals, and open boreholes. Location is approximate. Interval is variable.

Iodine-129 concentration in picocuries per liter for 2017-18, well and local well name in the USGS Water-Quality Monitoring Network

Figure 6-8. Distribution of ^{129}I in the Eastern Snake River Plain Aquifer on the INL Site in 2017–2018 (from Maimer and Bartholomay 2019).

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 2019. Samples from 30 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; and Bartholomay et al. 2014). Eleven purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-5).

Historically, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay et al. 2020). 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 2019, and concentrations exceeded the MCL of 5 µg/L during 10 of the 12 months (Table 6-6).

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 6.6.4.) Trend test results for tetrachloromethane concentrations in water from the RWMC production well indicated a statistically significant increase in concentrations has occurred from 1989 through 2015; however, Bartholomay et al. (2020) indicated that more recent data through 2018 showed no trend for the entire dataset and a decreasing trend for data collected since 2005. 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 6-5). There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2019

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown in Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at https://fluor-idaho.com/arir/. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.5.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 (TAN) to evaluate 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 6-9) and is not reflective of current concentrations. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. 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 2019, data collected during the ISB rebound test for the area near the former injection Well TSF-05 indicated that anaerobic conditions created by ISB were still present in the hot spot area, and that TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05. After background aquifer condi-

Table 6-5. Purgeable Organic Compounds in Annual USGS Groundwater Well Samples (2019).

Constituent[a]	GIN 2	RWMC-M7S	TAN-2271	USGS-26	USGS-87	USGS-88	USGS-120	USGS-132
1,1-Dichloroethane (MCL = 7 µg/L) [a]	<0.1	<0.1	0.297	<0.1	0.1	<0.1	<0.1	<0.1
1,1,1-Trichloroethane (MCL = 200 µg/L) [a]	<0.1	0.268	<0.1	<0.1	<0.1	<0.1	0.163	<0.1
cis-1,2-Dichoroethene [b] (MCL = 70 µg/L) [a]	<0.1	<0.1	1.51	<0.1	<0.1	<0.1	<0.1	<0.1
Ethylbenzene (MCL = 700 µg/L) [a]	<0.1	<0.1	<0.1	0.184	<0.1	<0.1	<0.1	<0.1
Tetrachloroethene [b] (MCL = 5 µg/L) [a]	2.86	0.355	<0.1	<0.1	0.192	<0.1	0.135	<0.1
Tetrachloromethane (PCS = 2 µg/L) [c]	<0.2	4.03	<0.2	<0.2	3.58	1.52	3.14	0.366
Trichloroethene [b] (MCL = 5 µg/L) [a]	9.31	2.35	2.74	<0.1	1.32	0.719	1.38	<0.1
Trichloromethane (MCL = 5 µg/L) [a]	<0.1	0.790	<0.1	<0.1	0.357	0.422	0.720	<0.1
Toluene (MCL = 1,000 µg/L) [a]	<0.2	<0.2	<0.2	0.521	<0.2	<0.2	<0.2	<0.2
trans-1,2-Dichloroethene [b] (MCL = 100 µg/L) [a]	<0.1	<0.1	87.6	<0.1	<0.1	<0.1	<0.1	<0.1
Vinyl chloride (MCL = 2 µg/L) [a]	<0.2	<0.2	1.33	<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 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

Table 6-6. Purgeable Organic Compounds in Monthly Production Well Samples at the RWMC (2019).

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1,1,1-Trichloroethane (MCL = 200 µg/L) [a]	0.269	0.296	0.337	0.270	0.262	0.269	0.289	0.267	0.263	0.280	0.319	0.328
Tetrachloroethene [b] (MCL = 5 µg/L) [a]	0.356	0.385	0.453	0.393	0.363	0.392	0.378	0.350	0.370	0.371	0.377	0.422
Tetrachloromethane (MCL = 5 µg/L) [a]	5.24	5.65	6.56	4.77	5.17	5.28	5.84	4.56	5.07	5.68	5.79	6.03
Trichloroethene [b] (MCL = 5 µg/L) [a]	3.66	3.74	4.25	3.51	3.57	3.59	3.36	3.59	3.62	3.53	3.75	4.00
Trichloromethane (PCS = 2 µg/L) [c]	1.73	1.82	2.12	1.63	1.57	1.56	1.66	1.46	1.58	1.68	1.78	1.87

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

b. The International Union of Pure and Applied Chemistry 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

tions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2020a).

Data from Wells TAN-28 and TAN-1860A 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-1860A, ISB injections were made into Wells TAN-37A and TAN-1860A. Three ISB injections were made during 2019 into Well TAN-37A, and two injections were made into Well TAN-1860A.

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 extracts contaminated groundwater, circulates the groundwater through air strippers to remove VOCs like TCE, and reinjects treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday–Thursday, except for shutdowns due to maintenance. All 2019 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 6-9), and do not reflect current concentrations. In 2019, only one well, Well TAN-28, was above 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 2019, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 19.1 to 39.8 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 defined by 1997 TCE concentrations (Figure 6-9). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Institutional controls are in place to protect current and future users from health risks associated with groundwater contamination until concentrations decline through natural attenuation to below the MCL.

TCE data collected in 2019 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 uranium-234 (^{234}U) are listed as contaminants of concern in the Record of Deci-

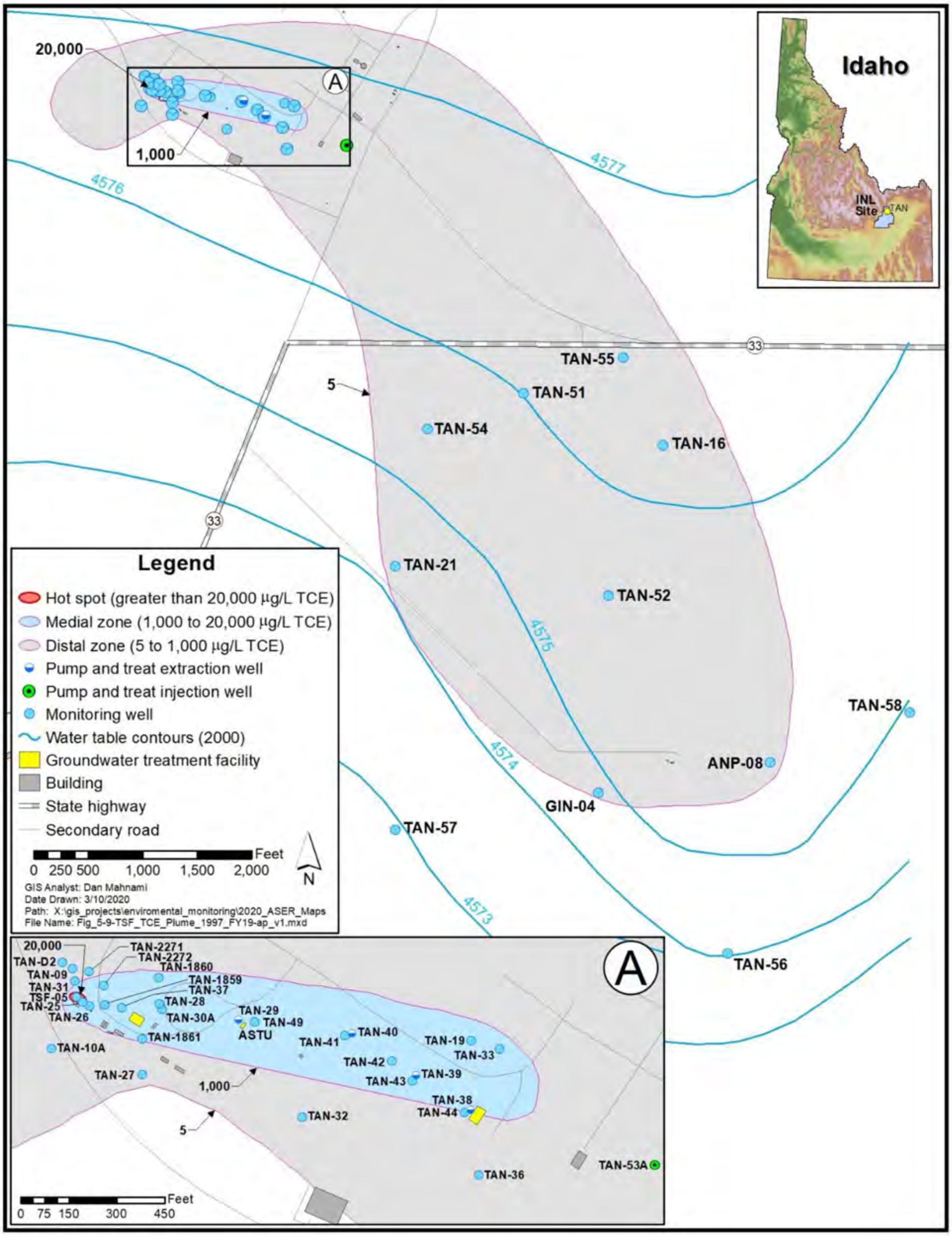


Figure 6-9. Trichloroethylene (trichloroethene) Plume at TAN in 1997.

sion Amendment (DOE-ID 2001). Strontium-90 and ^{137}Cs are expected to naturally 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. As competing cation concentrations decline toward background conditions, ^{90}Sr and ^{137}Cs are mostly trending lower. The radionuclide trends are expected to continue to decrease and trends will continue to be evaluated to determine if the remedial action objective of declining below MCLs by 2095 will be met. All 2019 results for tritium are below the MCL of 20,000 pCi/L with the highest tritium result of 1,890 pCi/L at Well TAN-28. Sampling will be conducted for ^{234}U after ISB conditions dissipate, because ISB conditions suppress uranium concentrations.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for monitoring WAG 2, ATR Complex, during 2019 (Figure 6-10). Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (target analyte is cobalt-60), tritium, and chromium (filtered). The data for the October 2019 sampling event will be included in the Fiscal Year 2020 Annual Report for WAG 2. The October 2019 sampling data are summarized in Table 6-7.

No analyte occurred above its MCL in the Snake River Plain aquifer. The highest chromium concentration occurred in Well TRA-07 at 77.7 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well USGS-065 was also elevated at 71.6 µg/L. Compared to the previous year, the chromium concentration increased in TRA-07 and decreased in USGS-065. However, 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 3,150 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.

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 2019 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 0.012 m (0.04 ft) on average from October 2018 to October 2019.

Table 6-7. WAG 2 Aquifer Groundwater Quality Summary for 2019.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	4	77.7	1.37	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	3,150	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

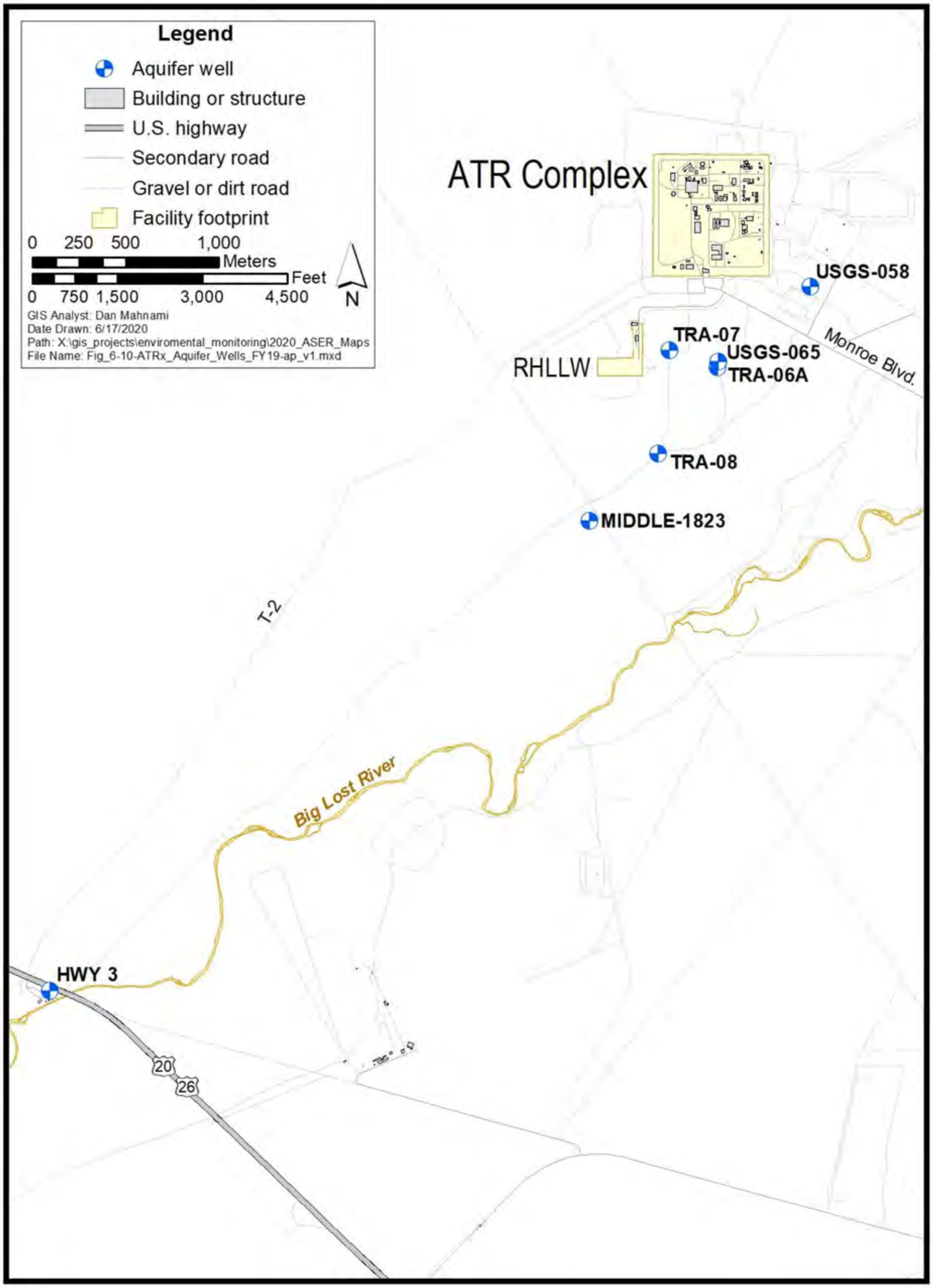


Figure 6-10. Locations of WAG 2 Aquifer Monitoring Wells.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 17 eastern Snake River Plain aquifer monitoring wells during 2019 (Figure 6-11). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2019 Annual Report (DOE-ID 2020b). Table 6-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, Technetium-99 (^{99}Tc), Iodine-129 (^{129}I), 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 five of the well locations sampled. During 2019, the highest ^{90}Sr level in eastern Snake River Plain aquifer groundwater was at monitoring Well USGS-047 (15.0 ± 1.43 pCi/L), located south (down-gradient) 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.

Technetium-99 was detected above the MCL (900 pCi/L) at two monitoring wells. During 2019, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at Well ICPP-2021-AQ (1,150 ± 65.8 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 (13.4 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 (1 pCi/L) at all Snake River Plain aquifer monitoring locations, with the exception of Well USGS-067, which is located east of INTEC's former percolation ponds. Iodine-129 was detected at four locations, with the highest detection at Well USGS-067 (1.07 ± 0.523 pCi/L), which received service wastewater until 2002. Well USGS-067 ^{129}I detections have remained below the MCL (1 pCi/L) with the exception of 2007 and 2019 monitoring results.

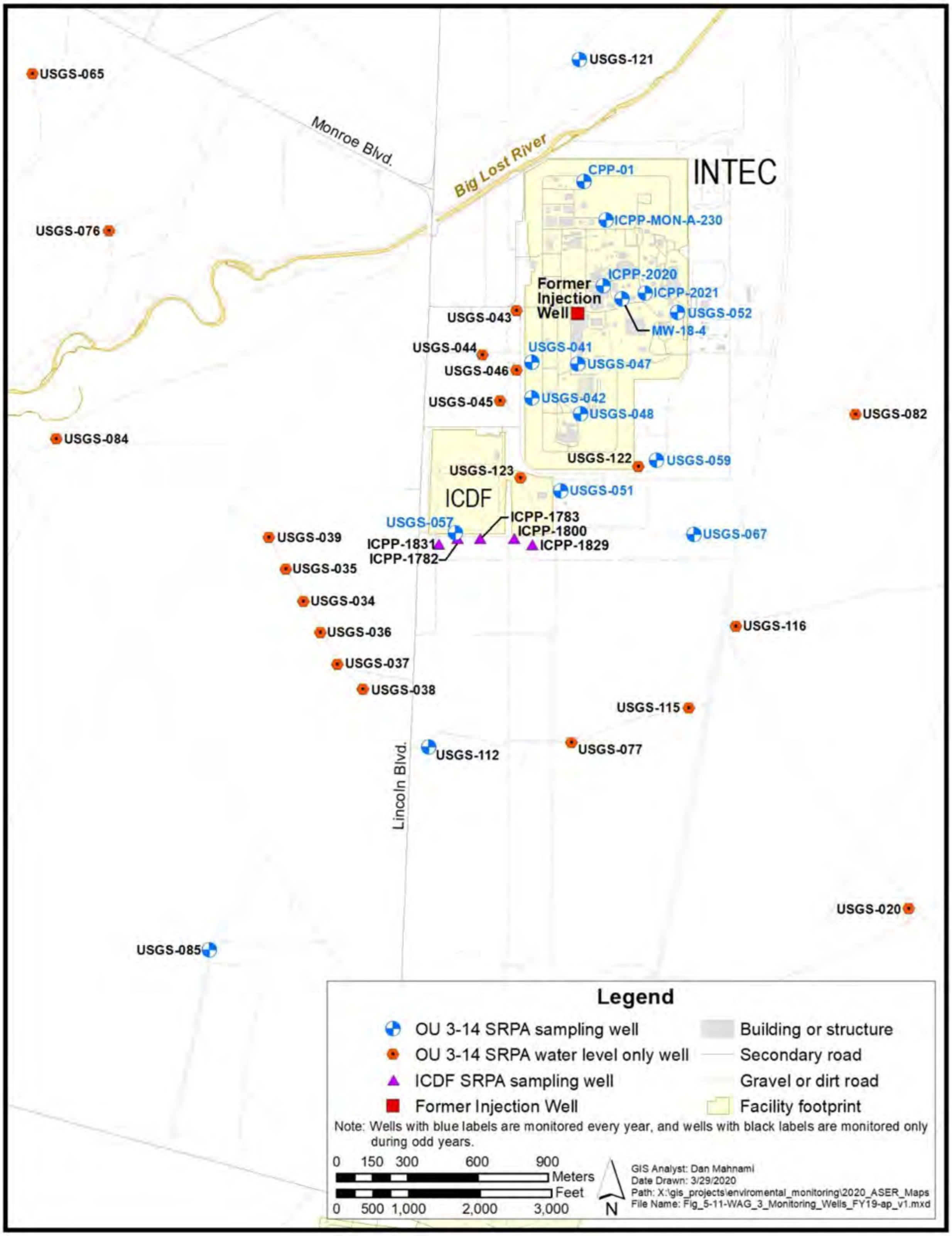
Tritium was detected in all the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well MW-18-4, southeast of the Tank Farm (2,460 ± 331 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotope analyses were performed because the current monitoring plan identifies the contingency for plutonium analysis if gross alpha exceeds 15 pCi/L. Uranium-238 (^{238}U) was detected at all eastern Snake River Plain aquifer well locations, with the highest concentration at Well ICPP-2021-AQ (1.54 ± 0.294 pCi/L). Similarly, ^{234}U also was detected in all groundwater samples, with the greatest concentrations of 2.11 ± 0.359 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. All 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 one groundwater sample, but a duplicate sample was collected at the monitoring well and was assessed to be a non-detection for ^{235}U. 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).

6.5.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

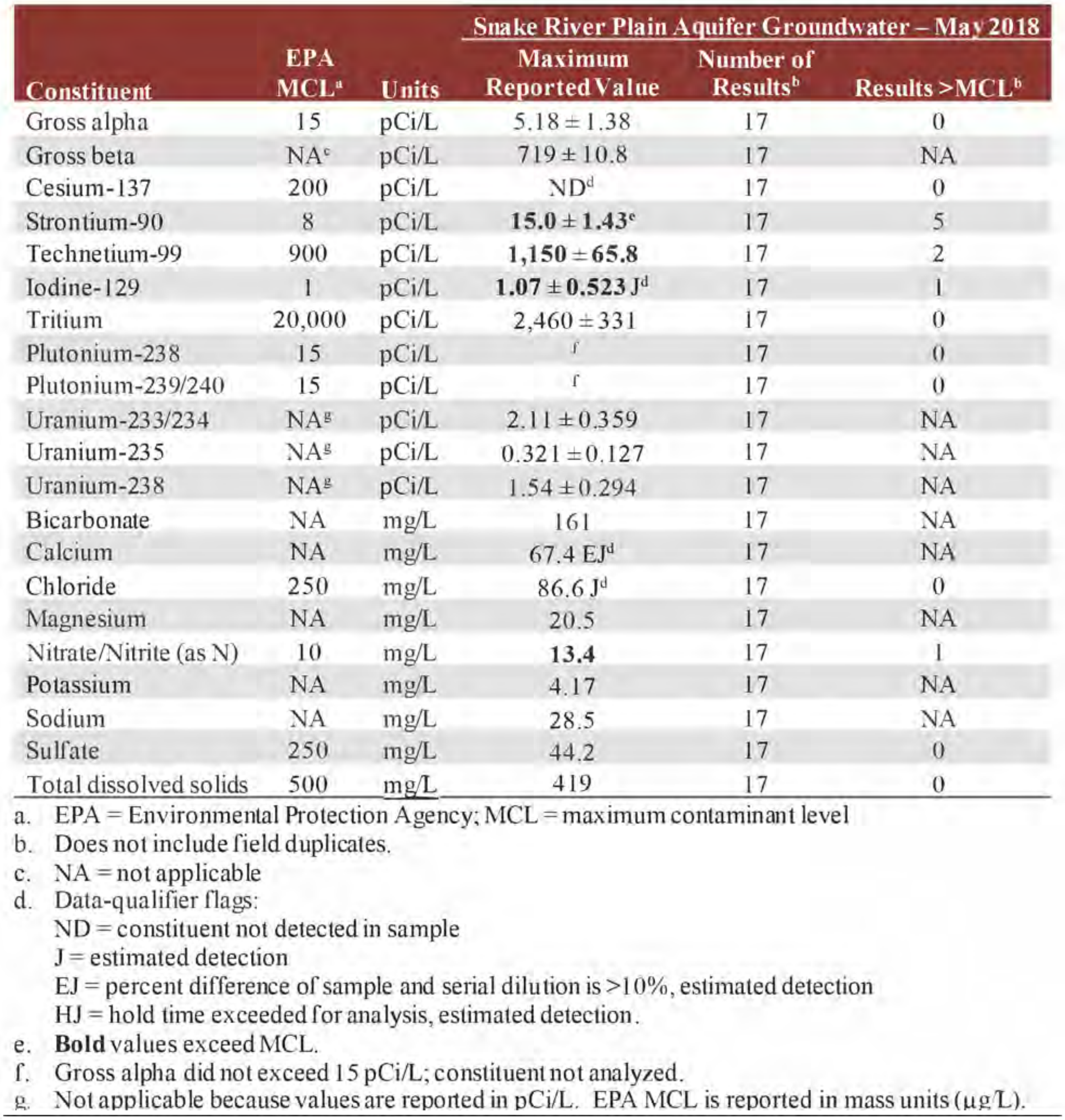
The WAG 4 groundwater monitoring consists of two different components: 1) CFA landfill monitoring and 2) monitoring of a nitrate plume south of CFA. The wells at the CFA landfills are monitored to determine potential impacts from the landfills, while the nitrate plume south of CFA is monitored to evaluate nitrate trends. 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 the CFA ni-



Note: Wells with blue labels are monitored every year, and wells with black labels are monitored only during odd years.

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

Table 6-8. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (Fiscal Year 2019).



			Snake River Plain Aquifer Groundwater – May 2018		
Constituent	EPA MCL[a]	Units	Maximum Reported Value	Number of Results[b]	Results >MCL[b]
Gross alpha	15	pCi/L	5.18 ± 1.38	17	0
Gross beta	NA[c]	pCi/L	719 ± 10.8	17	NA
Cesium-137	200	pCi/L	ND[d]	17	0
Strontium-90	8	pCi/L	**15.0 ± 1.43**[e]	17	5
Technetium-99	900	pCi/L	**1,150 ± 65.8**	17	2
Iodine-129	1	pCi/L	**1.07 ± 0.523 J**[d]	17	1
Tritium	20,000	pCi/L	2,460 ± 331	17	0
Plutonium-238	15	pCi/L	[f]	17	0
Plutonium-239/240	15	pCi/L	[f]	17	0
Uranium-233/234	NA[g]	pCi/L	2.11 ± 0.359	17	NA
Uranium-235	NA[g]	pCi/L	0.321 ± 0.127	17	NA
Uranium-238	NA[g]	pCi/L	1.54 ± 0.294	17	NA
Bicarbonate	NA	mg/L	161	17	NA
Calcium	NA	mg/L	67.4 EJ[d]	17	NA
Chloride	250	mg/L	86.6 J[d]	17	0
Magnesium	NA	mg/L	20.5	17	NA
Nitrate/Nitrite (as N)	10	mg/L	**13.4**	17	1
Potassium	NA	mg/L	4.17	17	NA
Sodium	NA	mg/L	28.5	17	NA
Sulfate	250	mg/L	44.2	17	0
Total dissolved solids	500	mg/L	419	17	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level
b. Does not include field duplicates.
c. NA = not applicable
d. Data-qualifier flags:
ND = constituent not detected in sample
J = estimated detection
EJ = percent difference of sample and serial dilution is >10%, estimated detection
HJ = hold time exceeded for analysis, estimated detection.
e. **Bold** values exceed MCL.
f. Gross alpha did not exceed 15 pCi/L; constituent not analyzed.
g. Not applicable because values are reported in pCi/L. EPA MCL is reported in mass units (µg/L).

trate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 6-12.

Analytes detected in groundwater are compared to regulatory levels in Table 6-9. In 2019, no laboratory analyte exceeded an EPA MCL for the CFA landfill monitoring. The only laboratory analyte for CFA landfill monitoring to exceed a secondary maximum contaminant level (SMCL) was iron. The elevated iron concentration is probably due to the interaction of the acid preservative in the sample bottle with particles that passed through the groundwater filter. 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 2019* (DOE-ID 2020c).

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed

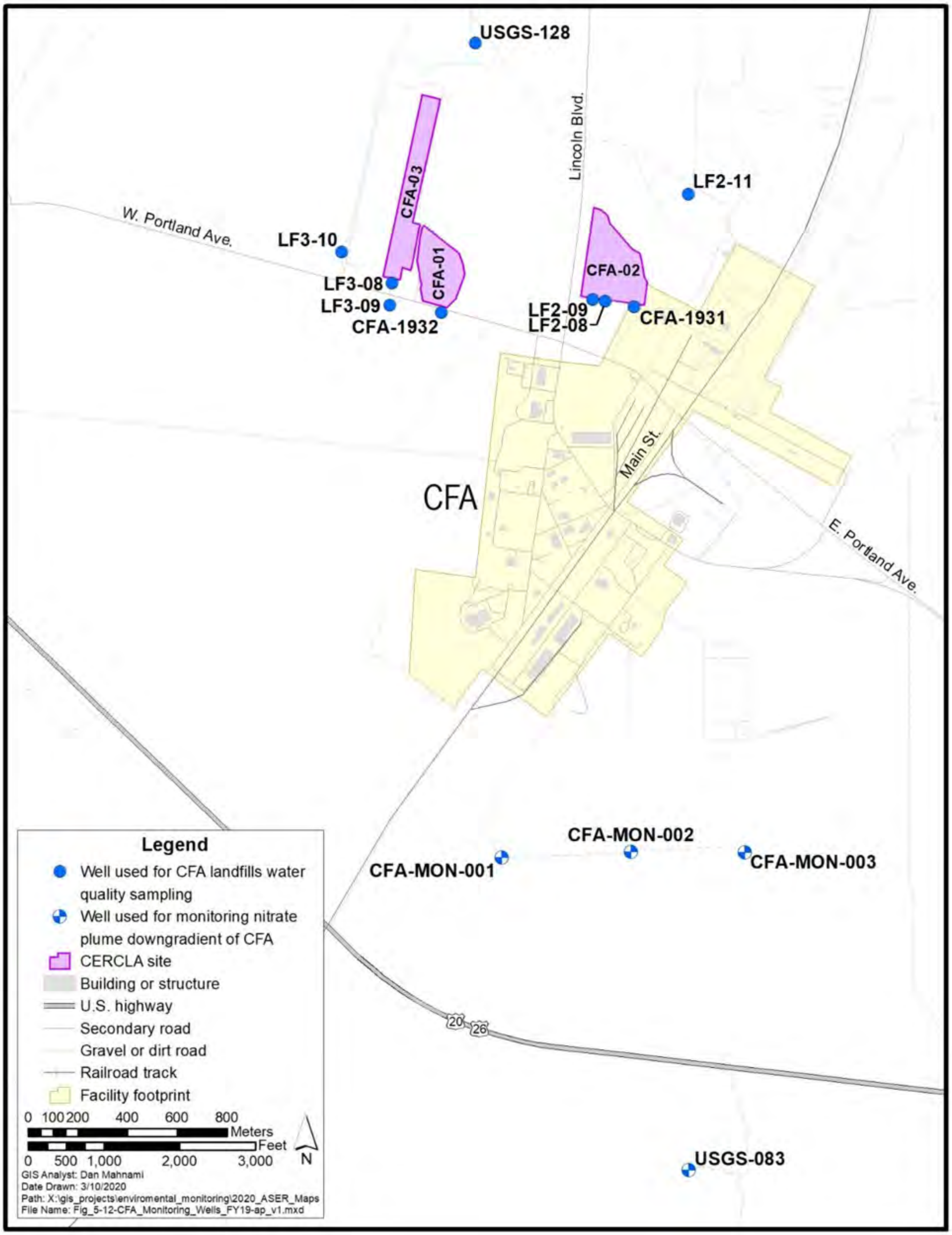


Figure 6-12. Locations of WAG 4/CFA Monitoring Wells.

Table 6-9. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2019).

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]	71.5	0
Sulfate (mg/L)	*250*	33.6	0
Nitrate/nitrite (mg-N/L)	10	**13.7**[d]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	65.8	0
Sulfate (mg/L)	*250*	41.0	0
Nitrate/nitrite (mg-N/L)	10	2.25	0
Common Cations			
Calcium (µg/L)	None	56,000	NA[e]
Magnesium (µg/L)	None	20,300	NA
Potassium (µg/L)	None	5,360	NA
Sodium (µg/L)	None	29,800	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	93.6	0
Arsenic (µg/L)	10	3.32	0
Barium (µg/L)	2,000	102	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	87.8	0
Copper (µg/L)	*1,300/1,000*	3.79	0
Iron (µg/L)	*300*	624	1
Lead (µg/L)	15	ND	0
Manganese (µg/L)	50	23	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	87.6	NA
Selenium (µg/L)	50	2.13	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	6.93	NA
Zinc (µg/L)	*5,000*	251	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	80	0.85	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

the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 decreased in 2019 to 13.7 mg/L-N. The nitrate concentration at Well CFA-MON-A-002 has been in a declining trend since 2006.

The nitrate concentration of 7.78 mg/L-N in Well CFA-MON-A-003 is below the MCL and has dropped below its historical range of 8 to 11 mg/L-N. This well also shows a declining trend.

Water level measurements taken in the CFA area decreased an average of 0.09 ft from August 2018 to August 2019. A water level contour map based on August 2019 water levels showed groundwater gradients and flow directions consistent with previous maps (DOE-ID 2020c).

6.5.5 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from nine monitoring wells near the RWMC in May 2019 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 253 analyses performed, 15 met reportable criteria established in the *Field Sampling Plan for Operable Unit 7-13/14 Aquifer Monitoring* (DOE-ID 2014b). Table 6-10 lists maximum concentrations of reportable contaminants of concern in 2019, and a discussion of those results follows. No analytes were detected above their respective MCLs in samples collected from the aquifer in May 2019. Figure 6-13 depicts the WAG 7 aquifer well monitoring network.

- ***Carbon tetrachloride*** – Carbon tetrachloride was detected above the quantitation limit (1 µg/L) at seven monitoring locations in May 2019 and in a field duplicate sample taken at Well M7S. The carbon tetrachloride concentrations appear to be trending downward in wells near the RWMC, thus approaching the quantitation limit (reporting threshold) (Figure 6-14). In wells downgradient of the RWMC, concentrations increased in both Wells A11A31 and USGS-120 from the November 2017 sampling event (Figure 6-15). Future monitoring will determine if upward trends are developing in these wells.
- ***Carbon -14*** – Carbon-14 was the only reportable radionuclide in May 2019. It was positively detected (reportable) in a sample from Well M1S at 23 ± 3 pCi/L, which is considerably below its MCL of 2,000 pCi/L (Table 6-10).
- ***Trichloroethylene*** – In May 2019, the concentrations of reportable trichloroethylene (> 1 µg/L) increased slightly in most wells near and downgradient of the RWMC (Figures 6-16 and 6-17) from the November 2017 sampling event. However, no concentrations were detected above the MCL of 5 µg/L.
- ***Inorganic analytes*** – Inorganic analytes were not detected above reporting thresholds in groundwater samples collected from the WAG 7 monitoring network in 2019.

Table 6-10. Summary of WAG 7 Aquifer Analyses for May 2019 Sampling.

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[a,b]	Concentration Maximum[a]	Location of Maximum Concentration	Number of Detections Greater than MCL[c]	MCL[c]
Carbon tetrachloride	9	11	8	3.95 µg/L[d]	M16S	0	5 µg/L
Carbon-14	9	11	1	23 ± 3 pCi/L	M1S	0	2,000 pCi/L
Trichloroethylene	9	11	6	2.29 µg/L[d]	M15S	0	5 µg/L

a. Includes field duplicate samples collected for quality control purposes.
b. Results that exceeded reporting criteria as established in the Operable Unit 7-13/14 Field Sampling Plan (Forbes and Holdren 2014).
c. MCL = maximum contaminant level. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141).
d. Result was qualified as "J" by the analytical validator which denotes an estimated value due to a high continuing calibration result.

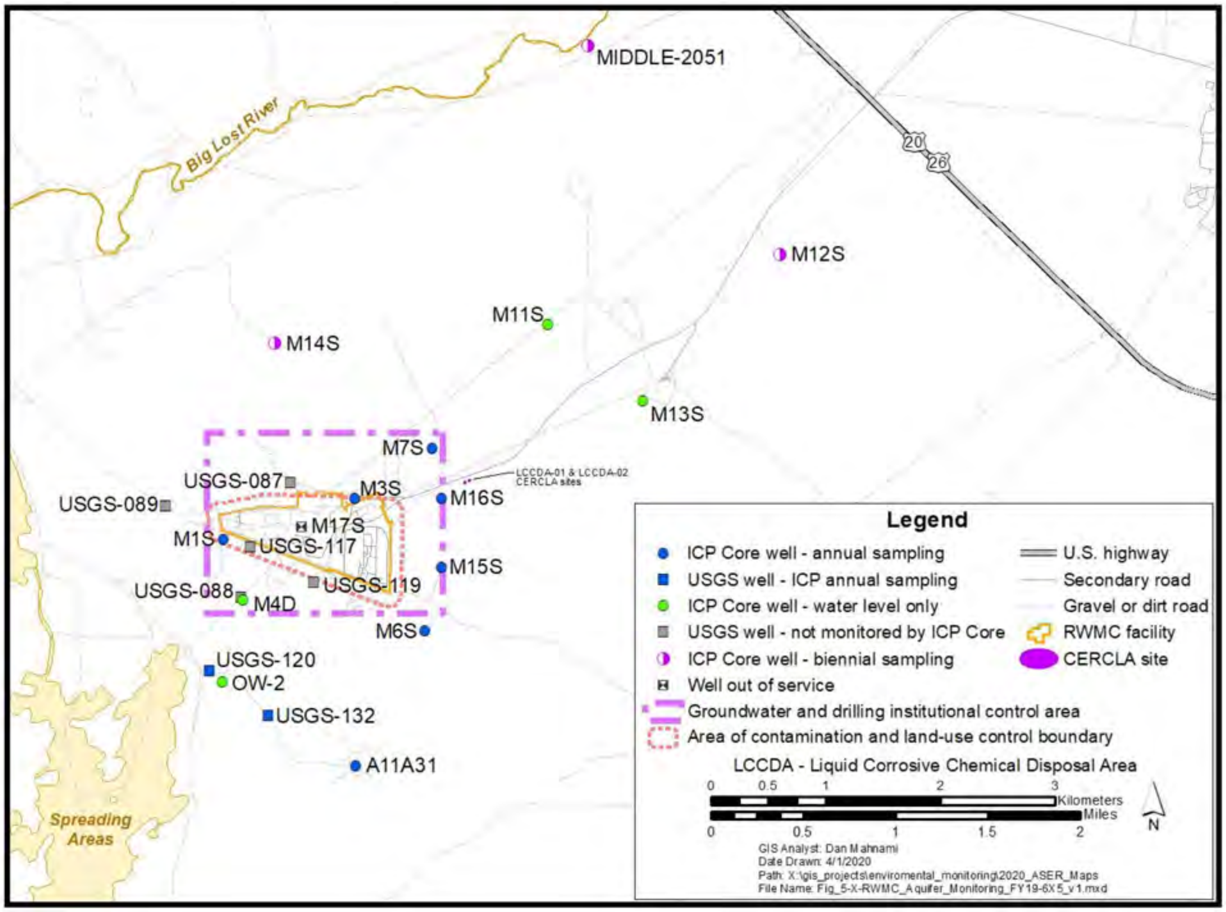


Figure 6-13. The WAG 7 Aquifer Well Monitoring Network at the RWMC.

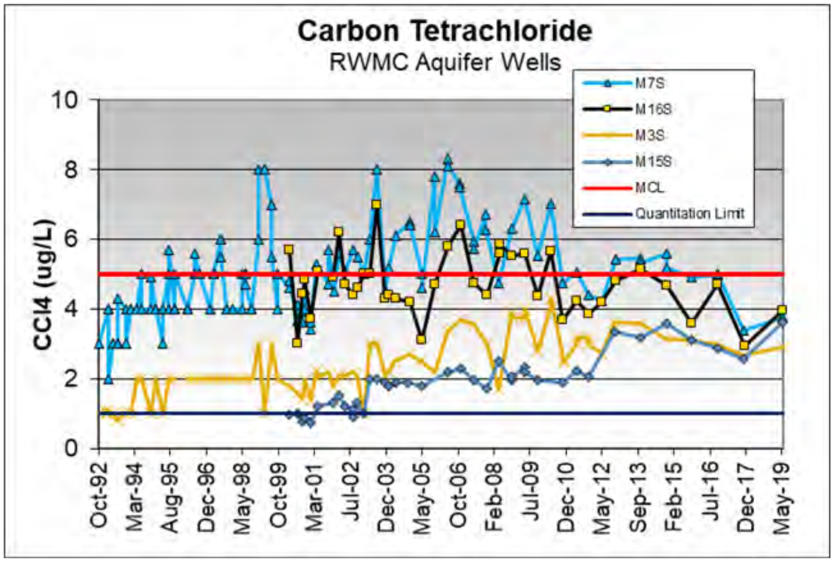


Figure 6-14. Carbon Tetrachloride (CC^{l4}) Concentration Trends in Wells near the RWMC.

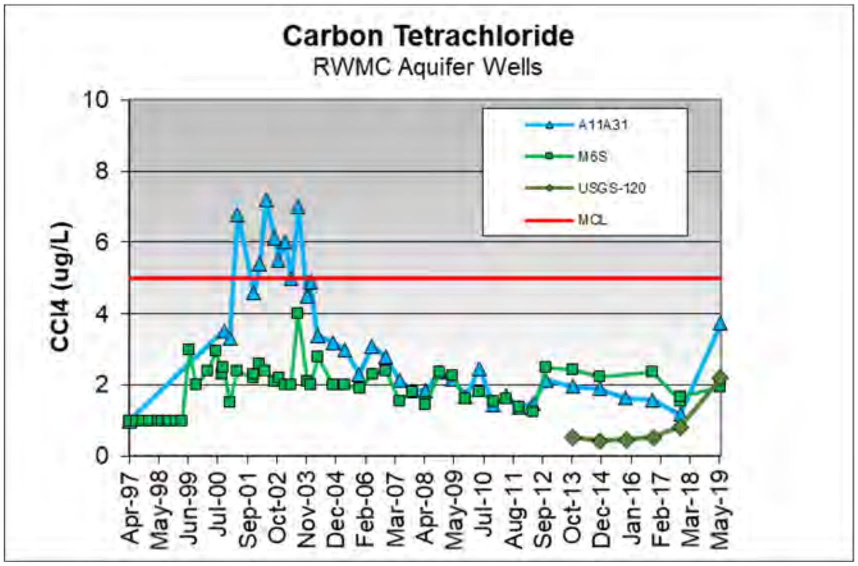


Figure 6-15. Carbon Tetrachloride (CC^{l4}) Concentration Trends in Wells Downgradient of the RWMC.

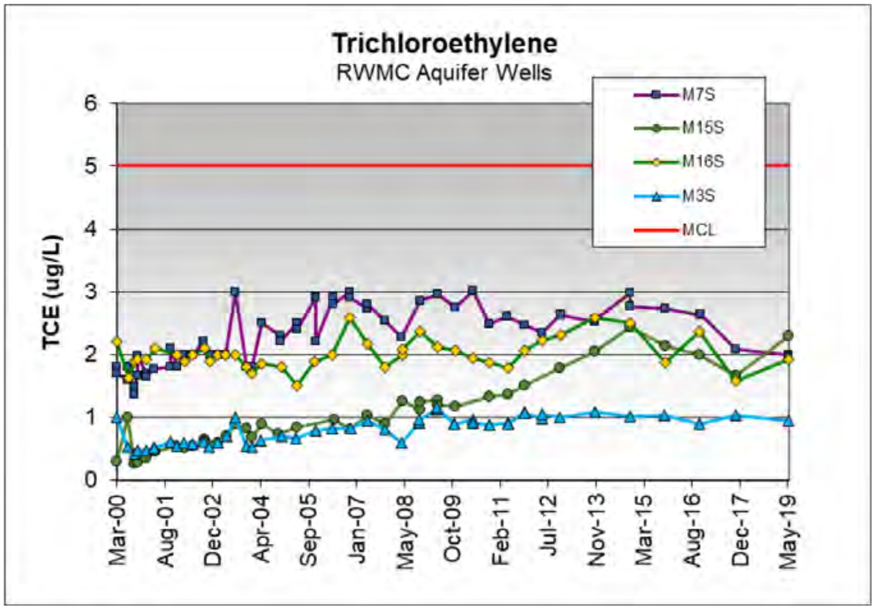


Figure 6-16. Trichloroethylene (TCE) Concentration Trends in Aquifer Wells near the RWMC.

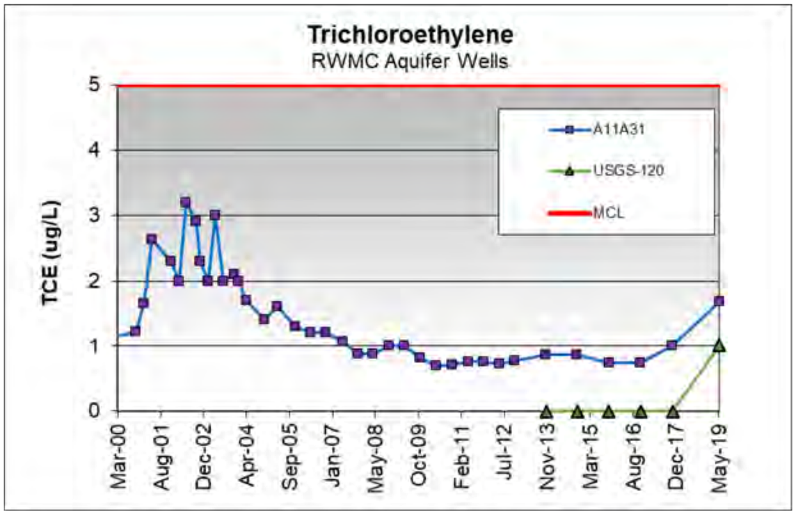


Figure 6-17. Trichloroethylene (TCE) Concentration Trends in Aquifer Wells Downgradient of the RWMC.

As in previous years, groundwater level measurements in RWMC-area monitoring wells during 2019 indicate groundwater flow to the south-southwest (Figure 6-18).

6.5.6 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 6-19; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

6.5.7 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2016), groundwater samples are collected every two years at the locations shown on Figure 6-20. In 2019, groundwater samples were collected for WAG 10. In 2019, eight wells and six intervals from three Westbay wells were sampled (DOE-ID 2020d). Groundwater analytes included volatile organic compounds, anions, and radionuclides (i.e., gross alpha and gross beta). No contaminant exceeded U.S. Environmental Protection Agency maximum contaminant levels or secondary maximum contaminant levels (Table 6-12).

6.6 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.

Until August of 2019, the INL Site had 11 drinking water systems monitored by the INL and ICP Core contractors to ensure a safe working environment. In August of 2019, the TAN/TSF water system was removed from service. The INL Fire Station, TAN 605, and TAN 1611 buildings were connected to the TAN/CTF water system, which supplies water to SMC. Bacteriological sampling was conducted at TAN/TSF until August, nitrate sampling was conducted in May, and radiological sampling was conducted there in March. The INL Site now has 10 water systems that are monitored by the INL and ICP Core contractors. The INL contractor monitors eight of these drinking water systems and the ICP Core contractor monitors two. The Naval Reactors Facility also monitors a drinking water system. The results are not included in this annual report but are addressed in the *Naval Reac-*

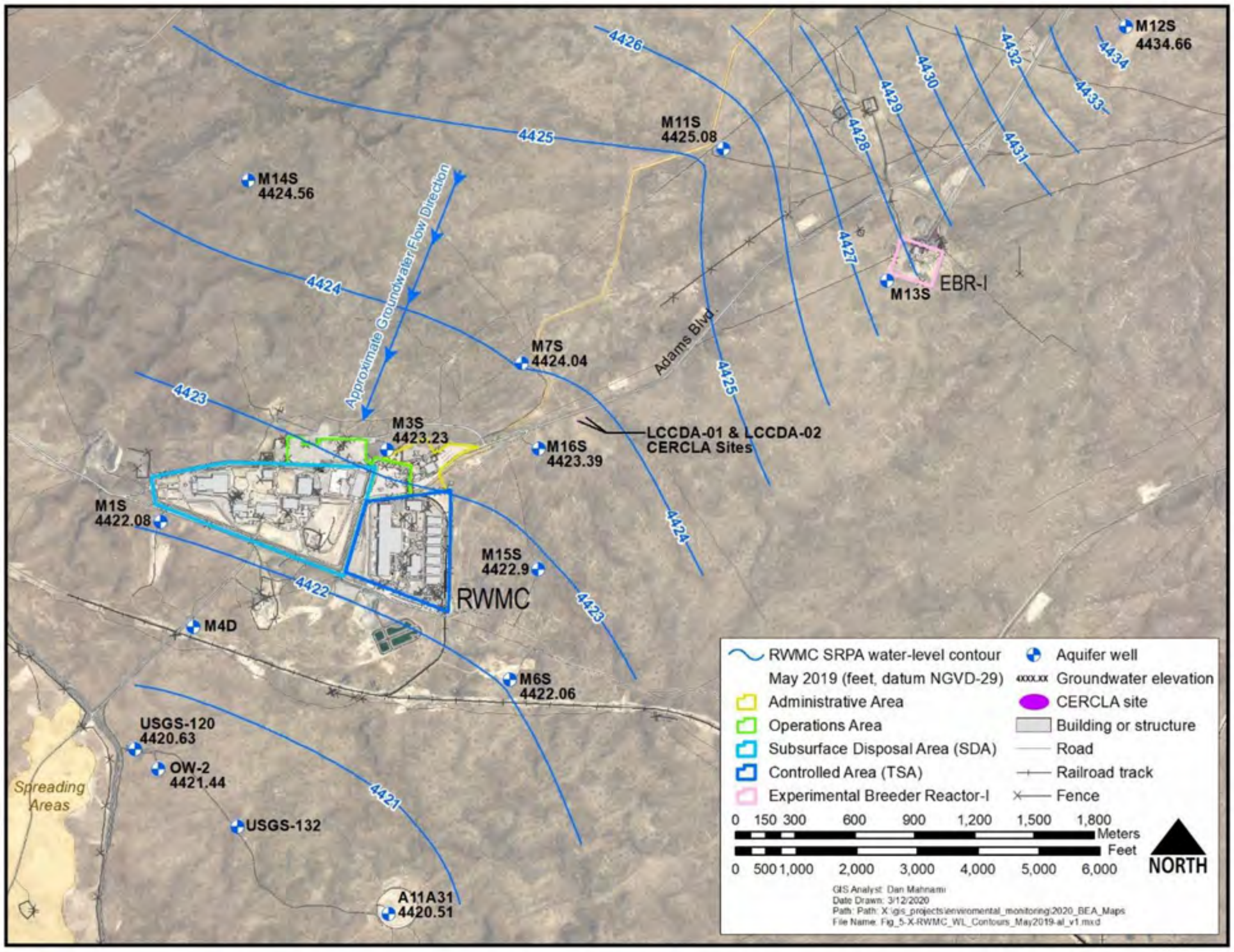


Figure 6-18. Groundwater-level Contours in the Aquifer near the RWMC, Based on May 2019 Measurements.

tors Facility Environmental Monitoring Report for Calendar Year 2019 (BMPC, 2020). 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, Gun Range (Live Fire Test Range), CITRC, TAN/TSF until August, 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 historical or problematic contaminants in the drinking water systems and to ensure the safety of the water to the public, 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 and for carbon tetra-

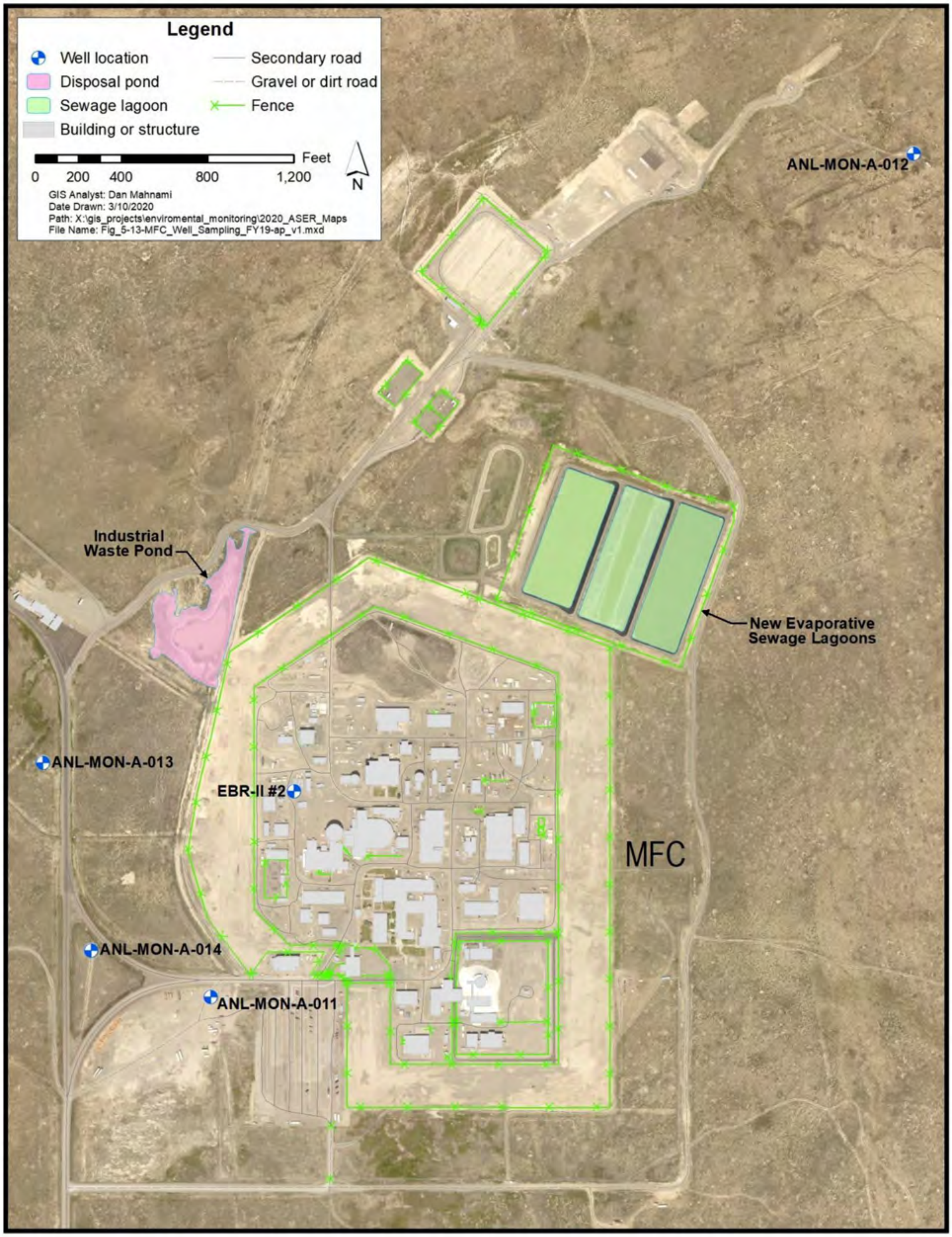


Figure 6-19. Locations of WAG 9 Wells Sampled in 2019.

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2019).

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:	4/24/2019	9/18/2019	4/24/2019	9/16/2019	4/24/2019	9/17/2019	4/24/2019	9/17/2019	4/25/2019	9/18/2019	
Radionuclides[c]											
Gross alpha (pCi/L)	2.16 ± 0.512[d]	1.01 ± 0.33	1.53±0.434	0.133 ± 0.378	ND[e]	ND (ND)	1.7 ± 0.54	ND	1.69 ± 0.49	1.19 ± 0.333	15 pCi/L
Gross beta (pCi/L)	3.49 ± 0.373	3.61 ± 0.334	3.06 ± 0.377	3.23 ± 0.336	2.81 ± 0.298	2.78 ± 0.273 (2.82 ± 0.313)	2.24 ± 0.306	2.49 ± 0.268	2.92 ± 0.393	2.73 ± 0.283	4 mrem/yr
Uranium-233/234 (pCi/L)	1.1 ± 0.12	1.64 ± 0.223	1.41 ± 0.138	1.55 ± 0.204	1.47 ± 0.161	1.55 ± 0.216 (1.37 ± 0.174)	1.34 ± 0.138	1.26 ± 0.171	1.42 ± 0.142	1.35 ± 0.172	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.558 ± 0.079	0.601 ± 0.123	0.689 ± 0.0874	0.72 ± 0.13	0.673 ± 0.0996	0.67 ± 0.132 (0.623 ± 0.107)	0.519 ± 0.0778	0.667 ± 0.117	0.56 ± 0.0809	0.671 ± 0.113	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND	ND	ND	ND (ND)	ND	ND	ND	ND	NE[f]
Metals[g]											
Arsenic (mg/L)	0.002U	0.00241	0.00207	0.00217	0.002U	0.00205 (0.00228)	0.002U	0.00227	0.002U	0.00216	0.05
Barium (mg/L)	0.035	0.0358	0.0372	0.0376	0.0351	0.0348 (0.0359)	0.0352	0.0348	0.0361	0.0358	2
Calcium (mg/L)	35.2	37.3	34.8	37.5	36.0	38.3 (37.4)	35.3	37.5	37.6	37.2	NE[f]
Chromium (mg/L)	0.003U	0.003U	0.003U	0.003U	0.00319	0.003U (0.003U)	0.003	0.003U	0.003U	0.003U	0.01
Copper (mg/L)	0.000336	0.000389	0.0003U	0.000401	0.000633	0.000604 (0.000533)	0.00055	0.000505	0.00676	0.0188	1.3
Iron (mg/L)	0.0557	0.030U	0.03U	0.03U	0.143	0.0356 (0.0314)	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	0.00184	0.00235	0.015
Magnesium (mg/L)	12.4J	11.8	11.0J	11.5	12.8J	12.4 (12.0)	11.6J	12.0	12.3J	11.8	NE
Manganese (mg/L)	0.001U	0.001U	0.001U	0.001U	0.0018	0.00106 (0.001U)	0.001U	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.0006U	0.0006U	0.000699	0.0006U	0.00101	0.000726 (0.000663)[g]	0.0006U	0.0006U	0.00938	0.0104	NE
Potassium (mg/L)	3.14	3.18	3.31	3.34	3.18	3.34 (3.26)	3.15	3.16	3.18	3.14	NE
Sodium (mg/L)	16.9	16.5	17.2	16.3	18.1	17.5 (17.0)	17.3	16.7	18.4	16.7	NE
Vanadium (mg/L)	0.0036	0.00533	0.00479	0.00496	0.00518	0.00591 (0.00544)	0.00458	0.00516	0.00459	0.00515	NE
Zinc (mg/L)	0.0033U	0.00374	0.0033U	0.00347	0.0033U	0.0033U	0.0033U	0.0033U	0.0372	0.039	5

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2019) (continued).

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:	4/24/2019	9/18/2019	4/24/2019	9/16/2019	4/24/2019	9/17/2019	4/24/2019	9/17/2019	4/25/2019	9/18/2019	
						(0.0212)					
Anions											
Chloride (mg/L)	17.7	17.3	16.3	18.1	17.9	19.1 (17.6)	17.6	17.7	17.0	17.2J	250
Nitrate-as nitrogen (mg/L)	2.31	2.29	2.28	2.34	2.23	2.37 (2.38)	2.29	2.38	2.29	2.32	10
Phosphorus (mg/L)	0.0167U	0.087U	0.0133U	0.0854U	0.0177U	0.0937U (0.0935U)	0.0168U	0.0889U	0.0193U	0.0877U	NE
Sulfate (mg/L)	18.9J	18.6	18.1J	18.3J	18.9J	19.8J (19.8J)	19.5J	19.2J	19.6J	18.9	250
Water Quality Parameters											
Alkalinity (mg/L)	139	140	143	139	140	142 (140)	140	138	138	138	NE
Bicarbonate alkalinity (mg/L)	139	140	143	139	140	142 (140)	140	138	138	138	NE
Total dissolved solids (mg/L)	244	219	249	244	276	233 (267)	226	197	337J	213	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

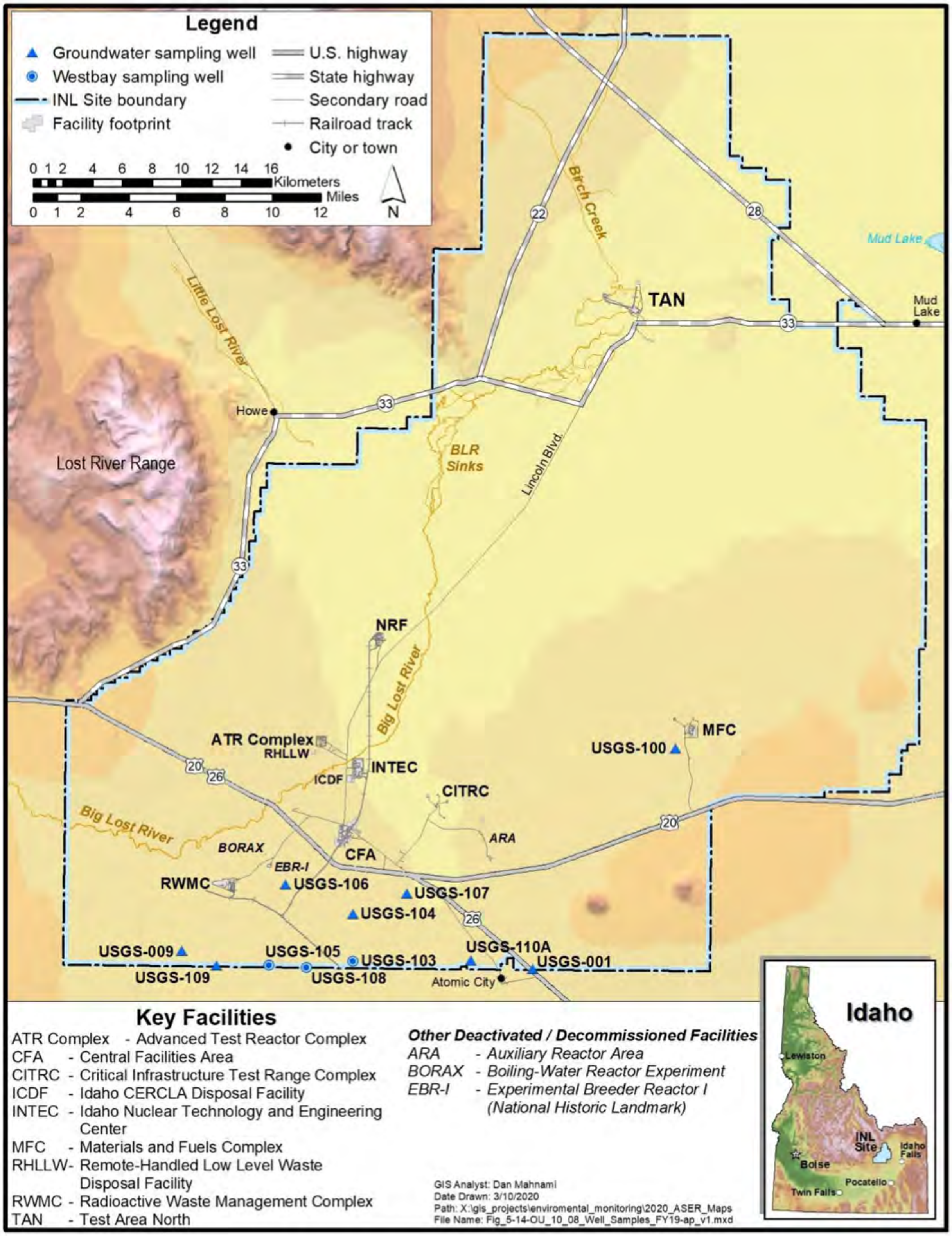


Figure 6-20. Well Locations Sampled for Operable Unit 10-08.

Table 6-12. Comparison of WAG 10 Groundwater Sampling Results to Regulatory Levels (2019).

Compound	MCL[a] or SMCL[b]	Maximum Detected Value	Number of Wells above MCL or SMCL
Anions			
Chloride (mg/L)	*250*	20.8	0
Sulfate (mg/L)	*250*	25.5	0
Nitrate/nitrite (mg-N/L)	10	2.07	0
Radionuclides			
Gross alpha (pCi/L)	15	2.21	0
Gross Beta (pCi/L)	4 mrem/yr	5	0
Tritium (pCi/L)	20,000	532	0
Detected Volatile Organic Compounds			
None detected	–	ND[c]	0

a. Numbers in *italic* text are for the secondary MCL. MCL = maximum contaminant level

b. SMCL = secondary maximum contaminant level

c. ND = not detected

chloride at RWMC. Monitoring for trichloroethylene at TAN/TSF was discontinued, because in 2019 the TAN/TSF water system was eliminated—which includes the wells where trichloroethylene was historically detected.

6.6.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2019, the INL contractor collected 280 routine samples and 25 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 65 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 12-1. Table 6-13 summarizes monitoring results for 2019. The quality control program associated with these data is discussed in Section 12.3.2.4.

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 or there were no detections; therefore, they are not discussed further in this report. In addition, all water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 3.01 mg/L at CFA and 2.36/2.42 mg/L at MFC well #1/2 respectively. Also, once every nine years the drinking water regulations require nitrite sampling, which was conducted with the nitrate sampling in 2019. There were no nitrite detections in 2019. Samples for total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at ATR-Complex, MFC, and TAN/CTF. Samples for VOCs were collected at ATR Complex and CFA. In addition, Phase II/V inorganic and metals sampling was conducted at ATR Complex, CFA, and MFC. Only arsenic sampling was required at TAN/CTF.

6.6.2 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 6-21) 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 12-1. Quality control is discussed in Section 12.2.5.4.

Prior to 2008, surveillance samples for the CFA water distribution system were collected semiannually from Well CFA #1 at CFA-651 and Well CFA #2 at

Table 6-13. Summary of INL Site Drinking Water Results (2019).

Constituent	MCL	ATR Complex	CFA	CITRC	EBR-I	GUN RANGE	MAIN GATE	MFC	TAN CTF	TAN TSF
Gross Alpha[a]	15 pCi/L	ND[b]	ND-2.91	ND-2.10	ND	ND	ND	ND-1.46	ND	ND
Gross Beta[a]	50 pCi/L screening or 4 mrem	ND	4.87-5.99	ND-.81-3.32	ND-4.15	3.32-4.13	ND-3.18	4.14-4.21	2.81	3.57
Tritium[a]	20,000 pCi/L	ND	2,400-2,670	ND	ND	483-484	ND	ND	ND	ND
Iodine-129[c]	1 pCi/L	–	ND	–	–	–	–	–	–	–
Nitrate	10 mg/L	0.9	3.01	1.29	ND	1.18	1.02	2.36/2.42	1.22	1.14
TTHMs	80 ppb	ND	NA	NA[d]	NA	NA	NA	4.0	4.4	NA
HAA5s	60 ppb	ND	NA	NA	NA	NA	NA	ND	ND	NA
VOCs	5 ppb for most VOCs	ND	ND	NA	NA	NA	NA	NA	NA	NA

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

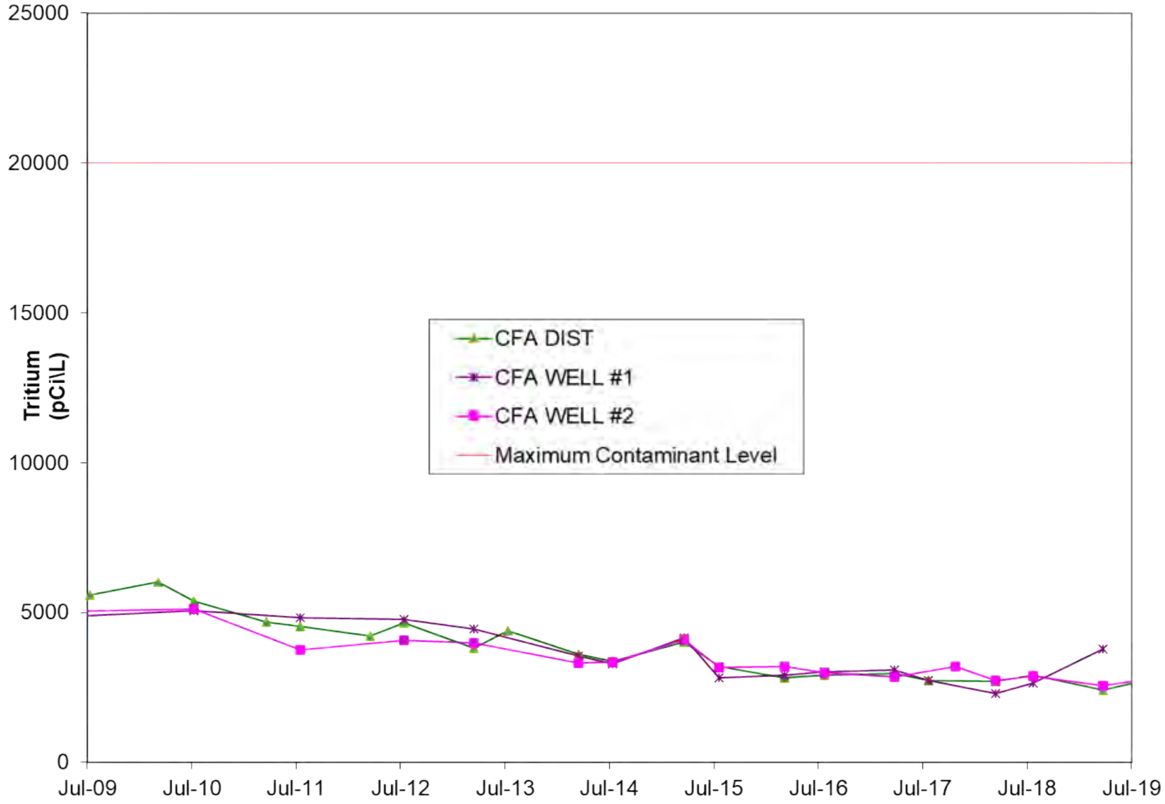


Figure 6-21. Tritium Concentrations in CFA Wells and Distribution System (2009–2019).

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 2019, Well CFA #1 was used to supply approximately 17% of drinking water at CFA. Well CFA #2 was used to supply approximately 83% 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 2019 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,

$\mathrm{Dose}_{\mathrm{ingw}}$ = effective dose from ingestion of water, mrem/yr (0.01 Sv/yr)

$\mathrm{TConc}_{\mathrm{w}}$ = average tritium concentration in drinking water, pCi/L

$\mathrm{Ing}_{\mathrm{w}}$ = annual intake of water for an adult (L/yr)

$\mathrm{EDC}_{\mathrm{T}}$ = effective dose coefficient for tritium ingested in water (mrem/pCi)

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

$\mathrm{TConc}_{\mathrm{w}}$ = 2,535 pCi/L (average concentration in water in CFA distribution system for 2019)

$\mathrm{Ing}_{\mathrm{w}}$ = 730 L/yr (calculated from Table 3 in DOE [2011])

$\mathrm{EDC}_{\mathrm{T}} = 7.07 \times 10^{-8}$ $\mathrm{mrem/pCi}_{\mathrm{tritium}}$ (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 2019, as calculated

from samples taken from the CFA distribution system, was 0.131 mrem (1.31 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems.

6.6.3 Idaho Nuclear Technology and Engineering Center

Drinking water for 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 2019, 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 12-1 Quality control is discussed in section 12.2.5.4. Results are presented in Tables 6-14 and 6-15 and are discussed in the following paragraphs.

Four compliance samples and 54 surveillance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for total coliform and *Escherichia coli* (E. coli) per Standard Method 9223B. The results for all samples were reported as absent.

Table 6-14. 2019 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	0.583 mg/L	NA[b]	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.0068 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	0.000586 mg/L	NA	0.06 mg/L

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

Table 6-15. 2019 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	54	4 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	54	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	4.64 pCi/L	ND – 4.64 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	ND	NA	20,000 pCi/L

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

One compliance sample was collected at CPP-614 on July 29, 2019, and analyzed for nitrate by EPA Method 300. The result was 0.583 mg/L, which is below the nitrate MCL of 10 mg/L.

One compliance sample was collected at CPP-1666 on August 20, 2019, and analyzed for TTHM by EPA Method 524.2. The result was 0.0068 mg/L, which is below the TTHM MCL of 0.080 mg/L.

One compliance sample was collected at CPP-1666 on August 20, 2019, and analyzed for HAA5 by EPA Method 552.2. The result was 0.000586 mg/L, which is below the HAA5 MCL of 0.060 mg/L.

A surveillance sample was collected at CPP-614 on February 26, 2019, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross beta, gross alpha, tritium, and ^{90}Sr were reported as non-detects. Another surveillance sample was collected at CPP-614 on August 28, 2019, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected at 4.64 pCi/L, below its screening level of 50 pCi/L.

6.6.4 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 2019, drinking water samples were collected from the point of entry to the distribution system (WMF-604) and from various buildings throughout the distribution system. The analytical laboratories that analyzed the RWMC drinking water samples are presented in Table 12-1. Quality control is discussed in Section 12.2.5.4. Results are presented in Tables 6-16 and 6-17 and are discussed in the following paragraphs.

Four compliance samples and 43 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 July 29, 2019, and analyzed for nitrate by EPA Method 300. The result was 0.929 mg/L, below the nitrate MCL of 10 mg/L.

One compliance sample was collected at WMF-678 on August 20, 2019, and analyzed for TTHM by EPA Method 524.2. The result was 0.00407 mg/L, which is below the TTHM MCL of 0.080 mg/L.

One compliance sample was collected at WMF-678 on August 20, 2019, and analyzed for HAA5 by EPA Method 552.2. The result was 0.000465 mg/L, which is below the HAA5 MCL of 0.060 mg/L.

Two 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 January 30, 2019, and the April 29, 2019 samples.

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. Total xylenes were detected in the August 12, 2019 sample (0.000190 mg/L) and the in the October 31, 2019 sample (0.00111 mg/L), which are both below the total xylenes MCL of 10 mg/L.

Four surveillance samples were collected at the WMF-603 production well and analyzed for VOCs by EPA Method 524.2. The purpose of these sampling events is to determine the concentrations of the VOCs in the WMF-603 production well prior to treatment utilizing an air stripper. This water is not available for use by personnel. Carbon tetrachloride was detected in all four samples and ranged in concentration from 0.0050 mg/L to 0.0055 mg/L. Trichloroethylene (trichloroethene) was also detected in all four samples and ranged in concentration from 0.0024 mg/L to 0.00313 mg/L. 1,1,1 trichloroethane (0.00028 mg/L and 0.00024 mg/L) and tetrachloroethylene (0.00036 mg/L and 0.00026 mg/L) were present in samples collected on August 12, 2019, and October 31, 2019, respectively. No other VOCs were detected in any of the samples.

Two separate surveillance samples were collected at WMF-604 on February 26, 2019, and August 2, 2019, respectively, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected in both samples, at 2.06 pCi/L and 2.78 pCi/L, each below the screening level of 50 pCi/L. A surveillance sample was collected at WMF-604 on February 26, 2019, and analyzed for ^{90}Sr and tritium. Only tritium was detected at 416 pCi/L, below its MCL of 20,000 pCi/L.

Table 6-16. 2019 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	0.929 mg/L	NA[b]	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.00407 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	0.000465 mg/L	NA	0.06 mg/L
Xylenes (total)	2	2 per year	ND	NA	10 mg/L

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

Table 6-17. 2019 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	41	2 to 4 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	41	2 to 4 per month	Absent	Absent	See 40 CFR 141.63(c)
Volatile organic compounds	8	1 per quarter	0.00243 mg/L	ND[b] to 0.0055 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	2.42 pCi/L	2.06 to 2.78 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	416 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).
d. NA = not applicable

6.7 Test Area North/Technical Support Facility

In August of 2019, the TAN/TSF water system was removed from service, except for the TAN Fire Station, TAN 1611, and TAN 605 buildings—which were then connected to the TAN/CTF water system. The elimination of the TAN/TSF water system included wells, tank, and buildings. Bacteriological sampling was conducted at TAN/TSF until August, nitrate sampling was conducted in May, and radiological sampling was conducted there in March for gross alpha/beta and tritium.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program performed by the ESER contractor, drinking water samples were collected off the INL Site for radiological analyses in 2019. 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 2019. 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 analytical laboratories used are listed in Table 12-1. Quality control is discussed in Section 12.3.2.5. The ESER contractor results are shown in Table 6-18. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Gross alpha activity was detected statistically (above 3σ) in two of nine samples (including the control) collected in spring 2019 (Atomic City and Shoshone) and in three of nine samples collected in fall 2019 (Craters of the Moon, Minidoka, and Shoshone) 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 1.9 ± 0.41 pCi/L, measured at Shoshone 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 4.1 ± 0.40 pCi/L, measured at the Mud Lake 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 Reports was 7.83 ± 0.61 pCi/L (Atomic City in spring of 2011).

Tritium was statistically detected in eight of the drinking water samples collected in 2019. The maximum result measured was 120 ± 24 pCi/L, measured at Shoshone in May. The results were generally within historical measurements and well below the EPA MCL of 20,000 pCi/L. The maximum tritium level was lower than the maximum measured since 2010 (209 ± 25 pCi/L at Minidoka in spring of 2018).

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2019 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls, Clear Springs near Buhl, and a trout farm near Hagerman (see Figure 6-22). ESER contractor results are shown in Table 6-19.

Gross alpha activity was detected in one sample collected at Hagerman in November (1.24 ± 0.38 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 (7.9 ± 0.50 pCi/L) was measured at Alpheus Springs in May. 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 (81 ± 23 pCi/L) and the second at Hagerman in May (98 ± 24 pCi/L). Concentrations were similar to those found in the drinking water samples and in other liquid media, such as precipitation throughout the year.

Table 6-18. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2019.

Location	Sample Results (pCi/L)[a]		
	Gross Alpha		
	Spring	*Fall*	*EPA MCL*[b]
Atomic City	1.1 ± 0.34	0.60 ± 0.34	15 pCi/L
Control (bottled water)[c]	0.03 ± 0.17	0.26 ± 0.18	15 pCi/L
Craters of the Moon	0.91 ± 0.30	1.1 ± 0.33	15 pCi/L
Howe	0.71 ± 0.33	0.71 ± 0.27	15 pCi/L
Idaho Falls	0.84 ± 0.40	0.63 ± 0.42	15 pCi/L
Minidoka	0.64 ± 0.39	1.86 ± 0.43	15 pCi/L
Mud Lake (Well #2)	0.12 ± 0.25	0.46 ± 0.26	15 pCi/L
Rest Area (Highway 20/26)	0.92 ± 0.34	0.99 ± 0.35	15 pCi/L
Shoshone	1.3 ± 0.39	1.9 ± 0.41	15 pCi/L
	Gross Beta		
	Spring	*Fall*	*EPA MCL*
Atomic City	3.0 ± 0.39	3.6 ± 0.43	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	0.08 ± 0.31	0.82 ± 0.35	4 mrem/yr (50 pCi/L)
Craters of the Moon	1.24 ± 0.37	2.4 ± 0.41	4 mrem/yr (50 pCi/L)
Howe	1.5 ± 0.37	1.1 ± 0.38	4 mrem/yr (50 pCi/L)
Idaho Falls	3.2 ± 0.44	3.4 ± 0.45	4 mrem/yr (50 pCi/L)
Minidoka	2.9 ± 0.42	3.0 ± 0.45	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.1 ± 0.40	3.9 ± 0.41	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	2.02 ± 0.38	3.1 ± 0.41	4 mrem/yr (50 pCi/L)
Shoshone	2.71 ± 0.40	3.3 ± 0.44	4 mrem/yr (50 pCi/L)
	Tritium		
	Spring	*Fall*	*EPA MCL*
Atomic City	113 ± 24	51 ± 25	20,000 pCi/L
Control (bottled water)	35 ± 23	7.5 ± 24	20,000 pCi/L
Craters of the Moon	95 ± 24	29 ± 25	20,000 pCi/L
Howe	78 ± 24	37 ± 25	20,000 pCi/L
Idaho Falls	96 ± 24	1.6 ± 25	20,000 pCi/L
Minidoka	114 ± 24	34 ± 25	20,000 pCi/L
Mud Lake (Well #2)	45 ± 23	89 ± 26	20,000 pCi/L
Rest Area (Highway 20/26)	47 ± 23	101 ± 27	20,000 pCi/L
Shoshone	120 ± 24	26 ± 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 Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called Big Lost River Sinks (see Figure 6-22). 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 the years 2017 through 2019. Samples were collected during the months of April, May, 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 6-20). None of the results exceeded these limits. The 2019 gross alpha results are similar to those reported for 2017 and 2018; however, the maximum result (5.9 pCi/L) reported for 2019 is higher than the maximum results (3.6) reported for 2017 and 2018. The 2019 gross beta results are like those reported for 2018; however, the maximum result (15 pCi/L) reported for 2019 is higher than the maximum results reported for 2017 and 2018. All 2019 tritium results are within the range of values reported for 2017 and 2018. 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 6-20.

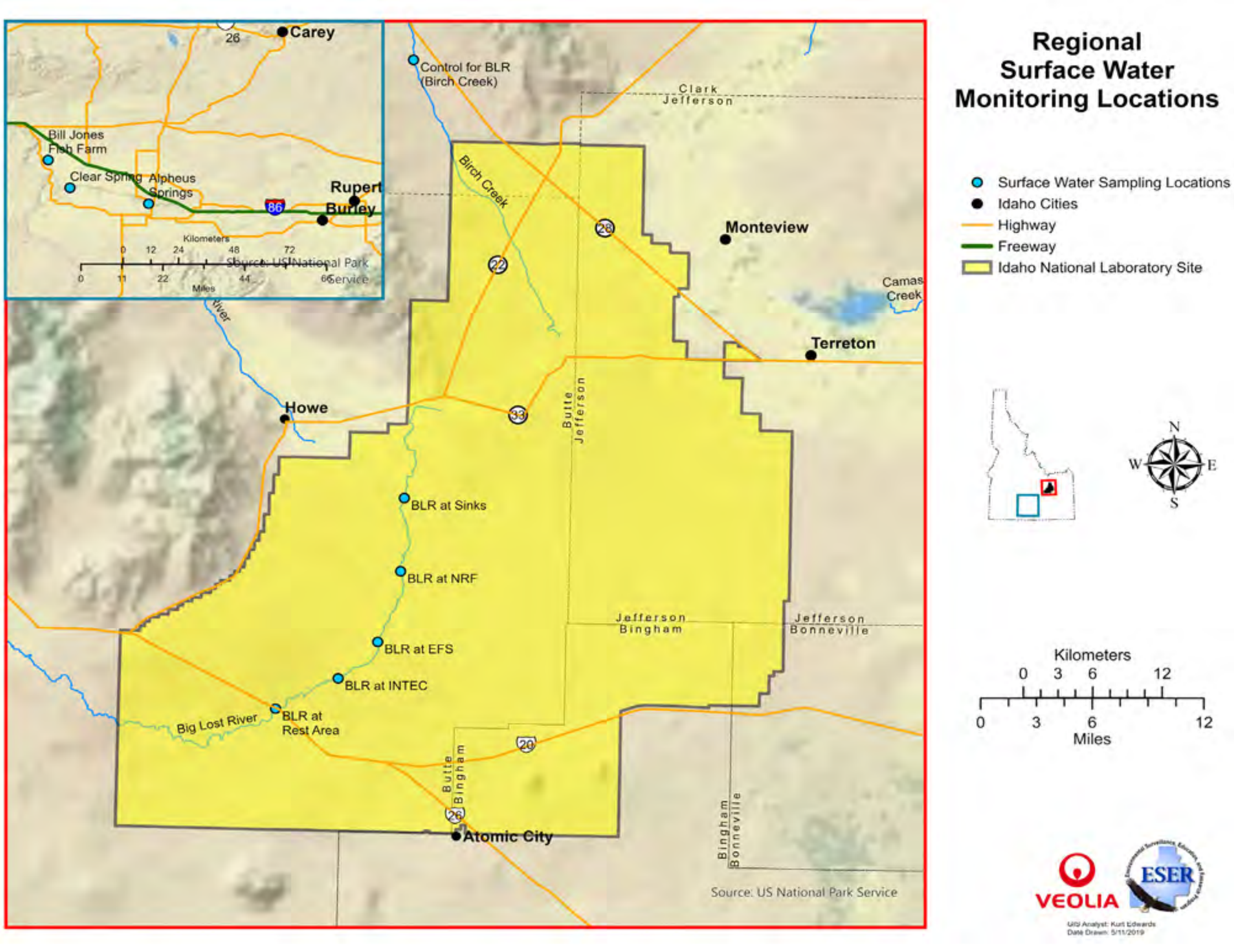
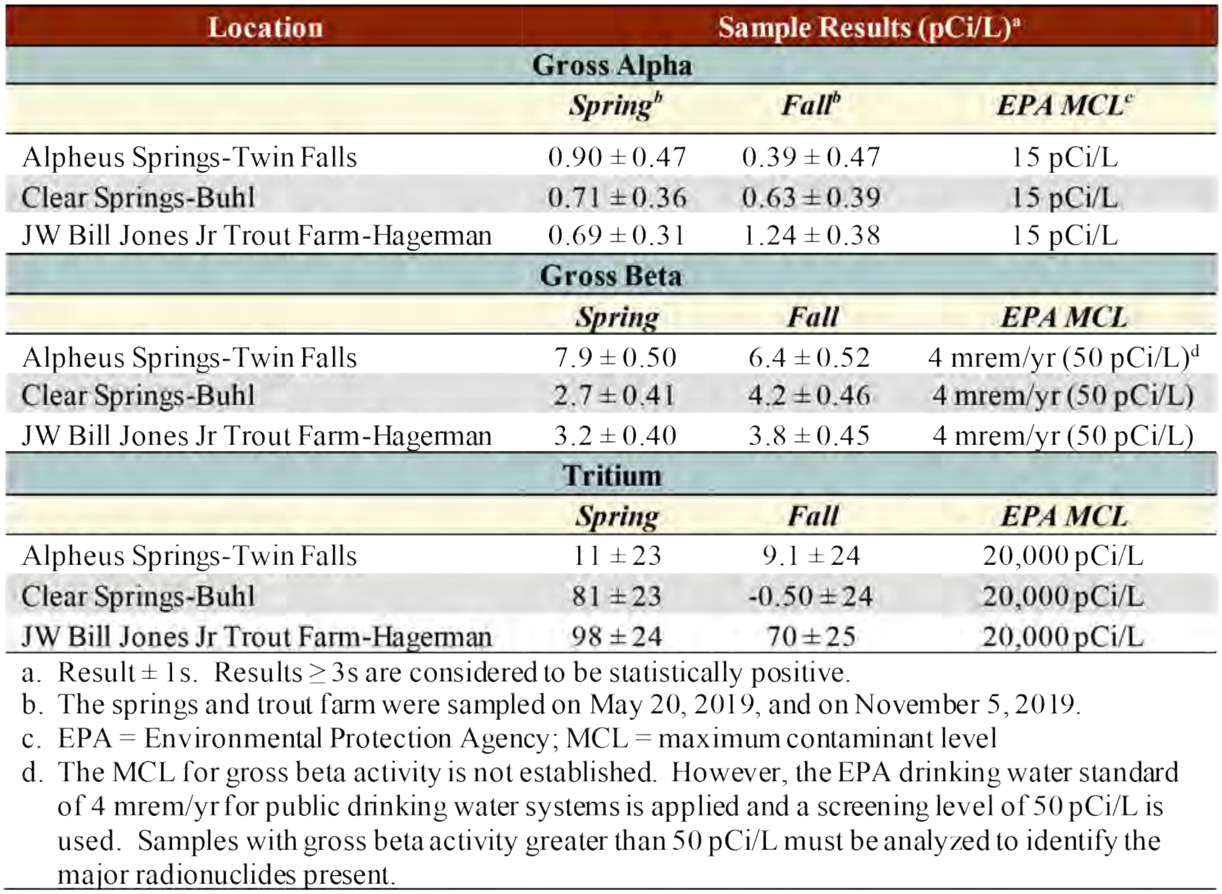


Figure 6-22. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-19. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2019.



Location	Sample Results (pCi/L)[a]		
	Gross Alpha		
	Spring[b]	***Fall***[b]	***EPA MCL***[c]
Alpheus Springs-Twin Falls	0.90 ± 0.47	0.39 ± 0.47	15 pCi/L
Clear Springs-Buhl	0.71 ± 0.36	0.63 ± 0.39	15 pCi/L
JW Bill Jones Jr Trout Farm-Hageman	0.69 ± 0.31	1.24 ± 0.38	15 pCi/L
	Gross Beta		
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	7.9 ± 0.50	6.4 ± 0.52	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	2.7 ± 0.41	4.2 ± 0.46	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hageman	3.2 ± 0.40	3.8 ± 0.45	4 mrem/yr (50 pCi/L)
	Tritium		
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	11 ± 23	9.1 ± 24	20,000 pCi/L
Clear Springs-Buhl	81 ± 23	-0.50 ± 24	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hageman	98 ± 24	70 ± 25	20,000 pCi/L

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

b. The springs and trout farm were sampled on May 20, 2019, and on November 5, 2019.

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.

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Table 6-20. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected Along the Big Lost River by the ESER Contractor in 2019.

Location	Sample Results (pCi/L)[a]			
	Gross Alpha			
	April	*May*	*June*	*EPA MCL[b]*
Rest Area	1.7 ± 0.41	5.9 ± 0.66	3.2 ± 0.44	15 pCi/L
INTEC	2.2 ± 0.45	5.4 ± 0.64	3.4 ± 0.51	15 pCi/L
Experimental Field Station (EFS)	1.8 ± 0.45	5.8 ± 0.66	2.8 ± 0.46	15 pCi/L
Naval Reactors Facility (NRF)	2.1 ± 0.45	4.5 ± 0.65	2.8 ± 0.46	15 pCi/L
Big Lost River (BLR) Sinks	1.6 ± 0.38	0.94 ± 0.31	3.3 ± 0.45	15 pCi/L
Birch Creek (control)	1.5 ± 0.38	2.5 ± 0.46	2.6 ± 0.43	15 pCi/L
	Gross Beta			
	April	*May*	*June*	*EPA MCL*
Rest Area	4.6 ± 0.40	12 ± 0.57	5.3 ± 0.44	4 mrem/yr (50 pCi/L)[c]
INTEC	2.2 ± 0.43	13 ± 0.58	8.2 ± 0.49	4 mrem/yr (50 pCi/L)
EFS	2.8 ± 0.43	14 ± 0.59	6.6 ± 0.46	4 mrem/yr (50 pCi/L)
NRF	2.5 ± 0.43	15 ± 0.61	5.9 ± 0.46	4 mrem/yr (50 pCi/L)
BLR Sinks	3.3 ± 0.40	1.7 ± 0.38	5.7 ± 0.45	4 mrem/yr (50 pCi/L)
Birch Creek (control)	1.9 ± 0.40	2.1 ± 0.41	3.1 ± 0.41	4 mrem/yr (50 pCi/L)
	Tritium			
	April	*May*	*June*	*EPA MCL*
Rest Area	6.6 ± 23	78 ± 25	69 ± 24	20,000 pCi/L
INTEC	40 ± 23	62 ± 25	109 ± 24	20,000 pCi/L
EFS	49 ± 24	100 ± 25	148 ± 24	20,000 pCi/L
NRF	49 ± 24	51 ± 25	37 ± 24	20,000 pCi/L
BLR Sinks	27 ± 23	88 ± 25	52 ± 24	20,000 pCi/L
Birch Creek (control)	15 ± 23	43 ± 24	22 ± 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.

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


Orange Globemallow (*Sphaeralcea munroana*)

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 and analyzed for human-made radionuclides because of the potential transfer of radionuclides to people through food chains. Strontium-90 (^{90}Sr) was detected in one of 13 milk samples collected at a concentration that is consistent with past measurements and is likely due to the presence of fallout radionuclides in the environment. The result was well below the Derived Concentration Standard established for ^{90}Sr in drinking water by the U.S. Department of Energy for protection of human health. Human-made radionuclides were not detected in any of the other agricultural products (lettuce, grain, potatoes, and alfalfa) collected in 2019.

No road-killed animals were available for analysis in 2019. Six human-made radionuclides (cobalt-60 [^{60}Co], zinc-65 [^{65}Zn], ^{90}Sr, cesium-137 [^{137}Cs], and plutonium-238) 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. Six human-made radionuclides (^{60}Co, ^{65}Zn, ^{90}Sr, ^{137}Cs, plutonium-238, and plutonium-230/240) were detected in 2019 in some of the sample groups. While ^{137}Cs may be of fallout origin, the presence of ^{60}Co, ^{65}Zn, and plutonium isotopes may indicate that the bats have visited radioactive effluent ponds on the INL Site.

Soil samples were not collected on or off the INL Site in 2019.

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 122 mrem off the INL Site. The total background dose to an average individual living in southeast Idaho was estimated to be approximately 382 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 Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility were near background levels.

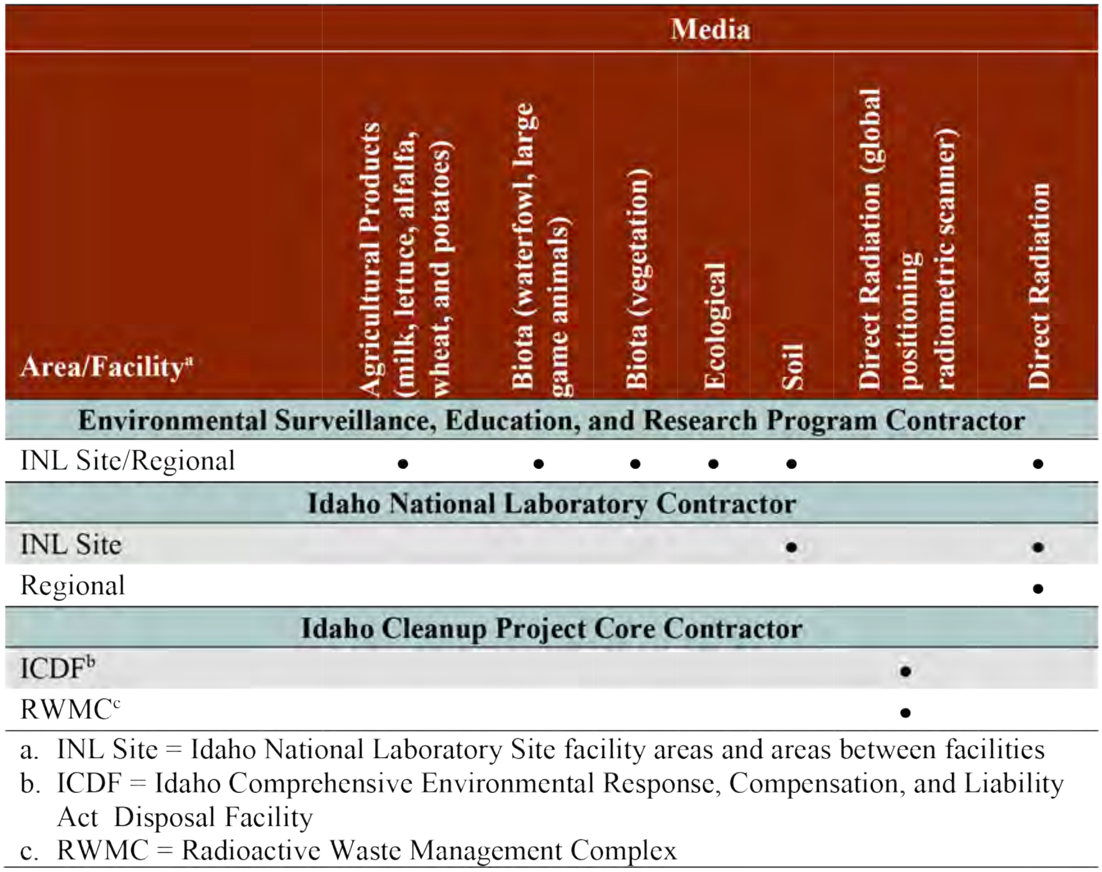
7. ENVIRONMENTAL MONITORING PROGRAMS: AGRICULTURAL PRODUCTS, WILDLIFE, SOIL AND DIRECT RADIATION

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2019. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a). The INL, Idaho Cleanup Project (ICP) Core, and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of INL and ICP Core contractor monitoring is on the INL Site, particularly on and around facilities (Table 7-1). The ESER contractor's primary responsibility is to monitor the presence of contaminants in media off the INL Site, which may originate from INL Site releases (Table 7-1).

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 4-1). Figure 7-1 shows the locations where agricultural products were collected in 2019.

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



	Media						
Area/Facility[a]	Agricultural Products (milk, lettuce, alfalfa, wheat, and potatoes)	Biota (waterfowl, large game animals)	Biota (vegetation)	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

7.1.1 Sampling Design for Agricultural Products

Agricultural 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, leafy green vegetables, 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 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

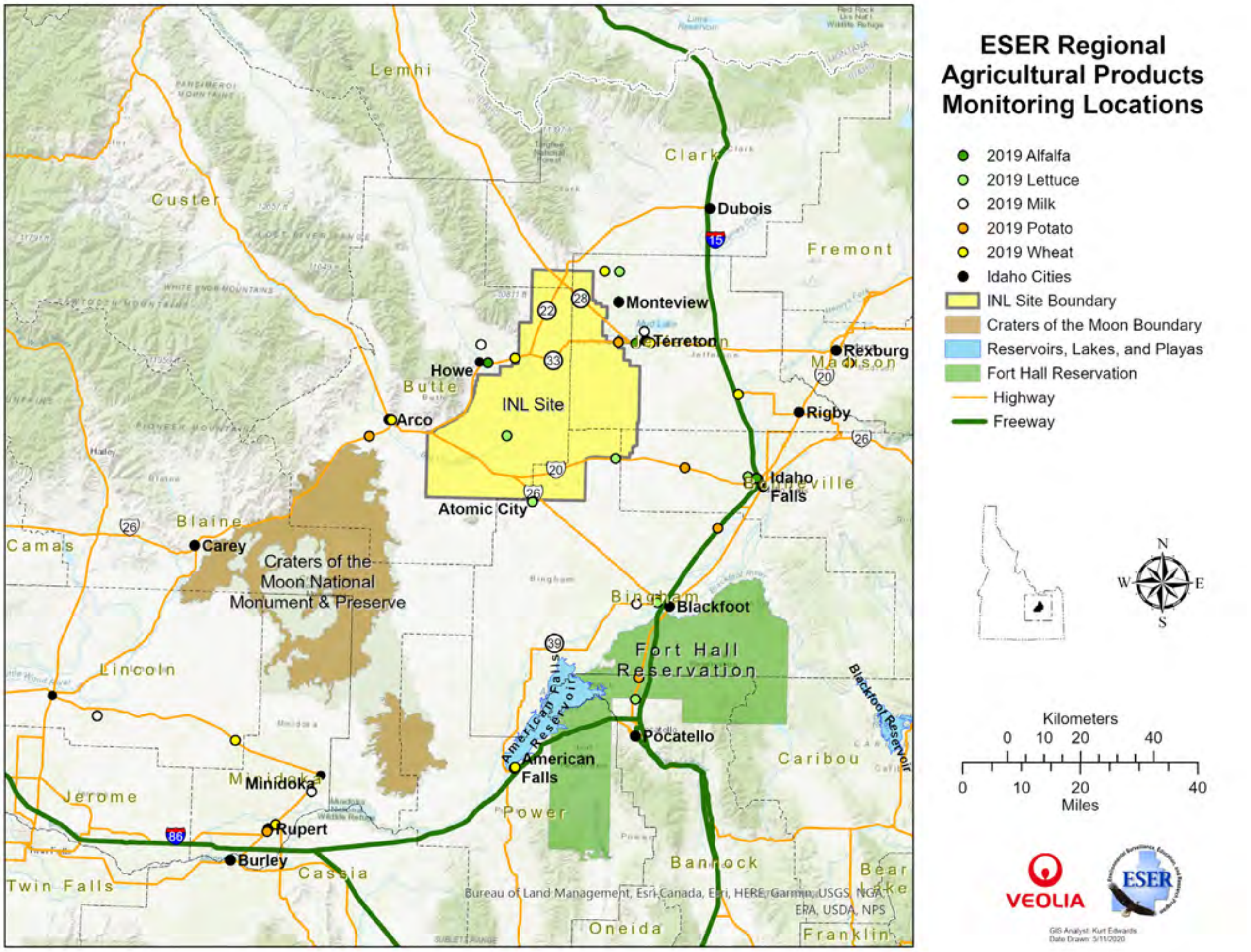


Figure 7-1. Locations of Agricultural Product Samples Collected (2019).

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.

7.1.2 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.

7.1.3 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 2019, the ESER contractor collected 194 milk samples (including duplicates and controls) at various locations off the INL Site (Figure 7-1) 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 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). During the second and fourth quarters, samples from each of the seven locations were analyzed for ^{90}Sr and tritium except for Blackfoot. Milk from the Blackfoot location was only analyzed during the second quarter.

The family-run goat dairy at that location did not have enough sample for ^{90}Sr and tritium analysis during the fourth quarter.

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 2019 was from the Materials and Fuels Complex (approximately 90.0 mCi). None was detected in air samples collected at or beyond the INL Site boundary (see Chapter 4). Iodine-131 was also not detected in any milk sample collected during 2019.

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 2019.

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 one of the 13 milk samples analyzed. It was not detected in the two control samples from outside the state. The milk sample collected in November 2019 at Terreton resulted in a detectable concentration of 0.27 ± 0.09 pCi/L (Table 7-2). 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 7.2). 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 (0.27 ± 0.09 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 not detected in any of the milk samples analyzed during 2019 (Table 7-2). The DCS for tritium in water is 1,900,000 pCi/L.

7.1.4 Lettuce

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 4-1). 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

Table 7-2. Strontium and Tritium Concentrations[a] in Milk Samples Collected off the INL Site in 2019.

Strontium-90 (pCi/L)		
Location	**April/May 2019**	**November 2019**
Blackfoot	0.15 ± 0.05	NS[b]
Dietrich	0.10 ± 0.05	0.10 ± 0.03
Howe	0.05 ± 0.05	0.03 ± 0.04
Idaho Falls	0.03 ± 0.05	-0.01[c] ± 0.08
Minidoka	0.08 ± 0.05	0.05 ± 0.04
Terreton	0.01 ± 0.05	0.27 ± 0.09
AVERAGE	0.07	0.09
Control (Colorado)	0.11 ± 0.05	0.10 ± 0.04
Tritium (pCi/L)		
Location	**April/May 2019**	**November 2019**
Blackfoot	65 ± 24	NS
Dietrich	-24 ± 23	23 ± 24
Howe	16 ± 23	56 ± 24
Idaho Falls	17 ± 24	17 ± 24
Minidoka	31 ± 24	69 ± 25
Terreton	20 ± 24	56 ± 25
AVERAGE	21	44
Control (Colorado)	48 ± 24	0.67 ± 24

a. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected.

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

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

the INL Site (Figure 7-1). The number and locations of gardens have changed from year to year depending on whether vegetables were available. Home gardens have generally been replaced with portable lettuce planters (Figure 7-2) because the availability of lettuce from home gardens was unreliable at some key locations.

Also, the planters can be placed, and lettuce collected at areas previously unavailable to the public, such as on the INL Site and near air samplers. The planters can allow radionuclides deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are placed in the spring, filled with soil and potting mix, sown with lettuce seed, and self-watered through a reservoir.

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 2019, soil from the vicinity of the sampling locations was used in the planters. This soil was amended with potting soil as a gardener in the region would typically do when they grow their lettuce. In addition to the portable samplers, a sample was obtained from farms in Blackfoot and Tyhee and a control sample was purchased at the grocery store from an out-of-state location (Oregon). A duplicate sample was collected at Tyhee.

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was not detected

Figure 7-2. Portable Lettuce Planter.

(at the 3s level) in the lettuce samples collected during 2019. Table 7-3 shows the average and range of all measurements from 2019. 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 measurable 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.

7.1.5 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2019 the ESER contractor collected grain samples at eleven locations from areas surrounding the INL Site (Figure 7-1), and an additional duplicate sample was collected from Howe. 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).

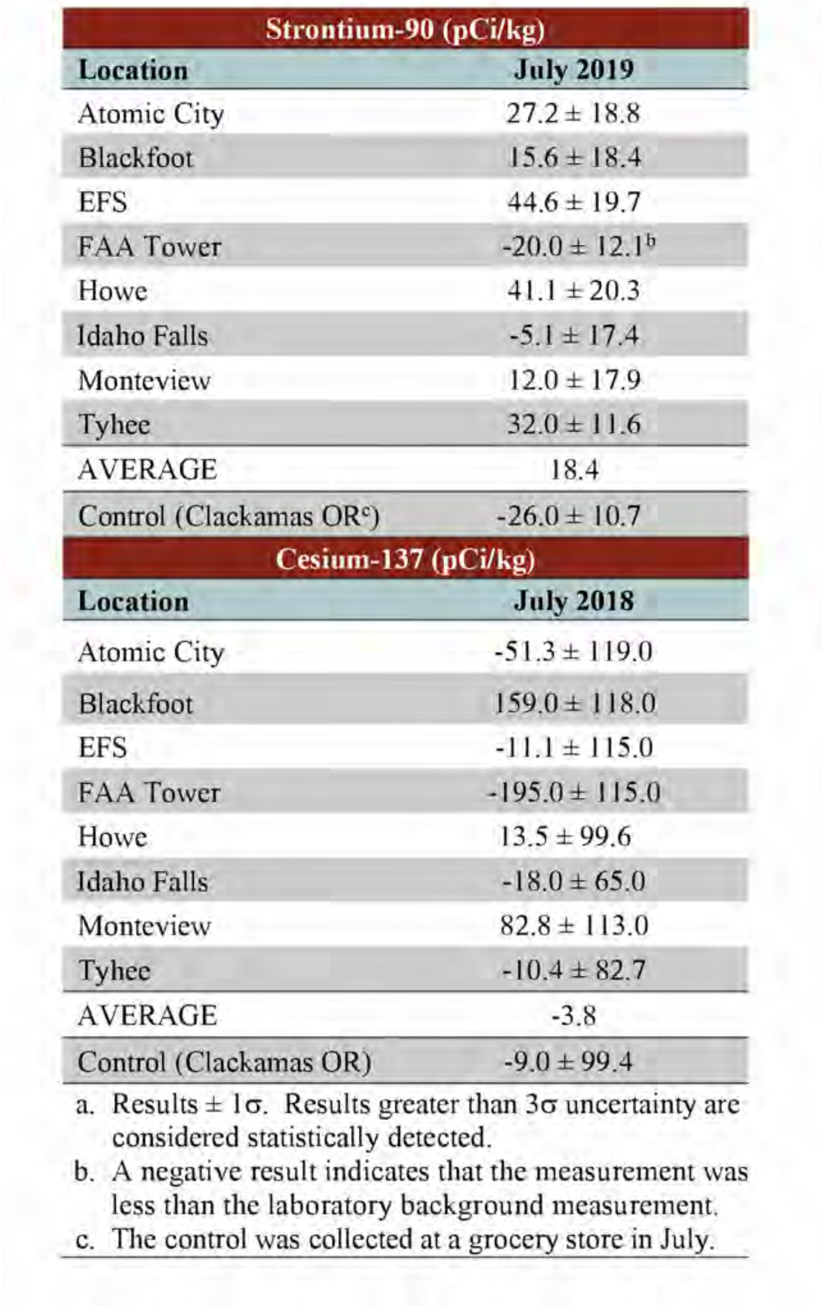
7.1.6 Potatoes

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 collected by the ESER contractor at eight locations in the vicinity of the INL Site (Figure 7-1) and obtained from one location outside eastern Idaho. None of the ten potato samples (including a duplicate) collected during 2019 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.

7.1.7 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 area, Howe, and Idaho Falls. Mud Lake is the agricultural area where the highest potential offsite air concentration was calculated using an air dispersion model (see Figure 8-6). (Note: The highest offsite air concentration used for estimating doses was located south of the INL Site; however, there is no agriculture conducted at that location.) The samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made radionuclides were found in the alfalfa samples collected during 2019.

Table 7-3. Cesium and Strontium Concentrations[a] in Lettuce Samples Collected on and off the INL Site in 2019.



Strontium-90 (pCi/kg)

Location	July 2019
Atomic City	27.2 ± 18.8
Blackfoot	15.6 ± 18.4
EFS	44.6 ± 19.7
FAA Tower	-20.0 ± 12.1[b]
Howe	41.1 ± 20.3
Idaho Falls	-5.1 ± 17.4
Monteview	12.0 ± 17.9
Tyhee	32.0 ± 11.6
AVERAGE	18.4
Control (Clackamas OR[c])	-26.0 ± 10.7

Cesium-137 (pCi/kg)

Location	July 2018
Atomic City	-51.3 ± 119.0
Blackfoot	159.0 ± 118.0
EFS	-11.1 ± 115.0
FAA Tower	-195.0 ± 115.0
Howe	13.5 ± 99.6
Idaho Falls	-18.0 ± 65.0
Monteview	82.8 ± 113.0
Tyhee	-10.4 ± 82.7
AVERAGE	-3.8
Control (Clackamas OR)	-9.0 ± 99.4

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. The control was collected at a grocery store in July.

7.1.8 Big Game Animals

No big game samples were available during 2019.

7.1.9 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 Menan and 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 five 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), ^{137}Cs, ^{238}Pu, and ^{90}Sr. A Ruddy Duck collected from the sewage lagoons at ATR Complex had three of these radionuclides in edible tissue, whereas, a Green-winged Teal had four of these radionuclides (Table 7-4). Two of these radionuclides (^{60}Co and ^{137}Cs) were also detected in the edible tissue of a Northern Shoveler collected at the same location. No human-made radionuclides were detected in the Northern Pintail collected from the ATR Complex ponds. A Northern Pintail and a Mallard were collected as control ducks. One radionuclide (^{241}Am) was detected in the edible tissue for 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 2018. The radionuclides detected in the control ducks is most likely from fallout from past weapons testing. The hypothetical dose to a hunter who eats a contaminated duck from the ATR Complex ponds is estimated in Chapter 8.

7.1.10 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 2019 were analyzed 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 the following areas in 2019: TAN, NRF, MFC, and ATR Complex/INTEC. Before reporting, results were converted from ashed weight concentrations to dry weight concentrations.

The bat analysis results are summarized in Table 7-5. The following radionuclides were detected in at least one sample during 2019: ^{60}Co, ^{65}Zn, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239/240}$Pu. 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 Complex ponds. Plutonium-238 (^{238}Pu) and $^{239/240}$Pu, which are present in radioactive waste as well as in the environment from past weapons testing, were each detected in one sample collected in 2019. The potential doses received by bats are discussed in Chapter 8.

7.2 Soil Sampling

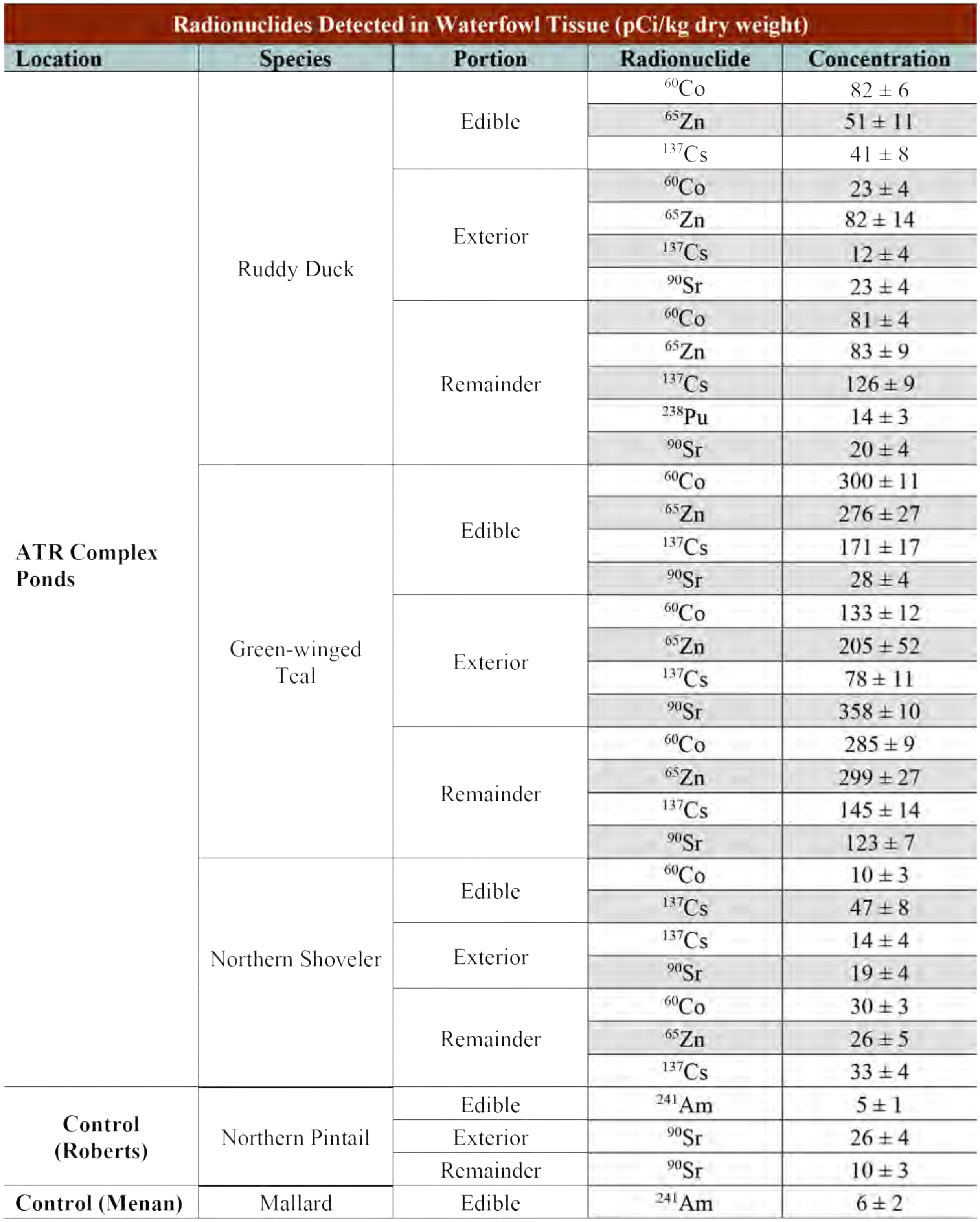
In the early 1970s, the DOE Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface soils (0–5 and 5–10 cm deep) on and around the INL Site. At that time, RESL established extensive onsite soil sampling grids outside facilities. Offsite locations 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 2019.

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

Table 7-4. Radionuclide Concentrations Detected in Waterfowl Collected in 2019.



Radionuclides Detected in Waterfowl Tissue (pCi/kg dry weight)				
Location	**Species**	**Portion**	**Radionuclide**	**Concentration**
ATR Complex Ponds	Ruddy Duck	Edible	^{60}Co	82 ± 6
			^{65}Zn	51 ± 11
			^{137}Cs	41 ± 8
		Exterior	^{60}Co	23 ± 4
			^{65}Zn	82 ± 14
			^{137}Cs	12 ± 4
			^{90}Sr	23 ± 4
		Remainder	^{60}Co	81 ± 4
			^{65}Zn	83 ± 9
			^{137}Cs	126 ± 9
			^{238}Pu	14 ± 3
			^{90}Sr	20 ± 4
	Green-winged Teal	Edible	^{60}Co	300 ± 11
			^{65}Zn	276 ± 27
			^{137}Cs	171 ± 17
			^{90}Sr	28 ± 4
		Exterior	^{60}Co	133 ± 12
			^{65}Zn	205 ± 52
			^{137}Cs	78 ± 11
			^{90}Sr	358 ± 10
		Remainder	^{60}Co	285 ± 9
			^{65}Zn	299 ± 27
			^{137}Cs	145 ± 14
			^{90}Sr	123 ± 7
	Northern Shoveler	Edible	^{60}Co	10 ± 3
			^{137}Cs	47 ± 8
		Exterior	^{137}Cs	14 ± 4
			^{90}Sr	19 ± 4
		Remainder	^{60}Co	30 ± 3
			^{65}Zn	26 ± 5
			^{137}Cs	33 ± 4
Control (Roberts)	Northern Pintail	Edible	^{241}Am	5 ± 1
		Exterior	^{90}Sr	26 ± 4
		Remainder	^{90}Sr	10 ± 3
Control (Menan)	Mallard	Edible	^{241}Am	6 ± 2

Table 7-5. Radionuclide Concentrations Measured in Bats Collected in 2019.

Bat Tissue Concentrations (pCi/kg dry weight)			
Radionuclide	*Minimum*[a]	*Maximum*[b]	*Number of Detections*[c]
^{241}Am	ND[d]	ND	0
^{137}Cs	ND	5,530 ± 173	2
^{60}Co	618 ± 54	9,710 ± 297	2
^{238}Pu	ND	15.7 ± 3.4	1
^{239}Pu	ND	9.01 ± 2.98	1
^{90}Sr	ND	14,400 ± 84	2
^{65}Zn	ND	4,230 ± 517	1

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

Site operations and is most likely derived from worldwide fallout activity (DOE-ID 2014b). Soil was not sampled by the ESER contractor in 2019.

7.2.1 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 2019.

7.2.2 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 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 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 not sampled by the ESER contractor in 2019.

7.2.3 Onsite Soil Sampling Results

Onsite soils were not collected in 2019.

7.3 Direct Radiation

7.3.1 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 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 Core 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 Idaho State University 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 and 2019, the ESER contractor TLDs were prepared and read by EAL.

Dosimeter locations are shown in Figure 7-3. The sampling periods for 2019 were from November 2018–April 2019 and May 2019–October 2019.

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.

7.3.2 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. The ESER OSLDs are sent to the EAL for analysis. The INL OSLDs are 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 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 2019). 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).

7.3.3 Results

The ESER and INL contractor OSLD data measured at common locations around the INL Site in 2019 are shown in Table 7-6. Using OSLD data collected by both the ESER and INL contractors, the mean annual ambient dose was estimated at 122 mrem (1,220 uSv) for boundary and 121 mrem (1,210 uSv) for distant locations. The mean annual ambient dose for all locations combined is 122 mrem (1,220 uSv).

The 2019 direct radiation results and locations collected by the INL contractor at sitewide and regional locations are provided in Appendix C. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2019 reported values for field locations were primarily below the historic six-month UTL. Table 7-7 shows locations that exceeded the specific six-month UTL, which was calculated using results measured from 2009 through 2018. As discussed in Section 7.3.2, a result greater than the background level UTL does not necessarily mean that radiation levels have increased. It is anticipated that 5% of the measurements will exceed the background dose. Rather it indicates that the measurement should be compared to other values in the area and to historical data to provide context and determine if the results may require further action. The facility dosimeters which exceeded the background level UTL in 2019 are located at INTEC (see Figure C-4) and along Lincoln Boulevard south of INTEC (see Figure C-11). The Lincoln Boulevard dosimeter result was only slightly above the UTL and results measured by other dosimeters located along Lincoln Boulevard. For this reason, the Lincoln Boulevard result did not require further action. The INTEC results presented in Table 7-7 appear to follow a pattern of elevated measurements made at the four locations. These locations were added in 2015. The locations have consistently shown higher results, when compared to other locations at INTEC. The locations are near the perimeter of INTEC and the higher measurements are most likely because of operations in the area. The 2019 environmental dosimetry results were provided to the Radiation Control Department for their consideration.

Neutron monitoring is conducted around buildings in Idaho Falls where sources may emit or generate neutron radiation. In Idaho Falls, these buildings include the IF-675 Portable Isotopic Neutron Spectroscopy Laboratory, IF-670 Bonneville County Technology Center, and IF-638 Physics Laboratory. Additional neutron dosimeters are placed at INL Research Center along the south perimeter fence at location IF-IRC O-39, and at the background location Idaho Falls O-10. All neutron dosimeters collected in 2019 were reported as "M" (dose equivalents below the minimum measurable quantity of 10 mrem). The background level for neutron dose is zero and the current dosimeters have a detection limit of 10 mrem. Any neutron dose measured is considered present due to sources inside the building. The INL contractor follows the recommendations of the manufacturer to prevent environmental damage to the neutron dosim-

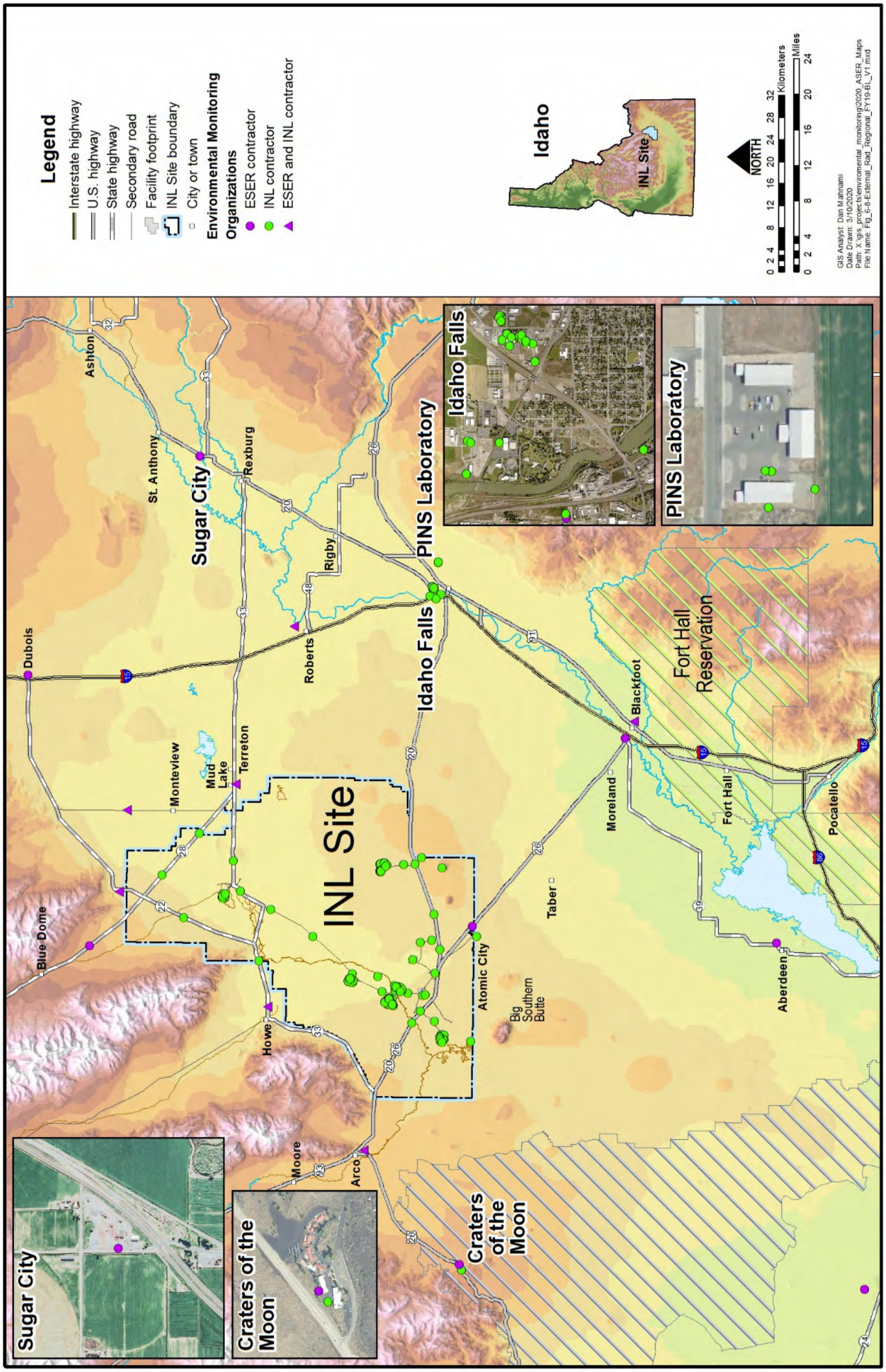


Figure 7-3. Regional Direct Radiation Monitoring Locations (2019).

Table 7-6. Annual Environmental Radiation Doses Using OSLDs at All Offsite Locations (2015–2019).

Location	2015		2016		2017		2018		2019	
	ESER[a]	INL Contractor[b]	ESER	INL Contractor	ESER	INL Contractor	ESER[c]	INL Contractor	ESER	INL Contractor
Distant										
Aberdeen	119	NA[d]	117	NA	120	NA	123	NA	134	NA
Blackfoot	114	NA	118	NA	112	NA	NA	NA	NA	NA
Craters of the Moon	115	125	113	118	116	125	118	132	122	116
Dubois	90	NA	103	NA	98	NA	103	NA	110	NA
Idaho Falls	113	124	122	113	110	119	118	126	134	114
IF-IDA	NA	109	NA	106	NA	106	NA	119	NA	106
Jackson	[e]	NA	[e]	NA	[e]	NA	109	NA	113	NA
Minidoka	99	NA	99	NA	102	NA	109	NA	118	NA
Mountain View[f]	102	114	107	115	102	110	110	125	116	113
Rexburg/Sugar City[g]	134	NA	151	NA	141	NA	151	NA	156	NA
Roberts[h]	117	135	132	122	119	124	130	145	134	133
Mean	109	116	118	115	113	117	119	129	126	116
Boundary										
Arco	113	125	114	121	111	122	122	134	127	118
Atomic City	119	117	122	128	117	122	122	132	135	122
Birch Creek Hydro[i]	98	108	108	107	93	94	110	119	114	110
Blue Dome	95	NA	103	NA	94	NA	106	NA	111	NA
Howe	105	[j]	111	101	109	115	119	129	121	119
Monteview	106	117	115	124	110	133	119	130	127	119
Mud Lake	63	135	132	129	117	131	132	143	131	130
Mean	111	112	115	118	107	120	119	131	124	120

Table 7-6. Annual Environmental Radiation Doses Using OSLDs at All Offsite Locations (2015–2019) (continued).

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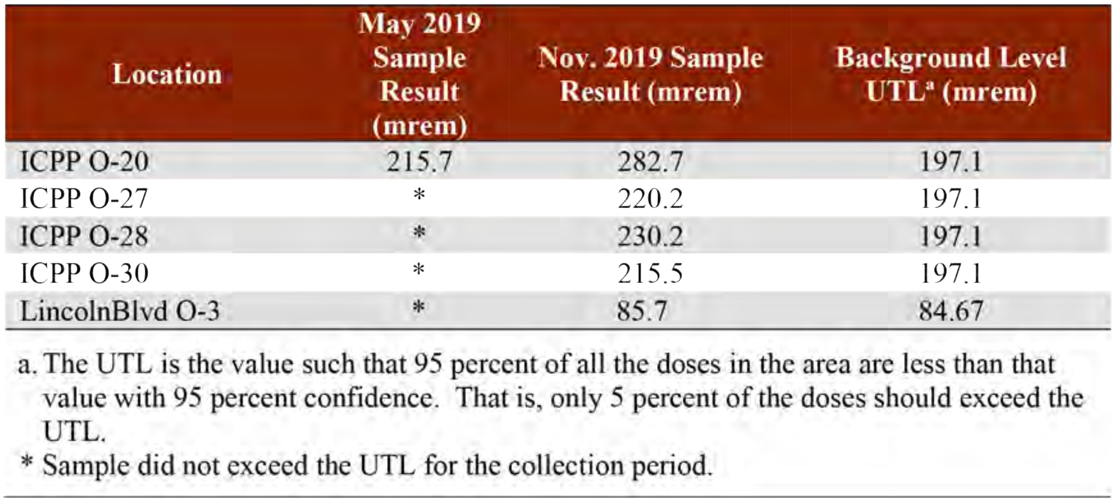
a. ESER = Environmental Surveillance, Education, and Research Program.
b. INL = Idaho National Laboratory.
c. The 2018 ESER OSLD results are approximately 10 mrem/yr higher than in previous years. This is due to the application of a revised standard control dose.
d. NA = Not applicable. The ESER or INL contractor does not sample at this location.
e. The Jackson location was not operating from May 2015 through January 2017 because a new location was identified and constructed during this period.
f. ESER has two locations at Blackfoot – one at Mountain View Middle School (MVMS) and one at Groveland, which is called "Blackfoot" by ESER. The INL has one OSL station at MVMS, which is called "Blackfoot." For the sake of consistency in this report, the MVMS site is called "Mountain View" for both ESER and the INL. The Blackfoot (Groveland) station was inadvertently removed by the Idaho Transportation personnel in early 2018 and is no longer used by ESER.
g. Dosimeter was moved to Sugar City in July 2013. The INL contractor ended surveillance at Rexburg/Sugar City in May 2015.
h. INL contractor calls this location RobNOAA.
i. INL contractor calls this location Reno Ranch.
j. Dosimeter was missing at collection time in May.

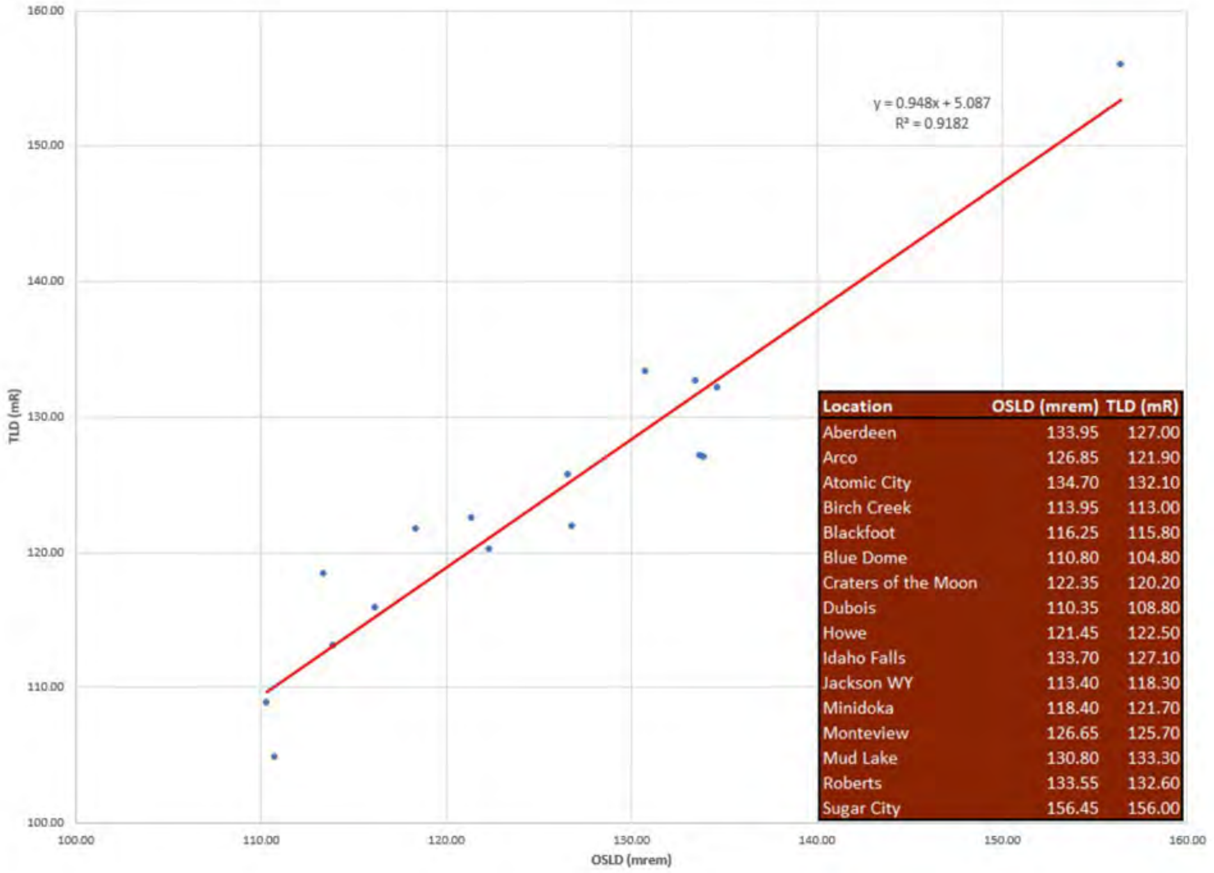
Table 7-7. Dosimetry Locations Above the Six-month Background Upper Tolerance Limit (2019).



Location	May 2019 Sample Result (mrem)	Nov. 2019 Sample Result (mrem)	Background Level UTL[a] (mrem)
ICPP O-20	215.7	282.7	197.1
ICPP O-27	*	220.2	197.1
ICPP O-28	*	230.2	197.1
ICPP O-30	*	215.5	197.1
LincolnBlvd O-3	*	85.7	84.67

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.

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



Location	OSLD (mrem)	TLD (mR)
Aberdeen	133.95	127.00
Arco	126.85	121.90
Atomic City	134.70	132.10
Birch Creek	113.95	113.00
Blackfoot	116.25	115.80
Blue Dome	110.80	104.80
Craters of the Moon	122.35	120.20
Dubois	110.35	108.80
Howe	121.45	122.50
Idaho Falls	133.70	127.10
Jackson WY	113.40	118.30
Minidoka	118.40	121.70
Monteview	126.65	125.70
Mud Lake	130.80	133.30
Roberts	133.55	132.60
Sugar City	156.45	156.00

Figure 7-4. Comparison of TLD Versus OSLD Results Measured by ESER in 2019.

Table 7-8. Calculated Effective Dose from Natural Background Sources (2019).

Source of Radiation Dose	Total Average Annual Dose	
	Calculated (mrem)	Measured[a] (mrem)
External Irradiation		
Terrestrial	68[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	125	122
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	382	NM

a. Calculated from the average annual external exposure at all offsite locations measured using OSLDs (see Table 7-6).
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.

etry by wrapping each in aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed.

The 2019 ESER TLD data are shown in Figure 7-4. The TLD results demonstrate a strong linear relationship ($r^2 = 0.92$) with the 2019 ESER OSLD results, indicating a good correlation (Figure 7-4). 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 respond in a similar fashion to penetrating radiation fields in the field. TLDs will continue to be deployed in 2020 in order to gain additional insight and increase confidence in the data.

Table 7-8 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, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snowcover 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 2019, this resulted in a reduction in the effective dose from soil to a value of 68 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 2019 was estimated to be 125 mrem/yr. This is similar to the 122 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 2019.

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 member of the public from ^{238}U plus decay products is short-lived decay products of radon (NCRP 2009). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of soil and rock in the area. The amount of radon also varies among buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-8 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 these contributions, the total background dose to an average individual living in southeast Idaho was estimated to be approximately 382 mrem/yr (Table 7-8). This value was used in Table 8-6 to calculate background radiation dose to the population living within 50 mi of INL Site facilities.

7.4 Waste Management Surveillance Sampling

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

7.4.1 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 7-5). Russian thistle was collected in even-numbered years. Crested wheatgrass and rabbitbrush were collected in odd-numbered years. In 2018, the ICP Core 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.

7.4.2 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; these guidelines 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 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.

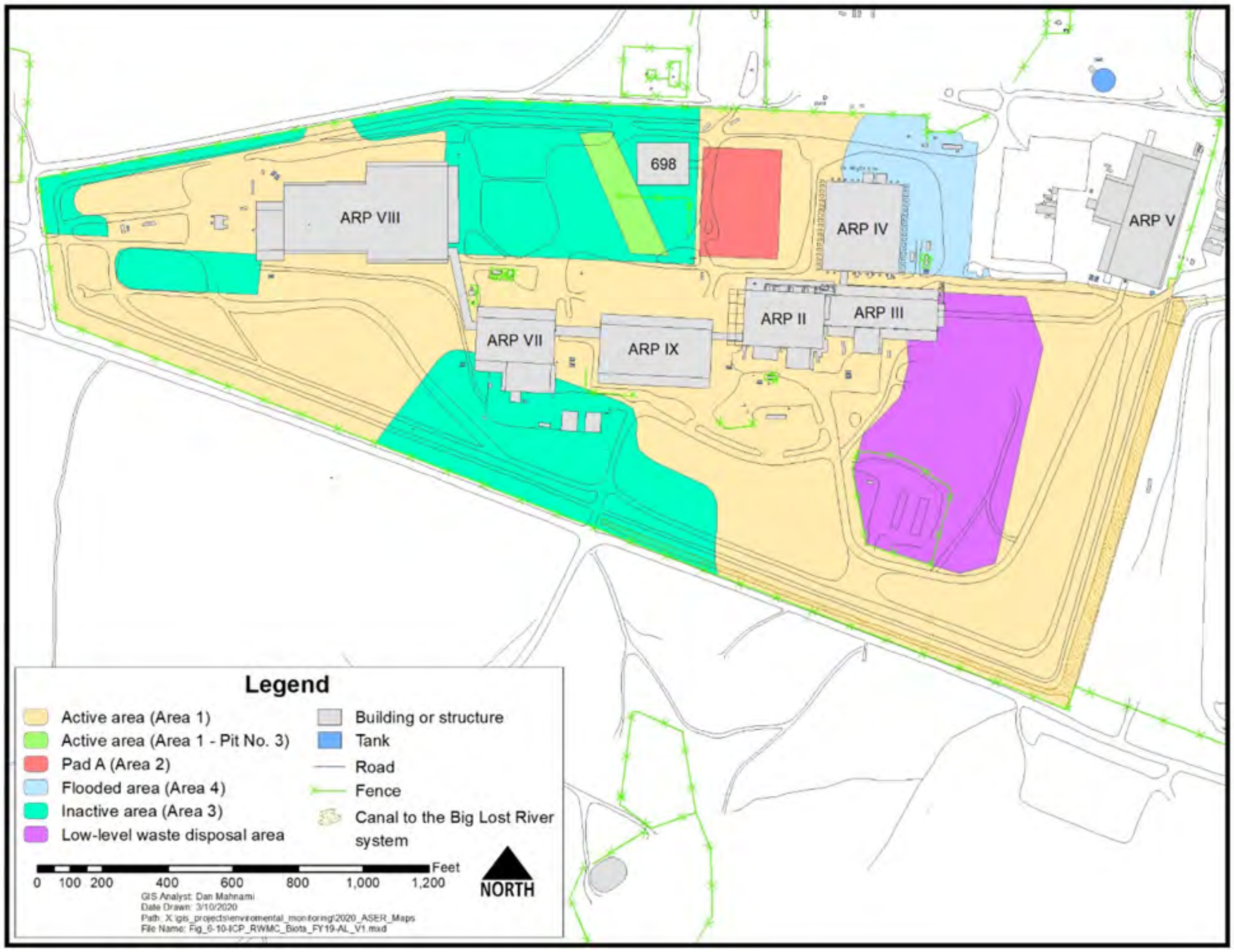


Figure 7-5. Historical Vegetation Sampling Areas at the RWMC.

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.

7.4.3 Surface Radiation Survey at the Radioactive Waste Management Complex and the Idaho CERCLA Disposal Facility

Surface radiation surveys are performed to characterize gamma radiation levels near the ground surface at waste management facilities. Comparing the data from these surveys year to year helps to determine whether radiological trends exist in specific areas. This type of survey is conducted at the RWMC SDA and at the 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 2019, in comparison to previous years.

Figure 7-6 shows a map of the area that was surveyed at RWMC in 2019. 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 2019 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 measurements from the buried waste in pits and trenches are more visible. Average background values near or around areas that were radiometrically scanned were generally at or below 4,000 counts per second. Most of the 2019 RWMC gross gamma radiation measurements were at or near background levels. The 2019 maximum gross gamma radiation measurement on the SDA was 97,256 counts per second, as compared to the 2018 measurement

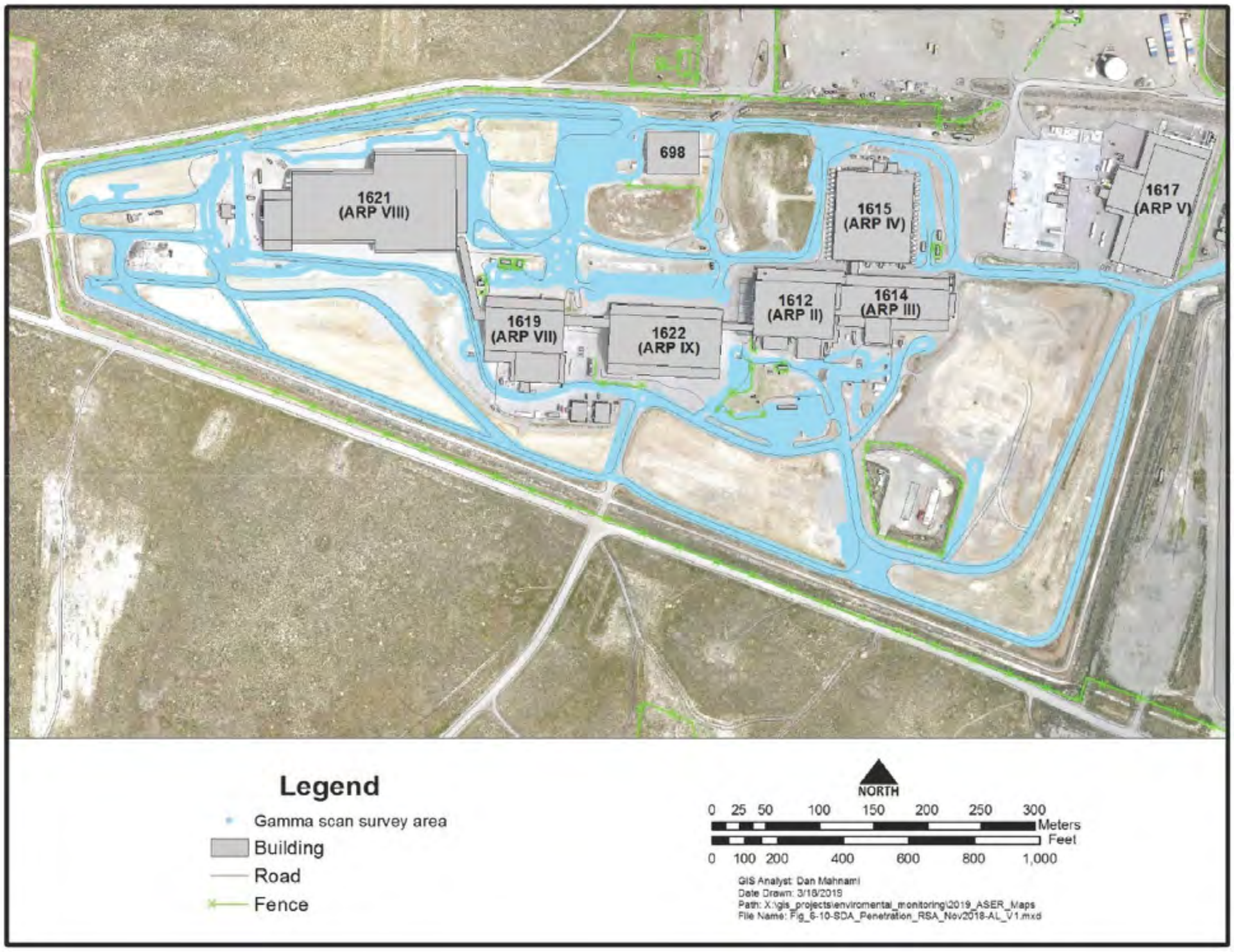


Figure 7-6. SDA Surface Radiation Survey Area (2019).

of 92,572 counts per second. In previous years, maximum readings were measured in a small area at the western end of the soil vault row SVR-7, but measurements were lower for this location in 2019. The maximum readings in 2019 were observed directly west of ARP VII (WMF-1619). This is likely attributed to waste operations and storage within that facility.

The area that was surveyed at the ICDF is shown in Figure 7-7. 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 2019, the readings were either at background levels or slightly above background levels (approximately 3,000 counts/second), which is expected until the facility is closed and capped.

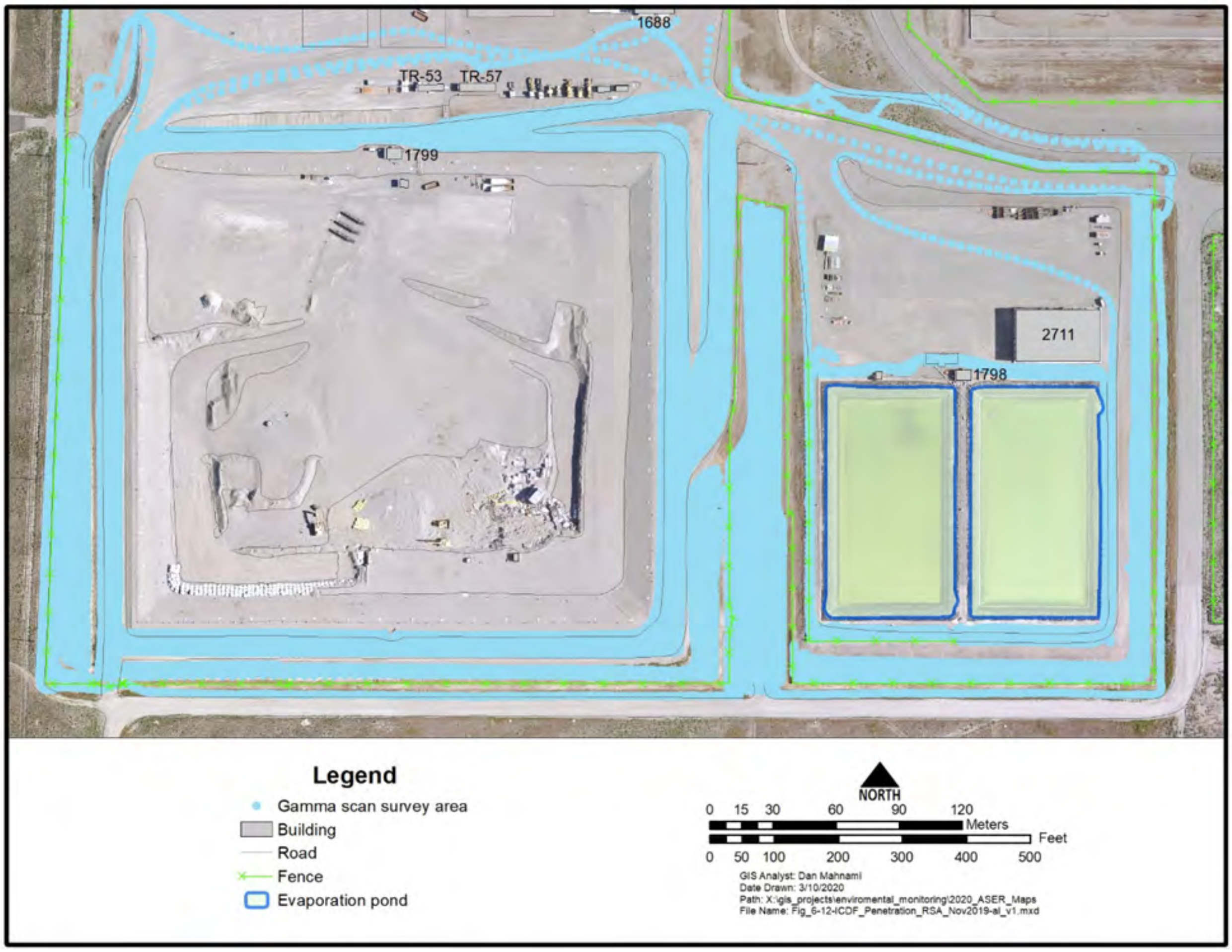


Figure 7-7. Idaho CERCLA Disposal Facility Surface Radiation Survey Area (2019).

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8. DOSE TO THE PUBLIC AND BIOTA


Sand Dock (*Rumex venosus*)

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 in 2019, as determined by this program, was 0.056 mrem (0.56 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 2019. The maximum potential dose to an individual who consumes the waterfowl (i.e., duck) was calculated to be 0.004 mrem (0.04 µSv). The total dose (via air and ingestion) estimated to be received by the maximally exposed individual during 2019 was thus 0.06 mrem (0.6 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 342,761 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 2019, the estimated potential population dose was 4.79×10^{-2} person-rem (4.79×10^{-4} person-Sv). This dose is approximately 0.00004 percent of that expected from exposure to natural background radiation of 130,935 person-rem (1,309 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 U.S. Department of Energy limits for biota.

8.0 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.

This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2019 environmental monitoring measurements or calculated emissions.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 4-1).

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.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released or could potentially be released by the facilities. The 2019 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2020) reported potential radionuclide releases from 67 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. Emissions from five 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), the Experimental Breeder Reactor-II main stack (MFC-764), and the Transient Reactor Test Facility (TREAT) stack. 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 stacks, ducts and vents and fugitive releases from ponds, soil, or other sources. Figure 8-1 shows the location of all sources modeled in the dose assessment. Releases from the Radiological Response Training Range–Northern Test Range (RRTR-NTR) were assumed collocated with releases from Specific Manufacturing Capability (SMC). Releases from the TREAT stack 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 4-2 and summarized in Table 8-1. The category of noble gases comprised the largest emission quantity, but only contributed slightly to the dose. 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 to the maximally exposed individual (MEI) were cesium-137 (^{137}Cs), uranium-238 (^{238}U), uranium-234 (^{234}U), chlorine-36 (^{36}Cl), zinc-65 (^{65}Zn), and tritium (^{3}H). These radionuclides are 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 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 (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

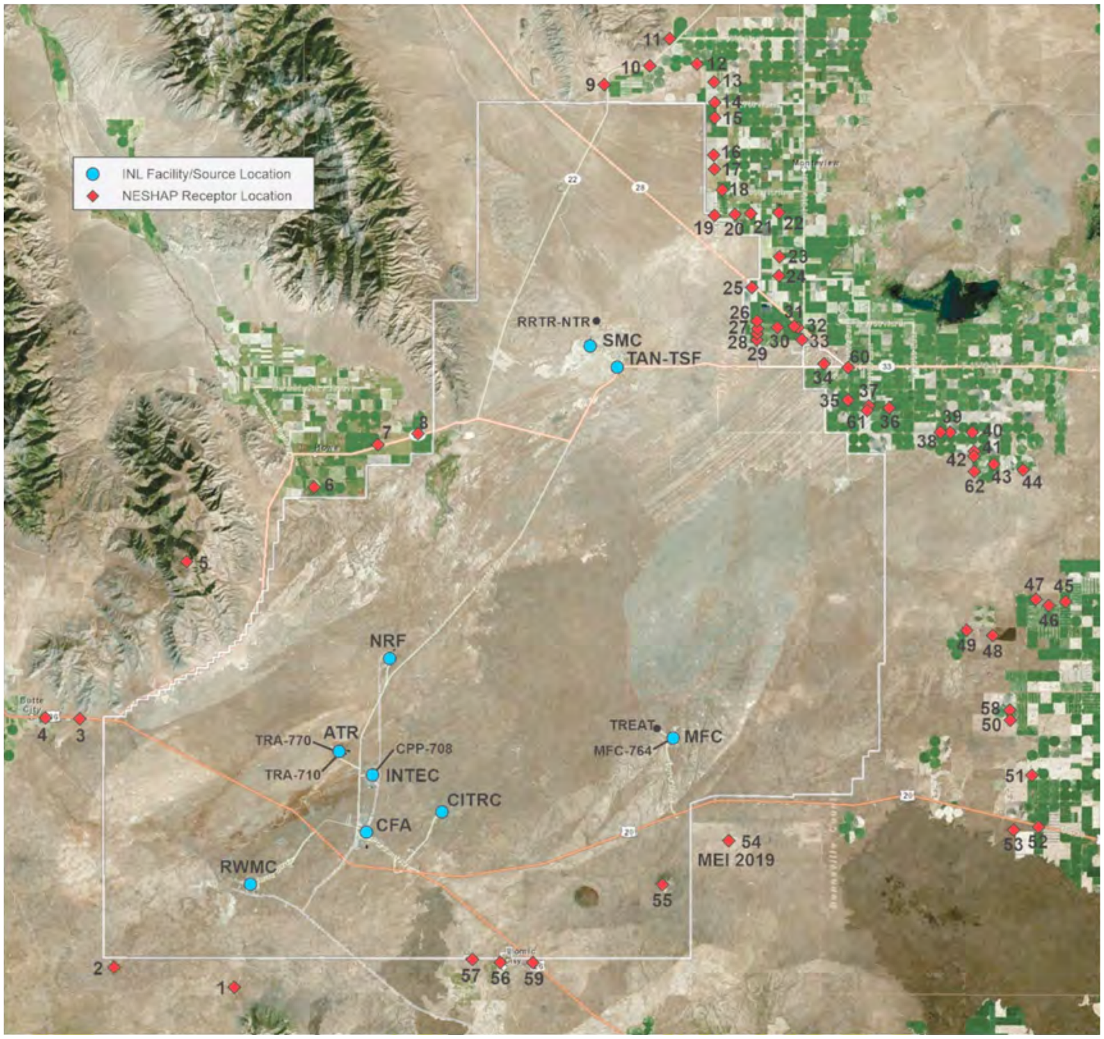


Figure 8-1. INL Site Major Facility Airborne Source Locations.
TRA-770, TRA-710, CPP-708, TREAT and MFC-764 were modeled as stack releases. The remaining sources were modeled as ground-level releases. Releases from RRTR-NTR were assumed collocated with releases from SMC. Releases from TREAT were assumed collocated with releases from MFC. Sixty-two specific receptor locations, including the Maximally Exposed Individual, modeled by CAP88-PC are also shown.

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 4-1). 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).

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAP regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (40 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

Table 8-1. Summary of Radionuclide Composition of INL Site Airborne Effluents (2019).

	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	3.89E+02	1.48E-19	8.65E+02	1.88E-01	1.92E-02	7.17E-05	2.35E-02	1.75E-09	8.46E-06	2.83E-05	3.12E-10
CFA	6.49E-01	1.67E-08	6.27E-03	5.20E-06	2.24E-07	3.38E-09	1.52E-09	4.37E-08	3.06E-09	1.61E-08	-
CITRC	-	5.00E+01	-	4.00E-06	7.28E-04	2.19E-05	-	4.07E-05	-	-	-
INTEC	1.76E-01	1.09E+00	-	-	1.47E-04	7.37E-04	9.11E-06	3.00E-07	2.24E-11	5.68E-06	-
MFC	3.66E-01	6.74E-02	2.25E+02	9.05E+00	1.14E+00	9.06E-02	3.87E-06	1.90E-01	9.93E-07	8.08E-09	-
NRF	1.60E-02	8.40E-02	-	-	5.70E-01	3.91E-05	5.00E-05	-	2.80E-06	-	
RWMC	5.93E+01	-	-	-	1.12E-01	-	1.42E-08	3.84E-09	1.03E-05	4.42E-05	-
TAN	3.26E-02	4.64E-06	1.18E-10	6.95E-11	8.56E+00	-	1.02E-06	7.51E-08	-	-	-
Total	**4.50E+02**	**5.12E+01**	**1.09E+03**	**9.24E+00**	**1.04E+01**	**9.14E-02**	**2.36E-02**	**1.90E-01**	**2.25E-05**	**7.81E-05**	**3.12E-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 2019 = ^{39}Ar, ^{42}Ar, ^{81}Kr and ^{85}Kr (^{39}Ar, ^{42}Ar and ^{81}Kr release is negligible).

[d] Noble gases ($T_{1/2} < 40$ days) released in 2019 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{89}Kr, ^{90}Kr, ^{91}Kr, ^{92}Kr, ^{220}Rn, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, ^{137}Xe, ^{138}Xe, ^{139}Xe and ^{140}Xe.

[e] Fission products and activation products ($T_{1/2} < 3$ hours) released in 2019 = ^{106}Ag, ^{109m}Ag, ^{110}Ag, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{83}Br, ^{60m}Co, ^{138}Cs, ^{139}Cs, ^{140}Cs, ^{68}Ga, ^{142}La, ^{56}Mn, ^{97}Nb, ^{65}Ni, ^{144}Pr, ^{88}Rb, ^{89}Rb, ^{90}Rb, ^{91}Rb, ^{92}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{81m}Se, ^{129}Te, ^{91m}Y and ^{69}Zn.

[f] Fission products and activation products ($T_{1/2} > 3$ hours) released in 2019 = ^{108m}Ag, ^{110m}Ag, ^{111}Ag, ^{112}Ag, ^{76}As, ^{77}As, ^{133}Ba, ^{140}Ba, ^{10}Be, ^{7}Be, ^{207}Bi, ^{210}Bi, ^{210m}Bi, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{113}Cd, ^{113m}Cd, ^{115}Cd, ^{115m}Cd, ^{139}Ce, ^{141}Ce, ^{142}Ce, ^{143}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{135}Cs, ^{137}Cs, ^{64}Cu, ^{67}Cu, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{157}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{72}Ga, ^{153}Gd, ^{68}Ge, ^{71}Ge, ^{175}Hf, ^{178m}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{115}In, ^{115m}In, ^{192}Ir, ^{194}Ir, ^{40}K, ^{42}K, ^{140}La, ^{141}La, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{95m}Nb, ^{144}Nd, ^{147}Nd, ^{59}Ni, ^{63}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{210}Pb, ^{107}Pd, ^{109}Pd, ^{147}Pm, ^{149}Pm, ^{151}Pm, ^{210}Po, ^{143}Pr, ^{145}Pr, ^{86}Rb, ^{87}Rb, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{105}Rh, ^{103}Ru, ^{105}Ru, ^{106}Ru, ^{35}S, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{126}Sb, ^{127}Sb, ^{46}Sc, ^{79}Se, ^{32}Si, ^{147}Sm, ^{151}Sm, ^{153}Sm, ^{113}Sn, ^{119}Sn, ^{121}Sn, ^{121m}Sn, ^{123}Sn, ^{125}Sn, ^{126}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{161}Tb, ^{99}Tc, ^{99m}Tc, ^{123m}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, ^{93}Zr, ^{95}Zr and ^{97}Zr.

[g] Radioiodine released in 2019 = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I.

[h] Radiostrontium released in 2019 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr.

[i] Uranium isotopes released in 2019 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U and ^{238}U.

[j] Plutonium isotopes released in 2019 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu.

[k] Other actinides released in 2019 = ^{241}Am, ^{243}Am, ^{249}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{237}Np, ^{239}Np, ^{233}Pa, ^{234}Pa, ^{234m}Pa, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th and ^{234}Th.

[l] Other = radioisotopes of elements that are not noble gases, activation or fission products, radioiodine, radiostrontium, or actinides released in 2019. These are typically heavy elements that are decay chain members of actinides. ^{226}Ra was the only one in 2019.

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 2019 INL Report for Radionuclides (DOE-ID 2020). In order to identify the MEI, the doses at 62 offsite locations (see Figure 8-1) 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 location was determined to be location 54, a farmhouse and cattle operation located 3.1 km south of Highway 20, 3 km from INL Site's east entrance. This is different from the MEI location for the past several years which was location 1 (a.k.a. Frenchman's Cabin), located 2.3 km south of the INL boundary, south of RWMC. Although the dose in 2019 was slightly higher at location 55 (East Butte) than location 54, location 55 does not currently qualify as a NESHAP receptor location. Privately owned communication (TV, radio, cell) towers are located on top of East Butte, but there are no dwellings or places of business and the site is visited only occasionally by maintenance workers. Nevertheless, doses are calculated at this point should the occupancy situation change. An effective annual dose of 0.0559 mrem (0.559 µSv) was calculated for a hypothetical person living at location 54 during 2019. The 2019 dose at the former MEI (location 1) was 0.022 mrem/yr and it was the 8th highest receptor location in terms of dose.

Figure 8-2 compares the maximum individual doses calculated for years 2010–2019. 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 during the past ten years was in 2010.

Although noble gases were the radionuclides released in the largest quantities, they accounted for less than 1% of the cumulative MEI dose from all pathways (affecting immersion only) largely because of their relatively short half-lives and because they only affect the immersion dose (i.e., they are excluded from the food supply). For example, about 55% of the total INL activity released was argon-41 (^{41}Ar) (Table 4-2), yet ^{41}Ar ac-

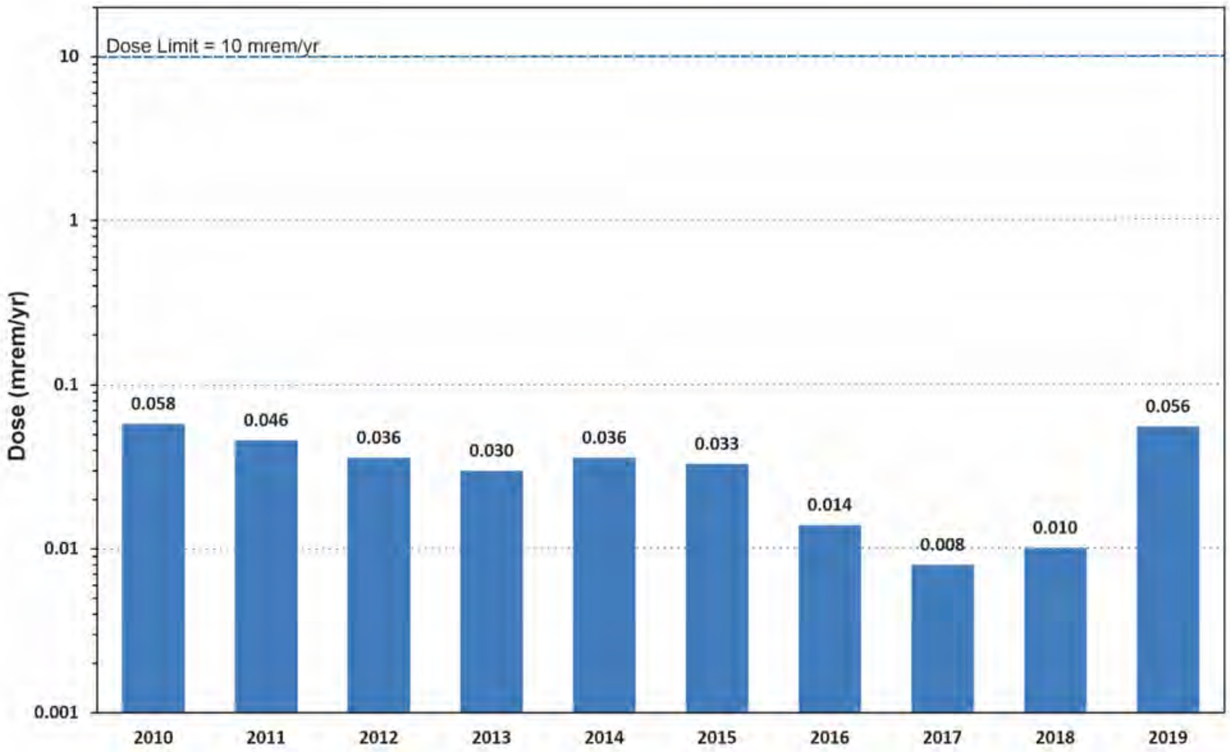


Figure 8-2. MEI Dose from INL Site Airborne Releases Estimated for 2010–2019.

counted for less than 1% of the estimated MEI dose. In contrast, radionuclides typically associated with airborne particulates, such as ^{137}Cs, ^{238}U, ^{234}U, ^{36}Cl and ^{65}Zn, comprised only a small fraction (less than 0.04% of the total amount of radionuclides reported to be released (Table 4-2) yet resulted in approximately 93.7% of the estimated MEI dose (Figure 8-3). The dose from ^{137}Cs (half-life 30.2 years) comes largely from deposition on the ground where it can enter the food chain and is a source of direct radiation. The direct radiation comes from gamma photons emitted from the short-lived decay product barium-137m. Uranium-234 and ^{238}U are isotopes of natural uranium with half-lives of 245,500 years and 4.5 billion years, respectively. During decay both isotopes emit alpha particles which are less penetrating than other forms of radiation, and ^{238}U emits a weak gamma ray. As long as it remains outside the body, uranium poses little health hazard, mostly from the gamma-rays. If inhaled or ingested, the radioactivity poses increased risks of cancer due to alpha particle emissions. Chlorine-36 also has a very long half-life that decays by emitting a relatively low-energy beta particle and a small amount of gamma radiation that poses a hazard only if ingested. Zinc-65 is the longest-lived zinc radioisotope with a half-life of 244 days. Zinc-65 causes direct radiation dose and dose from inhalation and ingestion.

Primary sources of the major radionuclides used to estimate the dose to the MEI (Figure 8-4) were identified during preparation of the annual NESHAP report (DOE-ID 2020) as follows:

- The largest dose contribution was from ^{137}Cs (56.2%) and the majority came from the Radiochemistry Laboratory (MFC-1702) located at MFC.
- ^{238}U and ^{234}U account for 20.1% and 7.7% of the MEI dose respectively and most came from the Advanced Fuel Facility (MFC-784) at MFC.
- ^{36}Cl and ^{65}Zn account for 6.3% and 3.4% of the MEI dose respectively and the majority came from the Electron Microscopy Laboratory (MFC-774) at MFC.
- Tritium accounts for only 2% of the MEI dose with 50% coming from beryllium blocks at RWMC, 49.1% from the ATR Complex, and the rest from CFA and MFC.

The largest contribution by facility to the MEI came overwhelmingly from MFC at 96%, followed by ATR Complex at 2.2%, and RWMC at 1.1%. This is expected for location 54. Primary wind directions at the INL Site are from the SW and NE directions and thus emissions from TAN, NRF, INTEC, ATR and RWMC are off axis from a receptor near MFC.

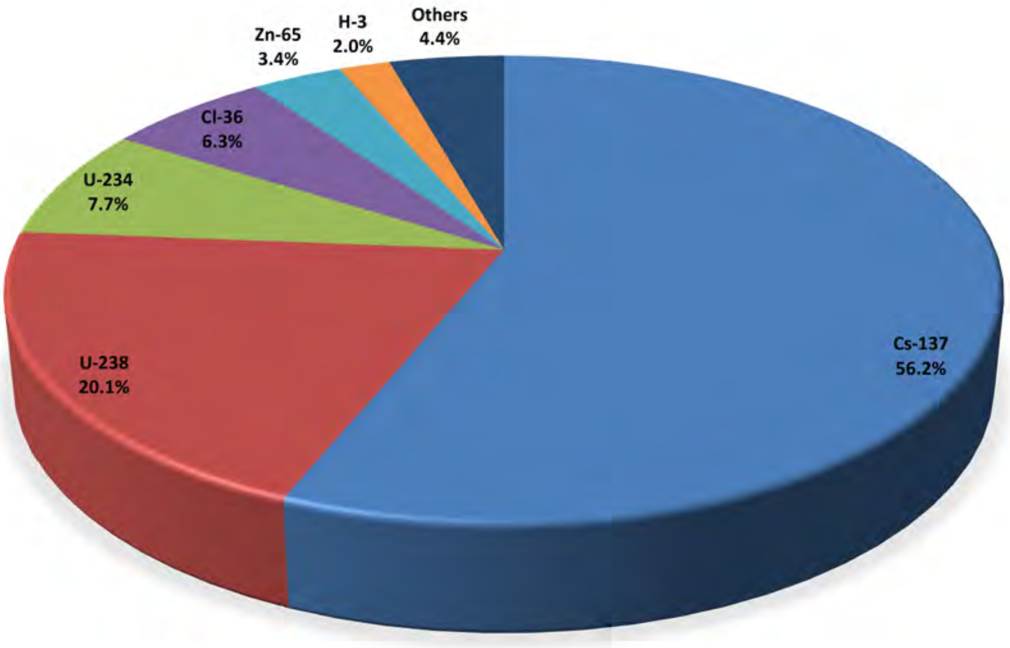


Figure 8-3. Radionuclides Contributing to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2019).

The primary reason for the dose increase in 2019 and the shift of the MEI from location 1 to location 54 is increased emissions from MFC and specifically the increase in ^{137}Cs emissions from the Radiochemistry Laboratory (MFC-1702). Cesium-137 emissions from MFC-1702 increased 322% from 2018 to 2019, and the MEI dose increased 460%. Although the dose increased in 2019, the MEI dose of 0.056 mrem/year is still far below the regulatory standard of 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H) and less than the maximum dose over the past 10 years (0.058 mrem/yr, 2010).

8.2.2 Eighty Kilometer (50 Mile) Population Dose

Total effective population dose from airborne releases was calculated using air dispersion modeling performed by the 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 8-5). 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 2020). 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 (Tables 8-2 and 8-3). For Idaho Falls facilities, radionuclides that result in a dose greater than 0.1% of the total dose at the MEI in Idaho Falls were included. The radionuclide source terms used for the modeling are shown in Table 8-4.

During 2019, 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

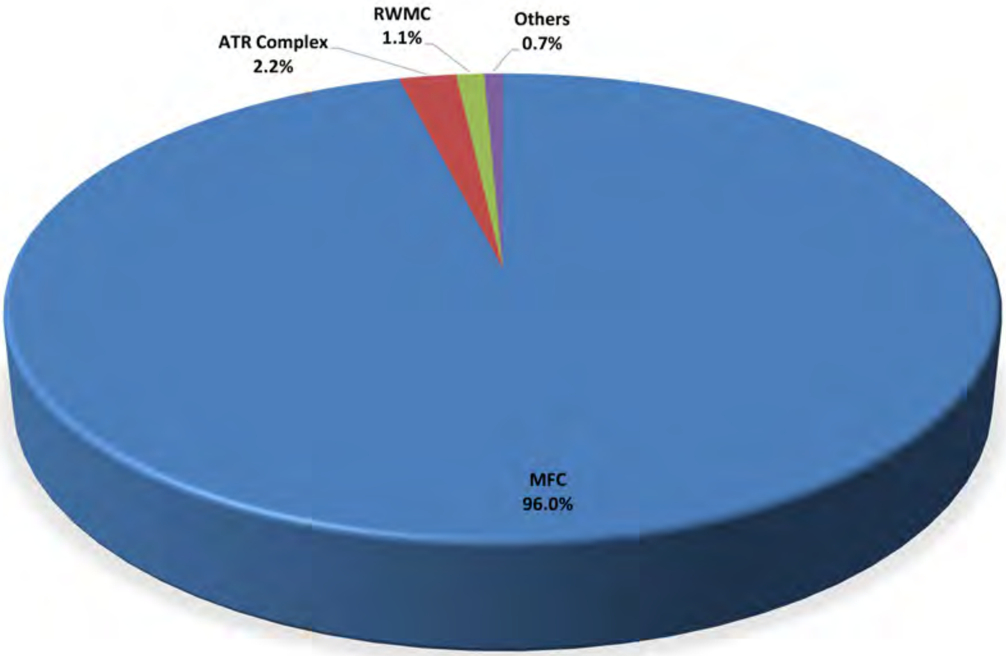


Figure 8-4. Percent Contributions, by Facility, to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2019).

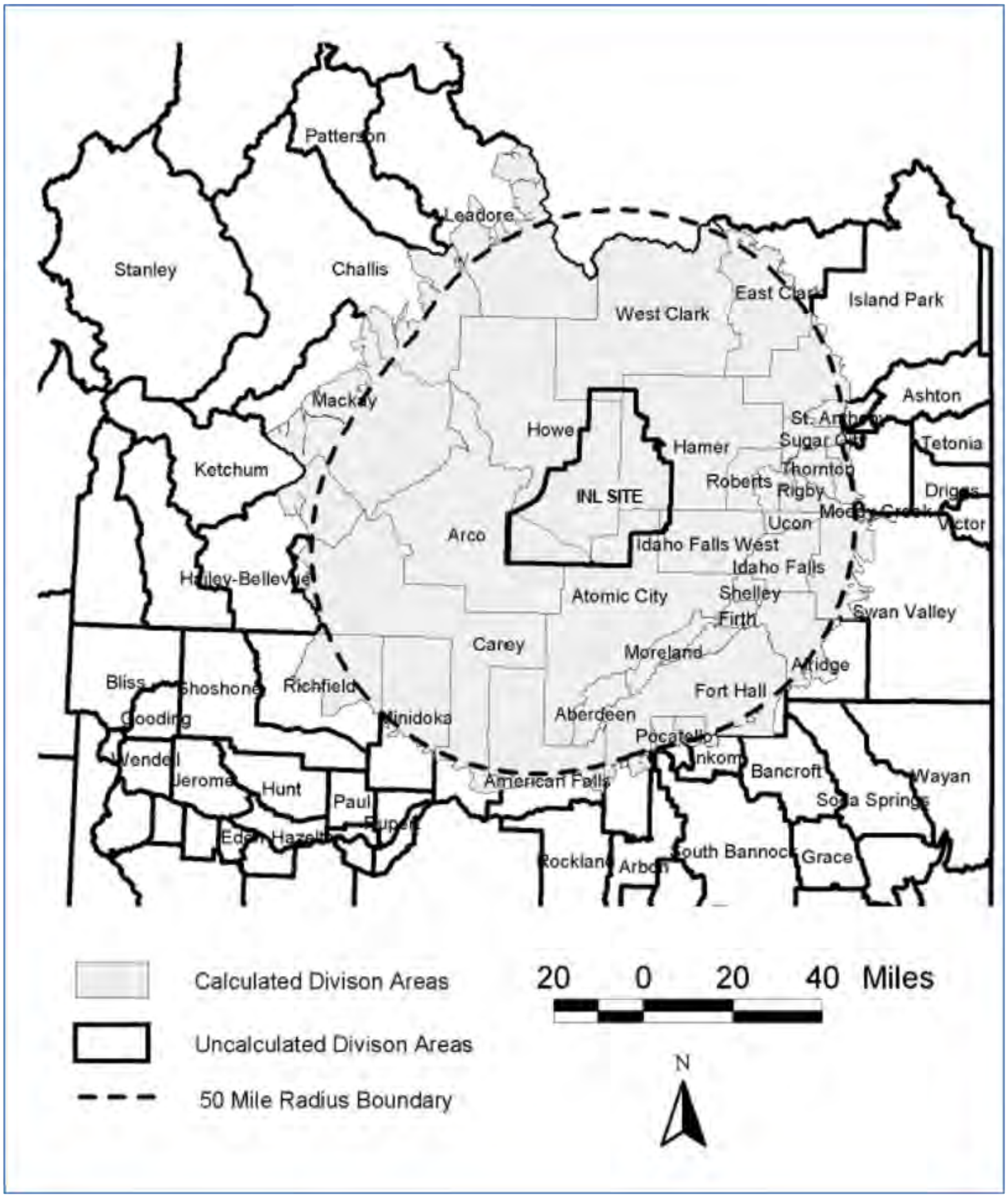


Figure 8-5. Region within 80 Kilometers (50 miles) of INL Site Facilities. Census Divisions used in the 50-mile population dose calculation are shown.

by the HYSPLIT model using hourly averaged observations from the meteorological stations throughout 2019 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 around the INL Site. The Cartesian grid was designed to encompass the region within 80 km (50 mi) of INL Site facilities (Figure 8-5). In addition, 27 boundary receptor locations, representing actual residences around the INL Site, were included in the modeling. These 27 receptor locations are a subset of the 62 receptor locations used for the NESHAP evaluation (compare Figure 8-1 and 8-6).

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).

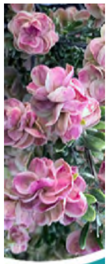


Table 8-2. Particulate Radionuclide Source Term (Ci yr-1) for Radionuclide-facility Combinations that Contributed Greater than 0.1% of the Total Dose for INL Site Facilities[a] at the MEI Location.

	Radionuclides[b]									
Source	Br-82	Cs-115m	Cl-36	Co-60	Cs-137	Sr-90	U-234	U-235	U-238	Zn-65
ATR	2.28E-04			8.21E-03	5.70E-03	2.35E-02	2.64E-13	4.15E-12	7.79E-10	1.05E-05
ATR-ATRC				5.73E-06	3.81E-05	3.27E-08				
ATR-MTR				6.74E-10	5.70E-11		1.40E-10	1.02E-11	7.73E-10	9.45E-10
CFA		6.57E-19	7.73E-12	2.11E-08	2.29E-09	1.21E-09	5.95E-09	2.26E-10	3.55E-10	9.00E-11
CITRC								5.30E-07	4.02E-05	
INTEC			4.37E-07	5.14E-14	4.51E-05	9.11E-06	1.69E-07	9.31E-09	1.20E-07	1.20E-16
INTEC-MS					5.99E-10	5.49E-10				
MFC		6.79E-01	7.19E-03	1.97E-12	2.61E-01	1.96E-06	5.88E-02	2.01E-03	1.29E-01	1.60E-01
MFC-MS						1.27E-07				
MFC-TREAT						1.78E-06				
NRF				1.00E-07	7.70E-05	5.00E-05				
RWMC				7.75E-06	7.75E-17	1.42E-08		8.77E-11	3.75E-09	
SMC	8.33E+00		2.20E-09				1.13E-08	7.93E-10	6.30E-08	3.47E-08
TAN-TSF						1.02E-06				
Total (Ci yr^{-1})	**8.33E+00**	**6.79E-01**	**7.19E-03**	**8.22E-03**	**2.67E-01**	**2.36E-02**	**5.88E-02**	**2.01E-03**	**1.29E-01**	**1.60E-01**

a. ATR = Advanced Test Reactor, ATRC = 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, MS = main stack, MTR = Material Test Reactor, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), SMC = Specific Manufacturing Capability, TAN = Test Area North (including Technical Support Facility), TREAT = Transient Reactor Test Facility

b. Br = bromine, Cl = chlorine, Co = cobalt, Cs = cesium, Sr = strontium, U = uranium, Zn = zinc

Table 8-3. Noble Gases, Iodine, Tritium and Carbon-14 Source Term (Ci yr-1) for Radionuclide-facility Combinations that Contributed Greater than 0.1% of the Total Dose for INL Site Facilities[a] at the MEI Location.

				Radionuclides[b]			
Source	Ar-41	Kr-88	Xe-138	C-14	H-3	I-129	I-131
ATR	5.40E-05	2.28E-03	1.18E-04	4.32E-10	1.03E+02	3.92E-14	1.26E-05
ATR-ATRC	8.03E+02	1.82E+00	2.97E+01		2.86E+02		2.54E-06
ATR-MTR				1.35E-14	8.96E-01		
CFA	4.70E-05	1.50E-05	5.90E-05	2.03E-09	6.49E-01	1.54E-15	4.37E-10
CITRC				7.22E-04		2.19E-05	
INTEC				1.01E-04	1.75E-01	7.33E-04	
INTEC-MS					1.28E-03	3.92E-06	
MFC					3.66E-01	5.54E-04	9.00E-02
MFC-TREAT	8.14E+01	9.58E+00	1.63E-01				
NRF				5.70E-01	1.60E-02	3.40E-05	5.10E-06
RWMC				1.12E-01	5.93E+01		
SMC	7.06E-11						
Total (Ci yr^{-1})	**8.84E+02**	**1.14E+01**	**1.93E+01**	**6.83E-01**	**4.50E+02**	**1.35E-03**	**9.00E-02**

a. ATR = Advanced Test Reactor, ATRC = 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, MS = main stack, MTR = Material Test Reactor, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), SMC = Specific Manufacturing Capability, TAN = Test Area North (including Technical Support Facility), TREAT = Transient Reactor Test Facility

b. Ar = argon, C = carbon, H-3 = tritium, I = iodine, Kr = krypton, Xe = xenon

Table 8-4. Radionuclide Source Term (Ci yr–1) for Radionuclides that Contributed Greater than 0.1% of the Total Dose for INL In-town Facilities[a] (2019).

Radionuclide[b]	IF-603	IF-611	IF-683 (RESL)	Annual Release (Ci yr^{-1})
Ac-227			5.75E-09	5.75E-09
Am-241			1.03E-07	1.03E-07
Am-243			1.04E-09	1.04E-09
Ba-133			4.09E-07	4.09E-07
Co-60	2.88E-11		1.50E-07	1.51E-08
Cs-134	1.17E-06		3.50E-08	1.20E-06
Cs-137	2.49E-07		7.51E-08	3.24E-07
Eu-152			4.98E-08	4.98E-08
Eu-154	1.81E-10		9.00E-08	9.02E-08
H-3			1.69E-07	1.69E-07
I-125		1.00E-03	3.81E-09	1.00E-03
Pa-231			1.15E-09	1.15E-09
Pu-238			7.96E-08	7.96E-08
Pu-239			1.32E-07	1.32E-07
Ra-226			7.53E-08	7.53E-08
Sr-90			7.38E-08	7.38E-08
U-232			3.24E-08	3.24E-08
U-233			1.64E-07	1.64E-07
Xe-133	4.05E-01	1.29E-04		4.05E-01

a. All three sources are located at the INL Research Center and were assumed to be released from the Radiological and Environmental Sciences Laboratory (RESL) stack location.

b. Ac = actinium, Am = americium, Ba = barium, Co = cobalt, Cs = cesium, Eu = europium, H-3 = tritium, I = iodine, Pa = protactinium, Pu = plutonium, Ra = radium, Sr = strontium, U = uranium, Xe = xenon

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/m^3. The deposition factor was calculated by dividing the total deposition (Ci/m^2) by the release time (seconds) and then by the unit release rate (1 Ci/s) to yield deposition factors in units in 1/m^2. Dispersion and deposition factors were calculated for each month of the year and were read into DOSEMM along with the annual radionuclide release rates from each source. Although annual release quantities were provided, monthly release quantities could have been used if available to account for seasonal variations in atmospheric dispersion.

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 8-6 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 value from 0.0008 to 0.8 mrem (0.008 to 8 µSv). The

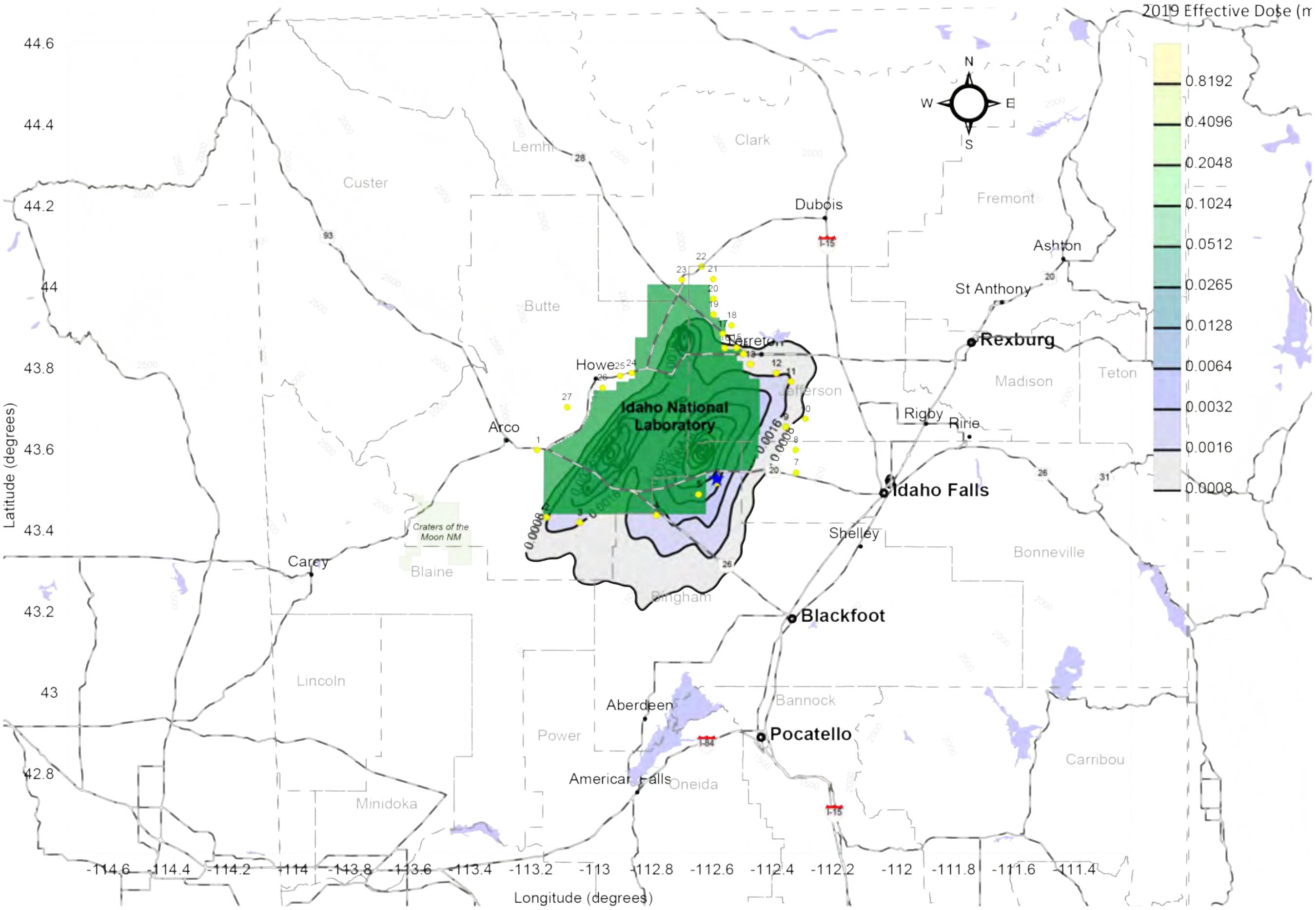


Figure 8-6. Effective Dose (mrem) Isopleth Map with Boundary Receptor Locations Displayed (2019). The 27 boundary receptor locations are depicted as yellow circles. The maximum receptor dose is projected at receptor 6, a farmhouse and cattle operation (depicted as a blue star east of the INL east entrance). This is the same location as receptor 54 in Figure 8-1.

highest dose to an INL Site boundary receptor was estimated to be 0.01 mrem at a farmhouse and cattle operation (Receptor location 6, same as Receptor location 54 in Figure 8-1). The farmhouse and cattle operation is also the location of the MEI used for the NESHAP dose assessment in 2019, which reported an estimated dose of 0.06 mrem (0.6 µSv) to the MEI (see Section 8.2.1). The lower dose of the HYSPLIT/DOSEMM model is mostly attributed to the generally lower HYSPLIT dispersion factors when compared to those from CAP88. The HYSPLIT dispersion factors reflect differences in plume trajectory, turbulent diffusion, terrain complexities, plume depletion and sector averaging between the HYSPLIT and CAP88 models. The lowest dose (0.00007 mrem [0.0007 µSv]) was estimated at Receptor location 3 located west of the INL Site along Highway 20/26, east of Butte City.

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 2019. 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 8-5. These doses were then summed over all census divisions to result in the 80-km (50-mi) population dose (Table 8-5). The estimated potential population dose was 4.79 x 10^{-2} person-rem (4.79 x 10^{-4} person-Sv) to a population of approximately 342,761. When compared with the approximate population dose of 130,935 person-rem (1,309 person-Sv) estimated to be received from natural background radiation (Table 8-6), this represents an increase of about 0.00004 percent. The largest collective doses were in the Atomic City census division due to its proximity to the INL Site and Idaho Falls census division due its large population size and the inclusion of the dose from in-town facilities.

The estimated population dose for 2019 is higher than that calculated for 2018 (7.46 x 10^{-3} person-rem). The increase in the dose for 2019 is due primarily to the increased emissions and dose from MFC (see Section 8.2.1) and a shift of the dose isopleth, as compared to that projected for 2018, to regions east of the INL Site that are more highly populated.

8.3 Dose to the Public from Ingestion of Wild Game from the INL Site

The potential dose an individual may receive from occasionally ingesting meat from game animals continues to be studied at the INL Site. These studies estimate the potential dose to individuals who may eat waterfowl that briefly reside at wastewater disposal ponds at the ATR Complex and MFC, and game animals that may reside on or migrate through the INL Site.

8.3.1 Waterfowl

The maximum potential dose of 0.004 mrem (0.04 µSv) calculated for an individual consuming contaminated waterfowl based on 2019 sample results is lower than the dose estimated for 2018 (0.016 mrem [0.16 µSv]). As in the past, the 2019 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.

8.3.2 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 2019, no road-killed big game animals were available for collection.

The contribution of game animal consumption to the population dose are 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.

8.4 Dose to the Public from Drinking Contaminated Groundwater from the INL Site

Tritium has previously been detected in three U.S. Geological Survey monitoring wells located 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 (5,041 ± 200 pCi/L) in 2019 is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). An individual dirnking water from these wells would hypothetically receive a dose, calculated using equation 6-1, of 0.3 mrem (0.003 mSv) in one year. Because these wells are not used for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to the MEI.

8.5 Dose to the Public from Direct Radiation Exposure along INL Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters and optically-stimulated luminescence dosimeters) (Figure 7-3).

In 2019, the external radiation measured along the INL Site boundary was statistically equivalent to that of background radiation and, therefore, does not represent a dose resulting from INL Site operations.

8.6 Dose to the Public from All Pathways

DOE 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

Table 8-5. Dose to Population within 80 km (50 miles) of INL Site Facilities (2019).

Census County Division[a,b]	Population[c]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,688	9.85E-04	9.85E-06
Alridge	584	1.37E-05	1.37E-07
American Falls	9,921	2.40E-03	2.40E-05
Arbon (part)	30	2.85E-06	2.85E-08
Arco	2,677	1.24E-03	1.24E-05
Atomic City (division)	2,693	1.30E-02	1.30E-04
Blackfoot	16,142	8.23E-04	8.23E-06
Carey (part)	1,106	1.75E-04	1.75E-06
East Clark	84	8.77E-06	8.77E-08
East Madison (part)	311	9.11E-06	9.11E-08
Firth	3,285	1.24E-04	1.24E-06
Fort Hall (part)	4,623	3.12E-04	3.12E-06
Hailey-Bellevue (part)	6	4.68E-08	4.68E-10
Hamer	2,364	4.95E-03	4.95E-05
Howe	395	5.49E-04	5.49E-06
Idaho Falls	114,329	9.81E-03	9.81E-05
Idaho Falls, west	1,681	7.34E-04	7.34E-06
Inkom (part)	664	2.57E-05	2.57E-07
Island Park (part)	99	9.35E-06	9.35E-08
Leadore (part)	6	1.63E-07	1.63E-09
Lewisville-Menan	4,414	4.56E-04	4.56E-06
Mackay (part)	1,283	1.19E-05	1.19E-07
Moreland	10,912	1.64E-03	1.64E-05
Pocatello	68,430	5.43E-03	5.43E-05
Rexburg	31,799	1.57E-03	1.57E-05
Rigby	22,485	1.17E-03	1.17E-05
Ririe	2,126	5.03E-05	5.03E-07
Roberts	1,656	3.46E-04	3.46E-06
Shelley	9,222	4.95E-04	4.95E-06
South Bannock (part)	337	2.75E-05	2.75E-07
St. Anthony (part)	2,718	1.55E-04	1.55E-06
Sugar City	7,913	5.98E-04	5.98E-06
Swan Valley (part)	7,014	1.65E-04	1.65E-06
Ucon	6,927	5.28E-04	5.28E-06
West Clark	837	8.02E-05	8.02E-07
Total	**342,761**	**4.79E-02**	**4.79E-04**

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 2019 values based on 2010 Census Report for Idaho.

Table 8-6. Contribution to Estimated Annual Dose from INL Site Facilities to a Maximally Exposed Individual by Pathway (2019).

	Annual Dose to Maximally Exposed Individual		Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose		Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Pathway	(mrem)	(µSv)		(person-rem)	(person-Sv)		
Air	0.056	0.56	0.056	0.048	0.00048	342,761	130,935
Waterfowl	0.004	0.04	NA[c]	NA	NA	NA	NA
Big game animals	-[d]	-[d]	NA	NA	NA	NA	NA
Total pathways	**0.06**	**0.6**	**0.06**	**0.048**	**0.00048**	**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 382 mrem or 0.382 rem in 2019 (Table 7-8). 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 road-killed big game animals were available for collection in 2019, so no dose was calculated.

direct exposure pathways. For 2019, 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 a farmhouse and cattle operation located 3.1 km south of Highway 20, 3 km from INL Site's east entrance (see Figures 8-1 and Figure 8-6), would receive a calculated dose from INL Site airborne releases reported for 2019 (Section 8.2.1) and from consuming a duck contaminated at the ATR Complex wastewater ponds (Section 8.3.1). No road-killed big game animals were available for collection in 2019 so no dose was calculated (Section 8.3.2).

The dose estimate for an offsite MEI is presented in Table 8-6. The total dose was conservatively estimated to be 0.06 mrem (0.6 µSv) for 2019. The total dose calculated to be received by the hypothetical MEI for 2019 represents about 0.016 percent of the annual dose expected to be received from background radiation (382 mrem [3.8 mSv], as shown in Table 7-8) 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 4.8 x 10^{-2} person-rem (4.8 x 10^{-4} person-Sv) (Table 8-5). This is approximately 0.00004 percent of the dose (130,935 person-rem, [1,309 person-Sv]) expected from exposure to natural background radiation in the region.

8.7 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 2019 NESHAP report include the 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 2019 INL

NESHAP evaluation (DOE-ID 2020) 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 8.2.2.) The IRC MEI for calendar year 2019 is approximately 110 meters south-southeast of the RESL. The effective dose equivalent to the MEI was conservatively calculated, using CAP88-PC, to be 0.01 mrem/yr (0.1 µSv/yr), which is 0.1 percent of the 10-mrem/yr federal standard.

8.8 Dose to Biota

8.8.1 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 1.8 (DOE 2016). 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.

8.8.2 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 2019 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 8-7). 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 or 2018).

Using the maximum radionuclide concentrations for all locations in Table 8-7, 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 B-17). The results for uranium-233/234 ($^{233/234}$U) and ^{238}U in Table B-17, 1.17 pCi/L and 0.51 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 8-8). 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 7-5). 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 8-9. The maximum dose received by bats at the INL Site was estimated to be 0.001 rad/d (0.01 mGy/d) in 2019. 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.

8.8.3 Aquatic Evaluation

Maximum radionuclide concentrations reported in Table B-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 2019 calculations. The results shown in Table 8-10 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 (0.008) and riparian animals (0.002).

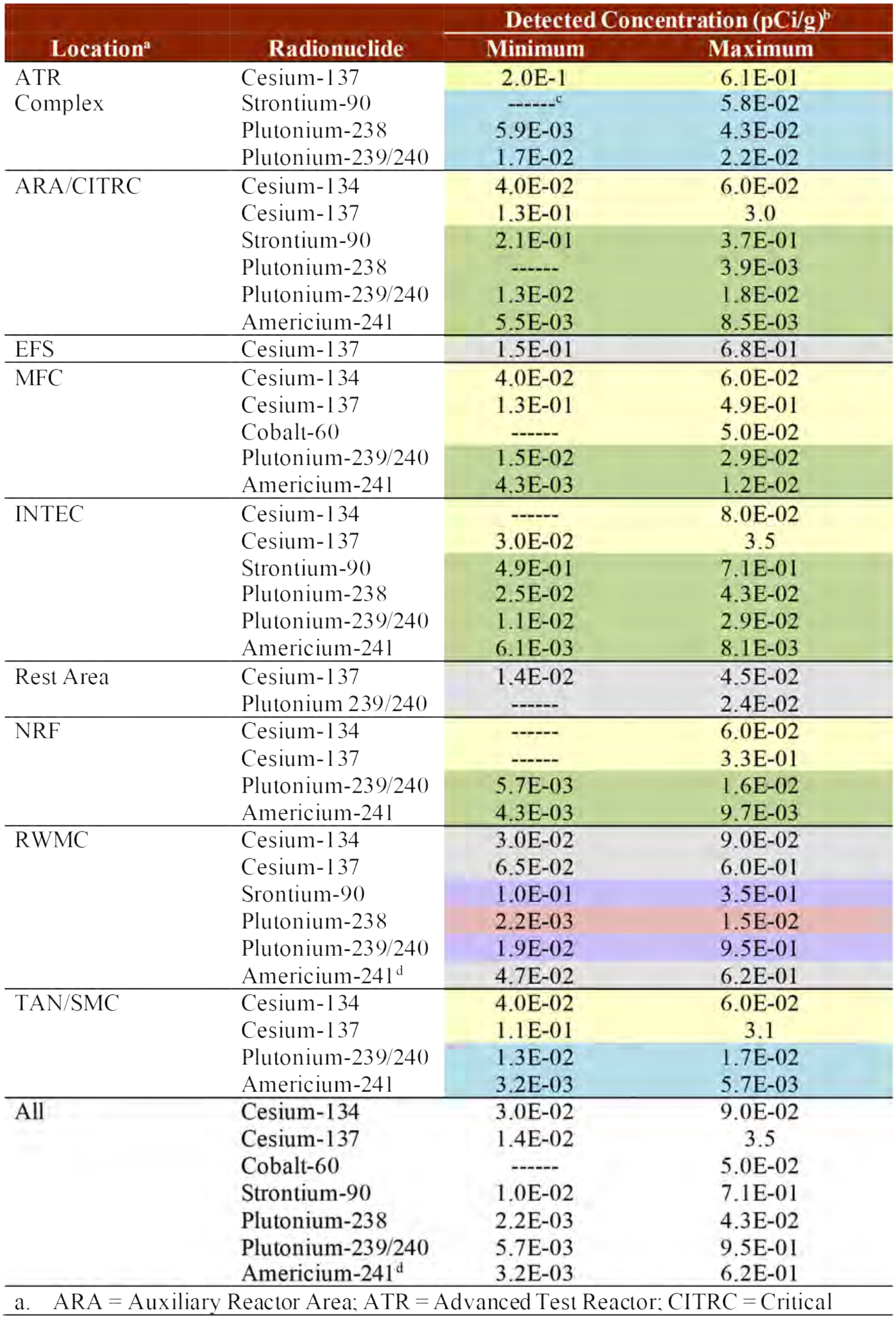
Tissue data from waterfowl collected on the ATR Complex ponds in 2019 were also available (Table 7-4). Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Table 7-4. 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 and estimated in sediment using uranium concentrations in water.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-11. The estimated dose to waterfowl was calculated by RESRAD-Biota to be 3.45×10^{-4} rad/d (3.45×10^{-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.

8.9 Doses from Unplanned Releases

No unplanned radioactive releases were detected from the INL Site in 2019. As such, no doses were associated with unplanned releases during 2019.

Table 8-7. Concentrations of Radionuclides in INL Site Soils, by Area.



Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Detected Concentration (pCi/g)[b] Maximum
ATR Complex	Cesium-137	2.0E-1	6.1E-01
	Strontium-90	------[c]	5.8E-02
	Plutonium-238	5.9E-03	4.3E-02
	Plutonium-239/240	1.7E-02	2.2E-02
ARA/CITRC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.3E-01	3.0
	Strontium-90	2.1E-01	3.7E-01
	Plutonium-238	------	3.9E-03
	Plutonium-239/240	1.3E-02	1.8E-02
	Americium-241	5.5E-03	8.5E-03
EFS	Cesium-137	1.5E-01	6.8E-01
MFC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.3E-01	4.9E-01
	Cobalt-60	------	5.0E-02
	Plutonium-239/240	1.5E-02	2.9E-02
	Americium-241	4.3E-03	1.2E-02
INTEC	Cesium-134	------	8.0E-02
	Cesium-137	3.0E-02	3.5
	Strontium-90	4.9E-01	7.1E-01
	Plutonium-238	2.5E-02	4.3E-02
	Plutonium-239/240	1.1E-02	2.9E-02
	Americium-241	6.1E-03	8.1E-03
Rest Area	Cesium-137	1.4E-02	4.5E-02
	Plutonium 239/240	------	2.4E-02
NRF	Cesium-134	------	6.0E-02
	Cesium-137	------	3.3E-01
	Plutonium-239/240	5.7E-03	1.6E-02
	Americium-241	4.3E-03	9.7E-03
RWMC	Cesium-134	3.0E-02	9.0E-02
	Cesium-137	6.5E-02	6.0E-01
	Srontium-90	1.0E-01	3.5E-01
	Plutonium-238	2.2E-03	1.5E-02
	Plutonium-239/240	1.9E-02	9.5E-01
	Americium-241[d]	4.7E-02	6.2E-01
TAN/SMC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.1E-01	3.1
	Plutonium-239/240	1.3E-02	1.7E-02
	Americium-241	3.2E-03	5.7E-03
All	Cesium-134	3.0E-02	9.0E-02
	Cesium-137	1.4E-02	3.5
	Cobalt-60	------	5.0E-02
	Strontium-90	1.0E-02	7.1E-01
	Plutonium-238	2.2E-03	4.3E-02
	Plutonium-239/240	5.7E-03	9.5E-01
	Americium-241[d]	3.2E-03	6.2E-01

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CITRC = Critical

Table 8-7. Concentrations of Radionuclides in INL Site Soils, by Area (continued).

Infrastructure Test Range Complex; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability. See Figure 8-1.

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.

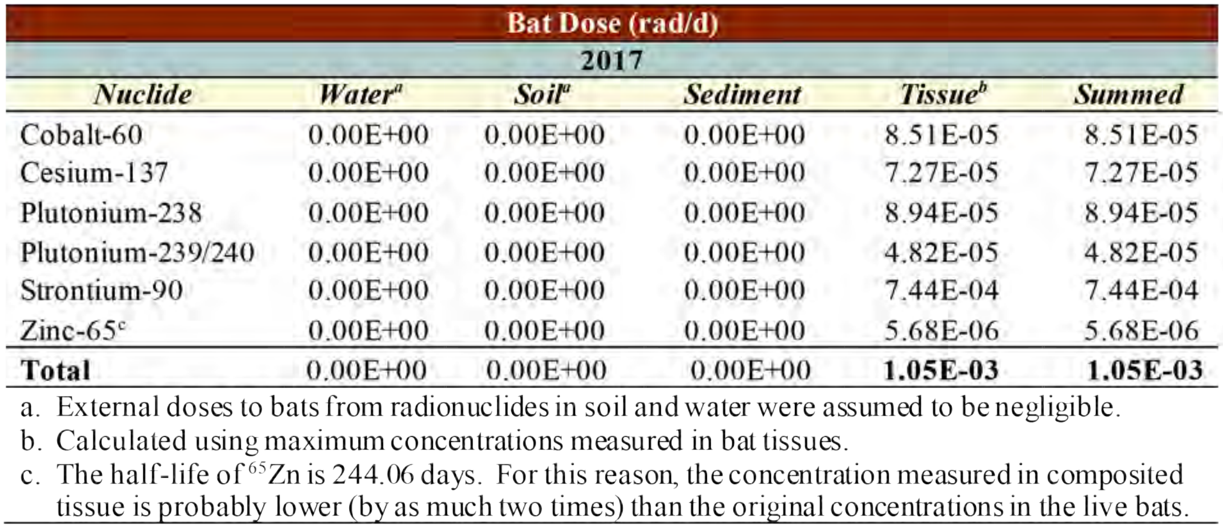
Table 8-8. RESRAD-Biota Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2019).

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	1.17	4.01E+05	3.14E-06	0	4.83E+03	0.00E+00
Uranium-238	0.51	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	1.17	1.06E+10	1.19E-10	0	5.23E+04	0.00E+00
Uranium-238	0.51	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.

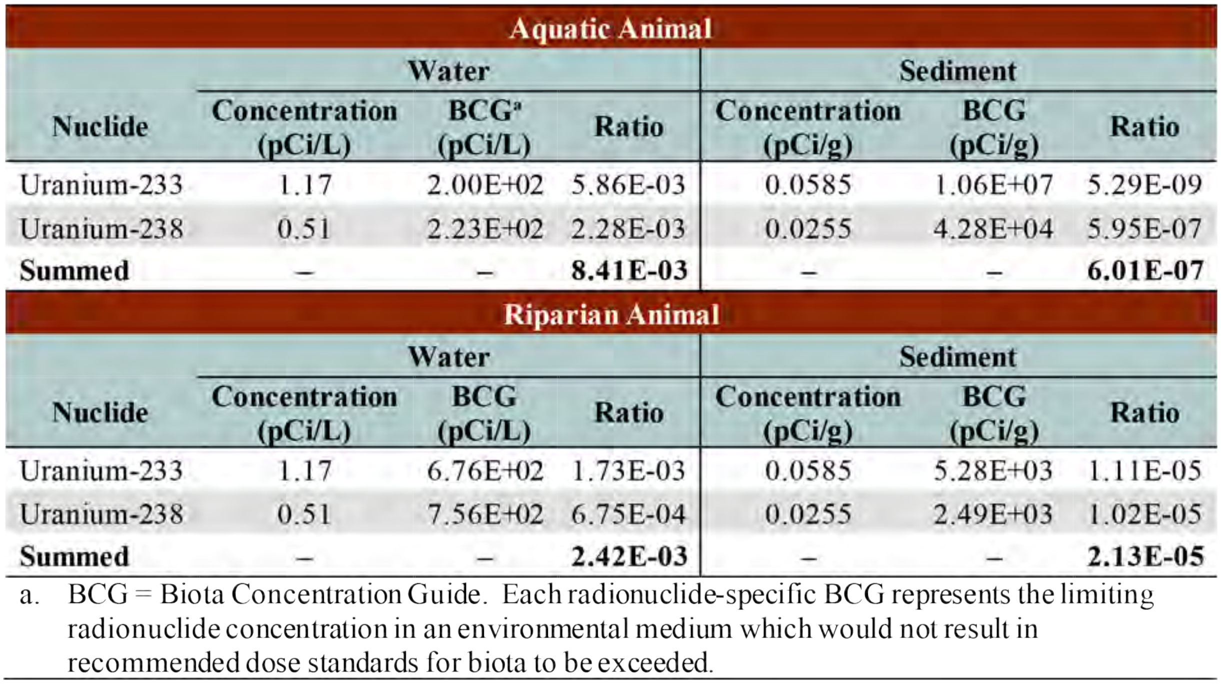
Table 8-9. RESRAD Biota Assessment (Level 3 Analysis) of Terrestrial Ecosystems on the INL Site Using Measured Bat Tissue Data (2019).



Bat Dose (rad/d)					
2017					
Nuclide	*Water*[a]	*Soil*[a]	*Sediment*	*Tissue*[b]	*Summed*
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	8.51E-05	8.51E-05
Cesium-137	0.00E+00	0.00E+00	0.00E+00	7.27E-05	7.27E-05
Plutonium-238	0.00E+00	0.00E+00	0.00E+00	8.94E-05	8.94E-05
Plutonium-239/240	0.00E+00	0.00E+00	0.00E+00	4.82E-05	4.82E-05
Strontium-90	0.00E+00	0.00E+00	0.00E+00	7.44E-04	7.44E-04
Zinc-65[c]	0.00E+00	0.00E+00	0.00E+00	5.68E-06	5.68E-06
Total	0.00E+00	0.00E+00	0.00E+00	**1.05E-03**	**1.05E-03**

a. External doses to bats from radionuclides in soil and water were assumed to be negligible.
b. Calculated using maximum concentrations measured in bat tissues.
c. 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.

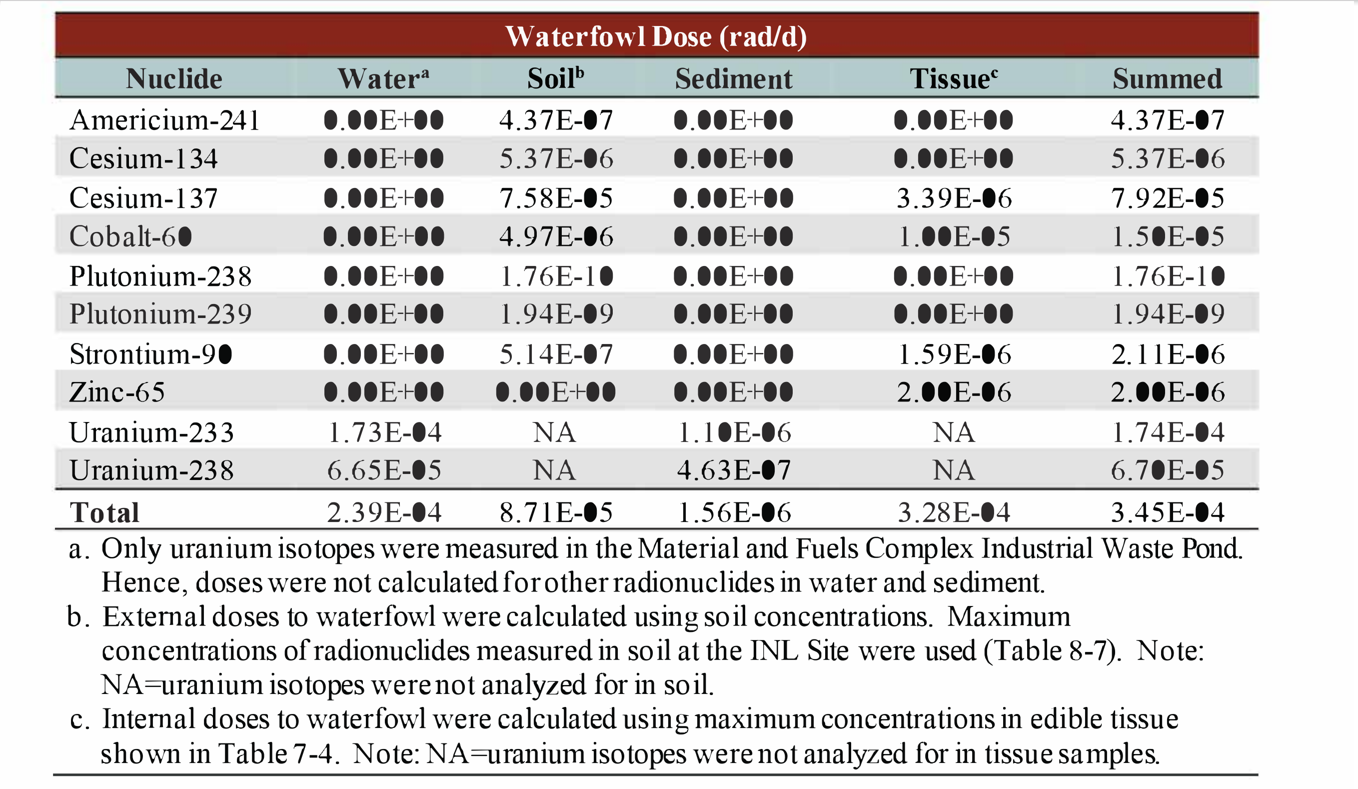
Table 8-10. RESRAD-Biota Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2019).



Aquatic Animal						
	Water			Sediment		
Nuclide	**Concentration (pCi/L)**	**BCG[a] (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Uranium-233	1.17	2.00E+02	5.86E-03	0.0585	1.06E+07	5.29E-09
Uranium-238	0.51	2.23E+02	2.28E-03	0.0255	4.28E+04	5.95E-07
Summed	–	–	**8.41E-03**	–	–	**6.01E-07**
Riparian Animal						
	Water			Sediment		
Nuclide	**Concentration (pCi/L)**	**BCG (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Uranium-233	1.17	6.76E+02	1.73E-03	0.0585	5.28E+03	1.11E-05
Uranium-238	0.51	7.56E+02	6.75E-04	0.0255	2.49E+03	1.02E-05
Summed	–	–	**2.42E-03**	–	–	**2.13E-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 8-11. RESRAD Biota Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2019).



Waterfowl Dose (rad/d)					
Nuclide	Water[a]	Soil[b]	Sediment	Tissue[c]	Summed
Americium-241	0.00E+00	4.37E-07	0.00E+00	0.00E+00	4.37E-07
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	3.39E-06	7.92E-05
Cobalt-60	0.00E+00	4.97E-06	0.00E+00	1.00E-05	1.50E-05
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	1.59E-06	2.11E-06
Zinc-65	0.00E+00	0.00E+00	0.00E+00	2.00E-06	2.00E-06
Uranium-233	1.73E-04	NA	1.10E-06	NA	1.74E-04
Uranium-238	6.65E-05	NA	4.63E-07	NA	6.70E-05
Total	2.39E-04	8.71E-05	1.56E-06	3.28E-04	3.45E-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 8-7). 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 7-4. Note: NA=uranium isotopes were not analyzed for in tissue samples.

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9. MONITORING WILDLIFE POPULATIONS


Longleaf phlox
(*Phlox longifolia*)

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 the protection of wildlife. During 2019, sage-grouse, raven, midwinter raptor, 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 more than 30 years and show long-term population decreases consistent with regional trends. 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 with the U.S. Fish and Wildlife Service to identify threats to the species and its habitat and develop conservation measures and objectives to avoid or minimize threats to sage-grouse. The Candidate Conservation Agreement for Greater Sage-grouse 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 U.S. Fish and Wildlife Service and DOE-ID would be initiated. Environmental Surveillance, Education, and Research 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. In 2019 the total number of known active leks on the INL Site was 40. Although still 142% of the population trigger threshold, the three-year running average of peak male attendance on 27 baseline active leks was 13.5% lower than in 2018.

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. In 2019, 29 active raven nests were identified on anthropogenic structures or in trees at facilities. Twenty-one of these were on utility structures.

The midwinter raptor 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. Two surveys were conducted in 2019. Observers documented 12 species and recorded a total of 378 total birds.

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 that border INL Site facilities. ESER biologists conducted surveys along 13 remote and facility routes in 2019. A total of 3,425 individual birds from 53 species was documented. Total observations were 24% lower than the 32-year average.

Research has been conducted on bats at the INL Site for several decades. Recently, white-nose syndrome 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 Environmental Surveillance, Education, and Research in 2012. In 2019 bat activity was detected acoustically at 8 facilities and 10 caves. Eleven of the 14 Idaho bat species are documented annually on the INL Site. In 2019 over 916 thousand files of bat ultrasonic echolocation calls were recorded at eighteen monitoring locations. In addition, monitoring of hibernating bat populations is conducted biennially. Hibernation counts were not conducted in 2019.

9. 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*), ravens, raptors, 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 documents and enables DOE-ID officials to make informed decisions for project planning and to maintain up-to-date information on potentially sensitive species on the INL Site. These surveys also support DOE-ID's compliance with several regulations, agreements, policies and executive orders including:

- Migratory Bird Treaty Act (1918)
- Migratory Bird Treaty Act Special Purpose Permit with U.S. Fish and Wildlife Service (FWS) calendar year 2019)
- 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 USFWS 2014)
- Executive Order 11514 (1970); Protection and Enhancement of Environmental Quality—(Created in furtherance of the purpose and policy of National Environmental Policy Act, directs federal agencies to monitor, evaluate, and control—on a continuing basis—their activities to protect and enhance the quality of the environment)
- Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (INL 2011)

The following sections summarize the results from wildlife surveys conducted by the ESER contractor on the INL Site during 2019.

9.1 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, Western Association of Fish and Wildlife Agencies 2015), Statewide, sage-grouse numbers have dropped 52% since the federal government decided not to list the birds as endangered in the fall of 2015 (IDFG 2019) and 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, during summer, young sage-grouse also require a diverse understory of native forbs and grasses. This vegetation provides protection from predators and supplies high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011b).

In 2014, DOE-ID and the FWS 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 9-1), 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 that, if tripped, would initiate a predetermined response by both agencies. To trip the trigger, the three-year running average of peak male attendance, summed across 27 baseline 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.

Male sage-grouse congregate on an open area called a lek to display and breed starting in March and continuing through May. During this period (field season), ESER biologists repeatedly visit all baseline, active, and a sample of inactive sage-grouse leks on the INL Site to count the number of males observed on the lek and capture peak male attendance. 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, allow ESER to track breeding population trends, and maintain accurate records of active lek locations.

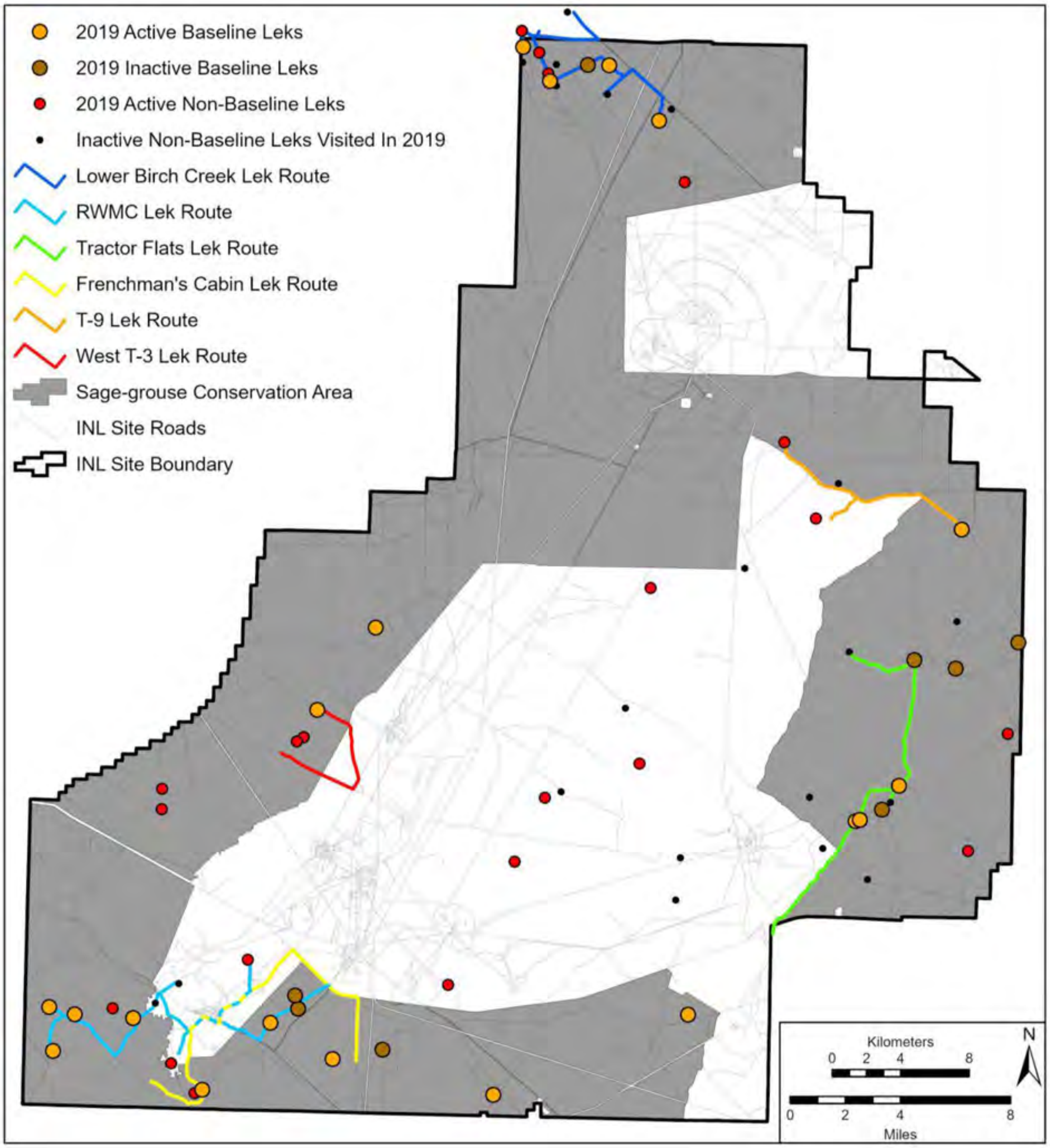


Figure 9-1. An Overview of Greater Sage-grouse Leks Surveyed on the Idaho National Laboratory Site in 2019. Lek activity designations (active vs. inactive) refer to lek statuses when surveys commenced in March 2019.

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 9-1). 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 (Frenchman's 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 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 2019. For greater detail about methods, analyses, and results, see Shurtliff et al. (2020).

On IDFG routes, the number of males per lek surveyed (MPLS) was lower than the previous three years. On the Tractor Flats route, the 2019 MPLS was 7.5% lower than 2018 (Table 9-1). On the Lower Birch Creek route, the 2019 MPLS was 15.3% lower than 2018 (Table 9-1). The RWMC route, experienced the greatest decline of IDFG routes with the 2019 MPLS 43.2% lower than in 2018

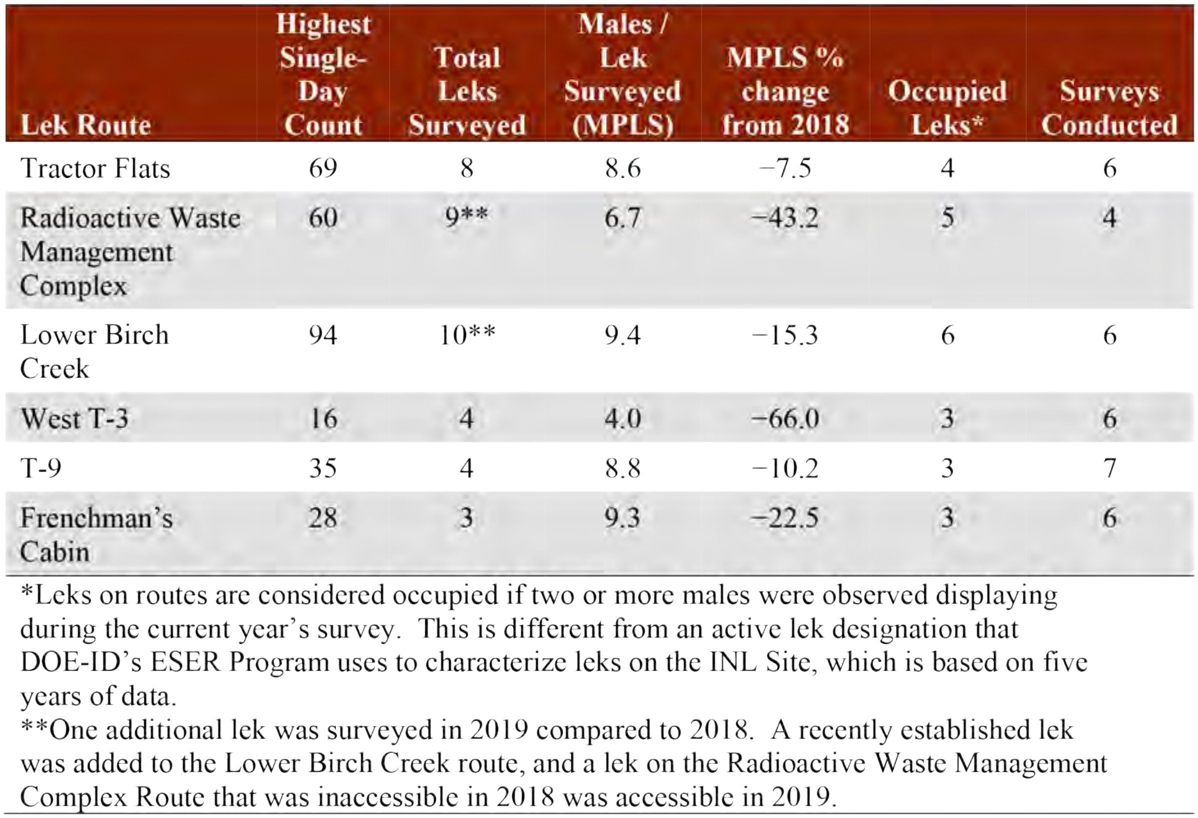
9.1.1 Lek Routes

Each of the six lek routes were surveyed 4–7 times ($\bar{x}$=5.8 surveys, SD=1.0). For all routes, the number of MPLS were lower in 2019 than in 2018, with reductions ranging from −7.5% to −66.0% (Table 9-1). This number is calculated by looking at the total peak number of males observed on a lek route count and then averaged between all leks on that route, On average, lek route counts declined 27.5% (SD = 22.8%) from 2018.

The 2019 MPLS values for the three new lek routes compare to 2018 values as follows: Frenchman's Cabin route dropped 22.5%, West T-3 route dropped 66%, and T-9 route decreased 10.2% (Table 9-1).

The Tractor Flats and Lower Birch Creek lek route data suggest that the breeding population of Sage-grouse on the INL Site may have peaked from about 2005 to 2007, with a subsequent, albeit lower, peak approximately 10 years later.

Table 9-1. Lek Route Data from 2019 Surveys on the Idaho National Laboratory Site.



Lek Route	Highest Single-Day Count	Total Leks Surveyed	Males / Lek Surveyed (MPLS)	MPLS % change from 2018	Occupied Leks*	Surveys Conducted
Tractor Flats	69	8	8.6	−7.5	4	6
Radioactive Waste Management Complex	60	9**	6.7	−43.2	5	4
Lower Birch Creek	94	10**	9.4	−15.3	6	6
West T-3	16	4	4.0	−66.0	3	6
T-9	35	4	8.8	−10.2	3	7
Frenchman's Cabin	28	3	9.3	−22.5	3	6

*Leks on routes are considered occupied if two or more males were observed displaying during the current year's survey. This is different from an active lek designation that DOE-ID's ESER Program uses to characterize leks on the INL Site, which is based on five years of data.

**One additional lek was surveyed in 2019 compared to 2018. A recently established lek was added to the Lower Birch Creek route, and a lek on the Radioactive Waste Management Complex Route that was inaccessible in 2018 was accessible in 2019.

9.1.2 SGCA Baseline Leks

Each baseline lek was surveyed 3–7 times ($\overline{x}$=4.9 surveys, SD=1.3) in 2019. The sum of peak male attendance across the baseline leks was 304, a 16.7% decrease from 365 males recorded in 2018 and the lowest value recorded on these leks since we began analyzing them as a unit in 2011 (Figure 9-2). Peak male attendance decreased at least 11% each of the past three years, and the 2019 count is 35.5% lower than the 471 males recorded in 2016.

The three-year (2017–2019) running average of peak male attendance on baseline leks was 360 males (SD = 54.2), a 13.5% decrease from 2018 (Figure 9-2). This result marks the first year a decrease in the three-year average has occurred. The average, however, remains higher than pre-2016 values and is 142% of the threshold (253 males) that would trigger specified action by DOE-ID and the FWS (DOE and USFWS 2014).

9.1.3 Inactive Leks

A subset of inactive leks are surveyed at least once every few years to verify activity status. In 2019, thirteen inactive leks that are not baseline leks nor part of lek routes, were surveyed at least twice. No male sage-grouse were observed on any of these leks, so each will retain its inactive status.

9.1.4 Summary of Known Active Leks and of Changes in Lek Classification

Prior to the 2019 field season, 44 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. Activity status of baseline leks did not change in 2019, as 19 of 27 remained active. After the field season, two leks that are assigned to lek routes and two non-baseline leks were downgraded from active to inactive status. No inactive leks were upgraded to active (Figure 9-3). Therefore, total known active leks on or near the INL Site is currently 40.

9.2 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 are known predators of other bird nests and are known to take both eggs and chicks. Raven predation of sage-grouse eggs and young 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 sage-grouse CCA, DOE-ID committed to support research aimed at developing methods to deter 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 (Section

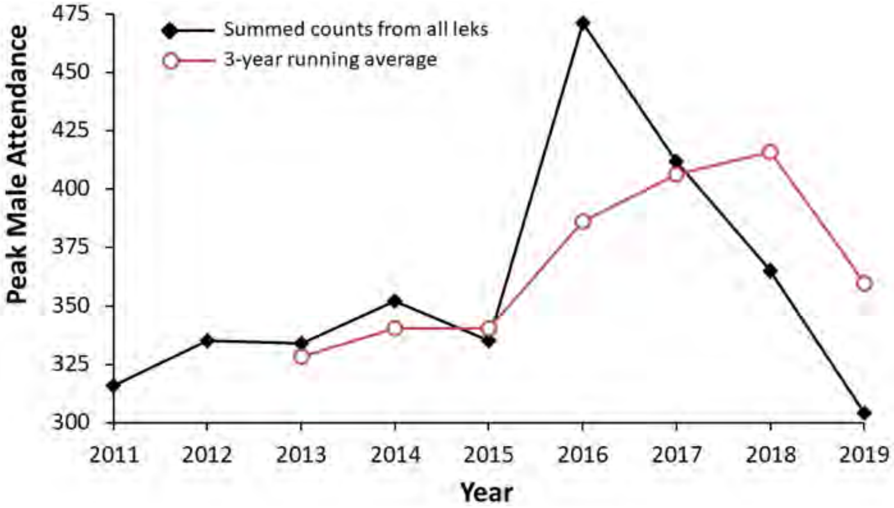


Figure 9-2. Peak Male Attendance of Greater Sage-grouse from 2011–2019 on the 27 Baseline Leks in the Sage-grouse Conservation Area Associated with the Population Trigger.

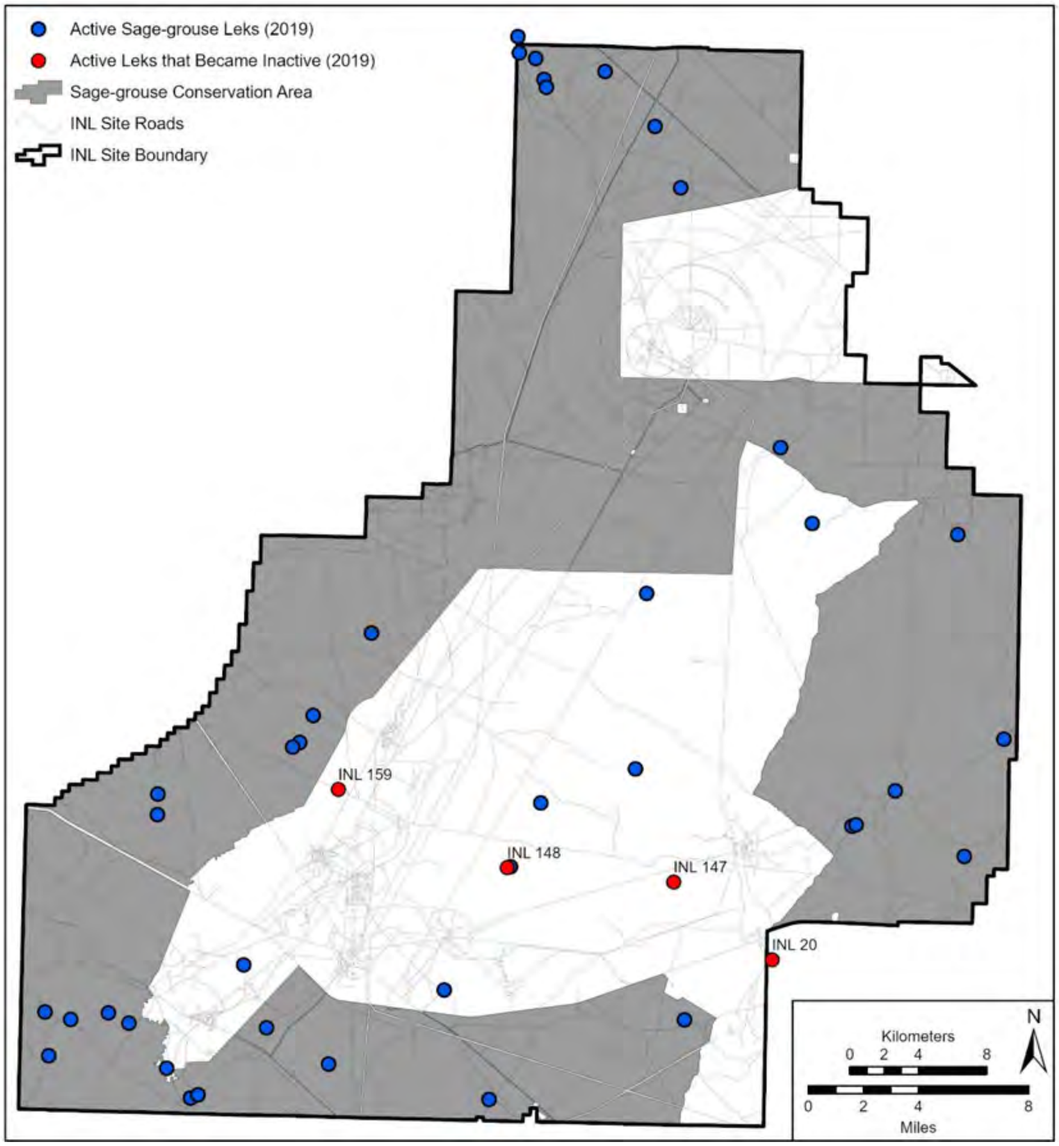


Figure 9-3. Locations of 40 Active Leks and Four Leks Reclassified as Inactive (Red) on or near the Idaho National Laboratory Site.

6.2.7). The DOE-ID continues to recognize the value of research that would improve its ability to deter raven nesting on 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 Atmospheric 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.

Systematic surveys of power lines, towers, facilities and associated ornamental trees, and raptor nesting platforms on the INL Site were conducted between April 1 and June 5, 2019. When a stick nest is observed on a structure, the associated corvid or raptor species is identified, if present, and nest activity determined. Nests are determined active if one or more of a breeding pair were observed incubating (i.e., sitting in the nest bowl), perched on or near the nest, carrying nesting materials to the nest, or engaging in other behavior that suggested they are tending or defending the nest. Presence of eggs or chicks also confirmed the activity status of a nest, and adults are observed in these cases to confirm the species identity. A single positive observation is sufficient for a nest to be classified as active; however, at the end of the season, any nest classified as active solely as a result of a single observation of a raven perched on a structure (but not on the nest) is downgraded to unknown status.

In 2019, 32 active raven nests were observed on anthropogenic structures along survey routes or in trees associated with facilities (Figure 9-4). However, this

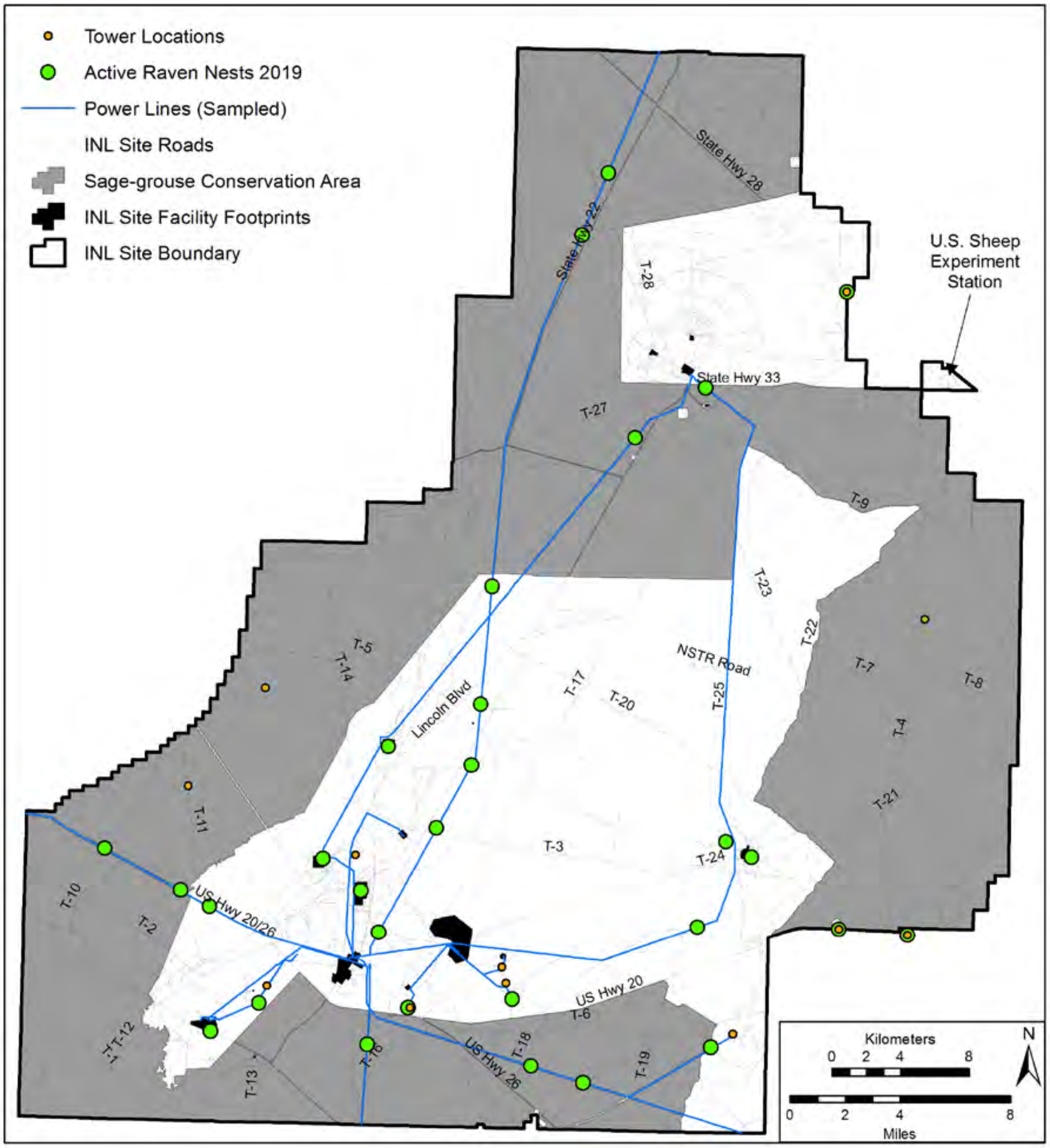


Figure 9-4. Results of the 2019 Raven Nest Survey Depicting all Documented Active Raven Nests on Infrastructure, after Accounting for Nests that were Potentially Occupied by the Same Breeding Pair. For clarity, towers associated with facilities are not shown.

number was adjusted to 29 due to three nests being determined to be attended by the same nesting pair. Of the 29 active raven nests observed, 21 were on power line structures, seven at facilities and four on towers outside of facility fences.

Four surveys were conducted on all transmission and distribution lines on the INL Site that could potentially support a raven nest. Of the 18 power line nests (adjusted), two were on distribution structures where they were supported by equipment attached to the pole. Rocky Mountain Power removed one of these nests early in May as it posed a fire hazard. Five nests were on “Closed H Cable” structures, 10 were on “Sloped H”, and one was on an unidentified transmission structure (see Shurtliff et al. 2017 for pictures of structures). Eighteen of the 21 nests observed on powerline structures were located within or immediately adjacent to (within 75 m) the SGCA (Figure 9-4).

Facilities are defined as any non-linear feature that includes at least one building. Thirteen facilities were surveyed twice between April 3 and April 30, 2019. We have found that if ravens nest at a facility, nest status can be confirmed in April and there is no need for repeated surveys in May. Active nests were observed at seven of the facilities. At Experimental Breeder Reactor-I, two nests were observed on a large structure next to the museum and initially recorded as active because ravens were observed perched nearby on more than one occasion. However, ravens were never observed using the nests and since they were only a few meters apart, we only designated one of them active.

Eleven towers located outside facilities, were surveyed two to five times between April 2 and June 5, 2019. Most surveys were performed in April, but we conducted extra surveys (i.e., more than two) when a nest was present on a tower and the activity level of that nest remained unknown after two surveys. Active raven nests were observed on four of the 11 towers surveyed (Table 9-2, Figure 9-4). One was a 50-ft NOAA meteorological tower near the Materials and Fuels Complex east fence. The others were on the three towers outside but adjacent to the INL Site.

The adjusted number of raven nests recorded on infrastructure associated with the INL Site was 33% lower in 2019 than 2018, matching the lowest number of raven nests recorded since 2014. The number of raven nests observed on power lines was 42% lower than in 2018 and 21% lower than in any other year (Figure 9-5).

DOE-ID does not own any of the weather monitoring or cellular service towers occupied by ravens in 2019, 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.

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. However, 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.

9.3 Midwinter Raptor, Corvid, and Shrike Surveys

Each January, hundreds of volunteers and wildlife professionals throughout the United States count eagles along standardized, non-overlapping survey routes as part of the midwinter Bald Eagle survey (Steenhof et al. 2008). These annual surveys commenced in 1979 and today are managed by the U.S. Geological Survey (USGS). The midwinter Bald Eagle surveys were originally established to develop a population index of wintering bald eagles in the lower 48 states, determine Bald Eagle distribution, and identify previously unrecognized areas of important winter habitat (Steenhof et al. 2008).

On the INL Site, midwinter Bald Eagle surveys have taken place since 1983. In early January of each year, two teams drive along established routes across the north and south of the INL Site and record the number and locations of all bald and golden eagles seen. Observers also record the same information for other raptors, common ravens, shrikes, and black-billed magpies seen along each route. Data are submitted to the regional coordinator of the USGS Biological Resource Division to be added to the nationwide database.

Table 9-2. Facilities Surveyed for Raven Nests in 2019.

Facility	# Times Surveyed	Days Between Surveys	Active Raven Nest Confirmed	Substrate Supporting Active Nest
Advanced Mixed Waste Treatment Project	2	14	Yes	Building Platform
Advanced Test Reactor Complex	2	19	Yes	Building Platform
Central Facilities Area	2	18	No	N/A
Central Facilities Area Main Gate	2	25	Yes	Building Platform
Critical Infrastructure Test Range Complex	2	25	No	N/A
Experimental Breeder Reactor I	4	14	Yes	Building Platform
Highway Department	2	15	No	N/A
Idaho Nuclear Technology and Engineering Center	2	15	Yes	Effluent Stack
Materials and Fuel Complex /Transient Reactor Test Facility	2	20	Yes	Building Platform
Naval Reactors Facility (NRF)	2[a]	22	Yes	Ornamental Tree
Radioactive Waste Management Complex	2	14	No	N/A
Specific Manufacturing Capability/Test Area North	2	20	No	N/A
U.S. Sheep Experiment Station	2	15	No	N/A

a. Environmental Surveillance, Education, and Research personnel are restricted from entering the NRF. Therefore, several years ago we trained an NRF representative to report to ESER two times each season on raven nest observations.

On January 9, 2019, ESER biologists completed two surveys along the traditional driving routes on the INL Site. Observers documented 12 species and recorded a total of 378 birds on both routes (Figure 9-6). This is almost double the 19-year median of 190 birds.

Figure 9-7 shows trends of the three most common birds observed during this survey: the common raven, rough-legged hawk and golden eagle. Common raven observations fell slightly from the previous two years but remain above the 19 year mean of 114 with 164 ravens recorded during this survey. Rough-legged hawk observations slightly increased with 148 birds observed. This is the greatest number of rough-legged hawks observed since 2010 when 217 rough-legged hawks were observed and is 1.6 times higher than the annual mean of 93. Golden eagle observations (*n* = 14) increased from last year (*n* = 6) and is slightly higher than the 19 year mean of 10.

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 abun-

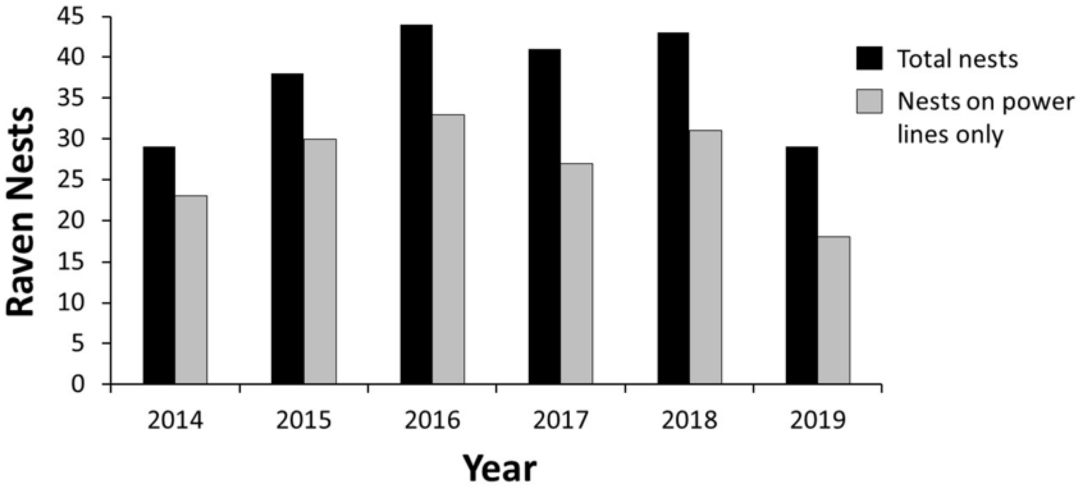


Figure 9-5. Adjusted Number of Common Raven Nests Observed on Idaho National Laboratory Site Infrastructure.

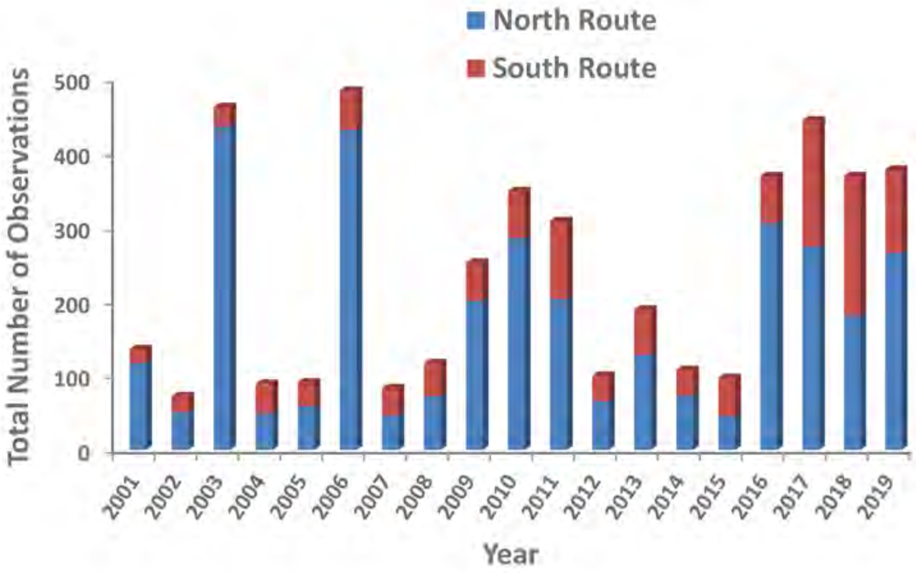


Figure 9-6. Total Number of Observations Separated by Survey Route, During the Mid-winter Bald Eagle Surveys since 2001.

dance or may only have a minor impact. Perhaps the most useful information for DOE-ID that can be gleaned from these surveys is a clear picture that many species' populations are cyclic. Understanding this ecological truism provides context for year-to-year observations.

9.4 Breeding Bird Surveys

The North American Breeding Bird Survey (BBS) was developed by the FWS along with the Canadian Wildlife Service to document trends in bird populations. Pilot surveys began in 1965 and immediately expanded to cover the United States east of the Mississippi and Canada, and by 1968 the surveys included all of North America (Sauer and Link 2011). The BBS program in North America is managed by the USGS and currently consists of over 4,100 routes, with approximately 3,000 of these being sampled each year. BBS data provide long-term species abundance and distribution trends across a broad geographic scale. These data have been used to estimate population changes for hundreds of

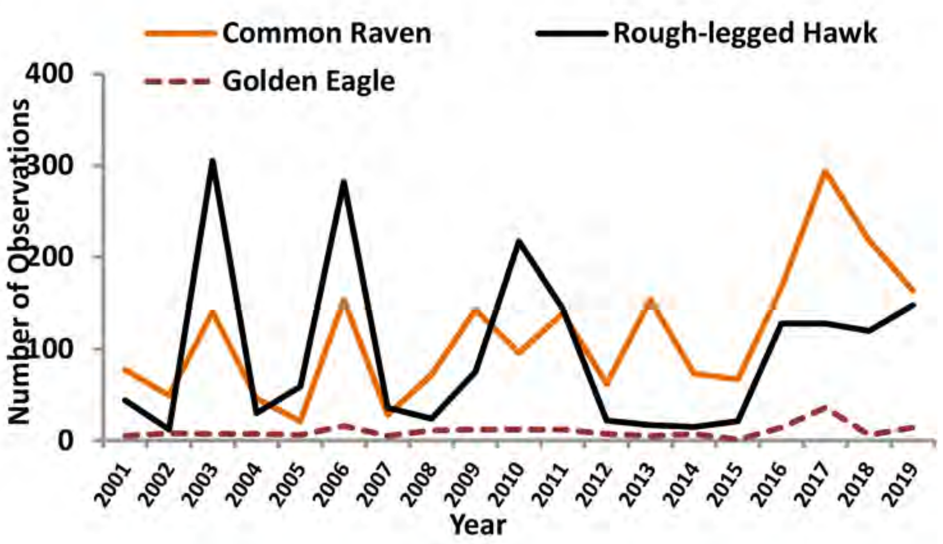


Figure 9-7. Trends of the Three Species Most Commonly Observed during Annual Midwinter Eagle Surveys. Data were pooled from both northern and southern routes.

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 9-8). Data from remote routes contribute to the USGS continent-wide analyses of bird trends, and also provides 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 from the end of May through early July 2019 and documented a total of 3,425 individuals from 53 bird species (Bybee and Vilord, 2020). Total observations were 24% lower than the 32-year mean of 4,649 birds (1985-1991 and 1994-2018; Figure 9-9), and we recorded fewer species (mean=56 species).

The six most abundant birds across all routes were: western meadowlark (*Sturnella neglecta, n* = 806), horned lark (*Eremophila alpestris, n* = 633), Franklin's gull (*Leucophaeus pipixcan, n* = 507), sage thrasher (*Oreoscoptes montanus, n* = 442), Brewer's sparrow (*Spizella breweri, n* = 237), and sagebrush sparrow (*Artemisiospiza nevadensis, n* = 218). These six species comprised >83% of all observations, and each, with the exception of Franklin's gull, 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 26 of the 33 years of INL Site BBS (in the other years they were among the seven most abundant species).

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, followed by Brewer's sparrow and sagebrush sparrow. These three species along with the greater sage-grouse are the only sagebrush obligate songbirds observed during the BBS. Sagebrush obligates make up only 7% of the number of species observed in 2019 but contribute 26.3% of the total number of individual birds observed. Prior to 2000, sagebrush obligate species represented an average of 41% of the total number of birds observed during the annual breeding bird survey. Since then, the percentage of sagebrush obligates has steadily declined to approximately 28% between 2000 to 2009 and 27% from 2010 to 2019, of the total number of birds observed during the survey (Figure 9-10).

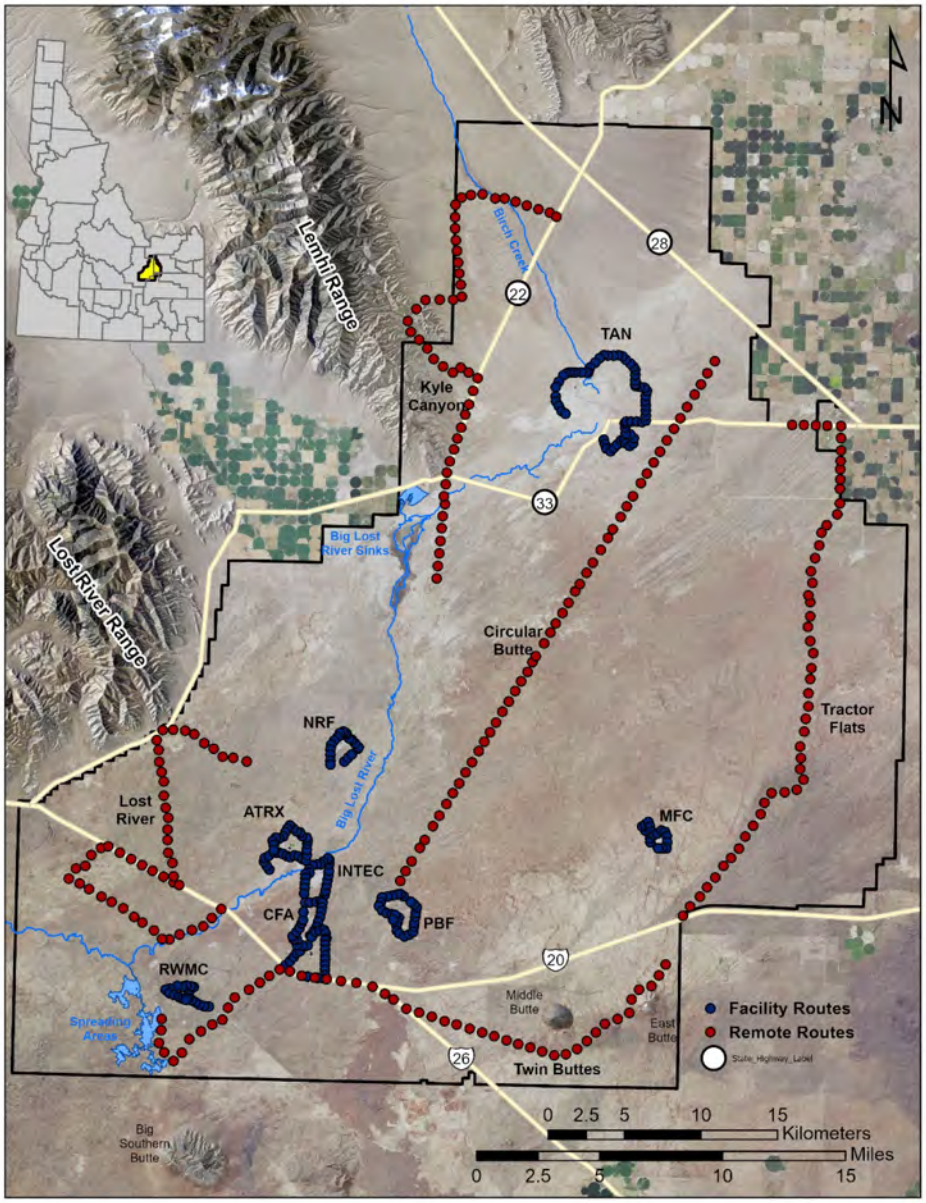


Figure 9-8. Breeding Bird Survey Routes on the INL Site. Blue dots represent survey points along facility routes and red dots represent the same for remote routes.

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 161–227, all of which were lower than the previous low count of 241 individuals recorded in 1987 (Figure 9-11). The decline in sagebrush obligate species is attributed to the loss of sagebrush habitat from large fires that have occurred on the INL Site since 2000.

The number of common ravens observed during the 2019 Breeding Bird Survey ($n = 107$) was lower than in 2018 ($n = 167$), but raven populations continue to show an upward trend (Figure 9-12). The combination of loss of sagebrush-dominated communities and the increased number of nest predators, such as the common raven, may affect the population growth potential of some species, especially sagebrush obligates such as the sage-grouse, which is a conservation concern for DOE-ID.

Species observed during the 2019 BBS that are considered by the IDFG as "Species of Greatest Conservation Need" included the greater sage-grouse (*Centrocercus urophasianus*, $n = 5$, Tier 1), burrowing owl

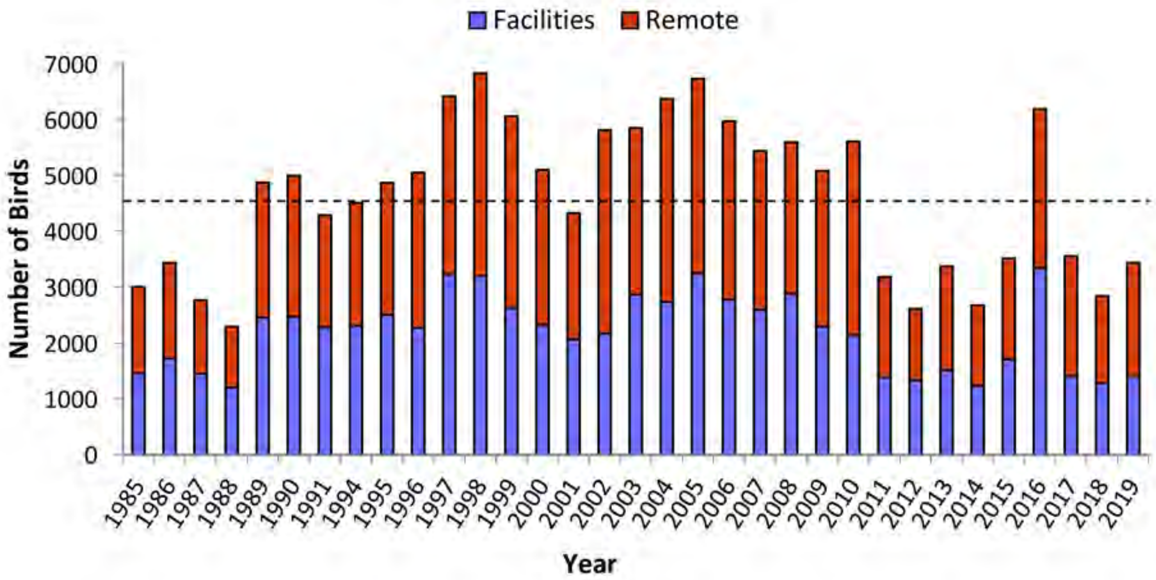


Figure 9-9. Number of Birds Observed during Breeding Bird Surveys on the INL Site. The dashed black line indicates the mean number of birds observed from 1985 to 2019. No BBSs were conducted on the INL Site in 1992 or 1993.

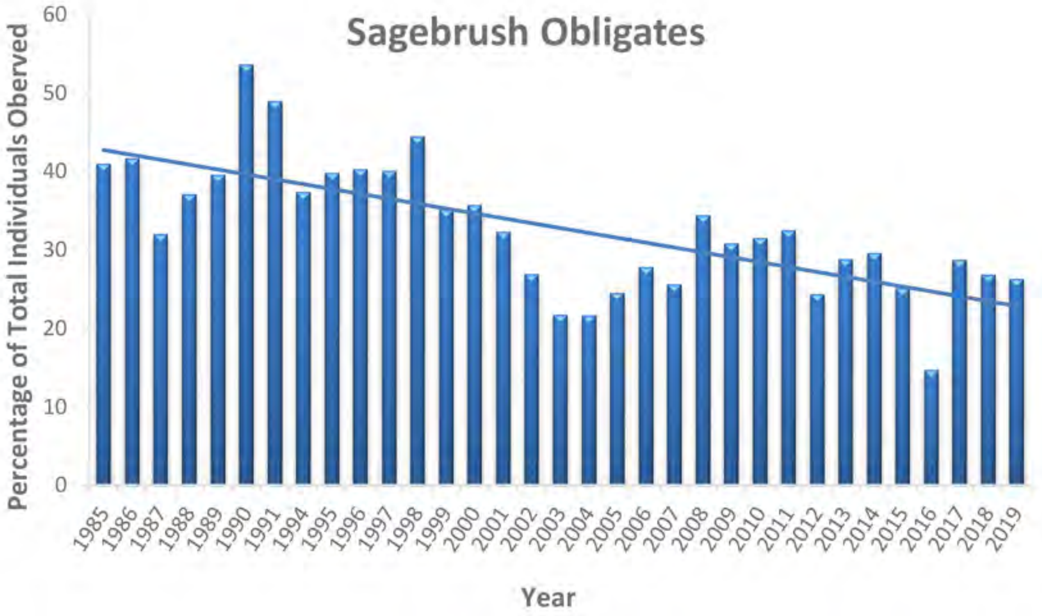


Figure 9-10. Percentage of Sagebrush Obligates Observed during the Annual BBS from 1985 to 2019.

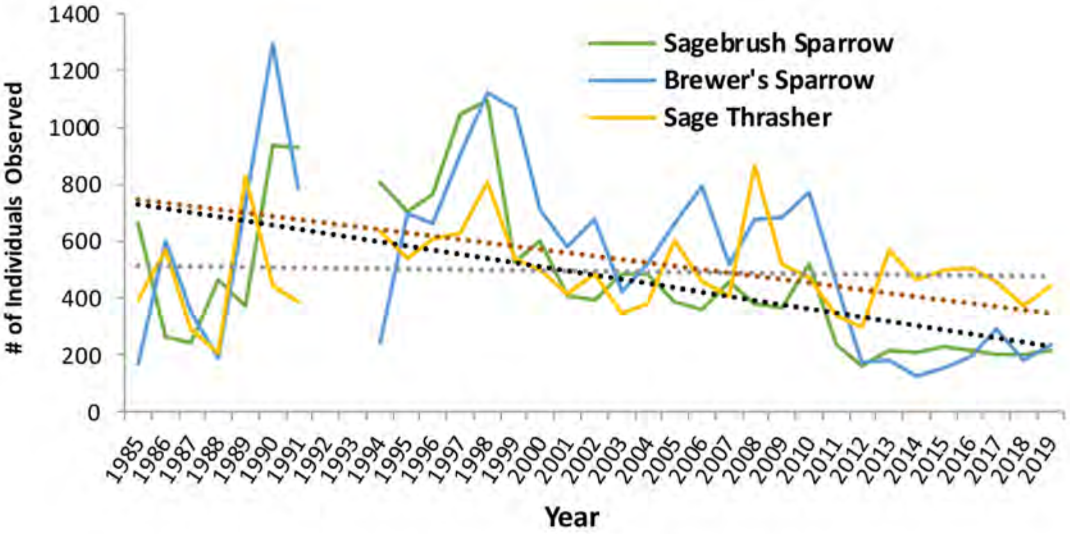


Figure 9-11. Trends of Three Sagebrush Obligates Recorded during Breeding Bird Surveys since 1985.
Surveys were not conducted in 1992 and 1993.

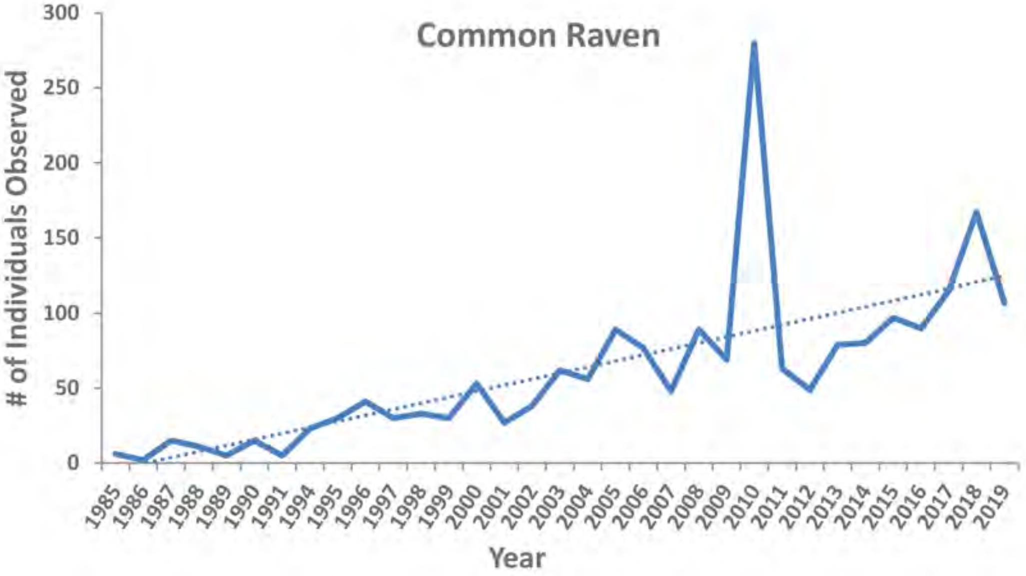


Figure 9-12. Trend of Ravens Observed during Breeding Bird Surveys since 1985.
Surveys were not conducted in 1992 and 1993.

(*Athene cunicularia, n* = 1, Tier 2), ferruginous hawk (*Buteo regalis, n* = 15, Tier 2), Franklin's gull (Tier 3), long-billed curlew (*Numenius americanus, n* = 7, Tier 2), sage thrasher (Tier 2), sagebrush sparrow (Tier 2), common nighthawk (*Chordeiles minor, n* = 29, tier 3), and grasshopper sparrow (*Ammodramus savannarum, n* = 4, Tier 3).

9.5 Bats

Temperate insectivorous bats serve important roles in many ecosystems, resulting in ecosystem services of benefit to humans (Kunz and Reichard 2010, Cryan 2011). For example, insectivorous bats are very effective at suppressing populations of nocturnal insects, and some authors estimate the value of bats to the agricultural industry in the United States at roughly $22.9 billion each year through the suppression of insect pest species (Boyles et al. 2011). Moreover, insectivorous bats are effective top-down predators of forest insects (Boyles et al. 2011). In nutrient-poor environments bats can serve as nutrient "resets," feeding intensely on aerial insects in nutrient-richer areas (e.g., riparian corridors, ponds, agricultural fields, etc.) and then transporting and depositing nutrient-rich material, in the form of guano, in nutrient-poorer upland roost sites or in caves (Kunz et al. 2011). In some cases, bat guano may be the sole source of nutrient input for entire cave ecosystems (Kunz et al. 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 globally (O'Shea et al 2016). 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 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 a total of four Washington counties and the western states of South Dakota, Wyoming, North Dakota, and California. Western species confirmed to be WNS susceptible include Big Brown Bat (*Eptesicus fuscus*), Fringed Myotis (*Myotis thysanodes*), Little Brown Bat, Long-legged Myotis (*Myotis volans*), Western Long-eared Myotis (*Myotis evotis*), and Yuma Myotis (*Myotis yumanensis*). All these species have been detected at the INL Site through acoustic monitoring. Four additional species that have been detected at the INL Site (Brazilian Free-tailed Bat [*Tadarida brasiliensis*], Silver-haired Bat [*Lasionycteris noctivagans*], Townsend's Big-eared Bat [*Corynorhinus townsendii*], and Western Small-footed Myotis [*Myotis ciliolabrum*]) have tested positive for the white-nose pathogen in some portion of their range. Currently neither WNS nor the pathogen have been detected at the INL Site or in the state of Idaho. WNS is considered one of the greatest wildlife crises of the past century with many once common bat species at risk of significant declines or even extinction (Kunz and Reichard 2010).

Wind-energy development is expanding rapidly across the western United States, and unprecedented mortality rates of bats have occurred recently at many of these facilities (Arnett et al. 2008; Cryan 2011; Cryan and Barclay 2009). Upper-end annual estimates for bat mortality from wind generation plants are approximately 900,000 individuals of mainly tree-roosting bat species (Smallwood 2013); however, widely accepted estimates remain elusive (Huso and Dalthorp 2014). Despite recent focus on emerging threats, direct impacts to hibernacula by humans remains the single most important conservation concern for bat populations in many areas (Adams 2003).

Over the past several decades, research and monitoring of bats have been conducted on the INL Site by contractors of DOE-ID in a somewhat ad hoc fashion. During that time, four theses (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 of Idaho (Keller 1985), eleven of those species are confirmed to occupy the INL Site during some part of the year (Table 9-3). All eleven of these species may be detected at the INL Site in appropriate habitats 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 9-3). An additional two species (Western Red Bat [*Lasiurus blossevillii*] and Brazilian Free-tailed Bat) are not listed as occurring in the state of Idaho and are possible vagrants at the INL Site (Table 9-3). To date, Brazilian Free-tailed

Table 9-3. 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	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	Yes	Yes
Brazilian Free-tailed Bat (*Tadarida brasiliensis*)	Unknown; single, dead specimen found at Test Area North; 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	Potentially	Potentially

a. These species are designated as Type 2 Idaho Special Status Species by BLM.
b. Year-round resident species.
c. Migratory tree species.
d. Detected acoustically only, possible vagrant.

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 (BLM), Western Bat Working Group, and other conservation organizations (Table 9-3).

To assess bat activity and species occurrence at critical features, a program of passive acoustic monitoring of bat calls was initiated by ESER in 2012. In 2019, ESER continued monitoring bat activity using acoustical detectors (Figure 9-13) set at hibernacula and other important habitat features (caves and facility wastewater ponds) used by these mammals. Analysis of the acoustic data set was initiated in 2015 and continued in 2019 (Figure 9-14). To date, approximately 7.7 million ultrasonic call files have been collected. This is the largest continuous dataset in Idaho and likely the western U.S. Over 916 thousand ultrasonic files were collected during the 2019 monitoring

Figure 9-13. 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 wastewater ponds.)

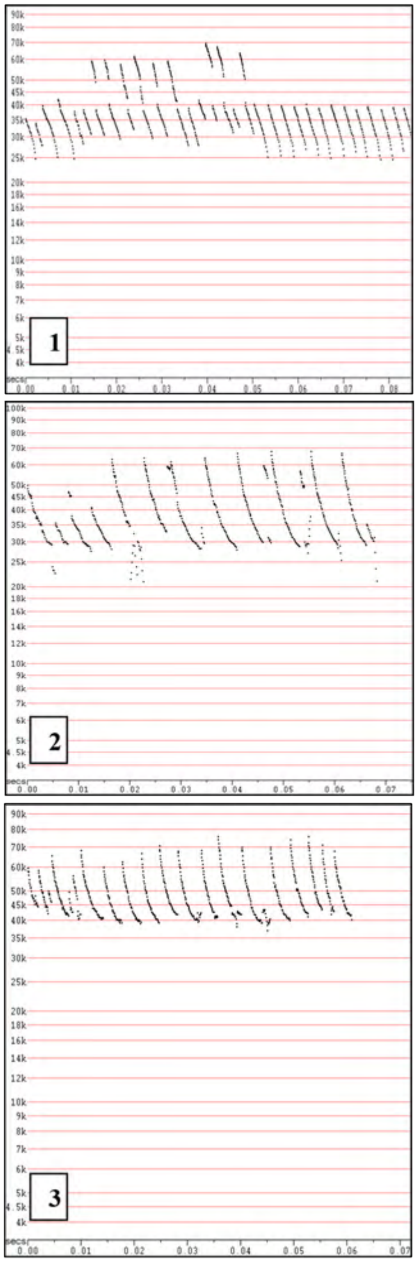


Figure 9-14. Sonograms (Frequency Versus Time Plots) of Bat Echolocation Calls of Three Species of Bats Recorded by AnaBat Detectors (1 = Townsend's Big-eared Bat, 2 = Big Brown Bat, 3 = Western Small-footed Myotis) from Caves on the INL Site.

season; more than 466,000 of these files were recorded at facilities, the rest at caves and other remote sites. Ongoing monitoring efforts show consistent patterns. Summer resident bat community appears to consist predominantly of Western Small-footed Myotis, Townsend's Big-eared Bat, Big Brown Bat, and Western Long-eared Myotis with some little Brown Myotis and Silver-haired Bat detected at moderate levels at a few locations. Low levels of summer activity of Hoary Bat (*Lasiurus cinereus*) were detected through the summer at many features. Western Small-footed Myotis was the most commonly detected bat at all surveyed features. Little Brown Bats are more commonly detected at facilities than at cave sites.

Most identified bat species were detected at all features (i.e., at both facilities and caves). One notable exception, Townsend's Big-eared Bat, appears to have a somewhat restricted distribution on the INL Site despite its being one of the most common bats on the INL Site and the most frequently counted hibernating bat in INL Site caves. To date it has only been detected at two facilities despite being detected at all caves. Townsend's Big-eared Bat 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 roost habitat (e.g., exposed rock outcrops, caves and cave-like features) is most common. Tree bats (Hoary Bats and Silver-haired Bats) were detected more frequently at facilities than caves. Patterns suggest both resident and migrant tree bats occur at INL Site facilities.

In conjunction with the IDFG, BLM, 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 two years, but because so few bats were recorded (0-2 bats each two-hour survey conducted twice monthly), it was felt these surveys did not produce useful information for DOE-ID and were discontinued for the 2017 season. At the request of IDFG, surveys were resumed in 2018, but very few or no bats have been detected during monthly surveys. The data appears to have little value for INL Site monitoring but is important for agency collaboration and possibly region-wide efforts.

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. In a number of cases, cold-trap crater caves that are too cool during summer to serve as day roosts will have high levels of evening activity as bats focus foraging at these sites. Beyond their use as roosts, caves at the INL Site serve as important habitat features for summer resident bats. Additionally, preliminary surveys indicate that caves may be used as stop-over habitat during fall migrations by previously undocumented forest bats, such as the Hoary Bat. Very little is known about the use of caves by migrating forest bats (Cryan 2011), and these areas may provide vital resources as bats traverse atypical habitats.

Currently, monitoring of hibernating bat populations is conducted biennially by ESER wildlife biologists at nine known INL Site hibernacula. Surveys are conducted in coordination with BLM 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 highest and most stable. Caves were scheduled to be counted again during the winter of 2016–2017; however, numerous instances 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 VNS-ID-ESER-PROC-022, ESER Cave Protection and Access, 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 is the most commonly counted over-wintering bat species, with western Small-footed Myotis being the second most common, but with far fewer numbers. A total of 487 Townsend's Big-eared Bats and 51 Western Small-footed Myotis were counted during our most recent (winter 2017-2018) hibernaculum counts. Historically over-wintering Big Brown Bats have been encountered, but not during the most recent surveys.

Passive acoustic monitoring at long-term stations operating at caves and facilities are revealing patterns of bat activity across the INL Site. An analysis of passive acoustic data collected at remote site (caves) and facility ponds indicated high variability and distinct patterns of activity across seasons with clear differences between developed and natural areas (Figure 9-15). Developed areas with anthropogenic structures (facilities, bridges, and culverts) are used as habitat by bats on the INL Site as well as natural areas. Developed areas, and their associated lands, occupy about 0.38% of the INL Site. Some of these facilities were constructed in the 1950s and are surrounded by mature landscaping trees and wastewater ponds, which provide bats with vertical-structure habitat, water, and foraging areas. Patterns shown in Figure 9-15 reveal good levels of summer activity at both developed and natural sites. May and August peaks at facilities reveal transient use at facilities 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 areas are important activity centers for resident bats and also serve as pre-hibernation gather sites (swarming sites).

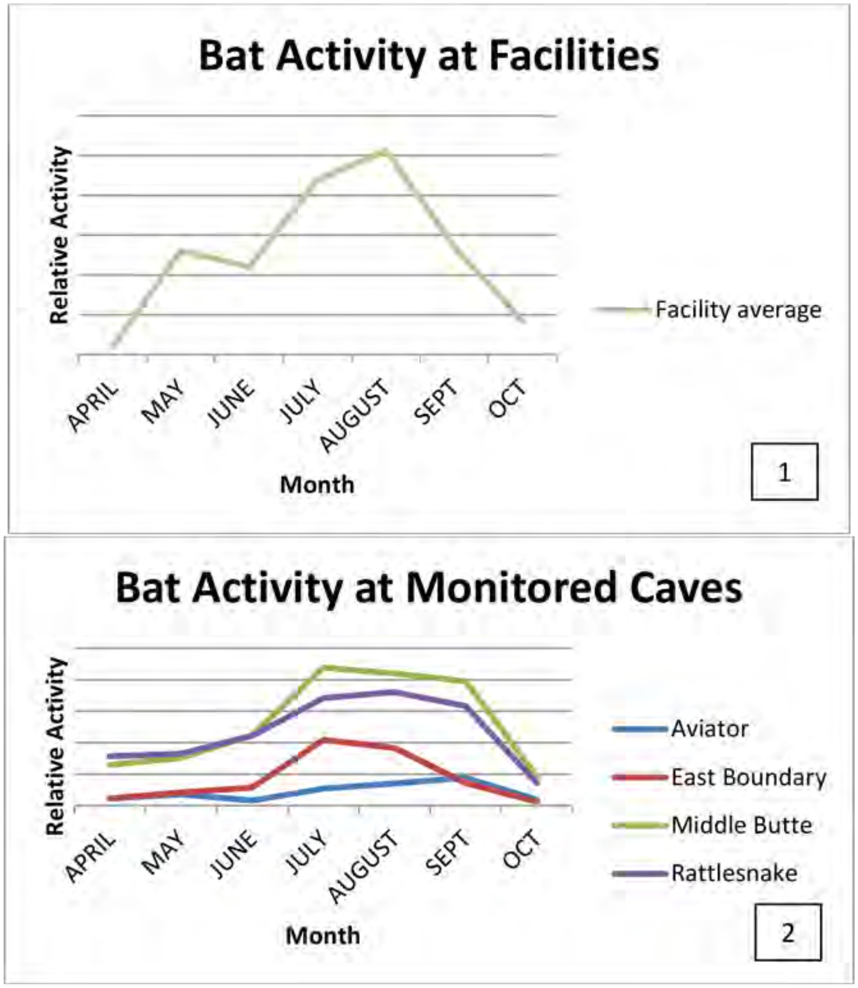


Figure 9-15. Average Relative Levels of Bat Activity Across the Summer Activity Season (April–October) for Acoustic Monitors Deployed at Facilities (1) and Caves (2). May and August activity peaks at facilities indicate a good deal of transient use as bats migrate back and forth between summer and winter habitats. High activity throughout summer months at caves indicate these areas are important summer activity centers for resident bats.

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10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

Ecological monitoring and research at the Idaho National Laboratory Site (INL) in 2019 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 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 2019 through an update to the INL Site vegetation classification and map. The new vegetation map dataset was finalized in 2019 and it includes the most detailed vegetation map ever produced for the INL Site. Key results from this effort are a statistical plant community classification defining 16 major vegetation types on the INL Site, mapped distributions of each class, and a comprehensive accuracy assessment for mapped classes. A final report detailing several quantitative and spatial data products is now available.

Sagebrush habitat monitoring and conservation measures to support the Candidate Conservation Agreement were addressed by three tasks in 2019. The first entails resampling 75 plots, which have been sampled annually since 2013, and 50 rotational plots, which were last sampled in 2015, to assess habitat condition. Absolute cover, height, and density of sagebrush and perennial grass/forbs were measured for this task. The second task, sagebrush habitat distribution, was updated using aerial imagery acquired after the Sheep Fire. The final task, which entails sagebrush habitat restoration, continued in 2019, and seedling survivorship assessments of shrubs planted in 2018 were completed.

The INL Site was designated as a NERP in 1975. The NERPs 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 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. During 2019, three ecological research projects were conducted on the Idaho NERP: continued studies of ants and ant guests at the INL Site, behavioral ecology of pregnant Great Basin Rattlesnakes, and sage-grouse movements and habitat use through nesting and brood-rearing seasons.

The United States Geological Survey has been studying the hydrology and geology of the eastern Snake River Plain and eastern Snake River Plain aquifer since 1949. The United States Geological Survey INL Project Office collects data from research and monitoring wells to create and refine hydrologic and geologic models of the aquifer; track contaminant plumes in the aquifer; and improve understanding of the complex relationships between the rocks,

10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological monitoring and research performed at the Idaho National Laboratory (INL) (Sections 10.1 through 10.4) and research conducted on the eastern Snake River Plain and eastern Snake River Plain aquifer by the United States Geological Survey (Section 10.5) during 2019.

10.1 Ecological Monitoring and Research at the Idaho National Laboratory

Ecological monitoring and research on the INL Site generally falls into three categories; 1) Monitoring the condition and conservation status of vegetation communities and sensitive plant species, 2) Annual assessment of sagebrush (*Artemisia tridentata*) 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 a technical report was completed in 2018. An INL Site Vegetation Map update was initiated in 2017 and a final map and technical report with supporting documentation were completed in 2019.

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 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 condition task is completed annually and the distribution task is completed periodically, based on available imagery. In 2019, imagery was acquired for the area affected by the Sheep Fire and the habitat distribution task was updated accordingly. 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. Sagebrush seedlings have been planted since 2015 and survivorship has been monitored every year since 2016.

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 three ecological research projects ongoing through the Idaho NERP; one includes documenting ants and associated arthropods on the INL Site, one involves tracking rattlesnake movements through gestation and dispersal of young, and one addresses sage-grouse movements and habitat use through nesting and brood-rearing seasons.

10.2 Vegetation Communities and Sensitive Plant Species

10.2.1 INL Site Vegetation Map Update

The new vegetation map dataset was finalized in 2019 and it includes the most detailed vegetation map ever produced for the INL Site. The most recent vegetation map prior to this update (Shive et al. 2011) represented a significant improvement over earlier mapping because the vegetation classes were statistically defined, and a quantitative accuracy assessment of the map was conducted. The current map was essentially an update to the Shive et al. (2011) map, and because the same general methods were used, the function and utility of the new map will seamlessly continue to support conservation monitoring and land management on the INL Site. The key improvements to the updated map are more straightforward vegetation and map classes and a finer mapping scale.

The comprehensive update to the current map was initiated in 2017 and involved 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. The final step of the process, an accuracy assessment of the draft map, was completed in 2019.

One of the fundamental elements of a mapping project is an independent accuracy assessment that adds validity to the project and provides a basis for evaluating the utility of the map for potential applications. There have been a number of proposed statistical methods for validating image classification accuracy, but the error matrix remains the most commonly used method to calculate map accuracies and serves as the basis for most descriptive and analytical statistics (Congalton 1991, Congalton and Green 1999). The error matrix, also known as a confusion matrix or contingency table, is a square array organized in rows and columns where predicted data is compared to measured data through cross-tabulation. The columns in an error matrix represent the reference data collected on the ground, and the rows in an error matrix represent the classified (or map) data.

The error matrix supports the calculation of numerous measures of map and class accuracy. The most reported measures of classification accuracy are the user's accuracy, producer's accuracy, and overall accuracy. User's accuracy represents the probability that a classified image pixel or map polygon is that category on the ground (Story and Congalton 1986). Producer's accuracy represents the probability that a true positive location on the ground is correctly classified (Congalton and Green 1999). Overall accuracy provides a measure of the agreement among all map classes and reference data and serves as a single metric that collectively represents the entire classified map (Congalton and Green 1999).

One critique of the overall accuracy metric is that it does not account for agreement between map and reference data that can occur by chance alone. Cohen (1960) introduced a discrete multivariate technique called the Kappa coefficient as a novel method to evaluate overall map accuracy which allows for compensation due to chance agreement. Calculation of the Kappa coefficient represents a measure of the agreement between predicted and reference data with values ranging from -1 to +1.

To assess accuracy for the most recent vegetation map update, field crews were provided GPS receivers with plot point locations uploaded as waypoint files. Each waypoint was assigned a nondescript plot identification number and information about the identity of the polygon class was excluded to avoid influencing crews about the class they were sampling. Because the validation plot locations were randomly selected, some ended up in a transition zone between vegetation classes or in a locally unique spot that was not representative of the surrounding landscape. Field crews were instructed to visually scan the landscape within the local vicinity to determine whether the plot was located within a homogenous region. Homogenous did not necessarily mean all the same species present, but rather all the same general vegetation class was present within the anticipated plot extent. Whenever appropriate, the field crew shifted the plot center point into an area more representative of the surrounding landscape, but they were limited to a 40 m (131.2 ft) total distance the plot could be relocated. This restriction was placed to avoid violating sample independence from other potentially close random plot locations.

Once the plot center point was located either by navigating to a GPS waypoint or after a shifting the plot into a more representative area, a stake was inserted into the ground. Then the plot perimeter was established and marked by extending a thin rope attached to the center stake and placing reference poles in the ground in the four cardinal directions. After suggested plot sizes for semi-arid shrublands and herbaceous vegetation were considered (Lea and Curtis 2010), a plot size that accounted for the range of variability across most vegetation classes on the INL Site was chosen. The standard plot area sampled for nearly all vegetation classes was 0.25 ha (28 m radius [91.9 ft]; Figure 10-1). The only exception was the Juniper Woodland class where plot size was increased to accommodate interspace distances between tree canopies that required a larger plot size to encompass natural tree spacing in this vegetation class. All Juniper Woodland accuracy assessment plots were denoted with a unique plot identification number and plot area was increased to 0.5 ha (40 m radius [131.2 ft]; Figure 10-1).

Once the general plot boundary was established, each field crew member walked around the plot noting the dominant and co-dominant species present. After each field crew member finished their visual assessment, they both worked through a dichotomous field key, developed during the plant community classification step of the map development process, to assign the most appropriate vegetation class to the plot. The field crews were given the opportunity to mark 'Yes' under a field called *Key Agreement* if the plot was accurately characterized by the dichotomous key, or 'No' to denote when the plot was difficult to fit into a class using the dichotomous key. Because the purpose of classification is to organize plant

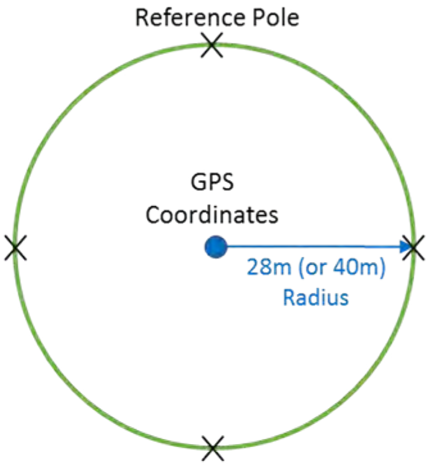


Figure 10-1. Idaho National Laboratory Site Vegetation Map Accuracy Assessment Plot Schematic. Plot size was 0.25 ha (28 m radius) for all semi-arid shrubland and herbaceous vegetation classes, or 0.5 ha (40 m radius) for all woodlands. The 'X' marks the locations of four reference poles that were visual aids for plot boundaries. Global Positioning System (GPS) coordinates were collected at the plot center, and representative plot photos were taken from the center aimed towards each reference pole.

communities into generalized vegetation classes, the key may not have performed well for identifying the rare or unique vegetation classes on the INL Site. There were two optional fields to record a second vegetation class if the key did not work well, and a data field for comments to provide context of the issues encountered at the plot or anything else that may help data interpretation. Once the plot data were recorded, reference photos were taken looking in the four cardinal directions from the plot center.

Initially, there were two big sagebrush classes (i.e., Big Sagebrush – Green Rabbitbrush [Threetip Sagebrush] Shrubland and Big Sagebrush Shrubland) maintained as separate, distinct classes that were each allocated the appropriate number of random field validation plots. But as field sampling progressed throughout the summer, there were two instances where independent field crews sampled the same plot location at different times. In both cases, the field crews chose different big sagebrush classes. There was considerable statistical classification overlap between these two vegetation classes and it was anticipated that these two could likely be difficult to distinguish in the field and could be distributed as a patchwork mosaic across the landscape making the determination subjective. Consequently, whenever either class Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland or Big Sagebrush Shrubland was recorded in the field or assigned to map polygons, they were combined prior to the accuracy assessment calculations. Two herbaceous vegetation classes were also combined into one map class due to difficulties in differentiating them in the imagery. Combining these two sets of vegetation classes resulted in 13 total map classes for the INL Site.

During the summer of 2018, a total of 453 validation plots were collected and used to support the accuracy assessment of the final vegetation map. The Spatial Join function in ArcGIS was used to add the vegetation class code assigned to the polygon that contained the plot location to the database table. Once the error matrix tabulation was competed, both user's and producer's accuracy were calculated for each map class including 90% confidence intervals. Overall accuracy and Kappa were also calculated as representative measures of map accuracy.

The accuracy assessment resulted in an overall accuracy of 77.3% and a Kappa value of 0.75 (Table 10-1). Considering there were 13 map classes distributed across the large extent of the INL Site, the results suggest the final vegetation map is a good representation of vegetation classes found on the ground. The map accuracy result values were higher than three of the four methods used to validate the previous vegetation map (Shive et al. 2011). The Kappa value is close to the 0.8 threshold which can be interpreted as strong agreement (Landis and Koch 1977); it is rarely achieved over large areas such as the INL Site, and is also higher than three of the four error matrix results from the previous vegetation map accuracy assessment (Shive et al. 2011).

The Juniper Woodland class had the highest user's and producer's accuracy at 100% with no documented mapping errors (Table 10-1). This map class is an exception compared to most of the others because it is unmistakable in the imagery and does not overlap with other vegetation classes spectrally. Utah Juniper (*Juniperus osteosperma*) is the only native tree species commonly found on site, although there are some individual cottonwood (*Populus sp.*) trees along the Big Lost River and historic Birch Creek drainages.

The map class with the next highest user's accuracy was the combined Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland and Big Sagebrush Shrubland class at 93.9% (Table 10-1). This result is no-

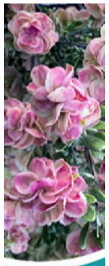
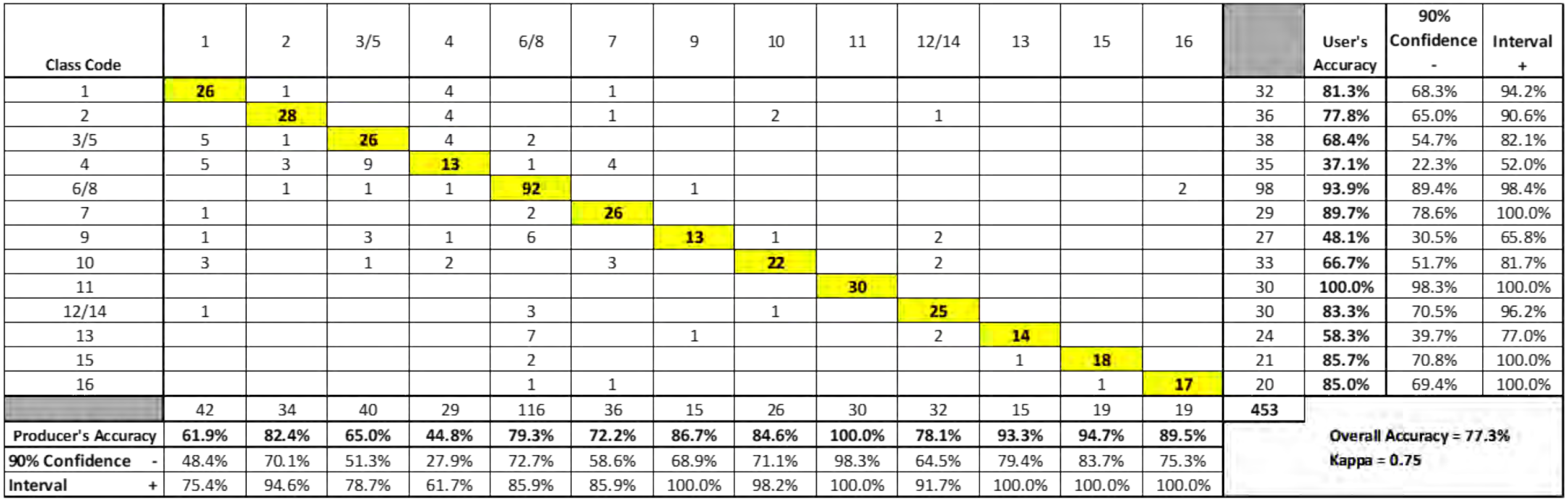


Table 10-1. Idaho National Laboratory Site Vegetation Map Accuracy Assessment Error Matrix and Associated Metrics including User's and Producer's Accuracy, Overall Accuracy, Kappa Coefficient Values, and 90% Confidence Intervals for Individual Classes. The columns in the error matrix represent field validation data, and the rows represents map data. Vegetation class codes: (1) Green Rabbitbrush / Sandberg Bluegrass – Bluebunch Wheatgrass Shrub Grassland, (2) Cheatgrass Ruderal Grassland, (3/5) Green Rabbitbrush / Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland, (4) Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland, (6/8) Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland and Big Sagebrush Shrubland, (7) Crested Wheatgrass Ruderal Grassland, (9) Western Wheatgrass Grassland, (10) (Basin Wildrye) – Mixed Mustards Infrequently Inundated Playa/Streambed, (11) Juniper Woodland, (12/14) Indian Ricegrass Grassland and Gardner's Saltbush (Winterfat) Shrubland, (13) Shadscale Saltbush – Winterfat Shrubland, (15) Black Sagebrush Shrubland, (16) Low Sagebrush Shrubland.



Class Code	1	2	3/5	4	6/8	7	9	10	11	12/14	13	15	16		User's Accuracy	90% Confidence -	Interval +
1	**26**	1		4		1								32	**81.3%**	68.3%	94.2%
2		**28**		4		1		2		1				36	**77.8%**	65.0%	90.6%
3/5	5	1	**26**	4	2									38	**68.4%**	54.7%	82.1%
4	5	3	9	**13**	1	4								35	**37.1%**	22.3%	52.0%
6/8		1	1	1	**92**		1						2	98	**93.9%**	89.4%	98.4%
7	1				2	**26**								29	**89.7%**	78.6%	100.0%
9	1		3	1	6		**13**	1		2				27	**48.1%**	30.5%	65.8%
10	3		1	2		3		**22**		2				33	**66.7%**	51.7%	81.7%
11									**30**					30	**100.0%**	98.3%	100.0%
12/14	1				3			1		**25**				30	**83.3%**	70.5%	96.2%
13					7		1			2	**14**			24	**58.3%**	39.7%	77.0%
15					2						1	**18**		21	**85.7%**	70.8%	100.0%
16					1	1						1	**17**	20	**85.0%**	69.4%	100.0%
	42	34	40	29	116	36	15	26	30	32	15	19	19	**453**			
Producer's Accuracy	**61.9%**	**82.4%**	**65.0%**	**44.8%**	**79.3%**	**72.2%**	**86.7%**	**84.6%**	**100.0%**	**78.1%**	**93.3%**	**94.7%**	**89.5%**	**Overall Accuracy = 77.3%** **Kappa = 0.75**			
90% Confidence -	48.4%	70.1%	51.3%	27.9%	72.7%	58.6%	68.9%	71.1%	98.3%	64.5%	79.4%	83.7%	75.3%				
Interval +	75.4%	94.6%	78.7%	61.7%	85.9%	85.9%	100.0%	98.2%	100.0%	91.7%	100.0%	100.0%	100.0%				

table as the map is used extensively to define the extent and location of sagebrush habitat on the INL Site. There were five other classes that all had a user's accuracy above 80%. The lowest user's accuracy was the Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland class at 37.1% (Table 10-1).

The second highest producer's accuracy was the Black Sagebrush Shrubland class at 94.7% (Table 10-1). The Shadscale Saltbush – Winterfat Shrubland class was also very high with a producer's accuracy of 93.3% (Table 10-1). There were four additional classes that had producer's accuracy above 80%. The lowest producer's accuracy was also in the Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland class at 44.8% (Table 10-1).

The update to the INL Site Plant Community Classification and Mapping project was completed in 2019. A final technical report summarizing the results of the project and including all major data products derived from the project, like the vegetation map, the dichotomous key to plant communities, and fact sheets describing each vegetation class, are available on the ESER website: (www.idahoeser.com/LandManagement/VegMap/Vegetation%20Community%20Classification%20and%20Mapping%20of%20the%20INL%20Site%202019.pdf).

10.3 Sagebrush Habitat Monitoring and Restoration

10.3.1 Sagebrush Habitat Condition

Sage-grouse cannot survive without healthy sagebrush stands that meet certain criteria related to the condition and distribution of their habitat (Connelly et al. 2000). Sage-grouse use sagebrush dominated lands year-round and rely on sagebrush for food, nesting, and concealment from predators. In addition to healthy stands of sagebrush, sage-grouse also require a diverse understory 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, one group consists of plots located in areas currently mapped as sagebrush habitat and the second group contains plots located in recovering habitat where sagebrush has been lost due to wildland fires. During the 2019 monitoring field season, the Sheep Fire caused a slight disruption to sampling efforts. Data were collected from 71 annual plots between June and August reflecting the loss of four plots from sampling this year due to the wildland fire. Enough data were collected to conduct planned comparative analyses on the annual plots; however, two sagebrush habitat plots were burned and will have to be allocated to the recovering habitat group for future monitoring.

To increase sample size and to address potential habitat threats, specifically wildland fire and livestock use, an additional 150 plots were added and are sampled on a rotational basis (Figure 10-2). Rotational plots are divided into three sets of 50 plots that are each sampled once over a five-year cycle. Set 2 of the rotational plots were scheduled to be sampled in 2019 and 48 of the 50 rotational were sampled; the remaining two plots were affected by the Sheep Fire prior to sampling. Rotational plots are analyzed, and results are reported once every five years, after all rotational plots have been sampled; the next scheduled analyses of the rotation plots will be reported in the 2021 CCA Monitoring Report. Annual and rotational plots are sampled for vegetation cover, height by species, sagebrush density, and sagebrush juvenile frequency. In 2019, results from annual plots were summarized and compared to site-specific (local) baseline values and to regional habitat guidelines (Connelly et al. 2000).

Total absolute cover on sagebrush habitat plots in 2019 was about 67% and just under half of the total cover was from shrubs (Shurtliff et al. 2020). Most of the shrub component was from sagebrush, and mean sagebrush cover in 2019 was slightly higher than the local baseline (Table 10-2a, Table 10-2b). Perennial grass/forb cover and height were substantially higher in 2019, when compared to the local baseline. Perennial herbaceous cover and height have been increasing since 2014

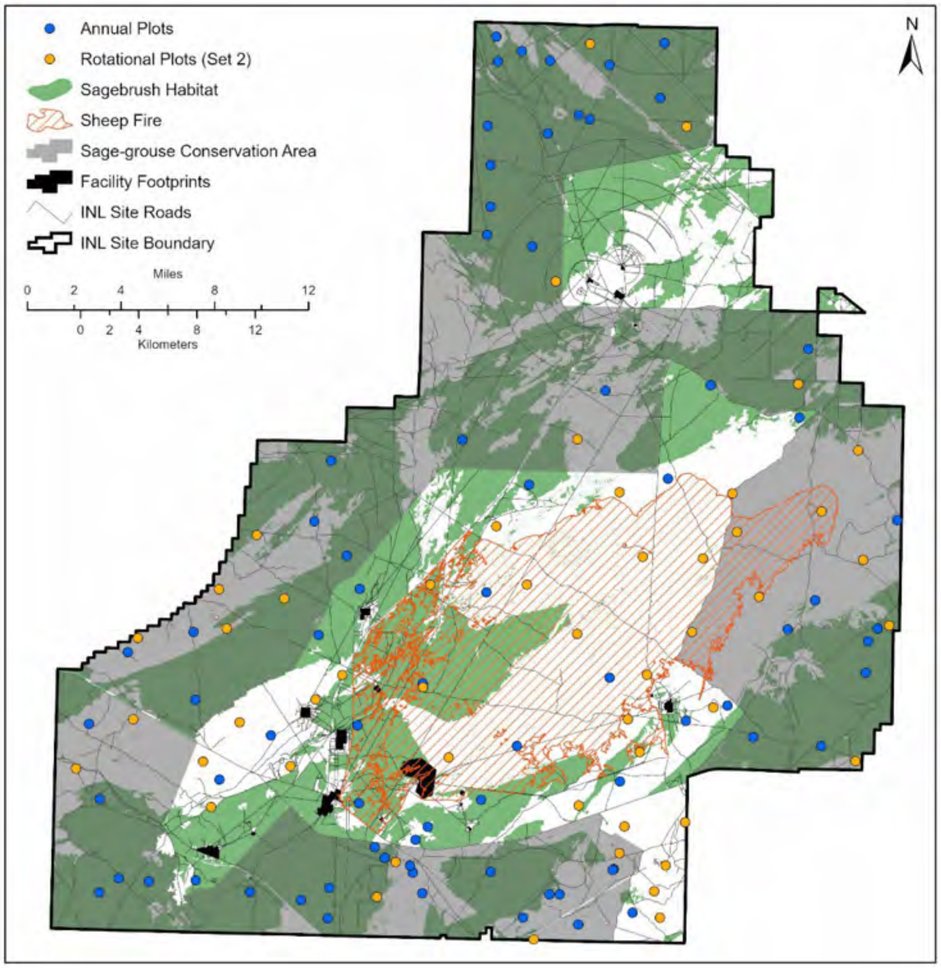


Figure 10-2. Annual and Rotational Set 2 of the Sage-grouse Habitat Condition Monitoring Plots on the Idaho National Laboratory Site. Seventy-one of the annual plots and 48 of the rotational plots were sampled in 2019; the remaining six plots were not sampled due to the Sheep Fire.

and both remain near the upper end of their range of variability (Shurtliff et al. 2020). Sagebrush density was lower in 2019 than the local baseline (Table 10-2a, Table 10-2b), but it is within the recorded range of variability from data collected since the beginning of this project.

Plots from recovering burned areas (non-sagebrush plots) were also compared to the baseline values (Table 10-2a, Table 10-2b). Total absolute cover on recovering burned areas was about 74% in 2019 and most of the vegetative cover was from herbaceous species (Shurtliff et al. 2020). Perennial grasses and forbs provided about 25% of the total cover on recovering burned plots and cheatgrass contributed a nearly equal amount of vegetative cover. It is notable, however, that cheatgrass cover declined from 37% in 2018 to 27% in 2019 (Shurtliff et al. 2020). Green rabbitbrush (*Chrysothamnus viscidiflorus*) was the most abundant shrub in the non-sagebrush plots with about 13% total cover (Shurtliff et al. 2020). Overall, perennial grass/forb cover were higher in 2019 than the baseline and sagebrush density remained very low in plots recovering from wildland fire, but it was slightly higher in 2019 when compared to the baseline.

Herbaceous functional groups are highly influenced by precipitation; therefore, habitat condition monitoring data can be interpreted within the context of local precipitation data. Precipitation data have been collected from Central Facilities Area (CFA) since 1950 comprising a long-term data set which is summarized by monthly, seasonal, and annual averages. Over the past decade, weather patterns have been highly variable with some of the driest years on record and with substantial departures from historical patterns of seasonality. These short-term precipitation patterns would certainly favor some plant species and functional groups over others. In 2019, pre-

Table 10-2a. Summary of Selected Vegetation Measurements for Evaluating the Condition of Sagebrush Habitat Monitoring Plots and Non-sagebrush Monitoring Plots on the Idaho National Laboratory Site in 2019.

2019	Mean Cover (%)	Mean Height (cm)	Mean Density (individuals/m^2)
Sagebrush Habitat Plots *(n = 46*)*			
Sagebrush	25.02	47.78	4.01
Perennial Grass/Forbs	20.46	26.33	
Non-sagebrush Plots *(n = 25*)*			
Sagebrush	0.40	41.14	0.16
Perennial Grass/Forbs	24.98	30.08	

*Indicates sample size difference from past sampling efforts.

Table 10-2b. Local Baseline Values of Selected Vegetation Measurements for Evaluating the Condition of Sagebrush Habitat Monitoring Plots and Non-sagebrush Monitoring Plots on the Idaho National Laboratory Site. Local baseline values were generated from 2013-2017 data.

Baselines	Mean Cover (%)	Mean Height (cm)	Mean Density (individuals/m^2)
Sagebrush Habitat Plots *(n=48)*			
Sagebrush	21.27	47.81	5.19
Perennial Grass/Forbs	9.99	20.70	
Non-sagebrush Plots *(n=27)*			
Sagebrush	0.22	33.54	0.07
Perennial Grass/Forbs	19.97	29.76	

cipitation was slightly below average due to a drier summer season but cover from perennial and annual species remained above the baseline, possibly due to a lag effect. However, cheatgrass cover was lower in 2019 than in 2018, after several years of trending upward (Shurtliff et al. 2020).

A monitoring report containing the full results of the habitat condition monitoring project through 2019 is available on the ESER website (www.idahoeser.com/Wildlife/PDF/2019%20CCA%20Full%20Report.pdf).

10.3.2 Sagebrush Habitat Distribution

Loss of sagebrush-dominated habitat has been identified as one of the primary causes of decline in sage-grouse populations (Idaho Sage-grouse Advisory Committee 2006). Direct loss of sagebrush habitat on the INL Site has occurred through several mechanisms including wildland fire and infrastructure development. In the future, the total area and extent of sagebrush habitat will continue to change following wildland fires, as new facilities are developed on the INL Site, and as lands recover naturally or are restored following decommissioning of existing facilities. Changes in land cover can be determined using airborne or satellite imagery that is readily available at little or no cost. ESER geographic information system (GIS) analysts routinely compare new imagery as it becomes available with results from the most current vegetation classification and mapping project. Ground-based point surveys and changes in plant species cover and composition documented through an associated habitat condition monitoring task are also used to provide spatial information to assist with periodic map updates needed to monitor sagebrush habitat distribution.

The Sage Grouse Conservation Area (SGCA) was defined as a portion of the INL Site where conservation of sage-grouse and their habitat is considered a priority, and in which a 20% loss of sagebrush habitat from the 2013 baseline has been identified as a conservation trigger in the CCA (DOE-ID and FWS 2014). The purpose of the habitat distribution monitoring task is to maintain and update regions of the INL Site vegetation map to accurately document changes in sagebrush habitat area and distribution within and outside of the SGCA. This task documents changes in sagebrush habitat following losses due to wildland fire or other disturbances that remove or significantly alter vegetation across the landscape. In addition to documenting losses of sagebrush habitat, this monitoring task also maps the addition of sagebrush habitat when sagebrush cover increases within a mapped polygon and warrants a new vegetation map class designation, or to refine existing vegetation map class boundaries when changes in species cover and composition are documented through associated habitat condition monitoring. Lastly, this task supports post-fire mapping when the fire extent is unknown and allows for modifying existing wildland fire boundaries and unburned patches of vegetation when mapping errors are observed on the ground.

There was one large wildland fire that burned on the INL Site in 2019 and it altered existing vegetation map class distribution, including sagebrush habitat. The Sheep Fire was first reported in the evening of July 22, 2019. The lighting-caused fire started in the east-central region of the INL Site within the 2010 Jefferson Fire footprint and initially spread primarily south and southwest. High, sustained winds the following day promoted the continued expansion generally to the southwest towards the Critical Infrastructure Test Range Complex and Idaho Nuclear Technology and Engineering Center facilities. The fire was fully contained on July 27 and it was one of the largest fires in INL Site history.

The initial boundary for the Sheep Fire was produced from limited field data collected by the BLM and some data from INL. However, experience with other recent large fires suggests the actual burned area boundary typically differs from the generalized boundary created immediately post-fire. To assist with post-fire evaluation and mapping, high resolution commercial satellite imagery was acquired on September 15, 2019 by Digital Globe's GeoEye-1 sensor. The GeoEye-1 sensor collected four spectral bands in the visible and near-infrared region of the electromagnetic spectrum with 2 m resolution, and a panchromatic band with 0.5 m resolution. Digital Globe delivered raw and processed imagery data products that were radiometrically corrected, pan-sharpened, orthorectified, and georeferenced for easy integration into a GIS.

A GIS Analyst first investigated the spatial accuracy by overlaying the GeoEye-1 imagery on the 2017 Idaho National Agricultural Inventory Program image dataset. Reference points around facilities were compared and the new satellite imagery was so closely aligned that no further coregistration spatial adjustments were deemed necessary. The Sheep Fire perimeter and burned area were manually digitized in a GIS at a 1:6,000 mapping scale. This matches the mapping scale used to produce the most recent INL Site vegetation map (Shive et al. 2019) and will enable the fire boundary to be used to clip the vegetation map for future post-fire mapping updates. The color-infrared image composite was used as the primary data source to help identify areas that burned or partially burned in the Sheep Fire. The color-infrared imagery displays recently burned areas with a blue hue while unburned vegetation appears as red tones.

There were multiple regions within the burned area where a mosaic of observable unburned patches of vegetation remained after the fire. The vast majority of the Sheep Fire moved through areas previously burned in the 2010 Jefferson and 2011 T-17 Fires. In areas where sagebrush habitat had already been removed and vegetation communities were in good ecological condition before the fire, the post-fire vegetation classes most likely to naturally establish after the fire will be the same vegetation classes mapped before the fire (Ratzlaff and Anderson 1995, Blew and Forman 2010). Therefore, we focused mapping efforts in the southwest region of the Sheep Fire that had not been burned previously, and where large stands of sagebrush habitat were recently mapped (Shive et al. 2019). After each patch of unburned vegetation was delineated, we used the Intersect geoprocessing tool in ArcGIS to automatically assign the class codes and boundaries from the vegetation map to each mapped polygon.

Mapping results indicated the Sheep Fire burned approximately 40,403.3 ha (99,838.8 acres), which is a reduction from the initial estimate of 45,368 ha (112,106.7 acres) using the original BLM boundary (Figure 10-3). Throughout the northern region of the Sheep Fire, there were many unburned patches of vegetation in previously burned areas where sagebrush is absent and were therefore not a focus for our mapping effort. Thus, the mapping results, while improving upon the initial estimate,

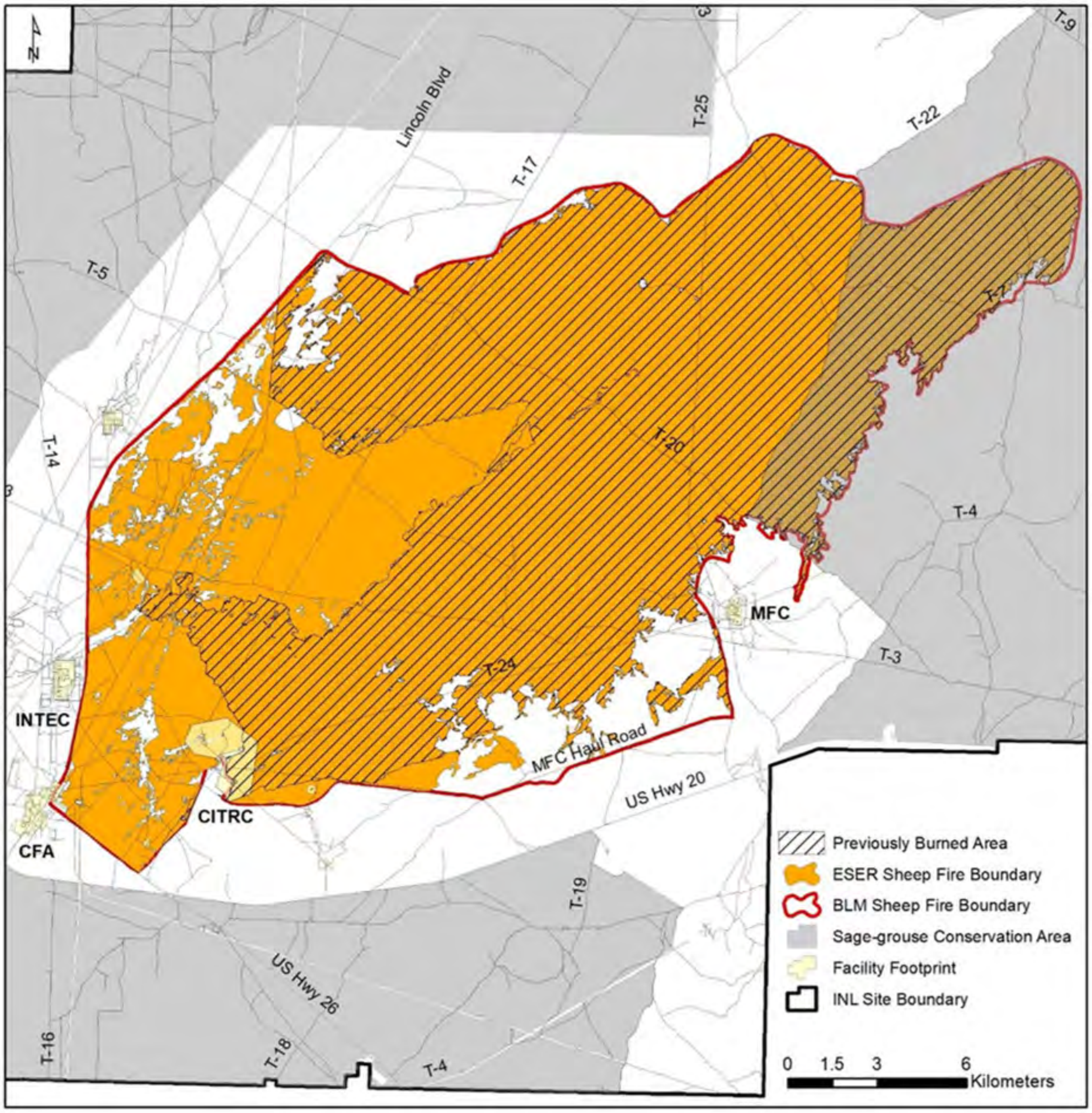


Figure 10-3. Sheep Fire Boundary on the Idaho National Laboratory Site Mapped from High Resolution Satellite Imagery Plotted over the Original Fire Boundary Produced by the Bureau of Land Management. Areas within the Sheep Fire footprint that have burned since 1994 and removed sagebrush habitat are denoted with cross-hatching.

still overestimate the actual burned area. There were 4,753.8 ha (11,746.9 acres) of vegetation burned within the SGCA, representing 11.8% of the total burned area (Figure 10-4). The only sagebrush habitat lost within the SGCA were a few unburned patches of sagebrush that remained within the footprint of the 2010 Jefferson Fire boundary totaling 2.3 ha (5.7 acres).

The sagebrush habitat outside of the SGCA is considered a "conservation bank" (DOE and FWS 2014, pg. 55) that could be incorporated into the SGCA to replace lost sagebrush habitat resulting from wildland fire or new infrastructure development (DOE and FWS 2014). Prior to the Sheep Fire, the total area of sagebrush habitat outside the SGCA was 38,742.5 ha (95,734.8 acres). The Sheep Fire burned 10,401.7 ha (25,703.1 acres) of sagebrush habitat outside the SGCA thus reducing the "bank" by 28.6% (Figure 10-4).

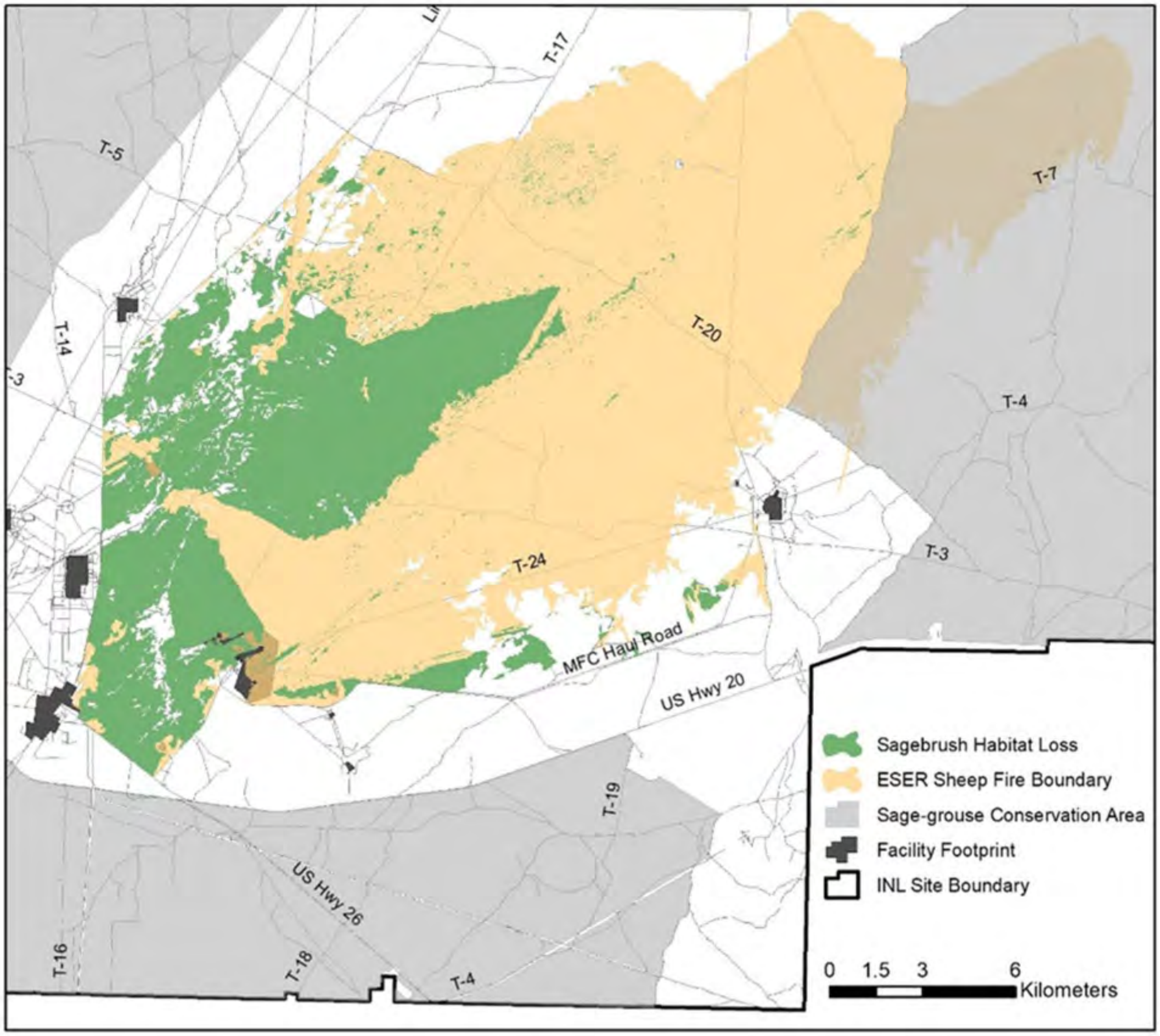


Figure 10-4. Distribution of Sagebrush Habitat Burned in the 2019 Sheep Fire on the Idaho National Laboratory Site.

There were three other small fires that burned on the INL Site in 2019, none of which were located within sagebrush habitat. On July 13, 2019, the Howe Junction fire burned 0.1 ha (0.25 acre) on the north side of Highway 20/26. On September 11, 2019, there were two separate lightning-caused fires near the ATR Complex. The Monroe 1 Fire was a small creeping fire totaling approximately 0.2 ha (0.5 acre). The Monroe 2 Fire occurred west of the ATR Complex and burned approximately 21 ha (52 acres).

Currently, the SGCA sagebrush habitat baseline value is defined as 78,558 ha (194,120 acres) and has remained virtually unchanged since the signing of the CCA. In 2018, infrastructure expansion removed 2.3 ha (5.7 acres) of sagebrush habitat. The Sheep Fire burned another 2.3 ha (5.7 acres), resulting in a current estimated sagebrush habitat area of 78,553.4 ha (194,109.7 acres). The reduction in sagebrush habitat within the SGCA was less than a 0.01% change from the baseline value, and even though a significant amount of habitat was burned in the Sheep Fire, the losses did not impact the habitat trigger status.

A monitoring report containing the full results of the habitat distribution monitoring project through 2019 is available on the ESER website (www.idahoeser.com/Wildlife/PDF/2019%20CCA%20Full%20Report.pdf).

10.3.3 Sagebrush Habitat Restoration

In the CCA for the INL Site (DOE-ID and FWS 2014), DOE committed to minimize the impact of habitat loss due to wildland fire and firefighting activities by taking steps to accelerate sagebrush reestablishment whenever a fire burns >40 hectares (>99 acres). Although no wildland fires >40 hectares (>90 acres) occurred between signing the CCA and the Sheep Fire of 2019, beginning in 2015 DOE 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 10.4.4). This ongoing habitat restoration effort has taken place annually over the past five years.

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 6 in^3 or 10 in^3 containers, 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 is not 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 2019, sagebrush seedlings were planted at a location in the northwest corner of the Jefferson Fire (Figure 10-5).

Although DOE committed to growing and planting at least 5,000 seedlings every year, more than the minimum number of seedlings have been planted every year since 2015. In 2019, approximately 10,000 seedlings were planted on 36.8 ha (91 acres) and the locations of 501 (~5%) seedlings were marked for future monitoring. Over the past four years, a total of 52,000 seedlings have been planted and sagebrush restoration has now been addressed on a total 172.3 hectares (425.9 acres).

In addition to planting seedlings, survivorship of previous planting efforts is monitored every year. Survivorship monitoring occurs at each planting location one- and five-years post-planting. To quantify 2018 seedling sur-

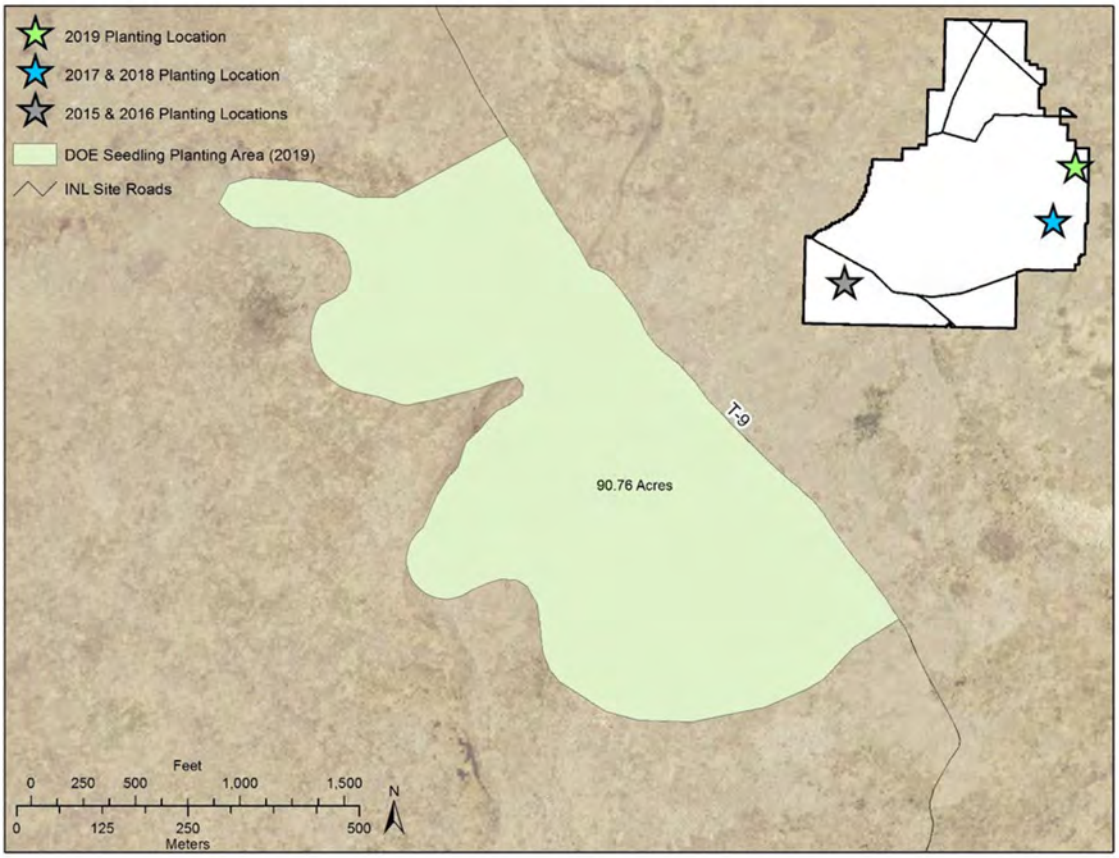


Figure 10-5. Area Planted with Big Sagebrush Seedlings in 2019.
The stars on the inset map shows the general location of all year's plantings.

vivorship and condition, 899 sagebrush seedlings were revisited in August 2019. The seedlings were assessed as 509 (57%) were healthy, 85 (9%) were stressed, 108 (12%) were dead, and 197 (22%) were missing. Assuming the missing seedlings were dead, a total of 66% of the seedlings survived the first year. For comparison, years 2015-2019 are also shown in Figure 10-6.

Many of these seedlings planted in 2018 and assessed in 2019 were growing in a lateral direction (Figure 10-7). Some were lying directly on the ground but were alive. While the cause is ultimately unknown, these seedlings were exceptionally tall at the time of planting and were snowed on almost immediately after planting (5+ in of heavy wet snow). The weight of the snow combined with the lack of structure of the plant may have been partially at fault for the more decumbent growth than seen in the seedlings planted in 2018 and prior. The unusual growth orientation of the seedlings does not appear to be affecting survivorship.

Precipitation patterns from fall 2018 to fall 2019 were characteristic of average growth conditions. Both timing and amount of precipitation did not depart substantially from normal, long-term averages. Spring precipitation was ideal for helping the seedlings planted in 2018 to establish. Late summer (July and August) was drier than normal, but a wetter than average September normalized the precipitation totals. Despite the lack of moisture during summer, many of the plants relocated were labeled as being healthy (57%) and very few were stressed or dead (9% and 12%, respectively). In a review of 24 projects where containerized sagebrush seedlings were planted and survivorship was measured after one year, researchers reported first year survival of stock ranged from 14% to 94% (median = 59%, weighted average = 57%; Dettweiler-Robinson et al. 2013). Thus, sagebrush establishment one-year post planting on the INL Site is at or above average even when the missing plants are considered dead. Young sagebrush plants experience the highest mortality during the first year (Dettweiler-Robinson et al. 2013), therefore survivorship of the seedlings surviving one year should remain high.

A monitoring report containing the full results of the sagebrush habitat restoration project through 2018 is available on the ESER website (www.idahoeser.com/Wildlife/PDF/2019%20CCA%20Full%20Report.pdf).

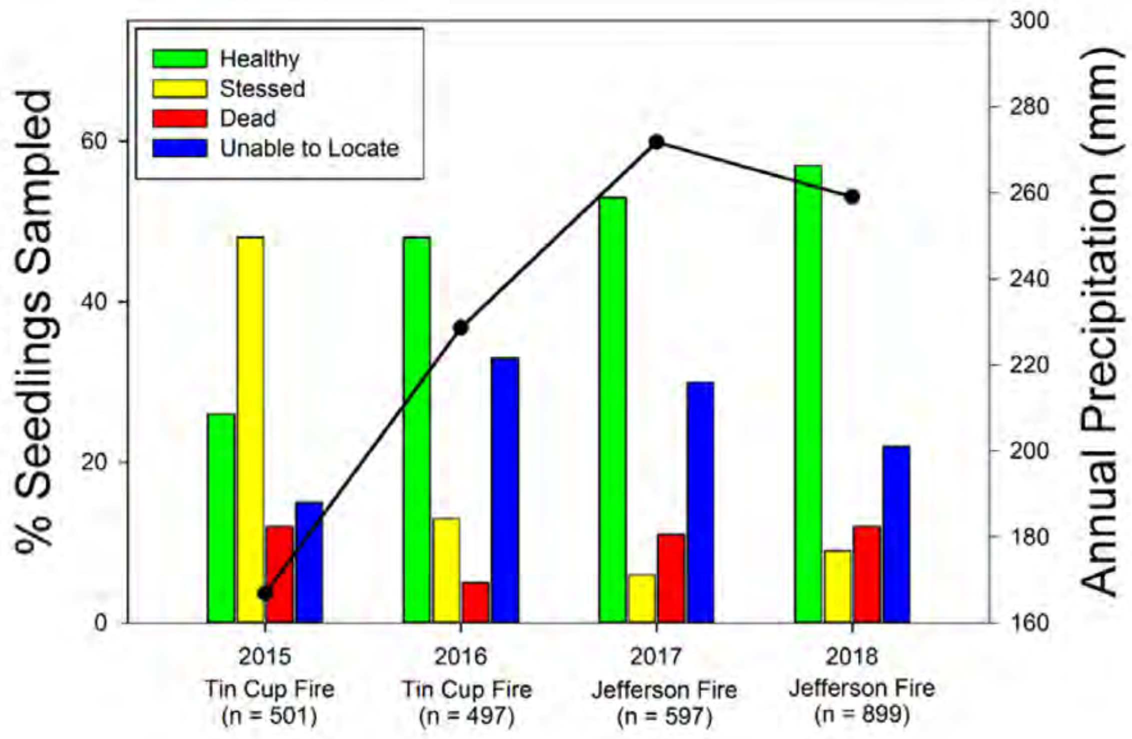


Figure 10-6. One-year Post Planting Survivorship Results for Sagebrush Seedlings Planted from 2015-2018 at the Idaho National Laboratory Site. The solid line depicts total annual precipitation.

Figure 10-7. Examples of Sagebrush Seedling Conditions for Seedlings Planted on the Idaho National Laboratory Site in 2018. Left: laterally growing healthy seedling. Right: stressed upright seedling.

10.4 Ecological Research at the Idaho National Environmental Research Park

10.4.1 Studies of Ants and Ant Guests at the INL Site

William H. Clark, Orma J. Smith Museum of Natural History, The College of Idaho, Caldwell, ID, 83605
bclark@collegeofidaho.edu

Funding is by the principal investigator with some assistance and collaboration with the Orma J. Smith Museum of Natural History.

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*; Figure 10-8, Figure 10-9) is not previously known from the INL Site (Stafford et al. 1986). We have 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 microscopes and SEM, 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 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 sp.* 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

Figure 10-8. Museum Specimen of *Philolithus elatus* from the Circular Butte Site at the Idaho National Laboratory. W.H. Clark Photo.

rearing and description. This relationship will require more study during future visits to the INL Site. The species will be described in the next couple of years as part of a North American study, by Dr. David Weissman of the California Academy of Sciences.

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 and as 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. This interaction has been reported in the literature by Clark and Comanor (1973) for *Pogonomyrmex occidentalis*, but not yet reported for *Pogonomyrmex salinus*. These seed stores in ant nests may represent a significant food source for the rodents at INL Site.

During July 2018 we observed numerous examples of the beetle *Disonycha latifrons* Schaeffer (Coleoptera, Chrysomelidae) feeding on the shrub, low narrowleaf rabbitbrush (*Chrysothamnus viscidifloris* [Hook.] Nutt. ssp. *viscidifloris* var. *stenophyllus* [Gray] Hall). The beetles were dense on the shrubs, often numbering 50-100 or more per plant.

July 22, 2019, we spent part of the night at the Circular Butte site searching for a rare cactus feeding beetle (*Moneilema sp.*). We did not find the beetle, but our field work was cut short by the Sheep Fire. We plan to continue searching areas at INL that contain cacti (*Opuntia*) this summer and see if we can find the beetles here. They were not reported from the INL Site by Stafford et al. (1986). We were able to find the beetles near Oakley in Cassia County, so it may be possible to find them at the INL Site.

Voucher specimens collected at the INL Site have been deposited in the insect collection at the Orma J. Smith Museum of Natural History, The College of Idaho and are available for research.

Field research will continue into the foreseeable future.

Figure 10-9. Living Specimen of Philolithus elatus from the Circular Butte Site at the Idaho National Laboratory Site, September 6, 2017, midday. W.H. Clark Photo.

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

Vincent A. Cobb, Department of Biology, Middle Tennessee State University, Murfreesboro, TN 37132, vincent.cobb@mtsu.edu

More ecological studies have been conducted on the Great Basin Rattlesnake, *Crotalus oreganus lutosus* than any other reptile species on the INL Site. This species occurs in large numbers in several areas on the INL Site and is best known for their large aggregations, of sometimes several hundred individuals, at underground overwintering sites (hibernacula). During their activity season, *C. o. lutosus* make a lengthy migration away from and back to a hibernaculum. While adult male and non-pregnant female rattlesnakes travel several km during their active season to forage and find mates, pregnant individuals move less and generally remain within 1 km of their hibernaculum. These pregnant snakes spend most of their active season gestating under rocks until they give birth. The selection of an appropriate gestation site is important for pregnant snakes to avoid predators such as badgers and hawks but also to provide proper thermoregulatory opportunities because embryonic development is influenced by temperature. Although any given female rattlesnake may only give birth once every 3-4 years, there is strong observational evidence that these gestation rocks are used frequently by multiple females. Therefore, one can hypothesize that the distribution and abundance of appropriate rocks is important for this species.

In 2018 and 2019, a project was conducted on the INL Site to locate gestation rocks used by pregnant *C. o. lutosus* and to measure their attributes to determine if pregnant rattlesnakes were selecting specific rocks. A total of 22 gestation rocks were identified by the continued presence of pregnant rattlesnakes at these rocks throughout their active season. Transects were set up at each of these gestation sites to measure the physical attributes of the gestation rocks and other nearby rocks that were available (n = 327) and could potentially be used. Results indicate that gestation rocks fall within a specific size range and have attributes that are a subset of the available rocks; this suggests pregnant snakes are likely making choices to use specific rocks. While the available rocks ranged in size from 20 - 200 cm^2 the majority were less than 80 cm^2 (mean = 49 cm^2). Pregnant snakes selected larger rocks (mean = 114 cm^2) and never chose rocks less than 71 cm^2. Additional rock features preferred by pregnant snakes were slightly thicker rocks, rocks with soil underneath (instead of rock on rock), and rocks with little or no vegetation cover. One potential benefit of larger rocks is that they provide greater thermal inertia, retaining heat throughout the night whereas smaller rocks would cool more quickly at night. Another benefit is that larger rocks may provide better protection from predators than smaller rocks. Nevertheless, badgers are a formidable predator of rattlesnakes and three observations were noted on the INL Site of badgers attempting to dig out rattlesnakes from under rocks; all three attempts appeared to be successful. From a management and conservation perspective, once identified, the persistence and non-destruction of gestation rocks could be important for maintaining Great Basin Rattlesnake populations because these rocks have specific characteristics that allow yearly success in reproduction.

Acknowledgments

I thank William Doering (University of Idaho undergraduate student) for assistance in locating gestation rocks and Derek Schleicher (Craters of the Moon student intern) for assistance in the measuring rock attributes.

10.4.3 Effects of Cattle Grazing on Sage-Grouse Demographic Traits

Courtney J. Conway, U.S. Geological Survey & University of Idaho, 875 Perimeter Dr., MS 114, Moscow, ID 83844, cconway@uidaho.edu

Despite many studies of greater sage-grouse (*Centrocercus urophasianus*) habitat requirements, surprisingly little is known about the effects of livestock grazing on sage-grouse populations and habitat characteristics. As a result, unsubstantiated claims are often made about the presumed effects (both positive and negative) of livestock grazing on sage-grouse, and litigation over this issue is common. A review of the effects of grazing on sage-grouse identified the paucity of information on the topic and the need for replicated field experiments to determine the effects of grazing on sage-grouse demographic traits (Beck and Mitchell 2000). Past and current studies that have evaluated the relationship between cattle grazing and sage-grouse have used a correlative rather than an experimental approach and have included insufficient replication and relatively small sampling plots.

To address this priority information need, we began implementing a series of replicated field experiments in Idaho during 2014 to rigorously evaluate the effects of different livestock grazing regimes on demographic traits and habitat characteristics of sage-grouse. Our experiments particularly focus on examining the effects of spring cattle grazing because spring is often considered the most crucial period for sage-grouse survival (Connelly et al. 2000, Wik 2002), and spring is often considered the season when grazing poses the biggest threat to sage-grouse. Results from our study will help guide management actions and inform policy and litigation decisions regarding the relationship between livestock grazing and sage-grouse habitat throughout the species' range. Results will also provide land managers and livestock operators with a credible answer to a commonly debated question and support science-based management actions when they are challenged by litigation.

Currently, our project encompasses five study sites (i.e., grazing allotments) in Idaho – see Figure 10-10. Each of the five study sites includes four pastures managed for livestock grazing, and we randomly assign them to four grazing treatments where we experimentally manipulate grazing intensity. One of the four grazing treatments is a control pasture where livestock grazing is completely removed for >4 years. Although this experimental design is robust, it is unable to address one of the

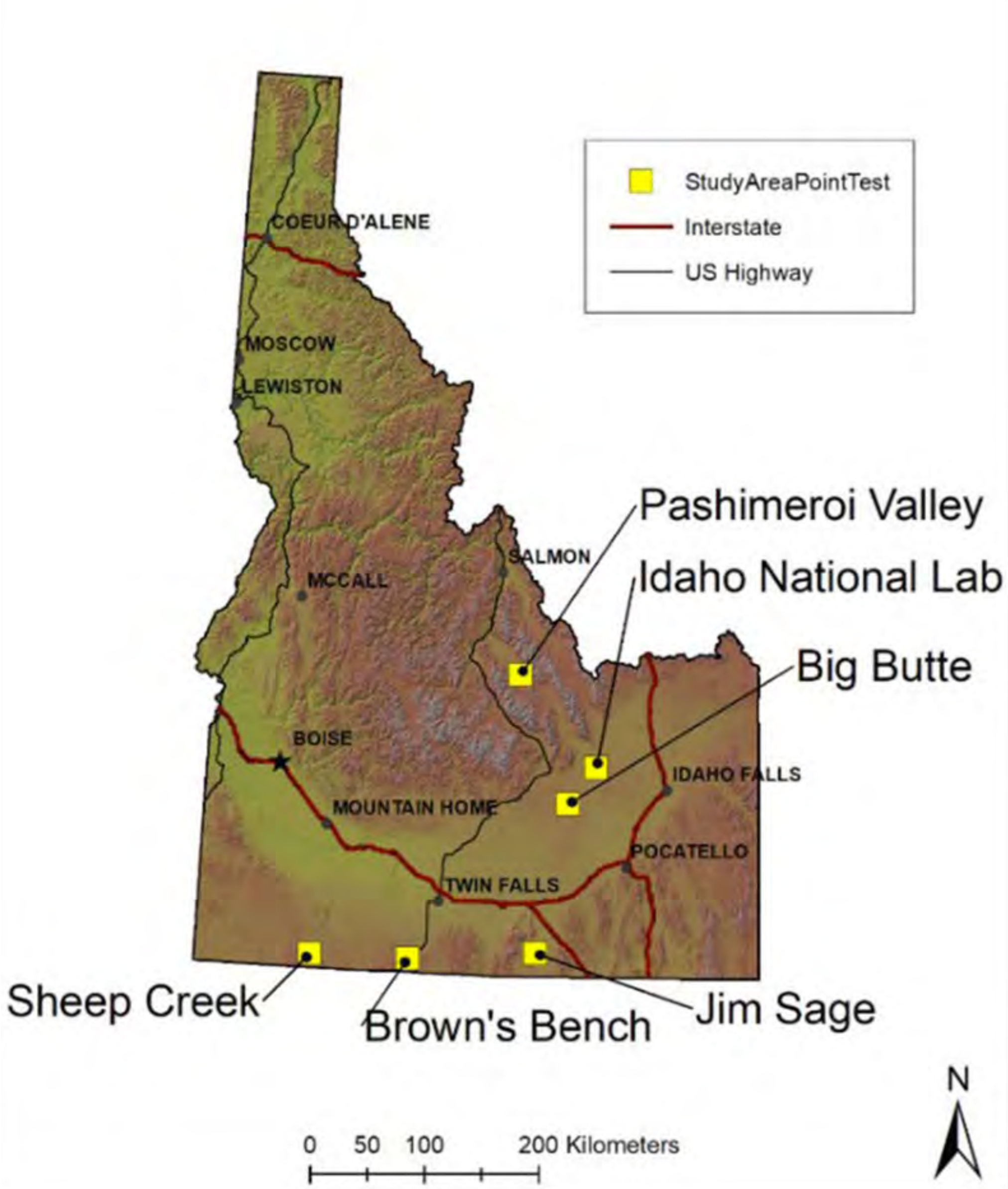


Figure 10-10. Idaho Study Sites for Study on Effects of Cattle Grazing on Sage-grouse Demographic Traits.

challenges inherent to any study that seeks to understand the potential effects of livestock grazing on Intermountain West rangelands. The challenge is that nearly all sagebrush steppe (including our five control pastures) have been grazed by livestock for over a century (West 1996, cited in Noss et al. 1995). Hence, we sought a study site that had not been grazed in many years so that we could assess the effects of long-term removal from grazing. If long-term residual effects of past grazing affect our five control pastures, our results might be discounted by some critics.

One of the very few places (if not the only place) within sage-grouse nesting habitat in Idaho that has not been grazed by livestock for many years is the INL Site where livestock grazing has not been allowed since at least 1950 (Harniss and West 1973). Hence, we initiated a 6th study site on portions of the INL Site in 2019. Specifically, our objective is to document sage-grouse demographic traits (e.g., daily nest survival, brood survival and movements) and vegetation features (e.g., sagebrush canopy cover) that contribute to sage-grouse habitat suitability. These data will provide a baseline to the larger grazing study and will allow us to better assess if removing livestock grazing for a few years from the other sites results in measurable differences in sage-grouse demographic traits and vegetative features.

In March and April 2019, we drove on two-track roads at night near several known lek locations on the INL Site, continually scanning the area using spotlights and binoculars. When we spotted a roosting sage-grouse hen, we continued to focus the spotlight beam on the bird while we approached and captured her with a hand-held net (Wakkinen et al. 1992). We attached a necklace style very high frequency transmitter on each bird, recorded capture location, body weight, and age, and released the bird at the capture site. In total, we captured seven adult and four yearling female sage-grouse on the study site (i.e., in areas that had not been grazed by livestock in decades) or elsewhere on the INL Site.

We were able to track four females until they nested, and then we monitored them at least once each week until their clutch hatched, or the nest was depredated. For a fifth hen, we obtained ≥1 location during at least 50% of monitoring weeks, but we never detected a nesting event. Of the six other females captured, one died before she initiated a nest and the other five were not tracked for long because we were unable to detect their collar signals soon after they were released or they moved off the study site into areas currently grazed by livestock.

Based on our observations of individual females, we estimate that nest incubation for the four nests was initiated between 17 April and 14 May 2019. Two nests (50%) were successful, with at least one chick hatching. We were unable to verify the cause of nest failure on the other two. For the two successful nests, clutch size was 7 and 8 eggs, and estimated hatch date was the 21st and 30th of May. We tracked successful hens and their broods until 42 days after hatching, and in both cases at least one chick survived to the end of that period.

We established 20 plots on the INL Site to sample arthropods, which are important for growth and development of sage-grouse chicks. Each plot had four pitfall traps that were opened approximately May 23 and closed approximately June 13. Each of four weeks, we visited the plots to empty captured arthropods from the traps and to conduct two sweep-net transects per plot. Additionally, we conducted ant mound surveys at each arthropod sampling plot. These data have not yet been analyzed, so a summary of results cannot be provided here.

In 2019, we completed the sixth year of field work on our Idaho sage-grouse and livestock grazing project. We added the INL Site in 2019 as a 6th study site to serve as an important baseline because areas in the interior of the INL Site have not been grazed by livestock for many decades. Unfortunately, we encountered few sage-grouse hens and, consequently we were unable to deploy as many radio collars as we had hoped. One possible reason for the low number of encounters is that sage-grouse abundance was relatively low in 2019. Across the INL Site, male attendance at a subset of 27 leks was down approximately 17% in 2019 compared to 2018, and peak male attendance on those leks had decreased at least 11% each of the past three years (Shurtliff et al. 2020). Another factor contributing to low encounter rates was that sagebrush height and density near target leks were relatively tall and dense, making it difficult to detect roosting sage-grouse at night. Moreover, we are permitted to drive off-road at the other 5 study sites to search for roosting sage-grouse, but we are restricted to roads at INL and that likely reduced our ability to find and capture grouse at INL.

10.5 U.S. Geological Survey 2019 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 eastern Snake River Plain (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: https://prd-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/atoms/files/INL_Bibliography3.pdf

Three reports were published by the USGS INL Project Office in 2019. The abstracts of these studies and the publication information associated with each study are presented below.

10.5.1 Iodine-129 in the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho, 2017–18 (Maimer and Bartholomay, 2019)

From 1953 to 1988, approximately 0.941 curies of iodine-129 (^{129}I) were contained in wastewater generated at the Idaho National Laboratory, with almost all of it discharged at or near the Idaho Nuclear Technology and Engineering Center (INTEC). Until 1984, most of the wastewater was discharged directly into the eastern Snake River Plain (ESRP) aquifer through a deep disposal well; however, some wastewater was also discharged into unlined infiltration ponds or leaked from distribution systems below the INTEC.

During 2017–18, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, collected samples for ^{129}I from 30 wells that monitor the ESRP aquifer to track concentrations and changes of the carcinogenic radionuclide that has a 15.7 million-year half-life. Concentrations of ^{129}I in the aquifer ranged from 0.000016 ± 0.000001 to 0.88+/- 0.03 picocuries per liter (pCi/L), and concentrations generally decreased in wells near the INTEC as compared with previously collected samples. The average concentration of 15 wells sampled during 5 different sample periods decreased from 1.15 pCi/L in 1990–91 to 0.168 pCi/L in 2017–18, but average concentrations were similar to 2011–12 within analytical uncertainty. All but four wells within a 3-mile radius of the INTEC showed decreases in concentration, and all samples had concentrations less than the U.S. Environmental Protection Agency's maximum contaminant level of 1 pCi/L. These decreases are attributed to the discontinuation of disposal of ^{129}I in wastewater and to dilution and dispersion in the aquifer. Some wells southeast of INTEC showed increasing trends; these increases were attributed to variable transmissivity.

Although wells near INTEC sampled in 2017–18 showed decreases in concentrations compared with data collected previously, some wells south of the INL boundary showed small increases. These increases are attributed to historical variable discharge rates of wastewater that eventually moved to these well locations as a pulse of water from a particular disposal period.

10.5.2 Evaluation of chemical and hydrologic processes in the eastern Snake River Plain aquifer based on results from geochemical modeling, Idaho National Laboratory, eastern Idaho (Rattray, G. W. 2019)

Nuclear research activities at the U.S. Department of Energy (DOE) Idaho National Laboratory (INL) produced liquid and solid chemical and radiochemical wastes that were disposed to the subsurface resulting in detectable concentrations of some waste constituents in the eastern Snake River Plain (ESRP) aquifer. These waste constituents may affect the water quality of the aquifer and may pose risks to the eventual users of the aquifer water. To understand these risks to water quality the U.S. Geological Survey, in cooperation with the DOE, conducted geochemical mass-balance modeling of the ESRP aquifer to improve the understanding of chemical reactions, sources of recharge, mixing of water, and groundwater flow directions in the shallow (upper 250 feet) aquifer at the INL.

Modeling was conducted using the water chemistry of 127 water samples collected from sites at and near the INL. Water samples were collected between 1952 and 2017 with most of the samples collected during the mid-1990s. Geochemistry and isotopic data used in geochemical modeling consisted of dissolved oxygen, carbon dioxide, major ions, silica, aluminum, iron, and the stable isotope ratios of hydrogen, oxygen, and carbon.

Geochemical modeling results indicated that the primary chemical reactions in the aquifer were precipitation of calcite and dissolution of plagioclase (An60) and basalt volcanic glass. Secondary minerals other than calcite included calcium montmorillonite and goethite. Reverse cation exchange, consisting of sodium exchanging for calcium on clay minerals, occurred near site facilities where large amounts of sodium were released to the ESRP aquifer in wastewater discharge. Reverse cation exchange acted to retard the movement of wastewater-derived sodium in the aquifer.

Regional groundwater inflow was the primary source of recharge to the aquifer underlying the Northeast and Southeast INL Areas. Birch Creek (BC), the Big Lost River (BLR), and groundwater from BC valley provided recharge to the North INL Area, and the BLR and groundwater from BC and Little Lost River (LLR) valleys provided recharge to the Central INL Area. The BLR, groundwater from the BLR and LLR valleys and the Lost River Range, and precipitation provided recharge to the Northwest and Southwest INL Areas. The primary source of recharge west and southwest of the INL was groundwater inflow from BLR valley. Upwelling geothermal water was a small source of recharge at two wells. Aquifer recharge from surface water in the northern, central, and western parts of the INL indicated that the aquifer in these areas was a dynamic, open system, whereas the aquifer in the eastern part of the INL, which receives little recharge from surface water, was a relatively static and closed system.

Sources of recharge identified from isotope ratios and geochemical modeling (major ion concentrations) were nearly identical for the North, Northeast, Southeast, and Central INL Areas, which indicated that both methods probably accurately identified the sources of recharge in these areas. Conversely, isotope ratios indicated that the BLR and groundwater from the LLR valley provided most recharge to the western parts of the Northwest and Southwest INL Areas, whereas geochemical modeling results indicated a smaller area of recharge from the BLR and groundwater from the LLR valley, a larger area of recharge from the Lost River Range, and recharge of groundwater from the BLR valley that extended to the west INL boundary. The results from geochemical modeling probably were more accurate because major ion concentrations, but not isotope ratios, were available to characterize groundwater from the BLR valley and the Lost River Range.

Sources of recharge identified with a groundwater flow model (using particle tracking) and geochemical modeling were similar for the Northeast and Southeast INL Areas. However, differences between the models were that the geochemical model represented (1) recharge of groundwater from the Lost River Range in the western part of the INL, whereas the flow model did not, (2) recharge of groundwater from the BC and BLR valleys extending farther south and east, respectively, than the flow model, and (3) more recharge from the BLR in the Southwest INL Area than the flow model.

Mixing of aquifer water beneath the INL included (1) mixing of regional groundwater and water from the BC valley in the Northeast and Southeast INL Areas and (2) mixing of surface water (primarily from the BLR) and groundwater across much of the North, Central, Northwest, and Southwest INL Areas. Localized recharge from precipitation mixed with groundwater in the Northwest and Southwest INL Areas, and localized upwelling geothermal water mixed with groundwater in the Central and Northeast INL Areas. Flow directions of regional groundwater were south in the eastern part of the INL and south-southwest at downgradient locations. Groundwater from the BC and LLR valleys initially flowed southeast before changing to south-southwest flow directions that paralleled regional groundwater, and groundwater from the BLR valley initially flowed south before changing to a south-southwest direction.

Wastewater-contaminated groundwater flowed south from the Idaho Nuclear Technology and Engineering Center (INTEC) infiltration ponds in a narrow plume, with the percentage of wastewater in groundwater decreasing due to dilution, dispersion, and (or) degradation from about 60–80 percent wastewater 0.7–0.8 mile (mi) south of the INTEC infiltration ponds to about 1.4 percent wastewater about 15.5 mi south of the INTEC infiltration ponds. Wastewater contaminated groundwater flowed southeast and then southwest from the Naval Reactors Facility industrial waste ditch, with the percentage of wastewater in groundwater decreasing from about 100 percent wastewater adjacent to the waste ditch to about 2 percent wastewater about 0.6 mi south of the waste ditch.

10.5.3 Transmissivity and geophysical data for selected wells located at and near the Idaho National Laboratory, Idaho, 2017–18 (Twining and Maimer, 2019).

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, conducted aquifer tests during 2017–18 on 101 wells at and near the Idaho National Laboratory, Idaho, to define the hydraulic characteristics for individual wells. These were short-duration aquifer tests, conducted with a limited number of observations during routine sampling. Pumped intervals (water columns) for individual wells ranged from 12 to 790 feet (ft). Semi-constant discharge rates during aquifer testing ranged from 1 to 45 gallons per minute, water-level response to pumping ranged from no observed drawdown to 52.4 ft, and length of aquifer tests for individual wells ranged from 10 to 160 minutes. Individual well data were analyzed to estimate the capacity of the well to produce water (specific capacity) and to estimate values for transmissivity. Estimates of specific capacity for individual wells ranged from less than 1.0 to greater than (>) 3.0 × 103 gallons per minute per foot; estimates of transmissivity for individual wells ranged from 2.0 to >5.4 x 105 feet squared per day.

Geophysical log data, well construction information, and general geology for individual wells were presented and included in this report. Basic hydrogeologic features for individual wells were described, along with a composite of natural gamma, neutron, gamma-gamma dual density, and acoustic televiewer data (when available). The geophysical and geologic data were used to suggest the location and thickness of sediment layers along with fractured and dense basalt areas for individual wells. Geophysical data were used to describe the general geology where geologic descriptions and (or) driller notes were not available.

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11. FIRE PROTECTION MANAGEMENT AND PLANNING


Northern Sweetvetch (*Hedysarum boreale*)

The potential for wildland fires on the Idaho National Laboratory (INL) Site is high, particularly during the months of July, August, and September. The INL Site has experienced numerous large fires, averaging about five fires per year which involve approximately 15,000 acres per year.

The INL Fire Department provides wildland fire suppression services on the rangeland within the INL Site boundary, as well as a 5-mile perimeter outside of the Site boundary. In addition, the fire department employs fire pre-incident strategies, such as identification of special hazards and mitigation procedures and mapping necessary to facilitate response to fires. The INL maintains mutual aid agreements with regional agencies, including the Bureau of Land Management and Forest Service, to assist in response to high challenge wildland fires.

The INL maintains the "Idaho National Laboratory Wildland Fire Management Plan," which incorporates essential elements of various federal and state fire management standards, policies, and agreements. A balanced fire management approach has been adopted to ensure the protection of improved laboratory assets in a manner that minimizes effects on natural, cultural, and biological resources. To this end, the INL has established a Wildland Fire Management Committee to review season fuel management activities and the potential impact of all fires greater than 100 acres. One specific responsibility is to determine if a post-fire recovery plan is warranted.

The Wildland Fire Management Committee recommended that a recovery plan be developed following the 2019 Sheep Fire, which was estimated by the Environmental Surveillance, Education, and Research Program, using high-resolution satellite imagery, to have burned over 99,000 acres. This plan involves soil stabilization for erosion and weed control, cheatgrass and noxious weed control, native herbaceous recovery, and sagebrush habitat restoration. Concurrent with development of the plan, U.S. Department of Energy-Idaho Operations Office and agency stakeholders will pursue aerially seeding approximately 25,000 acres of potentially important habitat with sagebrush in February 2020.

11. FIRE PROTECTION MANAGEMENT AND PLANNING

Figure 11-1. INL Fire Danger Rating Sign.

The potential for wildland fires on the Idaho National Laboratory (INL) Site is routinely high due to the rapid growth of prairie grasses and brush during cool, wet springs followed by extended dry weather in the late spring and early summer months. The resulting dried vegetation provides excellent fuel for potential wildfires every season. Sagebrush, crested wheatgrass, and rabbitbrush are the three main ground fuels that occur on the INL. During a typical fire season, the fire danger rating in May and June is "moderate" and upgraded to "high," "very high," or "extreme" during July, August, and September (Figure 11-1). This is dependent upon seasonal rainfall, humidity, wind, and ambient temperature trends. During the July–September time period, the INL Site characteristically experiences little rainfall (normal annual precipitation is 9.1 in.), low humidity, high daytime temperatures, and prevailing strong winds from the southwest. INL has experienced numerous large fires (e.g., Jefferson Fire in 2010 at 92,287 acres and Sheep

Fire in 2019 at 112,106 acres [45,367 hectares]) and averages approximately five fires involving over 15,000 acres (6,070 hectares) per year (1994–2019).

11.1 Boundary and Organization

The INL Fire Department provides wildland fire suppression services on the rangeland within INL Site boundaries, as well as a 5-mile perimeter outside of the INL Site boundary. The department staffs three fire stations 24 hours a day, seven days a week. Required response apparatus includes wildland fire engines, mobile water tenders and a variety of support equipment to combat wildland fires. The INL Fire Department is comprised of trained professionals tasked with responding to medical, hazardous material, rescue, and structural and wildland fire emergencies on the INL Site and state highways passing through the Site property.

11.2 Fire Mitigation Strategies

The Fire Department maintains fire pre-incident strategies. Wildland pre-planned strategies adopt recognized industry wildland fire tactics and ensure firefighter safety through the adoption of National Wildfire Coordinating Group Incident Response Pocket Guide fire line safety provisions. Additionally, the pre-plan strategies incorporate the identification of special hazards and mitigation provisions (e.g., power transmission equipment, radiological or chemical contamination areas, ordnance locations) and mapping necessary to facilitate response to fires. INL maintains mutual aid agreements with regional agencies, including the Bureau of Land Management and Forest Service, to assist in the response to high challenge wildland fires.

INL maintains PLN-14401, "Idaho National Laboratory Wildland Fire Management Plan," which implements comprehensive fire management elements. The INL Wildland Fire Management Plan incorporates essential elements of the following:

- DOE-STD-1066-2012, "Fire Protection"
- DOE O 420.1C Chg 3, "Facility Safety"
- 2001 Federal Wildland Fire Management Policy (NIFC 2001)
- National Fire Protection Association (NFPA) 1143, "Standard for Wildland Fire Management"
- NFPA 299, "Standard for Protection of Life and Property from Wildfire"
- *Idaho National Laboratory Wildland Fire Management Environmental Assessment* (DOE 2003)
- *INEEL Sagebrush Steppe Ecosystem Reserve, Final Management Plan Finding of No Significant Impact* (EA-ID-074-02-067)
- Candidate Conservation Agreement for Greater Sage-grouse (DOE and USFWS 2014).

Personnel and property near the wildland interface/intermix zones of each INL Site area are considered protected from wildland fire. The INL's fire management priority is to ensure firefighter, worker, and public safety first. Infrastructure, natural, cultural, and biological resources are then protected, based on the relative values of each resource. The INL takes necessary suppression actions to minimize the threat of wildland fire on mission important improved property, including protection of wildland urban interfaces and intermixes. Beyond this focus, the INL Site lies within the upper Snake River Plain sagebrush steppe ecosystem, which is threatened with irreversible conversion to non-native annual weeds by fire management practices in combination with the natural fire process. Consequently, the INL wildland fire plan incorporates a balanced fire management approach that ensures, to the extent possible, the protection of improved laboratory assets in a manner that minimizes effects on natural, cultural, and biological resources.

INL maintains defensible spaces between wildland vegetation and desert INL Site facilities. Vegetation is removed or reduced to create a substantial buffer area at the perimeter of all significant INL Site areas, and seasonal vegetation inspections are performed to ensure the buffer is maintained. Significant INL structures are built with noncombustible or fire-resistant materials and have automatic fire sprinkler systems to protect them.

INL has implemented comprehensive fire prevention programs to minimize the potential for human-caused fires. Fuels are managed near potential operational ignition sources seasonally. This includes mowing operations at INL gun ranges and along main roadways. Fire danger ratings and fire prevention messages are posted at strategic INL Site locations, including public highways. Employee bulletins are generated throughout the wildland fire season to maintain a heightened awareness of fire danger conditions. Fire restrictions are implemented during periods of elevated fire danger to minimize activities that could start a fire.

INL has established a Wildland Fire Management Committee (WFMC) that is chartered with reviewing seasonal fuel management activities and the potential impacts of all fires greater than 100 acres in size. The WFMC makes recommendations, as necessary, to maintain INL's cultural resources and an ecosystem of native vegetation, natural fire cycles and other resource values. One specific responsibility of the WFMC is to determine when the development of a post-fire recovery plan for fires larger than 100 acres is warranted. Post-fire recovery plans are developed to address impacts of fire suppression activities and the potential effects of a fire on native species recovery and associated wildlife habitat within the burned area. Following the 2019 Sheep Fire, INL's WFMC determined that a post-fire recovery plan should be developed and WFMC members expressed an interest in a plan where implementation is phased over five years and is flexible, where specific actions can be implemented individually depending on specific resource concerns and funding availability.

11.3 Sheep Fire

The lightning-caused Sheep Fire started on July 22, 2019, in a remote region of the INL Site. The INL Site Fire Department and Bureau of Land Management responded under a unified command employing multiple fire suppression strategies. By July 25, 2019, minimal fire activity was reported, and the Sheep Fire was 100% contained by the afternoon of July 26, 2019. The initial Sheep Fire boundary was created by the Bureau of Land Management and estimated the burned area to be approximately 112,106 acres (45,367 hectares). The Environmental Surveillance, Education and Research Program later used high-resolution satellite imagery collected after the fire to delineate the Sheep Fire burned area and, for post-fire recovery planning purposes, reduced the burned area estimate to approximately 99,839 acres (40,403 hectares).

The fire impacted a variety of ecological resources, including 21 different soil types, nine vegetation classes, and numerous wildlife species, including greater sage-grouse, which is designated as Species of Greatest Conservation Need by the state of Idaho. The Sheep Fire Ecological Resources Post-Fire Recovery Plan was initiated in October 2019 and will be finalized and delivered to the WFMC in late-winter 2020. It will discuss the potential risks of the Sheep Fire to ecological resources and challenges to the natural recovery of those resources. The WFMC can use the information presented in the plan to evaluate and prioritize specific fire recovery actions.

The Sheep Fire Recovery Plan will include four natural resource recovery objectives:

1) Soil stabilization for erosion and weed control immediately post-fire
2) Cheatgrass and noxious weed control within the larger burned area
3) Native herbaceous recovery
4) Sagebrush habitat restoration.

Multiple treatment options for improving post-fire recovery will also be included in the plan, as will steps that should be considered prior to implementing those options. Concurrent with development of the plan, U.S. Department of Energy and agency stakeholders will pursue aerially seeding approximately 25,000 acres of potentially important habitat with sagebrush in February 2020.

Figure 11-2. Emergency Crew Working to Contain Sheep Fire.

REFERENCES

DOE, 2003, *Idaho National Engineering and Environmental Laboratory Wildland Fire Management Environmental Assessment,* DOE/EA-1372, U.S. Department of Energy, April 2003.

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EA-ID-074-02-067, 2004, *INEEL Sagebrush Steppe Ecosystem Reserve, Final Management Plan Finding of No Significant Impact,* Idaho National Engineering and Environmental Laboratory, May 31, 2004.

DOE and USFWS, 2014, *Candidate Conservation Agreement for Greater Sage-grouse (Centrocercus urophasianus) on the Idaho National Laboratory Site in Southeast Idaho,* DOE/ID-11514, U.S. Department of Energy, U.S. Fish and Wildlife Service, February 14, 2018.

NFPA 1143, 2018, “Standard for Wildland Fire Management,” National Fire Protection Association.

NFPA 299, 1997, “Standard for Protection of Life and Property from Wildfire,” National Fire Protection Association.

NIFC, 2001, “Review and Update of the 1995 Federal Wildland Fire Management Policy,” National Interagency Fire Center, January 2001.

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12. QUALITY ASSURANCE OF ENVIRONMENTAL MONITORING PROGRAMS


Dustymaiden (*Chaenactis douglasii*)

12. 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.

12.1 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.

12.2 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 12-1 and are discussed below. Summaries of program-specific QC data are presented in Section 12.3. Documentation of the QA programs is provided in Section 12.4.

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

12.2.1 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).

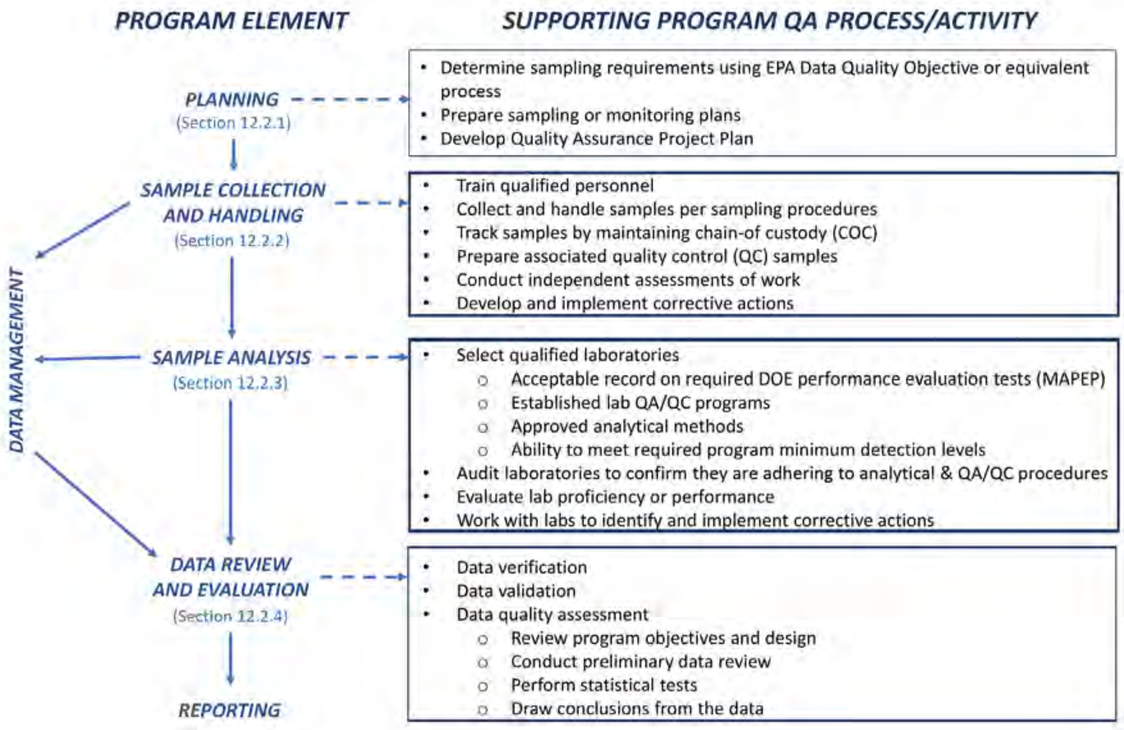


Figure 12-1. Flow of Environmental Monitoring Program Elements and Associated QA Processes and Activities.

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 2014a) 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 prepare a QA Project Plan.

12.2.2 Sample Collection and Handling

Strict adherence to program procedures is an implicit foundation of QA. In 2019, 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. The primary purpose of blanks (a sample of analyte-free media) is to trace sources of artificially introduced contamination. The blank sample results can be used to identify and isolate the source of contamination introduced in the field or the laboratory. A trip blank is a clean sample of matrix 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 field blank is collected to assess the potential introduction of contaminants and the adequacy of field and laboratory protocols during sampling and laboratory analysis. In air sampling, a field blank is a clean, analyte-free filter that is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. In water sampling, field blanks are prepared at the field site where environmental water samples are collected. A sample of analyte-free water is poured into the container in the field where environmental water samplers are collected, preserved and shipped to the laboratory with field samples. Results include total ambient conditions during sampling and laboratory sources of contamination.

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.

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.

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 above) of the sampling process. Field duplicates also provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures (see Section 12.2.3).

12.2.3 Sample Analysis

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 12-1.

Laboratories used for routine analyses of radionuclides in environmental media were selected by each

Table 12-1. 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	Inorganic, organic, and radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	Eurofins Eaton Analytical, Inc.	Organic
ICP Core Environmental Program	ALS Laboratory Group – Fort Collins	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	Bacteriological
	Eurofins Eaton Analytical, Inc.	Organic and inorganic
INL Liquid Effluent and Groundwater Program	GEL Laboratories, LLC	Inorganic and radiological
INL Environmental Surveillance Program	ALS Laboratory Group – Fort Collins	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) – Pocatello, ID	Gross radionuclide analyses (gross alpha and gross beta), optically stimulated luminescent dosimetry (OSLD), thermoluminescent dosimetry (TLD), liquid scintillation counting (tritium), and gamma spectrometry
	GEL Laboratories, LLC – Charleston, SC	Specific radionuclides (e.g., ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu) and gamma spectrometry
U.S. Geological Survey (USGS)	DOE's Radiological and Environmental Sciences Laboratory	Radiological
	USGS National Water Quality Laboratory, various USGS and contract laboratories	Non-radiological and low-level tritium and stable isotopes
	Purdue Rare Isotope Measurement Laboratory	Low-level ^{129}I
	GEL Laboratories	Radiological, nonradiological and volatile organic compounds, non-radiological for the Naval Reactors Facility sample program
	Test America Laboratories	Semi-volatile compounds for the Naval Reactors Facility sample program

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 12.3.1. 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 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 inter-laboratory 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 non-radioactive 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 12.3.1). The analytical results are expected to compare to the known value within a set of performance limits. Blind spikes are generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A double-blind spike is a sample with concentration and identity unknown to both the submitter and the analyst.

12.2.4 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

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).

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.

12.3 Quality Control Results for 2019

Results of the QC measurements for secific DOE contracted environmental programs in 2019 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.

12.3.1 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, non-radiological, 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 40 in the spring of 2019, and Series 41 was distributed in the fall of 2019. Both radiological and non-radiological 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., americium-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 2019, each radiological laboratory used by the INL, ICP Core, and ESER contractors participated in the 2019 MAPEP Series 40 and 41. 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.

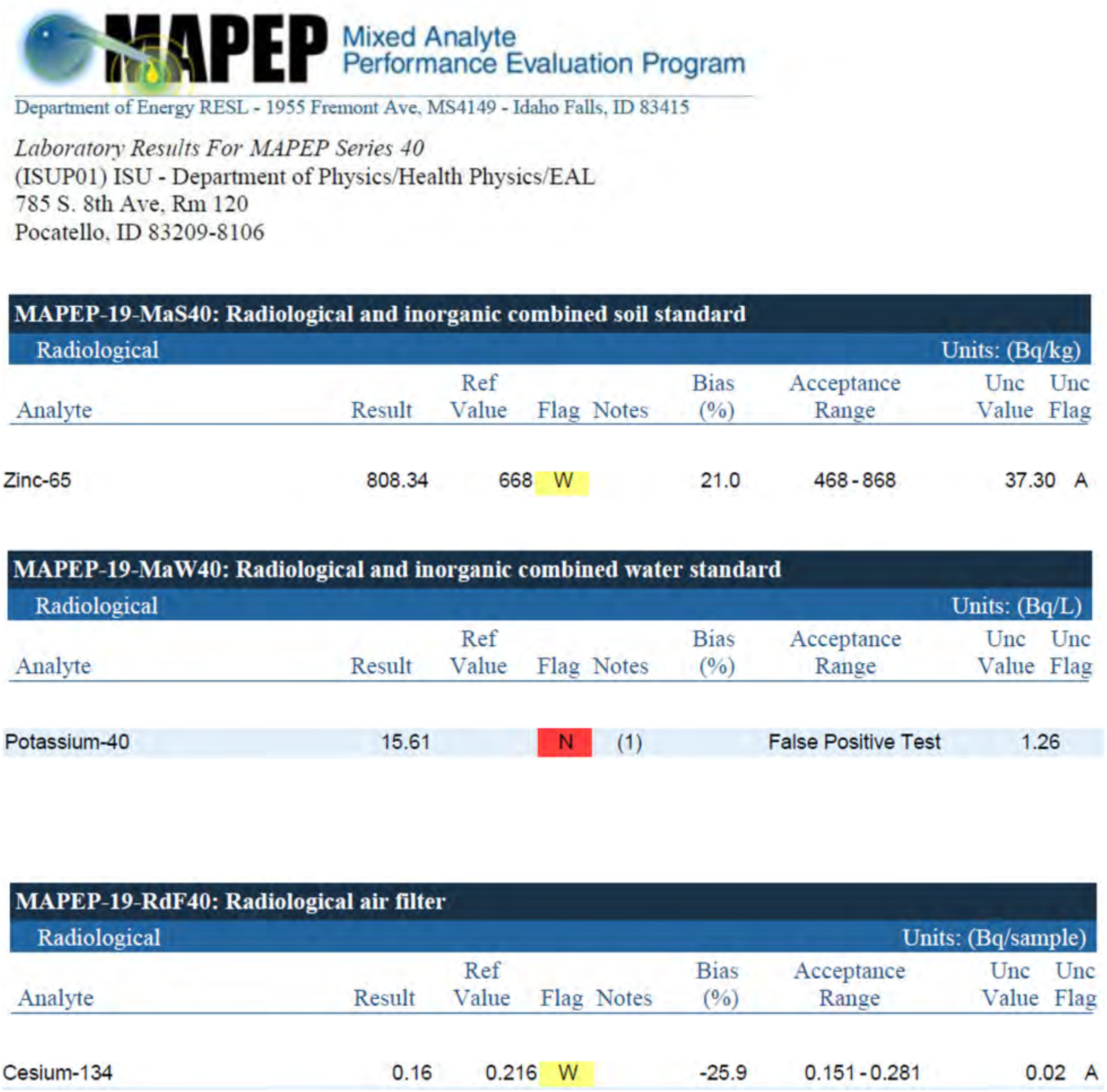
ALS-Fort Collins. ALS-FC is located in Fort Collins, Colorado. The INL and ICP Core contractors used ALS-FC for their surveillance programs. The isotopic analytes of common interest to the INL and ICP Core surveillance programs include: ^{90}Sr, ^{241}Am, ^{238}Pu, and plutonium-239/240 ($^{239/240}$Pu). 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), ^{137}Cs, europium-152 (^{152}Eu), and antimony-125 (^{125}Sb).

For MAPEP Series 40 and 41, all analytes of interest in air filters were acceptable except for three false positives. These false positives were traces of isotopes reported by the laboratory as present (i.e., ^{241}Am, ^{134}Cs, and ^{65}Zn) that were not actually present in the spike. The MAPEP results for the INL and ICP Core programs reported by ALS-FC do not demonstrate any issues of concern for the 2019 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 40 and 41, except for the below analytes. The MAPEP results do not demonstrate any issues of concern for the 2019 data reported by ISU-EAL. The Department of Energy issued a Letter of Concern (Subject: Potential Quality Concern | Laboratory Code: ISUP01 |Dated: January 10, 2020 | Re: potassium-40) to the ISU-EAL for the two potassium-40 Not Acceptable results in MAPEP water samples from MAPEP Series 40 and MAPEP Series 41. It is up to the laboratory to investigate and implement a Corrective Action if needed. The two potassium-40 samples in water were MAPEP False Positive tests. 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



MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP Series 40
(ISUP01) ISU - Department of Physics/Health Physics/EAL
785 S. 8th Ave, Rm 120
Pocatello, ID 83209-8106

MAPEP-19-MaS40: Radiological and inorganic combined soil standard

Radiological — Units: (Bq/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Zinc-65	808.34	668	W		21.0	468 - 868	37.30	A

MAPEP-19-MaW40: Radiological and inorganic combined water standard

Radiological — Units: (Bq/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Potassium-40	15.61		N	(1)		False Positive Test	1.26	

MAPEP-19-RdF40: Radiological air filter

Radiological — Units: (Bq/sample)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Cesium-134	0.16	0.216	W		-25.9	0.151 - 0.281	0.02	A

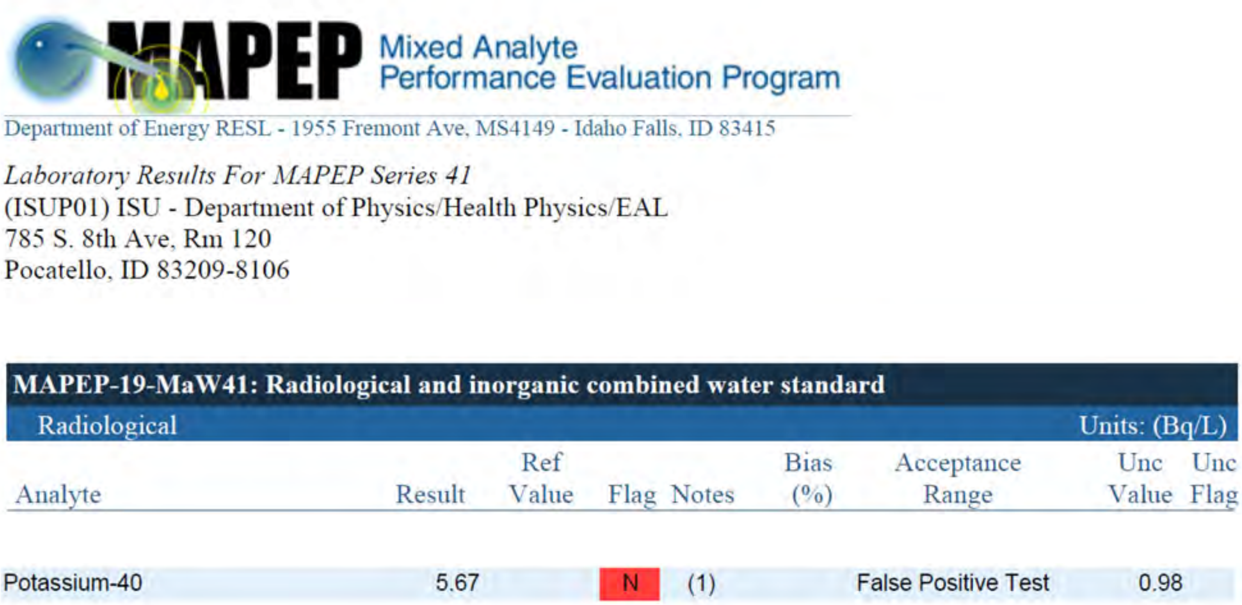
Carolina, for inorganic, organic, and radiological analysis of samples. 2019 analytes of interest are ^{241}Am, ^{238}Pu, $^{239/240}$Pu and ^{90}Sr in air filters, waterfowl, soil, and bats (including gamma spectrometry) and ^{90}Sr only in milk and produce (lettuce, alfalfa, wheat, and potatoes) samples.

All other analytes of interest for media of concern were “A” (Acceptable) for both Series 40 and 41 data, except for Series 41 radium-226 which received an “N” flag. The INL contractor will continue to monitor the MAPEP results to determine if any trends warrant further action.

12.3.2 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



MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP Series 41
(ISUP01) ISU - Department of Physics/Health Physics/EAL
785 S. 8th Ave, Rm 120
Pocatello, ID 83209-8106

MAPEP-19-MaW41: Radiological and inorganic combined water standard

Radiological — Units: (Bq/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Potassium-40	5.67		N	(1)		False Positive Test	0.98	

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 2019 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.

12.3.2.1 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 12-2 presents a summary of 2019 LEMP, GWMP, and Drinking Water Program (DWP) QC criteria and performance results.

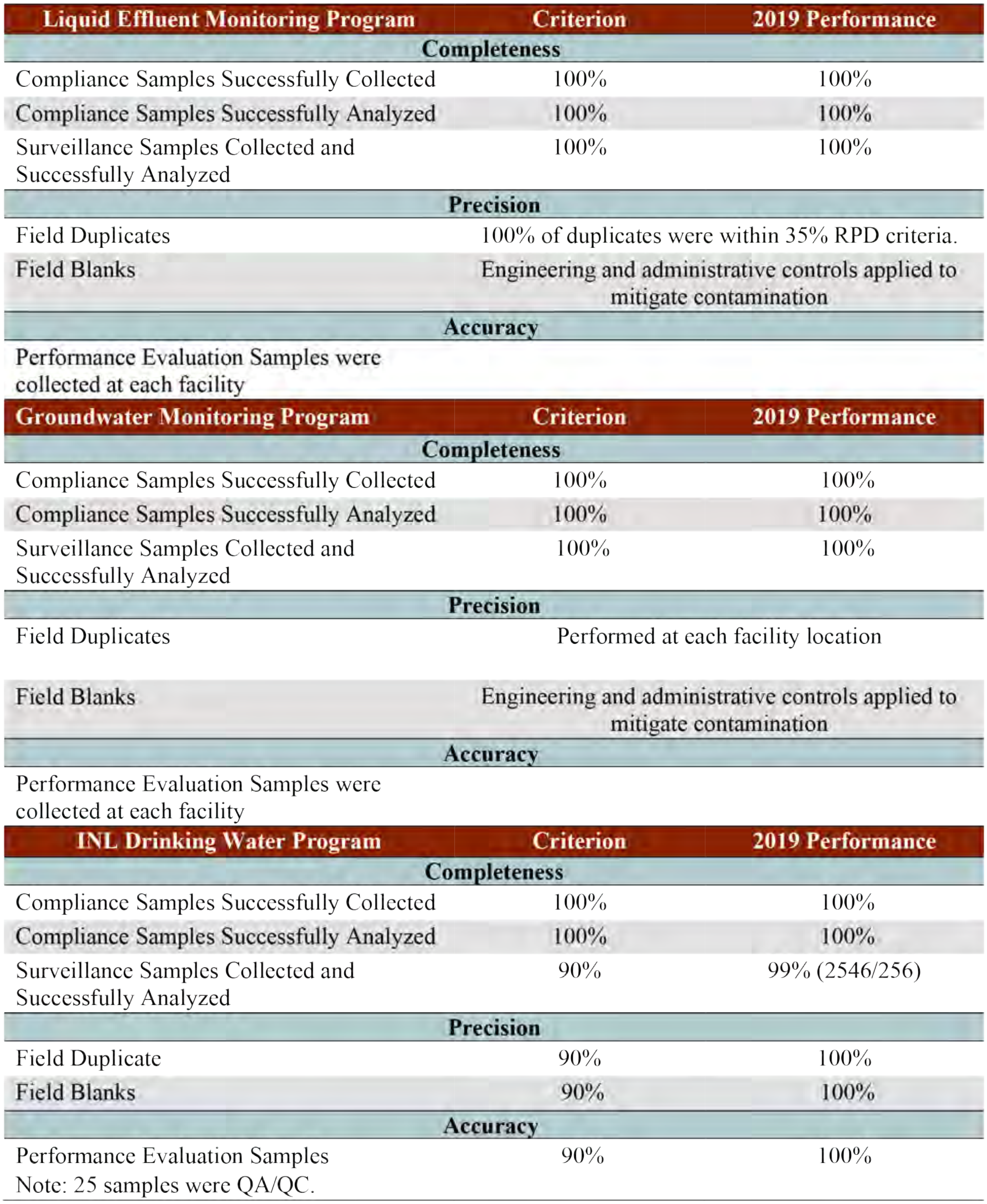
Completeness – Collection and Analysis. The goal for completeness is to collect 100% of all required compliance samples. In 2019 these goals were met.

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 2019, field duplicates were 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 2019, 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.

Table 12-2. 2019 INL Liquid Effluent Monitoring Program, Groundwater Monitoring Program, and Drinking Water Program QA/QC Criteria and Performance.



Liquid Effluent Monitoring Program	**Criterion**	**2019 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	100% of duplicates were within 35% RPD criteria.	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples were collected at each facility		
Groundwater Monitoring Program	**Criterion**	**2019 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 were collected at each facility		
INL Drinking Water Program	**Criterion**	**2019 Performance**
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	90%	99% (2546/256)
Precision		
Field Duplicate	90%	100%
Field Blanks	90%	100%
Accuracy		
Performance Evaluation Samples Note: 25 samples were QA/QC.	90%	100%

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 reviews the analytical laboratory's DOECAP audit program, MAPEP results, laboratory accreditation/certifications, and associated nonconformance reports to ensure that the analytical services are of the utmost quality to make environmental decisions. The ICP Core also ensures that the analytical laboratories are still approved by the applicable regulatory agencies (e.g., EPA, State of Idaho Department of Environmental Quality, or the Nuclear Regulatory Commission). For laboratories that are not part of the DOECAP audit process, the ICP Core, in cooperation with INL Contractor, perform laboratory audits to ensure that the analytical services are of the utmost quality to make environmental decisions.

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. Table 12-3 presents a summary of 2019 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 2019. 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 2019 Wastewater Reuse Report (ICP 2020) and summarized in Tables B-4, B-5, and B-6.

The goal for completeness was to collect and successfully analyze 90% of the LEMP surveillance samples. This goal was exceeded in 2019, because 100% of the samples were collected and analyzed. A total of 325 sample parameters were collected, and 325 parameters were successfully analyzed. The summary results are provided in Table B-15.

Precision – Field Duplicate Samples. To quantify measurement uncertainty from field activities, annual non-radiological field duplicate samples were collected at CPP-773 and CPP-797 during November and December 2019 and analyzed for the permit-specific parameters that could be influenced by field activities. 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%.

Accuracy – Performance Evaluation Samples. During 2019, ICP Core collected all the necessary QA/QC samples that are required by the specific analytical methods. These include the laboratory control samples, initial and continuing calibration verification samples, matrix spikes and duplicate samples collected during individual sampling events. During 2019, no laboratory issues were identified.

Decontamination – Equipment Rinsate Samples. Dedicated sampling equipment and flushing procedures were utilized to prevent sample contamination.

12.3.2.2 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. Table 12-3 presents a summary of 2019 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 2019. A total of 176 sample parameters were collected and submitted for analysis, and 176 parameters were successfully analyzed. The results are provided in Tables B-8 and B-9 and summarized in the 2019 Wastewater Reuse Report (ICP 2020).

The goal for completeness was to collect and successfully analyze 90% of the WRP GWMP surveillance samples. This goal was exceeded in 2019. Sixteen parameters, or 100%, were collected and successfully analyzed. The results are provided in Table B-16.

Precision-Field Duplicate Samples. To quantify measurement uncertainty from field activities, non-radiological field duplicate samples are collected semiannually and analyzed for the permit-specific parameters that could be influenced by field activities. The RPD between the sample result and the field duplicate sample result (using only parameters with two detectable quantities)

Table 12-3. 2019 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	2019 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 cleanliness	Dedicated sampling equipment and flushing procedures utilized	
Field blanks	Performed when required by field conditions	
Accuracy		
Performance evaluation samples	100% of the QA/QC samples required by the analytical methods were collected	
ICP Core WRP Groundwater Monitoring Program	**Criterion**	**2019 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	Dedicated sampling equipment and flushing procedures utilized	
Field blanks	Performed when required by field conditions	
Accuracy		
Performance evaluation samples	100% of the QA/QC samples required by the analytical methods were collected	
ICP Core Drinking Water Monitoring Program	**Criterion**	**2019 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%
Trip blanks	90%	100%

WRP = Wastewater Reuse Permit

should be 35% or less for 90% of the parameters analyzed. Field duplicate samples were collected from Well ICPP-MON-A-166 on May 1, 2019, and September 10, 2019. One hundred percent of the results had an RPD of less than or equal to 35%.

Radiological field duplicate samples are collected semiannually and analyzed for gross alpha and gross beta. Duplicate samples were collected from Well ICPP-MON-A-166 on September 10, 2019. 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. One of samples collected had statistically positive results, and the results had a mean difference of less than three.

Accuracy – Performance Evaluation Samples. ICP Core collected all the necessary QA/QC samples that are required by the specific analytical methods. These include the laboratory control samples, initial and continuing calibration verification samples, matrix spikes and duplicate samples collected during individual sampling events. During 2019, no laboratory issues were identified.

12.3.2.3 Idaho Cleanup Project Contractor Groundwater Monitoring Quality Control Data

QA/QC samples and results for Waste Area Groups (WAGs) 1 and 4 are discussed in the annual reports for Fiscal Year 2017 (DOE-ID 2018a, 2018b), for WAG 2 in the Fiscal Year 2018 report (DOE-ID 2018c), and for WAG 3 in the Fiscal Year 2019 report (DOE-ID 2020). QA/QC samples for WAG 7 are discussed in the following paragraphs.

Completeness, Precision, Representativeness, Comparability – Field Sampling Plan. For the WAG 7 May 2019 groundwater monitoring sampling event at the Radioactive Waste Management Complex, the QA parameters of completeness, precision, representativeness, and comparability met the project goals and DQOs as specified in the Field Sampling Plan (DOE-ID 2014b), except as noted below.

Accuracy-Performance Evaluation Sample. The project objectives were met for accuracy with the exception of the performance evaluation sample result discussed below.

Double-blind performance evaluation samples prepared by the DOE's RESL were submitted to the contract laboratory (GEL) for analysis of 20 radionuclides, along with the groundwater samples. Laboratory results for the performance evaluation samples were all within acceptable limits, except for americium-241. Although this result was not acceptable, it was analyzed using the gamma spectroscopy method rather than the more precise method of alpha spectroscopy. The unacceptable result did not affect the actual groundwater results for this event.

12.3.2.4 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 criterion 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 criterion 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 criterion was met.

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 2019, the DWP reported 24 samples with detectable radiological quantities, which all met the RPD goal. For non-radiological data, precision is evaluated by calculating the RPD if the result in the first sample and the duplicate exceeded the detection limit by a factor of five or more.

Accuracy – Performance Evaluation Samples. Blind spike samples are used to determine the accuracy of laboratory analyses for concentrations of parameters in drinking water. Within each calendar year, the program lead determines the percentage of the samples collected (excluding bacteria samples) that are QA/QC

samples, which include blind spikes. All blind spike percent recoveries must fall within the standards range.

Representativeness. Representativeness is ensured through use of established sampling locations, schedules, and procedures for field sample collections, preservation, and handling.

Comparability. Comparability is ensured through the use of 1) laboratory instructions for sample collection, preparation, and handling; 2) approved analytical methods for laboratory analyses; and 3) consistency in reporting procedures.

ICP Contractor

The ICP Core 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. Table 12-3 presents a summary of 2019 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 2019. A total of 16 parameters were collected and submitted for analysis, and 16 parameters were successfully analyzed. For the DWP surveillance samples, the goal for completeness was to collect and successfully analyze 90% of the samples. This goal was exceeded in 2019. A total of 117 parameters were collected and 100% of these parameters were successfully analyzed.

Precision – Field Duplicates. Field duplicate samples were collected on August 20, 2019 (disinfection byproducts), and July 29, 2019 (nitrate). 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%.

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 – Trip Blank Samples. Trip blanks were prepared as part of the April 29, 2019, and August 12, 2019, (volatile organic compounds) sampling events. One hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90%.

12.3.2.5 Environmental Surveillance, Education, and Research Program Quality Control Data

Table 12-4 presents a summary of 2019 ESER QC analysis results.

Completeness – Collection and Analysis. The ESER contractor met its completeness goals of greater than 98% in 2019. Three air samples were considered invalid because insufficient volumes were collected due to power interruptions (i.e., blown fuse and/or tripped breaker). All other samples were collected and analyzed as planned.

Precision – Field Duplicate Samples. Field duplicate samples were collected for air, milk, lettuce, potatoes, grain, 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 100% of all environmental samples collected during 2019, 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 12.3.1, for soil, wheat, air

Table 12-4. 2019 ESER Surveillance Program Quality Assurance Elements.

QC Program Element 2019	Criterion	Performance[a]
Completeness		
Surveillance Samples Successfully Completed	100%	99.5%
Submitted Surveillance Samples Successfully Analyzed	100%	100%
Accuracy		
Blind Spike Program		
Idaho State University - Environmental Assessment Lab (EAL)[b]	90%	94.3%
General Engineering Laboratory - (GEL)[c]	90%	62.5%
Precision		
Field Duplicates		
EAL	Differences within 3 standard deviations (3σ) or within ± 20 percent RPD	100%
GEL		100%
Field Blanks		
EAL	± 3σ of Zero	97.1%
GEL		100%

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).

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.

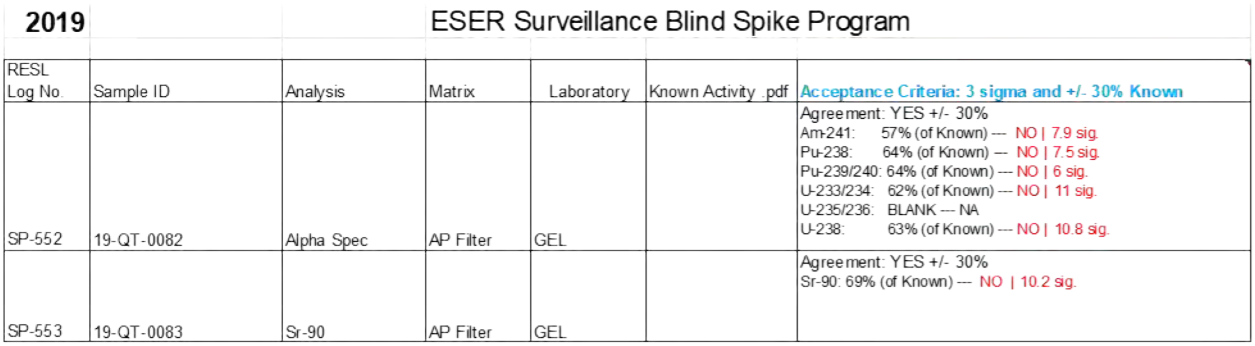
The ESER Program sent thirteen double blind spike sample sets to the ISU-EAL laboratory during the 2019 calendar year for gamma spectrometry and liquid scintillation analysis. The following matrices were spiked for the 2019 year: water, air particulate filters, milk, soil, wheat, potato, lettuce, and alfalfa. The ISU-EAL submitted sample results for 49 individual analytes that had recovery analysis completed by the RESL; 45 had an Agreement of "YES." This was a 95.7% (i.e., 45/47 x 100) performance in the ESER double blind spike program.

The ESER Program sent nine double blind spike sample sets to the GEL laboratory during the 2019 calendar year for radiochemical analysis. The following matrices were spiked for the 2019 year: water, air particulate filters, milk, lettuce, potato, and wheat. The GEL submitted sample results for 16 individual analytes that had recovery analysis completed by the RESL; 10 had an Agreement of "YES." This was 62.5% (i.e., 10/16 x 100) performance in the ESER double blind spike program.

The ESER Program requested a follow-up and for-cause-review for the blind spike AP filter composites, listed below, from the GEL laboratory to complete and get their findings back to the ESER. The GEL response letter to the ESER:

Introduction of Contamination – Field Blanks. Field blank samples were submitted with each set of samples to test for the introduction of contamination

> *"The laboratory has investigated these results and conferred on the issue. We cannot determine a root cause of this low bias. We have reviewed the data, including quality control sample recoveries, calibrations and instrument performance to pinpoint a root cause. No apparent errors were identified." (GEL Laboratory)*



2019 ESER Surveillance Blind Spike Program

RESL Log No.	Sample ID	Analysis	Matrix	Laboratory	Known Activity .pdf	Acceptance Criteria: 3 sigma and +/- 30% Known
SP-552	19-QT-0082	Alpha Spec	AP Filter	GEL		Agreement: YES +/- 30% Am-241: 57% (of Known) --- NO | 7.9 sig. Pu-238: 64% (of Known) --- NO | 7.5 sig. Pu-239/240: 64% (of Known) --- NO | 6 sig. U-233/234: 62% (of Known) --- NO | 11 sig. U-235/236: BLANK --- NA U-238: 63% (of Known) --- NO | 10.8 sig.
SP-553	19-QT-0083	Sr-90	AP Filter	GEL		Agreement: YES +/- 30% Sr-90: 69% (of Known) --- NO | 10.2 sig.

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 97.1% performance of blanks within one to three standard deviations of zero; the GEL had a 100% performance of blanks with the above stated criterion.

12.3.2.6 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 12-5).

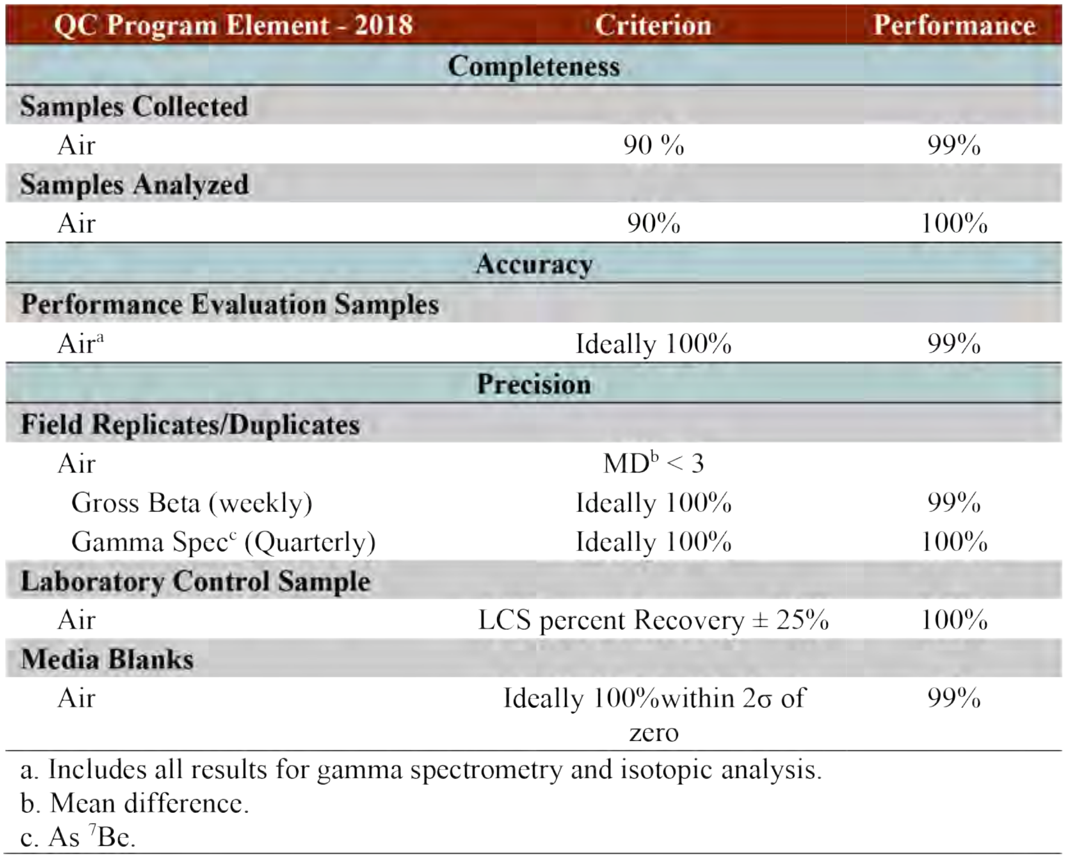
Completeness – Collection and Analysis. The INL Surveillance Monitoring Program met its completeness and precision goals. Samples were collected and analyzed from all available media as planned. Of approximately 1,100 planned air samples, thirteen were invalid because of power interruptions (i.e., blown 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 Central Facilities Area and Idaho Nuclear Technology and Engineering Center (INTEC) locations in 2019. 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 100% of the mean difference values were less than the goal of three.

Introduction of Contaminants – Media Blanks. In 2019, the majority of the media blanks were within two standard deviations of zero for air. See Table 12-5 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 2019 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 (^{90}Sr, ^{238}Pu, ^{239}Pu) were biased low and not in agreement with the known activities.

Table 12-5. 2019 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 ^{7}Be.

12.3.2.7 ICP Core Environmental Surveillance for Waste Management Quality Control Data

Table 12-6 summarizes the 2019 ICP Core Environmental Surveillance Program for Waste Management QC analysis results.

Completeness. The ICP Core Environmental Surveillance Program for Waste Management completeness goal, which includes samples collected and samples analyzed, is 90%. The collection of air samples was 91.6% in 2019. For gross alpha and gross beta analysis, 11 days of sampling in a two-week period is required. During the month of July, 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 some collection periods. Surface water samples collected was 66.7%. Overall sample collection for all media was 90.2%.

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, or the percentage of duplicate samples with a calculated RPD of less than 1.65, was 91.7% in 2019.

$$| R_1 - R_2 | \leq 3(s_1^2+s_2^2)^{1/2} \qquad (1)$$

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.

Table 12-6. 2019 ICP Core Environmental Surveillance Program QA Elements.

QC Program Element - 2019	Criterion	Performance[a]
Completeness		
Surveillance samples successfully completed	90%	90.2%
Surveillance samples successfully analyzed	90%	100%
Accuracy		
Blind Spike Program[b]		
ALS Environmental Laboratory – Fort Collins (ALS)	90%	83.0%[c]
Precision		
Field Replicates/Duplicates		
Differences within 3 standard deviations (3σ)	MD[b] > 3	91.7%
Laboratory Control Sample		
All media	Laboratory control sample percent recovery ±25%	100%
Field Blanks		
Air and surface water	Ideally 100% within 2s	N/A[d]

a. Sample matrices include: air filter and surface water.

b. Requested analyses—gamma spectrometry and isotopic.

c. Performance Evaluation (PE) samples are not completed on a per-calendar-year basis. Results indicated are from 2018 PE samples, which are the latest available.

d. Due to failure to collect semiannual surface water samples from the SDA Lift Station, as discussed in Chapter 4, no field blanks were collected in 2019.

Surface water samples are collected from the SDA Lift Station semiannually and from the WMF-636 Fire Water Catch Tanks when necessary to discharge accumulated run-in. In 2019, three field duplicates were taken during sampling of the catch tanks. When comparing results of the regular sample and the duplicate sample, precision was 83.9%.

The overall precision result for all media sampled was 85.5%.

Accuracy. The ICP Core contractor last 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 12.3.1. All air blind spike samples showed 100% satisfactory agreement (within ± 30% of the known value and within three-sigma) for all constituents of concern. Surface water runoff PE samples were not submitted for analysis in 2019.

Laboratory Inter-comparison QA Programs. ALS Laboratory Group participated in a variety of intercomparison QA programs, which verified all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the National Environmental Laboratory Accreditation Program. 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 2019, 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.

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.

12.3.2.8 U.S. Geological Survey Water Sampling Quality Control Data

Water samples are collected in accordance with a QA plan for quality-of-water activities by personnel assigned to the USGS INL project office; the plan was revised in 2014 (Bartholomay et al. 2014). Additional QA is assessed with QA/QC duplicates, blind replicates, replicates, source solution blanks, equipment blanks, field blanks, splits, trip blanks, and spikes (Bartholomay et al., 2014). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams et al. (1998), Bartholomay and Twining (2010), Rattray (2012), Davis et al. (2013), Rattray (2014); Bartholomay et. al. (2017), and Bartholomay et al. (2020). During 2019, the USGS collected 13 replicate samples, three field blank samples, two equipment blank samples, and one source solution blank sample. Evaluation of results will be summarized in future USGS reports.

12.4 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 12-7, Table 12-8, and Table 12-9, respectively.

12.4.1 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 12-7).

12.4.2 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 12-8).

12.4.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project maintains a QA program in accordance with 40 CFR 61, Appendix B, as required of all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in PLN-5231, “Quality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System,”

Table 12-7. 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-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

Table 12-7. INL Environmental Program Documentation (continued).

Document/Media Type	Document No.[a] and Title
	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 document
SOW = statement of work

and PLN-5778, "Quality Assurance Project Plan for the RCE and ICE NESHAP Stack Monitoring System."

12.4.4 Environmental Surveillance, Education, and Research Program

The ESER Program QA documentation (Table 12-9) 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.

12.4.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Water-Quality Activities and Water-Level Measurements (Bartholomay et al., 2014) defines procedures and tasks performed by USGS project office personnel that ensure the reliability of water quality and water level data. The plan addresses all elements needed to ensure:

- Reliability of the water-quality and water-level data
- Compatibility of the data with data collected by other organizations at the INL Site
- That data 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 Labora-

Table 12-8. 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 12-8. ICP Core Environmental Program Documentation (continued).

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.

tory. In addition, the USGS routinely evaluates its QC data and publishes analyses in USGS reports. Analyses of QA data collected from 2016–2018 are found in Bartholomay et al. (2020).

12.4.6 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.

12.5 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 2019 has not been issued at this time. Results for 2018 are compared in the DEQ-IOP Annual Report (https://www.deq.idaho.gov/inl-oversight/monitoring/reports/).

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 2018 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 2018.

Table 12-9. 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

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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, 2020, "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 May 6, 2020.
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- DOE O 231.1B, 2011, "Environment, Safety, and Health Reporting," Change 1, U.S. Department of Energy.
- DOE O 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy.
- DOE O 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy.
- DOE O 458.1, 2011, "Radiation Protection of the Public and the Environment," Change 3, U.S. Department of Energy.
- DOE Standard 1196-2011, 2011, "Derived Concentration Technical Standard," U.S. Department of Energy.
- Executive Order 11514, 1970, "Protection and Enhancement of Environmental Quality."
- Executive Order 11988, 1977, "Floodplain Management."
- Executive Order 11990, 1977, "Protection of Wetlands."
- Executive Order 12344, 1982, "Naval Nuclear Propulsion Program."
- Executive Order 12580, 1987, "Superfund Implementation."
- Executive Order 12856, 1993, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements."
- Executive Order 12873, 1993, "Federal Acquisition, Recycling, and Waste Prevention."
- Executive Order 13101, 1998, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition."
- Executive Order 13693, 2015, "Planning for Federal Sustainability in the Next Decade."
- IDAPA 58.01.01, 2020, "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 May 6, 2020.

- IDAPA 58.01.02, 2020, “Water Quality Standards,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580102.pdf, last visited May 6, 2020.
- IDAPA 58.01.03, 2020, “Individual/Subsurface Sewage Disposal Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580103.pdf, last visited May 6, 2020.
- IDAPA 58.01.05, 2020, “Rules and Standards for Hazardous Waste,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580105.pdf, last visited May 6, 2020.
- IDAPA 58.01.06, 2020, “Solid Waste Management Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580106.pdf, last visited May 6, 2020.
- IDAPA 58.01.08, 2020, “Idaho Rules for Public Drinking Water Systems,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580108.pdf, last visited May 6, 2020.
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- IDAPA 58.01.15, 2020, “Rules Governing the Cleaning of Septic Tanks,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/2006/58/0115.pdf, last visited May 6, 2020.
- IDAPA 58.01.16, 2020, “Wastewater Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580116.pdf, last visited May 6, 2020.
- IDAPA 58.01.17, 2020, “Recycled Water Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality; https://adminrules.idaho.gov/rules/current/58/580117.pdf, last visited May 6, 2020.

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.

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

Radiation Standard	Effective Dose Equivalent	
	(mrem/yr)	(mSv/yr)
DOE standard for routine DOE activities (all pathways)	100[a]	1
EPA standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

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 (2020) and the Idaho groundwater quality values from IDAPA 58.01.11 (2020).

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}	1.4×10^{-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[d,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[d,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[d,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}	4.0×10^{-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).

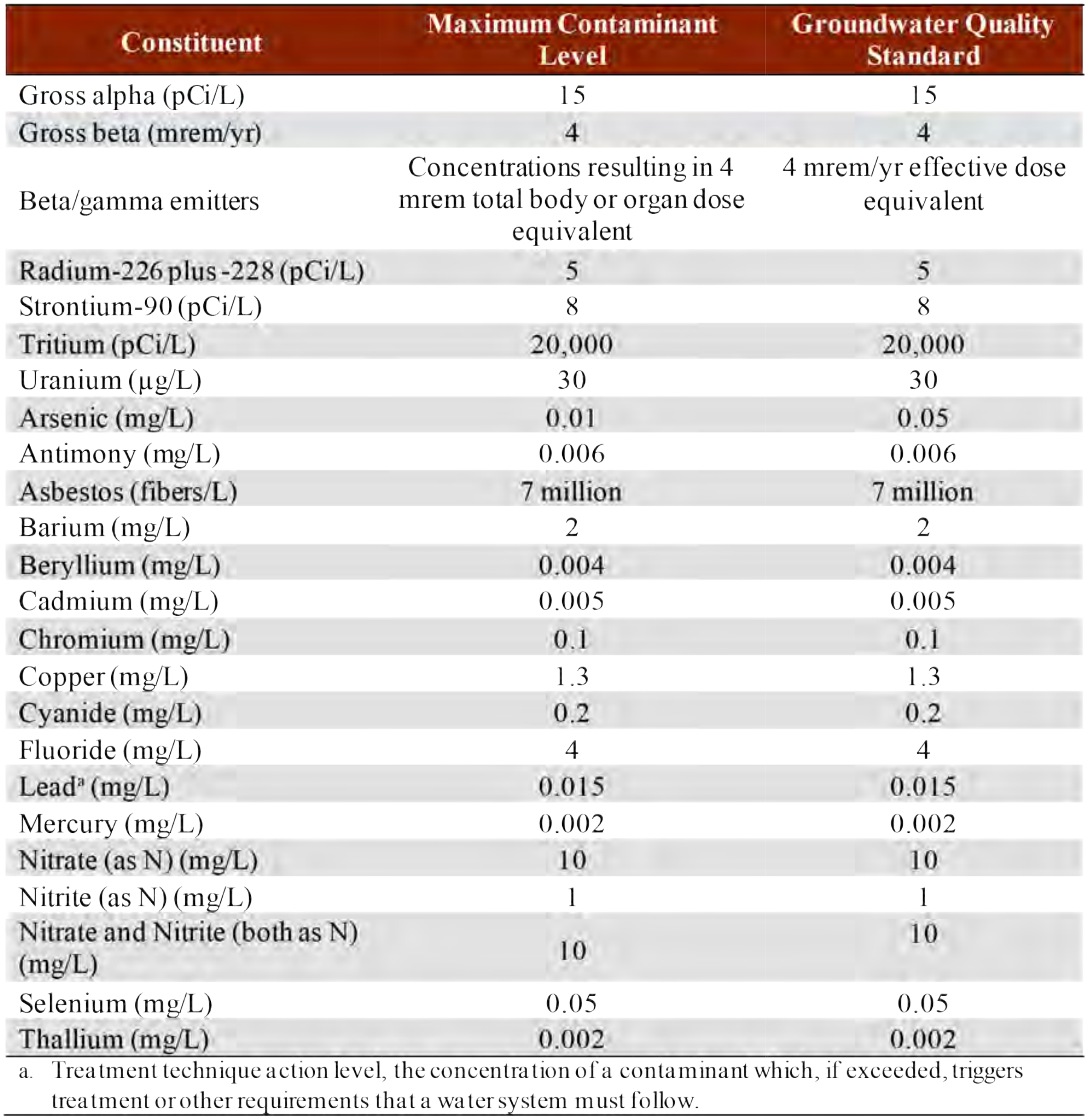
c. Based on the most restrictive human-made beta emitter (^{90}Sr).

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)	10	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.

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

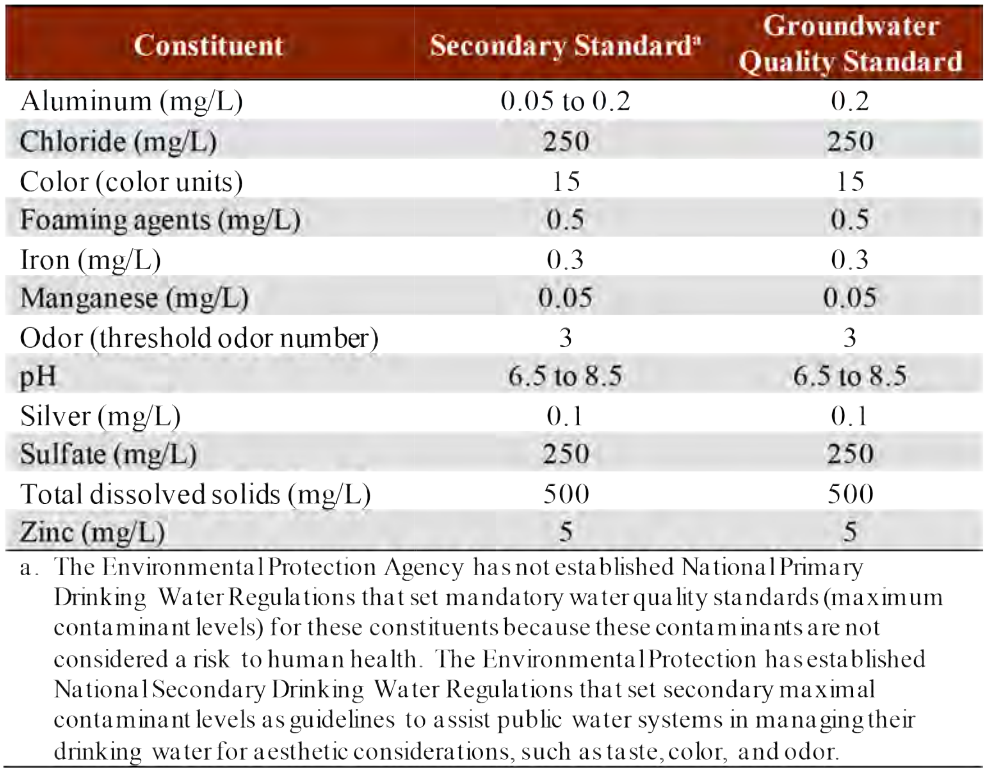
Constituent	Maximum Contaminant Level (mg/L)	Groundwater Quality Standard (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	—	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	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[a]	—	0.1
Bromoform[a]	—	0.1
Chlorodibromomethane[a]	—	0.1
Chloroform[a]	—	0.002
Chlorite	1.0	—
Haloacetic acids (HAA5)	0.06	—
Total Trihalomethanes (TTHMs)	0.08	0.1

a. These four compounds do not have individual MCLs. They are combined to give an MCL of 0.08 mg/L for total trihalomethanes.

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 x 10^{-8}	3 x 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 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. The Environmental Protection has established National Secondary Drinking Water Regulations that set secondary maximal contaminant levels as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

Appendix B. Chapter 5 Addendum

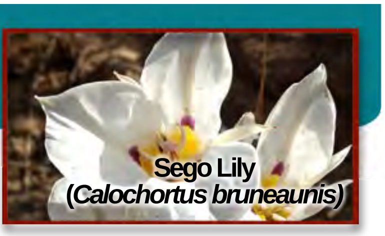

Sego Lily
(*Calochortus bruneaunis*)

Table B-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Permit-required Monitoring Results (2019).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.51	7.61	6.88
Conductivity (µS/cm)	405	1464	670
Aluminum, filtered (mg/L)	0.0193U[b]	0.0193U	0.0193U
Aluminum, total (mg/L)	0.0193U	0.0217	0.0193U
Chloride (mg/L)	11.1	54.5	14.5
Chromium, filtered (mg/L)	0.00367	0.0163	0.00534
Chromium, total (mg/L)	0.00362	0.0164	0.00567
Iron, filtered (mg/L)	0.033U	0.310, [0.0634B][c]	0.033
Iron, total (mg/L)	0.033U	0.356, [0.0847B][c]	0.0334
Manganese, filtered (mg/L)	0.001U	0.00444	0.001
Manganese, total (mg/L)	0.001U	0.00467	0.001
Nitrate + nitrite as nitrogen (mg/L)	0.885	4.01	1.10
Nitrogen, total kjeldahl nitrogen (TKN) (mg/L)	-0.00938U	0.566	0.1U
Nitrogen, Total (mg/L)[d]	0.89	4.40	1.10
Solids, total dissolved (mg/L)	203	1210	299
Sulfate (mg/L)	32.2	675	79

a. Duplicate samples were collected in April 2019 and the results for the duplicate samples are included in the statistical summary.

b. U qualifier indicates the result was below the detection limit.

c. June 2019 Iron results were re-analyzed. Results of the re-analysis are shown in brackets.

d. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen. For results reported below the laboratory instrument detection limit and with a negative value, the sample results are considered zero when used in the calculation.

Table B-2. Hydraulic Loading Rates for the Advanced Test Reactor Complex Cold Waste Pond.

	Yearly Total Flow
2019 flow	227.13 MG[a]
Annual permit limit[b]	375 MG
5-yr moving annual average permit limit	300 MG

a. MG = million gallons

b. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1st – October 31st.

Table B-3a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2019).

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard[a]
Sample Date:	***4/18/19***	***9/25/19***	***4/23/19***	***10/3/19***	***4/22/19***	***10/3/19***	***4/23/19***	***9/25/19***	***4/18/19***	***9/25/19***	**PCS/SCS**
Water table depth (ft) bls[b]	426.79	427.03	474.81	474.82	482.57	483.1	488.44	489.24	492.36	493.43	NA[c]
Water table elevation (ft)[d]	4462.42	4462.18	4453.76	4453.75	4450.64	4450.11	4450.62	4449.82	4450.51	4449.44	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)	1.04	1.1	1.43	1.5	1	1.06	0.995	1.07	0.995 (0.995)[f]	1.02	10 (PCS)
Total kjeldahl nitrogen (mg/L)	0.0418J[g]	0.100U[h]	0.033U	0.033U	0.0696J	0.033U	0.033U	0.100U	0.033U (0.033U)	0.100U	NA
Total nitrogen[i] (mg/L)	1.08	1.2	1.46	1.53	1.07	1.09	1.03	1.27	1.03	1.12	NA
pH (s.u.)	6.86	8.06	7.23	7.6	7.72	7.99	7.38	7.87	7.81	7.91	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	391	388	582	602	415	424	411	429	411	419	NA
Chloride (mg/L)	13.1J	14J	18.4	17.1	11.3J	12.2	10.9	10.9J	9.83J (10J)	10.5J	250 (SCS)
Sulfate (mg/L)	20.5	21.8J	146	144J	32	34.5J	45.8	48.9J	30.2 -30.9	32.7J	250 (SCS)
Total dissolved solids (mg/L)	249	239	409	396	92.9J	263	260	283	264 -281	269	500 (SCS)
Aluminum, filtered (mg/L)	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0202	0.0193U (0.0193U)	0.0193U	0.2 (SCS)
Chromium[j], total (mg/L)	0.00684	0.00632	0.0815	0.0838	0.0115	0.0119	0.0249	0.0211	0.0105 -0.0102	0.0101	0.1 (PCS)
Chromium[j], filtered (mg/L)	0.00657	0.00637	0.0793	0.0807	0.011	0.0115	0.0222	0.0206	0.0102 -0.0103	0.0102	0.1 (PCS)
Iron, filtered (mg/L)	0.03U	0.03U	0.148	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U (0.03U)	0.03U	0.3 (SCS)

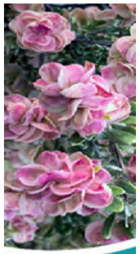


Table B-3a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2019) (continued).

Well Name	**USGS-098 (GW-016101)**		**USGS-065 (GW-016102)**		**USGS-076 (GW-016104)**		**TRA-08 (GW-016105)**		**Middle-1823 (GW-016106)**		**Standard[a]**
Sample Date:	*4/18/19*	*9/25/19*	*4/23/19*	*10/3/19*	*4/22/19*	*10/3/19*	*4/23/19*	*9/25/19*	*4/18/19*	*9/25/19*	**PCS/SCS**
Manganese, filtered (mg/L)	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U (0.001U)	0.00141J	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. Results shown in parenthesis are from the field duplicate samples.

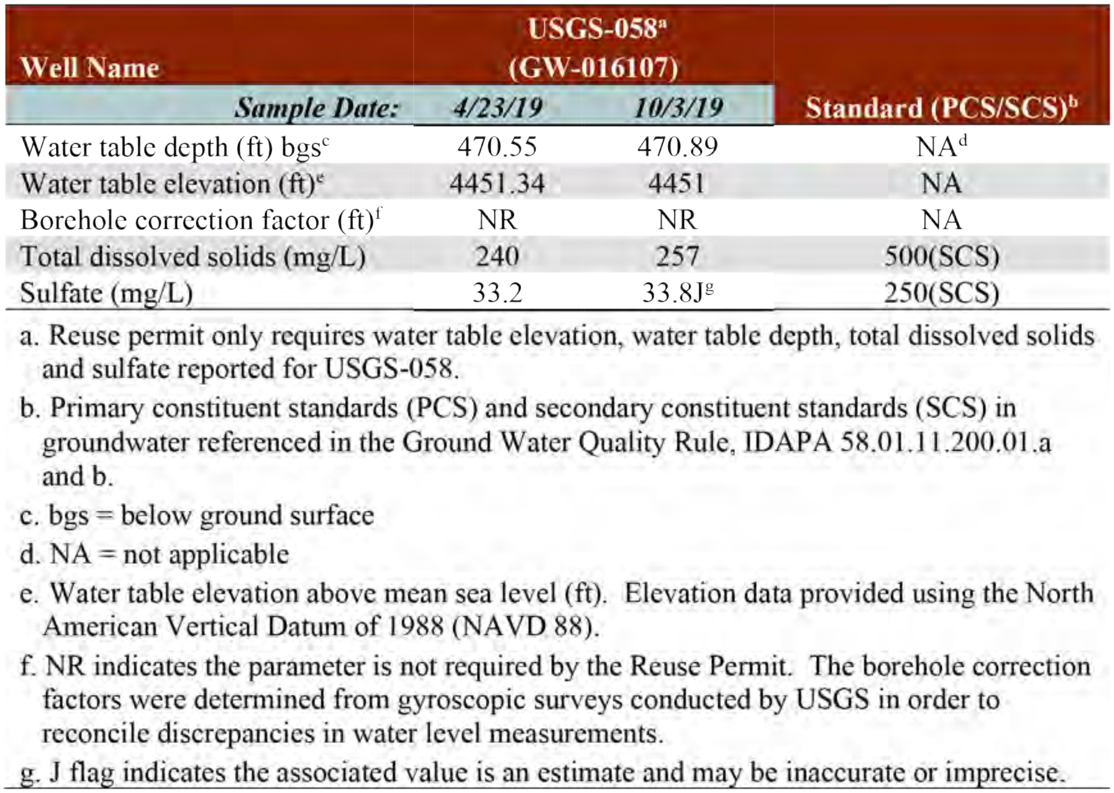
g. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

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 below detection, the method detection limit (MDL) was used in the total nitrogen calculation. Results were rounded to the nearest hundredth.

j. PCS for chromium does not apply under reuse permit I-160-02. The PCS does apply to new reuse permit I-160-03 issued by DEQ on October 30, 2019.

Table B-3b. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2019).



Well Name	USGS-058[a] (GW-016107)		Standard (PCS/SCS)[b]
Sample Date:	*4/23/19*	*10/3/19*	
Water table depth (ft) bgs[c]	470.55	470.89	NA[d]
Water table elevation (ft)[e]	4451.34	4451	NA
Borehole correction factor (ft)[f]	NR	NR	NA
Total dissolved solids (mg/L)	240	257	500(SCS)
Sulfate (mg/L)	33.2	33.8J[g]	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

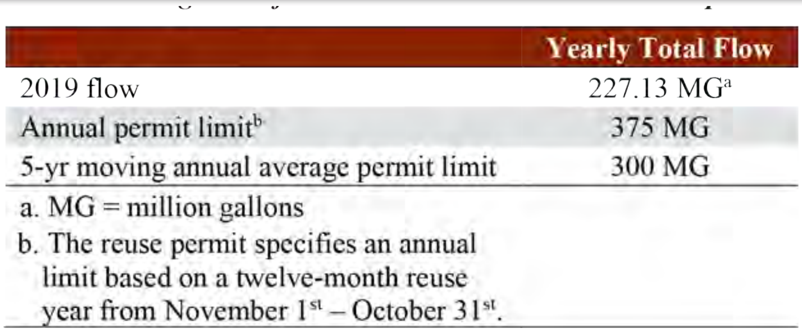
d. NA = not applicable

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.

g. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table B-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2019).



	Yearly Total Flow
2019 flow	227.13 MG[a]
Annual permit limit[b]	375 MG
5-yr moving annual average permit limit	300 MG

a. MG = million gallons

b. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1st – October 31st.

Table B-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2019).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	2.94U[a]	23.3	9.5
Nitrate + nitrite, as nitrogen (mg/L)	0.254	5.43	2.5
pH (standard units)[b]	7.39	9.05	8.03
Total coliform (MPN[c]/100 mL)[b]	31.8	>2,419	1,237.9
Total kjeldahl nitrogen (mg/L)	7.76	60.0	24.1
Total phosphorus (mg/L)	1.95	7.0	4.80
Total suspended solids (mg/L)	2.0U	46	15

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

b. As required by the permit, the results for this parameter were obtained from a grab sample.

c. MPN = most probable number

Table B-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2019).

Parameter	Minimum	Maximum	Mean
Chloride (mg/L)	12.4	79.9	42.8
Chromium (mg/L)	0.00472	0.00628	0.00505
Coliform, fecal (MPN/100 mL)[a]	<1	9	2
Coliform, total (MPN/100 mL)[a]	<1.0	>2,419.2	533.9
Fluoride (mg/L)	0.204	0.300	0.241
Manganese, total (mg/L)	0.002U[b]	0.002U	0.002U
Nitrate + nitrite, as nitrogen (mg/L)	0.771	2.390	1.275
pH (standard units)[a]	7.33	10.40	8.31
Selenium (mg/L)	0.002U	0.002U	0.002U
Total dissolved solids (mg/L)	193	357	263
Total phosphorus (mg/L)	0.508	2.910	0.870

a. As required by the permit, the results for this parameter were obtained from a grab sample.

b. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table B-7. Hydraulic Loading Rates for the INTEC New Percolation Ponds.

	Maximum Daily Flow	Yearly Total Flow
2019 flow	1,133,510 gallons	205 MG[a]
Permit limit	3,000,000 gallons	1,095 MG

a. MG = million gallons

Table B-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2019).

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:	***5/1/2019***	***9/10/2019***	***5/1/2019***	***9/10/2019***	***5/1/2019***	***9/9/2019***	
Water table depth (ft bls)[b]	502.84	503.18	510.03	510.31	501.89	502.27	NA[c]
Water table elevation (ft above mean sea level)[d]	4,450.07	4,449.73	4,449.51	4,449.23	4,450.28	4,449.90	NA
Chloride (mg/L)	33.3 (J)[e]	32.6	14.7 (J)[e]	14.6	9.42 (J)[e]	8.56	250
Chromium (mg/L)	0.011	0.00946	0.00573	0.00521	0.0118	0.00952	0.1
Coliform, fecal (MPN[f]/100 mL)	<1	<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	<1.0	1 CFU/100 mL[h]
Dissolved oxygen (mg/L)	6.40	6.54	4.38	6.08	5.81	6.00	NA
Electrical conductivity (µmhos/cm)	457	420	327	292	386	348	NA
Fluoride (mg/L)	0.236	0.236	0.290	0.296	0.219	0.215	4
Manganese, dissolved (mg/L)[i]	NR[j]	NR	NR	NR	NR	NR	0.05
Manganese, total (mg/L)	ND (<0.001)[k]	ND (<0.001)[k]	0.0158	0.0130	ND (<0.001)[k]	ND (<0.001)[k]	0.05
Nitrate / nitrite, as nitrogen (mg/L)	1.11	1.08	0.283	0.326	0.848	0.804	10
pH (standard units)	8.14	7.97	7.97	7.89	8.11	7.96	6.5–8.5
Selenium (mg/L)	ND (<0.0015)[k]	ND (<0.0015)[k]	ND (<0.0015)[k]	ND (<0.0015)[k]	ND (<0.0015)[k]	ND (<0.0015)[k]	0.05
Temperature (°F)	54.1	54.7	53.3	54.6	54.6	56.7	NA
Total dissolved solids (mg/L)	304	261	216	196	229	216	500
Total phosphorus (mg/L)	0.0438 (U)[l]	0.0251(J)[m]	0.0466 (U)[l]	0.0351(J)[m]	0.0474 (U)[l]	0.0589	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. J flag indicates the parameter was positively identified, but the reported value is an estimate. This is because the matrix spike recovery was outside U.S. Environmental Protection Agency Method Recovery Criteria.

f. MPN = most probable number

g. CFU = colony forming unit

Table B-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2019) (continued).

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:	*5/1/2019*	*9/10/2019*	*5/1/2019*	*9/10/2019*	*5/1/2019*	*9/9/2019*	

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. ND = Parameter not detected in sample. Value in parentheses is the detection limit.

l. U flag indicates the parameter was detected above the detection limit in the sample; however, the parameter was also detected in the blank. The validator flagged the data as nondetected because the result was >detection limit but was <5× the blank concentration.

m. J flag indicates the parameter was positively identified, but the reported value is an estimate. This is because the value is less than the laboratory reporting limit.

Table B-9. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2019).

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:	***4/30/2019***	***9/9/2019***	***4/30/2019***	***9/9/2019***	***4/30/2019***	***9/9/2019***	
Depth to water (ft bls)[b]	106.98	Dry[c]	110.2	117.62	235.61	236.31	NA[d]
Water table elevation (ft above mean sea level)[e]	4,841.05		4,842.9	4,835.48	4,722.89	4,722.19	NA
Chloride (mg/L)	3.28 (J)[f]		70.3 (J)[f]	79.4	29.5 (J)[f]	49.7	250
Chromium (mg/L)	0.00562		0.00666	0.00592	0.00667	0.00678	0.1
Coliform, fecal (MPN[g]/100 mL)	<1		<1	<1	<1	<1	<1 CFU[h]/100 mL
Coliform, total (MPN/100 mL)	<1.0		<1.0	<1.0	<1.0	<1.0	1 CFU/100 mL[i]
Dissolved oxygen (mg/L)	7.58		6.16	4.42	5.36	5.97	NA
Electrical conductivity (µmhos/cm)	322		572	537	438	453	NA
Fluoride (mg/L)	0.175		0.190	0.228	0.236	0.265	4
Manganese, dissolved (mg/L)[j]	NR[k]		NR	NR	NR	NR	0.05
Manganese, total (mg/L)	0.019		ND (<0.001)[l]	ND (<0.001)[l]	0.00566	0.00409 (B)[m]	0.05
Nitrate / nitrite, as nitrogen (mg/L)	0.246		1.41	1.12	1.49	1.43	10
pH (standard units)	8.03		7.90	7.69	8.63	8.40	6.5–8.5
Selenium (mg/L)	ND (<0.0015)[l]		ND (<0.0015)[l]	ND (<0.0015)[l]	ND (<0.0015)[l]	ND (<0.0015)[l]	0.05
Temperature (°F)	49.7		60.7	62.9	61.1	62.7	NA
Total dissolved solids (mg/L)	167		310	319	229	274	500
Total phosphorus (mg/L)	0.0525 (U)[n]		0.344	0.232	0.0555 (U)[n]	0.0744	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 2019.

d. NA = not applicable

e. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

f. J flag indicates the parameter was positively identified, but the reported value is an estimate. This is because the matrix spike recovery

Table B-9. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2019) (continued).

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:	*4/30/2019*	*9/9/2019*	*4/30/2019*	*9/9/2019*	*4/30/2019*	*9/9/2019*	

was outside United States Environmental Protection Agency Method Recovery Criteria.

g. MPN = most probable number

h. CFU = colony forming units

i. 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.

j. The results of dissolved concentrations of this parameter are used for SCS compliance determinations.

k. 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.

l. ND = Parameter not detected in sample. Value in parentheses is the detection limit.

m. B flag indicates the parameter was detected above the method detection limit but below the reporting limit.

n. U flag indicates the parameter was detected above the detection limit in the sample; however, the parameter was also detected in the blank. The validator flagged the data as nondetected because the result was >detection limit but was <5× the blank concentration.

Table B-10. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2019).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.66	8.43	7.6
Conductivity (µS/cm)	411	944	536
Chloride[b] (mg/L)	22.6	163	40.5
Nitrate + nitrite as nitrogen (mg-N/L)	2.29	3.37	2.57
Iron (mg/L)	0.03U[c]	0.204	0.103
Iron, filtered (mg/L)	0.03U	0.032	0.03U
Manganese (mg/L)	0.002U	0.00658	0.00234
Manganese, filtered (mg/L)	0.002U	0.00632	0.00221
Sodium[b] (mg/L)	21.6	115	35.0
Sodium[b], filtered (mg/L)	21.2	110	33.1
Total dissolved solids (mg/L)	207	559	320

a. Duplicate samples were collected in May and the results for the duplicate samples are included in the data summary.
b. Chloride and sodium are not required monitoring parameters in reuse permit I-160-02.
c. U qualifier indicates the result was below the detection limit.

Table B-11. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2019).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	7.30	8.87	8.00
Conductivity (µS/cm)	828	1484	918
Chloride[b] (mg/L)	41.8	128	49.0
Nitrate + nitrite as nitrogen (mg-N/L)	4.36	15.5	5.81
Iron (mg/L)	0.03U[c]	0.22	0.0956
Iron, filtered (mg/L)	0.03U	0.157	0.0446
Manganese (mg/L)	0.002U	0.0105	0.0054
Manganese, filtered (mg/L)	0.002U	0.00698	0.00371
Sodium[b] (mg/L)	44.6	123	50.9
Sodium, filtered[b] (mg/L)	44.2	126	50.1
Total dissolved solids (mg/L)	314	950	450

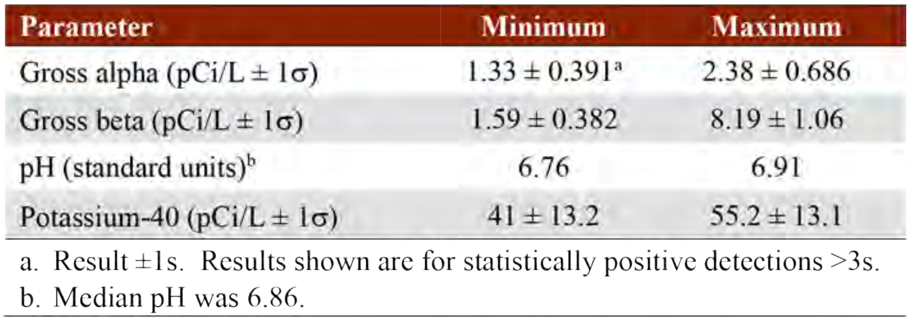
a. Duplicate samples were collected in May and the results for the duplicate samples are included in the data summary.
b. Chloride and sodium are not required monitoring parameters in reuse permit I-160-02.
c. U qualifier indicates the result was below the detection limit.

Table B-12. Summary of Groundwater Quality Data Collected for the Reuse Permit for the MFC Industrial Waste Ditch and Pond (2019).

Well Name	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		
Sample Date:	*4/24/2019*	*9/16/2019*	*4/24/2019*	*9/16/2019*	*4/24/2019*	*9/16/2019*	PCS/SCS[a]
Water table depth (ft bls)[b]	657.94	659.99	646.36	648.44	645.51	647.61	NA[c]
Water table elevation (ft above mean sea level)[d]	4474.76	4472.71	4474.01	4471.93	4472.57	4470.47	NA
Temperature (°F)	56.66	58.64	56.66	55.4	59.36	55.76	NA
pH (s.u)	6.91	7.81	7.5	7.16	7.7	7.36	6.5 to 8.5 (SCS)
Conductivity (µmhos/cm)	367	368	377	380	363	370	NA
Nitrite + nitrate as N (mg/L)	2.59	2.45	2.57	2.59 (-2.53)[e]	2.64	2.51	NA
Nitrate nitrogen (mg/L)[f]	2.28	2.34	2.23	2.37 (-2.38)	2.29	2.38	10 (PCS)
Total dissolved solids (mg/L)	249	244	276	233 (-2.67)	226	197	500 (SCS)
Iron, total (mg/L)	0.03U[g]	0.03U	0.143	0.0356 (-0.0314)	0.03U	0.03U	0.3 (SCS)
Iron, filtered (mg/L)	0.03U	0.03U	0.0592	0.03U (0.03U)	0.03U	0.03U	0.3 (SCS)
Manganese, total (mg/L)	0.001U	0.001U	0.0018	0.00106 (0.001U)	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. Duplicate sample results are shown in parentheses.
f. Constituent analyzed in response to comments from the 2016 annual report (John 2017).
g. 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

Table B-13. Advanced Test Reactor Complex Cold Waste Ponds Surveillance Monitoring Results (2019).



Parameter	Minimum	Maximum
Gross alpha (pCi/L ± 1σ)	1.33 ± 0.391[a]	2.38 ± 0.686
Gross beta (pCi/L ± 1σ)	1.59 ± 0.382	8.19 ± 1.06
pH (standard units)[b]	6.76	6.91
Potassium-40 (pCi/L ± 1σ)	41 ± 13.2	55.2 ± 13.1

a. Result ±1s. Results shown are for statistically positive detections >3s.
b. Median pH was 6.86.

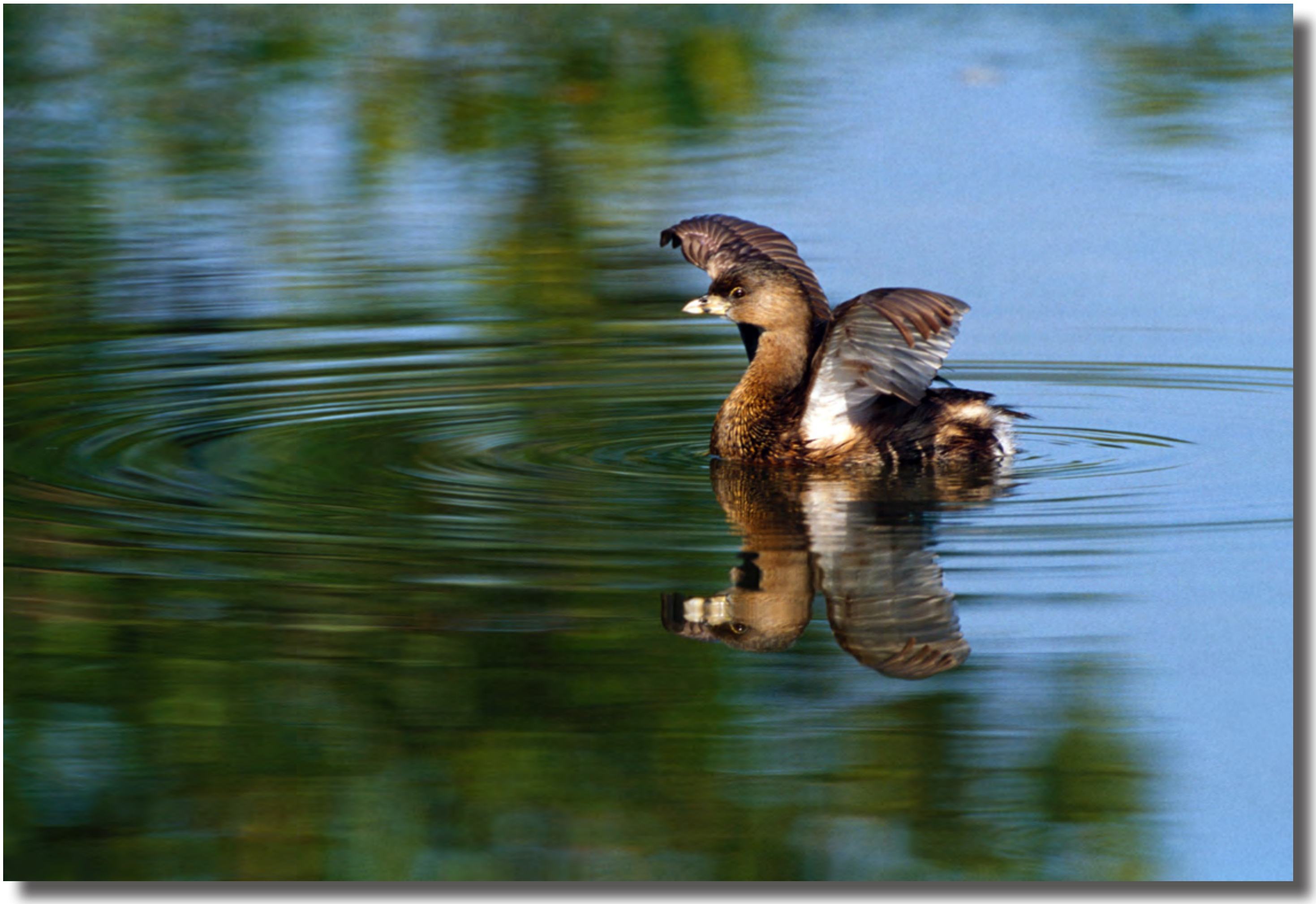


Table B-14. Radioactivity Detected in Surveillance Groundwater Samples Collected at the Advanced Test Reactor Complex (2019).

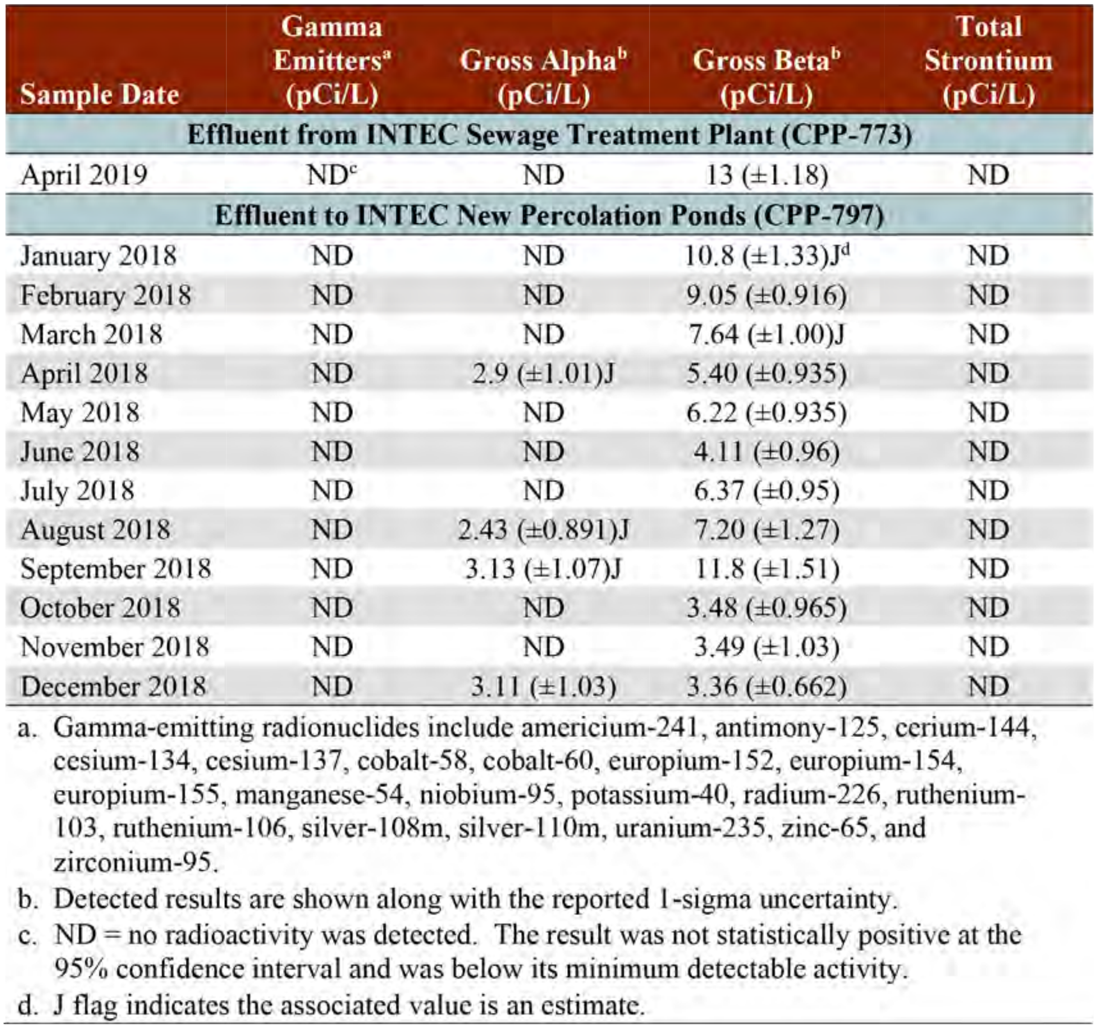
Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-098	4/18/2019	Gross Alpha	ND[a]
		Gross Beta	2.38 (±0.429) [b]
		Tritium	ND
	9/25/2019	Gross Alpha	1.01 (±0.324)
		Gross Beta	2.78 (±0.295)
		Tritium	ND
USGS-065	4/18/2019	Gross Alpha	2.91 (±0.528)
		Gross Beta	2.69 (±0.478)
		Tritium	1,600 (±209)
	9/25/2019	Gross Alpha	ND
		Gross Beta	3.11 (±0.446)
		Tritium	1,440 (±196)
TRA-08	4/18/2019	Gross Alpha	1.54 (±0.405)
		Gross Beta	1.59 (±0.449)
		Tritium	1020 (±158)
	9/25/2019	Gross Alpha	ND
		Gross Beta	3.12 (±0.295)
		Tritium	1040 (±150)
USGS-076	4/18/2019	Gross Alpha	ND
		Gross Beta	1.76 (±0.411)
		Tritium	480 (±122)
	9/25/2019	Gross Alpha	ND
		Gross Beta	1.9 (±0.399)
		Tritium	ND
Middle-1823	4/18/2019	Gross Alpha	ND [2.28 (±0.48)] [c]
		Gross Beta	2.48 (±0.43) [ND]
		Tritium	532 (±126) [503 (±123)]
	9/25/2019	Gross Alpha	1.2 (±0.295)
		Gross Beta	2.48 (±0.273)
		Tritium	542 (±112)
USGS-058	4/18/2019	Gross Alpha	1.01 (±0.275)
		Gross Beta	2.39 (±0.415)
		Tritium	411 (±119)
	9/25/2019	Gross Alpha	ND
		Gross Beta	2.06 (±0.332)
		Tritium	654 (±133)

a. ND = not detected

b. One sigma uncertainty shown in parentheses.

c. Analytical result from field duplicate sample collected on April 18, 2019, from Well Middle-1823. Results shown in brackets.

Table B-15. Liquid Effluent Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2019).



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)				
April 2019	ND[c]	ND	13 (±1.18)	ND
Effluent to INTEC New Percolation Ponds (CPP-797)				
January 2018	ND	ND	10.8 (±1.33)J[d]	ND
February 2018	ND	ND	9.05 (±0.916)	ND
March 2018	ND	ND	7.64 (±1.00)J	ND
April 2018	ND	2.9 (±1.01)J	5.40 (±0.935)	ND
May 2018	ND	ND	6.22 (±0.935)	ND
June 2018	ND	ND	4.11 (±0.96)	ND
July 2018	ND	ND	6.37 (±0.95)	ND
August 2018	ND	2.43 (±0.891)J	7.20 (±1.27)	ND
September 2018	ND	3.13 (±1.07)J	11.8 (±1.51)	ND
October 2018	ND	ND	3.48 (±0.965)	ND
November 2018	ND	ND	3.49 (±1.03)	ND
December 2018	ND	3.11 (±1.03)	3.36 (±0.662)	ND

a. Gamma-emitting radionuclides include americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95.

b. Detected results are shown along with the reported 1-sigma uncertainty.

c. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

d. J flag indicates the associated value is an estimate.

Table B-16. Groundwater Radiological Monitoring Results for the Idaho Nuclear

Monitoring Well	Sample Date	Gross Alpha[a] (pCi/L)	Gross Beta[a] (pCi/L)
ICPP-MON-A-165	5/1/2019	1.57 (±0.589)J[b]	3.08 (±0.772)
	9/10/2019	ND[c]	3.27 (±0.815)
ICPP-MON-A-166	5/1/2019	ND	ND
	9/10/2019	ND	3.71 (±0.941)
ICPP-MON-V-200	4/30/2019	2.24 (±0.794)J	4.16 (±0.945)
	9/9/2019	ND	5.70 (±1.00)
ICPP-MON-V-212	4/30/2019	ND	8.09 (±0.911)
	9/9/2019	ND	9.45 (±1.14)

a. Detected results are shown along with the reported 1-sigma uncertainty.

b. J flag indicates the associated value is an estimate.

c. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table B-17. Radiological Monitoring Results for Materials and Fuels Complex Industrial Waste Pond (2019).[a]

Parameter[b] (pCi/L)	Minimum	Maximum	DCS[c] (pCi/L)
Gross alpha	2.03 ± 0.649	11.65 ± 1.65 (2.79 ± 0.814)[d]	NA[e]
Gross beta	5.08 ± 0.911	31.2 ± 1.58 (ND)[d,f]	NA
Radium-226[d]	ND[f]	ND	
Uranium-238[g]	0.512 ± 0.103	0.512 ± 0.103	750
Uranium-233/234[g]	1.17 ± 0.169	1.17 ± 0.169	660[h]

a. Results shown are for statistically positive detections >3s, 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. It was noted during collection the water sample contained sediments due to sampling interference. Initial result was a non-detect but laboratory also noted the sample contained matrix interference due to sediment. The sample was filtered and re-analyzed, and the result remained non-detect.

e. NA = not applicable

f. ND indicates the result was below the detection limit.

g. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

h. DCS for uranium-233 is shown because it is more conservative than that for uranium-234.

Appendix C. Onsite Dosimeter Measurements and Locations

	mrem[a]	
Location	Nov. 2018– April 2019	May 2019 – Oct. 2019
ARA[b] I&II O-1	65	73
PBF SPERT[c] O-1	62	66

a. Millirem (mrem) in ambient dose equivalent.

b. Auxiliary Reactor Area (ARA)

c. Power Burst Facility Special Power Excursion Reactor Test (PBF SPERT)

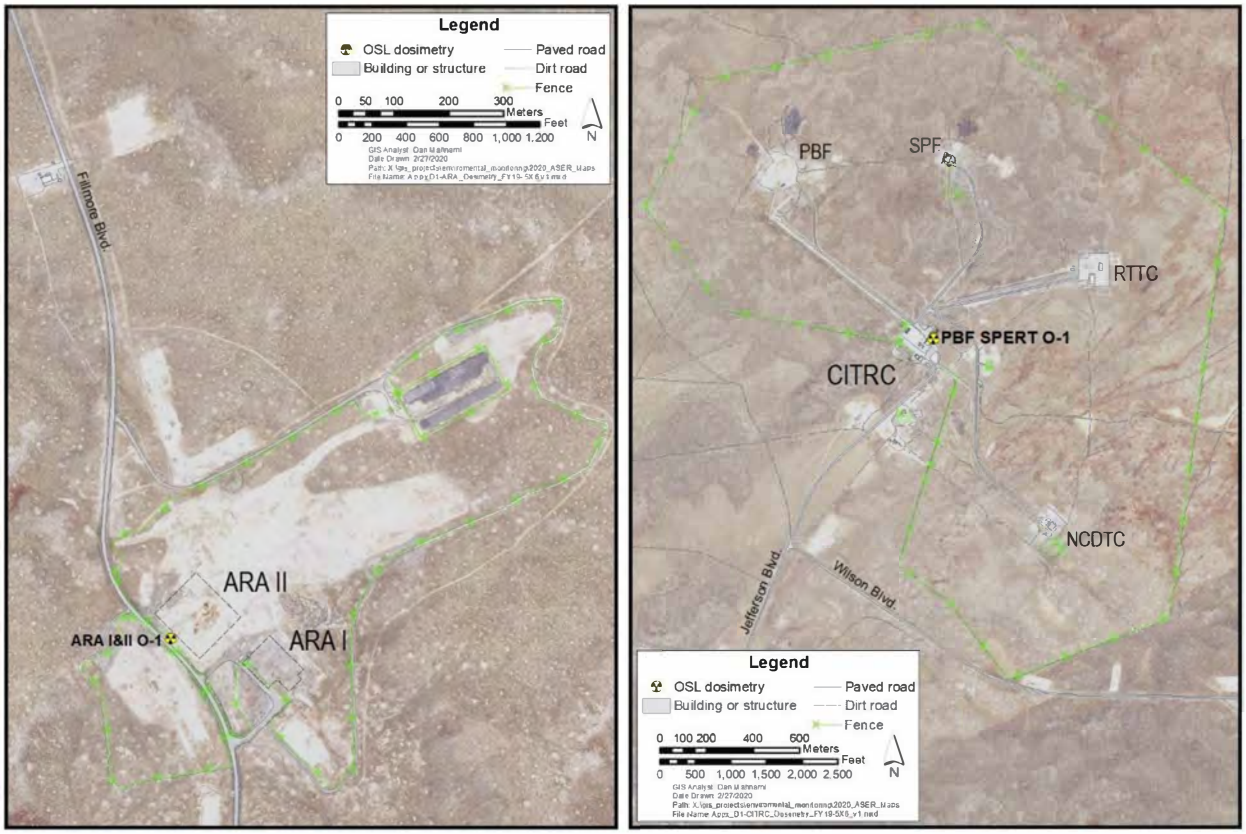


Figure C-1. Environmental Radiation Measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019– Oct. 2019	Location	Nov. 2018– April 2019	May 2019 – Oct. 2019
RHLLW[b] O-1	64	73	TRA O-14	64	71
RHLLW O-2	54	70	TRA O-15	62	76
RHLLW O-3	63	65	TRA O-16	60	76
RHLLW O-4	73	81	TRA O-17	74	86
RHLLW O-5	59	68	TRA O-18	62	77
RHLLW O-6	60	71	TRA O-19	74	97
TRA[c] O-1	67	73	TRA O-20	63	71
TRA O-6	64	74	TRA O-21	67	81
TRA O-7	69	74	TRA O-22	67	71
TRA O-8	68	87	TRA O-23	66	73
TRA O-9	64	77	TRA O-24	64	80
TRA O-10	71	91	TRA O-25	65	72
TRA O-11	73	93	TRA O-26	68	76
TRA O-12	58	72	TRA O-27	65	76
TRA O-13	66	81	TRA O-28	68	81

a. Millirem (mrem) in ambient dose equivalent.
b. Remote-Handled Low-Level Waste (RHLLW)
c. Test Reactor Area (TRA)

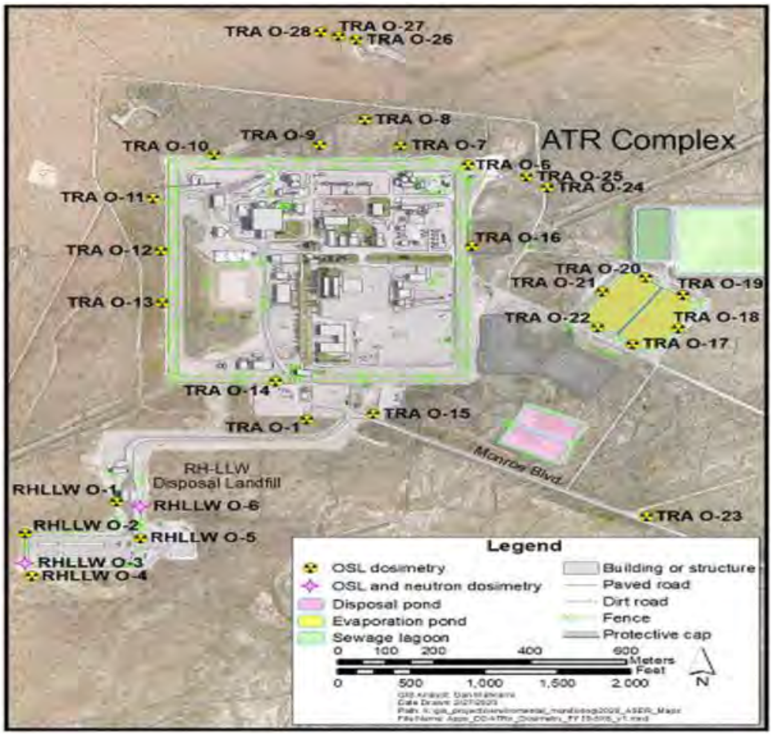


Figure C-2. Environmental Radiation Measurements at Advanced Test Reactor (ATR) Complex and Remote-handled Low-level Waste Disposal Facility (RHLLW) (2019).

	mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
CFA[b] O-1	60	74
LincolnBlvd[c] O-1	62	65

a. Millirem (mrem) in ambient dose equivalent.
b. Central Facilities Area (CFA)
c. Lincoln Boulevard (LincolnBlvd)

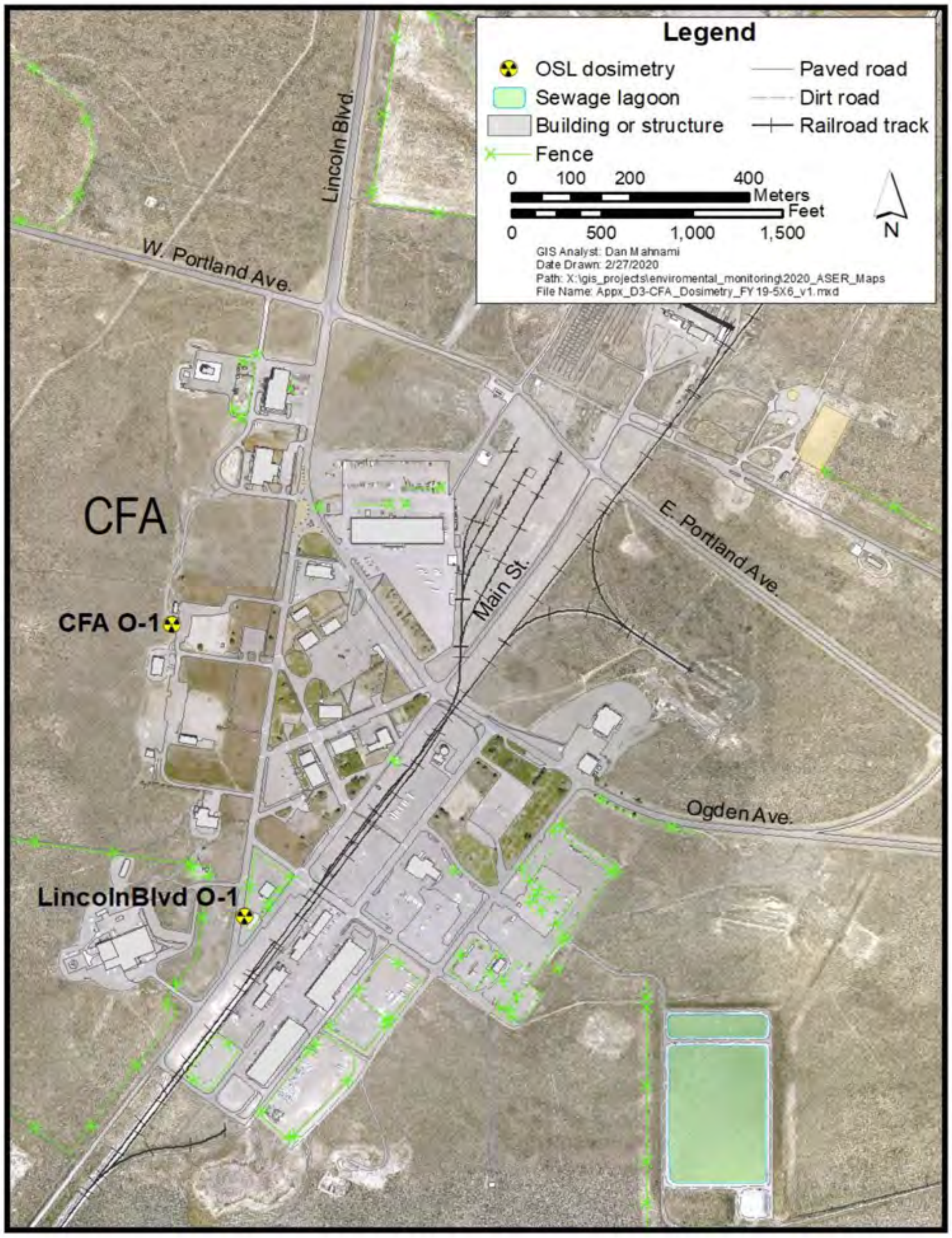


Figure C-3. Environmental Radiation Measurements at Central Facilities Area (CFA) and Lincoln Boulevard (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019	Location	Nov. 2018 – April 2019	May 2019– Oct. 2019
ICPP[b] O-9	77	89	ICPP O-26	63	79
ICPP O-14	107	113	ICPP O-27	185	220
ICPP O-15	129	181	ICPP O-28	191	230
ICPP O-17	63	78	ICPP O-30	165	216
ICPP O-19	88	100	TreeFarm O-1	107	136
ICPP O-20	216	283	TreeFarm O-2	76	102
ICPP O-21	77	99	TreeFarm O-3	81	102
ICPP O-22	85	101	TreeFarm O-4	113	139
ICPP O-25	84	108			

a. Millirem (mrem) in ambient dose equivalent.

b. Idaho Chemical Processing Plant (ICPP)

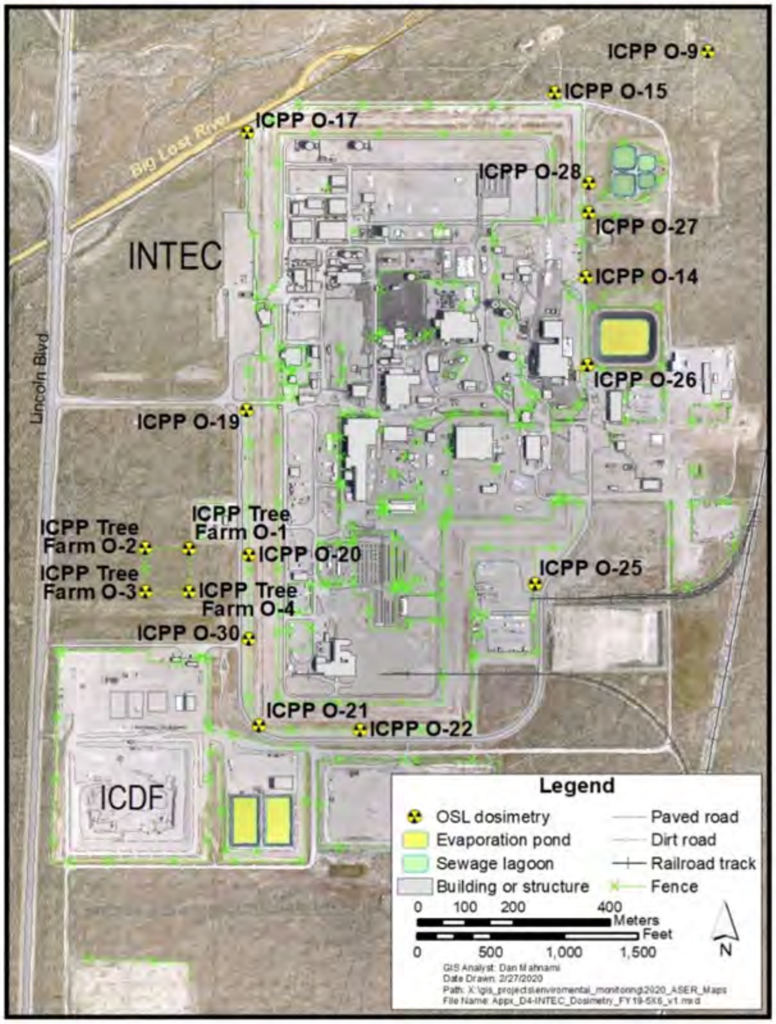


Figure C-4. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019– Oct. 2019	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
IF[b]-603N O-1	54	56	IF-670N O-31	50	58
IF-603E O-2	50	52	IF-670E O-32	51	54
IF-603S O-3	49	55	IF-670S O-33	55	57
IF-603W O-4	52	55	IF-670D O-34	54	60
IF-627 O-30	53	59	IF-670W O-35	63	64
IF-638N O-1	54	60	IF-689 O-7	54	55
IF-638E O-2	51	56	IF-689 O-8	55	54
IF-638S O-3	57	61	IF-IRC[c] O-39	51	65
IF-638W O-4	60	64			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF)
c. INL Research Center (IRC)

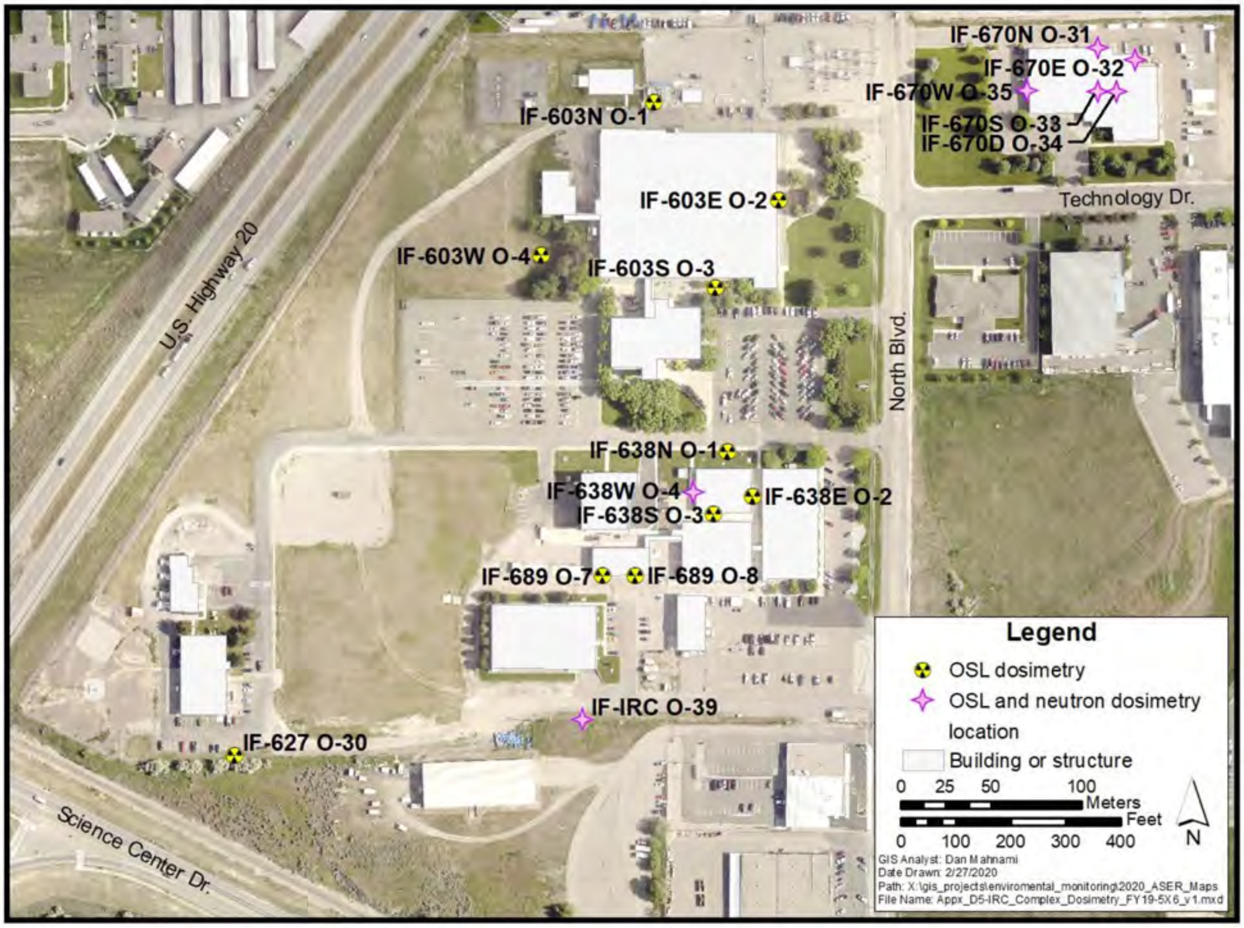


Figure C-5. Environmental Radiation Measurements at INL Research Center Complex (IRC) (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
ANL[b] O-7	64	65	ANL O-24	60	66
ANL O-8	62	64	ANL O-25	69	77
ANL O-12	51	55	ANL O-26	78	71
ANL O-14	53	66	TREAT[c] O-1	59	61
ANL O-15	66	68	TREAT O-2	57	65
ANL O-16	70	72	TREAT O-3	64	65
ANL O-18	58	64	TREAT O-4	61	66
ANL O-19	62	73	TREAT O-5	57	64
ANL O-20	66	70	TREAT O-6	59	66
ANL O-21	73	83	TREAT O-7	62	72
ANL O-22	68	76	TREAT O-8	53	75
ANL O-23	78	78			

a. Millirem (mrem) in ambient dose equivalent.
b. Argonne National Laboratory (ANL)
c. Transient Reactor Test (TREAT) Facility

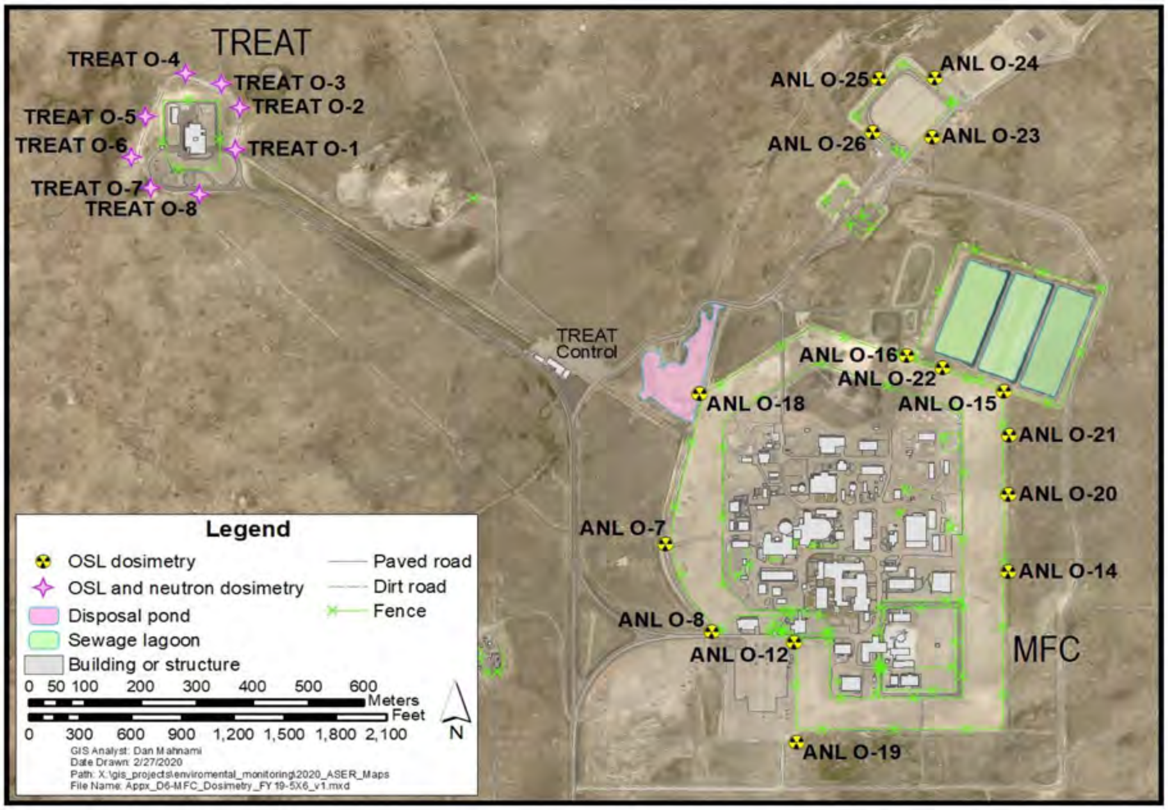


Figure C-6. Environmental Radiation Measurements at Materials and Fuels Complex (MFC) and Transient Reactor Test (TREAT) Facility (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 219	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
NRF[b] O-11	63	80	NRF O-21	60	74
NRF O-16	64	69	NRF O-22	60	70
NRF O-18	68	68	NRF O-23	65	65
NRF O-19	61	74	NRF O-24	59	62
NRF O-20	67	65			

a. Millirem (mrem) in ambient dose equivalent.
b. Naval Reactors Facility (NRF)

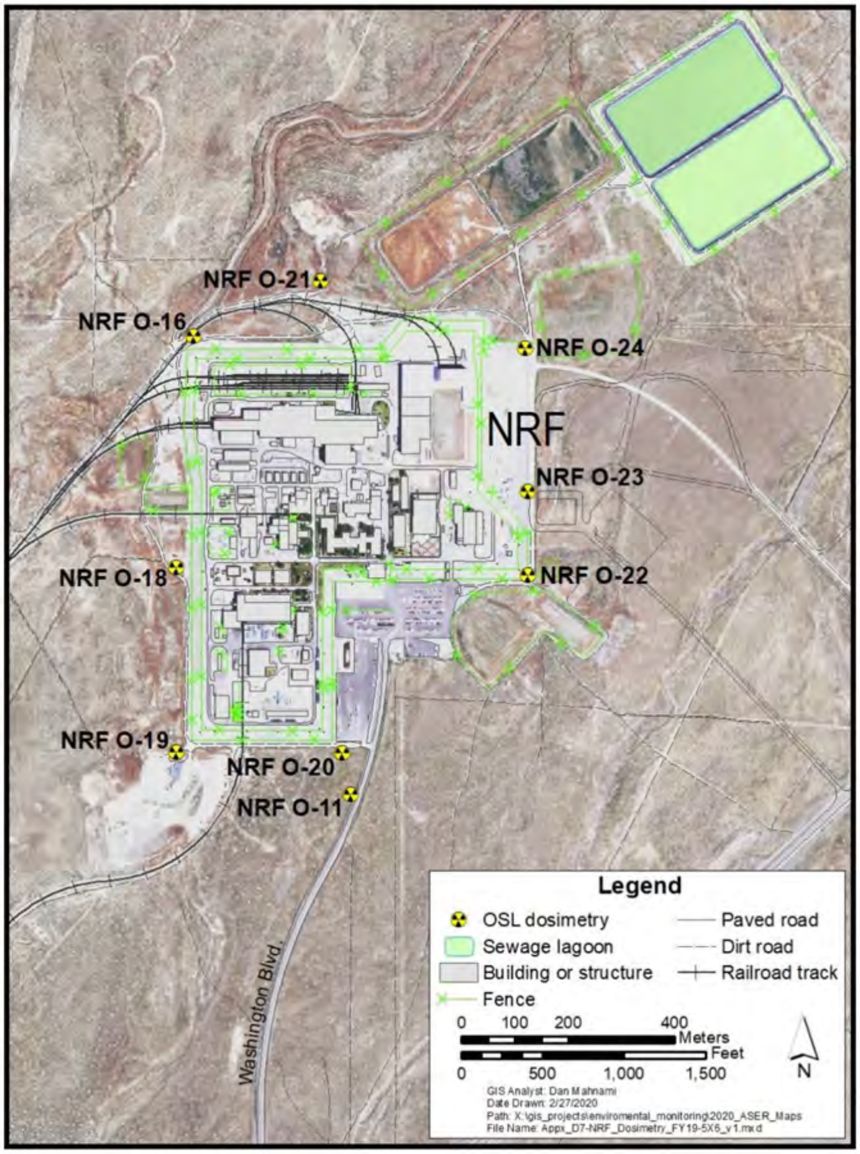


Figure C-7. Environmental Radiation Measurements at Naval Reactors Facility (NRF) (2019).

	mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
IF[b]-675E O-31	51	52
IF-675D O-33	49	57
IF-675S O-34	56	63
IF-675W O-35	55	58

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF)

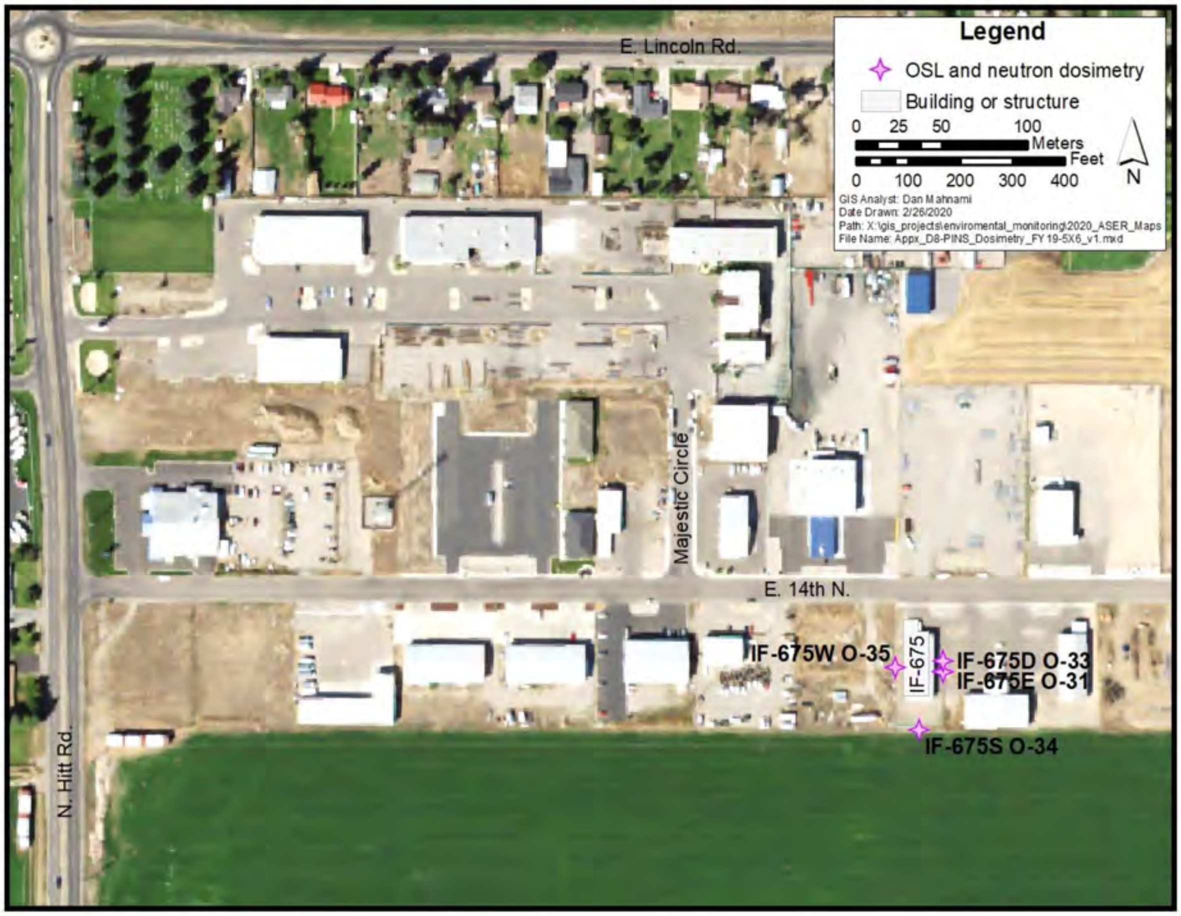


Figure C-8. Environmental Radiation Measurements at IF-675 Portable Isotopic Neutron Spectroscopy (PINS) Laboratory (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
RWMC[b] O-3A	57	69	RWMC O-25A	61	74
RWMC O-5A	57	69	RWMC O-27A	57	79
RWMC O-7A	56	72	RWMC O-29A	56	64
RWMC O-9A	66	86	RWMC O-39	64	78
RWMC O-11A	63	75	RWMC O-41	111	132
RWMC O-13A	86	81	RWMC O-43	63	70
RWMC O-19A	55	72	RWMC O-46	54	69
RWMC O-21A	58	81	RWMC O-47	57	74
RWMC O-23A	59	70			

a. Millirem (mrem) in ambient dose equivalent.

b. Radioactive Waste Management Complex (RWMC)

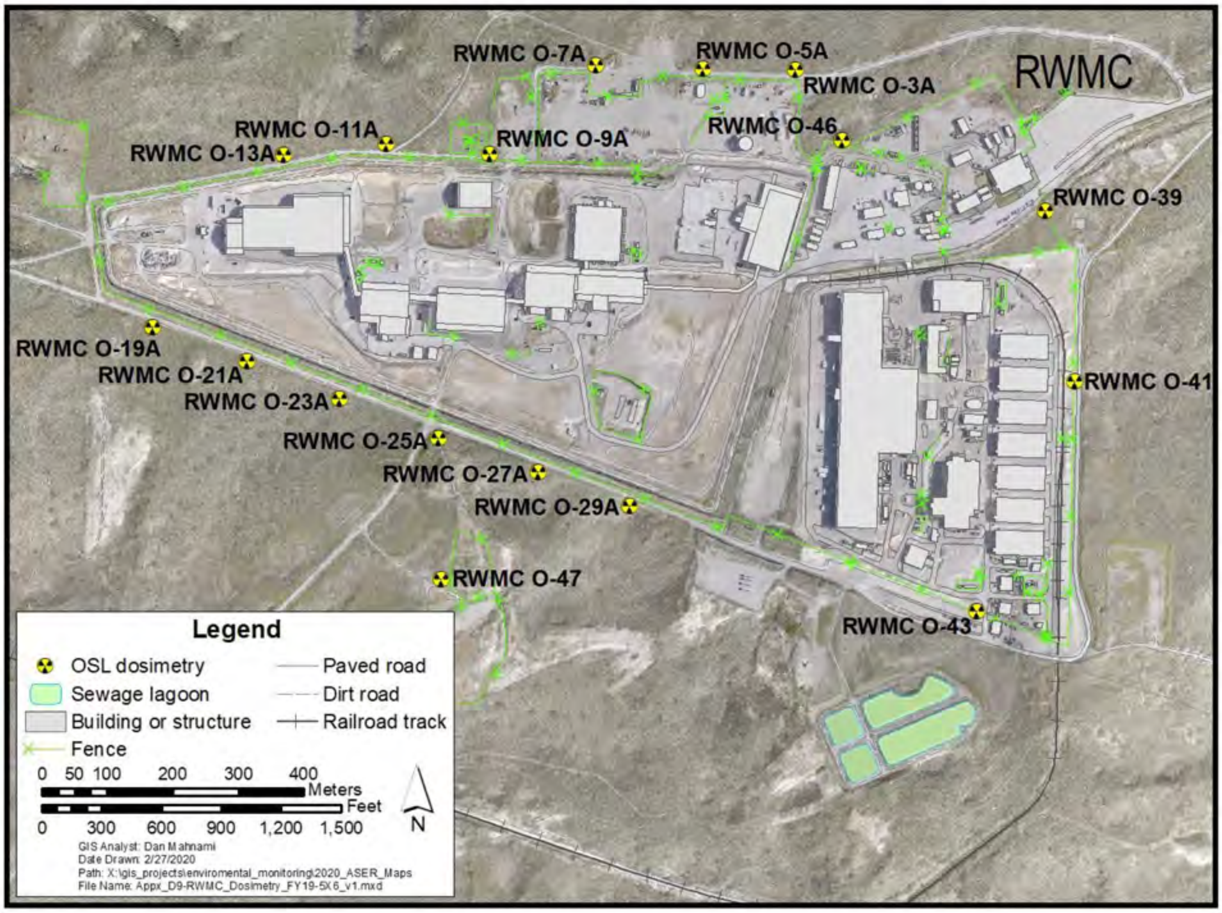


Figure C-9. Environmental Radiation Measurements at Radioactive Waste Management Complex (RWMC) (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
TAN LOFT[b] O-6	61	76	TAN LOFT O-10	64	77
TAN LOFT O-7	66	76	TAN LOFT O-11	61	75
TAN LOFT O-8	63	67	TAN LOFT O-12	57	62
TAN LOFT O-9	47	60	TAN LOFT O-13	60	72

a. Millirem (mrem) in ambient dose equivalent.

b. Test Area North, Loss-of-Fluid Test (TAN LOFT)

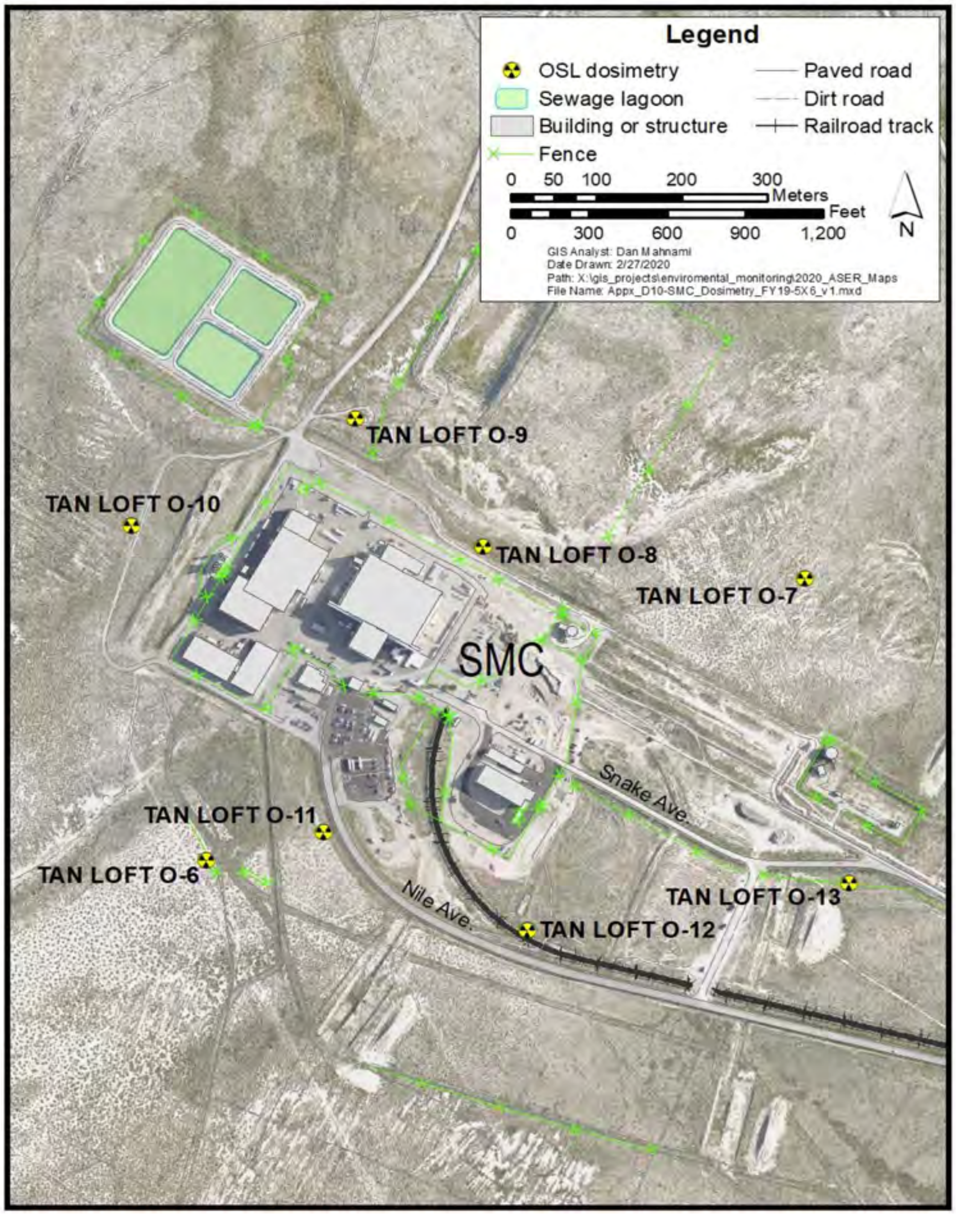


Figure C-10. Environmental Radiation Measurements at Specific Manufacturing Capability (SMC) (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019	Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
EFS[b] O-1	63	68	Hwy33 T17 O-3	50	59
Gate4 O-1	60	62	LincolnBlvd[d] O-3	66	86
Haul E O-1	60	71	LincolnBlvd O-5	67	73
Haul W O-2	56	67	LincolnBlvd O-9	63	76
Hwy[c]20 Mile O-266	54	64	LincolnBlvd O-15	65	77
Hwy20 Mile O-270	54	68	LincolnBlvd O-25	62	70
Hwy20 Mile O-276	61	63	Main Gate O-1	61	68
Hwy22 T28 O-1	57	59	Rest O-1	58	71
Hwy28 N2300 O-2	49	60	VANB[e] O-1	64	71

a. Millirem (mrem) in ambient dose equivalent.
b. Experimental Field Station (EFS)
c. Highway (Hwy)
d. Lincoln Boulevard (LincolnBlvd)
e. Van Buren (VANB)

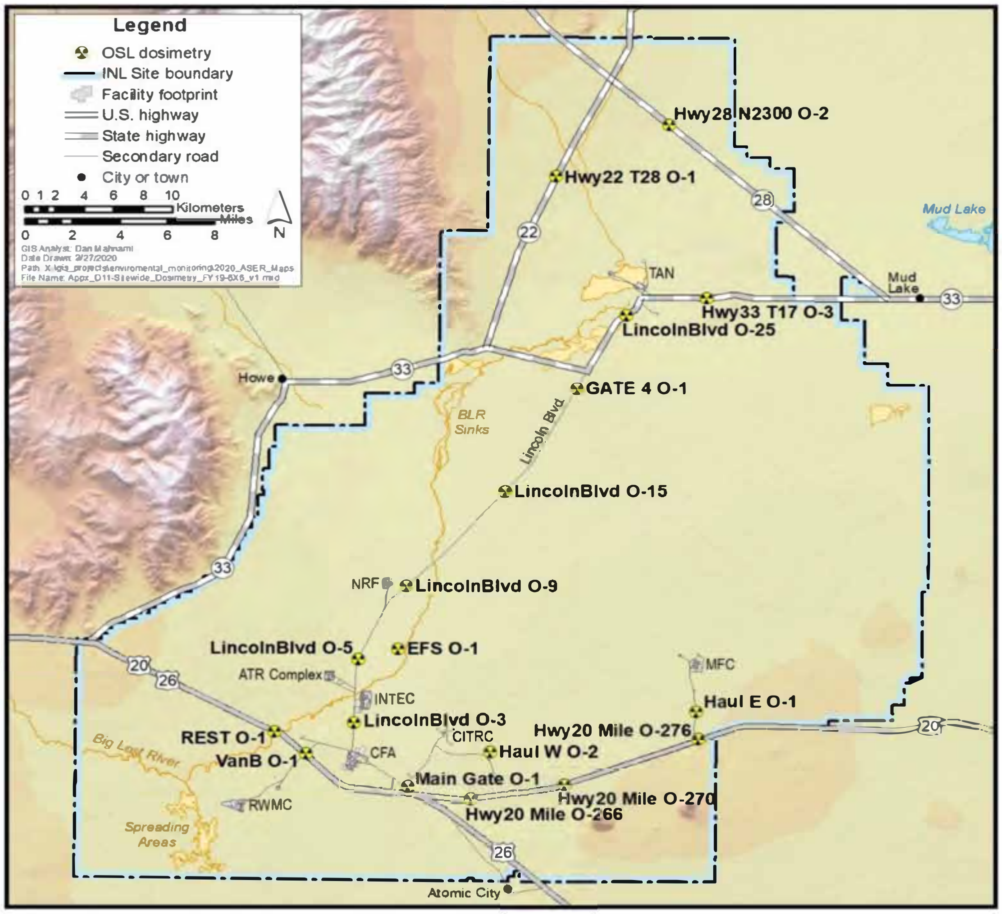


Figure C-11. Environmental Radiation Measurements at Sitewide Locations (2019).

	mrem[a]			mrem[a]	
Location	Nov. 2018–April 2019	May 2019 – Oct. 2019	Location	Nov. 2018–April 2019	May 2019 – Oct. 2019
Arco O-1	54	64	Mud Lake O-5	56	74
Atomic City O-2	55	67	Reno Ranch O-6	52	58
Blackfoot O-9	56	57	RobNOAA[c]	61	72
Craters O-7	49	67	[d]RRL3 O-1	55	63
Howe O-3	54	65	RRL5 0-1	68	lost
Idaho Falls O-10	56	58	RRL6 O-1	49	65
IF[b]-IDA O-38	51	55	RRL17 O-1	53	59
Monteview O-4	53	66	RRL24 O-1	53	58

a. Millirem (mrem) in ambient dose equivalent.

b. Idaho Falls (IF)

c. Roberts National Oceanic and Atmospheric Administration (Rob NOAA)

d. Resident Receptor Location (RRL)

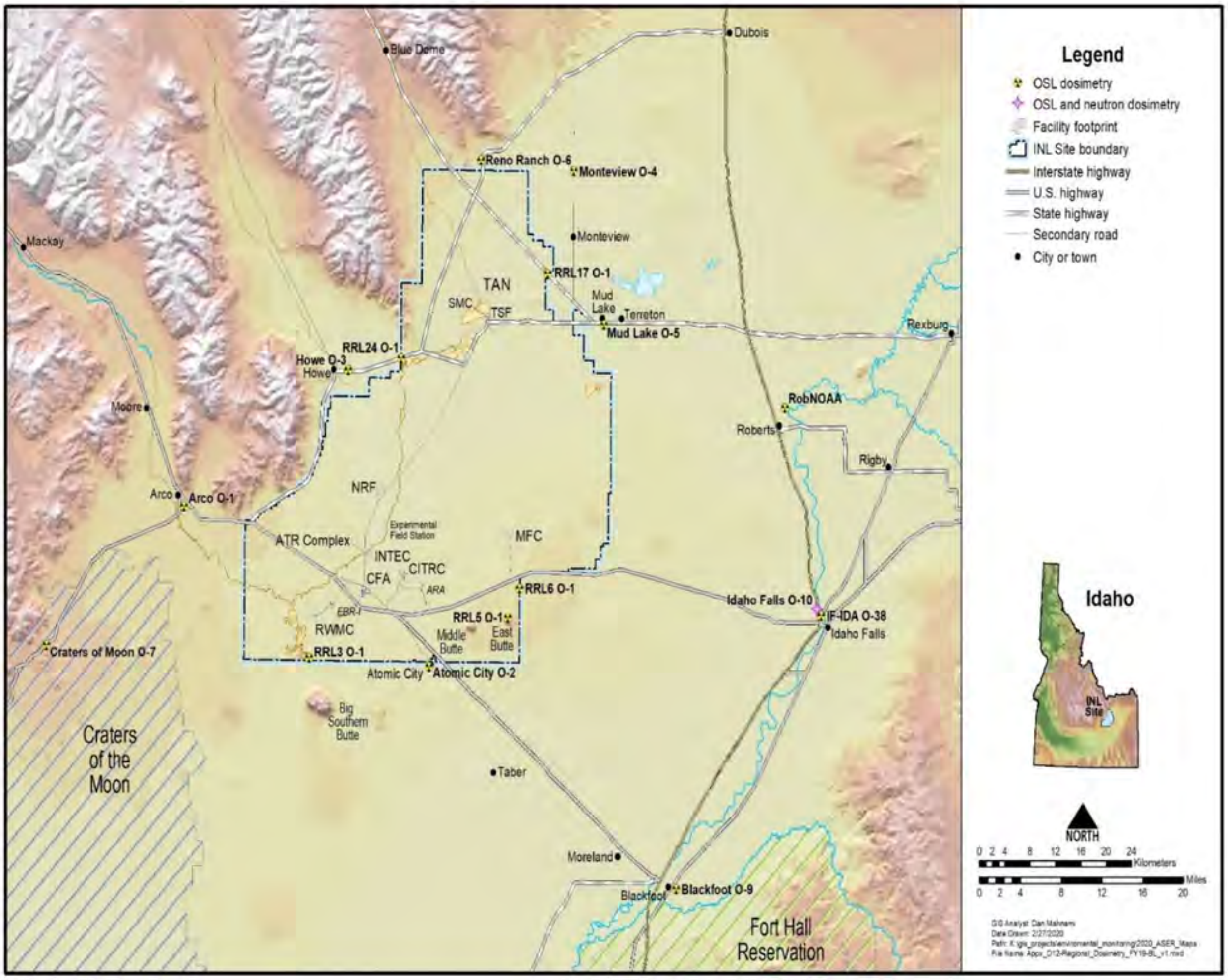


Figure C-12. Environmental Radiation Measurements at Regional Locations (2019).

Location	mrem[a]	
	Nov. 2018 – April 2019	May 2019 – Oct. 2019
IF[b]-616N O-36	57	51
IF-665W O-37	52	58

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF)

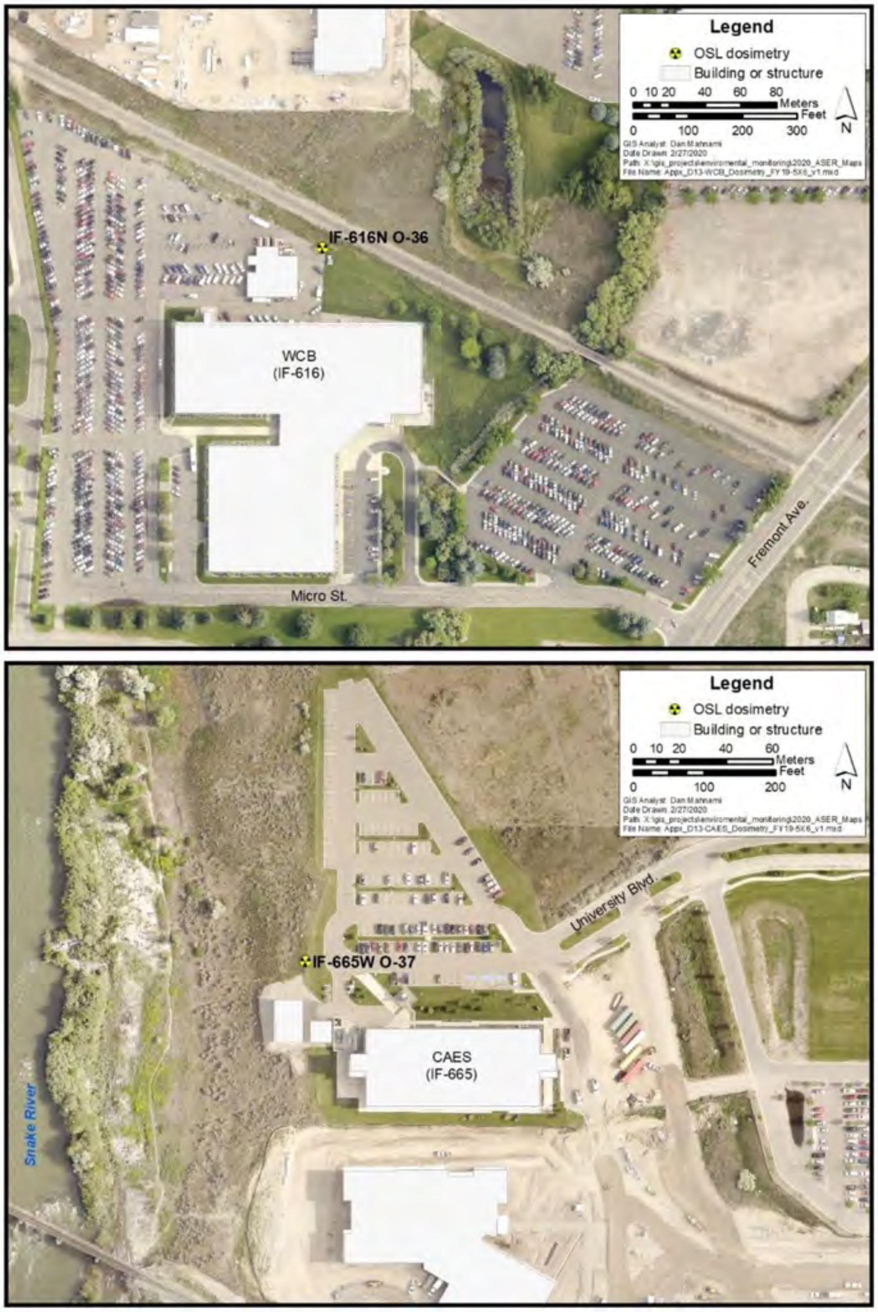


Figure C-13. Environmental Radiation Measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2019).

	mrem[a]	
Location	**Nov. 2018 – April 2019**	**May 2019 – Oct. 2019**
EBR1[b] O-1	57	66
EBR1 O-2	new	91
EBR1 O-3	N/A	new

a. Millirem (mrem) in ambient dose equivalent.

b. Experimental Breeder Reactor I (EBR1)

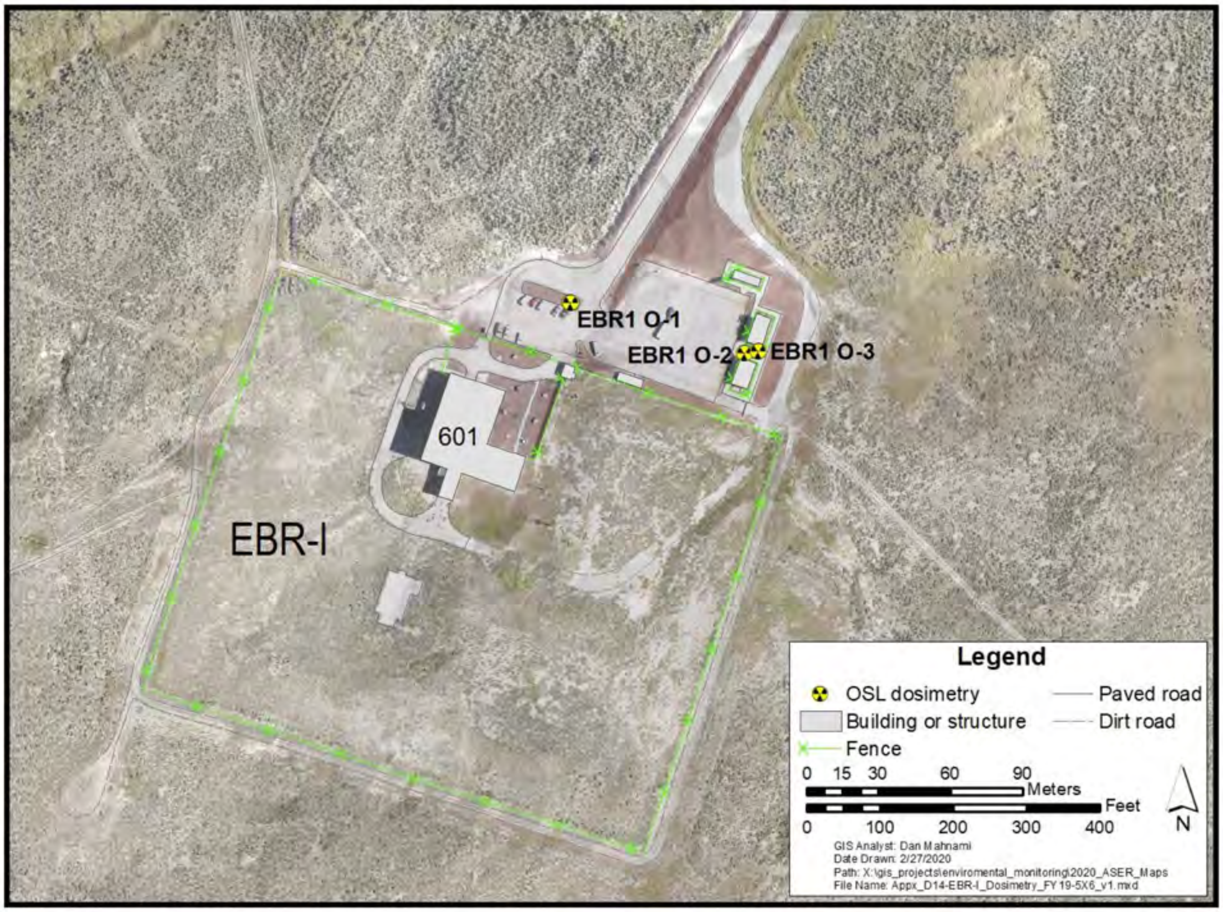


Figure C-14. Environmental Radiation Measurements at Experimental Breeder Reactor I (EBRI) (2019).

	mrem[a]	
Location	Nov. 2018 – April 2019	May 2019 – Oct. 2019
IF[b]-688B O-1	55	58
IF-688B O-2	48	53

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF)

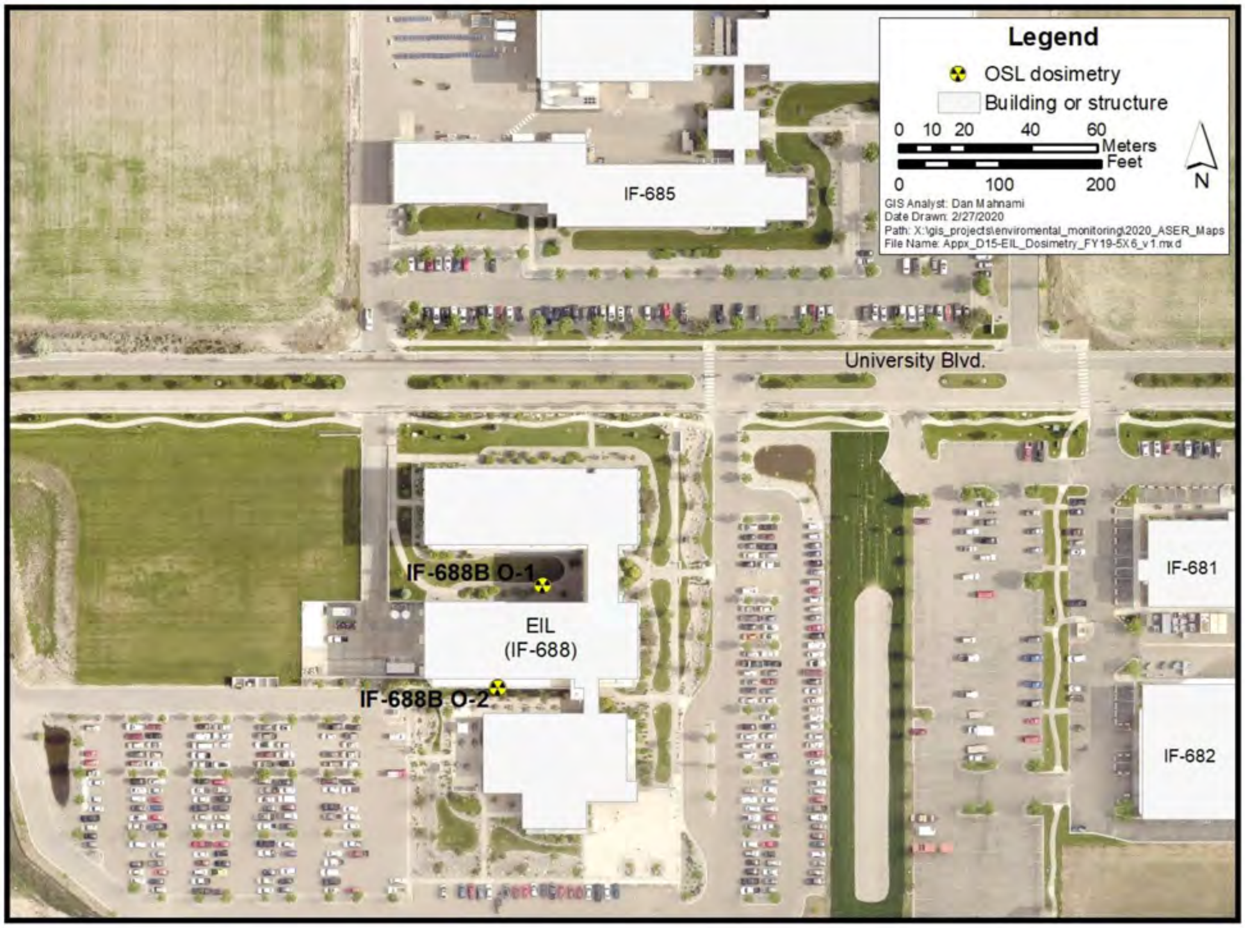


Figure C-15. Environmental Radiation Measurements at Energy Innovation Laboratory (EIL) (2019).

Appendix D. Glossary


Cushion Buckwheat (*Eriogonum ovalifolium*)

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 3.70×10^{10} disintegrations per second: it is approximately the amount of activity produced by 1 gram of radium-226. It is named for Marie and Pierre Curie who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. (See also **becquerel**).

D

data gap: A lack or inability to obtain information despite good faith efforts to gather desired information.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay products: Decay products are also called "daughter products." They are radionuclides that are formed by the radioactive decay of parent radionuclides. In the case of radium-226, for example, nine successive different radioactive decay products are formed in what is called a "decay chain." The chain ends with the formation of lead-206, which is a stable nuclide.

derived concentration standard (DCS): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose of 100 mrem (1 mSv). 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 aboveground nuclear weapons testing and deposited on the earth's surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage, and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning. Namely, any material that is fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission: The splitting of the nucleus of an atom (generally of a heavy element) into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the subsequent decay products of the radioactive fission fragments.

fissionable material: Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

flood plain: Lowlands that border a river and are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, and capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See **alpha radiation**.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See **beta radiation**.

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

hazardous air pollutant: See **hazardous substance**, **hazardous chemical.** Any hazardous chemical as defined under 29 CFR 1910.1200 (“Hazard Communication”) and 40 CFR 370.2 (“Definitions”).

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and it does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 (“Identification and Listing Hazardous Waste”) or that exhibits one or more of four characteristics (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 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. It does not include fallout radiation. Natural background radiation is comprised of several sources, the most important of which are:

- *Cosmic radiation:* Radiation from outer space (primarily the sun)
- *Terrestrial radiation:* Radiation from radioactive materials in the crust of the earth
- *Inhaled radionuclides:* Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Native American tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

optically stimulated luminescence dosimeter (OSLD): Used to measure direct penetrating gamma radiation through the absorption of energy from ionizing radiation by trapping electrons that are excited to a higher energy band. The trapped electrons in the OSLD are released by exposure to green light from a laser.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the

temperatures of the ambient air and of the plume, and the density of the contaminants.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: 1) Pollutant or contaminant as defined by Section 101(33) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States. 2) Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance (QA): Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control (QC): Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor: The factor by which the absorbed dose (rad or gray) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, quality factor, has now been replaced by "radiation weighting factor" in the latest system of recommendations for radiation protection.

R

rad: Short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area’s plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \text{ x } 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302 (“Designation, Reportable Quantities, and Notification”), the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory’s ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk: In many health fields, risk means the probability of incurring injury, disease, or death. Risk can be expressed as a value that ranges from zero (no injury or harm will occur) to one (harm or injury will definitely occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public, and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals; which are usually denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapidly growing plants for the purpose of holding bare soil in place.

standard: A sample containing a known quantity of various analytes. A standard may be prepared and certified by commercial vendors, but it must be traceable to the National Institute of Standards and Technology.

standard deviation: In statistics, the standard deviation (SD), also represented by the Greek letter sigma σ, is a measure of the dispersion of a set of data from its mean.

stochastic effect: An effect that occurs by chance and which may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effect is cancer.

storm water: Water produced by the interaction of precipitation events and the physical environment (buildings, pavement, ground surface).

surface radiation: See **direct radiation**. Surface radiation is monitored at the INL Site at or near waste management facilities and at the perimeter of Site facilities.

surface water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Monitoring of parameters to observe trends but which is not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total effective dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above listed quantities. See also hazardous chemical.

traceability: The ability to trace history, application, or location of a sample standard and like items or activities by means of recorded identification.

transient noncommmunity water system: A water system that is not a community water system, and serves 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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Veolia Nuclear Solutions-Federal Services
ESER Program
Idaho Falls, ID 83402
208.525.8250

U.S. Department of Energy
Idaho Operations Office

Idaho National Laboratory

Environmental Surveillance, Education and Research Program