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2022
IDAHO NATIONAL LABORATORY ANNUAL SITE ENVIRONMENTAL REPORT

Idaho National Laboratory

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SITE ENVIRONMENTAL REPORT
Idaho National Laboratory

October 2023

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Idaho National Laboratory INL

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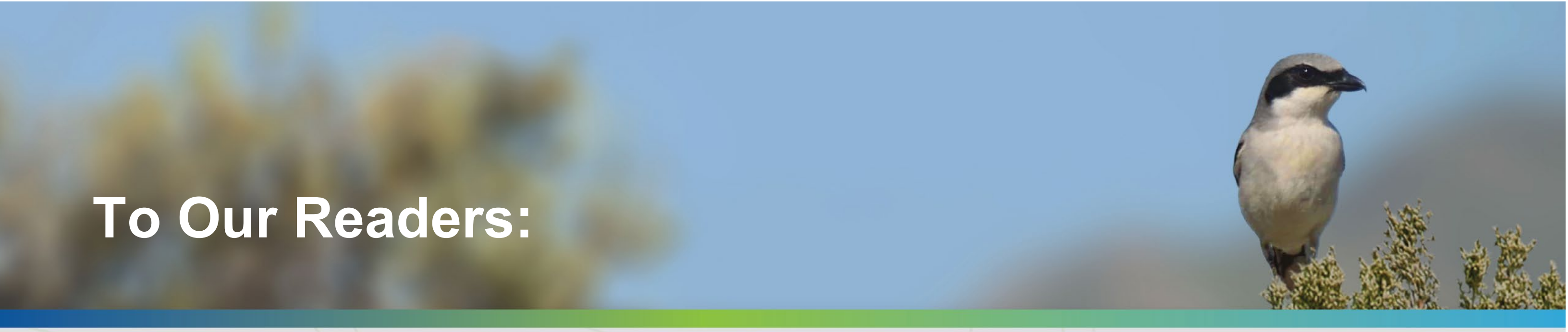
Horned lark



To Our Readers:

The Idaho National Laboratory (INL) Site Environmental Report for Calendar Year 2022 is an overview of environmental activities conducted on and in the vicinity of the INL Site from January 1 through December 31, 2022. This report includes the following components:

- 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 applicable standards and requirements 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 monitoring and other scientific research conducted onsite 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 a 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 Publications tab of the webpage at https://inl.gov/environmental-publications/.

The INL contractor is responsible for contributing to and producing the INL Annual Site Environmental Report. Environmental monitoring within the INL Site boundaries is primarily the responsibility of INL and Idaho Cleanup Project (ICP) contractors.

Major contributors to the annual INL Site Environmental Report include the INL contractor (BEA); ICP contractor (Idaho Environmental Coalition, LLC); U.S. Department of Energy–Idaho Operations Office; National Oceanic and Atmospheric Administration, Air Resources Laboratory, Special Operations and Research Division; and U.S. Geological Survey. Links to their websites are as follows:

- INL (https://www.inl.gov/)
- ICP (https://idaho-evnironmental.com)
- U.S. Department of Energy–Idaho Operations (https://www.id.energy.gov/)
- Special Operations and Research Division of National Oceanic and Atmospheric Administration's Air Resources Laboratory (https://www.noaa.inl.gov)
- U.S. Geological Survey (https://www.usgs.gov/centers/idaho-water-science-center).

Northwest indian paintbrush and bumblebee

Executive Summary:

Introduction

In operation since 1949, the 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% of the size of Rhode Island. It was established in 1949 as the National Reactor Testing Station, and for many years, it 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, INL is a science-based, applied engineering national laboratory dedicated to supporting DOE's nuclear and energy research, science, and national defense missions.

Figure ES-1. Regional location of the INL Site.

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

To mitigate environmental impacts and clear the way for the facilities required for the new nuclear energy research mission, the ICP has been charged with the environmental cleanup of the legacy wastes generated from World War II-era conventional weapons testing, government-owned reactors, and spent fuel reprocessing. The overarching aim of the project is to reduce risks to workers and production facilities, the public, and the environment and to protect the Snake River Plain Aquifer.

PURPOSE OF THE INL SITE ENVIRONMENTAL REPORT

The INL Site's operations, as well as the ongoing cleanup mission 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 U.S. Department of Energy, Idaho Operations Office (DOE-ID) in compliance with DOE O 231.1B, "Environment, Safety and Health Reporting." The purpose of the report is to provide the following:

- 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 (https://inl.gov/environmental-publications).

MAJOR INL SITE PROGRAMS AND FACILITIES

INL is a combination of all operating contractors and the U.S. Department of Energy, Idaho Operations Office (DOE-ID), and includes the Idaho Falls campus and the research and industrial complexes termed the "INL Site" that is located 50 miles west of Idaho Falls, Idaho. For the purpose of this report, INL consists of those facilities operated by Battelle Energy Alliance, LLC (INL contractor), or by the Idaho Environmental Coalition, LLC (Idaho Cleanup Project [ICP] contractor). INL and ICP contractors are referred to by their noted acronyms and include all facilities under their individual responsibilities.

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, Idaho, some 25 miles east of the INL Site border. About 30% of employees work in administrative, scientific support, and non-nuclear laboratory programs at offices in Idaho Falls, Idaho.

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 (NRF), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN), which includes the Specific Manufacturing Capability (SMC). The Research and Education Campus is located in Idaho Falls, Idaho. The locations of major facilities are shown in Figure ES-2, and their missions are outlined in Table ES-1.

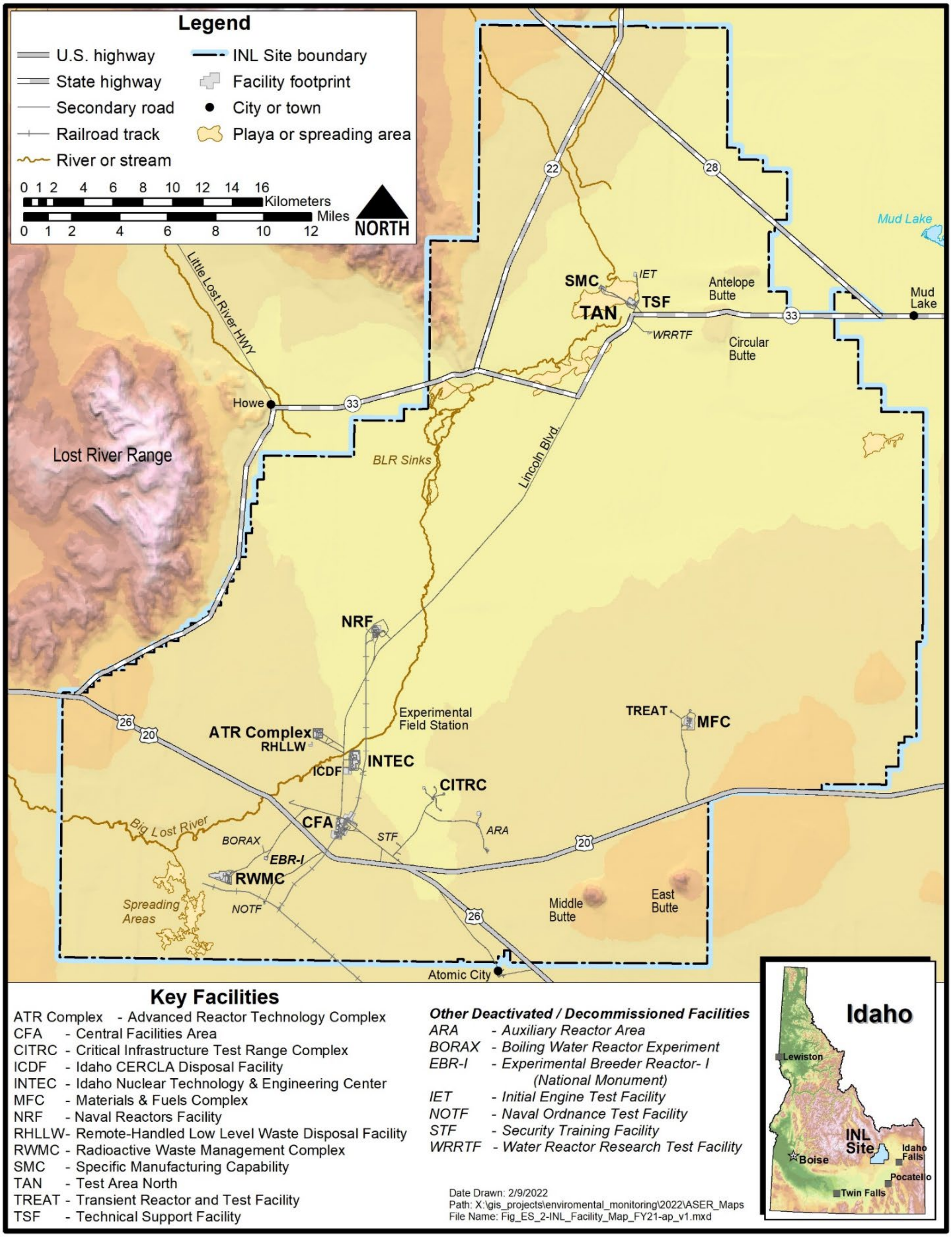


Figure ES-2. INL Site facilities.

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 the 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	Dry and wet storage of spent nuclear fuel; management of high-level waste calcine and sodium-bearing liquid waste; and operation of the Idaho Comprehensive Environmental Response, Compensation and Liability Act Disposal Facility, including a landfill, evaporation ponds, and a staging and treatment facility.
Materials and Fuels Complex	INL	Research and development of nuclear fuels. Pyro-processing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Nuclear batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex	ICP	Environmental remediation and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. The Advanced Mixed Waste Treatment Project characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities. 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 in underground storage tanks.
Research and Education Campus	INL	Located in Idaho Falls, Idaho, the Research and Education Campus 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 Reach 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 the manufacture of tank armor for the U.S. Army's battle tanks at the SMC for the U.S. Department of Defense.

a. NRF is also located onsite. It is operated for Naval Reactors by Fluor Marine Propulsion, LLC. The Naval Nuclear Propulsion Program is exempt from DOE requirements and is therefore not addressed in this report.

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, a radioactive waste management program, and programs addressing radiation protection of the public and the environment. The INL and ICP contractors have each established and implemented an EMS and have contributed 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 Site Sustainability Plan contains strategies and activities that will lead to continual greenhouse gas reductions as well as energy, water, and transportation fuels efficiency at the INL Site. Plan requirements are integrated into each INL Site contractor's Integrated Safety Management System and EMS.

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 the U.S. Environmental Protection Agency (EPA). The FFA/CO governs the INL Site's environmental remediation activities. It specifies actions that must be completed to safely clean up sites at INL 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 2022, all institutional controls and operational and maintenance requirements were maintained, and active remediation continued on WAGs 1, 3, and 7.

RADIATION DOSE TO THE PUBLIC AND BIOTA FROM INL SITE RELEASES

Humans, plants, and animals potentially receive radiation doses from various INL Site operations. 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 2022 from the air pathway was 0.018 mrem (0.18 µSv), which is 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 as 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 2022 to be 384 mrem (3,840 µSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 349,242 people residing within an 80 km (50 mi) radius of any INL Site facility was calculated as 0.019 person-rem (0.00019 person-Sv), below that expected from exposure to background radiation (134,109 person-rem or 1,341 person-Sv). The 50 mi population dose calculated for 2022 is lower than that calculated for 2021 (0.028 person-rem or 0.00028 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 0.0009 mrem (0.009 µSv). In 2022, none of the game samples collected (e.g., four elk and one pronghorn) had a detectable concentration of cesium-137 (^{137}Cs) or other human-made radionuclides. 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 0.019 mrem (0.19 µSv) in 2022. This is 0.019% of the DOE health-based dose limit of 100 mrem/yr (1 mSv/yr) from all pathways for the INL Site.

Table ES-2. Contribution to estimated annual dose from INL Site facilities by pathway (2022).

PATHWAY	ANNUAL DOSE TO MAXIMALLY EXPOSED INDIVIDUAL		PERCENT OF DOE 100 mrem/YR LIMIT[a]	ESTIMATED POPULATION DOSE		POPULATION WITHIN 80 km	ESTIMATED BACKGROUND RADIATION POPULATION DOSE (PERSON-rem)[b]
	(mrem)	(μSv)		(PERSON-mrem)	(PERSON-Sv)		
Air	0.018	0.18	0.018	0.019	0.00019	349,242	134,109
Waterfowl	0.0009	0.009	0.0009	NA[c]	NA	NA	NA
Big game animals	0.000	0.00	NA	NA	NA	NA	NA
Total pathways	**0.019**	**0.19**	**0.019**	**0.019**	**0.00019**	**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 384 mrem or 0.384 rem in 2022, as shown previously in 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.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located onsite along the southern boundary. A hypothetical individual ingesting the maximum concentration of tritium (3,970 pCi/L) via drinking water from these wells would receive a dose of approximately 0.2 mrem (0.002 mSv) in one year. This is an unrealistic pathway to humans because there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for tritium (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, Idaho, 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 2022, the dose was conservatively estimated to be 0.004 mrem (0.04 μSv), which is less than 0.1% 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 and DOE-ID programs compliance with federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders and DOE directives are presented in Table 2-1.

ENVIRONMENTAL MONITORING OF AIR

Airborne releases of radionuclides from INL Site operations are reported annually in a document 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.” An estimated total of 357 curies (1.32×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2022. This was a significant decrease in emissions compared to the previous year and was primarily due to the shutdown of the ATR reactor. 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 INL and ICP contractors emphasize the measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2022, the INL contractor monitored ambient air at 34 locations (18 onsite, 8 boundary, and 8 offsite). The ICP contractor focused on ambient air monitoring of waste management facilities, namely INTEC and RWMC.

Air particulate samples were collected weekly by the INL contractor and biweekly by the ICP contractor. These samples were initially analyzed for gross alpha and gross beta activity. The particulate samples were then combined into monthly (ICP contractor) or quarterly (INL contractor) composite samples and were analyzed for gamma-emitting radionuclides such as ^{137}Cs. Particulate filters were also composited quarterly by INL and ICP contractors. INL contractor analyzed for specific alpha- and beta-emitting radionuclides, specifically strontium-90 (^{90}Sr), plutonium-238, plutonium-239/240, americium-241, uranium-233/234, and uranium-238. Charcoal cartridges were also collected weekly by the INL contractor 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 onsite, boundary, and offsite locations. Trends in the data appear to be seasonal in nature and do not demonstrate any INL Site influence. This indicates that INL Site airborne effluents were not measurable in environmental air samples.

The INL contractor collected atmospheric moisture samples at three stations onsite, three stations offsite, and two boundary stations in 2022. Precipitation was collected at one location onsite, two boundary locations, and one offsite location. The samples were all analyzed for tritium. The results were within measurements made historically and below DOE Derived Concentration Standards. Tritium measured in these samples is most likely the result of natural production in the atmosphere and not the result of INL Site effluent releases.

ENVIRONMENTAL MONITORING OF GROUNDWATER, DRINKING, AND SURFACE WATER

The INL and ICP contractors monitor liquid effluents (wastewater), drinking water, groundwater, and storm water runoff at the INL Site, primarily for nonradioactive constituents, for compliance 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 effluent discharges occur at percolation ponds southwest of INTEC, a cold waste pond at the ATR Complex, and an industrial waste pond at MFC. DOE-ID complies with the state of Idaho groundwater quality, wastewater, and reuse rules for these effluents through reuse permits, which provide for monitoring of the wastewater and, in some instances, groundwater in the area. During 2022, liquid effluent and groundwater monitoring were conducted in support of reuse permit requirements. An annual site performance report for each permitted reuse 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 Cold Waste Pond, INTEC, and MFC Industrial Waste Pond 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 the authority of the Safe Drinking Water Act. The INL and ICP contractors monitored 11 drinking water systems at the INL Site in 2022. (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.

Surface water flows off the Subsurface Disposal Area (SDA) following periods of heavy precipitation or rapid snowmelt. During these times, water may be pumped out of the SDA retention basin into a drainage canal, potentially carrying radionuclides originating from radioactive waste or contaminated surface soil off the SDA. Surface water is collected when it is available. Americium-241, plutonium-239/240, and ^{90}Sr were detected in 2022 samples collected from the SDA Lift Station. 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 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 monitoring 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 use an extensive network of strategically placed monitoring wells on and around the INL Site. In 2022, 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. 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 (VOCs) are present in water from the eastern Snake River Plain Aquifer because of historical waste disposal practices at the INL Site. Several purgeable VOCs were detected by USGS in 26 groundwater monitoring wells and one perched well sampled at the INL Site in 2022. Most concentrations of the 61 analyzed compounds 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 that 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 RWMC, have had an increasing trend since 1987; however, concentrations have decreased through time at USGS-88. Trichloroethelene was detected above the maximum contaminant level (MCL) in one well sampled by the USGS at TAN, which was expected as there is a known groundwater plume at this location as well as one perched well.

Groundwater surveillance monitoring continued for the Comprehensive Environmental Response, Compensation, and Liability Act WAGs onsite in 2022. At TAN (WAG 1), groundwater monitoring continues to monitor the progress of remediation of the plume of trichloroethylene and to monitor ^{90}Sr and ^{137}Cs. 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.

Groundwater samples were collected from six aquifer wells in the vicinity of ATR Complex (WAG 2) during 2022 and were analyzed for ^{90}Sr, cobalt-60 (^{60}Co), tritium, and chromium. Chromium and tritium were the only analytes detected; however, neither of the concentrations were above their respective drinking water MCL established by the EPA.

Groundwater samples were collected from 13 aquifer monitoring wells at and near INTEC (WAG 3) during 2022 and analyzed for a suite of radionuclides and inorganic constituents. Strontium-90, technetium-99, and nitrate exceeded their respective drinking water MCLs in one or more aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin in a well south (downgradient) of the former INTEC injection well. All other well locations showed ^{90}Sr levels similar to or slightly lower than those reported in previous samples.

Monitoring 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 2022 for metals (filtered), VOCs, and anions (e.g., nitrate, chloride, fluoride, sulfate). No CFA landfill monitoring samples exceeded a MCL or secondary maximum contaminant level (SMCL). Nitrate continued to exceed the EPA MCL in one well in the plume south of the CFA in 2022; however, the data shows a downward trend since 2006.

Groundwater samples were collected from monitoring wells near and downgradient of the RWMC (WAG 7) in May 2022, which were analyzed for radionuclides, inorganic constituents, and VOCs. Carbon tetrachloride was detected slightly above the MCL (5 ug/L) in one regular sample and its field duplicate from Well M15S. Carbon tetrachloride concentrations in all other well locations were below the MCL and consistent with historical detections in May 2022.

Wells at MFC (as part of WAG 9, and the MFC Industrial Waste Pond Reuse Permit) were sampled for radionuclides, metals, and other water quality parameters in the spring and fall of 2022. Overall, the results were not above the primary constituent standard/secondary constituent standard and show no evidence of impacts from MFC activities.

Wells along the southern INL Site boundary (as part of WAG 10) are sampled every two years. Groundwater samples were not collected in 2022. WAG 10 monitoring wells will be sampled in 2023.

Groundwater is monitored at the Remote-Handled Low-Level Waste Facility for gross alpha, gross beta, carbon-14 (^{14}C), iodine-129, technetium-99, and tritium. Samples were collected from three monitoring wells in the spring and fall of 2022. The results were not above the primary constituent standard/secondary constituent standard and show no discernable impacts to the aquifer from Remote-Handled Low-Level Waste Facility operations.

Drinking water and surface water samples were sampled downgradient of the INL Site and analyzed for gross alpha and beta activity and tritium. Tritium was not detected in any of these surface or drinking water samples. Gross alpha and beta results were within historical measurements and below the EPA's screening level. The data appear to show no discernible impacts from activities at the INL Site.

MONITORING OF AGRICULTURAL PRODUCTS, WILDLIFE, SOIL, AND DIRECT RADIATION MEASUREMENTS

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (e.g., milk, lettuce, alfalfa, grain, potatoes) and wildlife were sampled and analyzed for radionuclides in 2022. The agricultural products were collected onsite, offsite, and at INL boundary locations by the INL contractor.

Some human-made radionuclides were detected in agricultural products; however, measurements were consistent with those made historically.

No human-made radionuclides were detected in big game animal samples collected in 2022. Cobalt-60 and ^{90}Sr were detected in tissues of waterfowl collected near the ATR Complex ponds, indicating that they accessed the contaminated ponds. Zinc-65 was detected in one waterfowl collected near TAN.

Cobalt-60, ^{90}Sr, and ^{137}Cs 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 onsite, offsite, and boundary locations were consistent with historical and natural background levels.

NATURAL AND CULTURAL RESOURCES CONSERVATION AND MONITORING

Natural resources conservation, monitoring, and land stewardship activities onsite are organized in four categories: (1) frequently evaluating the regulatory rankings, distribution, and populations for special status species; (2) planning and implementing conservation efforts for high priority natural resources; (3) ongoing monitoring and research to provide baseline and trend data for specific taxa and broader ecological communities; and (4) conducting land stewardship activities to minimize impacts to natural resources and restore ecological condition, where appropriate.

The INL Site provides breeding and foraging habitat for a variety of animal species, including 24 species of birds and 12 species of mammals that are of elevated conservation concern by state or federal agencies. There are also currently 20 special status plant species that have been documented to occur onsite. Many of those species are rare and occur very infrequently within their optimal habitats. While several animals and plants listed as threatened or endangered under the Endangered Species Act are present in Idaho, none are known to occur onsite.

For some species of elevated concern or with extensive populations and key habitats onsite, DOE-ID has developed conservation plans to protect species and the valuable ecosystems they inhabit. Conservation plans that are specific to or include the INL Site are the Candidate Conservation Agreement for Greater sage-grouse (*Centrocercus urophasianus*), the INL Site Bat Protection Plan, the Sagebrush Steppe Ecosystem Reserve, the Migratory Bird Conservation Plan and Avian Protection Planning documents, and the DOE Conservation Action Plan. Many of these plans include conservation measures, best management practices, monitoring programs, and annual reports to facilitate, evaluate, and communicate results of conservation efforts for species with high conservation priority.

Additional ecological monitoring has been conducted for more than 70 years onsite, with some studies dating back to the 1950s. The focus of this work is to better understand the INL Site's ecosystem and biota and to determine the impact on populations of these species from activities conducted at the INL Site. Natural resource monitoring activities include breeding bird surveys, midwinter raptor survey, long-term vegetation transects, and vegetation mapping. Furthermore, the INL Site was designated as a National Environmental Research Park in 1975 and serves as an outdoor laboratory for environmental scientists to study Idaho's native plants and wildlife in an intact and relatively undisturbed ecosystem. Ongoing National Environmental Research Park activities range from characterizing sagebrush steppe ecohydrology to identifying high quality foodscape for sage-grouse.

Land stewardship involves managing ecosystems onsite through planning, assessment, restoration, and rehabilitation activities. Areas where DOE-ID is actively employing land stewardship activities include wildland fire protection planning, management, and recovery; restoration and revegetation; weed management; and ecological support for the National Environmental Policy Act.

The INL Cultural Resource Management Office coordinates cultural resource-related activities at the INL Site and implements the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Cultural resource identification and evaluation studies in fiscal year 2022 included (1) archaeological field surveys, (2) cultural resource monitoring and site record updates related to INL Site project activities and research, and (3) comprehensive evaluations of pre-1980 built environment resources. Additionally, the Cultural Resource Management Office supports the DOE-ID with their government-to-government consultation and meaningful collaboration with members of the Shoshone-Bannock Tribes to include the Fort Hall Business Council, the Language and Cultural Committee, and the Heritage Tribal Office (known as the HeTO), as well as other public stakeholders.

USGS RESEARCH

The USGS INL Project Office drills and maintains research wells that 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 2022, the USGS published two research reports and one software release.

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 2022. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To ensure quality results, these laboratories participated in several laboratory quality check programs. Quality issues that arose with laboratories used by INL and ICP contractors and USGS during 2022 were addressed with the laboratories and have been or are being resolved.

Western skink

Helpful Information:

What is Radiation?

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.

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 throughout 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, as observed in Figure HI-1. Alpha particles can be stopped by thin layers of materials, such as a sheet of paper or a 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, as can be seen in 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 with 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 in their origin. Gamma-rays originate from an atomic nucleus, and X-rays originate from interactions with the electrons orbiting around atoms. All photons travel at the speed of light. Their energies, however, vary over a large range. The penetration of X-ray or gamma-ray photons depend 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, as shown in 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.

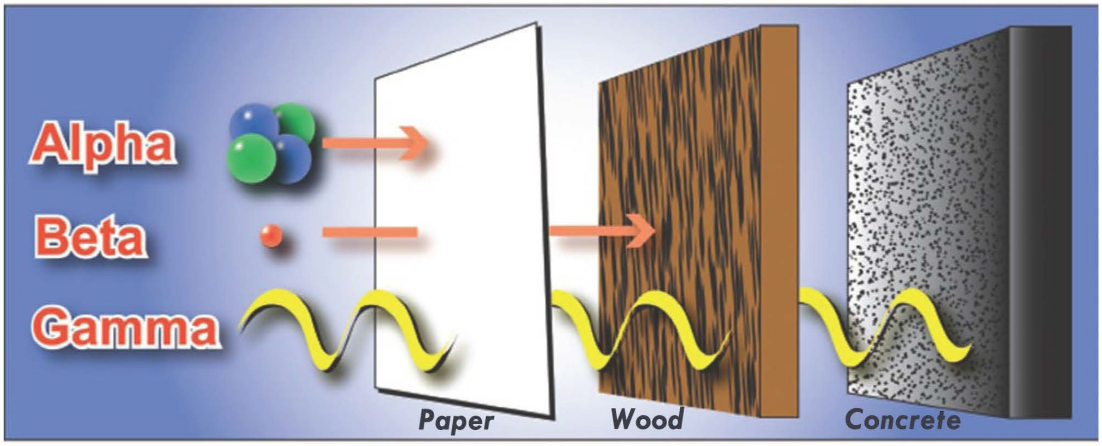


Figure HI-1. Comparison of penetrating ability of alpha, beta, and gamma radiation.

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. This table also shows the half-life of each radionuclide. Half-life refers to the time in which one-half of the atoms of a radioactive sample transforms or decays in the quest to achieve a more energetically stable nucleus. Most radionuclides do not decay directly to a stable element, but rather they 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-emitting 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-emitting 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 ^{90}Sr, requires chemical separation first.

Table HI-1. Radionuclides and their half-lives.

SYMBOL	RADIONUCLIDE	HALF-LIFE[a,b]	SYMBOL	RADIONUCLIDE	HALF-LIFE[a,b]
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.12 d
^{243}Am	Americium-243	7,370 yr	^{59}Ni	Nickel-59	1.01×10^5 yr
^{125}Sb	Antimony-125	2.75856 yr	^{63}Ni	Nickel-63	100.1 yr
^{41}Ar	Argon-41	109.61 min	^{238}Pu	Plutonium-238	87.7 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.411×10^4 yr
^{140}Ba	Barium-140	12.752 d	^{240}Pu	Plutonium-240	6,564 yr
^{7}Be	Beryllium-7	53.22 d	^{241}Pu	Plutonium-241	14.35 yr
^{14}C	Carbon-14	5,700 yr	^{242}Pu	Plutonium-242	3.75×10^5 yr
^{141}Ce	Cerium-141	32.508 d	^{40}K	Potassium-40	1.251×10^9 yr
^{144}Ce	Cerium-144	284.91 d	^{226}Ra	Radium-226	1,600 yr
^{134}Cs	Cesium-134	2.0648 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.1671 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.7025 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.2713 yr	^{103}Ru	Ruthenium-103	39.26 d
^{152}Eu	Europium-152	13.537 yr	^{106}Ru	Ruthenium-106	373.59 d
^{154}Eu	Europium-154	8.593 yr	^{90}Sr	Strontium-90	28.79 yr
^{3}H	Tritium	12.32 yr	^{99}Tc	Technetium-99	2.111×10^5 yr
^{129}I	Iodine-129	1.57×10^7 yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.0207 d	^{233}U	Uranium-233	1.592×10^5 yr
^{55}Fe	Iron-55	2.737 yr	^{234}U	Uranium-234	2.455×10^5 yr
^{59}Fe	Iron-59	44.495 d	^{235}U	Uranium-235	7.04×10^8 yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468×10^9 yr
^{87}Kr	Krypton-87	76.3 min	^{90}Y	Yttrium-90	64.1 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	244.06 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	64.032 d

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

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 ^{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 the 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 (in this case, six). 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.

Table HI-2. Multiples of units.

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

Units of Radioactivity. The basic unit of radioactivity used in this report is the curie (abbreviated Ci), which is based on the disintegration rate occurring in 1 gram of the radionuclide radium-226 (^{226}Ra) that 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 the air, is measured in terms of the roentgen ®. Dose is a general term to express how much radiation energy is deposited into something. The energy deposited can be expressed in terms of absorbed, equivalent, and 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 considers the effect of different types of radiation on tissues and is therefore the potential for biological effects, is expressed as the R equivalent man or rem. Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of effective dose was developed.

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 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 3.7×10^{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 that 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 99% 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, then the 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 or instrumentation used.

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

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 dataset. 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 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 showing 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.

A ***pie chart*** is used in this report to illustrate fractions of a whole. For example, Figure HI-3 shows the approximate contribution to dose that a typical person might receive while living in southeast Idaho. The percentages are derived from the table in the lower left-hand corner of the figure. The medical, consumer, and occupational/industrial portions are from the National Council on Radiation Protection and Measurements Report No. 160 (NCRP 2009). The contribution from background (e.g., natural radiation, mostly radon) is estimated in Table 7-7 of this report.

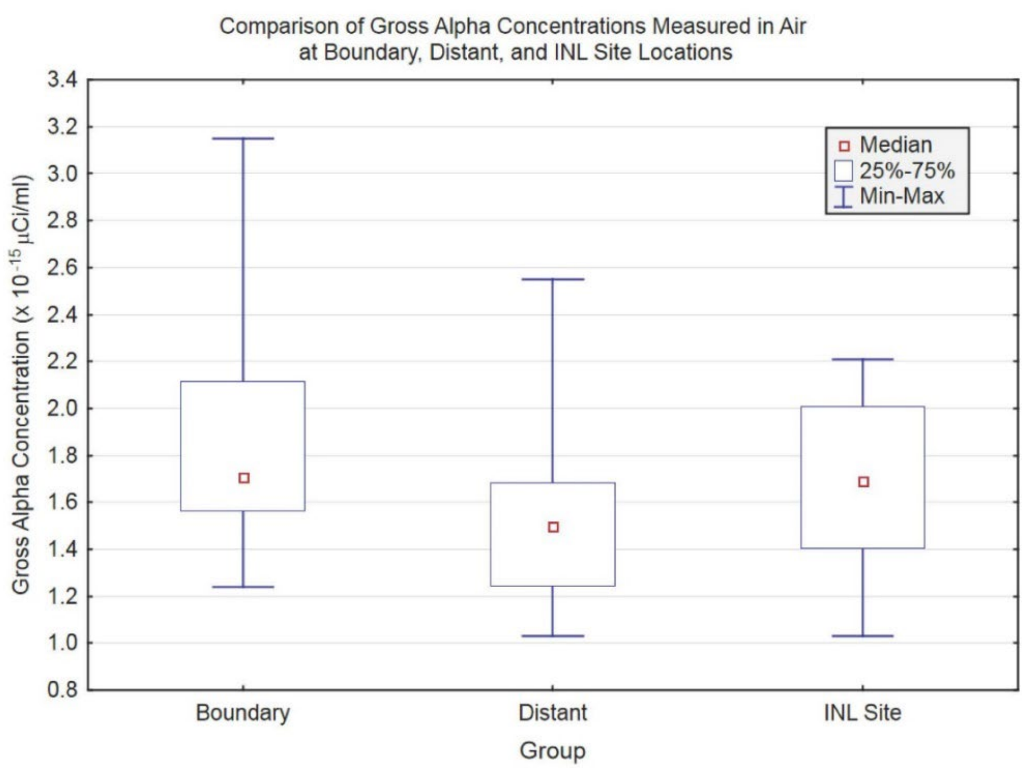


Figure HI-2. A graphical representation of minimum, median, and maximum results with a box plot. *The 25th and 75th percentiles are the values such that 75% of the measurements in the dataset are greater than the 25th percentile, and 75% of the measurements are less than the 75th percentile.*

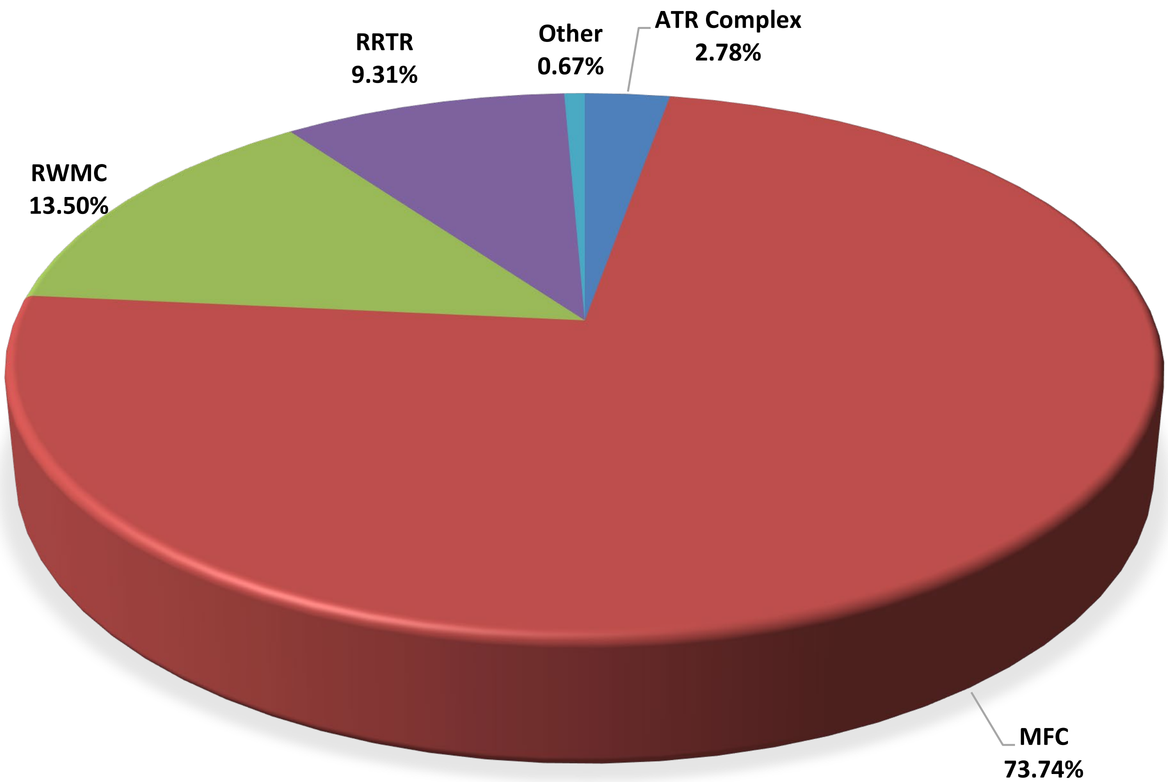


Figure HI-3. Data presented using a pie chart.

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 2013 through 2022. 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 trend of the dose over time.

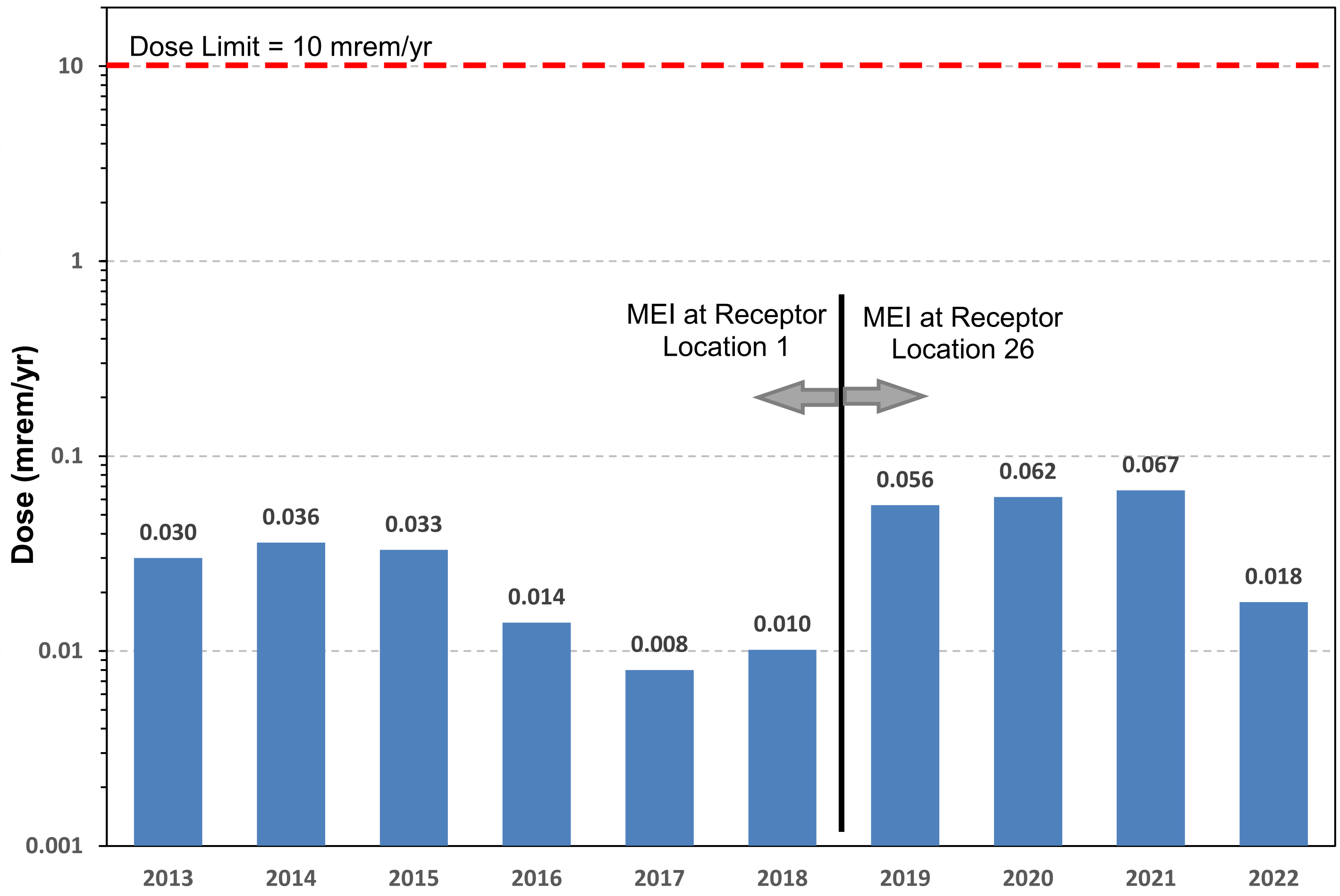


Figure HI-4. Data plotted using a column chart.

A ***plot chart*** 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 (2002–2022). The results are plotted by year.

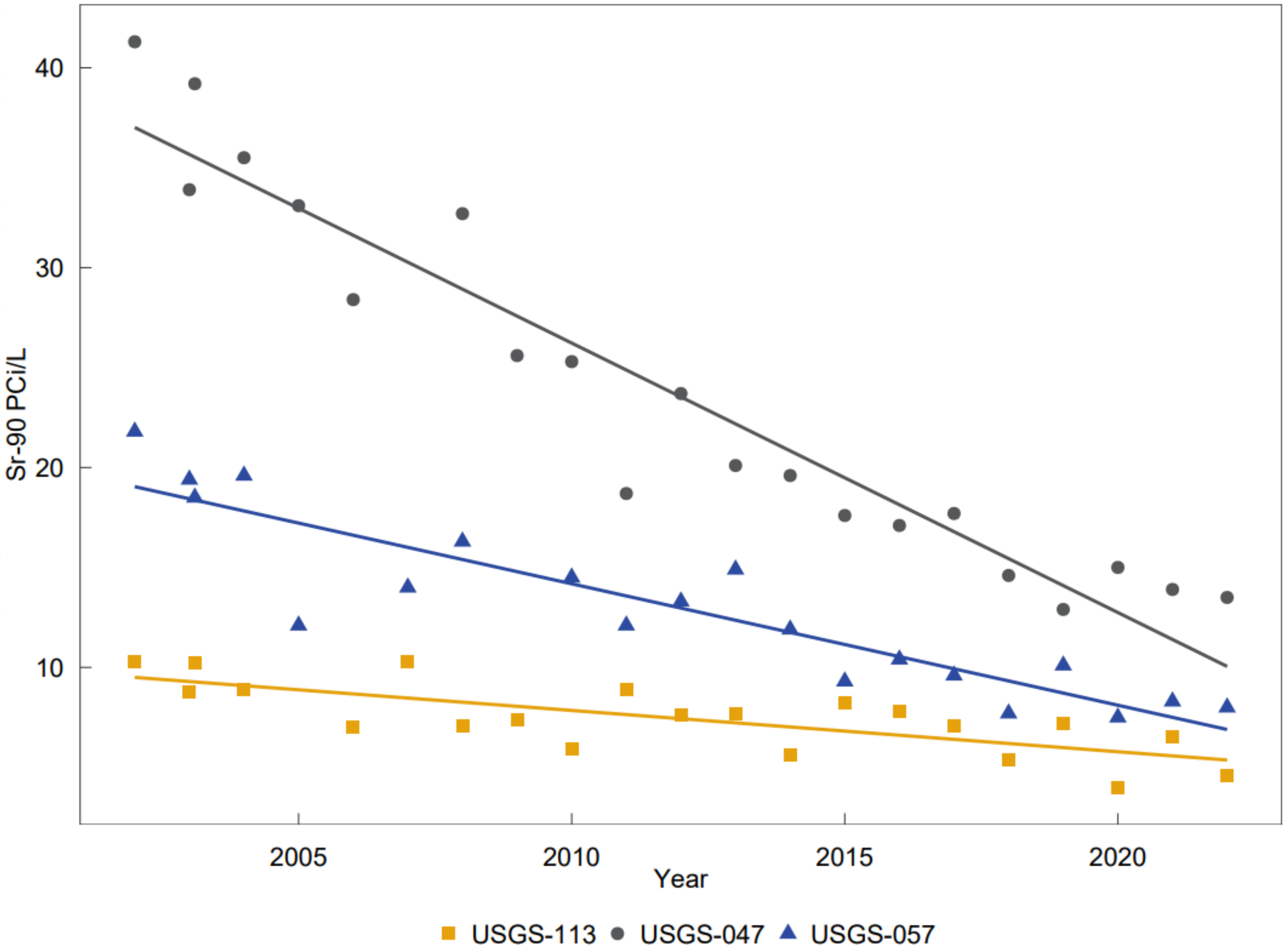


Figure HI-5. Data plotted using a linear plot.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of ^{90}Sr in groundwater around INTEC. Each contour line, or isopleth, represents a specific concentration of the radionuclide in groundwater. It was estimated from measurements of samples collected from wells around INTEC. Each contour line separates areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

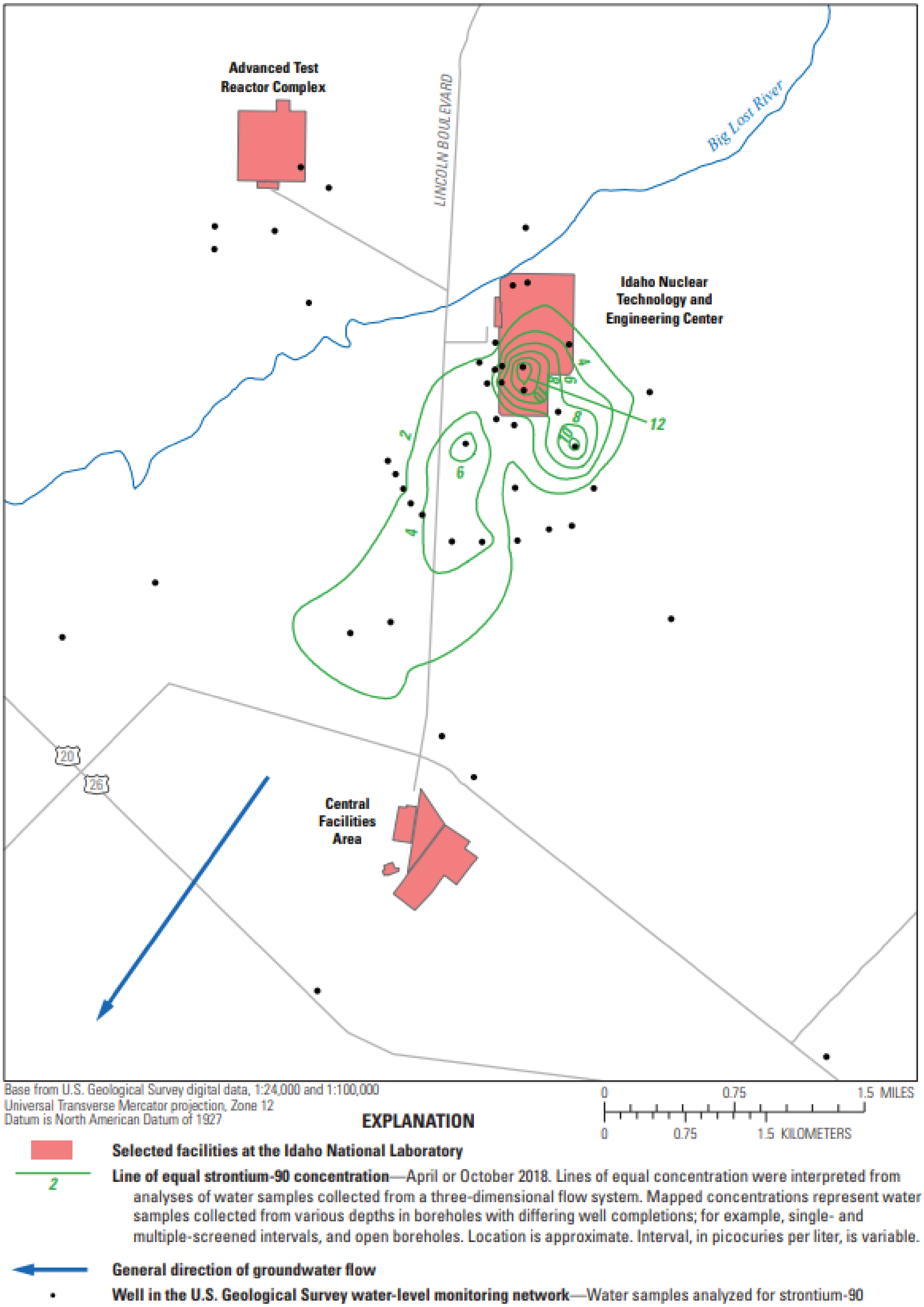


Figure HI-6. Data plotted using contour lines. *Each contour line drawn on this map connects points of equal* ^{90}*Sr concentration in water samples collected at the same depth from wells onsite.*

How Are Results Interpreted?

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

- Comparison of results collected at different locations. For example, measurements made at INL Site locations are compared with those made at locations near the boundary of the INL Site and offsite 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 2013 to 2018, followed by a slight increase in 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 (1) radiation of extraterrestrial origin (called cosmic rays), (2) radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides), and (3) 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 radiation and radioactivity in the environment, which 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 2022, to receive an average dose of about 384 mrem/yr (3.8 mSv/yr) from natural background sources of radiation on earth, as observed in Figure HI-7. These sources include cosmic radiation and naturally occurring radionuclides.

Cosmic radiation is radiation that constantly bathes the earth in 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, and ^{14}C. Cosmogenic radionuclides, particularly ^{3}H and ^{14}C, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. Concentrations are generally higher at mid-latitudes than at low- or high-latitudes. Cosmogenic radionuclides contribute only about 1 mrem/yr to the total average dose, mostly from ^{14}C, that might be received by an adult living in the U.S. (NCRP 2009). Tritium and beryllium-7 are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site, as observed in Figure HI-5, but these contribute little to the dose that might be received from natural background sources.

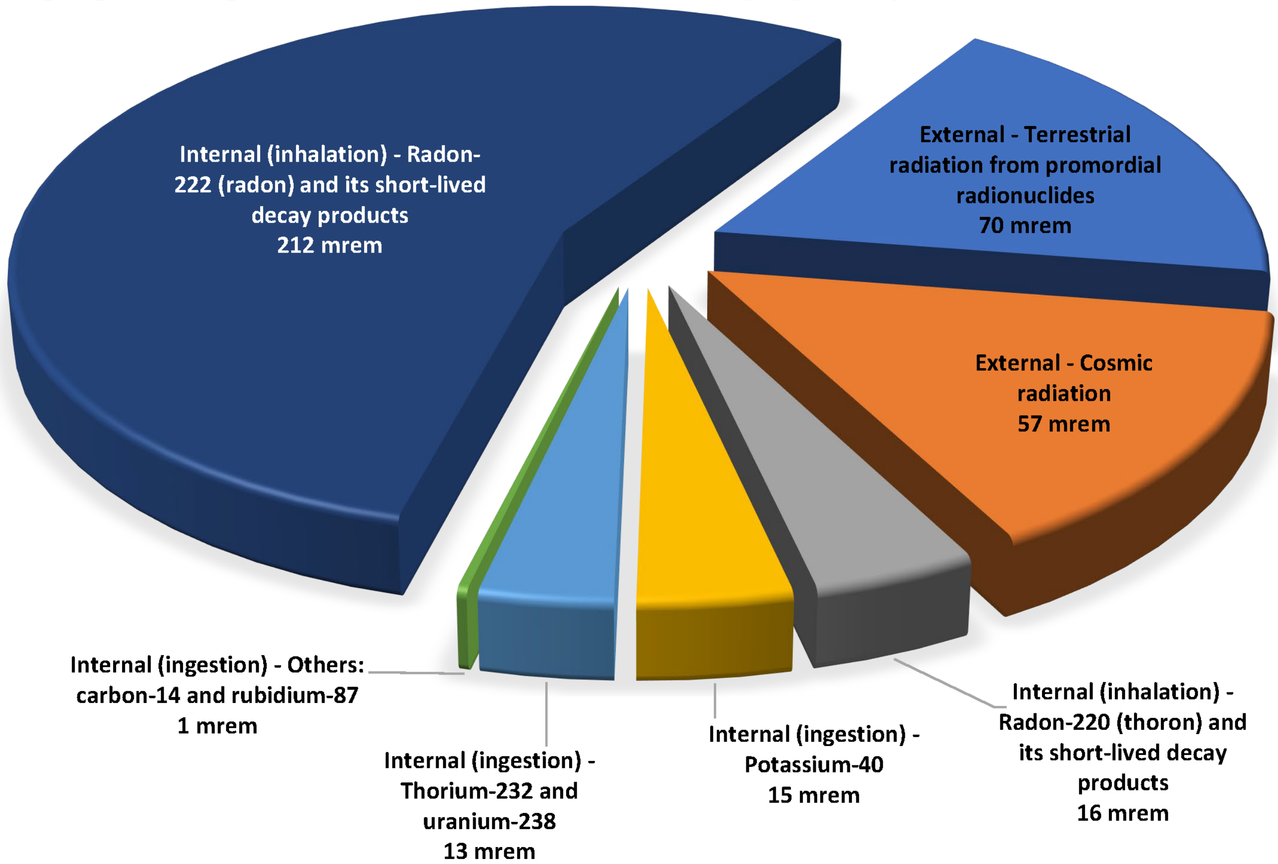


Figure HI-7. Calculated doses (mrem per year) from natural background sources for an average individual living in southeast Idaho (2022).

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

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, 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 (73 mrem/yr or 0.73 mSv/yr) has been estimated using concentrations of potassium-40, ^{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 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. This is a gas that can accumulate in buildings. Radon and its progeny are responsible for most of the inhalation dose (e.g., an average of 200 mrem/yr [2.0 mSv/yr] nationwide) produced by naturally occurring radionuclides, as shown in Figure HI-7.

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

Global Fallout. The U.S., the Union of Soviet Socialist Republics, and China tested nuclear weapons in the Earth's atmosphere in the 1950s and 1960s. This testing resulted in the release of radionuclides into the upper atmosphere, and such a release is referred to as fallout from weapons testing. Concerns over worldwide fallout rates eventually led to the Partial Test Ban Treaty in 1963, which limited signatories to underground testing. Not all countries stopped atmospheric testing with the treaty. France continued atmospheric testing until 1974, and China continued 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 degrees. 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 34 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 U.S. 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 50–400 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 EPA estimated a $5.8 \times 10^{-2}\ Gy^{-1}$ 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 381 mrem (3.8 mSv) every year from natural background sources of radiation.

DOE limits the dose to a member of the public from all sources and pathways to 100 mrem (1 mSv) and the dose from the air pathway to 10 mrem (0.1 mSv) (DOE O 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:

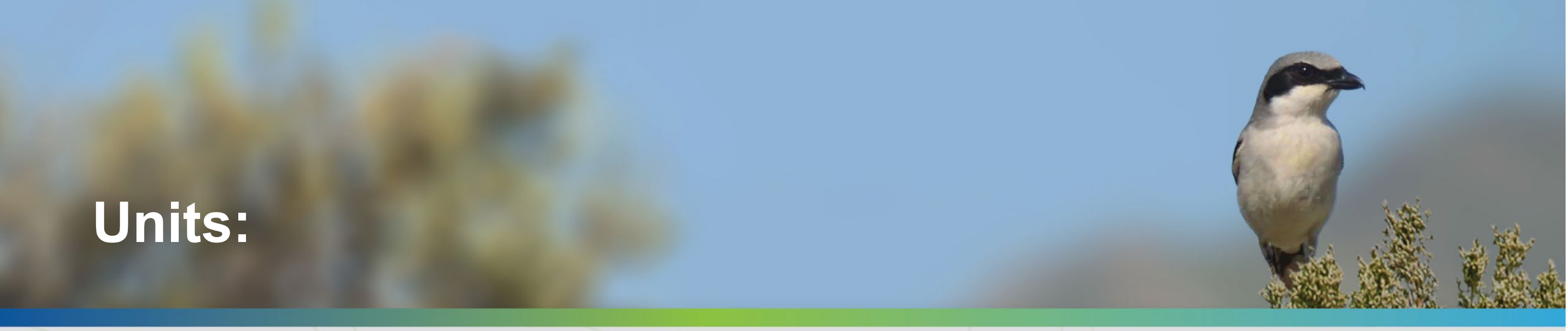
AFV	alternative fuel vehicle
ALLWDF	active low-level waste disposal facility
ARP	Accelerated Retrieval Project
ATR	Advanced Test Reactor
BBS	breeding bird survey
BCG	Biota Concentration Guide
BEA	Battelle Energy Alliance, LLC
BLM	Bureau of Land Management
BMP	best management practices
BRR	Biological Resource Review
C&D	construction and demolition
CA	corrective action
CAA	Clean Air Act
CAP	criteria air pollutant
CAP88-PC	Clean Air Act Assessment Package-1988 computer model, PC
CARP	Climate Adaptation and Resilience Plan
CCA	Candidate Conservation Agreement
CEJST	Climate and Economic Justice Screening Tool
CEMML	Center for the Environmental Management of Military Lands
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CRMO	Cultural Resource Management Office
CTF	Contained Test Facility
CWA	Clean Water Act
CWMA	Cooperative Weed Management Area
CWP	Cold Waste Pond
D&D	decontamination and decommissioning
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
DOE-ICP	DOE Idaho Cleanup Project
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOSEMM	dose multi-media
DQO	data quality objective
EAs	Environmental Assessments
EBR-I	Experimental Breeder Reactor-I
ECP	Environmental Compliance Permits
EFS	Experimental Field Station
EJ	environmental justice
EJP	Environmental Justice Program
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
EPI	emergency plan implementing procedures
ESA	Endangered Species Act
ESPC	Energy Savings Performance Contract
EV	electric vehicle
FEC	facility emission cap

FFA/CO	Federal Facility Agreement and Consent Order
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	fiscal year
GPRS	Global Positioning Radiometric Scanner
HeTO	Heritage Tribal Office
HFC	hydrofluorocarbons
HLW	high-level waste
HYSPLIT	Hybrid Single-particle Lagrangian Integrated Trajectory
IC	institutional control
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICPP	Idaho Chemical Processing Plant
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
IDNH	Idaho Museum of Natural History
IEC	Idaho Environmental Coalition, LLC
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRC	INL Research Center
ISA	Idaho Settlement Agreement
ISB	in situ bioremediation
ISO	International Organization for Standardization
ISU-EAL	Idaho State University-Environmental Assessment Laboratory
ITEK	Indigenous and Traditional Ecological Knowledge
IWCS	Industrial Wastewater Collection System
IWD	Industrial Waste Ditch
IWTU	Integrated Waste Treatment Unit

LLW	low-level waste
LOFT	Loss-of-Fluid Test
LTS	Long-Term Stewardship
LTV	long-term vegetation
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	maximum contaminant level
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
NA	not applicable
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NM	not measured
NOAA	National Oceanic and Atmospheric Administration
NON/CO	Notice of Noncompliance/Consent Order
NRF	Naval Reactors Facility
NS	no sample
O&M	Operations & Maintenance
OSLD	optically stimulated luminescence dosimeter
PA	performance assessment
PCB	polychlorinated biphenyls
PCC	Precontact Context
PCS	primary constituent standard
PE	performance evaluation
PFAS	perfluoroalkyl substances
PL	primary line
PT	performance testing
PTC	permit to construct

PWS	public water system
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
RHLLW	Remote-Handled Low-level Waste Disposal Facility
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RWMC	Radioactive Waste Management Complex
SBL	Southwestern Branch Line
SCS	Secondary Constituent Standard
SDA	Subsurface Disposal Area
SGCA	Sage-grouse Conservation Area
SCGN	Species of Greatest Conservation Need
SMC	Specific Manufacturing Capability
SMCL	secondary maximum contaminant level
SNF	spent nuclear fuel
SSER	Sagebrush Steppe Ecosystem Reserve
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	trichloroethylene
TFF	Tank Farm Facility
TLD	thermoluminescent dosimeter
TMI	Three Mile Island
TREAT	Transient Reactor Experiment and Test Facility
TRU	transuranic
TSCA	Toxic Substances Control Act
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
UTV	utility task vehicle
VARP	Vulnerability Assessment and Resilience Plan
VOC	volatile organic compound
WAG	waste area group
WFMC	Wildland Fire Management Committee
WMF	Waste Management Facility
XRF	x-ray fluorescence spectroscopy
YOY	year-over-year

Mountain bluebird



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	kilograms (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	milliard (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

Sage-grouse habitat monitoring crew

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Chapter 1: Introduction

1. INTRODUCTION

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

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

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

- 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 an 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 entrance 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 U.S. Bureau of Land Management lands and Craters of the Moon National Monument and Preserve to the southwest, Salmon-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 Reservation is located approximately 60 km (37 mi) to the southeast.

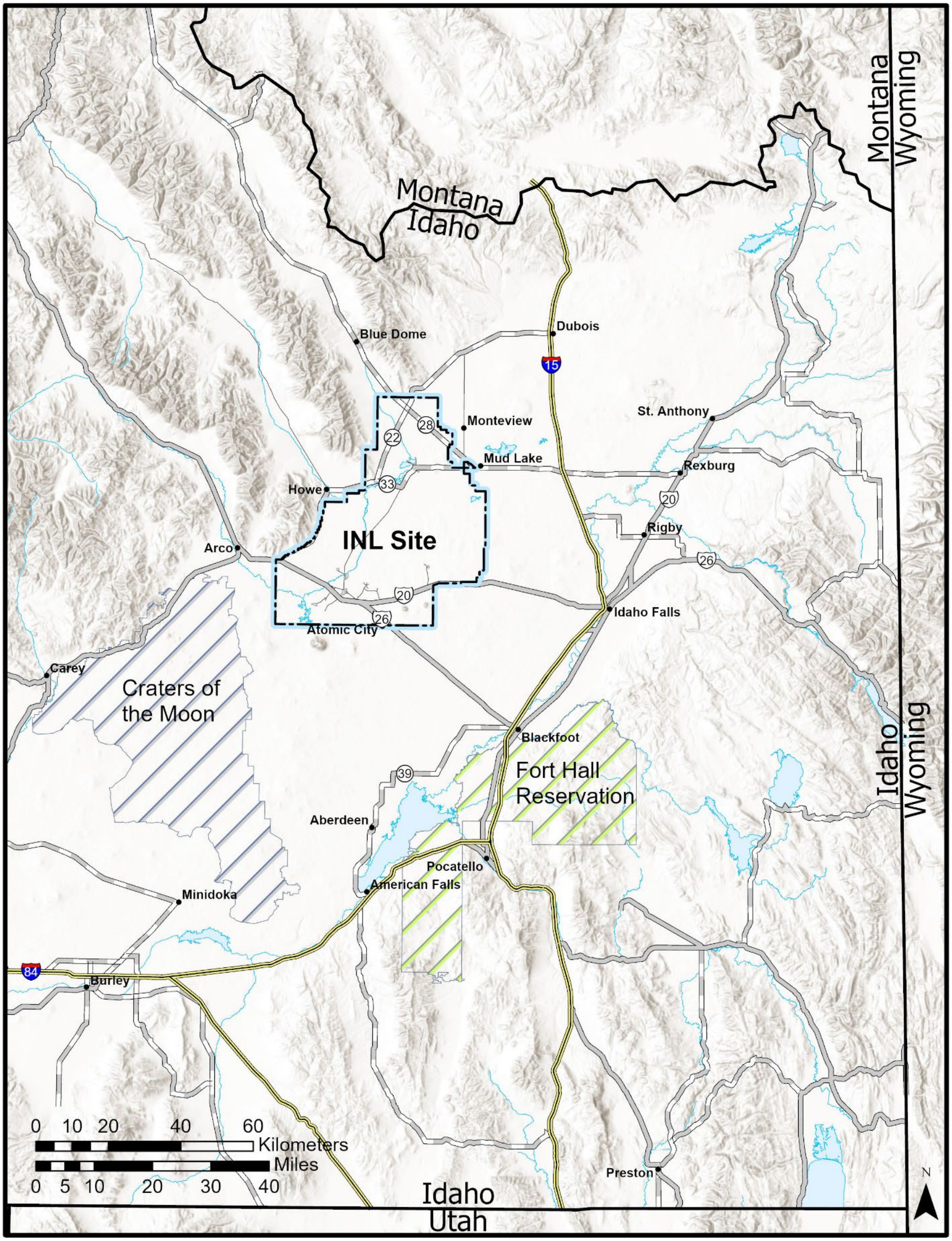

Figure 1-1. Location of the INL Site.

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 (see Figure 1-2).

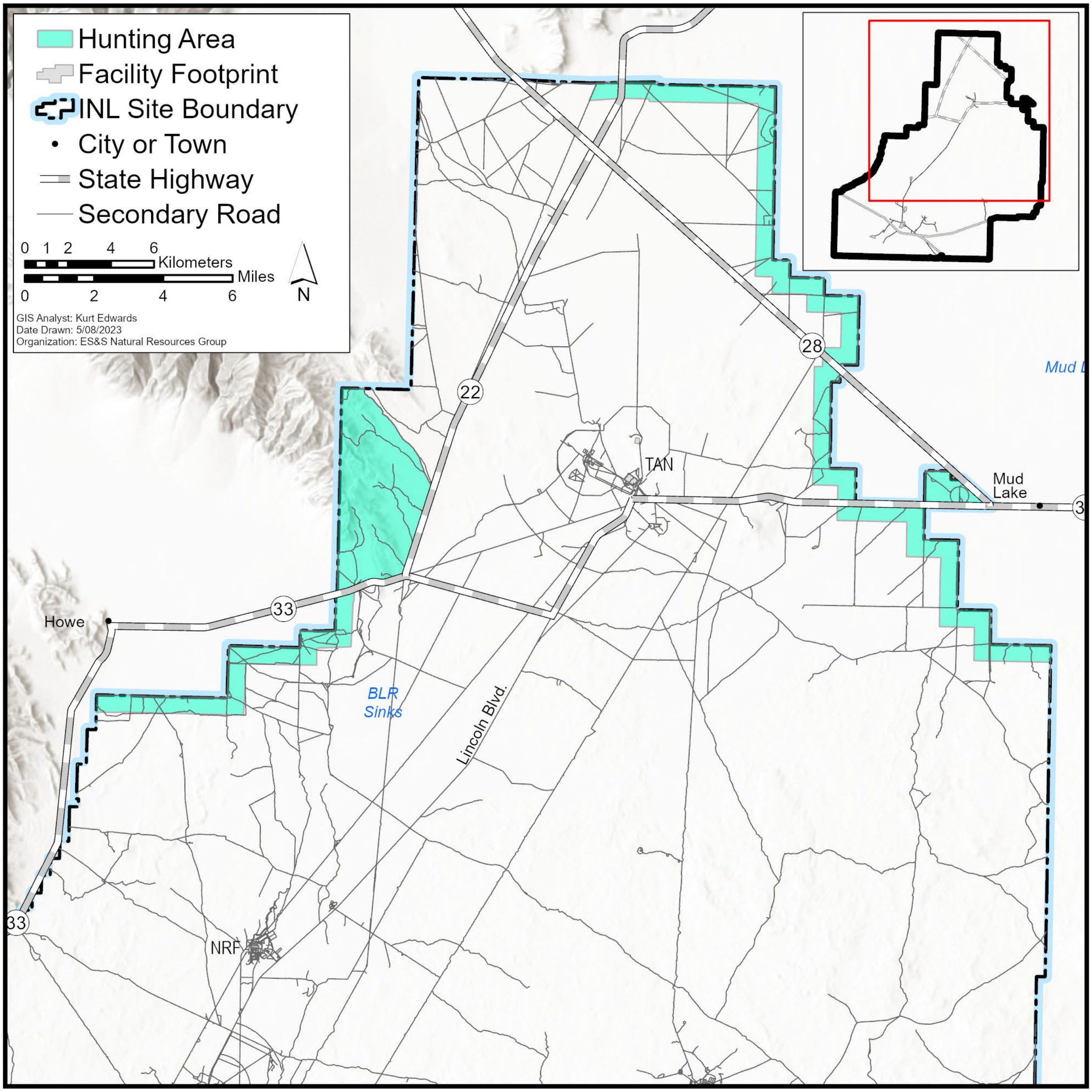

Figure 1-2. Designated elk and pronghorn hunting boundary on the INL Site.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.4 cm/yr [8.43 in./yr]), warm summers (average daily temperature of 18.8°C [65.8°F]), and cold winters (average daily temperature of -7.3°C [18.9°F]), based on observations at Central Facilities Area from 1991 through 2020 (NOAA 2023). 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 adapted to the harsh climate.

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 6 fishes, 1 amphibian, 9 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 1-3). The river rarely flows onto the INL Site. Water demands upstream at the Mackay Reservoir inhibited river flow onto the INL Site from March to May 2022, and water flow never went as far as the Lincoln Boulevard bridge. No river samples were collected during 2022 from the INL Site because of the lack of surface water flow in the Big Lost River.

Fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain Aquifer (Figure 1-4), 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 247–370 billion m^3 (200–300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from Henry's Fork and the south fork of the Snake River, and to a lesser extent, the aquifer is recharged 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 (5–20 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.

Figure 1-3. Big Lost River. *Dry riverbed in 2016 (upper). Flowing river in May 2017 (lower).*

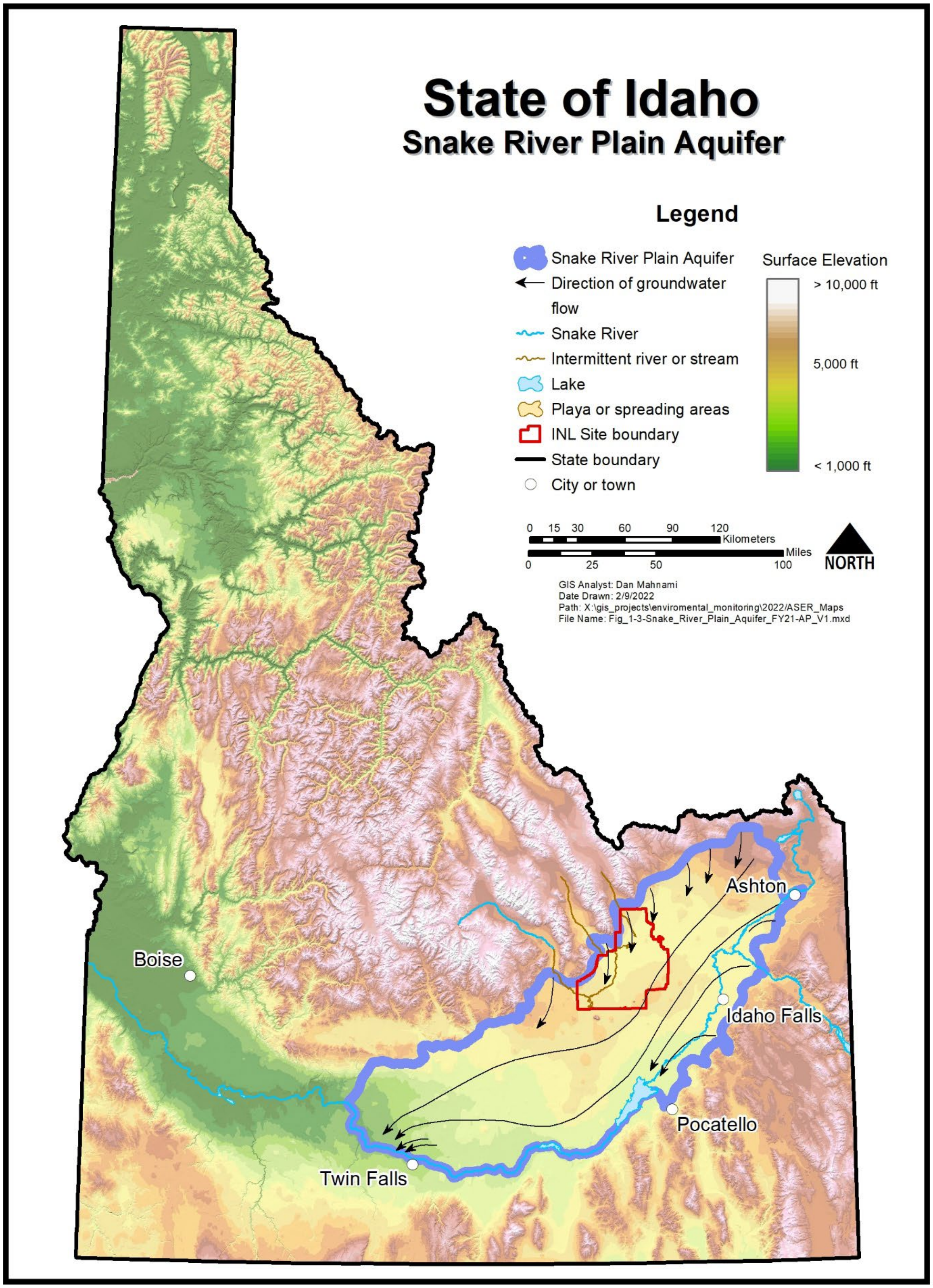

Figure 1-4. INL Site relation to the eastern Snake River Plain Aquifer.

1.3 History of the INL Site

The geologic events that have shaped the modern Snake River Plain took place during the last two million years (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 million years, a series of giant, caldera-forming eruptions occurred, with the most recent occurrence at Yellowstone National Park 630,000 years ago. The youngest silicic volcanic centers correspond to the Yellowstone volcanic field that are less than 2 million years old and are followed by a sequence of silicic centers that occurred about 6 million years ago southwest of Yellowstone. A third group of centers, which occurred approximately 10 million years old, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the Snake River Plain are approximately 16 million years old and are distributed across a 150-km-wide (93-mi-wide) zone from southwestern Idaho to northern Nevada; they are the suspected origin of the Yellowstone-Snake River Plain (Smith and Siegel 2000).

The earliest human occupants of the eastern Snake River Plain were the Shoshone and Bannock people, the ancestors of the present-day Shoshone-Bannock Tribes. Their presence dates back 13,000 years. Tools recovered from this period indicate they were hunters of large game. Plants, animals, geological features, water, and other resources on the INL Site were important to the Shoshone and Bannock people and continue to hold significance to the present-day Shoshone-Bannock Tribes.

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. The Shoshone and Bannock people entered into peace treaties in 1863 and 1868, known today as the Fort Bridger Treaty. The Fort Hall Reservation was reserved for the various tribes under the treaty agreement. 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 (e.g., the Homestead Act of 1862, the Desert Claim Act of 1877, the Carey Act of 1894, the Reclamation Act of 1902) provided sufficient incentive for homesteaders to build diversionary canals to claim the desert. Most of these 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 Arco Naval Proving Ground.

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

After the war ended, the nation turned to peaceful uses of atomic power. DOE's predecessor, the U.S. Atomic Energy Commission, needed an isolated location with an ample groundwater supply on which to build and test nuclear power reactors. In 1949, the Arco Naval Proving Ground became the National Reactor Testing Station.

In 1951, the 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, which was the first time a nuclear reactor powered an entire community in the United States. The laboratory also developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas.

The National Reactor Testing Station was renamed the Idaho National Engineering Laboratory in 1974 and was changed to 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 Idaho National Engineering and Environmental Laboratory would be the lead laboratories in developing the next generation of power reactors. On February 1, 2005, Battelle Energy Alliance, LLC, took over operation of the laboratory and merged with Argonne National Laboratory-West. 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 (ICP), which is currently managed by Idaho Environmental Coalition, LLC (IEC). 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 to be 349,242, based on the 2020 census and projected growth. Over half of this estimated population (194,088) resides in the census divisions of Idaho Falls (117,664) and northern Pocatello (76,424). Another 38,845 are projected to live in the Rexburg census division. Approximately 21,607 are estimated to reside in the Rigby census division and 15,353 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

1.5 INL 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. These operations fall outside the purview of DOE-ID and therefore 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 develop nuclear energy and national and homeland security leadership highlighted by achievements such as the demonstration of Generation IV reactor technologies; the creation of national user facilities, including the Advanced Test Reactor National Scientific User Facility, Wireless National User Facility, and Biomass Feedstock National User Facility; the Critical Infrastructure Test Range Complex; piloting 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.

On February 22, 2021, an addendum to the 2019 memorandum of understanding between DOE and the Nuclear Regulatory Commission formalized the coordination between these two federal agencies in regard to National Reactor Innovation Center projects. This addendum specifically focuses on research, development, and demonstration projects, and it solidifies a partnership to deliver successful nuclear reactor demonstrations. The National Reactor Innovation Center is a national DOE program led by INL allowing collaborators to harness the world-class capabilities of the U.S. National Laboratory System. The center is charged with and committed to demonstrating advanced reactors by the end of 2025.

Battelle Energy Alliance, LLC, is responsible for the management and operation of INL.

1.5.2 Idaho Cleanup Project

The ICP 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. IEC is responsible for the ICP.

Most of the cleanup work under the contract is driven by regulatory compliance agreements. The two foundational agreements are (1) 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 (2) 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 involves treating nearly one 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 INL Site Facilities

Most INL Site buildings and structures are located within developed areas that are typically less than a few square miles in size and are separated from each other by miles of undeveloped land. DOE controls all the land within the INL Site (Figure 1-5). In addition to the INL Site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, about 40 km (25 mi) east of the INL Site.

Advanced Test Reactor Complex – The Advanced Test Reactor (ATR) Complex was established in the early 1950s and has been the primary operations site for three major test reactors: (1) the Materials Test Reactor (1952–1970), (2) the Engineering Test Reactor (1957–1982), and (3) the ATR (1967–present). The current primary mission at the ATR Complex is the operation of the ATR, 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 Safety and Tritium Applied Research Facility, which is a national fusion safety user facility. The ATR Complex is operated by the INL contractor.

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: (1) physical security, (2) contraband detection, and (3) infrastructure testing. It is operated by the INL contractor.

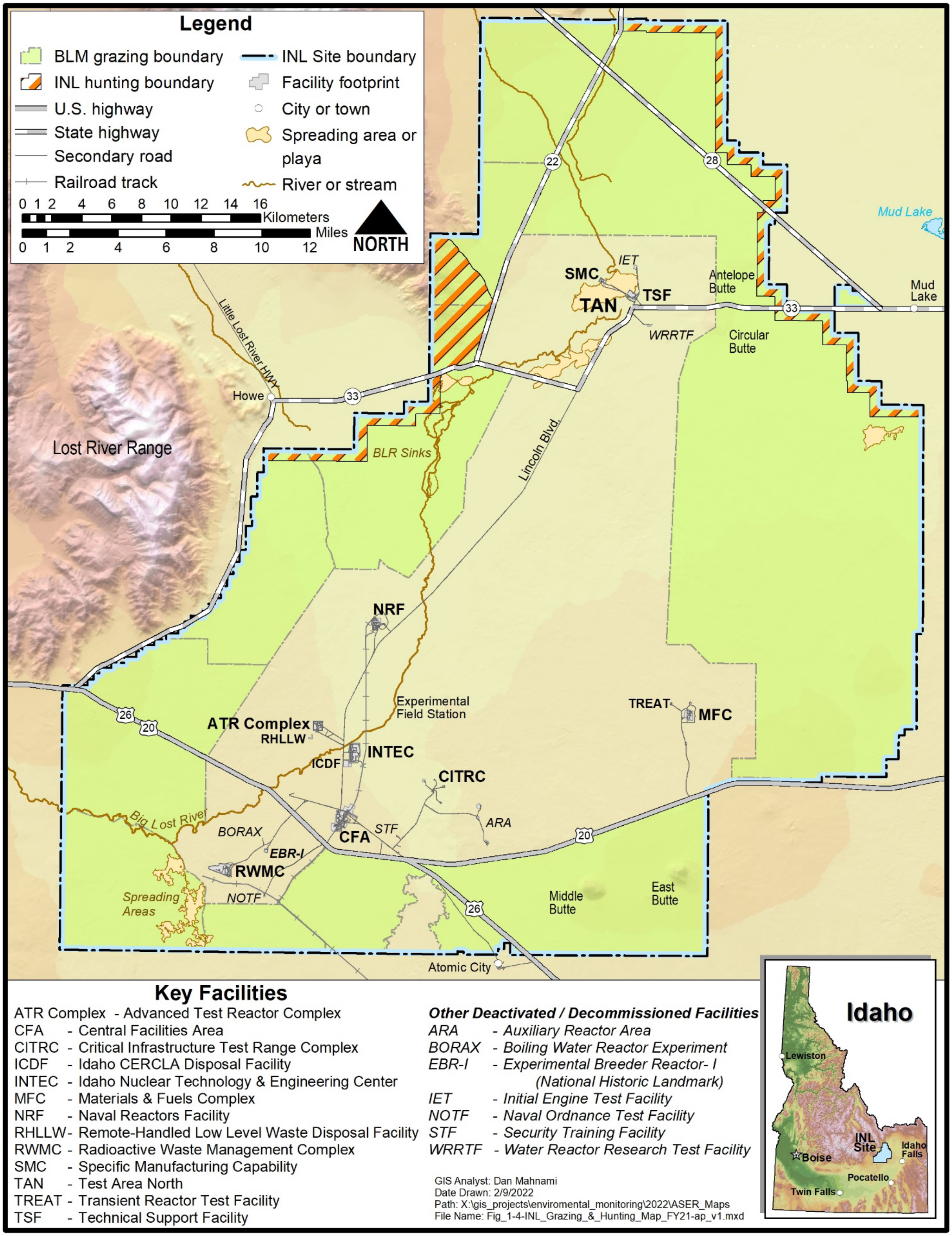

Figure 1-5. Location of the INL Site, showing key facilities.

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 U.S. 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 the 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 the closure of the remaining liquid waste storage tank, spent nuclear fuel storage, environmental remediation, and disposal of excess facilities; and the 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 IEC, the ICP 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, LLC. As established in Executive Order (EO) 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE O 436.1, DOE O 458.1, and DOE O 414.1D. Therefore, NRF is excluded from this report. The director of the Naval Nuclear Propulsion Program establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (FMP 2023).

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 offsite disposition of targeted waste. Cleanup of RWMC is managed by the ICP contractor.

Remote-Handled Low-Level Waste Disposal Facility – The Remote-Handled Low-Level Waste Disposal Facility is a Hazard Category 2 nuclear facility providing a below-grade, permanent radioactive waste disposal capability critical for INL nuclear research and Naval Reactors missions at the INL Site. Remote-Handled Low-Level Waste is generated from nuclear programs conducted at INL Site facilities, including the NRF, the ATR Complex, and the Materials and Fuels Complex. The facility began operations in 2018 and will support an anticipated 20 years of waste disposal operations with an expansion capability for up to 50 years. The facility comprises an administration building, a maintenance building, and a 175,000-square-foot vault yard that includes monitoring wells, a robust drainage system, and 446 below-grade concrete waste disposal vaults sized to accommodate 939 stainless steel waste canisters of various configurations dependent on the waste type and waste generator facility.

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, Idaho, 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 Energy Innovation Laboratory—were constructed in 2013 and 2014. In 2019, the Idaho Board of Education and INL completed the construction of two new research facilities: the (1) Cybercore Integration Center and the (2) Collaborative Computing Center. The Cybercore Integration Center leads national efforts to secure critical infrastructure control systems from cybersecurity threats while the Collaborative Computing Center will advance the computational science needs of INL and provide academia and industry with unprecedented access to high-performance computing. These and other facilities are integral to transforming INL into a renowned research laboratory.

The DOE Radiological and Environmental Sciences Laboratory (RESL) is located within the REC and 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 and its goal to build and fly a nuclear-powered airplane. When President John F. 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 (e.g., 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 the state of 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 the 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 U.S. Department of Defense by the INL contractor and manufactures protective armor for the Army M1-A1 and M1-A2 Abrams tanks.

1.5.4 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.

1.5.5 Citizens Advisory Board

The ICP Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on the 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 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 nonvoting liaisons include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality (DEQ). These 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 Citizens Advisory Board's recommendations, membership, and meeting dates and topics can be found at https://www.energy.gov/em/icpcab.

1.5.6 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, Shoshone-Bannock Tribes, the State of Idaho DEQ-INL Oversight Program, the National Oceanic and Atmospheric Administration, NRF, and the 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; coordinate efforts; and 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.

1.5.7 Environmental Oversight and Monitoring Agreement

A new five-year Environmental Oversight and Monitoring Agreement (DOE-ID 2021) between DOE-ID, Naval Reactors Laboratory Field Office/Idaho Branch Office, and the Idaho DEQ was signed in March 2021. The 2021 version is the latest in a succession of agreements that was 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 nonregulatory, independent oversight of INL Site impact 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.

1.5.8 Environmental Education Outreach

The INL contractor provides communications, educational outreach, and K–12 science, technology, engineering, and mathematics (STEM) activities. 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 impact of INL Site operations on the environment and public. Involvement of students, especially K–12, is emphasized.

INL Environmental Education staff worked together with DOE-ID, ICP contractor, and other businesses and agencies to present community outreach programs when possible. Since the prohibition against large gatherings was lifted, traditional large-scale events, such as Earth Day and Water Awareness Festival, were again possible and highly successful.

In 2022, the INL contractor collaborated with the Museum of Idaho and Boise State University on teacher outreach program development. The program was designed to educate teachers about native Idaho habitats, provide tools and hands-on activities that can be adapted to their classrooms, and introduce them to experts who may serve as classroom resources. An expanded grant from the Idaho Department of Education allowed the expansion of an online course called “Bring Idaho Alive in Your Classroom.” By increasing funding and using the online format, 225 teachers were able to attend a two-credit six-month course. Toolkits were also provided to the teachers to supplement learning.

Figure 1-6. Teachers attending joint INL/Museum of Idaho Project Water Education Today workshop.

INL Environmental Education staff worked with the education staff at the Museum of Idaho to provide summer camps for both students and educators through the Rocky Mountain Adventure Program. Three sets of 12 student camps were offered for younger children, and three sets of 12 student camps were offered for middle-school students. These workshops focused on a combination of scientific, habitat, and historical aspects. Three teacher workshops were also offered. These workshops were offered in conjunction with Northwest Nazarene College for two credits (Figure 1-6). Staff from INL assisted with the field portion of the teacher classes and various locations were used to expose teachers to different habitats.

The INL STEM Summer Scholars Program for grades K–12 entailed three full-week courses of 65 students. Each week different age groups were addressed ranging from grades 1–3, 3–5, and 6–8 (Figure 1-7). In addition, a week-long Green Energy Camp for 20 high school students was held. INL Environmental Education staff worked to ensure all existing STEM activities and presentations also contained information related to environmental awareness, sustainability, and environmental justice.

Figure 1-7. Children participating in INL Earth Day activity at the Idaho Falls Zoo.

The programmatic impact scope increased by incorporating mission aspects into existing K–12 STEM tours to Twin Falls, Boise, and northern Idaho.

Biologists, with funding from the INL contractor Monitoring and Natural Resources Division, continued to work with the Idaho Falls Zoo to develop the only chiropterarium at a zoo in the country. Three bat nights were offered, allowing approximately 300 guests to learn about, view, and hear bats (Figure 1-8).

Figure 1-8. Members of public attending bat night led by INL staff at Idaho Falls Zoo.

1.6 References

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Chapter 2: Environmental Compliance Summary

CHAPTER 2

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and U.S. Department of Energy (DOE) directives. 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. Environmental permits have been issued to the INL Site, primarily by the State of Idaho (Table 2-5). There were no reportable environmental releases at the INL Site during calendar year 2022. In 2022, the U.S. Department of Energy Idaho Operations Office (DOE-ID) operated in compliance with most of the requirements defined in governing documents. Instances of noncompliance were reported to regulatory agencies and resolved. Environmental compliance status for 2022 is provided in Table 2-1.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter presents the compliance status for operations at the INL Site and DOE-ID programs that are subject to federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders, and DOE directives.

2.1 Enforcement and Compliance History Online Database

The U.S. Environmental Protection Agency (EPA) developed the Enforcement and Compliance History Online website (https://echo.epa.gov/) that provides integrated compliance and enforcement that can be used to search and view information on permit data, inspection dates and findings, violations, enforcement actions, and penalties assessed.

2.2 Compliance with Requirements

INL Site activities must adhere to environmental standards established by federal, state and local regulations, DOE directives, permits, and compliance and settlement agreements where applicable. The EPA and Idaho Department of Environmental Quality (DEQ) are the principal regulating agencies that issue permits, review compliance reports, and participate in joint monitoring programs, inspect facilities and operations, and enforce compliance with applicable requirements as identified in Table 2-1.

Table 2-1. Federal, state, and local laws and regulations established for protection of human health and the environment.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
AIR QUALITY AND PROTECTION			
40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," 42 USC 7401 et seq. The CAA is the basis for national air pollution control. Emissions of radioactive hazardous air pollutants are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutant (40 CFR 61, Subpart H).	EPA has not delegated the 40 CFR Part 61, Subpart H regulations and is the primary agency to which DOE-ID reports compliance. Idaho DEQ incorporates the requirements of the subpart into the sitewide PTC-FEC and is therefore included in all reporting and non-compliance occurrences. The INL Site is in compliance, as reported in compliance report, *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2022*.	N	2.2.1 4.2 4.3 8.2.1
40 CFR 84, "Phasedown of Hydrofluorocarbons" In October 2021, EPA issued regulations to decrease the production of hydrofluorocarbons (HFCs) over the next fifteen years, thereby decreasing the supply. HFCs were developed and manufactured to replace chlorofluorocarbons, which damage the stratospheric ozone layer. HFC uses include refrigerants, solvents, fire suppressants, and aerosols. Through these regulations, EPA seeks to reduce HFC consumption and production to 15% of a 2011–2013 baseline by 2036. These regulations do not prevent entities from using equipment containing HFCs that have already been purchased and are currently in use. However, as the phasedown progresses, these HFCs will become less available and more expensive. The DOE Office of Environment, Health, Safety, and Security published OE-3: 2021-06, "Hydrofluorocarbon Phasedown," to provide information and suggestions to DOE programs and sites about these new regulations.	A summary of the INL and Idaho Cleanup Project (ICP) contractors' HFC uses, replacements, procurement, and proactive measures taken as a result of the HFC phasedown can be found in Section 4.2.1.	N	4.2.1
Clean Air Act (1970), 42 USC 7401 et seq. The Clean Air Act (CAA) provides the EPA with broad authority to implement and enforce regulations to reduce air pollutant emissions with an emphasis on cost-effective methods. In addition to EPA, states, tribes, and local governments play a key role in the implementation of the CAA. *Other environmental statutes and regulations apply, in whole or in part:* • 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards."	The Idaho DEQ has been delegated authority to implement the CAA through the development of an EPA-approved state implementation plan and is codified in Idaho Administrative Code, Rules for the Control of Air Pollution in Idaho (IDAPA 58.01.01). DOE-ID holds a synthetic minor, sitewide, air quality permit from Idaho DEQ. This permit to construct (PTC) contains a facility emission cap (FEC) component which enforces a limit on criteria air pollutants (CAP) and hazardous air pollutants emissions to less than major source thresholds. Without the synthetic limits on sitewide CAP emissions, the INL Site would be considered a major source for CAP emissions and require Tier I/Title V permit. This permit covers all the non-exempt air emission sources located on the INL Site, but does not cover air emitting sources located at the Research and Education Campus in Idaho Falls, Idaho. All air emission sources located at the Research and Education Campus have been	Y	4.3 8.2

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	determined minor and have been exempted from the permitting requirements in IDAPA 58.01.01. As reported in the annual compliance report required by the PTC-FEC, the INL Site emitted CAP and HAP emissions significantly below the permitted limits in calendar year 2022. No air quality inspections were performed by the Idaho DEQ during calendar year 2022.		
CULTURAL AND ENVIRONMENTAL RESOURCES PROGRAMS			
Endangered Species Act (1973), 16 USC 1531-1544 The Endangered Species 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. *Other environmental statutes and regulations apply, in whole or in part:* • 50 CFR 17, "Endangered and Threatened Wildlife and Plants" • 50 CFR 226, "Designated Critical Habitat" • 50 CFR 402, "Interagency Cooperation – Endangered Species Act of 1973, as Amended" • 50 CFR 424, "Listing Endangered and Threatened Species and Designating Critical Habitat" • 50 CFR 450-453, "Endangered Species Exemption Process."	There are currently no resident INL Site species listed as threatened or endangered under the Endangered Species Act and there is no designated critical habitat on the INL Site. In 2014, DOE-ID entered into a voluntary candidate conservation agreement with the U.S. Fish and Wildlife Service to conserve and protect Greater sage-grouse and sagebrush habitat on the INL Site prior to the Service determining the species was not warranted for listing. In 2022, DOE-ID published an annual report of sage-grouse and sagebrush monitoring activities and held an annual meeting with the U.S. Fish and Wildlife Service and other stakeholders to discuss the report and progress towards achieving conservation objectives. The INL Natural Resources Group conducts ecological research, field surveys, and NEPA evaluations regarding resources on the INL Site. These program activities complied with all requirements. Details of related activities can be found in Chapter 9.	Y	9.1.1.1
Executive Order 11988, "Floodplain Management" Executive Order (EO) 11988 requires federal agencies to consider, evaluate, and avoid to the extent possible, adverse impacts associated with the occupancy and modification of floodplains, to reduce the risk of flood loss, to minimize the impacts of flood on human safety, health, and welfare, and to restore and preserve the natural and beneficial values of floodplains. *Other environmental statutes and regulations apply, in whole or in part:* • 10 CFR 1022, "Compliance with Floodplain and Wetland Environmental Review Requirements."	It is the intent of EO 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA. 10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an Environmental Impact Statement under NEPA, alternative floodplain evaluation requirements are established through the INL Site Environmental Checklist process. For the Big Lost River, DOE-ID has accepted the *Big Lost River Flood Hazard Study* (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.	N	N/A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	For facilities at Test Area North, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).		
Executive Order 11990, "Protection of Wetlands" EO 11990 requires federal agencies to identify potential impacts on wetlands resulting from proposed activities and to minimize the destruction, loss, or degradation of wetlands and preserve and enhance the natural and beneficial values of wetlands.	The only areas of the INL Site currently identified as potentially jurisdictional wetland are the Big Lost River corridor and Big Lost River Sinks. The U.S. Fish and Wildlife Service National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2022, a review of these areas was performed by the U.S. Army Corps of Engineers: no new actions took place within potential wetland areas on the INL Site that would require an update to the Jurisdictional Determination.	N	N/A
Executive Order 13751, "Safeguarding the Nation from the Impacts of Invasive Species" This EO calls on federal agencies to prevent the introduction, establishment, and spread of invasive species, as well as to eradicate and control populations of invasive species that are established. *Other environmental statutes and regulations apply, in whole or in part:* • Federal Noxious Weed Act (1974), 7 USC 2801 • IDAPA 02.06.09, "Rules Governing Invasive Species and Noxious Weeds" • Idaho Statute Title 22, Chapter 19, "The Idaho Invasive Species Act of 2008" • Idaho Statute Title 22, Chapter 24, "Noxious Weeds."	INL implements a sitewide plan for managing invasive species. This sitewide plan addresses each requirement of federal agencies as outlined in EO 13112, as amended by EO 13751. Additionally, federal agency requirements outlined in The Federal Noxious Weed Act of 1974 and State of Idaho requirements related to invasive species and noxious weeds are met with compliance of EO 13112, as amended by EO 13751. For more detail on how this plan is carried out and how requirements are met, see Section 9.4.3.	N	9.4.3
Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad" The purpose of EO 14008, "Tackling the Climate Crisis at Home and Abroad" is to make climate considerations an essential element of U.S. foreign policy and national security planning, and to understand how domestic policy can address the implications of climate change. Overarching goals for domestic policy include strengthening clean air and water protections, holding polluters accountable, delivering environmental justice, and driving the mitigation of climate-related risks in our economy.	At INL, several initiatives have been undertaken to address EO 14008. These initiatives include activities as diverse as evaluating infrastructure to identify opportunities to increase efficiency in electricity and water use, assessing the materials supply chain to reduce INL's carbon footprint, implementing the INL Net-Zero Plan, and aligning land use/land stewardship objectives with ecosystems resilience and ecosystem services priorities. With respect to ecological resource conservation, INL implements several conservation plans. Land stewardship activities prioritize conserving and restoring native communities to maximize ecosystem services such as carbon sequestration. Wildland fire management is an important focus for INL land stewardship, particularly minimizing losses of native plant communities to wildland fire and restoring	N	3.7 Chapter 9

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	communities affected by wildland fire to their historical ecological function. Another aspect of maintaining healthy, native ecosystems at INL is consistent implementation of the site-wide noxious weed plan. Ecological monitoring activities are conducted to continuously evaluate the condition of natural resources and ensure the local sagebrush steppe ecosystem remains healthy and resilient in its ability to respond to the stresses associated with climate change. See Chapter 9 for a more thorough discussion of the ecological aspects of implementing EO 14008 on the INL Site. Concerning site resiliency, INL is taking actions to bolster adaptation and increase the resilience of DOE-ID facilities and operations. INL is currently working on several sustainable actions. For example, in 2021, INL included sustainable acquisition clauses in electronic purchases. These new acquisitions use the Electronic Product Environmental Assessment Tool products to reduce energy use. In 2021, INL committed to becoming a national model for achieving net-zero emissions by 2031. INL will do this by developing and implementing carbon-free and carbon-capture technologies on the forefront of the move to zero-carbon emissions. INL and ICP contractors issued the Vulnerability Assessment and Resiliency Plan. The Vulnerability Assessment and Resiliency Plan documents climate vulnerabilities, implementable solutions, lays out a path to institutionalize climate adaptation policies, provides climate adaptation tools, and socializes the need to deploy emerging climate technologies. The performance status of current sustainable activities and further details of new initiatives are further discussed in Chapter 3.		
Migratory Bird Treaty Act (1918), 16 USC 703-712 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. *Other environmental statutes and regulations apply, in whole or in part:* • EO 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds" • Bald and Golden Eagle Protection Act (1940), 16 USC 668-668d • Idaho Statute Title 36, Chapter 1, 106 e.5.	DOE-ID has a U.S. Fish and Wildlife Service Special Purpose Permit for limited nest relocation and destruction and the associated take of migratory birds, if necessary, for mission-critical activities. DOE-ID and INL and ICP contractors also have permits from the Idaho Department of Fish and Game to manage migratory birds and collect other wildlife specimens for scientific research. All stipulated reporting requirements were met for 2022. One instance of a take was reported in 2022 and is further discussed in Chapter 9.	Y	7.2.6 9.2.4

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
National Environmental Policy Act (1969), 42 USC 4332(2) NEPA requires federal agencies to consider potential environmental impacts of proposed actions in the decision making process. Federal agencies are required to provide a detailed statement on proposals for major federal actions significantly affecting the quality of the human environment. The purpose and function of NEPA is satisfied if federal agencies have considered relevant environmental information and the public has been informed regarding the decision making process. *Other environmental statutes and regulations apply, in whole or in part:* • 10 CFR 1021, "National Environmental Policy Act Implementing Procedures" • 40 CFR 1500-1508, "National Environmental Policy Act (NEPA), Purpose, Policy, and Mandate."	As a federal agency, DOE complies with the NEPA requirements (procedural provisions, 40 CFR 1500 through 1508), as outlined in DOE's NEPA Implementing Procedures (10 CFR 1021). DOE's commitment to NEPA is performed by thoroughly evaluating the potential impacts of proposed federal actions that affect the quality of the environment at INL Site. DOE ensures that reasonable alternatives for implementing such actions have been considered in the decision making process and that such decisions are documented in accordance with DOE and the Council on Environmental Quality regulations. Such a prescribed evaluation process ensures the proper level of environmental review (called a NEPA review) is performed before an irreversible commitment of resources is made while considering other statutory requirements. The INL contractor enters the scope for proposed projects into the Environmental Review Process (ERP), an electronic system developed specifically for INL, in which project personnel, laboratory environmental staff, and other identified personnel can review the scope to identify the regulatory requirements that project proponents will need to meet for proposed actions to proceed. In 2022, laboratory staff reviewed approximately 575 proposed projects. The output of the ERP is the issuance of an Environmental Compliance Permit (ECP). An ECP states the level of NEPA compliance needed for the proposed project as well as project specific instructions project proponents will follow to ensure compliance to regulatory requirements. Of the approximately 575 projects reviewed in 2022, 70 were issued a new categorical exclusion determination under NEPA. Other projects were covered under existing categorical exclusion determinations (i.e. facility improvements), existing Environmental Assessments or Environmental Impact Statements (i.e. Environmental Assessment for Use of DOE-Owned High-Assay Low-Enriched Uranium Stored at Idaho National Laboratory [DOE/EA-2087]), or required the completion of a new NEPA review. DOE-ID projects categorically excluded from further NEPA review can be viewed at https://www.id.energy.gov/NEPA/nepa.htm. The ICP contractor uses an Environmental Checklist (EC) which captures the purpose and need of a project proposal and identifies environmental aspects associated with the project. The Environmental Checklist identifies project specific instructions the project is required to follow to meet NEPA compliance to regulatory requirements. The ICP contractor reviewed six ECs, all of which were covered by existing Environmental Assessments, Environmental Impact Statements, Records of Decision, or other previously approved NEPA documents.	N	NA

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	The proposed projects or activities that do not have coverage under existing NEPA documents or do not meet the requirements of categorical exclusion require new or additional analyses. In July of 2022, DOE began to develop an Environmental Assessment for the proposed Molten Chloride Reactor Experiment (MCRE) project. The proposed MCRE project would be sited within existing facilities at the Materials and Fuels Complex (MFC) on the INL Site and use existing infrastructure. The proposed MCRE project is intended to confirm key physics phenomena relevant to the design and safe operation of fast spectrum molten salt reactors and reduce the uncertainty associated with predicting those phenomena. The Environmental Assessment is drafted and is currently being processed.		
National Historic Preservation Act (NHPA) (1966), as amended, 54 USC 300101 et seq. The NHPA requires federal agencies to establish programs to identify, record, and protect cultural resources and to assess the impacts of proposed projects on historic or culturally important sites, structures, or objects within the area of potential effect for a proposed project. The NHPA further requires federal agencies to assess archaeological sites, historical buildings, and objects on such sites to determine their qualification for inclusion in the National Register of Historic Places. In addition, NHPA requires federal agencies to consult with State Historic Preservation Offices, affected tribes, and the Federal Advisory Council on Historic Preservation, as appropriate, when determining whether the proposed actions would adversely affect properties eligible for listing on the National Register of Historic Places. Compliance is achieved via adherence to Sections 106 and 110 of the NHPA. *Other environmental statutes and regulations apply, in whole or in part to DOE-INL's cultural resource management obligations:* • The Archaeological Resources Protection Act (1979), 16 USC §470aa-470mm • 36 CFR 79, "Curation of Federally Owned and Administered Archaeological Collections" • 36 CFR 800, "Protection of Historic Properties" • 43 CFR 7, "Protection of Archaeological Resources"	The INL Cultural Resource Management Office (CRMO) works with DOE-ID's Cultural Resource Coordinator to steward archaeological and architectural cultural resources across INL. During 2022, the CRMO continued to operate under the INL Cultural Resource Management Plan (DOE-ID 2016a) which was developed through a programmatic agreement with the Idaho State Historic Preservation Office and the Advisory Council on Historic Preservation in 2004. A new programmatic agreement is being negotiated among DOE-ID, Idaho State Historic Preservation Office, Advisory Council on Historic Preservation, the Shoshone-Bannock Tribes, and other consulting parties to tailor the Section 106 process to the current needs of the INL Site. The CRMO has been integrated into the National Environmental Policy Act (NEPA) Environmental Review Process since April 2022, allowing better coordination with NEPA reviews and greater streamlining of the Section 106 review process. Archaeologists conducted multiple field surveys to identify and record or re-record archaeological resources that would be impacted by proposed INL activities under Section 106. Additionally, archaeologists surveyed 535 acres and recorded or re-recorded 53 archaeological resources, including both sites and isolates, pursuant to Section 110. Work continued on the built environment inventory update. Individual resources and historic districts constructed prior to 1980 were surveyed, recorded, and evaluated to determine which were eligible for inclusion on the National Register. The CRMO continues to support DOE-ID with their government-to-government consultation efforts with the Shoshone-Bannock Tribes under the Agreement-in-Principle (AIP). The DOE-ID, CRMO, and the Shoshone-Bannock Heritage Tribal Office collaborate regularly and tribal representatives contribute to Sections 106 and 110 projects in the field, as report co-authors, and reviewers, and lead visits for tribal members. DOE-ID and CRMO provided an annual update to the Fort Hall Business Council on June 29, 2022, and facilitates meetings of the INL Site Cultural Resource Working Group.	N	9.5

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
• Native American Graves Protection and Repatriation Act (1990), as amended, 25 USC 3001-3013 • American Indian Religious Freedom Act (1996), 42 USC 1996 Religious Freedom Restoration Act (1993), 42 USC §200bb-200bb4 • EO 13007, "Indian Sacred Sites" • EO 13175, "Consultation and Coordination with Indian Tribal Governments."			
HAZARDOUS MATERIALS AND WASTE MANAGEMENT			
Comprehensive Environmental Response, Compensation, and Liability Act (1980), 40 CFR 300, 42 USC 9601 et seq The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release or threat of release of chemically hazardous, radioactive substances, or both. *Other environmental statutes and regulations apply, in whole or in part:* • 40 CFR 300, "National Oil and Hazardous Substance Pollution Contingency Plan."	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. The DOE-ID, the State of Idaho DEQ, and the EPA Region 10 signed the Federal Facility Agreement and Consent Order (FFA/CO) in December of 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 the cleanup of past release sites. The INL Site is divided into ten Waste Area Groups (WAGs) 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 whether 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 the 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 Idaho DEQ 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 of 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated	N	Table 2-2 6.5

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	biphenyls, heavy metals, and other hazardous materials. All 24 RODs that were scheduled have been signed and are being implemented or have been completed. 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 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 2022a). The status of on-going active remediation activities at WAGs 1, 3, 7, and 10 are described in Table 2-2. Documentation associated with the remedial actions and other removal actions are publicly available in the CERCLA Administrative Record and can be accessed at https://idahoenvironmental.com/ARIR/. Decontamination and decommissioning activities are also performed at the INL Site in accordance with the CERCLA (42 USC 9601 et seq.), as amended by the "Superfund Amendments and Reauthorization Act of 1986" (Public Law 99-499), and in accordance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300). Decontamination and decommissioning activities are consistent with the joint DOE and EPA *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act* (DOE and EPA 1995), which establishes the CERCLA non-time critical removal action process as an approach for decommissioning. pursuant to CERCLA, Section 104(a), and EO 12580, "Superfund Implementation," as recognized by Section 5.3 of the FFA/CO (DOE-ID 1991). In accordance with 40 CFR 300.415(j) and DOE guidance, on-INL Site removal actions conducted under CERCLA are required to meet ARARs to the extent practicable considering the exigencies of the situation. This approach satisfies environmental review requirements and provides for stakeholder involvement, while providing a framework for selecting the decommissioning alternative.		
DOE Order 435.1 The Atomic Energy Act of 1954 (42 U.S.C § 2011 1954) Section 161(i) authorizes DOE to regulate activity involving certain radioactive materials, including radioactive waste, to "protect human health and minimize danger to life or property." This authority is implemented through DOE O 435.1, "Radioactive Waste Management," and the accompanying DOE Manual 435.1-1, "Radioactive Waste Management Manual," which set forth the requirements for	The INL contractor manages all radioactive waste generated at INL facilities. The Waste Management Program is the lead organization for ensuring compliant cradle-to-grave waste management of containerized waste as described in PDD-17000, "Waste Management Program." The INL contractor maintains facility-specific Radioactive Waste Management Basis documents to demonstrate DOE O 435.1 compliance. The INL and ICP contractors manage all hazardous, mixed low-level waste, low-level, transuranic, high level, remote handled, recyclable waste, waste with no	N	N/A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
assuring the safety of the generation, treatment, storage, and disposal of DOE-owned radioactive waste. These DOE directives ensure that radioactive waste management activities are systematically planned, documented, executed, and evaluated. Specifically, the order and the manual: • Establish requirements to implement DOE regulating authority and responsibilities for radioactive waste management • Define DOE radioactive waste types: (1) high-level waste, (2) transuranic (TRU) waste, and (3) low-level waste • Emphasize management for disposal and establish requirements for waste characterization, waste certification, and waste acceptance criteria • Identify performance-based requirements • Require life-cycle management (i.e., from generation planning to disposal) • Rely on existing nuclear safety philosophies (e.g., Integrated Safety Management System, Graded Approach, Defense-in-Depth) • Require a DOE-approved Radioactive Waste Management Basis to ensure hazards have been identified, analyzed, and mitigated. *Other environmental statutes and regulations apply, in whole or in part:* • DOE O 435.1, Change 2, “Radioactive Waste Management” • DOE Manual 435.1, Change 3, “Radioactive Waste Management Manual (January 2021).”	identified path to disposal, industrial, Toxic Substances Control Act (TSCA), and universal waste streams that are generated and stored at the INL Site and approved off-INL Site waste streams. Management activities include, but are not limited to, storing waste, treating waste, and transporting and disposing of waste. The overall responsibility for managing waste at INL contractor facilities resides in the INL contractor’s Waste Management Programs organization, according to LWP-17000, “Waste Management” and the ICP contractor manages waste that is generated and stored at the ICP facilities, and approved off-Site waste streams per PDD-234, “Waste Management Program.” All waste management activities described herein are conducted in compliance with all applicable provisions of DOE O 435.1. See Table 2-3 for information on wastes managed at the INL Site by INL and ICP contractors. See Table 2-3 for the status of each phase of the LLW management process for facilities managed at the INL Site by INL and ICP contractors.		
Federal Facility Compliance Act of 1992, as amended. Enacted by Congress on October 6, 1992, the *Federal Facility Compliance Act of 1992* amends Section 6001 of the Resource Conservation and Recovery Act of 1976 (RCRA) to	The INL and ICP contractors manage all mixed waste generated at their respective facilities. The Waste Management Program is the lead organization for ensuring compliant cradle-to-grave management of INL containerized mixed waste as	N	N/A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
specify that the U.S. waives sovereign immunity from civil and administrative fines and penalties for RCRA violations. In addition, RCRA requires EPA to conduct annual inspections of all federal facilities. Authorized states are given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs. DOE-ID is required to submit and receive approval of the INL Site Treatment Plan from the Idaho DEQ.	described in PDD-17000, "Waste Management Program." Waste Management at ICP facilities is described in PDD-234, "Waste Management Program." The INL and ICP contractors maintain facility-specific Radioactive Waste Management Basis documents to demonstrate DOE O 435.1 compliance. DOE-ID submitted the fiscal year (FY) 2023 Site Treatment Plan Annual Update and FY 2022 Site Treatment Plan Annual Report to Idaho DEQ in November 2022 in accordance with sections 2.3.3 and 2.3.4. DOE-ID and INL Site contractors met quarterly with Idaho DEQ to discuss the status of milestones, treatment projects, and other activities conducted under the Site Treatment Plan.		
Federal Insecticide, Fungicide, and Rodenticide Act (1996), 7 USC 136 et seq. The Federal Insecticide, Fungicide, and Rodenticide Act is the federal statute that governs the registration, distribution, sale, and use of pesticides in the United States. The FIFRA regulations found in 40 CFR parts 150-189 are promulgated and administered by the EPA. *Other environmental statutes and regulations apply, in whole or in part:* • IDAPA 02.03.03, "Rules Governing Pesticide and Chemigation Use and Application" • Idaho Statute Title 22 Chapter 34, "Idaho Pesticides and Chemigation Law."	All pesticide applications on the INL Site are conducted in accordance with the specific pesticide label instructions in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act. Additionally, all appropriate records associated with pesticide applications are kept for a minimum of three years by each pesticide applicator in accordance with IDAPA 02.03.03, "*Rules Governing Pesticide and Chemigation Use and Application*." For details on pesticide application on the INL Site see Section 9.4.3.	N	9.2.4
Resource Conservation and Recovery Act (1976), 40 CFR 259-282, 42 USC 6901 et seq. The Resource Conservation and Recovery Act established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. *Other environmental statutes and regulations apply, in whole or in part:* • 40 CFR 270.13, "Contents of Part A of the Permit Application" • 40 CFR 262, "Standard Applicable to Generators of Hazardous Waste" • 40 CFR 263, "Standards Applicable to Transporters of Hazardous Waste"	*RCRA Permits:* Form 8700-23, along with maps, drawings, and photographs, as required by 40 CFR 270.13, is included with the Part A permit (Volume 1) and in each Part A Application included with the partial Part B permits. The INL Site currently has one RCRA permit (Volume 1) for the interim status unit, Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility. One interim status unit, TSA1/R at the Radioactive Waste Management Complex (RWMC), is not included in Volume 1. Information on this unit is found in the Advanced Mixed Waste Treatment Project Hazardous Mixed Waste Management Act (HWMA)/RCRA Transuranic Storage Area Interim Status Document (DEQ 2021). An interim status unit is a Part A (interim status) unit that has not been RCRA closed or has not been permitted under a Part B hazardous waste permit application. The INL Part B permits are considered a single RCRA permit that comprises several volumes, all under a single EPA ID number, ID4890008952. Therefore, each of the seven Part B permit volumes is called a partial permit. Each partial Part B Permit includes the Part	Y	N/A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
• 40 CFR 263, "Standards Applicable to Transporters of Hazardous Waste" • 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" • 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" • 40 CFR 266, "Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Units" • 40 CFR 267, "Standard for Owners and Operators of Hazardous Waste Facilities Operating Under a Standardized Permit" • 40 CFR 268, "Land Disposal Restrictions" • 40 CFR 270, "EPA Administered Permit Programs: The Hazardous Waste Permit Program" • 40 CFR 273, "Standards for Universal Waste Management" • 40 CFR 273, "Standards for Universal Waste Management" • 40 CFR 279, "Standards for the Management of Used Oil."	A application specific to the permitted units in that Part B and the Part B of the RCRA hazardous waste permit that contains detailed, site-specific information and hazardous waste operations as described in applicable sections of 40 CFR 262 through 270.27. *RCRA Reports.* As required by Idaho DEQ, the INL Site submitted the 2022 annual Idaho Hazardous Waste Generator Annual Report (CCN 330317) on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remain in storage. Federal regulations require large quantity generators to submit a report every two years regarding the nature, quantities, and disposition of hazardous waste generated at their facility. The EPA refers to this as the National Biennial RCRA Hazardous Waste Report or Biennial Report. The Biennial Report form (EPA form 8700-13A/B) is submitted to the Idaho DEQ by March 1 of every even-numbered year for the previous calendar year. The biennial report was submitted to the electronic RCRA Info Industry Application (CCN 328539) for 2022. *RCRA Closure Plan.* There were no closure activities completed in 2022. *RCRA Inspection.* For FY 2022, Idaho DEQ performed an RCRA inspection from May 16–19, 2022. On July 21, 2022, Idaho DEQ issued a warning letter to DOE-ID and IEC related to two previously self-disclosed events resulting in permit noncompliances and one area of concern identified by Idaho DEQ during the May inspection. *RCRA Consent Order.* Due to DOE-ID's inability to meet commitments to initiate waste treatment in the Integrated Waste Treatment Unit (IWTU) and cease the use of the INTEC interim status tanks, Idaho DEQ assessed a penalty to DOE-ID pursuant to the provisions under Section VII of the fifth modification to the Notice of Noncompliance-Consent Order, in the amount of $1,458,000 for the period of noncompliance from March 1, 2021, to March 30, 2022. Supplemental environmental projects were utilized in lieu of the Original payment, and the fines were reduced due to adverse impacts to IWTU's outage schedule resulting from the COVID-19 global pandemic.		
OTHER ENVIRONMENTAL REQUIREMENTS			
DOE Order 231.1B, "Environmental, Safety, and Health Reporting" Environmental, Safety, and Health Reporting requires the timely collection and reporting of information on	This report, "*2022 Idaho National Laboratory Annual Site Environmental Report*," fulfills DOE O 231.1B, the radiation protection requirements of DOE O 458.1, and documents and communicates the environmental performance to members of the public living near the INL Site and to other interested parties.	N	All chapters

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
environmental issues that could adversely affect the human and safety of the public and the environment at DOE sites. *Other environmental statutes, regulations, and directives apply, in whole or in part:* • DOE O 458.1, Change 4, "Radiation Protection of the Public and the Environment."			
DOE Order 232.2A, "Occurrence Reporting and Processing of Operations Information" In accordance with DOE O 232.2A, Occurrence Reporting and Processing of Operations Information, the INL Site ensures DOE personnel are notified of events that could adversely affect the health and safety of workers, the public, the environment, DOE's missions, or the credibility of the Department. Events are provided report levels (High, Low, and Informational) to reflect the impact associated with a given occurrence in terms of health, safety and security. INL has a Tailoring Agreement in place that allows reporting most Informational events to DOE-ID through the INL issues management software (LabWay). Other events are also reported to DOE Headquarters through the Occurrence Reporting and Processing System (ORPS).	From January 1, 2022, to December 31, 2022, INL reported one event related to an environmental release. This event was reported and tracked in LabWay under Condition CO 2022-0600. On April 6, 2022, while conducting a corrective maintenance activity on MFC-786 substation transformer N-TF-055, a holding tank in the subcontractors self-contained filtration trailer failed and spilled approximately 200 gallons of transformer dielectric fluid to the ground. The process to filter the dielectric fluid (a soy-based oil) involves draining the oil to a tank, then heating and filtering it to remove impurities until it is clean enough to return it to the transformer. The cause of the tank failure is unknown. As a vegetable-based oil, the transformer dielectric fluid is deemed eco-friendly with no known hazardous constituents. No injuries or facility impacts resulted from the oil tank failure. Work was immediately stopped, and actions were taken to mitigate the spread of the oil by applying floor dry, pig mats, and spill blankets. Management, Environmental, and DOE were notified. Oil on the pavement was cleaned up on April 6, 2022. Oil that was spilled on the soil was cleaned and the INL Environmental Group evaluated the area on April 28, 2022, and determined no further action was required.	N	N/A
Emergency Planning and Community Right-to-Know Act (1986), 42 USC 11001, et seq. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 was created to help communities plan for emergencies involving hazardous substances. The Act helps increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities, working with facilities, can use the information to improve chemical safety and protect public health and the environment. *Other environmental statutes and regulations apply, in whole or in part:*	The INL Site's 2022 compliance with key EPCRA provisions is summarized below. • *Section 304: Extremely Hazardous Substance Release Notification* – There were no CERCLA-reportable chemicals released at the INL Site during 2022. 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). • *Section 311-312: Safety Data Sheet/Chemical Inventory* – Extremely hazardous substances, such as chlorine, cyclohexylamine, nitric acid, nitrogen dioxide, and sulfuric acid were among the chemicals reported in 2022.	N	2.5

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
• IDAPA 58.01.02.851, "Petroleum Release Reporting, Investigation, and Confirmation."	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 2022, the chemical inventory report included 75 individual chemicals at INL Site facilities and 14 at Idaho Falls facilities. The INL Site also stores extremely hazardous substances, a category of chemicals that could cause serious irreversible health effects from accidental releases. • *Section 313: Toxic Chemical Release Inventory Reporting* – The INL Site submitted Toxics Release Inventory Forms for chromium, diisocyanates, lead,naphthalene, nickel, nitrates and nitric acid, to EPA and Idaho DEQ by the regulatory due date of July 1. Section 313 requires facilities to submit a Toxics 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. *Reportable Environmental Releases* – No reportable spills for INL and ICP contractors in 2022.		
DOE Order 436.1, "Departmental Sustainability" The order defines requirements and responsibilities for managing sustainability withing DOE and to ensure that the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future.	DOE contractors at INL Site have developed site sustainability plans and have implemented environmental management systems (EMS) that are incorporated with the contractors' integrated safety management systems to promote sound stewardship practices and ensure compliance with DOE Order 436.1. Each contractor's EMS has been certified to the ISO 14001 Standard since 2005 and is certified by an external registrar every three years. Chapter 3 contains details on contractor EMS.	N	Chapter 3

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
Other environmental statutes and regulations apply, in whole or in part: • EO 13990, "Protecting Public Health and the Environmental and Restoring Science to Tackle the Climate Crisis" • EO 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability."			
Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" The purpose of this EO is to focus federal attention on the environmental and human health effects of federal actions on minority and low-income populations with the goal of achieving environmental protection for all communities. *Other environmental statutes and regulations apply, in whole or in part:* • EO 14008, "Tackling the Climate Crisis at Home and Abroad" • EO 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability."	DOE-ID and the INL evaluate the potential for environmental justice matters as part of the review processes implemented to identify potential environmental impacts from any and all proposed federal actions routinely as part of the NEPA compliance program. Consideration of environmental justice in NEPA analysis is driven by EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," and is further supported by EO 14008. The executive orders effectively direct federal agencies to identify disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority, low-income, and minority and low-income populations and to take action to address such impacts. Section 2.3 contains details of DOE-ID and INL's promotion of environmental justice and the outreach efforts that were taken in 2022.	N	2.3
RADIATION PROTECTION			
DOE Order 458.1, Change 4, "Radiation Protection of the Public and the Environment" "Radiation Protection of the Public and the Environment" was established to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE and DOE contractors.	The Order sets the public dose limit at a total effective dose not to exceed 100 mrem/yr (1 mSv/yr) above background radiation levels. Chapter 8 presents dose calculations for INL Site releases for 2022. The annual dose to the maximally exposed individual in 2022, as determined using Clean Air Act Assessment Package 88-PC, was 0.018 mrem (0.18 µSv). DOE standard DOE-STD-1196-2022 (DOE 2022), Derived Concentration Technical Standard, supports the implementation of DOE O 458.1. The standard defines the quantities used in the design and conduct of radiological environmental protection programs at DOE facilities and sites. These quantities, known as Derived Concentration Standards, 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)	N	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8 Appendix A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	effective dose following continuous exposure for one year via each of the following pathways: (1) ingestion of water, (2) submersion in air, and (3) inhalation. Measurements of radionuclides in environmental media sampled on and around the INL Site were all below applicable Derived Concentration Standards. DOE O 458.1 specifies the limits for unrestricted release of property to the public. All INL and ICP contractors use a graded approach for release of material and equipment for unrestricted public use. Material has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from controlled areas and includes the following: • Personal items or materials • Documents, mail, diskettes, compact disks, and other office media • Paper, cardboard, plastic products, aluminum beverage cans, toner cartridges, and other items for recycling • Office trash • Non-radiological area housekeeping materials and associated waste • Breakroom, cafeteria, and medical wastes • Medical and bioassay samples • Other items with an approved release plan. Items originating from radiological areas within the INL Site's controlled areas not in the listed categories are either surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces). When the process knowledge approach is employed, the history of the material confirms that no radioactive material has passed through or contacted the item. Items advertised for public sale via an auction are also surveyed by the contractor prior to shipment to the INL Site property/excess warehouse, where the materials are again resurveyed on a random basis by personnel prior to release, giving further assurance that material and equipment are not being released with inadvertent contamination.		

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	All contractors complete material surveys prior to release and transport to the state-permitted landfill at the Central Facilities Area. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the offsite treatment, storage, and disposal facilities that can accept low-level contamination. DOE-ID, using a graded approach, provides oversight of the INL clearance processes. For the 2022 calendar year there were 1,419 releases of personal property items with over 99% of these releases being for reuse at the INL (i.e., instruments for calibration, miscellaneous tools, and equipment). Those that were not released for reuse were released for appropriate disposal. On January 12, 2000, the Secretary of Energy established a DOE moratorium on the unrestricted release of all volumetrically contaminated metals. On July 13, 2000, DOE suspended "the unrestricted release for recycling of scrap metal from radiological areas within DOE facilities" (DOE Secretarial Memorandum: Release of Surplus and Scrap Materials; Memorandum from Bill Richardson to Heads of Departmental Elements). The moratorium and suspension of the release of metals from DOE sites remain in effect. INL and ICP contractors continue to follow the requirements of these Secretarial Memorandums. No scrap metal directly released from radiological areas is recycled.		
Toxic Substance Control Act (1976), 15 USC 2601 et seq The TSCA, which is administered by the EPA, requires the regulation of production, use, or disposal of chemicals. TSCA supplements sections of the CAA, the Clean Water Act (CWA), and the Occupational Safety and Health Act. *Other environmental statutes and regulations apply, in whole or in part:* • 40 CFR 761, Subpart J, "General Records and Reports."	Because the INL Site does not produce chemicals, compliance with the TSCA is primarily directed towards the use and management of certain chemicals—particularly polychlorinated biphenyls (PCBs). The INL Site manages radioactive mixed waste containing PCBs received from other DOE Sites many years ago for disposal. Environmental remediation activities include the re-processing of these waste materials for disposition off-site. In addition, PCBs were used in the manufacture of many different items and materials including liquid filled electrical equipment such as transformers and capacitors, paint, and caulking. Whenever any of these items or materials are discovered, they are disposed of off the INL Site at a TSCA-approved disposal facility. Requirements for the reporting of PCB-related activities are found in 40 CFR 761, Subpart J, "General Records and Reports." These regulations require a facility to maintain a written record documenting all PCB management activities until the PCBs are disposed of; the written record must be available for inspection or submission if requested by the EPA. It must be prepared each year by July 1 and maintained at the facility for at least three years after the	Y	N/A

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
	facility ceases using or storing PCBs and PCB items. INL Site prepares the required annual documentation each year. It includes an inventory of PCB/radioactive waste in storage at INL for the previous year and documents progress made toward disposal in accordance with applicable regulations. The written record for the annual documentation is issued on the Electronic Document Management System by July 1 in accordance with CCN 246686 and the "Interface Agreement between INL, ICP, and NRF contractors for Environmental Reporting," IAG-681 (INL 2022). CCN 246686 documents EPA's approval to revise our procedures for issuing the written record to match the TSCA regulations. The INL contractor manages TSCA Risk-based Disposal Approval (RBDAs) at the ATR Complex that establishes an agreement with the EPA to properly dispose of and/or contaminate PCB waste in accordance with 40 CFR 761. TSCA RBDAs are situation based off discovery with the intentions of minimizing risk to human health and the environment. TRA-641 was developed to address painted surfaces in the empty canal under 40 CFR 761.62(c) for paint, and under 40 CFR 761.61(c) for PCBs that may have penetrated the concrete. TRA-619 was developed to address the short-term cleanup and disposal of PCBs under 40 CFR 761.61(c) that have penetrated the concrete flooring from the application of PCB paint. The ICP contractor holds RBDAs, granted by EPA Region 10, which allow for processing of PCB-contaminated legacy sludge wastes from Rocky Flats Plant at two of the facilities located at the RWMC. Per 40 CFR 761.20(c)(2)(ii), processing activities which are primarily associated with and facilitate treatment or disposal require a TSCA PCB approval. Work performed under these RBDAs ensures that these wastes can be accepted for disposal at the Waste Isolation Pilot Plant near Carlsbad, New Mexico.		
WATER QUALITY AND PROTECTION			
Clean Water Act (1972), 40 CFR 109-140, 33 USC 1251, et seq. The CWA established goals to control pollutants discharged to U.S. 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. *Other environmental statutes and regulations apply, in whole or in part:*	The Idaho DEQ is authorized by the EPA as the permitting authority over the National Pollutant Discharge Elimination System program. The Idaho DEQ program is called the Idaho Pollutant Discharge Elimination System (IPDES). INL and ICP contractors do not currently hold any IPDES permits but in-town facilities discharge to the city of Idaho Falls wastewater treatment plant, which is required by the IPDES permit program to set pretreatment standards for nondomestic discharges to publicly owned treatment works. The INL Research Center complied with an Industrial Wastewater Acceptance permit for discharges to the city of Idaho Falls in Idaho. This program is set out in Title 8, Chapter 1 of the Municipal Code of the city of Idaho Falls, Idaho. All discharges in 2022 were within levels established in the INL Research Center Industrial Wastewater Acceptance permit. The city of Idaho Falls, Idaho, did not perform an inspection in 2022.	Y	N/A

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
• IDAPA 58.01.16, "Wastewater Rules" • IDAPA 58.01.25, "Rules Regulating the Idaho Pollutant Discharge Elimination System Program."			
Idaho Reuse Permits Idaho defines recycled water as water that has been treated by a wastewater treatment system and is used in accordance with the Recycled Water Rules. *Other environmental statutes and regulations apply, in whole or in part:* • IDAPA 58.01.11, "Ground Water Quality Rule" • IDAPA 58.01.16, "Wastewater Rules" • IDAPA 58.01.17, "Recycled Water Rules."	Wastewater is the spent water or effluent from activities and processes occurring in dwellings, commercial buildings, industrial plants, institutions, and other establishments. If the wastewater contains sewage, it is considered municipal wastewater. If it does not contain sewage, it is considered industrial wastewater. Recycled water is wastewater effluent that is treated, if necessary, and then reused for other purposes. The Idaho DEQ encourages reuse, which is the practice of using recycled water for irrigation, ground water recharge, landscape impoundments, toilet flushing in commercial buildings, dust control, and other beneficial uses. The Idaho DEQ requires anyone choosing to use recycled water to obtain a reuse permit. Reuse permits consider the site-specific conditions of each facility and include site-specific limits and conditions, as applicable, to protect public health and the environment, including groundwater. The Idaho DEQ issues these 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." The following facilities have reuse permits at the INL Site: • Advanced Test Reactor Complex Cold Waste Ponds (I-161-03) • INTEC New Percolation Ponds (M-130-06) • MFC Industrial Waste Pond (I-160-02). Idaho DEQ inspected the INL and ICP contractors reuse systems in April 2022. All reuse systems at the INL Site were operated in substantial compliance with permit requirements during 2022.	Y	Chapter 5 Chapter 6 Appendix A
Safe Drinking Water Act (1974), 40 CFR 141-143, 42 USC 300f, et seq. The Safe Drinking Water Act establishes primary standards for public water supplies to ensure it is safe for consumption. *Other environmental statutes and regulations apply, in whole or in part:* • 40 CFR 141, "National Primary Drinking Water Regulations"	INL Site drinking water complied with all applicable federal and state water quality standards in 2022. Eleven potable water systems are permitted by Idaho DEQ. Each potable water system is sampled according to a monitoring cycle that identifies specific contaminants and sampling frequency, ranging from monthly, quarterly, or once every 1, 3, 6, or 9 years. In addition to regulatorily required sampling, INL Site contractors performed additional surveillance monitoring for bacteriological contaminants, radiological	N	2.3.2 6.7

Table 2-1. continued.

REGULATORY PROGRAM DESCRIPTION	2022 COMPLIANCE STATUS	PERMIT REQUIRED Y/N	REPORT SECTIONS
• 40 CFR 143, "National Secondary Drinking Water Regulations" • IDAPA 58.01.08, "Idaho Rules for Public Drinking Water Systems."	contaminants, and per- and poly-fluoroalkyl substances in 2022. The ICP contractor did not sample for per- and poly-fluoroalkyl substances in 2022.		
QUALITY ASSURANCE			
10 CFR 830, Subpart A, "Quality Assurance Requirements" 10 CFR 830, Subpart A establishes quality assurance requirements for contractors conducting activities, including providing items or service that affect, or may affect, nuclear safety of DOE nuclear facilities. *Other environmental statutes and regulations apply, in whole or in part:* • DOE O 414.1D, Change 2, "Quality Assurance"	Quality assurance and quality control programs were maintained in 2022 by INL Site contractors and laboratories performing environmental analyses. Results are summarized in Chapter 10, Section 10.3. Field sampling elements, laboratory measurements, and performance evaluation samples were reviewed and evaluated for each INL contractor laboratory. Together this information was used to assess the quality of data provided to INL Site contractors, and to follow-up and/or conduct corrective action to improve processes when necessary. This multi-faceted approach to quality assurance and quality control added value to each INL Site contractor's monitoring program by providing confidence that all laboratory data reported in this report are reliable and of acceptable quality.	N	Chapter 10

Table 2-2. 2022 status of active Waste Area Groups.

WASTE AREA GROUP	FACILITY	STATUS
1	Test Area North	Groundwater cleanup of trichloroethene for Operable Unit 1-07B continued through 2022 in accordance with EPA and Idaho DEQ approved plans (DOE-ID 2022b, 2022c). 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 (ISB) 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. Two ISB injection wells were constructed in 2015 to further ISB efforts and one monitoring well was constructed in 2017 to better monitor the plume at its distal edge. During 2021, one ISB injection well was constructed, and further ISB continues in a specific area where previous efforts had not achieved the desired reduction in contaminant levels. All institutional controls (IC) and operations and maintenance (O&M) requirements were maintained during 2022. However, the required daily inspections were completed during this time. The agencies were notified and corrective actions were completed.
3	Idaho Nuclear Technology and Engineering Center	The Idaho CERCLA Disposal Facility, located southwest of INTEC, disposes of contaminated soils and debris from CERCLA remediation operations for the protection of human health and the environment. Operations and monitoring at Idaho CERCLA Disposal Facility (ICDF) are carried out in accordance with EPA and Idaho DEQ approved plans (DOE-ID 2018a, 2019b, 2019c). Consolidation of waste at the ICDF reduces the risk of exposure to contaminants for human and ecological receptors, and the use of an engineered facility with leachate collection protects the underlying Snake River Plain Aquifer (SRPA). The ICDF functions as an INL sitewide disposal facility for CERCLA soils and debris from other WAGs in compliance with strict waste acceptance criteria. 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 and SRPA are sampled annually; results are sent to the EPA and Idaho DEQ. Remedial actions and monitoring required by the WAG 3, Operable Unit 3-14 ROD (DOE-ID 2007a) are implemented through EPA- and Idaho DEQ-approved plans (DOE-ID 2018b, 2018c). Remedial actions at the Tank Farm Facility (TFF) are designed to reduce water infiltration that potentially could transport contaminants from the vadose zone and the perched water to the underlying aquifer. An interim low-permeability asphalt barrier was placed over the western two-thirds of the TFF during 2017 to further reduce infiltration of precipitation water until a final cover is constructed over the TFF after closure of the final four tanks. Perched and groundwater monitoring under and near the TFF will continue until the risk posed by contamination left in place is below target levels. All ICs and O&M requirements were maintained in 2022.
7	Radioactive Waste Management Complex	WAG 7 includes the Subsurface Disposal Area (SDA), a 97-acre radioactive waste landfill that is the major focus of remedial response actions at the RWMC (Figure 2-2). Waste is buried in approximately 35 of the 97 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 disposal time. Initial operations began in 1952 and 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 RWMC for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era.

Table 2-2. continued.

WASTE AREA GROUP	FACILITY	STATUS
		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 (TRU) isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of TRU 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 at the active low-level waste disposal facility (ALLWDF). Disposal of waste from offsite generators was discontinued in the early 1990s, and disposal of contact-handled waste was discontinued at the end of FY 2008. Disposal operations at the ALLWDF were completed in May 2021, and interim closure of the ALLWDF was completed in August 2022 (MacRae 2022). Final closure of the SDA and ALLWDF is addressed under the Operable Unit (OU) 7-13/14 ROD. The OU 7-13/14 ROD (DOE-ID 2008) is consistent with DOE's obligations for TRU waste removal under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the Idaho DEQ and DOE-ID, 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) of targeted waste from a minimum combined area of 5.69 acres. Targeted waste for retrieval contains TRU 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 and were completed in December 2021. The retrieved targeted waste is packaged, certified, and shipped out of Idaho. As of April 2022, 10,417.5 m^3 (13,625.58 yd^3) of targeted waste has been retrieved and packaged for off-site shipment. In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of vapor-vacuum extraction and treatment of solvent vapors from the subsurface (completed in July 2022; RPT-1904) and in situ grouting of specified waste forms containing mobile contaminants (completed in 2010; DOE-ID 2011a). Quarterly monitoring of the solvent vapors in the vadose zone will continue in accordance with the Operations and Maintenance Plan (DOE-ID 2017a). The third and final phase of the ROD includes constructing an evapotranspiration surface barrier over the entire SDA landfill, followed by long-term management and control after construction is complete. Construction is scheduled to be complete by 2028.
10	10-04 INL Site-wide Miscellaneous Sites and Comprehensive RI/FS	OU 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 2022, under the site-wide IC/O&M Plan (DOE-ID 2017b). The fourth site-wide CERCLA five-year review covering the period from 2015 through 2019 was finalized in January 2021. The purpose of the CERCLA five-year review is to verify that implemented cleanup actions continue to meet cleanup objectives documented in RODs.
	10-08 INL Sitewide Groundwater, Miscellaneous Sites, and Future Sites	OU 10-08 addresses site-wide groundwater, miscellaneous sites, and future sites (DOE-ID 2009). Response actions for OU 10-08 are mostly complete, and ongoing activities include groundwater monitoring and evaluating and remediating potential new sites that are discovered. Biennial groundwater monitoring will continue in 2023 (DOE-ID 2014) to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

Table 2-3. Radioactive wastes managed at the INL Site.

FACILITY	GENERATION	TREATMENT	STORAGE	DISPOSAL
INL CONTRACTOR				
Advanced Test Reactor Complex	LLW[a]	—	LLW	—
Central Facilities Area	LLW	—	LLW	—
MFC/INTEC	TRU[a]/LLW	LLW	TRU/LLW	—
Material Security and Consolidation Complex	LLW	—	LLW	—
Remote-Handled Low-Level Waste Disposal Facility	LLW	—	LLW	LLW
Research and Education Campus	LLW	—	LLW	—
Specific Manufacturing Capability	LLW	LLW	LLW	—
ICP CONTRACTOR				
Advanced Mixed Waste Treatment Project	TRU/LLW	TRU/LLW	TRU/LLW	—
ICDF	—	—	—	LLW
INTEC Calcined Solids Storage Facility	—	—	HLW	—
INTEC Tank Farm Facility	—	—	HLW	—
IWTU	—	HLW[a]	HLW	—
RWMC Accelerated Retrieval Project	TRU/LLW	TRU/LLW	TRU/LLW	—
RWMC ALLWDF	—	—	—	LLW

a. HLW – high-level waste; LLW – low-level waste; TRU – transuranic.

Table 2-4. Listing of the status of each phase of the LLW management process for sites authorized to manage a LLW facility.

PHASE	REMOTE-HANDLED LLW DISPOSAL FACILITY	RADIOACTIVE WASTE MANAGEMENT COMPLEX (RWMC) ACTIVE LLW DISPOSAL FACILITY	ICDF
Performance Assessment (PA)	DOE/ID-11421 (DOE-ID 2018d), “Performance Assessment for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility”	DOE/NE-ID-11243 (DOE-ID 2007b), “Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site”	DOE/ID-10978 (DOE-ID 2011b), “Performance Assessment for the Idaho CERCLA Disposal Facility Landfill”
Composite Analysis (CA)	DOE/ID-11422 (DOE-ID 2016b), “Composite Analysis for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility”	DOE/NE-ID-11244 (DOE-ID 2008b), “Composite Analysis for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site”	DOE/ID-10979 (DOE-ID 2006), “Composite Analysis for the INEEL CERCLA Disposal Facility Landfill”
Closure Plan	PLN-3370, “Preliminary Closure Plan for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility”	RPT-576, “Interim Closure Plan for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site”	A preliminary closure plan was developed for the entire ICDF Complex closure. This plan was included in the “ICDF Complex Remedial Action Work Plan” (DOE/ID-10984) (DOE-ID 2012)

Table 2-4. continued.

PHASE	REMOTE-HANDLED LLW DISPOSAL FACILITY	RWMC ACTIVE LLW DISPOSAL FACILITY	ICDF
PA/CA Maintenance Program	PLN-3368, "Maintenance Plan for the Remote-Handled Low-Level Waste Disposal Facility Performance Assessment and Composite Analysis"	RPT-431, "Performance Assessment and Composite Analysis Maintenance Plan for the RWMC Active Low-Level Waste Disposal Facility"	RPT-791, "Performance Assessment and Composite Analysis Maintenance Plan for the Idaho CERCLA Disposal Facility"
Latest Annual PA/CA Summary Report	INL/RPT-23-70876 (INL 2023), "Annual Summary Report for the Remote-Handled Low-Level Waste Disposal Facility – FY 2022"	RPT-2080, "Annual Summary Report: Review for Continued Adequacy of the Performance Assessment, Composite Analysis, and Supporting Documents for the Active Low-Level Waste Disposal Facility at the RWMC – FY 2022"	RPT-2079, "Annual Summary Report: Review for Continued Adequacy of the Performance Assessment, Composite Analysis, and Supporting Documents for the ICDF Landfill – FY 2022"
Disposal Authorization Statement (DAS)	Bishop, T., memorandum to R. Provencher, May 22, 2018, "Operating Disposal Authorization Statement for the Remote-Handled Low-Level Waste Disposal Facility Idaho National Environmental Laboratory, Idaho," U.S. DOE-NE, May 22, 2018	Marcinowski, F., memorandum to E. Sellers, January 30, 2008, "Revision of the Disposal Authorization Statement for the Idaho National Laboratory Active Low-Level Waste Disposal Facility within the Radioactive Waste Management Complex," CCN 323845	Marcinowski, F., memorandum to R. Provencher, April 7, 2011, "Revision of the Disposal Authorization Statement for the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility," CCN 311791

2.3 Environmental and Energy Justice

The DOE defines environmental justice (EJ) as the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (energy.gov). Several executive orders require federal departments to address EJ: EO 12898*, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, Section 1-1; EO 14008, *Tackling the Climate Crisis at Home and Abroad*, Section 219; and EO 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*, Section 402.

Additionally, the federal government established the Justice40 Initiative with a goal that 40 percent of the overall benefits of certain federal investments flow to disadvantaged communities, which have been marginalized, underserved, and overburdened by pollution. The seven categories of investment include climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, training and workforce development, remediation and reduction of legacy pollution, and the development of critical clean water and wastewater infrastructure. Through the Inflation Reduction Act, Bipartisan Infrastructure Law, and the American Rescue Plan, federal agencies are making historic levels of investment to advance EJ.

To aid in the identification and tracking of these disadvantaged communities, the President's Council on Environmental Quality has developed the Climate and Economic Justice Screening Tool (CEJST). The tool identifies U.S. communities that have faced historic injustices and have been overburdened and underserved. This includes federally recognized tribes, including Alaska Native Villages. CEJST contains an interactive map tied to several datasets and uses established thresholds to determine if census tracts meet the definition of a disadvantaged community. The eight categories for burden indicators include: climate change, energy, health, housing, legacy pollution, transportation, water, and wastewater, and workforce development. Additionally, the categories must be at or above the threshold for an associated socioeconomic burden to be highlighted as a disadvantaged community. The CEJST has identified several tracts within the Idaho counties of Bingham, Clark, Butte, and Jefferson as disadvantaged. CEJST also identifies the entirety of the Fort Hall Indian Reservation as a disadvantaged community.

2.3.1 Initiatives

The INL Site established an Environmental Justice Program (EJP) in 2021. The INL Site's EJP recognizes that communities across the globe will be tackling similar challenges in the transition to clean energy. The INL Site aspires to be an EJ leader, setting an example of how to incorporate multiple voices and viewpoints in efforts to ensure a just energy transition inclusive of EJ priorities and community engagement. The program focuses on the sustainable stewardship of natural resources through relationships between humans and environmental systems.

To that end, the INL Site and EJP have worked diligently to incorporate Indigenous and Traditional Ecological Knowledge (ITEK) into laboratory policies, procedures, and practices. ITEK is a repository of natural and ecological knowledge refined through thousands of years of tribal stewardship. ITEK-informed decision making is a federal priority and is recognized as one of the many important bodies of knowledge that contributes to the scientific, technical, social, and economic advancements of the U.S. and our understanding of the natural world. ITEK-informed science and decision making will be essential as the nation navigates climate change and energy transition. These global challenges demand disparate knowledge and solutions to inform and work cohesively with the scientific process toward a sustainable future.

DOE-ID established a Working Agreement with the Shoshone-Bannock Tribes in 1992 that was later developed into an Agreement-In-Principle or AIP. DOE-ID and the Tribes have negotiated multiple five-year AIPs since that initial Working Agreement, the latest of which was signed in September 2022 (https://idweb.id.doe.lcl/IDMSOther/PDF/AIP_Signed.pdf). The AIP is designed to promote increased interaction and cooperation on issues of mutual concern. This AIP reflects the understanding and commitment between the parties to increase the tribes' level of assurance that activities conducted at the INL Site protect the health, safety, environment, and cultural resources and address tribal interests in DOE-administered programs. It is applicable to actions and operations of DOE-ID and its contractors on the lands of the INL Site that affect original ancestral territory and tribal lands. DOE-ID considers the AIP as an important mechanism through which environmental and energy justice matters are addressed. Annual funding from DOE-ID through Cooperative Agreements support the Tribal DOE and Office of Emergency Management programs.

The INL Site established a Memorandum of Understanding with the Shoshone-Bannock School District #537 and collaborated closely with the tribes to create meaningful education and career pathways for tribal students. This Memorandum of Understanding creates a place-based, culturally responsive program designed to both bring opportunities to tribal schools and bring students to the laboratory for work-based learning. The K–12 Education team assisted faculty and administration to design culturally responsive teaching and learning through project-based, place-based and service-learning approaches as they work towards science, technology, engineering, and mathematics (STEM) school designation. At the request of a tribal elder, students received a valuable cultural lesson making a *bodo'* (stick), which is traditionally used to dig up bulbs harvested on tribal lands.

First-year coursework was successfully designed and delivered in both the industrial mechanics and construction trades pathways. Shoshone-Bannock High School Career technical students studying either industrial mechanics or construction trades were eligible to participate in a six-week paid summer internship at the INL Site, working under the supervision of instructors and safety personnel through the INL Site Future Corps Program. In 2022 the first cohort of high school students for the Work-Based Learning Program spent six weeks working onsite with mentors from INL Site's Facilities and Site Services and MFC directorates to explore trades, crafts, fabrication, and operations. The coursework and Work-Based Learning Program prepares students with the skills and experience necessary for entry-level trades and crafts positions at the INL Site.

The INL Site K–12 Education team collaborated with the lab's INL Site's Cultural Resource Management Office to sponsor Earth Day activities for every age group, including an art contest, a traditional native ceremony, a cultural resource tour of the Middle Butte Cave, and a Shoshone-Bannock-led dancing exhibition at the lab's Central Facilities Area for nearly 80 Shoshone-Bannock Tribal members and students. The INL Ste also held an event at Chief Tahgee Elementary Academy in Fort Hall with hands-on activities for students. Nearly 1,800 Earth Day STEM learning kits were distributed to local and regional classrooms (Figure 2-1).

The INL Site's K–12 Education team hosted community STEM nights at all Shoshone-Bannock lodges and at the Shoshone-Bannock High School on the Fort Hall Indian Reservation for students and their families with interactive STEM learning activities.

The DOE Idaho Cleanup Project (DOE-ICP) is working towards the end state and long-term stewardship (LTS) of the INL Site. It is commonly accepted amongst DOE, tribes, and stakeholders that LTS is the actions that survey/monitor and maintain Land Use Controls and ensures the protection of human and health and the environment is accomplished in perpetuity. In FY 2022, DOE-ICP provided funding for the Shoshone-Bannock Tribal DOE and Air Quality Program and Heritage Tribal Office cultural resources program involvement in LTS activities to develop and implement a Tribal LTS Program on the INL Site. The Tribal LTS Program will work to integrate culturally based knowledge and principles into existing ICP LTS plans and activities. The tribal LTS Program will form a "Tribal LTS Collaborative Group" to ensure the Tribes' goals are implemented in coordination with the Fort Hall Business Council, Tribal Departments, and the DOE-ICP.

Figure 2-1. Students from the Shoshone-Bannock Tribes discussing salmon migration with INL staff.

The DOE-ID and INL Site evaluate the potential for EJ matters as part of the review processes implemented to identify potential environmental impacts from all proposed federal actions routinely as part of the NEPA compliance program. Consideration of EJ in NEPA analysis is driven by EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," and is further supported by EO 14008. The EOs effectively direct federal agencies to identify disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority populations and low-income populations and to take action to address such impacts. Although EJ has been a part of the INL Site NEPA processes since President Clinton signed the EO 12898 in 1994, the INL Site's NEPA team and the EJ program have made significant efforts in recent months to become a leader in EJ within the national laboratory system.

In the sustainability realm, the DOE Bioenergy Technologies Office (BETO), Argonne National Laboratory, and the INL Site K–12 Education Team created a bioenergy toolkit for educators as part of the Bioenergy Research and Education BRIDGES project. The toolkit translates DOE scientific bioenergy research to the classroom, providing equitable access to high quality learning materials and easing the transition from academics to industry, as part of a workforce development and diversity, equity, and inclusion initiative. The INL Site designed and field tested two case studies aligned to the laboratory's Bioenergy Science and Technology portfolio and industry needs, called "Regional Feedstocks: Are They the Answer to Achieving Net Zero?" and "Solid Waste to Energy: Traditional Ecology and Environmental Justice." The case studies draw inspiration from BETO science and technology research for long-term adaptation, resiliency, and sustainable practices and policies for historically marginalized communities across the United States. BRIDGES is built on a framework that allows for place-based learning and culturally responsive teaching, supporting diversity, equity, and inclusion initiative.

2.4 INL Site Agreements

DOE-ID has three major site agreements that contain regulatory commitments and milestones. These major site agreements are known as the Site Treatment Plan (STP), the Idaho Settlement Agreement (ISA), and the Notice of Noncompliance/Consent Order (NON/CO).

The Federal Facility Compliance Act of 1992 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 Federal Facility Compliance Act Consent Order and STP was finalized and signed by the state of Idaho on November 1, 1995, and is updated annually (DEQ 1995). This plan outlines DOE-ID's proposed treatment strategy for the mixed waste streams, called the backlog, and identifies onsite and offsite mixed low-level waste treatment capabilities.

During 2022, DOE-ID completed four STP milestones including two milestones associated with the treatment of remote-handled waste, one certification milestones of original volume TRU-contaminated contact-handled waste, and the treatment of sludge contaminated waste. DOE-ID made a request to the Idaho DEQ to extend milestones associated with the start-up of the IWTU and treatment of sodium bearing waste, which the state approved in October of 2022.

On October 16, 1995, DOE-ID, the U.S. Navy, and the Idaho DEQ entered into an agreement (also known as ISA) that guides management of Spent Nuclear Fuel (SNF), high-level waste, and TRU waste at the INL Site. The agreement (DOE 1995) limits shipments of DOE-ID and Naval SNF into the state and sets milestones for shipments of SNF and radioactive waste out of the state.

The ISA, as related to requirements found in the Agreement to Implement, dated May 25, 2006, required the exhumation of transuranic waste from the SDA at the RWMC. The DOE and the ICP workforce safely completed the required 5.69-acre exhumation and removal of associated targeted waste ahead of the regulatory milestone due date.

The STP and the ISA required DOE-ID to process and ship all covered waste out of Idaho by December 31, 2018, respectively, stored as TRU waste on the INL Site in 1995, when the agreements were signed. 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 Idaho DEQ; an addendum to the ISA was signed on November 6, 2019, to address the milestone.

As of December 31, 2022, a total of 61,508 m^3 (80,449 yd^3) of original volume TRU-contaminated waste had been processed (i.e., shipped or certified for disposal to Waste Isolation Pilot Plant [WIPP]). DOE-ID completed certification of 25% of the original volume TRU contaminated waste remaining inventory to be certified for shipment and disposal at WIPP. DOE-ID made 150 shipments of ISA TRU waste to WIPP in 2022, comprised of 148 shipments of legacy TRU waste and two shipments of buried TRU.

The ICP contractor manages and operates several projects to facilitate the disposition of radioactive waste as required by the ISA and STP. The Advanced Mixed Waste Treatment Project performs retrieval, characterization, treatment, packaging, and shipment of TRU 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 TRU radioactive elements (primarily plutonium).

The final agreement, the NON/CO and recent modification, in conjunction with the STP, requires the treatment of sodium-bearing waste to be stored at the INTEC Tank Farm at the IWTU. To meet the milestones in the NON/CO and STP, DOE-ID and its ICP contractor continued their methodical approach to start up the IWTU, which is designed to process the remaining 3,407,000 L (900,000 gal) of liquid waste stored at INTEC. This waste is stored in three stainless steel underground tanks, and a fourth is always kept empty as a spare. All four tanks 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 begin processing in 2012, but several technical problems have delayed IWTU.

The IWTU completed a facility outage implementing needed facility modifications in preparation for supporting sustained radiological waste treatment operations in July 2021. Following successful completion of readiness verification activities, the IWTU commenced a final confirmatory run-on simulant waste feed in late 2021. Technical challenges delayed completion of the final confirmatory run until mid-2022. These issues were adequately resolved, and the facility re-commenced its test run in May. The facility successfully completed the final confirmatory run-in late July 2022 along with a final round of readiness assessments for radiological operations. The facility processed 137,000 gallons of simulated waste over 65 days of continuous operation filling 125 product canisters. The facility shutdown and entered a planned outage to inspect process vessels/components, conduct maintenance and make minor modifications which concluded in November. The facility-initiated plant start-up for simulant testing in late 2022 with the intent to transition into radiological waste treatment operations. Radiological operations were targeted to begin in early calendar year 2023. The facility initiated a controlled shutdown in late December 2022 to investigate and repair an observed solids leak in a canister fill cell.

2.5 Low-Level and Mixed Radioactive Waste

In 2022, approximately 994 m^3 (1,300 yd^3) of mixed low-level waste and 360 m^3 (471 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both, by the ICP contractor. In 2022, no low-level waste was disposed of at the SDA (Figure 2-2).

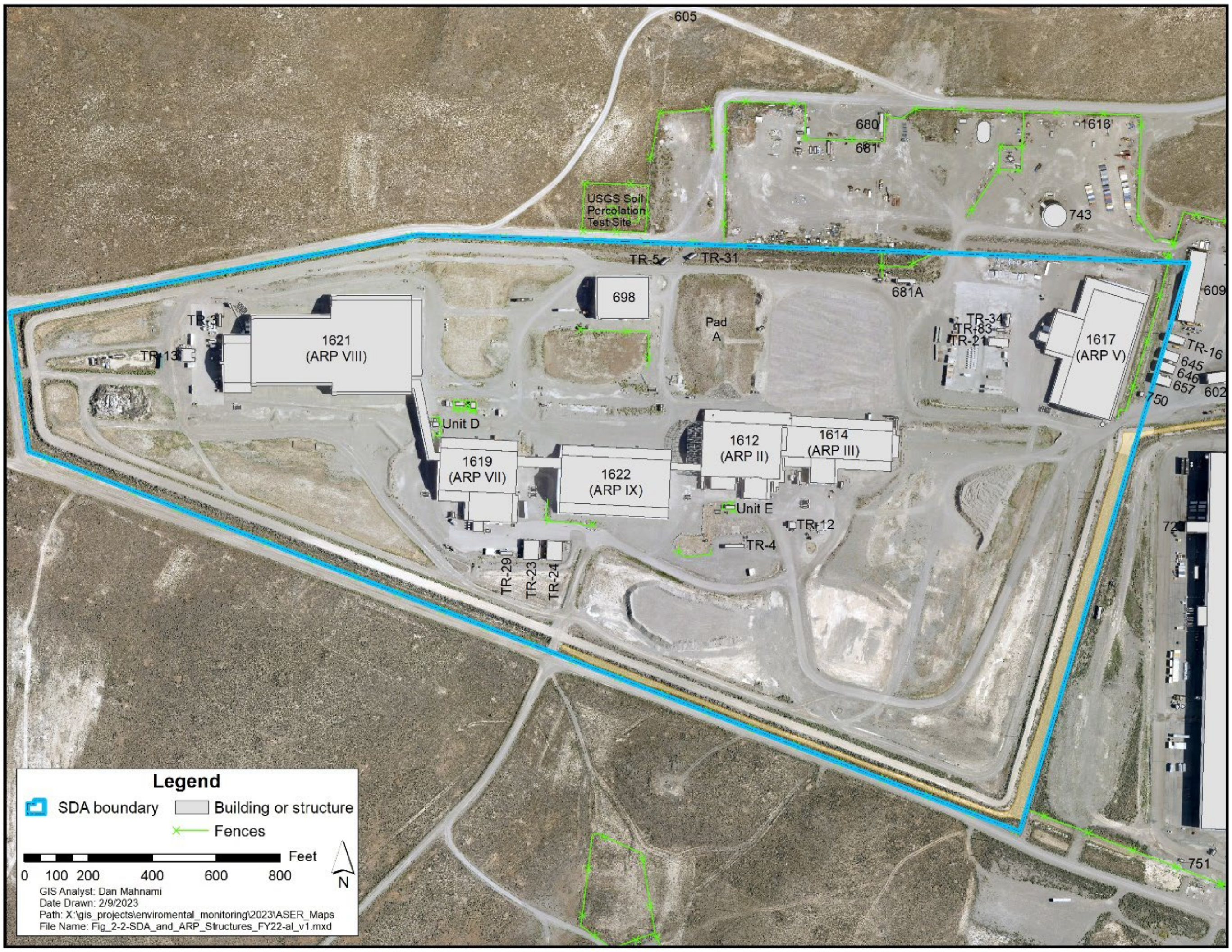

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2022).

2.5.1 Spent Nuclear Fuel

SNF is nuclear fuel that has been withdrawn from a nuclear reactor following irradiation and the constituent elements have not been separated. SNF contains unreacted uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. DOE-ID's SNF is from the 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 Idaho Energy Coalition, the ICP contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility, and the INL contractor at the Advanced Test Reactor Complex and MFC.

The ISA put milestones into place for the management of SNF at the INL Site:

- DOE-ID shall complete the transfer of spent fuel from wet storage facilities by December 31, 2023 (Paragraph E.8)

- DOE-ID 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.

2.6 Release and Inventory Reporting at the INL Site

2.6.1 Spills and Releases

There were no reportable spills for INL or ICP in 2022.

2.6.2 Unplanned Releases

INL and ICP had no unplanned release of a hazardous substance that required notification to the regulatory agencies for 2022.

2.7 Environmental Permits

Table 2-5 presents the complete list of all federal and state permits active during 2022 for INL Site operations. This table includes those pertaining to air emissions, groundwater, surface water, RCRA, and ecological.

Table 2-5. Environmental permits for the INL Site (2022).

PERMIT TYPE	ACTIVE PERMITS
AIR EMISSIONS	
Synthetic Minor	1
ECOLOGICAL	
Migratory Bird Treaty Act Special Purpose Permit	2
Wildlife Collection/Banding/Possession Permit	2
GROUNDWATER	
Injection Well	2
Well Construction	3[a]
RESOURCE CONSERVATION AND RECOVERY ACT	
Part A (Interim Status)	2[b]
Part B	7[b]
RECYCLED WATER	
Reuse Permits	3
SURFACE WATER	
Industrial Wastewater Acceptance	1
TOXIC SUBSTANCES CONTROL ACT	
Risk-Based Disposal Approval[c]	4

a. Construction of wells USGS-151, and USGS-152 have been cored and continued construction is planned for FY 23-24. Borehole USGS-150 is planned for abandonment in FY 23-24. Permits are only required for construction of wells, not operation.

b. Part A interim status units are those units with Part A permit applications (interim status) that have not been RCRA closed. Partial Part B permits include the Part A application and the Part B application. The Part A addresses each of the permitted units in the Part B, and the Part B includes specific details and permit operating requirements. A partial permit that includes the unit-specific Part A and B is considered a RCRA partial Part B permit. There are seven RCRA partial Part B permits for the INL Site.

c. Risk-Based Disposal Approvals are permit-like documents granted by the EPA.

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Chapter 3: Environmental Management Systems

CHAPTER 3

The Idaho National Laboratory (INL) and Idaho Cleanup Project Environmental Management Systems implement the U.S. Department of Energy (DOE) commitments for the 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, natural, archeological, and cultural resources potentially affected by operations and activities conducted at the INL Site. This policy is implemented by integrating environmental requirements, pollution prevention, and sustainable practices into work planning and execution and by taking actions to minimize the impact of INL Site operations and activities.

3. ENVIRONMENTAL MANAGEMENT SYSTEMS

The framework that 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, 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 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," and DOE O 436.1, "Departmental Sustainability," which require federal facilities to put EMSs into practice. Sites must maintain their EMS either by being certified for use or in conformance with the ISO 14001:2015 standard following the accredited registrar provisions or self-declaration instructions.

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. INL complies 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 and the U.S. Department of Energy, Idaho Operations Office (DOE-ID), and includes the Idaho Falls campus and the research and industrial complexes termed the "INL Site" that is located 50 miles west of Idaho Falls, Idaho. For the purpose of this report, INL consists of those facilities operated by Battelle Energy Alliance, LLC (INL contractor), or by the Idaho Environmental Coalition, LLC (Idaho Cleanup Project [ICP] contractor). INL and ICP contractors are referred to by their noted acronyms and include all facilities under their individual responsibilities.

The two main contractors have established EMSs for their respective operations. The INL and ICP have been certified to meet the requirements of ISO 14001 since 2005. In 2019, the INL contractor became the first DOE national laboratory to be certified by the Nuclear Quality Assurance Certification Program. Many elements of the Nuclear Quality Assurance-1 align with and complement the ISO 14001:2015 standard.

INL and ICP contractors have established EMSs for their respective operations and were last certified to the ISO 14001:2015 standard in 2020. Recertification of the EMS is required every three years. INL and ICP contractors will undergo a recertification audit in 2023 to the current standard. The EMS is audited annually to verify that it is operating as intended and in conformance with ISO 14001:2015 standards. INL and ICP contractors were both audited in 2022 by an external, accredited auditor and were recommended for continued certification to the ISO 14001:2015 standard. Results from the INL contractor audit showed no nonconformities, four management system strengths, and no opportunities for improvement. Results from the ICP audit showed no nonconformities and four management system strengths.

3.1 Environmental Management System Structure

The INL and ICP contractors' EMSs incorporate a Plan-Do-Check-Act approach to provide a framework under which the environmental, safety, and health programs are managed.

- Plan – Defines work scope, identifies environmental aspects, analyzes hazards, and develops hold points and mitigations
- Do – Implements defined controls and performs the work scope
- Check – Evaluates performance, management reviews, and contractor's assurance practices
- Act – Incorporates corrective actions, improvements, and lessons learned into practices.

This approach is interactive and iterative through the various work activities and functions, including policies, programs, and processes. The approach is also an integral part of the overall management of the Site's environmental compliance and performance. The main focuses of this cycle are on (1) environmental policy, (2) planning, (3) implementation and operation, (4) checking and corrective action, and (5) management review.

3.2 Environmental Policy

INL and ICP contractors state their commitments to the environment through an overarching policy that is displayed to employees. The policy commits specifically to do the following:

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

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

3.3 Plan

3.3.1 Environmental Aspects

INL and ICP contractors have evaluated their activities, products, and services to identify the environmental aspects of its work activities that could affect the environment or the public or result in noncompliance with regulatory requirements. INL and ICP contractors perform these evaluations against all applicable federal and state regulations, state permits, and local laws. These regulations and permits are the foundation for environmental standard operating procedures and implementing documents. INL and ICP contractors use the National Environmental Policy Act planning tool for all proposed actions that would take place onsite. INL uses the Environmental Compliance Permit Process, while ICP uses the Environmental Checklist process to evaluate all activities and projects to ensure the proposed actions consider and mitigate environmental aspects as necessary. Environmental aspects are listed below:

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 and ICP contractors have an Environmental As Low As Reasonably Achievable 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 As Low As Reasonably Achievable Committee evaluates activities that have the potential for radiological impact on the environment and the public and determines the requirements for radiological emissions.

Chemical Use and Storage. Chemical use and storage apply to activities that purchase, store, or use laboratory or industrial chemicals, pesticides, or fertilizers. INL and ICP contractors have processes in place to maintain adequate inventory of appropriate emergency response equipment and to report inventories and releases.

Contaminated Sites Disturbance. Contaminated site disturbance applies to activities in Comprehensive Environmental Response, Compensation, and Liability Act areas of contamination or Resource Conservation and Recovery Act corrective action sites. INL and ICP contractors have processes to properly identify contaminated sites.

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

Drinking Water Contamination. Drinking water contamination activities are related to constructing, operating, and maintaining drinking water supply systems and equipment or activities with the potential to contaminate drinking water supplies. This includes bacteriological, radiological, or chemical contamination of drinking water.

Disturbing Cultural 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 the 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 the impact on 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 of hazardous, radioactive, or industrial waste. INL and ICP contractors have 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 noncontaminated or previously contaminated locations. All INL and ICP contractors' 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.

Polychlorinated biphenyls (PCB) Contamination. PCB contamination applies to activities that use PCB-contaminated equipment or store and dispose of PCB-contaminated waste. INL and ICP contractors have processes in place to identify PCBs in excess equipment and to comply with regulatory requirements related to the use, marking, storage, and disposal of PCB equipment or waste.

Interaction with Wildlife/Habitat. Interaction with wildlife/habitat activities includes the potential to disturb or affect wildlife or their habitat or activities involving revegetation and weed control. INL and ICP contractors have processes in place to ensure that identification and consideration is given to the cumulative impacts required by the National Environmental Policy Act, the Endangered Species Act, or the Migratory Bird Treaty Act. Procedures and processes are also implemented to control noxious weeds and revegetation of disturbed sites.

Using, Reusing, and Conserving Natural Resources. Using, reusing, and conserving natural 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 natural resources.

3.4 Do (Implementation and Operations)

3.4.1 Structure and Responsibility

The organizational structures INL and ICP contractors have in place establish roles and responsibilities for environmental management within research, development, and demonstration; operations; waste management; decontamination and decommissioning; and other support organizations within Environmental, Safety, Health, and Quality. Identified technical points of contacts communicate environmental regulatory requirements and required document submittals to the U.S. Environmental Protection Agency, the Idaho Department of Environmental Quality (DEQ), and other stakeholders. The technical points of contact work with the projects, researchers, and facilities to ensure the requirements are implemented.

3.4.2 Competence, Training, and Awareness

INL and ICP contractor training directorates conduct training analysis and designs and develop and evaluate environmental training. Environmental training gives personnel the opportunity to gain experience, knowledge, skills, and abilities necessary to accomplish the following:

- Perform their 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 action in an emergency.

3.4.3 Communication

INL and ICP contractors implement comprehensive communication programs that distribute timely information to interested parties such as the public, news media, regulatory agencies, and other government agencies. These programs provide communications about the environmental aspects of work activities, among other topics. Examples include the Media and Community Relations Program and the Strategic Initiatives Program, which distribute information to the public through public briefings, workshops, personal contacts, news releases, media tours, public tours, and news conferences. The programs also coordinate tours of INL for schools, members of the public, special interest groups, and government and elected officials. Internal communications regarding environmental aspects are available via intranet sites, procedures, emails, posters, brochures, booklets, trainings, and personal interaction with environmental 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 using protective equipment and barriers to minimize or avoid environmental impact.

3.4.5 Document and Record Control

Environmental documents are prepared, reviewed, revised, and issued per INL and ICP contractors' 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 Check

INL and ICP contractors internally monitor compliance with environmental laws and regulations through the Assurance Portfolio process in the Contractor Assurance System. INL and ICP contractors conduct 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 the environmental organization are documented in a management review.

Various regulators also perform external assessments. Idaho DEQ conducts several inspections annually to verify that INL is complying with state permits. The U.S. Environmental Protection Agency also participates in Federal Facility Act-driven inspections and, on a determined frequency, participates alongside Idaho DEQ in compliance evaluation inspections. Chapter 2, "Environmental Compliance Summary," provides results of the annual external agency audits and inspections of INL's Environmental Program.

Annually, INL and ICP contractors perform a surveillance audit as required by the ISO 14001 standard. Additionally, every three years, INL and ICP contractors are audited for recertification to the ISO 14001 standard. A qualified party outside the control or scope of the EMS must perform the formal recertification of the EMS audit. INL and ICP contractors have been certified to the ISO 14001 standard since 2005.

3.6 Act

INL and ICP contractors establish, implement, and maintain an issues management program in accordance with an internal procedure for contractor assurance. It deals with actual or potential conditions of nonconformity, such as Notices of Violation, nonconformities with regulation, and opportunities for improvement from internal assessments and audits. All employees have access to the issues management software and the authority to identify and document any conceived issue. Communication of these identified issues is performed through the management review process. Throughout all operations, environmental concerns, safety, and emergency preparedness issues are documented and submitted for management review.

INL and ICP contractors' management review of EMS occurs through a process that includes weekly, monthly, quarterly, and annual meetings with committees and councils. Management review identifies issues that carry the largest environmental risks and provides mitigations and hold points. Through the Contractor Assurance System, EMS performance trends, audit findings, objectives and targets, improvements, and risks are documented in a management review that is sent to senior management. Through this process, senior management is aware of the largest environmental risks to the INL Site. Senior management evaluates the management review and recommends actions to continually improve environmental performance.

3.7 INL Site Resiliency

Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents. Energy resiliency is the ability to prepare, prevent, and recover from energy and water disruptions that impact mission assurance on federal installations. This means providing reliable power under routine and off-normal conditions, including those caused by extreme weather events. Adaptation refers to actions taken to reduce risks from changed climate conditions and to prepare for expected future changes.

As outlined in Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," the DOE Climate Adaptation and Resilience Plan issued in August of 2021 and the Climate Adaptation Policy Statement build upon prior DOE actions that were taken to bolster adaptation and increase the resilience of DOE facilities and operations. INL and ICP contractors completed the studies for the Climate Vulnerability Assessment and Resilience Plan (VARP) (INL/RPT-22-68812) (CCN 329748) in 2022 as a tool for decision makers to establish resilient priorities across INL and associated communities.

3.7.1 Performance Status

All sustainable activities support energy resiliency and, by default, make the INL Site a more resilient institution. Sustainable activities include the following:

- Replace permanent closure of an aged underground diesel storage tank, thereby increasing environmental protection and lessening the environmental risks of maintaining underground storage tanks. This is an interim step as INL moves toward net-zero emissions.
- Add sustainable acquisition clauses in electronics acquisition blanket purchase orders. As noted in the INL Green Purchaser award, using Electronic Product Environmental Assessment Tool (EPEAT) products reduces energy use, thus helping to reduce electric load and demand.
- Ensure procurement requirements lend preference to local suppliers and manufacturers, thereby shortening the supply chain and reducing the chances of delivery disruptors.
- Complete the annual update of operational procedures, engineering documents and processes guidelines to address sustainability, emergency planning, and operational resiliency.
- Complete energy and water-reduction projects, resulting in lower energy use and load demands on the servicing utility.
- Evaluate and consider alternative energy solutions ranging in scope from microgrid renewable generation to potential small modular reactor projects capable of providing local clean alternative energy.
- INL contractor continues developing net-zero carbon strategies and reporting.

Ecosystem resiliency is also an integral component of sustainability. Because much of the INL Site is managed as a native sagebrush steppe ecosystem, it is vulnerable to the effects of climate change. Proactive land stewardship practices can mitigate the effects of climate change and preserve natural ecosystem services such as water balance, nutrient cycling, wildlife habitat availability, and carbon sequestration. A brief list of activities INL undertook that support ecosystem sustainability are included here, but additional information can be found in Chapter 9:

- Continued to implement conservation planning documents for sage-grouse, bats, migratory birds, and their habitats
- Managed the Sagebrush Steppe Ecosystem Reserve according to the Environmental Assessment and Management Plan
- Restored sagebrush to several hundred acres where it had been lost to wildland fire and continued to monitor natural vegetation recovery according to current fire recovery plans
- Stabilized disturbed soils using revegetation of native species, where appropriate
- Controlled noxious weeds to limit the risk of spreading and maintained the integrity of native plant communities
- Continued monitoring the abundance and distribution of vegetation and several wildlife taxa across the INL Site
- Facilitated ongoing ecological research led by university collaborators through the National Environmental Research Park.

Comprehensive emergency response procedures are in place that cover all INL Site facilities:

- The INL contractor procedures include PLN-114, “Idaho National Laboratory (INL) Emergency Plan/Resource Conservation and Recovery Act (RCRA) Contingency Plan,” which addresses the elements of—and is the primary component in—defining and directing the INL Emergency Management Program. The plan implements DOE policy and requirements for an EMS and an RCRA contingency plan specified in INL Requirements Document 16100, “Emergency Management System,” which includes citations to DOE O 151.1D, “Comprehensive Emergency Management System,” and other DOE requirements. The plan was updated in Fiscal Year (FY) 2022.

- The ICP contractor procedures include PLN-2012, “ICP Emergency Plan/RCRA Contingency Plan,” and the emergency response elements that are required in DOE O 151.1D, “Comprehensive Emergency Management System,” for the Idaho Nuclear Technology and Engineering Center (INTEC), the Radioactive Waste Management Complex, the Advanced Mixed Waste Treatment Project, Accelerated Retrieval Project, and the ICP contractor-operated buildings in Idaho Falls, Idaho.

Several INL Emergency Management procedures, including PLN-4267, “INL Continuity of Operations Plan” were updated to better prepare the INL Site for naturally occurring phenomenon. INL’s emergency plans and emergency plan implementing procedures (EPIs) are reviewed at least annually and revised if necessary. The plans and EPIs may be revised based on the following factors:

- Changes in emergency planning or company operations, policy, concept of operations, procedures, organization and staffing, and facility operations or mission
- Direction of the DOE-ID Emergency Management Program administrator
- Failure of emergency plan implementing procedures during drills, exercises, and real events
- Results of audits, evaluations, appraisals, and self-assessments
- New facility information.

3.7.2 Plans and Projected Performance

The concept of resiliency is evolving in real time. In this season of change, all built environments will require careful reconsideration, and it will fall to the facility management to promote a building culture that stands on the pillars of safety, quality, and efficiency.

INL and ICP contractors will be guided by science to build resilience into DOE-ID-managed lands, facilities, and equipment. A general framework used in resiliency planning includes identifying exposure, translating that exposure into potential impacts, prioritizing risk, devising solutions, and securing funding. INL and ICP contractors will work with internal and external stakeholders to address threats to missions and programs.

Both INL and ICP contractors completed and submitted a VARP to the DOE Sustainability Dashboard for the facilities within their respective stewardships. The VARP enables INL and ICP to identify, prepare for, and meet the challenges posed by climate change, and will build upon other existing DOE risk assessments processes.

In FY 2022, DOE sites were required to complete a Climate Change VARP. Both INL and ICP contractors completed and submitted a VARP to the DOE Sustainability Dashboard for the facilities within their respective stewardships. The VARP is both a plan and a process. It is a plan that lays out climate change vulnerabilities of specific facilities and systems, and it is the process of managing climate change-related risks to DOE’s assets and operations. Therefore, it begins the implementation of the five priority adaptation actions found in the VARP: (1) assess vulnerabilities and implement resilience solutions; (2) enhance climate adaptation and mitigation co-benefits; (3) institutionalize climate adaptation and resilience across INL policies, directives, and processes; (4) provide climate adaptation tools, technical support, and climate science information; and (5) advance deployment of emerging climate technologies.

The INL contractor VARP identified 11 categories of resilient solutions to be tracked for implementation:

- Upgrade or replace older, inefficient heating, ventilation, and air conditioning systems
- Upgrade site drainage plan and systems
- Harden energy supply and infrastructure, including modular reactor installation, electric distribution and system upgrades, and install a second point of interconnect to the utility
- Harden/stabilize road infrastructure.
- Enhance fire-safe protective design (i.e., enhance firebreaks around structures, such as parking lots or landscaping)

- Fortify critical infrastructure and supply chains (i.e., develop a next generation Continuity of Operations Plan, identify vendors of critical supplies within a 500-mile radius)
- Install additional backup power for vulnerable critical buildings and operations
- Support the study, development, and installation of microgrid infrastructure systems.
- Update existing underperforming infrastructure and implement adaptable infrastructure strategies (upgrading building envelope, installing efficient lighting and controls, and other energy and water efficiency measures).
- Improve human capital systems that contribute to increasing human resilience
- Implement processes that allow for a healthy and robust ecosystem that sustains sagebrush-dependent species.

The IEC contractor VARP identified seven categories of resilient solutions to be tracked for implementation:

- Dust damage and heat exposure prevention through heating, ventilation, and air conditioning updates and maintenance
- Weatherization and hardening of infrastructure
- Worker education and on mitigating risks around outdoor work
- Partnership with INL to limit the spread and damage from wildfires
- Flood mitigation through local stormwater evaluation, maintenance, and potential landscaping
- Establishment of additional monitoring wells
- Additional backup energy generation.

The VARP will be improved and updated continuously to account for changing climate conditions and new strategies to mitigate climate risks. Resilience solutions proposed in the VARP will be tracked on DOE's Sustainability Dashboard, and progress on those solutions will be reported at least annually. As specified in the Vulnerability Assessment and Resilience Planning Guidance, VARPs will be revised at least every four years to incorporate new information and data from the latest National Climate Assessment.

INL contractor continues the process of incorporating resilient design into new and existing buildings. Engineering specification documents were updated to reflect current federal energy efficiency requirements and an updated *INL High Performance and Sustainable Building* guidebook will be published early in FY 2024.

Highly energy-efficient lighting, roofing, and automation systems continue to be installed in new buildings and during retrofit activities. The result is not just an increase in the resilience of the building but of the surrounding community as well because it decreases the demand for available resources and infrastructure.

Proactive land stewardship is an important component of supporting continued mission-critical activities and future development with minimal disruption. INL's Natural Resources group continues to monitor the ecological condition of wildlife and vegetation resources across the INL Site, which includes assessing current resource conditions and the effects of stressors like climate change on the ecosystem. While the region is adapted to current climate trends and events, increased frequency and severity of hazards can alter the integrity of the ecosystem without proactive land stewardship to implement adaptive management solutions.

The resiliency team across the Natural Resources group identified the following recommended resilience solutions:

- Adaptive landscape management using ecological monitoring data
- Inventory sensitives species vulnerable to climate change
- Update/Develop biological/ecological resource planning documents
- Reduce wildland fire risk and enhance natural resource recovery strategies
- Update restoration/revegetation guidance documents
- Develop and implement integrated pest management system

- Manage wildlife/human interactions and reduce conflicts
- Engage agency stakeholders for developing best management practices.

INL is well-positioned to address the need for organizational resilience elements in future plans. With leadership commitment, INL will continue to ensure that appropriate events and risk elements are considered as part of INL Site programs and planning activities. Policies and procedures will be evaluated to determine whether they should be modified to consider organizational risks. Emergency response, workplace safety and health, and the most updated scientific knowledge will continue to be incorporated into all facets of organizational resilience.

3.8 Sustainability Goals

In 2021, Executive Order 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," was issued. The executive order establishes sustainable environmental stewardship goals that advance sustainable practices. Specifically, it directs agencies to reduce emissions across federal operations, invest in American clean energy industries and manufacturing, and create clean, healthy, and resilient communities. The president's executive order directs the federal government to use its scale and procurement power to achieve five goals:

1. By 2030, 100% carbon pollution-free electricity, at least half of which will be locally supplied clean energy to meet 24/7 demand.
2. By 2035, 100% zero-emission vehicle acquisitions, including 100% zero-emission light-duty vehicle acquisitions by 2027.
3. Net-zero emissions from federal procurement no later than 2050, including a "Buy Clean" policy to promote the use of construction materials with lower embodied emissions.
4. A net-zero emissions building portfolio by 2045, including a 50% emissions reduction by 2032.
5. Net-zero emissions from overall federal operations by 2050, including a 65% emissions reduction by 2030.

The evolving priorities for sustainability are incorporated into the annual update of the *Idaho National Laboratory Site Sustainability Plan* (DOE-ID 2022) at the beginning of each new fiscal year. It describes the overall sustainability strategy for INL and ICP contractors for the current fiscal year and includes a performance status 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 for the completed fiscal year. Each sustainability goal, INL and ICP contractors' performance status, and planned actions are detailed in Table 3-1.

3.9 Environmental Operating Objectives and Targets

INL establishes objectives based on the environmental policy, legal and other requirements, environmental aspects, INL's Strategic Plan, and the perspectives of its stakeholders. The INL contractor plans, implements, monitors, and reports quarterly on these objectives and targets in management review reports and in an annual Performance Evaluation and Measurement Plan. The ICP contractor develops its objectives and targets annually and reports the status biannually to senior management through the Executive Safety Review Board.

The INL contractor completed 95% of the EMS objectives and targets in FY 2022. Each year, the ICP contractor identifies environmental objectives and targets to be met during the FY. During FY 2022, the ICP contractor had 10 objectives implemented by 10 targets; 90% of the EMS Objectives and Targets were completed.

3.10 Accomplishments, Awards, and Recognition

The INL and ICP contractors were both audited in 2022 by an external, accredited auditor and achieved recertification for conformance to the ISO 14001:2015 standard. The results from the INL contractor audit found no nonconformities, four management system strengths, and no opportunities for improvement. Results from the ICP audit showed no nonconformities and four management system strengths.

INL and ICP contractors' EMS performance data was submitted to DOE's EMS Database Application and received a "green" for the EMS performance metrics listed below:

- Environmental aspects were identified or reevaluated using an established procedure and were updated as appropriate.
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate.
- Operational controls were documented to address how significant environmental aspects that were 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, conducted, monitored, tracked, recorded, and refreshed, as appropriate, to maintain competence.
- EMS requirements were included in all appropriate contracts. 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.
- Using an established procedure(s), previously identified activities, products, and services (and their associated environmental aspects) and all newly identified activities, products, and services (and their associated environmental aspects) were evaluated for significance within the past fiscal year. In addition, the results of the analysis were documented, and any necessary changes were made or are scheduled to be made. Documented, measurable environmental objectives are in place at relevant functions and levels, and by the end of FY 2022, at least 80% of the objectives had either already been accomplished or scheduled to be met.
- Within the past fiscal year, operational controls associated with identified significant environmental aspects are established, implemented, controlled, and maintained in accordance with operating criteria.
- Within the past fiscal year, an environmental compliance audit program was in place, audits were completed according to schedule, audit findings were documented, and corrective and preventative actions were defined/documented and on schedule for completion by an established date.

INL was named one of 76 winners nationwide for the 2022 EPEAT Purchaser Awards. The EPEAT awards recognize leadership in the procurement of sustainable electronics. INL has earned the prestigious annual award since 2015 and earned the 5-star award level two years in a row.

Now in the award program's eighth year, the Green Electronics Council—the organization that manages the EPEAT ecolabel—recognized INL for contributing to DOE reaching a savings of $10.7 million from their purchases of IT products. Winners were recognized for their purchases from six EPEAT product categories: (1) computers and displays, (2) imaging equipment, (3) mobile phones, (4) servers, (5) televisions, and (6) photovoltaic modules.

The council honored 2022 EPEAT winners on July 28 at a virtual ceremony. Award winners earned one star for each product category in which they purchased EPEAT registered products, and INL was recognized as a 4-star winner.

Table 3-1. Summary table of DOE sustainability goals (DOE-ID 2023).

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
ENERGY MANAGEMENT			
Reduce energy-use intensity (Btu per gross square foot) in goal-subject buildings	Energy-use intensity was 146,033.7 Btu/ft² for FY 2022, which represents a decrease of 5.4% from FY 2015 and 2.9% from FY 2021.	Twenty light-emitting diode lighting and other projects are planned for FY 2023, providing an estimated $72K (1,160 megawatt hours [MWh]) in energy savings at total a cost of $772K. Investigate feasibility of a large energy-reduction performance contract project from the compiled results of the energy and water audits.	**Medium/Financial** Low cost of energy and water make project payback difficult to justify on a lifecycle basis.
Energy Independence and Security Act Section 432 continuous (four-year cycle) energy and water evaluations	Energy and water evaluations were completed in 16 covered buildings in FY 2022. These audits represent 15% of the current covered buildings for the second year of the third four-year audit cycle (June 1, 2020, through May 31, 2024). INL contractor is on track with its planned and scheduled audits.	Complete annual energy audits for 25% of INL's 105 covered buildings for each year of the third four-year audit cycle (June 1, 2020, through May 31, 2024). INL plans to audit 23 buildings in FY 2023. ICP plans to audit 35 buildings in FY 2023, ensuring all ICP covered buildings will be evaluated.	**Low/None** INL contractor's building audit program is fully established.
Meter individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate	Idaho Falls: 42 buildings metered for electricity with either standard or advanced metering. Twenty-five buildings use and are metered for natural gas with standard meters. Twenty-one buildings are metered for water with standard meters. Research and Industrial Complexes: 87 buildings with electric meters, 65 of which have advanced meters.	Two new INL buildings planned for completion in FY 2023 will have advanced metering. Advanced electric and natural gas meters are planned in INL Idaho Falls buildings (approximately 44 meters) to connect to SkySpark energy management system. This activity is planned for FY 2023 and FY 2024.	**Low/None** New INL buildings are specified for advanced metering, and selected appropriate buildings are specified for sub-metering.

Table 3-1. continued.

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
Reduce potable water-use intensity (gal per gross square foot)	Water intensity was 119.7 gal/ft² in FY 2022, a decrease of 31.2% from FY 2007 and 14.6% from FY 2021. Updated water balance and identified high water use intensity processes and buildings.	Prepare and implement a more detailed water balance evaluation. Implement audit-identified low and moderate cost water conservation measures, including high-efficiency water technologies.	**Medium** Water usage is highly dependent upon the varying process water consumption at the Advanced Test Reactor Complex and INTEC.
WATER MANAGEMENT			
Reduce non-potable freshwater consumption (gal) for industrial, landscaping, and agricultural	Not applicable. Water obtained from the Snake River Plain Aquifer and is considered potable.	Industrial, landscape, and agricultural (water is not applicable).	**Low/None** Industrial, landscape, and agricultural water is not used.
WASTE MANAGEMENT			
Reduce nonhazardous solid waste sent to treatment and disposal facilities	Generated 2,748,832.5 lbs (1,246.9 metric tons [MT]) of nonhazardous municipal solid waste in FY 2022. In FY 2021, 2,695,757.0 lbs (1,222.8 MT) was generated, resulting in an increase of municipal solid waste generated of 2.0% year-over-year (YOY). Diverted 53.8% of nonhazardous solid waste in FY 2022 by recycling 1,478,831.6 lbs (670.8 MT) of materials.	Continue to educate personnel emphasizing the priority of waste reduction from the previous year. Continue to evaluate potential outlets and expansion of recyclable waste. Explore glass recycling partnership with the city of Idaho Falls. Investigate and develop a regional composting facility based on West Yellowstone pilot project.	**Medium** Fluctuations in building use, including classified spaces, employee engagement, and market forces, greatly affect this goal.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities	Generated 11,794.4 MT of construction and demolition (C&D) waste in FY 2022 compared to 23,184.3 MT in FY 2021, resulting in a decrease of 49.13% of C&D waste generated YOY. Diverted 28.1% (7,304,071.1 lbs or 3,313.1 MT) of its C&D waste in FY 2022.	Continue employee education and contract language inclusion and incorporate additional materials into current C&D waste diversion processes. Work with regional industrial recycle entities and develop a strategy to recycle two construction waste streams: concrete and gypsum.	**Medium** Construction continues to increase while markets accepting construction debris are limited. The cost of transporting to an acceptable recycler is a major factor in the decision process.

Table 3-1. continued.

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
FLEET MANAGEMENT			
Reduce petroleum consumption	Fuel usage data indicate 725,392 gasoline-gal equivalents of petroleum-based fuels was used in FY 2022, which is a 22.7% reduction from FY 2005 and a 9.4% reduction from FY 2021. This data was unavailable at time of submission due to the Federal Automotive Statistical Tool reporting schedule being later than DOE Dashboard reporting schedule. INL resumed its use of R99 renewable diesel as a sustainable alternative to aid INL in reaching its zero-emission goals.	The INL contractor implements its Net Zero Plan, a greater emphasis will be placed on acquiring electric buses and heavy equipment along with electrifying its light-duty fleet and installing supporting charging stations. Hydrogen-powered vehicles are also being considered. Optimize fleet composition by reducing vehicle size, eliminating underused vehicles, and acquiring vehicles to match local fuel infrastructure.	**Medium** The petroleum reduction goal will be challenging due to the cost and availability of electric motor coaches and heavy equipment.
Increase alternative fuel consumption	Data indicates 70,426 gasoline-gal equivalents of alternative fuels were used in FY 2022, which is a 7.9% reduction from FY 2005 and a 97.5% increase from FY 2021. INL contractor installed three electric vehicles (EVs) charging stations for a total of 23 and installed one electric bus charging station.	Determine less-costly sources of R99 for the interim while electric buses are being evaluated and procured.	**Medium** The alternative fuel increase goal will be challenging due to cost and availability of EVs and the excessive cost of renewable diesel.
Acquire alternative fuel and EVs	Acquired 29 new light-duty vehicles in FY 2022, five of which were alternative fuel vehicles (AFVs) or EVs.	Identify the next group of petroleum-fueled vehicles for replacement with AFVs or EVs and ensure that all existing AFVs are replaced EVs when available. Work with General Services Administration to achieve 75% or greater AFV and EV light-duty acquisitions.	**Medium** This goal has historically been met but it may be difficult to reach in the future due to the availability of appropriate EV light-duty vehicle fuel types supplied by General Services Administration.

Table 3-1. continued.

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
CLEAN AND RENEWABLE ENERGY			
Increase consumption of clean and renewable electric energy	Procured 16,488 MWh of renewable energy certificates from Idaho Falls Power at a total cost of $90,684. This purchase of renewable energy certificates, in addition to the 78.1 MWh of onsite generation (e.g., microgrid and, small photovoltaic) plus bonuses, totals 17,274 MWh (7.9%) of renewable energy for FY 2022.	The INL contractor implements its recently developed Net Zero Plan, a greater emphasis will be placed on the internal applications of renewable energy generation to meet this goal. Incremental increases of purchased renewable energy certificates and onsite generation will continue to be made to meet a minimum of the 7.5% goal each YOY.	**Low** Established process for procuring renewable energy certificates.
Increase consumption of clean and renewable non-electric thermal energy	Two 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.	**Medium** Due to the low cost of electric energy, it is challenging to justify the installation of thermal renewable energy.
SUSTAINABLE BUILDINGS			
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings	At the end of FY 2022, 26 DOE-owned buildings were compliant with the Guiding Principles for Sustainable Federal Buildings (Guiding Principles), which represents 40.63% of applicable buildings. This includes 21 buildings with less than 25,000 gross square feet. Completed update to INL High Performance and Sustainable Building Strategy.	Document Guiding Principles compliance on two new construction buildings in FY 2023 and four additional new construction buildings by the end of FY 2024. Implement a program to reassess buildings on a four-year cycle per the 2020 Guiding Principles.	**Low** The 15% goal was achieved.

Table 3-1. continued.

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
ACQUISITIONS AND PROCUREMENT			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate	In FY 2022, 97.8% of the contracts contained applicable clauses.	Achieve 100% compliance. Continue to incorporate improvements to the Sustainable Acquisition Program, including procedures, policies, and enhanced work processes that increase visibility, availability, and use of sustainable products.	**Low** The goal continues to be achieved.
EFFICIENCY AND CONSERVATION MEASURE INVESTMENTS			
Implement lifecycle cost-effective efficiency and conservation measures with appropriated funds or performance contracts	Fifteen energy-reduction projects were completed in FY 2022, providing over $45K in energy cost-savings. No additional Energy Savings Performance Contract (ESPC) projects were developed in FY 2021.	Light-emitting diode lighting projects are planned for 20 buildings. Continue to evaluate the cost effectiveness of ESPC options.	**Low** While there are no current plans for an additional ESPC project, the INL Site does have established plans and goals for projects awarded and targeted in FY 2023.
ELECTRONIC STEWARDSHIP AND DATA CENTERS			
Electronics stewardship from acquisition and operations, to end of life	In FY 2022, 100% of electronic devices were reused or recycled; however, only 96.4% were recycled with a certified recycler.	Unless federal requirements dictate otherwise, 100% of electronics are reused or recycled. Continue to partner with Information Management and Property Disposal Services to improve electronics end-of-life disposition.	**Low** This goal continues to be achieved.
Increase energy and water efficiency in high-performance computing and data centers	Continued consolidating server infrastructure in the old high-performance computing data center by virtualizing physical machines and taking advantage of cloud and container hosting options.	Install and monitor advanced energy meters in all data centers and accurately quantify power usage effectiveness.	**Medium** Low energy costs and long construction times may prohibit major investments in updated resiliency measures.

Table 3-1. continued.

DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
ORGANIZATIONAL RESILIENCE			
Implement climate adaptation and resilience measures	Completed a comprehensive VARP initiative. INL contractor identified 11 categories of resilient solutions categories and ICP contractor identified 7. INL contractor emergency plans and EPIs were reviewed and revised, as necessary. Operating policies and procedures were evaluated to determine whether they should be modified to consider organizational risks.	Initiate detailed analysis (e.g., cost estimates and schedules) for projects identified in the VARP process. Emergency response, workplace safety and health, and updated scientific knowledge will be incorporated into all facets of organizational resilience, procedures, and protocols. Pursue lifecycle cost-effective energy resilience solutions that provide the most reliable energy to critical mission operations.	**Low to Medium** Investment upgrades in existing buildings are a long-term process. New buildings are being built to include resiliency measures.
MULTIPLE CATEGORIES			
Reduce Scopes 1 and 2 greenhouse gas emissions	Scopes 1 and 2 emissions were 77,267.1 MT of carbon dioxide equivalent (MT CO2e) compared to 89,391.4 MT CO2e in FY 2021, for a YOY reduction of 13.6% and a 45.2% reduction from the FY 2008 baseline. Emissions decreased due to the reduced Emissions and Generation Resource Integrated Database (eGRID) emission factors and a slight decrease in facility energy use.	Refine a targeted list of high-value, low-cost energy conservation measure projects with a focus on those reducing total emissions 45% by the end of FY 2024. Reduce or minimize the quantity of toxic and hazardous chemicals acquired, used, or disposed that will assist INL in pursuing agency greenhouse gas reduction targets.	**Medium** INL contractor has committed to be carbon net-zero by the end of FY 2031. Significant progress was made toward exceeding the overall goal, but YOY Scopes 1 and 2 greenhouse gases emissions may continue to vary.
Reduce Scope 3 greenhouse gas emissions	FY 2022 Scope 3 emissions were 20,366.8 MT CO2e compared to 15,586.6 MT CO2e in FY 2021, for a YOY increase of 30.7% and a 42.2% reduction from the FY 2008 baseline. The increase from previous year is due mainly to lifting of restrictions on business travel.	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 five years for a total 10% reduction.	**Medium** Significant progress was made toward exceeding the overall goal, primarily due to ongoing telework and travel restrictions. YOY Scope 3 greenhouse gases emissions may continue to vary.

3.11 References

DOE-ID, 2022, "FY 2022 Idaho National Laboratory Site Sustainability Plan," DOE/ID-11383, Rev. 13, Idaho National Laboratory, December 2021.

DOE O 151.1D, 2019, "Comprehensive Emergency Management System," Change 1, U.S. Department of Energy, October 4, 2019.

DOE O 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy, May 2, 2011.

DOE O 458.1, 2013, "Radiation Protection of the Public and the Environment," Administrative Change 4, U.S. Department of Energy.

Endangered Species Act (ESA) of 1973 (16 USC § 1531 et seq.).

Executive Order 14008, 2021, "Tackling the Climate at Home and Abroad," the U.S. White House, Office of NEPA Policy and Compliance, January 27, 2021.

Executive Order 14057, 2021 "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," the U.S. White House, Executive Office of President, December 8, 2021.

INL/RPT-22-68812, 2022, "Climate Vulnerability Assessment and Resilience Planning for Idaho National Laboratory," September 2022.

ISO 14001:2015, "Environmental Management Systems – Requirements with Guidance for Use," International Organization for Standardization, September 15, 2015.

Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 USC § 703 et seq.).

PLN-114, 2022, "Idaho National Laboratory (INL) Emergency Plan/Resource Conservation and Recovery Act (RCRA) Contingency Plan," Idaho National Laboratory, September 12, 2022.

PLN-2012, 2022, "ICP Emergency Plan/RCRA Contingency Plan," Rev. 64, Idaho Cleanup Project, February 21, 2022.

PLN-4267, 2021, "Idaho National Laboratory Continuity of Operations Plan," Rev. 9, Idaho National Laboratory, May 2, 2022.

American pronghorn

Chapter 4: Environmental Monitoring Programs – Air

CHAPTER 4

An estimated total of 357 Ci (1.32×10^{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 2022. The highest contributors to the total release were the Materials and Fuel Complex (MFC) at 73.7%, the Radioactive Waste Management Complex (RWMC) at 13.5%, the Radiological Response Training Range (RRTR) at 9.31%, and the Advanced Test Reactor (ATR) Complex at 2.78%. Other INL Site facilities contributed less than 0.67% per facility to the total. The estimated maximum potential dose to a member of the public from all INL Site air emissions (0.018 mrem/yr) is below the regulatory standard of 10 mrem/yr (see Chapter 8 for details).

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 onsite, at INL Site boundary locations, and at offsite communities. These samples were analyzed for radioactivity in 2022.

Particulates were filtered from the 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, plutonium-238, uranium-234, uranium-238, zinc-65, and strontium-90. Results were compared to detection levels, background measurements, historical results, and radionuclide-specific Derived Concentration Standards (DCSs) established by the U.S. Department of Energy (DOE) to protect human health and the environment. Gross alpha and gross beta activities were used primarily for trend analyses, which indicated fluctuations were observable that correlate with seasonal variations in natural radioactivity.

Specific gamma-emitting (primarily cesium-137) radionuclides were not detected by the INL contractor during 2022. Strontium-90 was detected in six quarterly composited samples during 2022. Plutonium-239/240 and americium-241 were detected in a quarterly composited samples collected during the fourth quarter. All concentrations were within historical measurements made during the past ten years (2012-2021) and well below the DCSs for these radionuclides. Plutonium-238 was not detected in any quarterly composite samples during 2022.

Airborne particulates were also collected biweekly around the perimeters of the Subsurface Disposal Area (SDA) at the RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility at the Idaho Nuclear Technology and Engineering Center (INTEC). Gross alpha and gross beta activities measured on the filters were comparable with historical results, and no new trends were identified in 2022. Americium and plutonium isotopes were detected within levels measured in previous years. The results were three to four orders below the DCS values established for those radionuclides.

Atmospheric moisture and precipitation samples were analyzed for tritium. Tritium was detected in some samples and was most likely from natural production in the atmosphere rather than INL Site releases. All measured results were below health-based regulatory limits.

4. ENVIRONMENTAL MONITORING PROGRAMS – AIR

Although all INL Site facilities are carefully managed and controlled the potential exists to release radioactive and nonradioactive hazardous constituents in amounts above regulatory limits during an operational upset or emergency incident situation. In such an event, pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations. Figure 4-1 is a conceptual model showing potential routes of exposure for these potential releases. 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 operates constantly and is a critical component of the INL Site's environmental monitoring programs. It monitors for routine and unforeseen releases, provides verification that the INL Site complies 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 and the Idaho Cleanup Project (ICP) contractors. Table 4-1 summarizes the radiological air monitoring activities relative to INL's major radiological sources as well as the minor onsite and offsite radiological sources. Details may be found in the INL Site Environmental Monitoring Plan (DOE-ID 2021).

4.1 Organization of Air Monitoring Programs

The INL and ICP contractors document airborne radiological effluents at all 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 2022 INL Report for Radionuclides* (DOE-ID 2023), 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 and ICP contractors to ensure that the INL Site remains in compliance with DOE O 458.1, "Radiation Protection of the Public and the Environment."

The INL contractor collects air samples primarily around the INL Site encompassing a region of 23,390 km^2 (9,000 mi^2) that extends to Jackson, Wyoming, as observed in Figure 4-2. In 2022, the INL contractor collected approximately 2,200 air samples (including duplicate samples and blanks) for various radionuclide analyses. The INL contractor collected air moisture at eight locations and precipitation samples at four locations for tritium analysis.

The ICP contractor collects air samples primarily on the INL Site at Low-Level Waste disposal facilities subject to DOE O 435.1, "Radioactive Waste Management," and downwind of facilities subject to an U.S. Environmental Protection Agency (EPA)-approved alternative for the NESHAP air monitoring method in accordance with 40 CFR 61.93(g). In 2022, the ICP contractor collected approximately 280 air samples (including duplicate samples) for various radionuclide analyses. While the INL contractor, being the operations and maintenance contractor for the INL Site, maintains a large network of onsite and offsite receptors, the ICP contractor's monitoring network is configured to identify potential releases from specific ICP facilities.

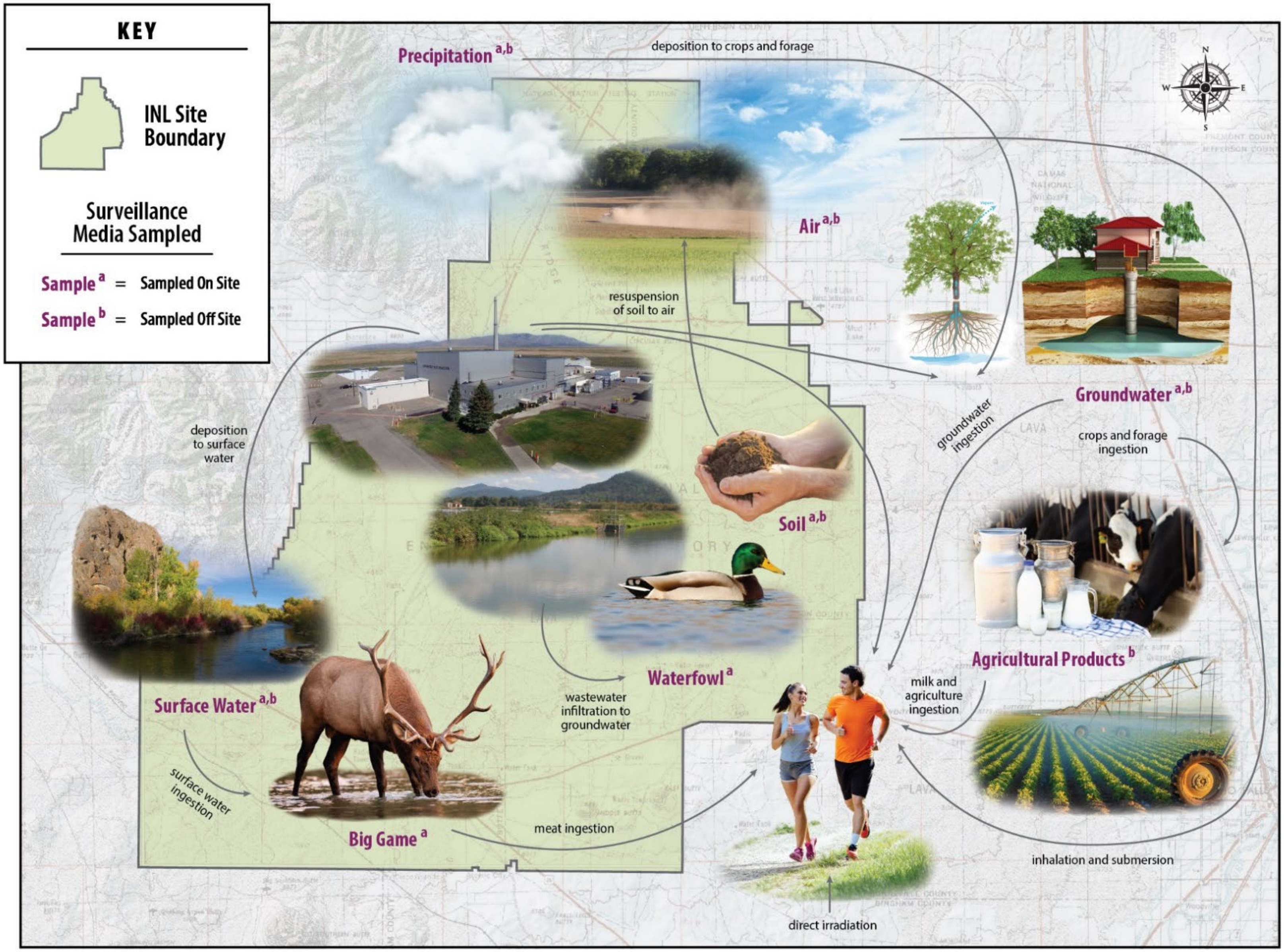


Figure 4-1. INL Site conceptual model.

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 (^{131}I)	LOW-VOLUME GROSS ALPHA	LOW-VOLUME GROSS BETA	SPECIFIC RADIONUCLIDES[c]	ATMOSPHERIC MOISTURE	PRECIPITATION
ICP CONTRACTOR[d]							
INTEC	●		●	●	●		
RWMC	●		●	●	●		
INL CONTRACTOR[e]							
MFC	●						
INL Site/Regional		●	●	●	●	●	●

a. 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 2022 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 contractor monthly and by the INL contractor quarterly. Cesium-137, americium-241, plutonium-239/240, plutonium-238, uranium-234, uranium-238, zinc-65 and strontium-90 are measured by the INL and ICP contractors quarterly.

d. The ICP contractor monitors waste management facilities to demonstrate compliance with DOE O 435.1, "Radioactive Waste Management." A combination of continuous monitoring and ambient air sampling are used to demonstrate compliance with 40 CFR 61, Subpart H.

e. The INL contractor monitors airborne effluents at MFC and also collects samples onsite, around, and offsite from the INL Site to demonstrate compliance with DOE O 458.1, "Radiation Protection of the Public and the Environment".

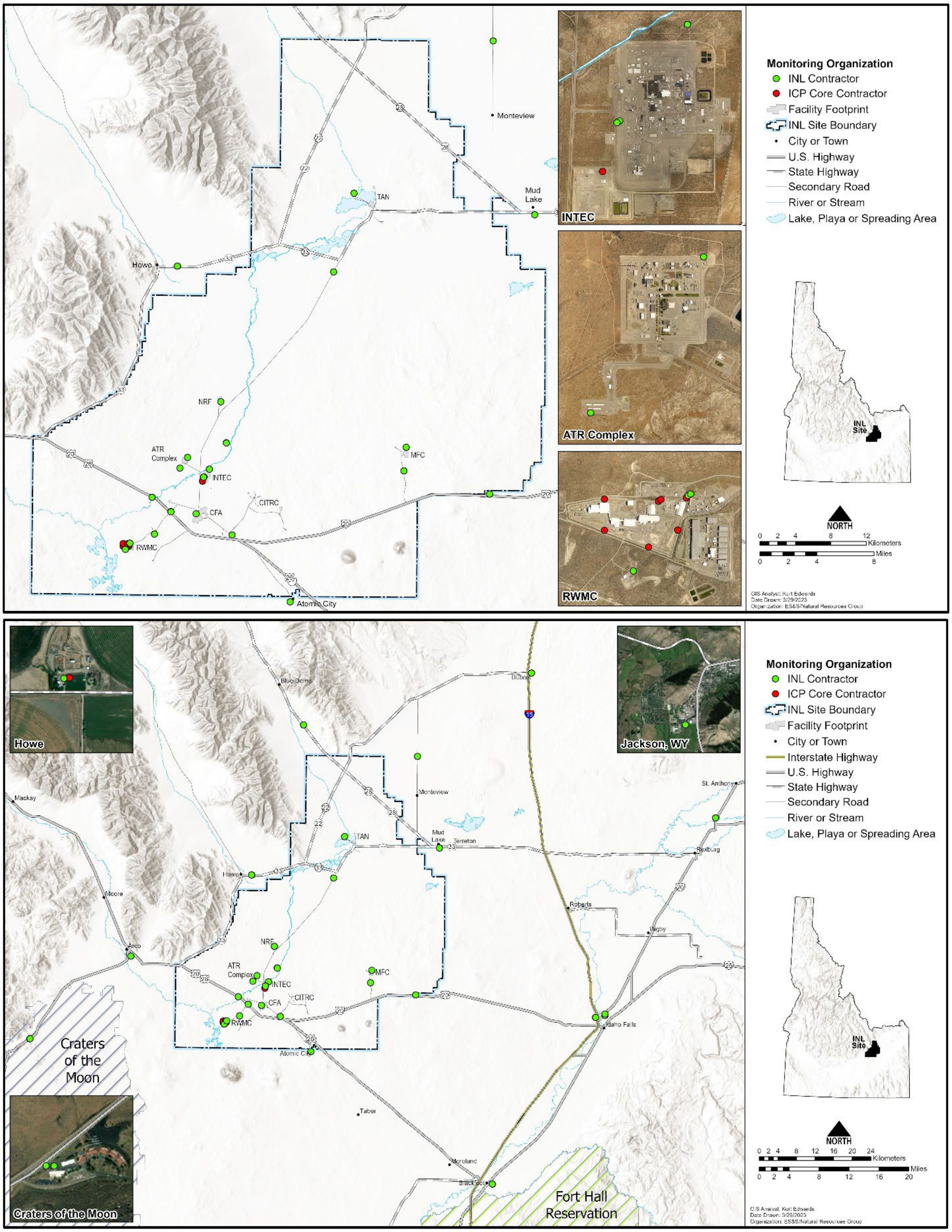


Figure 4-2. INL Site environmental surveillance radiological air sampling locations (regional [top] and onsite [bottom]).

The ICP contractor monitors air around waste management facilities to comply with DOE O 435.1, “Radioactive Waste Management.” These facilities are the SDA at the RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility (ICDF) near the INTEC. These locations are shown in Figure 4-2. Section 4.4 discusses air sampling the ICP contractor performs in support of waste management activities. In 2022, the ICP contractor collected approximately 200 air samples (including duplicate samples) for various radiological analyses.

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 and used 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 NOAA Field Research Division (since renamed the Special Operations and Research Division) of the Air Resources Laboratory 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 Special Operations and Research Division to scientists modeling the dispersion of INL Site releases (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 2022 are reported in the NESHAP Modeling Report (INL 2023) and the NESHAP Report (DOE-ID 2023a).

The NESHAP Report includes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAP regulation are primarily the stacks at the Materials and Fuels Complex (MFC), the Advanced Mixed Waste Treatment Project, 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 2022, an estimated 357 Ci (1.32×10^{13} Bq) of radioactivity was released to the atmosphere from all INL Site sources. The 2022 release is 67% lower than the estimated total of 1,076 Ci (3.98×10^{13} Bq) released in 2021. The reduction is primarily the result of the ATR shutdown during most of 2022 for refurbishment of the reactor core.

The following facilities were major contributors to the total emissions, as observed in Figure 4-3:

- ***MFC Emissions Sources (73.7% of total INL Site source term).*** Radiological air emissions are primarily associated with spent fuel treatment at the Fuel Conditioning Facility, waste characterization and fuel research development at the Hot Fuel Examination Facility, fuel research and development at the Fuel Manufacturing Facility, and post-irradiation examination at the Irradiated Materials Characterization Laboratory. To satisfy the requirements of 40 CFR 61 Subpart H, stack filters from the effluent streams of these four facilities are sampled and analyzed for particulate radionuclides on a regular basis because of their potential to discharge radionuclides into the air in quantities that could cause an effective dose of more than 1% of the standard. Other effluent streams with a smaller potential dose (less than 1% of the standard) such as the Transient Reactor Test Facility, are sampled and analyzed periodically to confirm the lower emissions. 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. While the ATR Complex is generally the greatest emissions contributor at the INL Site, the shutdown of its reactor during the core internal changeout operations resulted in reduced emissions reported from ATR. This reduction resulted in MFC being the greatest relative emissions contributor, however the actual amount in curies is still significantly lower than average ATR estimated annual emissions. While ATR emissions dropped from 827 Ci to 9.92 Ci in 2022, MFC emissions grew slightly from 188 Ci to 263 Ci from 2021 to 2022. Since overall emissions are down in 2022, the 263 Ci from MFC accounts for 73.74% of all estimated emissions.

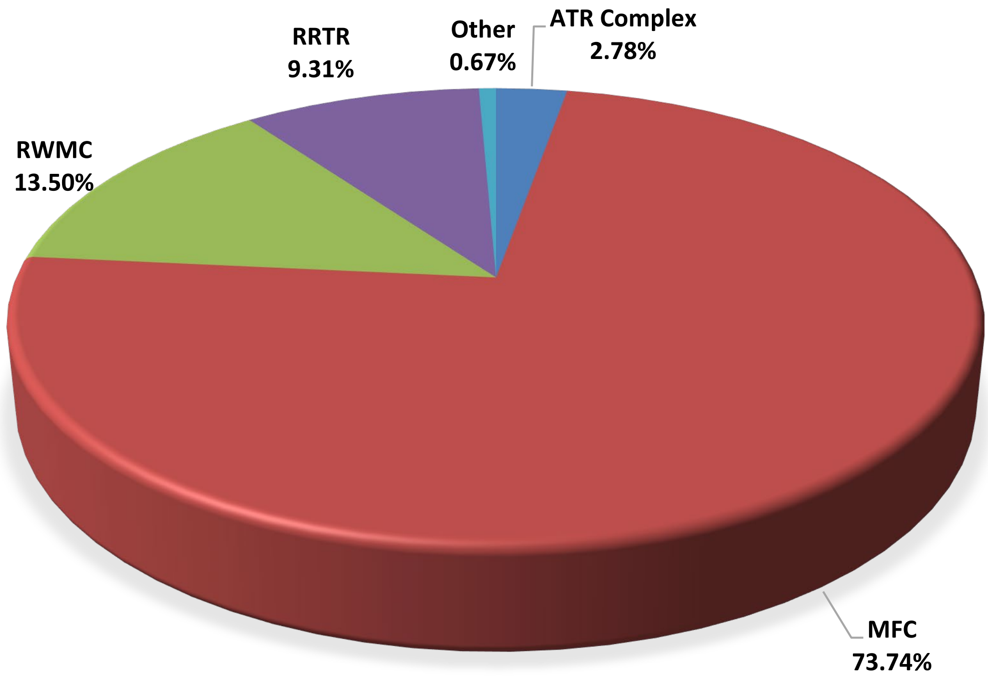


Figure 4-3. Percent contributions in Ci, by facility, to total INL Site airborne radiological releases (2022).

- ***RWMC Emissions Sources (13.5% 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. Various projects are being conducted to achieve these objectives: waste retrieval activities at the Accelerated Retrieval Projects (ARPs), operation of the Resource Conservation and Recovery Act permitted Sludge Repackage waste processing project, storage of waste within the Type II storage modules at Advanced Mixed Waste Treatment Project, storage and characterization of waste at the Drum Vent and Characterization facilities, storage of wastes at the Transuranic Storage Area-Retrieval Enclosure (WMF-636), and treatment of wastes at the Advanced Mixed Waste Treatment Facility (WMF-676). Data from 13 emission sources (both point and diffuse) at RWMC were reported in the 2022 NESHAP Report for Radionuclides (DOE-ID 2023), including three continuously monitored point sources. WMF-676 has two continuously monitored stacks, while WMF-636 had one continuously monitored stack, for which monitoring was ceased during 2022. Radionuclide emissions monitoring from the Comprehensive Environmental Response, Compensation, and Liability Act ARP facilities and the two Resource Conservation and Recovery Act facilities (WMF-1617 and WMF-1619) is achieved with the EPA-approved ambient air monitoring program, which has been in place since 2008. Radiological emissions at RWMC include tritium and carbon-14 associated with buried beryllium blocks at the SDA. Transuranic radionuclides releases from ARP facilities, including americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and plutonium-241 (^{241}Pu) have declined in recent years as waste exhumation and processing activities progress to completion.
- ***RRTR Emissions Sources (9.3% of total INL Site source term).*** The north RRTR is located 1.6 km (1 mile) NNE of SMC and began operations in July 2011 to support federal agencies responsible for the nuclear forensics mission. These sites are used to train personnel, test sensors, and develop detection capabilities (both aerial and ground-based) under a variety of scenarios in which radioactive materials are used to create a radioactive field for training in activities such as contamination control, site characterization, and field sample collection activities. Previously,

emissions from RRTR were reported in combination with emissions from SMC. As described in INL/RPT-23-72759, *Update of Receptor Locations for INL NESHAP Assessments* (INL 2023b), a number of facilities that were once modeled as collocated emission sources are now modeled as separate sources, resulting in a more realistic modeling scenario. Estimated emissions from RRTR were greater in 2022 (33.2 Ci) compared to 2021 (10.6 Ci) due primarily to use of a new source (pellets containing Cu-64). Although the increase in emissions from RRTR was moderate in 2022, RRTR emissions as a percentage of total INL Site emissions increased due to the reduced emissions reported from ATR.

- ***ATR Complex Emissions Sources (2.78% of total INL Site source term).*** Radiological air emissions from the ATR Complex are primarily associated with the operation of the ATR. 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, which has been in operation since 2011, is another emission source at the ATR Complex. Activities at the lab include inorganic, general purpose analytical chemistry, and wet chemical analysis for trace and high-level radionuclide determination. The laboratory contains high-efficiency particulate air-filtered hoods that are used for the analysis of contaminated samples. There are no sources at the ATR Complex that require continuous emissions monitoring due to the low dose contribution (see Section 8.2). On a regular basis, the ATR effluent stream is sampled and analyzed for particulate, radioiodine, and noble gas radionuclides. Effluent from the Safety and Tritium Applied Research Facility (TRA-666) is sampled and analyzed for tritium.
- ***INTEC Emissions Sources (0.37% 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 U.S. Nuclear Regulatory Commission (NRC). These sources contribute gaseous radionuclides, including tritium, iodine-129, and krypton-85, with contributions of particulate radionuclides cesium-137 (^{137}Cs) and ^{90}Sr from ICDF. INTEC has one stack continuously monitored for radionuclide emissions (resulting from Waste Management activities) located outside of CPP-666. Additional sources include the INTEC Main Stack (CPP-708), which emits gaseous and particulate radionuclides associated with liquid waste operations, including effluents from the Tank Farm Facility, Process Equipment Waste Evaporator, and Liquid Effluent Treatment and Disposal facility. Other 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.
- ***Central Facilities Area (CFA) Emissions Sources (0.20% of total INL Site source term).*** Minor emissions occur from CFA where work with small quantities of radioactive materials is routinely conducted. This includes sample preparation and verification and radiochemical research and development. Other minor emissions result from groundwater usage via evapotranspiration from irrigation or evaporation from sewage lagoons.
- ***Test Area North Emissions Sources (0.004% of total INL Site source term).*** Emissions sources at Test Area North are primarily from the New Pump and Treat Facility, which serves to reduce concentrations of trichloroethylene and other volatile organic compounds in the medial zone portion of the OU 1-07B contamination groundwater plume to below drinking water standards. 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.
- ***Specific Manufacturing Capability (SMC) Emissions Sources (0.000000038% of total INL Site source term).*** Operations at SMC include material development, fabrication, and assembly work to produce armor packages. The operation uses standard metal-working equipment in fabrication and assembly. Other activities include developing tools and fixtures and preparing and testing metallurgical specimens. Radiological air emissions from SMC are associated with processing depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny.
- ***Critical Infrastructure Test Range Complex (CITRC) Emissions Sources (0.000000013% of total INL Site source term).*** Emissions from CITRC are primarily the result of activity related to 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 testing, unmanned aerial vehicles, explosives detection, and training

radiological counter-terrorism emergency response. Radionuclide releases from CITRC were less in 2022 due to the curtailment of some activities because of COVID-19.

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. To calculate dose to the MEI, radionuclides with very short half-lives must be converted to the first progeny with a suitable half-life for modeling. The estimated emissions are then scaled based on the difference in activity between the parent and progeny. The estimated dose to the MEI in calendar year 2022 was 0.018 mrem/yr (0.18 μSv/yr) which is below the regulatory standard of 10 mrem/yr. Seven radionuclides—uranium-238 (^{238}U), chlorine-36 (^{36}Cl), uranium-234 (^{234}U), americium-241 (^{241}Am), strontium-90, (^{90}Sr), cesium-137 (^{137}Cs), and tritium (^{3}H)—are responsible for more than 90% of the MEI dose. Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report.

4.2.1 Hydrofluorocarbon Phasedown

Hydrofluorocarbons (HFC) are the third generation of refrigerants; they were developed to replace Class II ozone depleting substances. HFCs are used in the same applications in which ozone-depleting substances have historically been used, such as refrigeration and air conditioning, foam blowing agents, solvents, aerosols, and fire suppression. HFCs are non-ozone-depleting; however, they are also potent greenhouse gases with 100-year global warming potentials (a measure of the relative climatic impact of greenhouse gases) that can be hundreds to thousands of times more potent than carbon dioxide.

Atmospheric observations of most currently measured HFCs confirm their amounts are increasing in the global atmosphere at accelerating rates. Total emissions of HFCs increased by 23% from 2012 to 2016. The four most abundant HFCs in the atmosphere—in global warming potential-weighted terms—are HFC-134a, HFC-125, HFC-23, and HFC-143a (Federal Register Volume 86, Number 95 published May 19, 2021). The American Innovation and Manufacturing Act of 2020 included reductions for the production and the consumption of HFCs.

Additionally, the INL contractor is participating in the voluntary HFC Task Team led by AU-21, National Nuclear Security Administration. The goal of the task team is to better understand and address DOE's needs and determine next steps. The HFC Task Team wrote an Operating Experience Summary for the DOE complex that provides information on operational impacts to critical systems from these regulations that will decrease the amount of HFCs manufactured in the future (OES-2022-03, HFC Phasedown Impacts Critical Operations. The task team is currently exploring methods for documenting and sharing the review of alternatives with the DOE complex. HFC phasedown proactive measures being taken by the INL Site contractors are listed below.

4.2.1.1 INL Contractor

The INL contractor compiled a list of equipment at its facilities that contains HFCs and completed an impact analysis to better understand the potential impacts of this HFC phasedown. This list was obtained from a variety of sources: facility/operations personnel, laboratory personnel, fire protection personnel, research and development organizations, engineer personnel, maintenance personnel, and environmental support and services personnel. The list includes heating, ventilation, and air conditioning systems that contain 50 pounds or more of refrigerant and computer room air conditioning units that contain 50 pounds or more of refrigerant, fire protection systems, and laboratory equipment. Most of the laboratory equipment that contained HFCs were chillers used to cool specific pieces of equipment. Other laboratory equipment that contains HFCs includes environmental chambers, a microwave digester, non-rad and rad separator ion sources, non-rad and rad separator magnets, and a laser flash. The list does not include small heating, ventilation, and air conditioning equipment (units containing less than 50 pounds of refrigerant), refrigerators, drinking water fountains, or other small appliances. The INL contractor manages thousands of these small appliances at the facilities; most would be operated until failure and then replaced. The INL contractor identified 236 pieces of equipment and systems.

4.2.1.2 ICP Contractor

An inventory of refrigeration equipment at ICP facilities, using HFCs scheduled for phasedown, was conducted in December 2021. This activity identified two chillers (four circuits total) using HFC-134a at the Integrated Waste Treatment Unit. The total charge for both chillers is approximately 830 lbs. These units will continue to be used for the

Table 4-2. Radionuclide composition of INL Site airborne effluents (2022).[a]

		AIRBORNE EFFLUENT (Ci)[b]										
RADIONUCLIDE[c]	HALF-LIFE[d]	ATR COMPLEX[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RRTR[e]	RWMC[e]	SMC[e]	TAN[e]	TOTAL
Americium-241	432.2 y	2.21E-05	NS[f]	–[g]	5.79E-04	2.11E-03	–	–	1.03E-04	–	–	2.81E-03
Argon-41	1.827 h	NS	NS	–	–	8.19E+01	–	NS	–	–	–	8.19E+01
Bromine-82	1.471 d	–	NS	–	–	–	–	6.02E+00	–	–	–	6.02E+00
Carbon-14	5700 y	NS	NS	–	NS	–	3.20E-01	–	2.22E-02	–	–	3.42E-01
Cadmium-109	461.4 d	NS	NS	–	–	5.28E-03	–	NS	–	–	–	5.28E-03
Californium-252	966.1 d	–	–	–	–	5.00E-05	–	–	–	–	–	5.00E-05
Cesium-137	30.16 y	5.36E-03	NS	–	3.39E-04	3.55E-03	NS	–	NS	–	–	9.24E-03
Chlorine-36	3.01E+05 y	–	–	–	NS	7.17E-03	–	NS	–	–	–	7.17E-03
Copper-64	12.7 h	–	NS	–	–	–	–	2.70E+01	–	–	–	2.70E+01
Cobalt-60	5.271 y	6.31E-03	NS	–	NS	NS	–	–	NS	–	–	6.31E-03
Europium-152	13.53 y	6.78E-05	NS	–	NS	–	–	–	–	–	–	6.78E-05
Hydrogen-3	12.32 y	9.88E+00	5.39E-01	–	NS	3.82E-01	NS	–	4.81E+01	–	NS	5.89E+01
Iodine-129	1.57E+07 y	NS	NS	–	7.93E-05	4.94E-05	NS	–	–	–	–	1.29E-04
Iodine-131	192.5 h	NS	NS	–	–	8.93E-02	NS	–	–	–	–	8.93E-02
Krypton-85m	4.48 h	NS	NS	–	–	1.01E+01	–	–	–	–	–	1.01E+01
Krypton-87	76.3 m	NS	NS	–	–	1.06E+01	–	NS	–	–	–	1.06E+01
Krypton-88	2.84 h	NS	8.95E-03	–	–	9.63E+00	–	–	–	–	–	9.64E+00
Plutonium-238	87.7 y	NS	NS	–	6.32E-06	NS	–	–	NS	–	–	6.32E-06
Plutonium-239	24110 y	8.46E-06	NS	–	2.14E-04	NS	2.70E-06	–	3.75E-05	–	–	2.63E-04
Plutonium-240	6564 y	NS	NS	–	2.14E-04	NS	–	–	8.61E-06	–	–	2.23E-04
Strontium-90	28.79 y	2.75E-02	NS	–	2.99E-03	1.97E-03	5.50E-05	–	NS	–	3.01E-05	3.25E-02
Tellurium-129	69.6 m	–	NS	–	–	2.71E+01	–	–	–	–	–	2.71E+01
Tellurium-129m	33.6 d	–	NS	–	–	3.93E-02	–	–	–	–	–	3.93E-02
Uranium-234	2.45E+05 y	NS	NS	–	NS	4.32E-02	–	–	–	2.03E-08	–	4.32E-02
Uranium-235	7.04E+08 y	NS	NS	NS	NS	2.44E-03	–	–	NS	NS	–	2.44E-03
Uranium-238	4.46 E+09 y	NS	NS	8.71E-10	NS	5.98E-02	–	–	NS	1.13E-07	–	5.98E-02

Table 4-2. continued.

AIRBORNE EFFLUENT (Ci)[b]												
RADIONUCLIDE[c]	HALF-LIFE[d]	ATR COMPLEX[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RRTR[e]	RWMC[e]	SMC[e]	TAN[e]	TOTAL
Xenon-135	9.14 h	NS	1.49E-01	–	–	NS	–	–	–	–	–	1.49E-01
Xenon-138	14.08 m	NS	NS	–	–	1.64E+01	–	–	–	–	–	1.64E+01
TOTAL CI RELEASED[h]		9.92E+00	6.97E-01	8.71E-10	4.42E-03	1.56E+02	3.20E-01	3.30E+01	4.81E+01	1.33E-07	3.01E-05	2.48E+02
DOSE (MREM)[i]		6.08E-04	3.13E-06	2.56E-11	2.77E-04	1.61E-02	4.58E-05	2.14E-04	6.12E-04	4.08E-09	1.23E-06	1.78E-02

a. Radionuclide release information provided by the INL contractor (INL 2023a).

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-life units: m = minutes, h=hours, d = days, 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, RRTR = Radiological Response Training Range, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project and Accelerated Retrieval Projects), TAN = Test Area North, SMC = Specific Manufacturing Capability.

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 2022.

h. Total curies may be less than the total curies in Table 8-1 in Chapter 8 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. Total curies may be less than the originally reported amounts due to changes in total activity associated with conversion from short-lived radionuclides into progeny with half-lives long enough to be modeled, and for dose to be calculated.

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

Integrated Waste Treatment Unit mission. ICP preventative maintenance practices will minimize the potential for leaks. ICP possesses an inventory of recovery cylinders dedicated to these units, ensuring that refrigerant recovered during maintenance is available to recharge the equipment. Should there be a major failure resulting in a loss of HFC-134a that renders the units inoperable, they would be replaced or retrofitted. New equipment at ICP will be specified to use refrigerants that are not subject to the HFC phasedown.

4.3 Ambient Air Monitoring

Ambient air monitoring is conducted onsite and offsite to identify regional and historical trends, to detect accidental and unplanned releases, and to determine if air concentrations are below DCSs established by DOE for inhaled air (DOE 2021). Each radionuclide-specific DCS corresponds to a dose of 100 mrem for continuous exposure during the year. The Clean Air Act NESHAP regulatory standard is 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 (including four quality assurance samplers), one high-volume air sampler, eight atmospheric moisture samplers, and four precipitation samplers operated in the network in 2022, as shown in 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 centers, and at background locations. In 2015, the network was evaluated quantitatively, using atmospheric transport modeling and frequency of detection methods (Rood, Sondrup, and Ritter 2016). A Lagrangian Puff air dispersion model (CALPUFF) with three years of meteorological data was used to model atmospheric transport of radionuclides released from six major facilities and to predict air concentrations at each sampler location for a given release time and duration. Frequency of detection is defined as the fraction of events resulting in a detection at either a single sampler or network. The frequency of detection methodology allowed for an 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 (i.e., the fraction of samplers in the network that have a positive detection for a given event) ranged from 3.75% to 62.7%. An evaluation of individual samplers indicated some samplers were poorly located and added little to the overall effectiveness of the network. Using this information, some monitors were relocated to improve the performance of the network. In 2019, the frequency of detection method was used to evaluate the Idaho Falls facilities (INL 2019), which resulted in the installation of an additional monitor at the IRC.

Tritium is present in air moisture due to natural production in the atmosphere, the remnants of global fallout from historical nuclear weapons testing, and releases from INL Site facilities (Table 4-2). Historical emissions data show that most tritium is released from the ATR Complex, INTEC, and RWMC. 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 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 areas of the highest projected air concentration. Atomic City and Howe are Idaho communities located 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 because the estimated potential dose for INL Site releases is less than 0.1 mrem/yr, which is the recommended DOE limit for routine surveillance (DOE 2015). See Chapter 8 for additional information on dose.

Historical tritium concentrations in precipitation and atmospheric moisture samples collected by the INL contractor during the 10-year period from 2011 through 2021 were compared statistically; results indicate there are no differences between the datasets. For this reason, INL contractor precipitation samplers were placed at the same locations as the atmospheric moisture samplers at Atomic City, EFS, Howe, and Idaho Falls, Idaho. In addition, Idaho Falls can be easily and readily accessed by the INL contractor personnel after a precipitation event. The EPA has a precipitation sampler in Idaho Falls and subsamples are collected for the INL contractor.

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

Table 4-3. INL Site and regional ambient air monitoring summary (2022).

MEDIUM SAMPLED	TYPE OF ANALYSIS	FREQUENCY	NUMBER OF LOCATIONS ONSITE	NUMBER OF LOCATIONS OFFSITE	MDC
Air (low volume)[a,b]	Gross alpha	Weekly	20	18	1E-15 µCi/mL
	Gross beta	Weekly	20	18	2E-15 µCi/mL
	Specific gamma[c]	Quarterly	20	18	2E-16 µCi/mL
	Plutonium-238	Quarterly	18-19	18	3.5E-18 µCi/mL
	Plutonium-239/240	Quarterly	18-19	18	3.5E-18 µCi/mL
	Americium-241	Quarterly	18-19	18	4.6E-18 µCi/mL
	Strontium-90	Quarterly	18-19	18	3.4E-17 µCi/mL
	Iodine-131	Weekly	20	18	1.5E-15 µCi/mL
Air (high volume)[d]	Gross beta scan	Biweekly	–	1	1E-15 µCi/mL
	Gamma scan	Continuous	–	1	Not applicable
	Specific gamma[c]	Annually[e]	–	1	1E-14 µCi/mL
	Isotopic Uranium & Plutonium	Every 4 yrs	–	1	2E-18 µCi/mL
Air (atmospheric moisture)[f]	Tritium	3–6/Quarter	3	5	2E-13 µCi/mL (air)
Air (precipitation)[g]	Tritium	Monthly	0	1	88 pCi/L
		Weekly	1	2	

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, Experimental Breeder Reactor No. 1 (EBR-I), Experimental Field Station (EFS), Highway 26 Rest Area, INTEC (two air samplers), Gate 4, Main Gate, MFC (two air samplers), NRF, Power Burst Facility (PBF [sampling began at the end of September 2022]), RWMC (two air samplers), SMC, and Van Buren Boulevard. Additionally, there are rotating duplicate samplers for quality assurance. In 2022, the samplers were located at INTEC (westside), RWMC, and Van Buren Boulevard. This table does not include high volume 'event' monitoring by the INL contractor.

b. The INL contractor operates low volume samplers offsite at Arco, Atomic City, Blackfoot, Blue Dome, Craters of the Moon, Dubois, Federal Aviation Administration Tower, Howe, Idaho Falls, INL Research Center (IRC) (two air samplers), Jackson (WY), Monteview, Mud Lake, Sugar City, and Terreton (sampling began at the end of September 2022). In addition, there is a rotating duplicate sampler for quality assurance. In 2022, the sampler was placed in Dubois.

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

d. The EPA RadNet stationary monitor at Idaho Falls runs 24 hours a day, seven days a week, and sends near-real-time measurements of gamma radiation to EPA's National Analytical Radiation Environmental Laboratory (NAREL). Filters are collected by INL 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 and Van Buren Boulevard by the INL contractor. Samples are collected offsite at Atomic City, Craters of the Moon, Howe, and at Idaho Falls (two samplers) by the INL contractor.

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

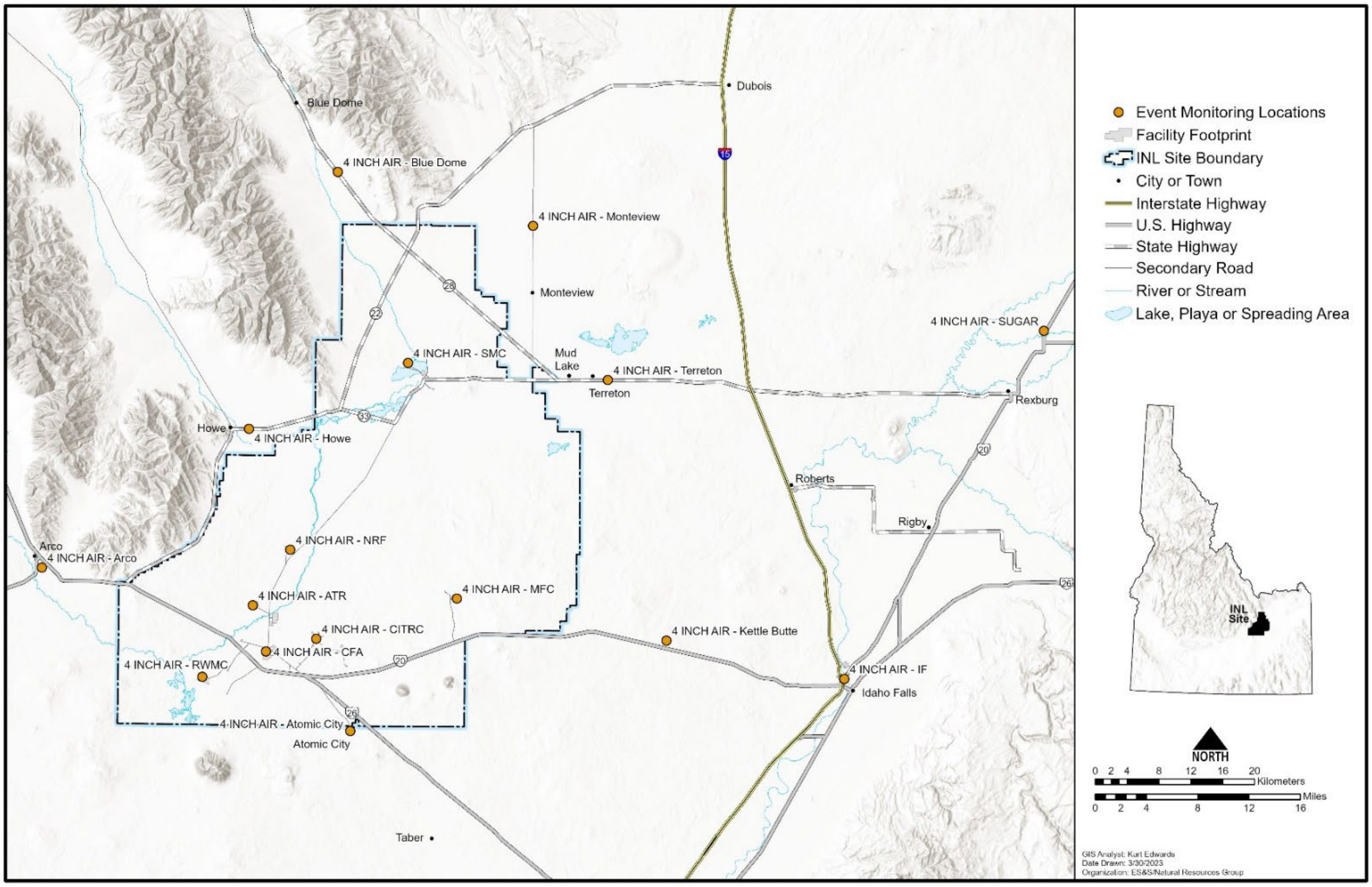


Figure 4-4. Locations of INL contractor high-volume event monitors at NOAA weather stations.

4.3.2 Air Particulate, Radioiodine, and Tritium Sampling Methods

4.3.2.1 Air Particulates

Filters are collected weekly by the INL contractor from a network of low-volume air samplers, as shown in Table 4-3. 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 at each low-volume air sampler. 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 typically 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 are used to identify specific radionuclides of concern. Gross alpha and gross beta activity are also examined over time and between locations to detect trends, which might indicate the need for more specific analyses.

The filters are composited quarterly for each location by the INL contractor for laboratory analysis of gamma-emitting radionuclides, such as ^{137}Cs, which is a man-made radionuclide present in soil both onsite and offsite 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 INL contractor also uses a contracted laboratory to radiochemically analyze quarterly composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{238}Pu, ^{234}U, ^{238}U, ^{65}Zn, 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 the resuspension of surface soil particles contaminated by INL Site activities or global fallout. INL contractor samples are analyzed on a rotating basis; each quarter five or six composites are selected for alpha spectrometry and five or six 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 contractor at the locations shown in Table 4-3. 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 INL contractor monitors tritium in atmospheric water vapor in ambient air onsite at EFS and Van Buren Boulevard and offsite at Atomic City, Howe, Craters of the Moon, and Idaho Falls. Air passes through a column of molecular sieve, which is a material that adsorbs water vapor. The molecular sieve is sent to a laboratory for analysis once 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 INL contractor at Atomic City, EFS, Howe, and Idaho Falls and are analyzed for tritium using liquid scintillation counting.

4.3.3 Ambient Air Monitoring Results

4.3.3.1 Gaseous Radioiodines

The INL contractor collected and analyzed approximately 2,200 charcoal cartridges (including blanks and duplicates) in 2022. There were no statistically positive measurements of ^{131}I.

4.3.3.2 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 dataset provide useful information for trending of the total activity over time.

Concentrations of gross alpha and gross beta radioactivity detected by ambient air monitoring conducted by the INL contractor are summarized in Tables 4-4 and 4-5. Results are further discussed below.

Table 4-4. Median annual gross alpha concentrations in ambient air samples collected by the INL contractor in 2022.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] (× 10^{-15} µCi/mL)	ANNUAL MEDIAN CONCENTRATION (× 10^{-15} µCi/mL)
Boundary	Arco	51	0.26 – 5.35	1.5
	Atomic City	50	0.29 – 6.44	1.6
	Blue Dome	50	0.43 – 5.19	1.6
	FAA Tower	51	0.29 – 3.69	1.4
	Howe	49	0.51 – 4.87	1.7
	Monteview	51	0.44 – 6.29	1.7
	Mud Lake	50	0.26 – 4.66	1.6
	Terreton	12	0.65 – 2.59	1.8
			Boundary Median:	*1.6*
Offsite	Blackfoot	88	-0.09 – 5.88	1.5
	Craters of the Moon	90	-0.36 – 5.15	1.2
	Dubois	50	0.24 – 4.20	1.6
	Idaho Falls	88	-0.21 – 4.63	1.5
	IRC[d]	51	-0.44 – 3.90	1.2
	IRC (north)	47	-0.20 – 3.90	1.3
	Jackson, WY	51	0.48 – 5.32	1.6
	Sugar City	89	-0.58 – 4.30	1.4
			Offsite Median:	*1.4*
Onsite	ATR Complex (NE corner)	47	-0.27 – 3.42	1.4
	CFA	50	0.03 – 4.20	1.3
	EBR-I	49	-0.57 – 5.16	1.1
	EFS	85	-0.42 – 5.93	1.5
	Gate 4	51	-0.42 – 5.38	1.6
	Highway 26 Rest Area	51	-0.52 – 5.21	1.5
	INTEC	48	-0.25 – 5.54	1.3
	INTEC (west side)	50	0.10 – 4.91	1.4
	Main Gate	50	0.37 – 9.73	1.6
	MFC (north)	49	-0.09 – 6.20	1.4
	MFC (south)	51	-0.53 – 4.95	1.4
	NRF	49	-0.55 – 4.98	1.3
	PBF	12	0.28 – 1.55	1.1
	RHLLW	51	-0.73 – 6.60	1.2
	RWMC	51	-0.52 – 4.04	1.3
	RWMC (South)	50	-1.50 – 4.27	1.5
	SMC	47	-0.39 – 5.62	1.1
	Van Buren Boulevard	89	-0.17 – 5.04	1.2
			Onsite Median:	*1.4*

Table 4-4. continued.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] (× 10^{-15} µCi/mL)	ANNUAL MEDIAN CONCENTRATION (× 10^{-15} µCi/mL)

a. FAA = Federal Aviation Administration, RHLLW = Remote Handled Low-Level Waste Disposal Facility. 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 the INL contractor, except for duplicate measurements made for quality assurance purposes, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

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

Gross Alpha – Gross alpha concentrations are measured on a weekly basis in individual air samples ranged from a low of (-1.5 ± 1.5) × 10^{-15} µCi/mL, collected by the INL contractor at RWMC (south) on June 15, 2022, to a high of (9.7 ± 1.0) × 10^{-15} µCi/mL, collected by the INL contractor at Main Gate on November 15, 2022, as shown in Table 4-4.

The median annual gross alpha concentrations were typical of previous measurements. The maximum result is less than the DCS (DOE 2021) of 1.1 × 10^{-13} µCi/mL for $^{239/240}$Pu, which is the most conservative specific radionuclide DCS that could be—although unrealistically—applied to gross alpha activity.

Gross Beta – Weekly gross beta concentrations measured in air samples ranged from a low of (1.0 ± 1.0) × 10^{-15} µCi/mL at Blackfoot, collected by the INL contractor on June 1, 2022, to a high of (11.4 ± 0.2) × 10^{-14} µCi/mL collected by the INL contractor at Main Gate on November 22, 2022, as observed in Table 4-5. The lowest detected value (i.e., greater than three sigma [3σ]) was (2.9 ± 0.38) × 10^{-15} µCi/mL collected by the INL contractor at MFC (north) on September 14, 2022. All results were less than the maximum concentration of 1.0 × 10^{-13} µCi/mL which was reported in previous Annual Site Environmental Reports (2012–2021). In general, median airborne radioactivity levels for the onsite, boundary, and offsite locations tracked each other closely throughout the year. The typical temporal fluctuations for natural gross beta concentrations in the air were observed, with higher values usually occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). This pattern occurs over the entire sampling network, is representative of natural conditions, and is not caused by a localized source, such as a facility or activity at the INL Site. An inversion can lead to natural radionuclides being trapped close to the ground. The maximum weekly gross beta concentration is significantly below the DCS of 9.6 × 10^{-12} µCi/mL for the most restrictive beta-emitting radionuclide in the air, ^{90}Sr.

Table 4-5. Median annual gross beta concentrations in ambient air samples collected the INL contractor in 2022.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] ($\times 10^{-14}$ µCi/mL)	ANNUAL MEDIAN CONCENTRATION[c] ($\times 10^{-14}$ µCi/mL)
Boundary	Arco	51	1.29 – 5.37	2.4
	Atomic City	50	1.24 – 6.59	2.6
	Blue Dome	50	1.15 – 5.44	2.5
	FAA Tower	51	1.28 – 4.98	2.3
	Howe	49	1.24 – 6.21	2.7
	Monteview	51	1.28 – 6.96	2.7
	Mud Lake	50	0.41 – 6.35	2.7
	Terreton	12	1.14 – 5.05	2.4
			Boundary Median:	*2.5*
Offsite	Blackfoot	88	0.10 – 6.31	2.3
	Craters of the Moon	90	0.56 – 5.47	2.0
	Dubois	50	1.28 – 5.12	2.4
	Idaho Falls	88	0.95 – 6.05	2.4
	IRC[d]	51	0.88 – 4.67	2.4
	IRC (north)	47	0.99 – 5.57	2.3
	Jackson, WY	51	1.26 – 6.13	2.6
	Sugar City	89	0.96 – 5.02	2.4
			Offsite Median:	*2.3*
Onsite	ATR Complex (NE corner)	47	0.98 – 5.55	2.2
	CFA	50	0.93 – 5.35	2.5
	EBR-I	49	1.02 – 4.88	2.2
	EFS	85	0.52 – 8.76	2.6
	Gate 4	51	0.93 – 5.63	2.4
	Highway 26 Rest Area	51	1.16 – 4.79	2.5
	INTEC	48	0.90 – 5.61	2.5
	INTEC (west side)	50	0.74 – 5.17	2.5
	Main Gate	50	1.14 – 11.40	2.6
	MFC (north)	49	0.29 – 5.41	2.2
	MFC (south)	51	0.19 – 5.01	2.1
	NRF	49	1.04 – 4.61	2.4
	PBF	12	0.97 – 2.62	1.6
	RHLLW	51	0.99 – 4.68	2.4
	RWMC	51	0.90 – 5.57	2.4
	RWMC (south)	50	1.07 – 5.37	2.6
	SMC	47	1.05 – 4.94	2.3
	Van Buren Boulevard	89	0.92 – 5.15	2.4
			Onsite Median:	*2.4*

Table 4-5. continued.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] ($\times 10^{-14}$ µCi/mL)	ANNUAL MEDIAN CONCENTRATION[c] ($\times 10^{-14}$ µCi/mL)

a. FAA = Federal Aviation Administration, RHLLW = Remote Handled Low-Level Waste Disposal Facility. 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 the INL contractor, 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 INL Research and Education Campus.

4.3.3.3 Gross Activity Statistical Comparisons

Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected by the INL contractor from the onsite, boundary, and offsite locations For these analyses, uncensored analytical results (i.e., values less than their analysis-specific minimum detectable concentrations) were included. There were a few statistical differences between monthly boundary and offsite data sets collected by the INL contractor during 2022 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 https://idahoeser.inl.gov/publications.html.

The INL contractor compared gross beta concentrations from samples collected at onsite and boundary locations. Statistical evaluation revealed no significant differences between onsite and boundary concentrations. Onsite and boundary mean concentrations ($2.5 \pm 1.0 \times 10^{-14}$ and $2.7 \pm 1.0 \times 10^{-14}$ µCi/mL, respectively) showed equivalence at one sigma (1σ) uncertainty and are attributable to natural data variation.

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.

Specific Radionuclides – The INL contractor observed six detections of ^{90}Sr throughout 2022. The detectable concentrations ranged from 3.0×10^{-17} µCi/mL at Monteview during the fourth quarter to 9.4×10^{-17} µCi/mL at Dubois in the first quarter, as observed in Table 4-6. Plutonium-239/240 was detected in quarterly composited samples that were collected at Blue Dome, RWMC, and RWMC (duplicate) during the fourth quarter (Table 4-6). Americium-241 was detected in quarterly composited samples collected at RWMC and the RWMC (duplicate) in the fourth quarter. Plutonium-238 was not detected in any sample collected by the INL contractor. All results were within historical measurements made during the past ten years (2012-2021). The results were well below the DCSs for these radionuclides in air (i.e., 9.6×10^{-12} µCi/mL for ^{90}Sr, 1.1×10^{-13} µCi/mL for $^{239/240}$Pu, and 1.3×10^{-13} µCi/mL for ^{241}Am). In addition to the radionuclides discussed earlier, the INL contractor began monitoring for uranium during 2022. While not enumerated in Table 4-6, detections of uranium radionuclides occur routinely at concentrations that suggest a natural origin (INL 2023c, INL 2023d). Natural ^{7}Be was detected in numerous 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.

Table 4-6. Human-made radionuclides detected in ambient air samples collected by the INL contractor in 2022.

RADIONUCLIDE	RESULT[a] (µCi/mL)	LOCATION	GROUP	QUARTER DETECTED
Americium-241	$(4.5 \pm 0.8) \times 10^{-17}$	RWMC	Onsite	4th
Americium-241	$(3.1 \pm 0.7) \times 10^{-17}$	RWMC (duplicate)	Onsite	4th
Strontium-90	$(5.0 \pm 0.9) \times 10^{-17}$	Howe	Boundary	1st
Strontium-90	$(6.6 \pm 0.6) \times 10^{-17}$	Blue Dome	Boundary	1st
Strontium-90	$(8.1 \pm 0.6) \times 10^{-17}$	FAA Tower	Boundary	1st
Strontium-90	$(9.4 \pm 0.8) \times 10^{-17}$	Dubois	Offsite	1st
Strontium-90	$(6.4 \pm 0.7) \times 10^{-17}$	Dubois (duplicate)	Offsite	1st
Strontium-90	$(3.0 \pm 0.6) \times 10^{-17}$	Monteview	Boundary	4th
Plutonium-239/240	$(3.1 \pm 0.7) \times 10^{-17}$	Blue Dome	Boundary	4th
Plutonium-239/240	(2.6 ± 0.6) x 10^{-17}	RWMC	Onsite	4th
Plutonium-239/240	(1.8 ± 0.5) x 10^{-17}	RWMC (duplicate)	Onsite	4th

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

4.3.4 Atmospheric Moisture Monitoring Results

During 2022, the INL contractor collected 66 atmospheric moisture samples at six locations. Table 4-7 presents the percentage of samples containing detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in eight INL samples, with a high of $(14.5 \pm 2.9) \times 10^{-13}$ µCi/mL$_{air}$ at Idaho Falls on August 24, 2022. The highest concentration of tritium detected in an atmospheric moisture sample collected since 2011 was 31×10^{-13} µCi/mL$_{air}$ at EFS in 2015. The highest observed tritium concentration in a 2022 sample collected by the INL contractor is far below the DCS for tritium in air (as water vapor) of 1.3×10^{-7} µCi/mL$_{air}$.

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 are highly localized and although they may be detected immediately adjacent to the facility, they 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 compositions in precipitation around the globe since 1961 (https://www.iaea.org/services/networks/gnip). 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 most likely cosmogenic in origin and not from weapons testing.

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

A total of 74 precipitation samples were collected during 2022 from the four sites. Tritium was detected in seven samples, and detectable results ranged from 104 pCi/L at EFS in March to 203 pCi/L at Howe in April. Most detections were near the approximate detection level of 93 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 below the DCS level of 2.6 × 10^6 pCi/L for tritium in water and within the historical range (-173 to 413 pCi/L) measured from 2012–2021.

Table 4-7. Tritium concentrations[a] in atmospheric moisture samples collected by the INL contractor onsite and offsite in 2022.

	ATOMIC CITY	CRATERS OF THE MOON	EFS	HOWE	IDAHO FALLS	VAN BUREN BOULEVARD
Number of samples	10	6	17	8	17	8
Number of detections[b]	1	0	4	1	2	0
Detection percentage	10%	0%	24%	13%	12%	0%
Concentration range (×10^{-13} µCi/mL$_{air}$)[c]	0.5 ± 0.8 – 7.2 ± 2.2	-22 ± 35 – 176 ± 480	-104 ± 49 – 14 ± 41	-4.0 ± 2.7 – 4.1 ± 1.1	-5.1 ± 22.0 – 14.5 ± 2.9	-50 ± 58 – 51 ± 32
Mean concentration (×10^{-13} µCi/mL$_{air}$)[c]	2.5	27.2	-3.2	1.2	2.4	0.58
Median concentration (×10^{-13} µCi/mL$_{air}$)	1.8	3.1	4.0	2.3	1.9	1.6
Mean detection level (×10^{-13} µCi/mL$_{air}$)	4.2	300	36	4.7	22	93

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 INL contractor in 2022.[a,b]

	ATOMIC CITY	EFS	HOWE	IDAHO FALLS
Number of samples	20	21	21	12
Number of detections	2	2	3	0
Detection percentage	10%	10%	14%	0%
Concentration range (pCi/L)	-57.4 ± 107 – 136 ± 27.2	-58.3 ± 32.6 – 167 ± 31.9	-25.1 ± 23.4 – 203 ± 35.1	-16.0 ± 33.2 – 104 ± 35.7
Mean concentration (pCi/L)	32.3	26.3	50.6	45.3
Median concentration (pCi/L)	32.5	28.7	36.5	49.9
Mean detection level (pCi/L)	92.9	93.9	93.0	95.9

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

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://enviro.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 datasets (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 illustrating annual tritium concentrations measured in atmospheric moisture (as water) and precipitation samples collected by the INL contractor for the past 10 years, as can be seen in Figure 4-5. The results appear to be similar for each year. A statistical comparison of both datasets (using the non-parametric 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.

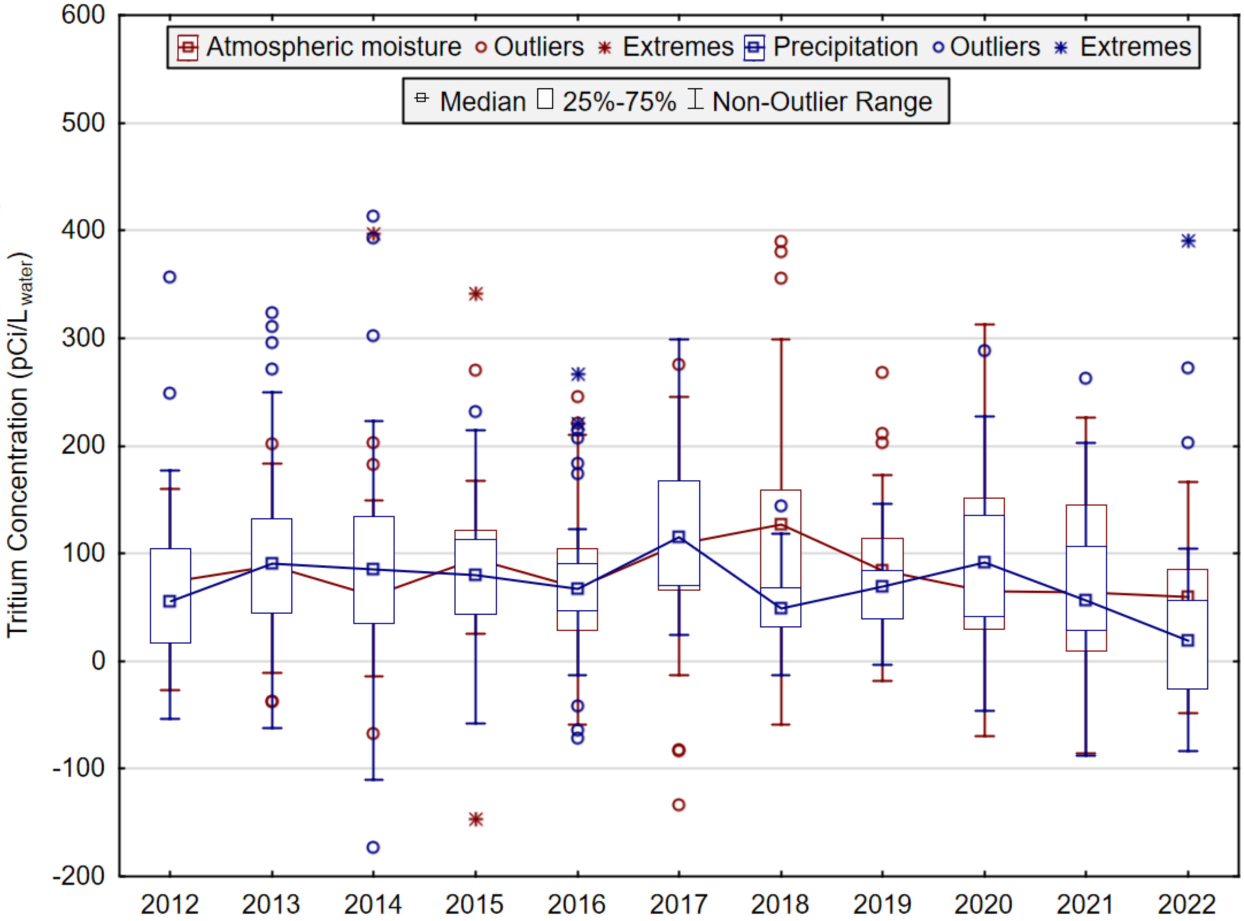


Figure 4-5. Box plots of tritium concentrations measured in atmospheric moisture and in precipitation from 2012–2022.

4.4 Waste Management Environmental Surveillance Air Monitoring

4.4.1 Gross Activity

The ICP contractor conducts environmental surveillance in and around waste management facilities to comply with DOE O 435.1, "Radioactive Waste Management." Currently, ICP 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 contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2022, as observed in Figure 4-6. Samples were also collected at a control location at Howe, Idaho, as shown in 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 contractor. The air filters have a 4-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 (0.57 ± 0.09) × 10^{-15} µCi/mL collected at location SDA 6.3 on September 15, 2022, to a high of (4.62 ± 0.68) × 10^{-15} µCi/mL, collected at location SDA 9.3 on February 15, 2022.

Table 4-10 shows the annual median and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of (0.10 ± 0.01) × 10^{-14} µCi/mL at location SDA 6.3 on September 15, 2022, to a high of (5.50 ± 0.47) x 10^{-14} µCi/mL at location HOWE 400.4 on February 15, 2022.

Figure 4-7 compares gross alpha and gross beta sample results from 2011 through 2022 to the most restrictive DCS values ($^{239/240}$Pu for gross alpha and ^{90}Sr for gross beta) established by DOE for inhaled air (DOE 2021). The 2022 results for the SDA and ICDF are well below their respective DCS values. Results from the SDA and ICDF were compared with the results collected from the background monitoring location in Howe, Idaho. The ranges of concentrations measured at the SDA and ICDF were aligned with the range measured at the Howe (background) monitoring location.

4.4.2 Specific Radionuclides

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

In 2022, no human-made, gamma-emitting radionuclides were detected in air samples at the ICDF at INTEC. However, multiple human-made specific alpha-emitting radionuclides were detected at the SDA at RWMC.

Table 4-11 shows human-made specific radionuclides detected at INTEC and the SDA in 2022. These detections are consistent with levels measured in the air at the SDA in previous years. All detections were three to four orders of magnitude below the DCS stipulated in the DOE Order (2021), 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 contractor also monitors for uranium. While not enumerated in Table 4-11, detections of uranium radionuclides occur routinely at concentrations that suggest a natural origin.

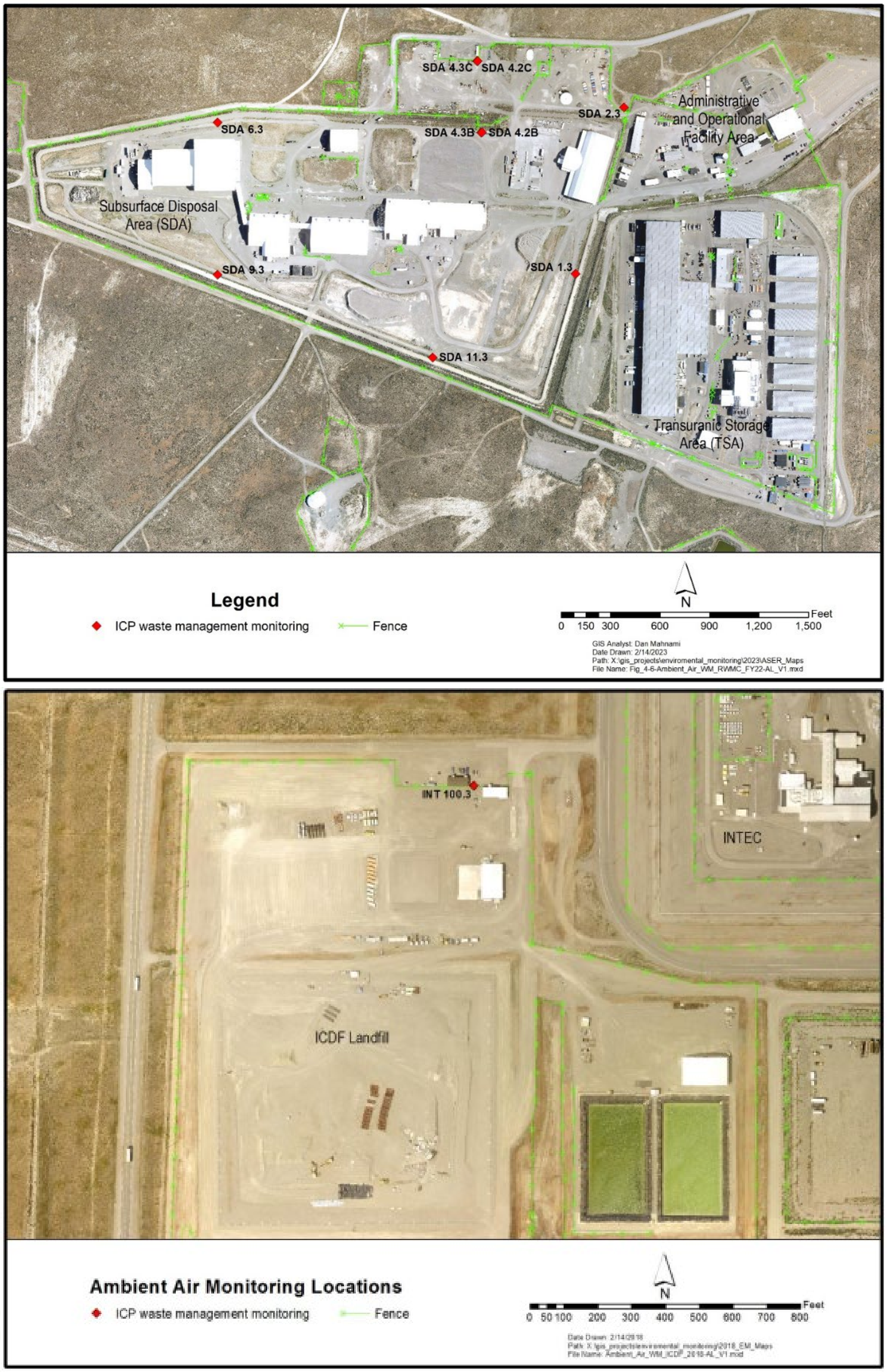


Figure 4-6. Locations of ICP contractor low-volume air samplers at waste management areas (SDA [top] and ICDF [bottom]).

Table 4-9. Median annual gross alpha concentration in air samples collected at waste management sites in 2022.[a]

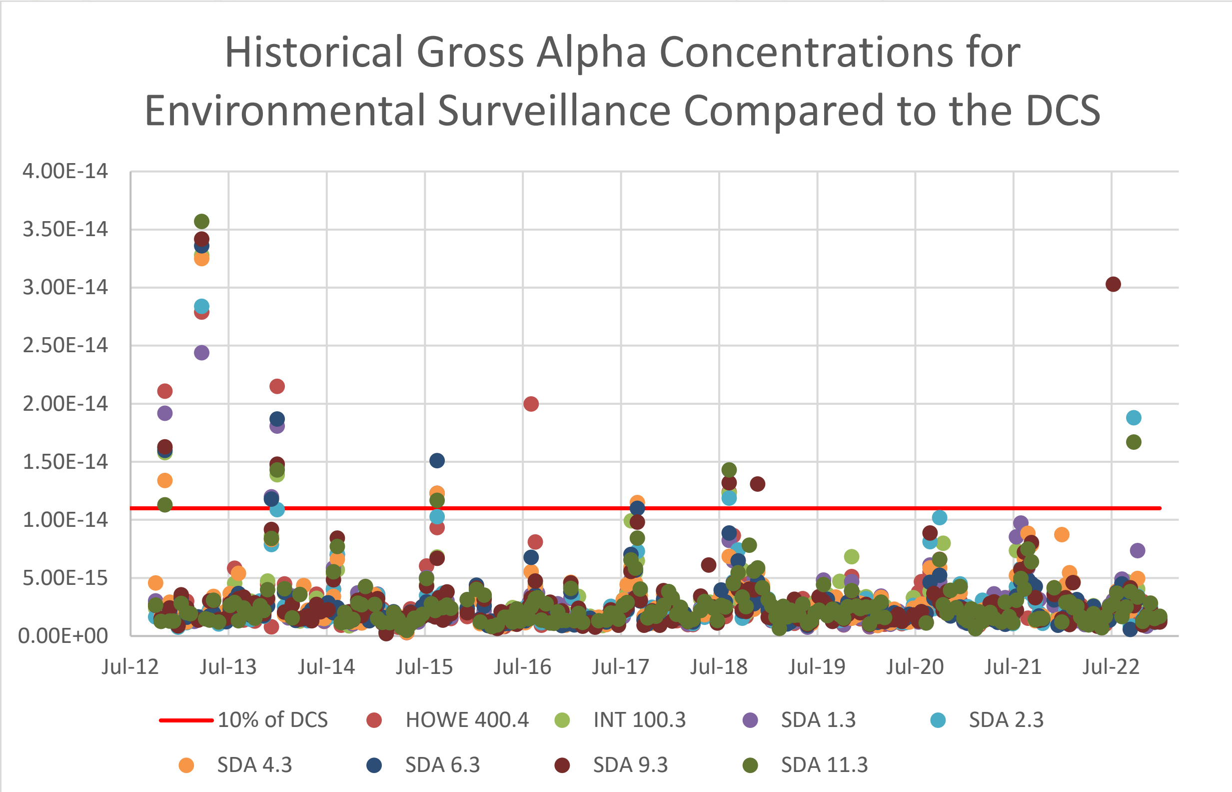
GROUP	LOCATION	NO. OF SAMPLES COLLECTED	RANGE OF CONCENTRATIONS (× 10^{-15} µCi/mL)	ANNUAL MEDIAN (× 10^{-15} µCi/mL)
SDA	SDA 1.3	16	0.86 - 3.06	1.66
	SDA 2.3	18	0.90 - 3.44	1.66
	SDA 4.2B/C and 4.3B/C [a]	26	0.79 - 3.69	1.83
	SDA 6.3	20	0.57 - 3.20	1.77
	SDA 9.3	17	0.86 - 4.62	1.84
	SDA 11.3	19	0.73 - 3.37	1.72
ICDF	INT 100.3	19	1.16 - 4.07	1.74
Boundary	HOWE 400.4	18	1.02 - 3.22	1.97

a. Results for SDA 4.2B/C, a replicate of SDA 4.3B/C, are included in the table for 2022 because of mechanical issues with SDA 4.3B/C occurring in 2022.

Table 4-10. Median annual gross beta concentration in air samples collected at waste management sites in 2022.[a]

GROUP	LOCATION	NO. OF SAMPLES COLLECTED	RANGE OF CONCENTRATIONS (× 10^{-14} µCi/mL)	ANNUAL MEDIAN (× 10^{-14} µCi/mL)
SDA	SDA 1.3	16	0.28 - 3.89	0.81
	SDA 2.3	19	0.18 - 4.93	0.98
	SDA 4.2B/C and 4.3B/C [a]	29	0.13 - 4.93	1.00
	SDA 6.3	21	0.10 - 4.68	0.80
	SDA 9.3	17	0.14 - 4.91	1.16
	SDA 11.3	19	0.12 - 5.24	0.95
ICDF	INT 100.3	20	0.27 - 4.28	1.00
Boundary	HOWE 400.4	18	0.19 - 5.50	0.92

a. Results for SDA 4.2B/C, a replicate of SDA 4.3B/C, are included in the table for 2022 because of mechanical issues with SDA 4.3B/C occurring in 2022.



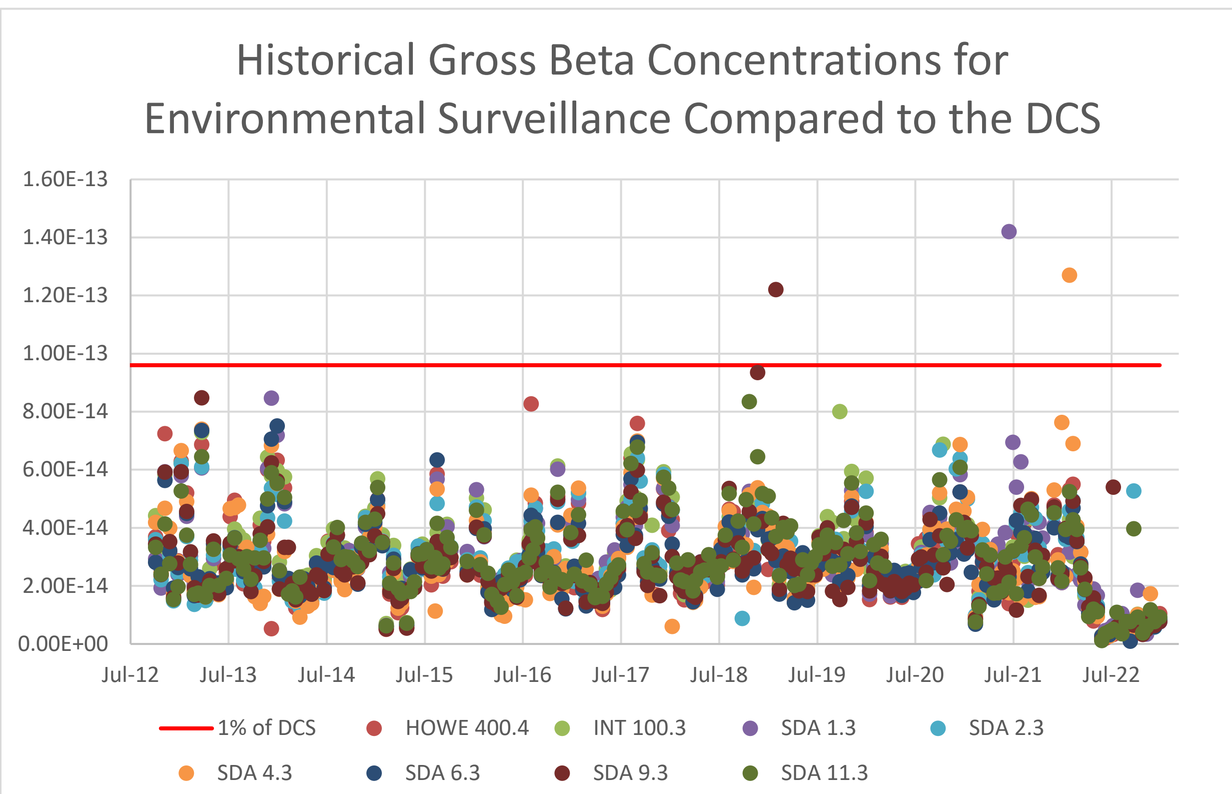


Figure 4-7. Gross alpha (top) and gross beta (bottom) results from waste management site air samples (µCi/mL) compared to their respective DCSs.

Table 4-11. Human-made radionuclides detected in air samples collected at waste management sites in 2022.[a]

RADIONUCLIDE	LOCATION	RESULT (µCi/mL)	UNCERTAINTY (1 SIGMA)	PERIOD DETECTED
Americium-241	SDA 1.3	3.70E-18	9.94E-19	12/20/2021–3/31/2022
	SDA 2.3	4.11E-18	1.28E-18	12/20/2021–3/31/2022
	SDA 4.2B/C and 4.3B/C [b]	1.44E-17	2.34E-18	12/20/2021–3/31/2022
	SDA 4.2B/C and 4.3B/C [b]	8.06E-18	1.60E-18	3/31/2022–5/16/2022 [c]
	SDA 4.2B/C and 4.3B/C [b]	8.18E-18	1.76E-18	3/31/2022–5/16/2022 [c]
Plutonium-238	SDA 4.2B/C and 4.3B/C [b]	2.90E-18	7.85E-19	3/31/2022–5/16/2022 [c]
Plutonium-239/240	SDA 1.3	2.12E-18	5.15E-19	12/20/2021–3/31/2022
	SDA 2.3	1.56E-18	9.94E-19	12/20/2021–3/31/2022
	SDA 4.2B/C and 4.3B/C [b]	2.99E-18	6.16E-19	12/20/2021–3/31/2022
	SDA 4.2B/C and 4.3B/C [b]	2.70E-18	8.02E-19	12/20/2021–3/31/2022
	SDA 4.2B/C and 4.3B/C [b]	1.65E-18	5.15E-19	3/31/2022–5/16/2022 [c]
	SDA 4.2B/C and 4.3B/C [b]	4.82E-18	9.97E-19	3/31/2022–5/16/2022 [c]
	SDA 11.3	2.44E-18	9.97E-19	3/31/2022–5/16/2022 [c]

a. Results shown are ≥ 3σ.

b. Results for SDA 4.2B/C, a replicate of SDA 4.3B/C, are included in the table for 2022 because of mechanical issues with SDA 4.3B/C occurring in 2022.

c. Samples collected in calendar year quarters 2–4 were not composited correctly by the laboratory as agreed upon in the task order statement of work. Laboratory staff were not aware of the need to composite the samples due to unfamiliarity (the previous lab shut down mid-year).

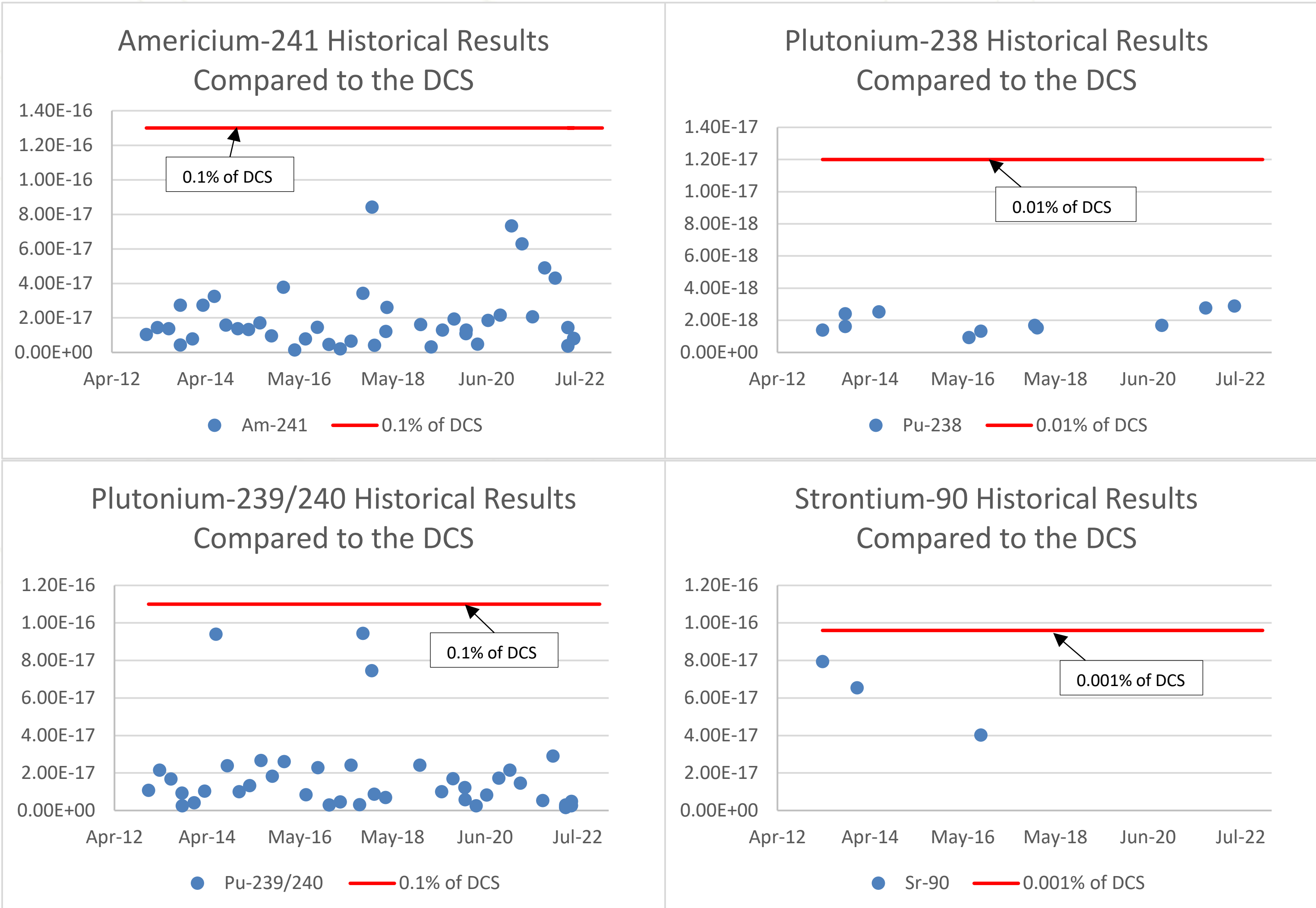


Figure 4-8. Specific human-made radionuclide detections (µCi/mL) from waste management air samples compared to various fractions of their respective DCSs.

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Chapter 5: Environmental Monitoring Programs – Liquid Effluents Monitoring

CHAPTER 5

Wastewater discharged to land surfaces and infiltration basins (percolation ponds) at the Idaho National Laboratory (INL) Site is regulated by the state of Idaho groundwater quality and recycled water rules and requires a reuse permit. Liquid effluents and surface water runoff were monitored in 2022 by the INL contractor and the Idaho Cleanup Project (ICP) contractor for compliance with permit requirements and applicable Department of Energy (DOE) orders established to protect human health and the environment.

During 2022, permitted reuse facilities included the Advanced Test Reactor Complex Cold Waste Ponds, Idaho Nuclear Technology and Engineering Center New Percolation Ponds and Sewage Treatment Plant, and Materials and Fuels Complex Industrial Waste Pond. Liquid effluent and groundwater at these facilities were sampled for parameters required by their facility-specific permits. No permit limits were exceeded in 2022.

Additional liquid effluent and groundwater monitoring was performed in 2022 at the Advanced Test Reactor Complex, Idaho Nuclear Technology and Engineering Center, and Materials and Fuels Complex to comply with environmental protection objectives of DOE. All parameters were below applicable health-based standards in 2022.

Surface water that runs off the Subsurface Disposal Area at the Radioactive Waste Management Complex during periods of rapid snowmelt or heavy precipitation was sampled and analyzed for radionuclides. Additionally, water sheet flowed across asphalt surfaces and infiltrated around/under door seals at Waste Management Facility-636 at the Advanced Mixed Waste Treatment Project and collected in catch tanks. Specific human-made gamma-emitting radionuclides were not detected. Detected concentrations of americium-241, plutonium-239/240, and uranium isotopes did not exceed DOE Derived Concentration Standards.

5. ENVIRONMENTAL MONITORING PROGRAMS – LIQUID EFFLUENTS MONITORING

Some INL Site operations retain wastewater in lined, total containment evaporative ponds constructed to eliminate liquid effluent discharges to the environment. Other INL Site operations discharge liquid effluents to unlined infiltration basins or ponds that may potentially contain nonhazardous levels of radioactive, or nonradioactive, contaminants. Effluent discharges are subject to specified discharge limits, permit limits, or maximum contaminant levels. INL and ICP personnel conduct liquid effluent monitoring through liquid effluent and surface water runoff sampling and surveillance programs to ensure compliance with applicable permits, limits, and maximum contaminant levels. These programs also sample groundwater related to liquid effluent.

Table 5-1 presents the requirements for liquid effluent monitoring performed at the INL Site. Maps and a comprehensive discussion 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 *INL Environmental Monitoring Plan* (DOE-ID 2021). 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 A.

Table 5-1. Liquid effluent monitoring at the INL Site.

MONITORING REQUIREMENTS			
AREA/FACILITY	IDAHO REUSE PERMIT[a]	DOE O 458.1[b] LIQUID EFFLUENT MONITORING	DOE O 435.1[c] SURFACE RUNOFF SURVEILLANCE
INL CONTRACTOR			
ATR[d] Complex Cold Waste Ponds	•	•	
MFC[d] Industrial Waste Pond	•	•	
ICP CONTRACTOR			
INTEC[d] New Percolation Ponds and Sewage Treatment Plant	•	•	
RWMC[d] SDA[d] surface water runoff		•	•

a. Required by permits issued according to the Idaho Department of Environmental Quality Rules, IDAPA 58.01.17, “Recycled Water Rules.” This includes wastewater effluent monitoring and related groundwater monitoring.

b. Paragraph 4(g) of DOE Order 458.1, “Radiation Protection of the Public and the Environment,” establishes specific requirements related to control and management of radionuclides from DOE activities in liquid discharges. Radiological liquid effluent monitoring recommendations in DOE Handbook Environmental Radiological Effluent Monitoring and Environmental Surveillance (DOE-HDBK-1216-2015) (DOE 2015) are followed to ensure quality. DOE Standard DOE-STD-1196-2021, “Derived Concentration Technical Standard,” (DOE 2021) supports the implementation of DOE O 458.1 and provides Derived Concentration Standards as reference values to control effluent releases from DOE facilities.

c. 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. DOE Handbook DOE-HDBK-1216-2015 suggests that potential impacts of stormwater runoff as a pathway to humans or biota should be evaluated.

d. Advanced Test Reactor (ATR), Materials and Fuels Complex (MFC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Subsurface Disposal Area (SDA).

5.1 Liquid Effluent and Related Groundwater Compliance Monitoring

Discharge of liquid effluent to the land surface for treatment or disposal is known as “reuse” in the state of Idaho and 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 Procedures Act. The Idaho Department of Environmental Quality (DEQ) issues reuse permits for operation of the reuse systems. Reuse permits may require monitoring of nonradioactive constituents in the effluent and groundwater in accordance with the monitoring requirements specified within each permit. Some facilities may have specified radiological constituents monitored for surveillance purposes (but are not required by regulations). The permits may specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2023a and 2023b; INL 2023a, 2023b, 2023c, and 2023d) were prepared and submitted to the Idaho DEQ.

During 2022, the INL and ICP contractors monitored, as required by the permits, the following reuse facilities shown in Table 5-2:

- ATR Complex Cold Waste Ponds (Section 5.1.1)
- INTEC New Percolation Ponds and Sewage Treatment Plant (STP) (Section 5.1.2)
- MFC Industrial Waste Pond (Section 5.1.3).

Table 5-2. 2022 status of reuse permits.

FACILITY	PERMIT STATUS AT END OF 2022	PERMIT EXPIRATION DATE	EXPLANATION
ATR Complex Cold Waste Ponds	Active	October 29, 2029	Idaho DEQ issued Reuse Permit I-161-03 on October 30, 2019 (DEQ 2019), with Modification 1 issued May 23, 2022 (DEQ 2022a).
INTEC New Percolation Ponds	Active	June 1, 2024	Idaho DEQ issued Permit M-130-06 on June 1, 2017 (DEQ 2017).
MFC Industrial Waste Pond	Active	January 25, 2027	Idaho DEQ issued Reuse Permit I-160-02 on January 26, 2017, with modifications issued March 7, 2017; May 8, 2019; May 21, 2020[a] (DEQ 2020); and May 23, 2022 (DEQ 2022b).

a. MFC Modification 3, issued May 21, 2020, removed the Industrial Waste Ditch as a permit Management Unit, resulting in changes to monitoring and reporting requirements. Idaho DEQ re-issued Modification 3 on September 15, 2020, to correct administrative matters.

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 RWMC is presented in Section 5.3.

5.1.1 Advanced Test Reactor Complex Cold Waste Ponds

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, as shown in Figure 5-1. The CWP was excavated in 1982 and consist of two unlined cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms and with 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).

The CWP function as percolation basins for the infiltration of nonhazardous industrial liquid effluent consisting 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. The cold waste effluent reports through collection piping to a monitoring location where flow rates to the CWP are measured using a v-notch weir and effluent samples are collected using an automated composite sampler.

Effluent Monitoring Results for the Reuse Permit. Reuse Permit I-161-03 Modification 1 requires monthly sampling of the effluent to the CWP (DEQ 2022a). The 2022 permit reporting year monitoring results are presented in the 2022 annual reuse report (INL, 2023c) and the 2022 calendar year monitoring results are summarized in Table A-1 in Appendix A. The total dissolved solids concentrations ranged from 204–266 mg/L. Sulfate ranged from 21.1 mg/L to 30.1 mg/L. 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. Due to the composition and characteristics of the effluent, the reuse permit does not require pre-treatment or specify maximum constituent loading limits or concentration limits for the cold waste effluent discharged to the CWP. The 2022 constituent concentrations continue to remain consistent with historical results.

The permit specifies the maximum annual and five-year moving average hydraulic loading rate limits of 300 MG/yr and 375 MG/yr, respectively, based on the annual reporting year of the permits. As shown in Table A-2, the 2022 annual reporting year flow of 279.21 MG did not exceed either of these hydraulic loading limits.

Groundwater Monitoring Results for the Reuse Permit. The permit requires groundwater monitoring twice annually in April/May and September/October, at seven groundwater wells (see Figure 5-1), to measure potential impacts from the CWP. In 2022, none of the constituents exceeded their respective primary or secondary constituent standards. The constituents are presented in Table A-3a and Table A-3b. The metals concentrations continue to remain at low levels and are consistent with historical ranges.

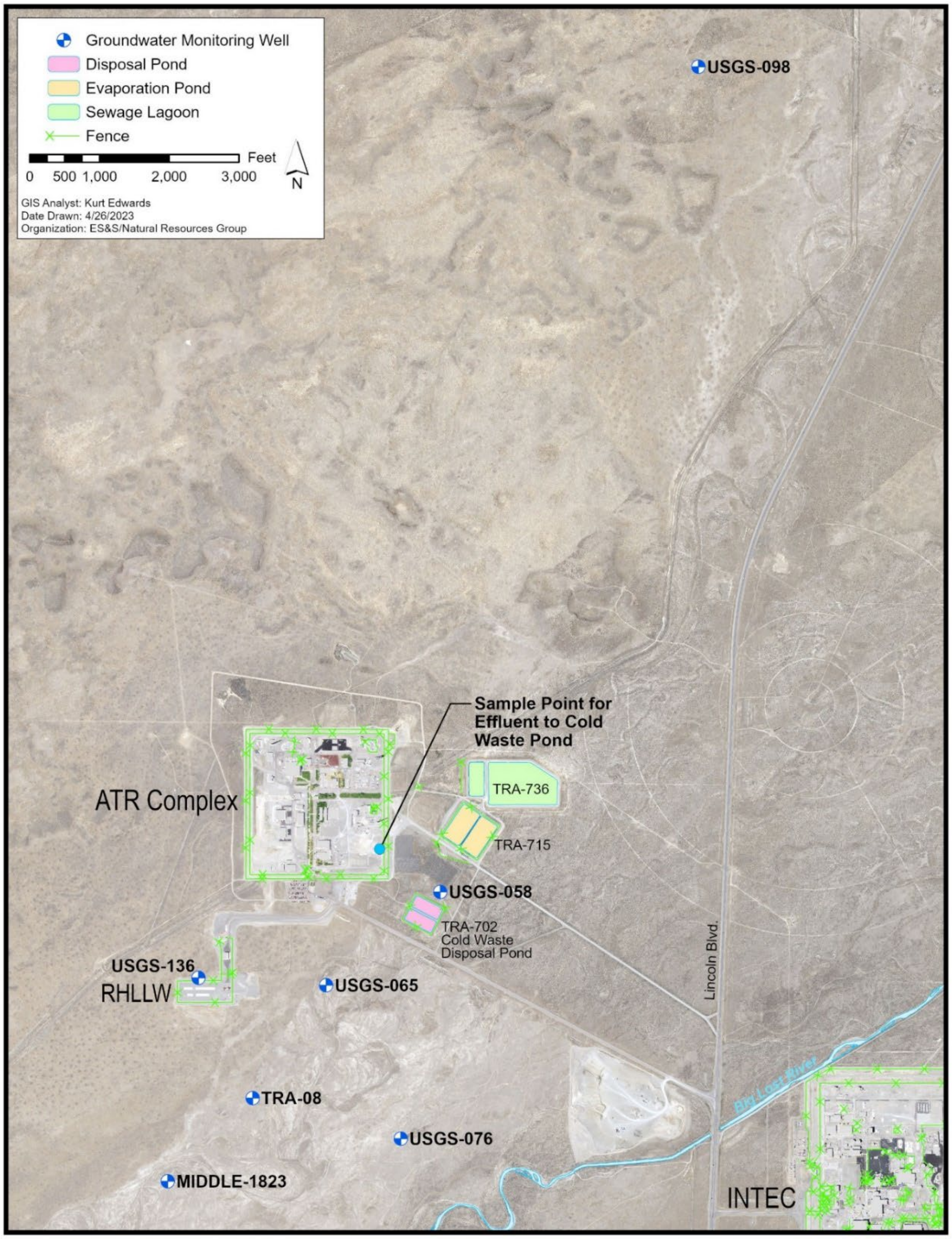

Figure 5-1. Permit monitoring locations for the ATR Complex Cold Waste Pond.

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 rapid infiltration ponds excavated into the surficial alluvium and surrounded by bermed alluvial material, as observed in Figure 5-2. The rapid infiltration system uses the soil ecosystem to treat wastewater. Each pond is 93 m × 93 m (305 ft × 305 ft) at the top of the berm and is 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, stormwater, 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 (e.g., 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 Idaho 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), as shown in 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 2022 reporting year monitoring results for CPP-769, CPP-773, and CPP-797 are provided in the 2022 Wastewater Reuse Report (ICP 2023a), and the 2022 calendar year monitoring results are summarized in Tables B-4, B-5, and B-6 (in Appendix B).

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table A-7, the maximum daily flow and yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2022.

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

The permit requires that groundwater samples are 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 A-8 shows the 2022 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 A-9 presents similar information for the perched water wells.

Tables B-8 and B-9 show all permit-required constituents associated with the aquifer monitoring wells were below their respective primary constituent standards and secondary constituent standards in 2022. The pH values in perched water well ICPP-MON-V-212 were elevated in both April and September. The pH values associated with this well are consistently higher in the spring versus the fall, indicative of surface water recharge. Historically, each recharge of this perched water well results in decreasing pH values. Purge times are being evaluated to ensure that pH values have stabilized prior to sampling.

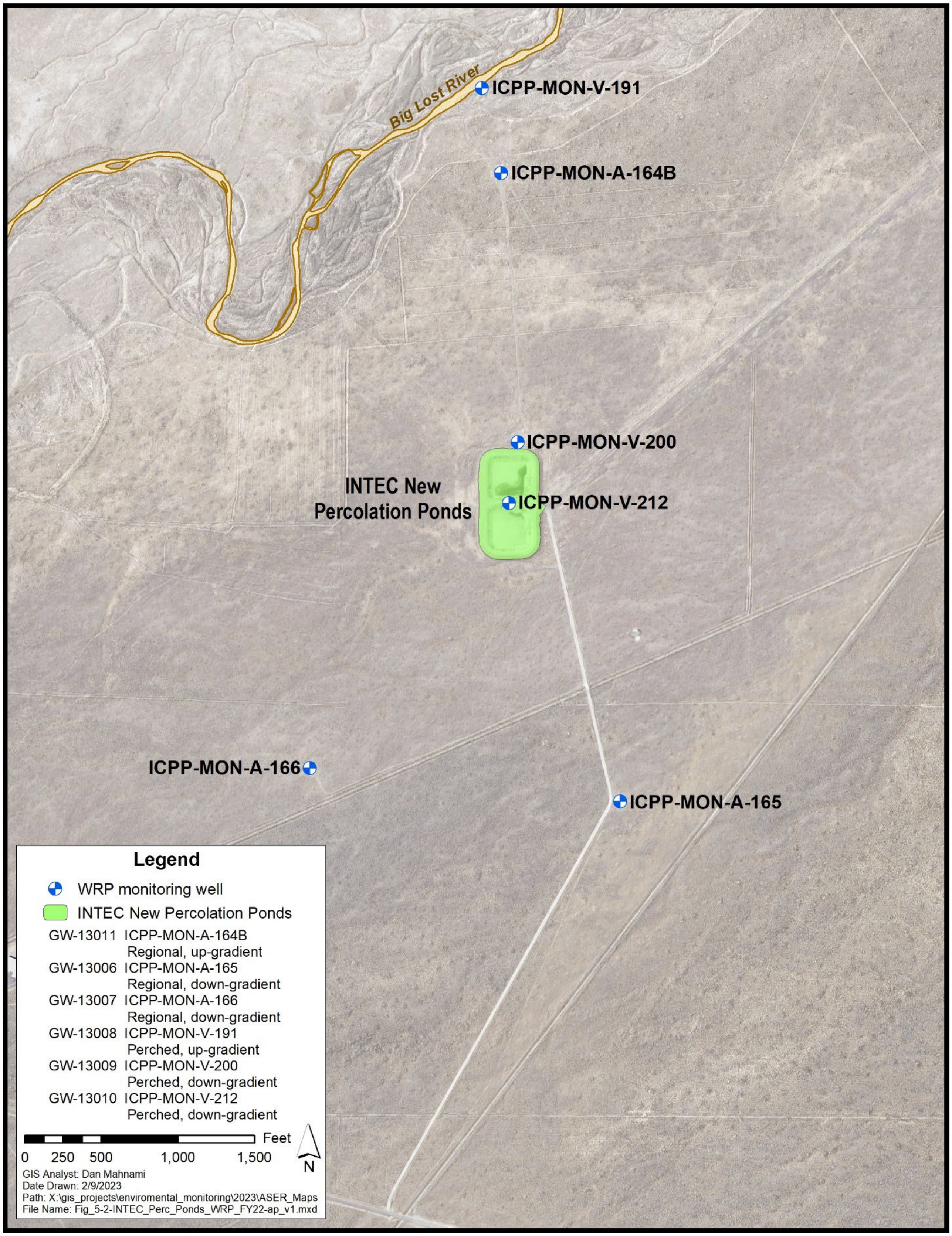

Figure 5-2. Reuse permit groundwater monitoring locations for INTEC New Percolation Ponds.

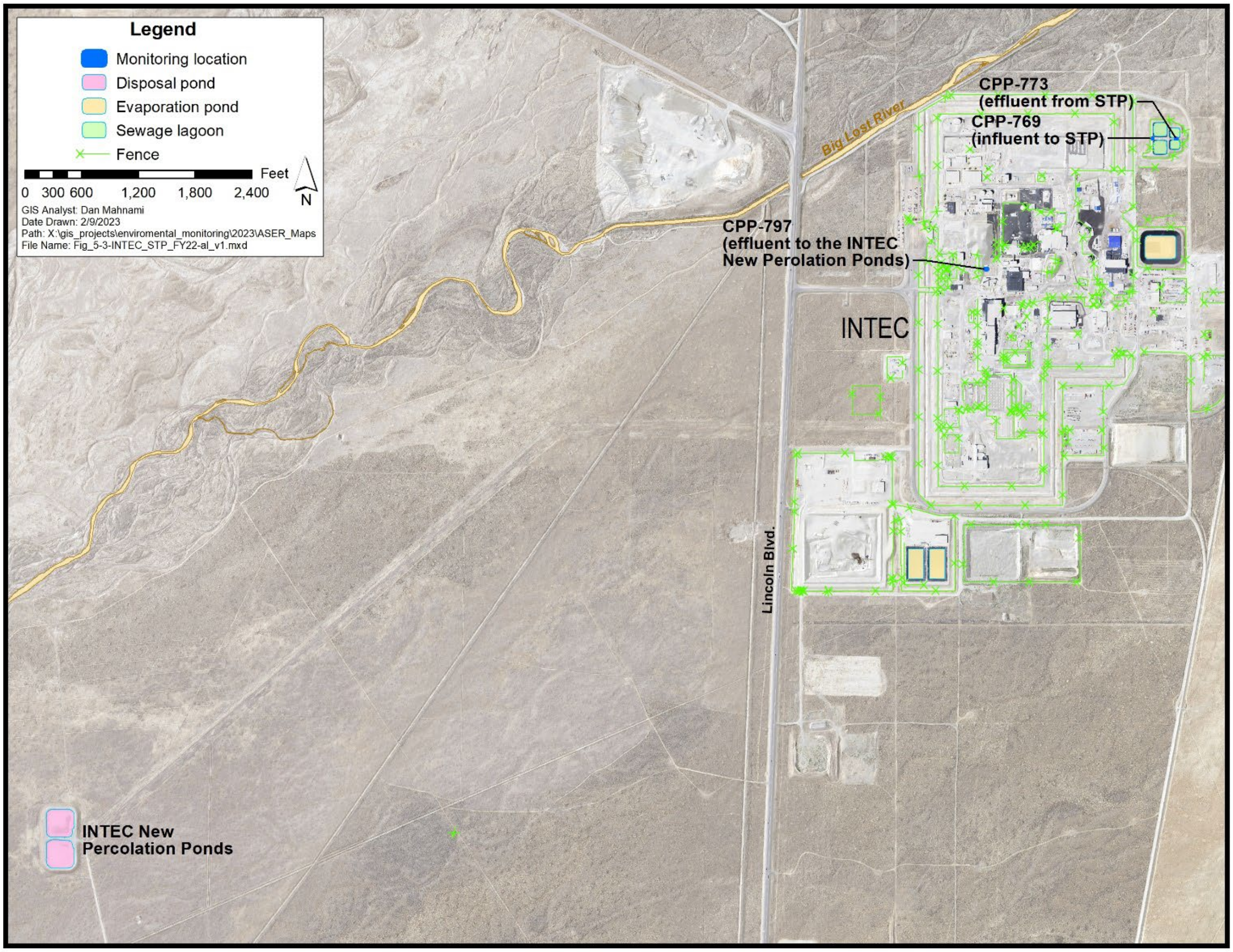

Figure 5-3. INTEC wastewater monitoring for reuse permit.

5.1.3 Materials and Fuels Complex Industrial Waste Pond

Description. The MFC Industrial Waste Pond is an unlined basin that 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) identified in Figure 5-4. In previous years the pond received industrial wastewater from the stormwater runoff from the nearby areas and industrial wastewater from the Industrial Waste Ditch (IWD) (Ditch C).

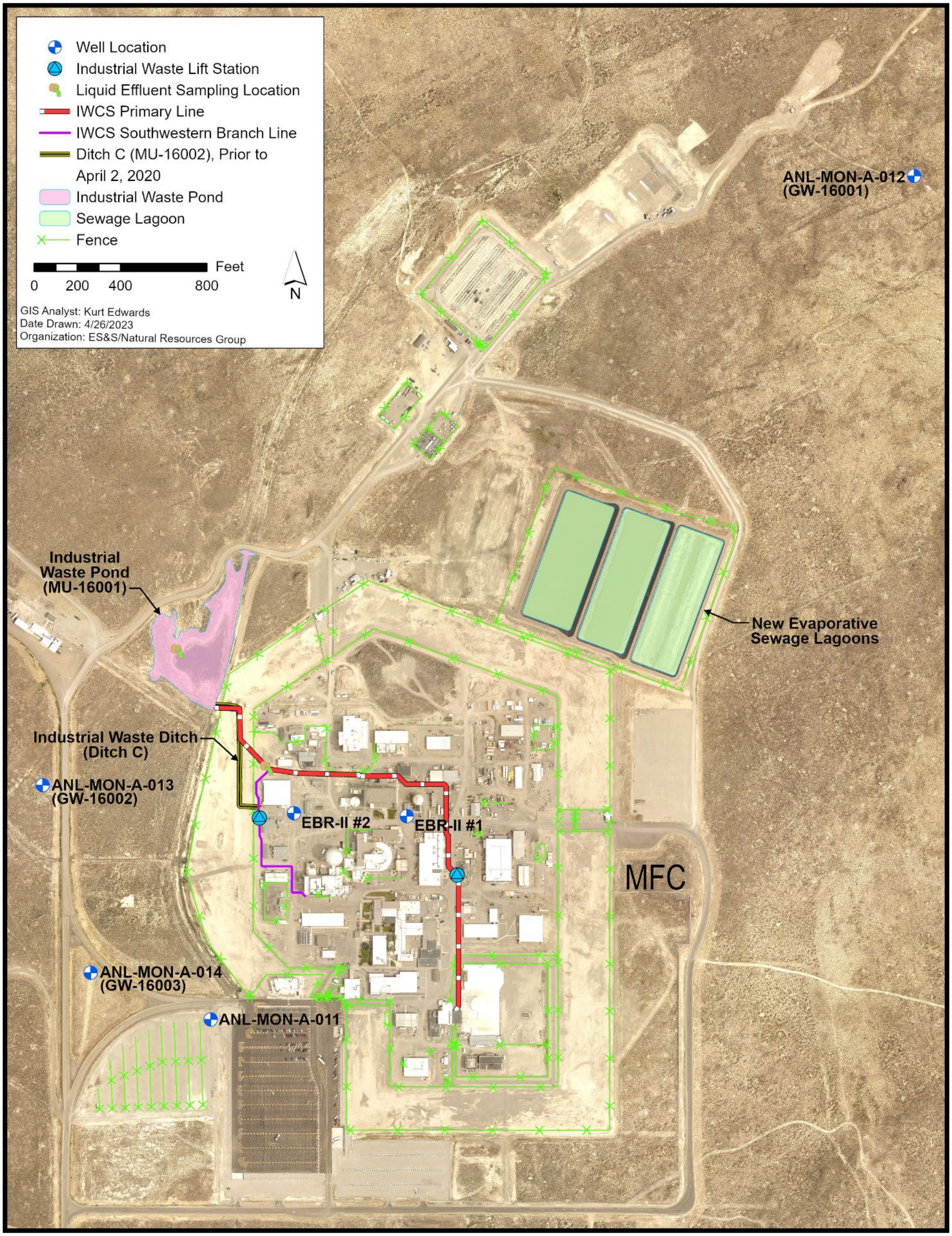

Figure 5-4. Wastewater and groundwater sampling locations MFC.

As part of the MFC Utility Corridor Upgrade Project completed in 2020, industrial wastewater discharges into the IWD (Ditch C) were eliminated. The Ditch C industrial wastewater is now collected in a new lift station and rerouted into the primary industrial waste pipeline via a new connecting pipeline. Reuse Permit I-160-02 Modification 3 issued May 21, 2020 (DEQ 2020) removed the IWD (Ditch C) Management Unit and associated monitoring from the permit as a result of INL permanently joining the industrial wastewater collection system (IWCS) pipelines together, upstream of the existing flow monitoring and sampling station, prior to discharging the combined effluent into the Industrial Waste Pond.

Now that the two MFC IWCS pipelines are joined together and have one flow/sample monitoring location, the system has been given more descriptive, common names. The combination of industrial wastewater pipelines/branches, lift stations, flow meter, sampling station, and associated components are now designated as the industrial wastewater collection system (IWCS). The pipeline, previously known as the industrial waste pipeline, that captures the majority of industrial wastewater and eventually discharges into the pond is referred to as the IWCS Primary Line (PL) since it is the pipeline that collects wastewater from all sources and on which the flow meter and sampling station are located. The pipeline that collected small amounts of industrial wastewater, which previously discharged into the IWD (Ditch C) but now discharges into the PL upstream of the existing sampling station via the new lift station and connecting pipeline, is referred to as the IWCS Southwestern Branch Line.

The Industrial Waste Pond functions as a percolation basin for the infiltration of nonhazardous industrial effluent. Industrial wastewater, which is discharged to the pond via the IWCS PL, consists primarily of noncontact cooling water, boiler blowdown, cooling tower blowdown and drain, air wash flows, and steam condensate. A small amount of wastewater collected within the IWCS Southwestern Branch Line (that now discharges into the PL via a new lift station) consists of intermittent reverse osmosis effluent and laboratory sink discharge from the MFC-768 Power Plant.

Wastewater Monitoring Results for the Reuse Permit. Reuse Permit I-160-02 Modification 4 requires monthly sampling of effluent discharging from the IWCS PL into the Industrial Waste Pond. The 2022 permit reporting year monitoring results are presented in the 2022 annual reuse report (INL 2023d), and the calendar year results are summarized in Table A-10. Based on the composition of the industrial effluent, the reuse permit does not require pre-treatment or specify maximum constituent loading limits or concentration limits. In 2022, concentrations of iron and manganese continued to be at or near the laboratory instruments' minimum detection levels. Total dissolved solids ranged from 204–356 mg/L. The 2022 constituent concentrations continue to be within historical ranges.

The permit specifies an annual reporting year hydraulic loading limit of 17 MG/yr. As shown in Table A-11, the 2022 reporting year flow of 10.188 MG/yr was well below the permit limit.

Groundwater Monitoring Results for the Reuse Permit. The reuse permit requires groundwater monitoring twice annually, in April/May and September/October, at one upgradient well and two downgradient wells (Figure 5-4) to measure potential impacts from the pond. The analytical results are summarized in Table A-12. In 2022, none of the constituents exceeded their respective primary or secondary constituent standards, and the analyte concentrations in the downgradient wells remained consistent with background levels in the upgradient well.

5.2 Liquid Effluent Surveillance Monitoring

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

5.2.1 Advanced Test Reactor Complex

The effluent to the CWP receives a combination of process water from various ATR Complex facilities. Table A-13 lists wastewater effluent surveillance monitoring results for those constituents with at least one detected result. In 2022, gross alpha and gross beta were the only constituents detected in the CWP effluent. Groundwater radionuclide surveillance monitoring results are summarized in Table A-14. All detected constituents, including strontium-90, tritium, gross alpha, and gross beta, were well 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-797 (effluent to the INTEC New Percolation Ponds), and the groundwater monitoring was conducted at the INTEC New Percolation Ponds. Table A-15 summarizes the results of radiological monitoring at CPP-797, while Table A-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 flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. Each collected monthly composite sample was analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table A-15, no total strontium activity was detected in any of the samples collected at CPP-797 in 2022. Gross alpha was not detected, while gross beta was detected in all 12 samples collected in 2022.

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 2022 and September 2022 and were analyzed for gross alpha and gross beta. As shown in Table A-16, gross alpha was detected in one of the four monitoring wells in September 2022. Gross beta was detected in all the monitoring wells in April 2022 and in three of the monitoring wells in September 2022. All detected constituents, including strontium-90, tritium, gross alpha, and gross beta, were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

5.2.3 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly and analyzed for gross alpha, gross beta, gamma spectrometry, and tritium, as shown in Figure 5-4. Annual samples are collected and analyzed for selected isotopes of americium, strontium, plutonium, and uranium. Gross alpha, gross beta, and uranium isotopes were detected in 2022, as summarized in Table A-17, and are below applicable Derived Concentration Standards (DCS) (DOE 2022).

Additionally, five ground water monitoring wells are sampled twice per year for select radionuclides, metals, anions, cations, and other water quality parameters as surveillance monitoring under the WAG 9 Record of Decision. The 2022 groundwater surveillance monitoring results are discussed in Chapter 6, Section 6.5.6, and summarized in Table 6-11. Overall, the detected results were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11, and show no discernable impact from activities at the MFC.

5.3 Waste Management Surveillance Surface Water Sampling

Radionuclides could be transported outside the RWMC boundaries via surface water runoff. Surface water runs off the SDA only during periods of rapid snowmelt or heavy precipitation. At these times, water may be pumped out of the SDA retention basin into a drainage canal, which directs the flow outside the RWMC. The canal also carries runoff from outside the 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 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 WMF-636 Fire Water Catch Tanks were not collected during 2022 as periodic measurements of tank levels did not indicate pumping to be necessary.

Two samples were collected from the SDA Lift Station in 2022. These samples were analyzed for a suite of radionuclides that includes americium-241 and strontium-90 and plutonium and uranium isotopes. There were positive detections (three sigma [3σ]) of americium-241, plutonium-238, plutonium-239/240, and strontium-90 in samples taken in 2022. The maximum concentration detected for americium-241 was 0.95 (± 0.09) pCi/L, which is well below the 740 pCi/L DCS for americium-241. The maximum concentration detected for plutonium-238 was 0.04 (± 0.01) pCi/L, which is well below the 430 pCi/L DCS. The maximum concentration detected for plutonium-239/240 was 0.17 (± 0.02) pCi/L, which is well below the applicable DCS (400 pCi/L). Finally, the maximum concentration detected for strontium-90 was 0.68 (± 0.17) pCi/L, which is also well below the applicable DCS (1,700 pCi/L). In addition to these nuclides, uranium isotopes were detected at levels consistent with historical results, which are below any applicable DCS.

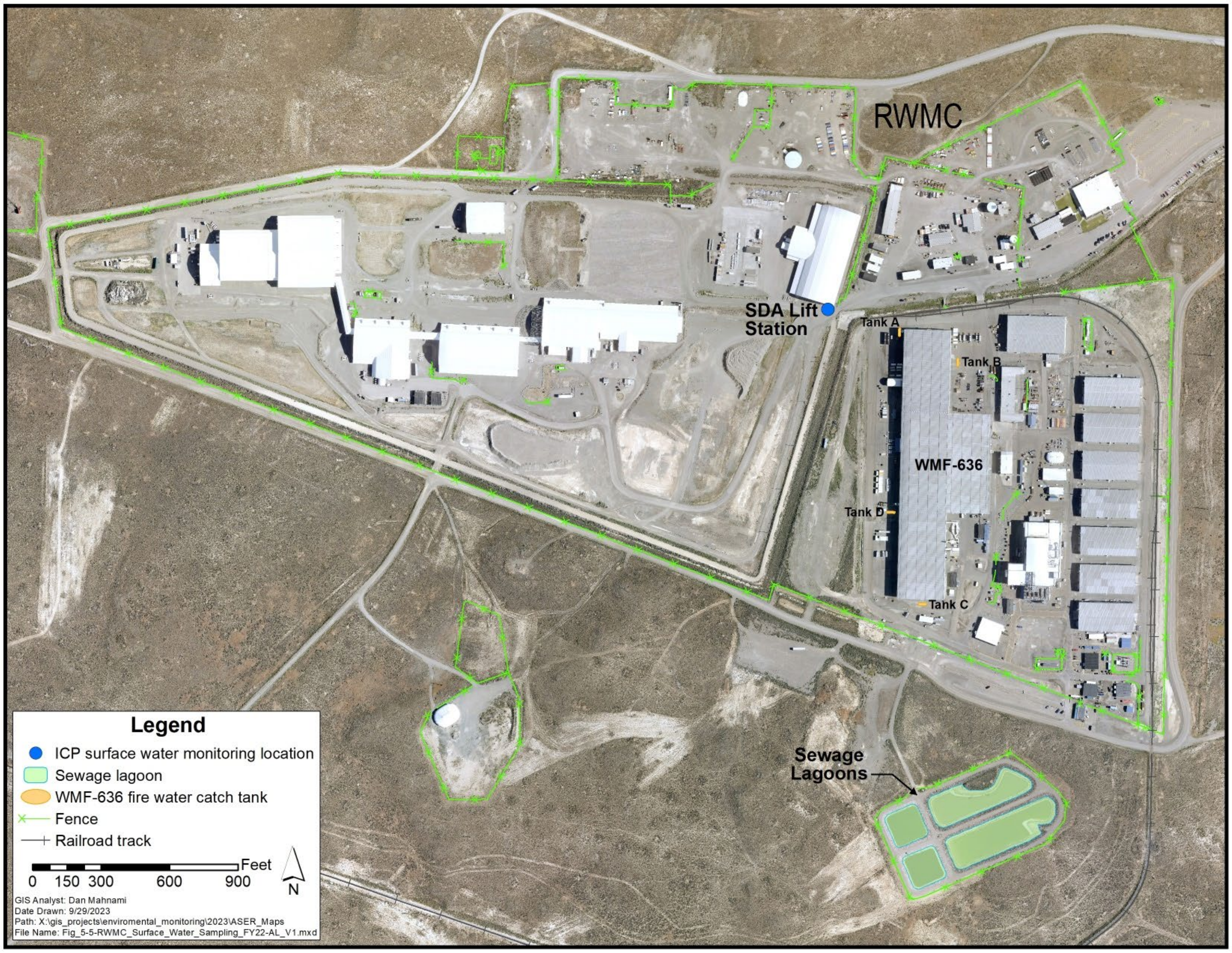

Figure 5-5. Surface water sampling location at the RWMC SDA.

Table 5-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The ICP contractor took samples from the SDA Lift Station twice during 2022 at times when water was available and evaluated the results to identify any potential abnormal trends or results that would warrant further investigation. ICP will also 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 (2022).

LOCATION	PARAMETER	MAXIMUM CONCENTRATION[a] (pCi/L)	% DERIVED CONCENTRATION STANDARD[b]
SDA Lift Station	Americium-241	0.95 ± 0.09	0.13
	Plutonium-238	0.04 ± 0.01	0.01
	Plutonium-239/240	0.17 ± 0.02	0.04
	Strontium-90	0.68 ± 0.17	0.04
	Uranium-234	0.46 ± 0.03	0.04
	Uranium-235	0.03 ± 0.01	0.00
	Uranium-238	0.36 ± 0.03	0.03

a. Result ±1s. Results shown are greater than 3σ.
b. See DOE-STD-1196-2021, Table A-6 (DOE 2022).

5.4 References

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Smoke on Middle Butte

Chapter 6: Environmental Monitoring Programs – Eastern Snake River Plain Aquifer Monitoring

CHAPTER 6

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

In 2022, USGS sampled 26 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds. Eleven purgeable organic compounds were detected in at least one well. Most of the detected concentrations were less than the maximum contaminant levels established by the U.S. 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 (RWMC). This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Trichloroethene was detected above the maximum contaminant levels (MCLs) at a perched well at the RWMC and a well at Test Area North (TAN), 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 (CERCLA) was performed at Waste Area Groups (WAGs) 1–4, WAG 7, and WAG 9 in 2022.

In addition to the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex (MFC), the INL contractor also monitors groundwater at the Remote-Handled Low-Level Waste Disposal (RHLLW) Facility for the surveillance of select radiological analytes. Groundwater samples were collected from three monitoring wells at the RHLLW Disposal Facility in 2022. The 2022 results show no discernable impacts to the aquifer.

There are 11 drinking water systems on the INL Site monitored by INL and Idaho Cleanup Project (ICP) contractors. All contaminant concentrations measured in drinking water systems in 2022 were below regulatory limits.

Drinking water and springs were sampled 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 Idaho Department of Environmental Quality (DEQ) 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 INL Site within the eastern Snake River Plain Aquifer hydrogeologic system. This includes the 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 the following:

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities.
- Areas of known underground contamination from past INL Site operations are monitored and trended.
- Drinking water consumed by workers and visitors at the INL Site and by the public downgradient of the INL Site is safe.
- The Big Lost River, which occasionally flows through the INL Site, is not contaminated by INL Site activities before entering the aquifer via channel loss and 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)
- EPA health-based MCLs for drinking water (40 CFR 141)
- U.S. Department of Energy (DOE) Derived Concentration Standards for the ingestion of water (DOE 2021).

6.1 Summary of Monitoring Programs

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

- The 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. The USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site, as shown in Figure 6-2, and at locations throughout the eastern Snake River Plain.

  Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2022, USGS personnel collected and analyzed more than 1,200 samples for radionuclides and inorganic constituents, including trace elements, and 26 samples for purgeable organic compounds. USGS INL Project Office personnel also published two documents and one software package covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Section 6.10.

- The ICP contractor conducts groundwater monitoring at various WAGs delineated on the INL Site, which are identified in Figure 6-3, for compliance with the CERCLA. The ICP contractor also conducts drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC), RWMC, and the Naval Reactors Facility (NRF). In 2022, the ICP contractor monitored groundwater at the TAN, 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 contractor drinking water program.

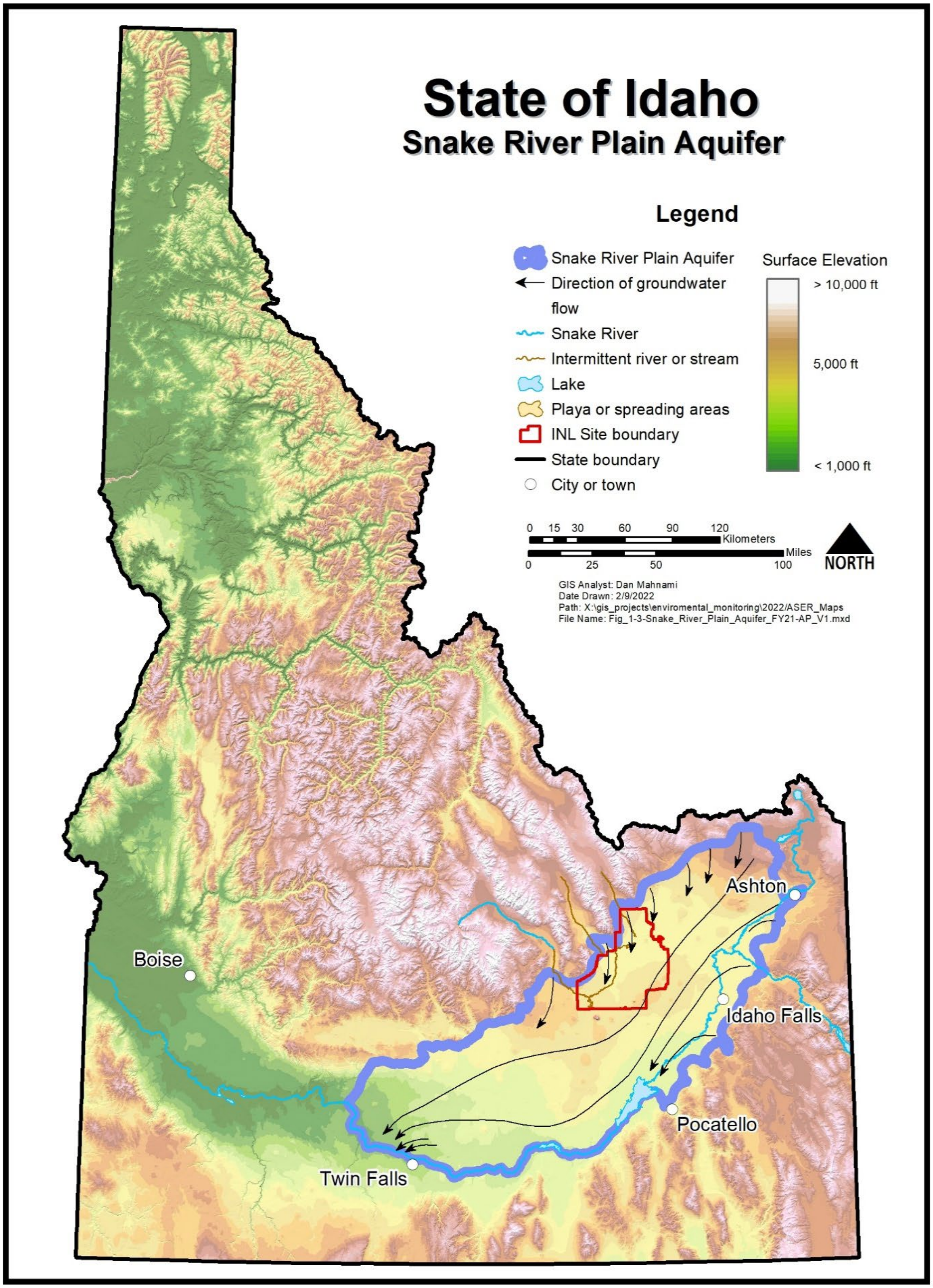

Figure 6-1. The eastern Snake River Plain Aquifer and direction of groundwater flow.

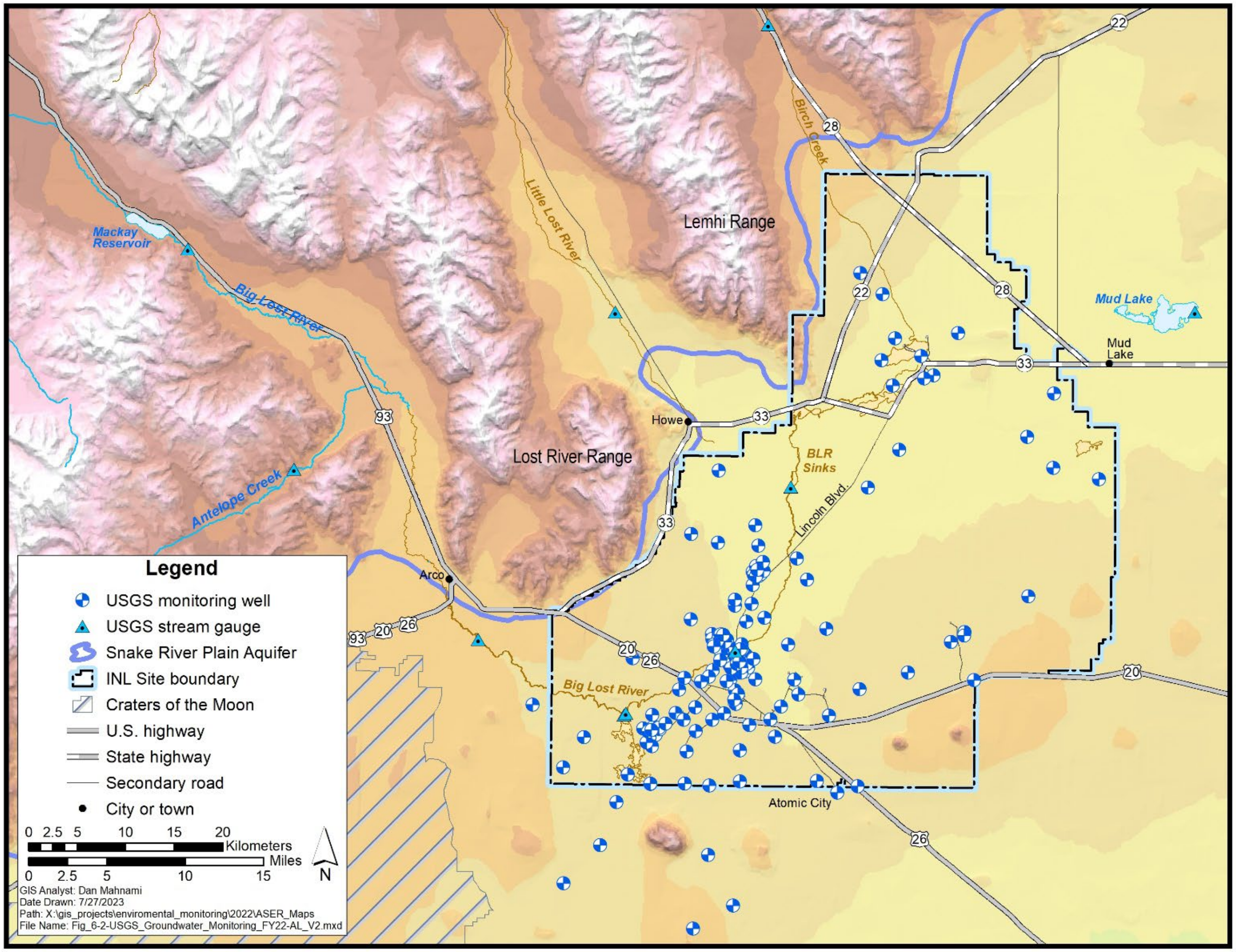

Figure 6-2. USGS groundwater monitoring locations on and off the INL Site.

Table 6-1. USGS monitoring program summary (2022).

CONSTITUENT	GROUNDWATER		SURFACE WATER		MINIMUM DETECTABLE CONCENTRATION OR ACTIVITY
	NUMBER OF SITES[a]	NUMBER OF SAMPLES	NUMBER OF SITES	NUMBER OF SAMPLES	
Gross alpha	58	66	0	0	8 pCi/L
Gross beta	58	66	0	0	3.5 pCi/L
Tritium	138	138	3	3	200 pCi/L
Gamma-ray spectroscopy	43	43	—[b]	—	—[c]
Strontium-90	64	64	—[b]	—	2 pCi/L
Americium-241	9	9	—[b]	—	0.03 pCi/L
Plutonium isotopes	9	9	—[b]	—	0.02 pCi/L
Iodine-129	30	30	—[b]	—	<1 pCi/L
Specific conductance	144	144	3	3	NA[d]
Sodium ion	135	135	—[b]	—	0.4 mg/L
Chloride ion	139	139	3	3	0.02 mg/L
Nitrates (as nitrogen)	117	117	—[b]	—	0.04 mg/L
Fluoride	4	4	—[b]	—	0.01 mg/L
Sulfate	124	124	—[b]	—	0.02 mg/L
Chromium (dissolved)	99	99	—[b]	—	1 µg/L
Purgeable organic compounds[e]	26	38	—[b]	—	Varies
Mercury	9	9	—[b]	—	0.005 µg/L
Trace elements	9	9	—[b]	—	Varies

a. Number of samples does not include 13 replicates and 4 blanks collected in 2022. The number of samples was different from the number of sites because one site for volatile organic compounds (VOCs) is sampled monthly, and three sites had pump problems or were dry, so they were not sampled. The number of sites does not include 24 zones from 10 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. NA = not applicable.

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

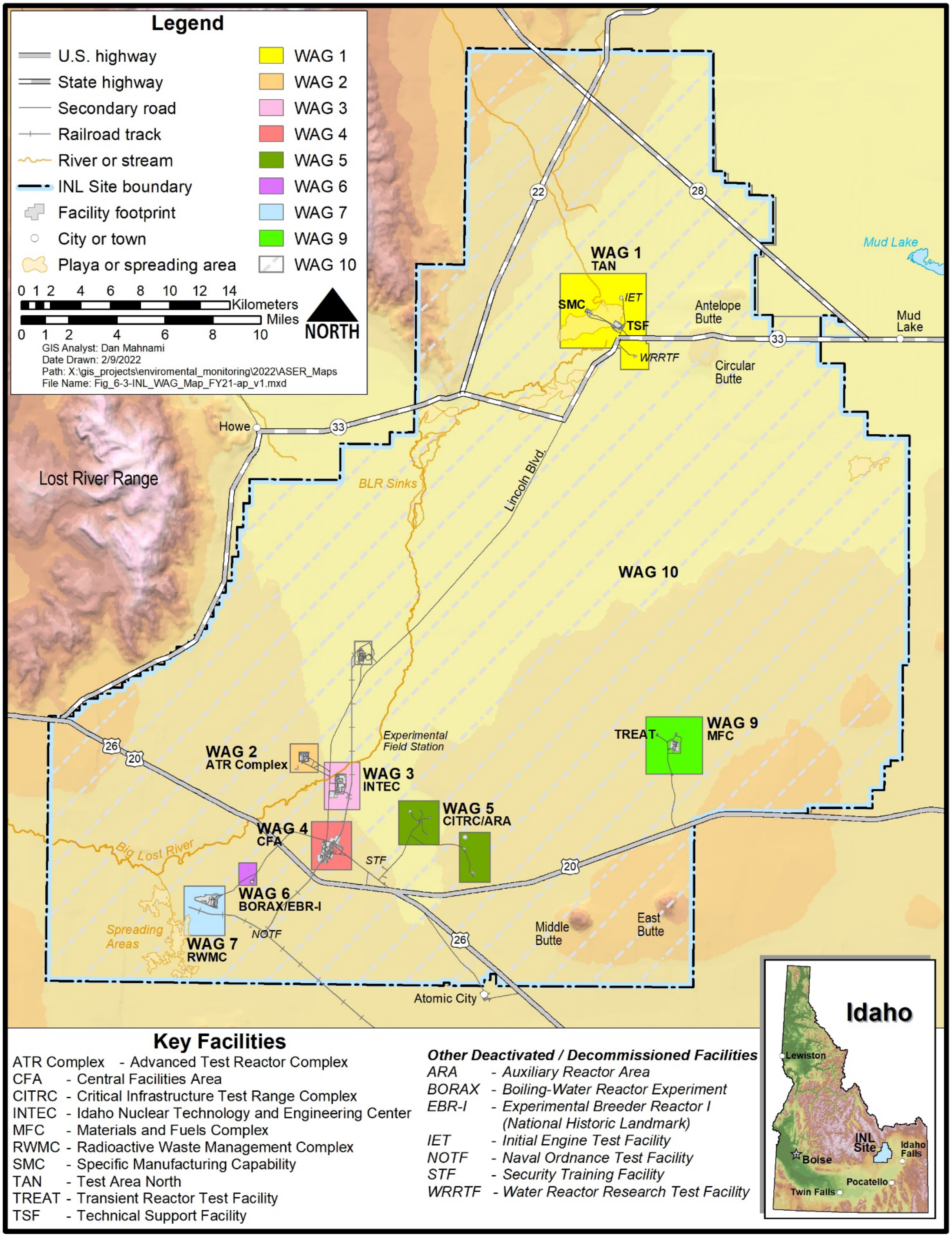

Figure 6-3. Map of the INL Site showing locations of facilities and corresponding WAGs.

Table 6-2. ICP contractor drinking water program summary (2022).

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 4mrem/yr
Haloacetic acids (HAA5)[a]	2 annually	0.06 mg/L
Total coliform[b]	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli[b]	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	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium	2 every 9 years	30 µg/L
VOCs	2 annually	Varies

a. Haloacetic acids = sometimes referred to as HAA5, which includes the most common haloacetic acids found in drinking water. These consist of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid.

b. Total coliform and E. coli are sampled monthly at the Naval Reactors Facility Deactivation and Decommissioning Facility.

- The INL contractor monitors groundwater at the MFC (WAG 9), the ATR Complex, and the RHLLW Disposal Facility. The INL contractor also monitors the drinking water at eight INL Site facilities: ATR Complex, CFA, the Critical Infrastructure Test Range Complex (CITRC), the Experimental Breeder Reactor-I (EBR-I), the Gun Range, the Main Gate, MFC, and TAN/Contained Test Facility (CTF). Table 6-3 summarizes the routine monitoring for the INL contractor drinking water program.
- The INL contractor collects drinking water samples from offsite locations and natural surface waters on and off the INL Site for surveillance purposes. 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 2022, the INL contractor sampled and analyzed 26 surface and drinking water samples. Samples were not collected from the Big Lost River in 2022 due to water demands upstream inhibiting river flow onto the INL Site.

Table 6-3. INL contractor drinking water program summary (2022).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha[a]	10 to 12 semiannually	15 pCi/L
Gross beta[a]	10 to 12 semiannually	4 mrem/yr
Haloacetic acids[b]	4 annually	0.06 mg/L
Iodine-129[c]	1 semiannually	1 pCi/L
Lead/Copper[b]	35 triennially	0.015/1.3 mg/L
Nitrate[d]	10 annually	10 mg/L (as nitrogen)
Radium-226/228	4 annually	5 pCi/L
Total coliform and E. coli	12 to 14 monthly	See 40 CFR 141.63
Total trihalomethanes[b]	4 annually	0.08 mg/L
Tritium[a]	10 to 12 semiannually	20,000 pCi/L
Uranium	4 annually	30 µg/L

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., ATR Complex, CFA, CITRC, EBR-1, Gun Range, Main Gate, MFC, and TAN/CTF).

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

c. Iodine-129 is only sampled at the CFA water system.

d. Nitrate and microbes are sampled at all INL water distribution systems.

Table 6-4. INL surface water and offsite drinking water summary (2022).

MEDIUM SAMPLED	TYPE OF ANALYSIS	LOCATIONS AND FREQUENCY		MINIMUM DETECTABLE CONCENTRATION
		ONSITE	OFFSITE	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 semiannually	100 pCi/L

a. Samples are co-located with the 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, the Experimental Field Station, and 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 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.

Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021a) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021b).

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 environmental data management and storage location for the ICP and INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS. It also stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP 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 Hydrogeologic Data Repository houses geologic and hydrologic information compiled to support remedial investigation and feasibility study activities, Environmental Impact Statement preparation, site selection and characterization, and transport modeling in vadose and saturated zones. The information available includes (1) well construction and drill hole information, (2) maps, (3) historical data, (4) aquifer characteristics, (5) soil characterization, and (6) sediment property studies.
- 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.

6.3 USGS Radiological Groundwater Monitoring at the INL 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 contractor and USGS above the primary constituent standard in some surveillance wells at TAN and between INTEC and CFA. 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 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 in groundwater at CFA.

Two monitoring wells downgradient of the ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 20 years, as shown in Figure 6-5. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The concentration of tritium in USGS-065 near the ATR Complex decreased from 1,380 ± 90 pCi/L in 2021 to 400 ± 30 pCi/L in 2022; the tritium concentration in USGS-114, south of INTEC, decreased slightly from 4,280 ± 150 in 2021 to 3,970 ± 130 pCi/L in 2022.

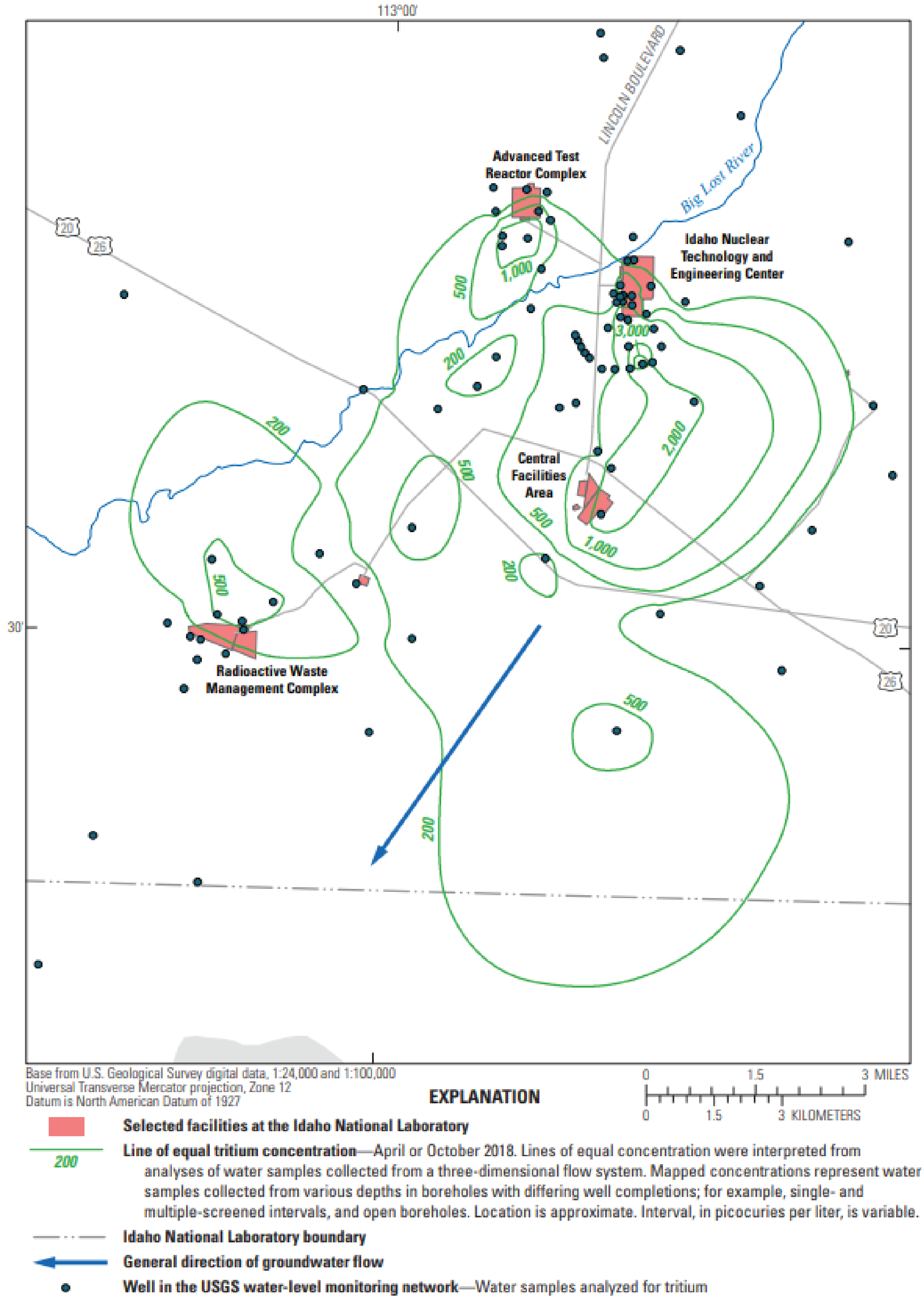

Figure 6-4. Distribution of tritium (pCi/L) in the eastern Snake River Plain Aquifer onsite in 2018 (from Bartholomay et al. 2020).

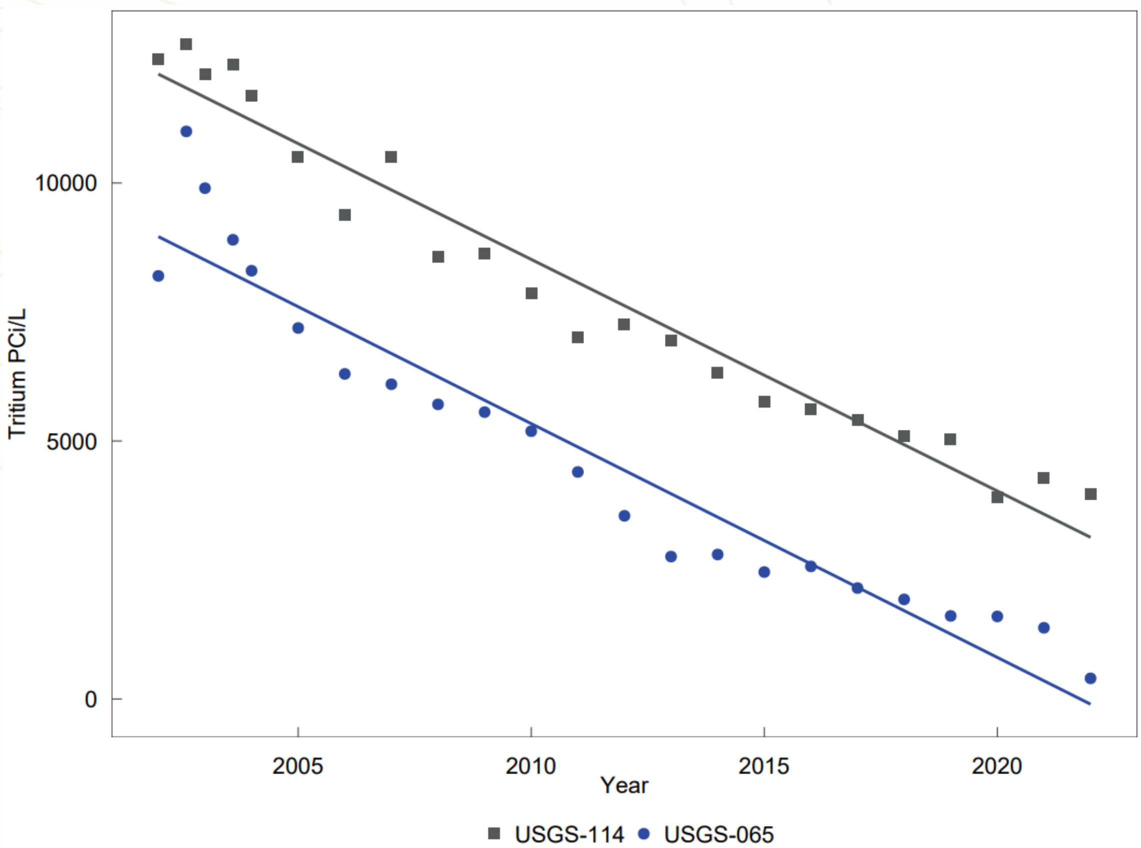

Figure 6-5. Long-term trend of tritium in wells USGS-065 and USGS-114 (2002–2022).

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-65 and USGS-114 dropped below this limit in 1997 due to radioactive decay (tritium has a half-life of 12.33 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend after an analysis of the 2018 data (Bartholomay et al. 2020, 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 the historical injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain Aquifer near the ATR Complex during 2022. All ^{90}Sr at the ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At the 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 (i.e., 2002–2022) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied throughout 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 to, in part, 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.

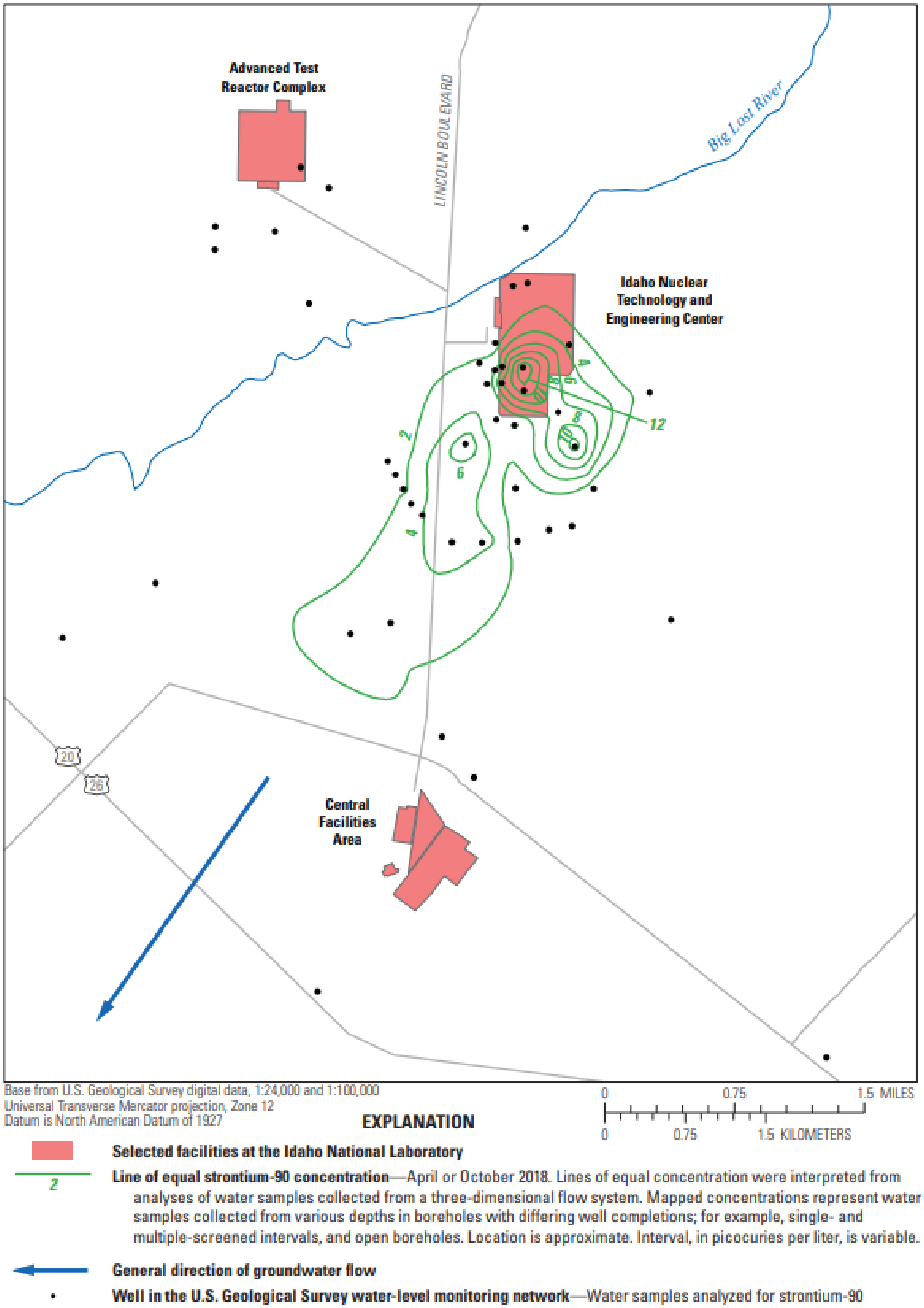

Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the eastern Snake River Plain Aquifer onsite in 2018 (from Bartholomay et al. 2020).

These values are shown in Table 6-1. Results for wells sampled in 2022 are available at https://waterdata.usgs.gov/id/nwis/ (U.S. Geological Survey 2021). Monitoring results for 2016–2018 are summarized in Bartholomay et al. (2020). During 2016–2018, concentrations of cesium-137 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 analyzed samples 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. 2020). Monitoring results from 2019–2021 will be published in 2023.

Periodically, the USGS 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), Maimer and Bartholomay (2019), and (2021–2022) in preparation. The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2021 and collected additional samples in the spring of 2022. 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 2017 was 0.877 ± 0.032 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 2021 increased to 0.968 ± 0.023 pCi/L. In general, 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. Select wells showed a slight increase ^{129}I, which could be controlled by preferential flow from legacy contamination source locations southwest of INTEC. 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).

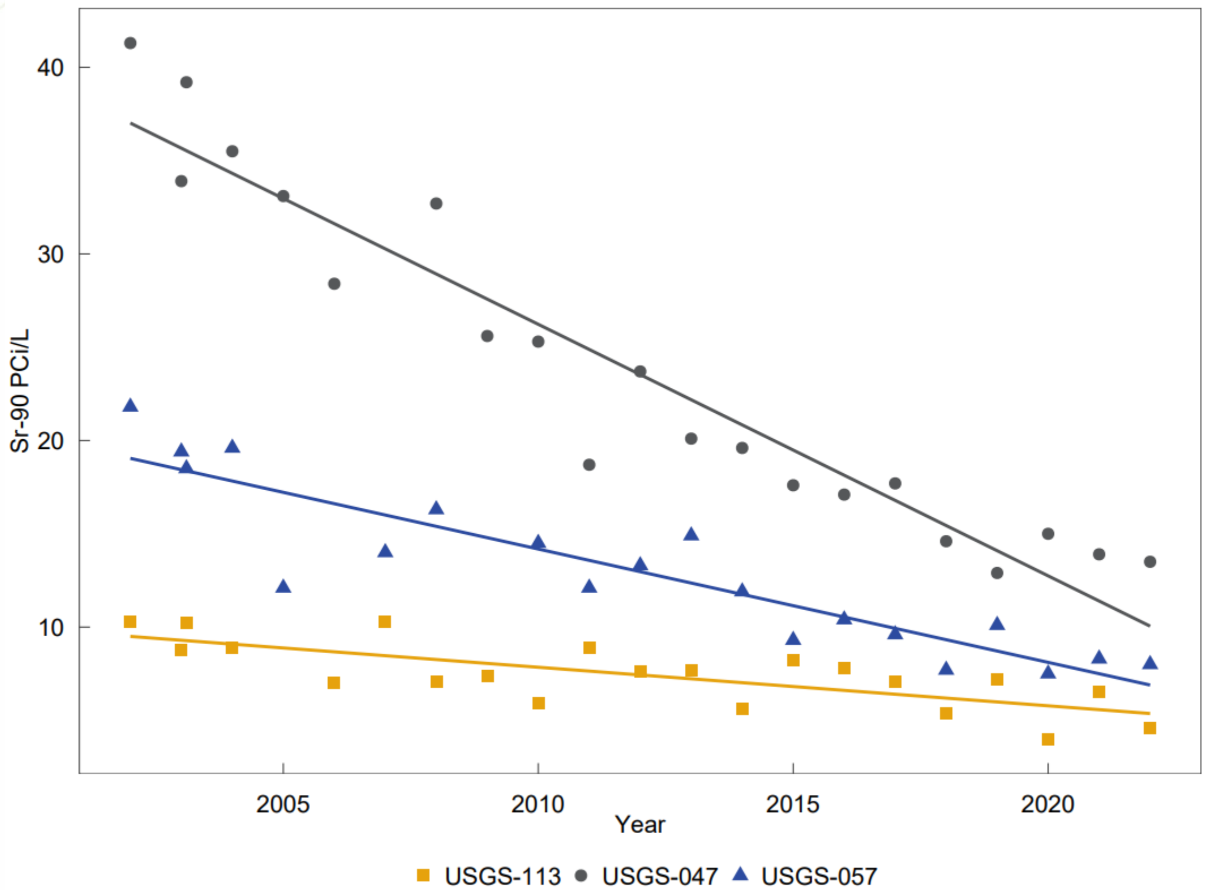

Figure 6-7. Long-term trend of ^{90}Sr in wells USGS-047, USGS-057, and USGS-113 (2002–2022).

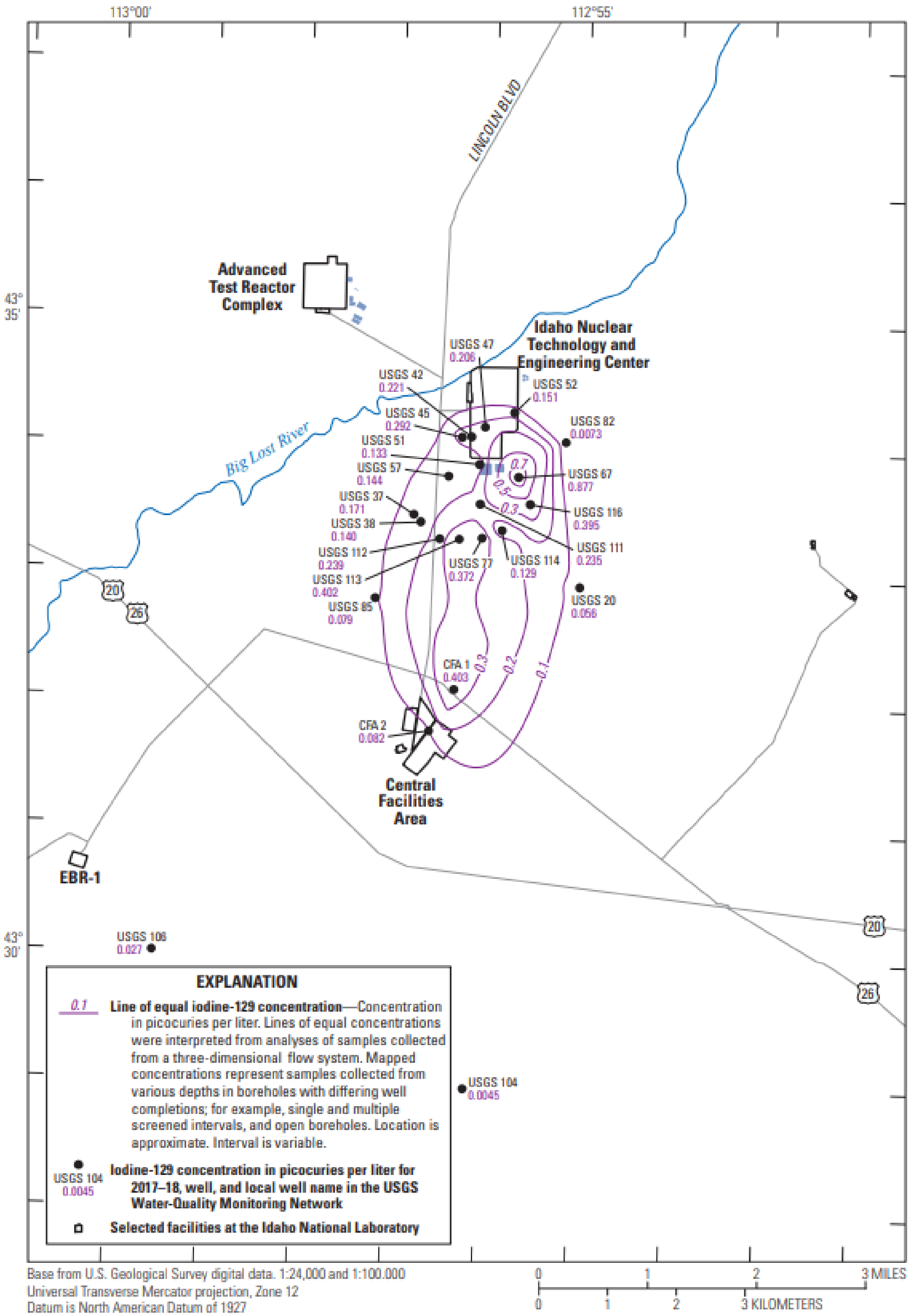

Figure 6-8. Distribution of ^{129}I in the eastern Snake River Plain Aquifer onsite in 2017–2018 (from Maimer and Bartholomay 2019).

6.4 USGS Non-radiological Groundwater Monitoring at the INL Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and other trace elements and purgeable organic compounds identified in 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 USGS-065 in 2009 (Fisher et al., 2021), but its concentration has since been below the MCL and was 78.8 µg/L in 2022. This well has shown a long-term decreasing trend (Fisher et al. 2021, Appendix 7).

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).

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 purgeable (volatile) organic compounds in groundwater at the INL Site during 2022. Samples from 26 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado; the samples analyzed 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. 2021). 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 identified in 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) and trichloroethene 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 2022, and concentrations exceeded the MCL of 5 µg/L during 11 of the 12 months measured, as shown in Table 6-6.

Since 1998, concentrations have routinely exceeded the MCL for tetrachloromethane in drinking water (5 µg/L) at RWMC. (Note: VOCs are removed from production well water prior to human consumption—see Section 6.7.1.10.) 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 Wells USGS-87 and USGS-120, south of RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at Well USGS-88 (Davis et al. 2015; Bartholomay et al. 2020; Fisher et al. 2021).

Trichloroethylene (trichloroethene) (TCE) exceeded the MCL of 5 µg/L from one sample collected from GIN 2 at TAN, identified in Table 6-5. There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1. The sample collected at a perched well, USGS-92, at RWMC also detected TCE above the MCL.

Table 6-5. Purgeable organic compounds in annual USGS groundwater well samples (2022).

CONSTITUENT	USGS-120	USGS-88	RWMC M3S	USGS-87	RWMC M7S	USGS-77	USGS-065	TAN-2312	GIN 2	TAN-2271
1,1-Dichloroethane (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.308
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	<0.1	<0.1	0.160	<0.1	0.306	<0.1	<0.1	<0.1	<0.1	<0.1
cis-1,2-Dichoroethene[b] (MCL = 70 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.126	0.950
Ethylbenzene (MCL = 700 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	<0.1	<0.1	0.173	0.115	0.419	<0.1	<0.1	<0.1	3.61	<0.1
Tetrachloromethane (PCS = 2 µg/L)[c]	1.092	0.797	3.65	2.80	4.32	<0.2	<0.2	<0.2	<0.2	<0.2
Trichloroethene[b] (MCL = 5 µg/L)[a]	0.220	0.513	1.05	0.738	2.43	<0.1	<0.1	0.160	10.9	1.69
Trichloromethane (MCL = 5 µg/L)[a]	0.155	0.441	0.320	0.328	0.905	<0.1	0.216	<0.1	0.138	<0.1
Toluene (MCL = 1,000 µg/L)[a]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
trans-1,2-Dichloroethene[b] (MCL = 100 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	59.17
Vinyl chloride (MCL = 2 µg/L)[a]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.12
1,1-Dichloroethene (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	0.102	<0.1	<0.1	<0.1	<0.1
Dichlorodifluoromethane[d]	<0.2	<0.2	<0.2	0.485	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

a. MCL = maximum contaminant level from the EPA (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.

d. No MCL has been established for Dichlorodifluoromethane (40 CFR 141).

Table 6-6. Purgeable organic compounds in monthly production well samples at the RWMC (2022).

CONSTITUENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	0.276	0.241	0.270	0.266	0.249	0.243	0.263	0.238	0.233	0.256	0.304	0.238
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	0.361	0.380	0.381	0.351	0.289	0.309	0.350	0.286	0.303	0.366	0.431	0.341
Tetrachloromethane (MCL = 5 µg/L)[a]	5.12	4.75	5.17	5.60	5.23	5.08	5.88	5.20	5.13	5.35	6.60	5.02
Trichloroethene[b] (MCL = 5 µg/L)[a]	3.48	3.84	3.64	3.38	2.78	2.93	3.27	3.01	2.96	3.24	3.47	3.60
Trichloromethane (PCS = 2 µg/L)[c]	1.93	1.69	1.66	1.78	1.49	1.57	1.70	1.51	1.57	1.73	1.97	1.76

a. MCL = maximum contaminant level values from the EPA (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.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2022

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 the 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 Administrative Record Information Repository (ARIR) Home – ARIR (idaho-environmental.com). 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 based on the 1997 TCE concentrations with three different remedy components, which 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, which is identified in Figure 6-9 and is not reflective of current concentrations, as shown in Figure 6-10. 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.

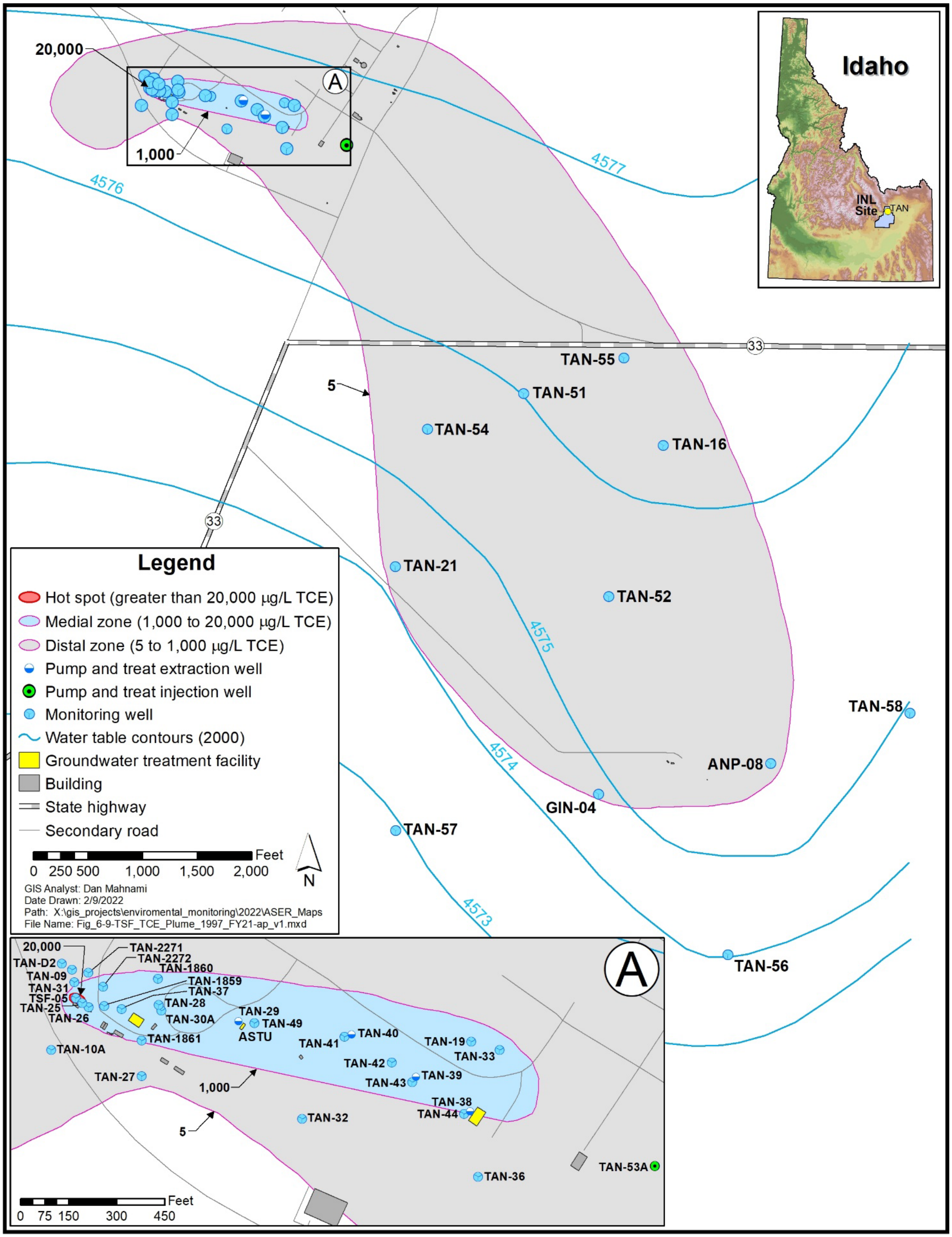

Figure 6-9. TCE plume at TAN in 1997.

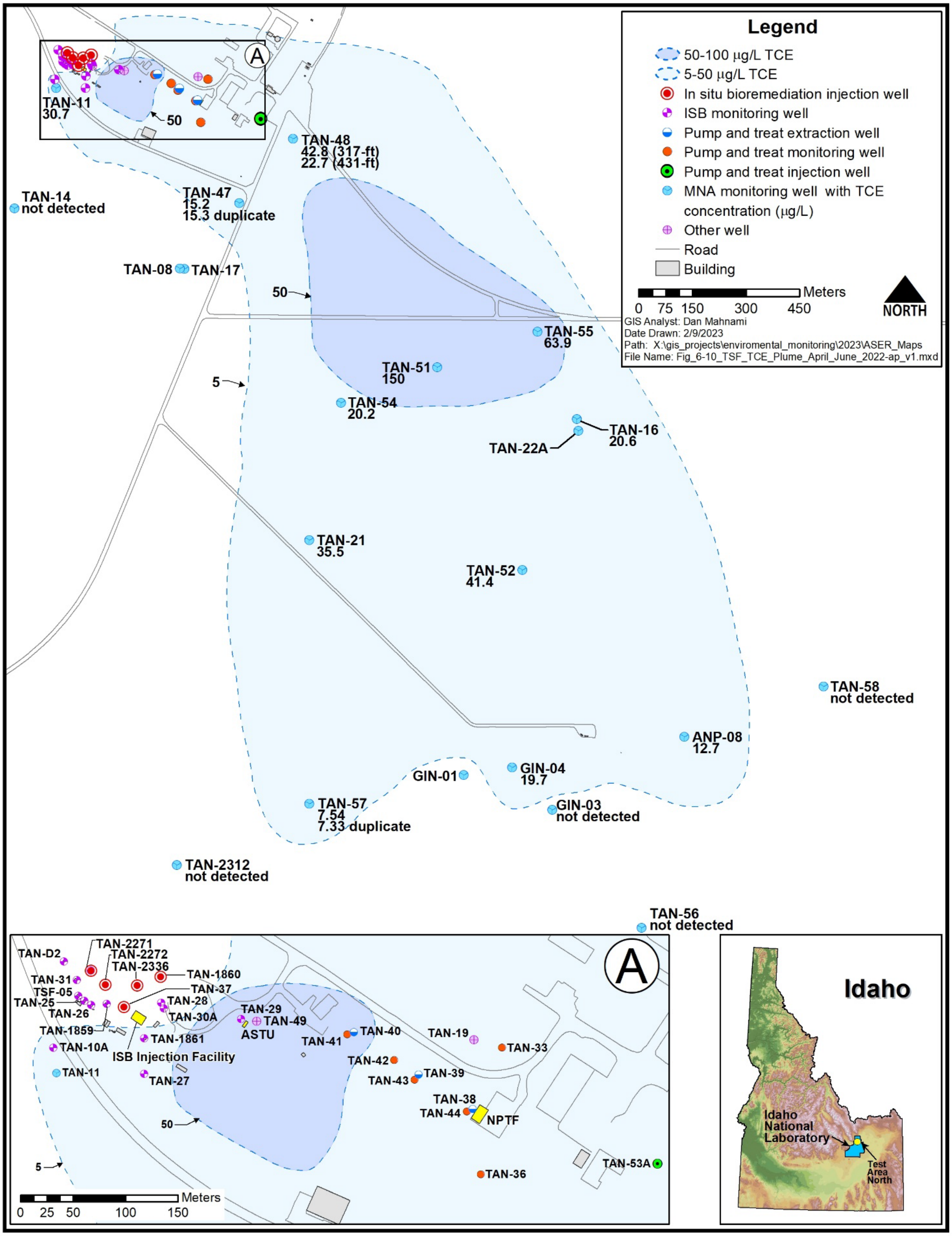

Figure 6-10. Distribution of TCE in the Snake River Plain Aquifer from April–June 2022.

In FY 2022, 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, as shown in Figure 6-10. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2023a).

To address the source of TCE in Well TAN-28, continued ISB injections have been made into TAN-2336. Five ISB injections were made into TAN-2336 in 2022. Despite some variations, TCE concentrations have declined in TAN-28 because of the ISB injections to treat the TAN-28 TCE source. ISB injections will continue into these wells until it can be determined that the TAN-28 TCE source has been successfully treated and a transition to a rebound test for the TAN-28 TCE source can be made.

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 generally operated Monday through Thursday in 2022, except for shutdowns due to maintenance. All 2022 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, which is before remedial actions began shown in Figure 6-9, and do not reflect current concentrations, as identified in Figure 6-10. In 2022, none of the wells were above the concentration of 1,000 µg/L used historically to define the medial zone. 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 FY 2022, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 10.5 to 34.9 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 (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 groundwater contaminants. 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 FY 2022 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 Decision Amendment (DOE-ID 2001). Strontium-90 and ^{137}Cs are expected to naturally decline below their respective MCLs before 2095. However, wells in the source/ISB area currently show elevated ^{90}Sr and ^{137}Cs concentrations compared to levels prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to enhanced mobility created by elevated concentrations of competing cations (e.g., 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 trending lower. The radionuclide concentrations are expected to continue to decrease, and concentration trends will continue to be evaluated to determine if the remedial action objective of declining below MCLs by 2095 will be met. All 2022 results for tritium are below the MCL of 20,000 pCi/L, with the highest tritium result of 1,510 pCi/L at Well TAN-25. 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 six aquifer wells to monitor WAG 2 in the ATR Complex during 2022. All of the wells shown in Figure 6-11 were sampled except for TRA-07, which could not be sampled due to a malfunctioning pump. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (e.g., the target analyte is cobalt-60), tritium, and chromium (filtered) in accordance with the groundwater monitoring plan (DOE-ID 2016). The data for the October 2022 sampling event will be included in the FY 2023 Annual Report for WAG 2 (DOE-ID 2023b). The October 2022 sampling data are summarized in Table 6-7.

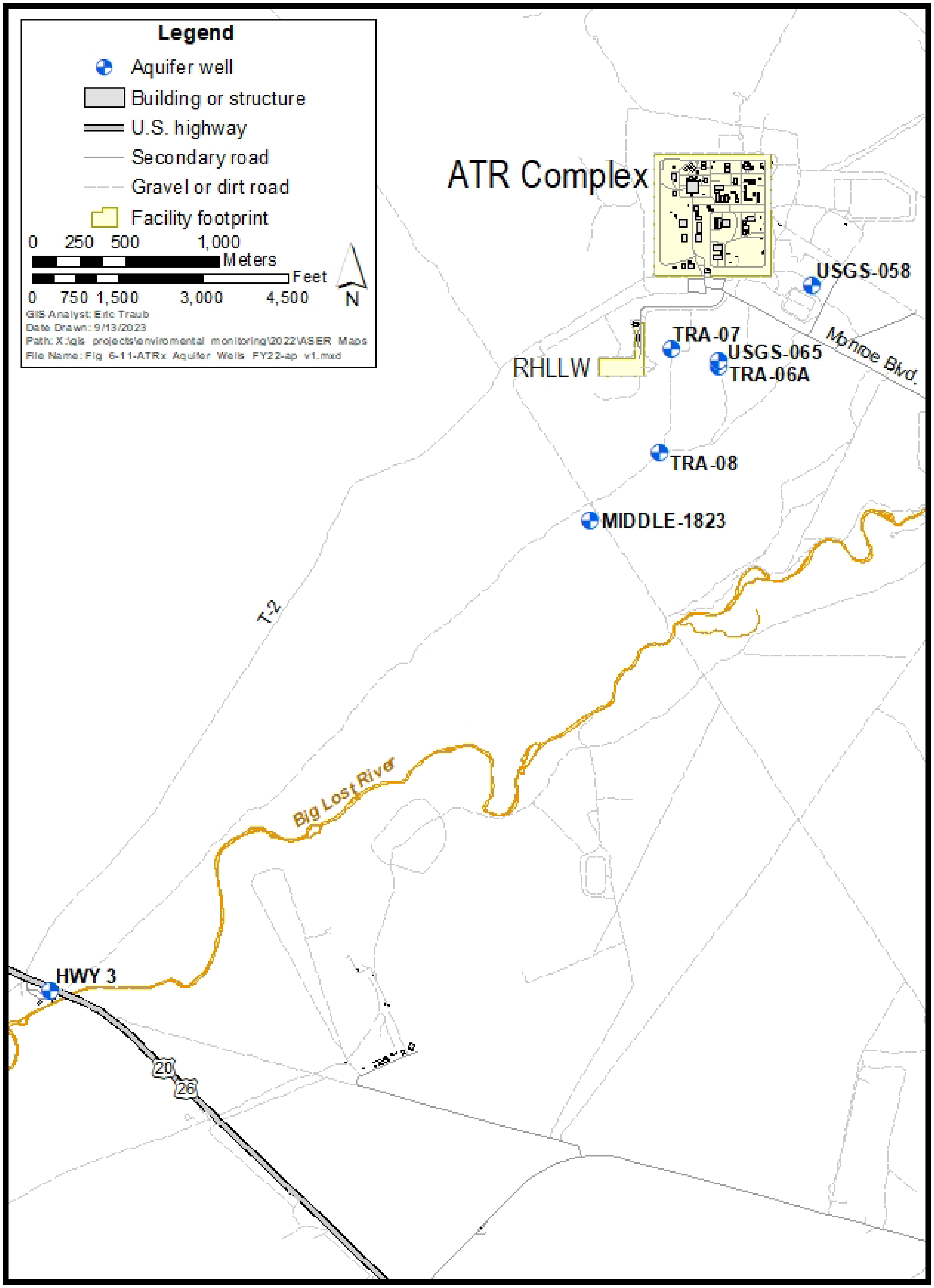

Figure 6-11. Locations of WAG 2 aquifer monitoring wells.

Table 6-7. WAG 2 aquifer groundwater quality summary (October 2022).

ANALYTE	MCL	BACKGROUND[a]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
Chromium (filtered) (µg/L)	100	4	82.2	2.96	0
Cobalt-60 (pCi/L)	100	0	ND[b]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	34	1,160	ND	0

a. Background concentrations are for western tributary water for the eastern Snake River Plain Aquifer from Bartholomay and Hall (2016).

b. ND = not detected.

No analyte occurred above its MCL in the Snake River Plain Aquifer at WAG 2. The highest chromium concentration occurred in Well USGS-065 at 82.2 µg/L and was below the MCL of 100 µg/L. The second highest chromium concentration was in Well TRA-08 at 17.2 µg/L. The chromium concentrations in both wells have been mostly stable in recent years.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all the sampled wells. The highest tritium concentration was 1,160 pCi/L in Well USGS-065.

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 2022 eastern Snake River Plain Aquifer water table map prepared for the vicinity of the ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Aquifer water levels in the vicinity of the ATR Complex declined by approximately 1.45 ft on average from October 2021 to October 2022.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples are collected from 17 Snake River Plain Aquifer monitoring wells during odd-numbered years and 14 wells during even-numbered years. During the reporting period, 13 of the 14 required wells were sampled. Well ICPP-2020-AQ was not sampled because the sample pump was not functional (Figure 6-12). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2022 Annual Report (DOE-ID 2023c). 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), and nitrates 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 2022, the highest ^{90}Sr level in eastern Snake River Plain Aquifer groundwater was at monitoring Well USGS-047 (15 ± 1.36 pCi/L), located south (downgradient) of the former INTEC injection well. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events, except for Well USGS-048 (11.1 pCi/L), which remains elevated relative to 2015–2020 reported ^{90}Sr levels.

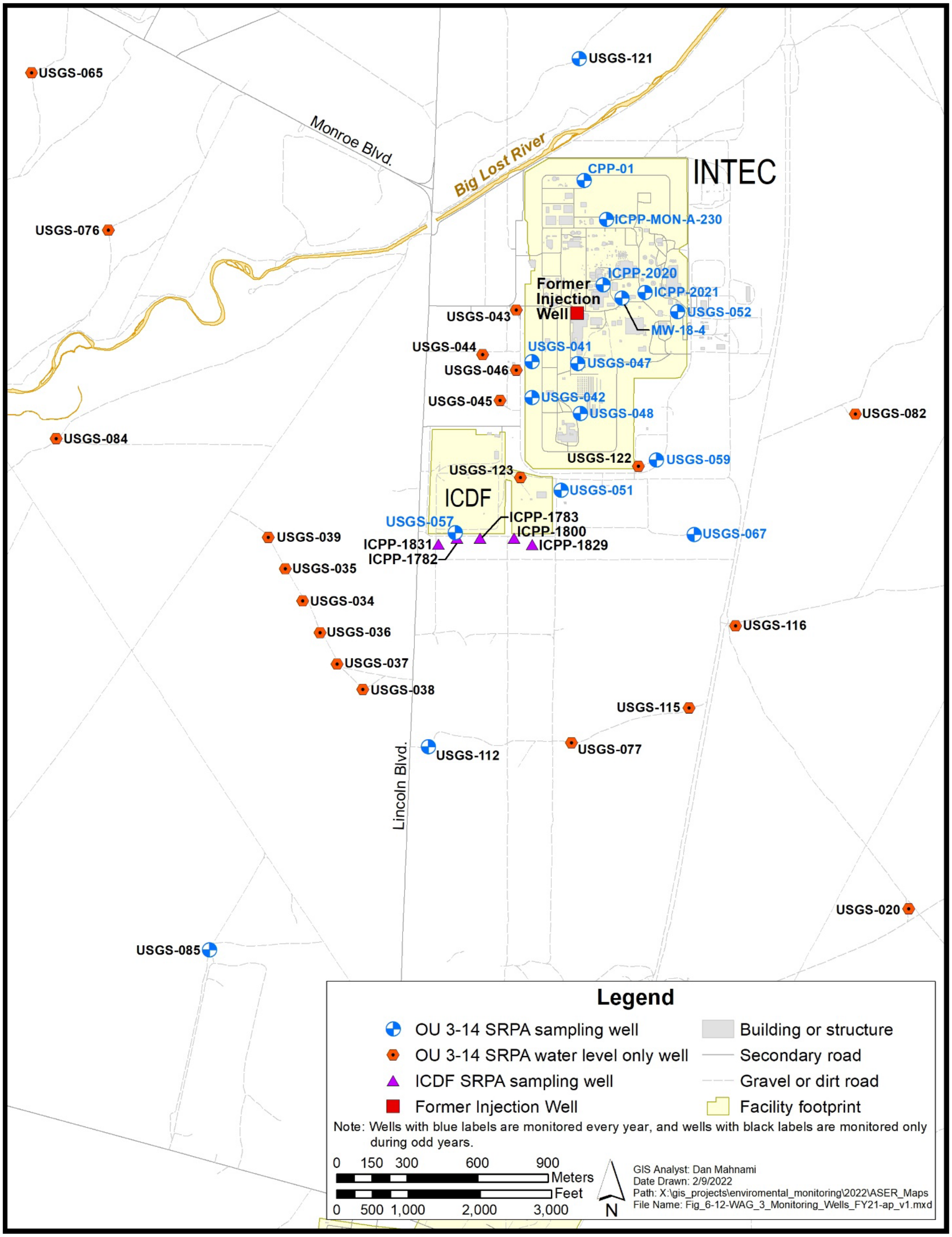

Figure 6-12. Locations of WAG 3 monitoring wells. *(Well names in blue are sampled every year; well names in black are sampled only during odd-numbered years.)*

Table 6-8. Summary of constituents detected in WAG 3 aquifer monitoring wells (FY 2022).

CONSTITUENT	EPA MCL[a]	UNITS	SNAKE RIVER PLAIN AQUIFER GROUNDWATER – APRIL 2022		
			MAXIMUM REPORTED VALUE	NUMBER OF RESULTS[a]	RESULTS > MCL[a]
Gross alpha	15	pCi/L	ND[b]	15	0
Gross beta	NA[c]	pCi/L	593 ± 6.97	15	NA[c]
Cesium-137	200	pCi/L	ND	15	0
Strontium-90	8	pCi/L	**15 ± 1.36**[d]	15	8
Technetium-99	900	pCi/L	**1,200 ± 69**	15	3
Iodine-129	1	pCi/L	0.6 ± 0.124	15	0
Tritium	20,000	pCi/L	1,930 ± 232	15	0
Plutonium-238	15	pCi/L	—[e]	—[e]	—[e]
Plutonium-239/240	15	pCi/L	—[e]	—[e]	—[e]
Uranium-233/234	NA MCL[f]	pCi/L	2.1 ± 0.315	15	NA
Uranium-235	NA MCL	pCi/L	0.146 ± 0.0655 J[b]	15	NA
Uranium-238	NA MCL	pCi/L	1.26 ± 0.223	15	NA
Bicarbonate	NA	mg/L	150	15	NA
Calcium	NA	mg/L	72.6	15	NA
Chloride	250	mg/L	142 J	15	0
Magnesium	NA	mg/L	24.7	15	NA
Nitrate/Nitrite (as N)	10	mg/L	**12.1**	15	1
Potassium	NA	mg/L	5.3	15	NA
Sodium	NA	mg/L	35.2	15	NA
Sulfate	250	mg/L	35.9	15	0
Total dissolved solids	500	mg/L	457	15	0

a. Include field duplicates.

b. Data-qualifier flags:
ND = constituent not detected in sample.
J = estimated detection.

c. NA = not applicable.

d. **Bold** values exceed MCL.

e. — = Gross alpha did not exceed 15 pCi/L; constituent not analyzed.

f. NA MCL = EPA MCL is reported in mass units (µg/L), and values listed are reported in pCi/L.

Technetium-99 was detected above the MCL (900 pCi/L) at two monitoring wells. During 2022, the highest ^{99}Tc level in eastern Snake River Plain Aquifer groundwater was at Well ICPP-MON-A-230 (1,200 ± 69 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (12.1 mg/L as N). This was the only location where the nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations were similar or slightly lower than observed in previous years.

Tritium was detected at most of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well USGS-051, southeast of INTEC (1,930 ± 232 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-MON-A-230 (1.26 ± 0.223 pCi/L). Uranium-234 was also detected in all groundwater samples, with the greatest concentrations of 2.1 ± 0.315 pCi/L at Well USGS-047. 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. The $^{234}U/^{238}U$ ratio for all samples fell within the background range of 1.5 to 3.1 except for the sample from Well ICPP-MON-A-230. A slightly elevated ^{234}U result for this well may be attributed to sediment within the sample, as noted for some previous samples (Roback et al. 2001).

Uranium-235 (^{235}U) was detected at one monitoring well, USGS-042, with a level of 0.146 pCi/L. 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) monitoring the CFA landfill 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 nitrate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 6-13.

Analytes detected in groundwater are compared to regulatory levels identified in Table 6-9. In 2022, no metals exceeded an EPA MCL or secondary maximum containment level (SMCL); however, three wells exceeded a pH SMCL. The elevated pH in the three wells was due to grout placed beneath the well screens during well construction. A complete list of the groundwater sampling results will be included in the FY 2022 Annual Report for WAG 4 (DOE-ID 2023d).

In the CFA nitrate plume monitoring wells south of CFA, one well—CFA-MON-A-002—continued to exceed the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 remained stable with a concentration of 14.5 mg/L-N in 2021 and 14.0 mg/L-N in 2022, but the concentration is still consistent with a declining trend starting in 2006. The nitrate concentration of 7.91 mg/L-N in Well CFA-MON-A-003 is below the MCL and shows a slight downtrend.

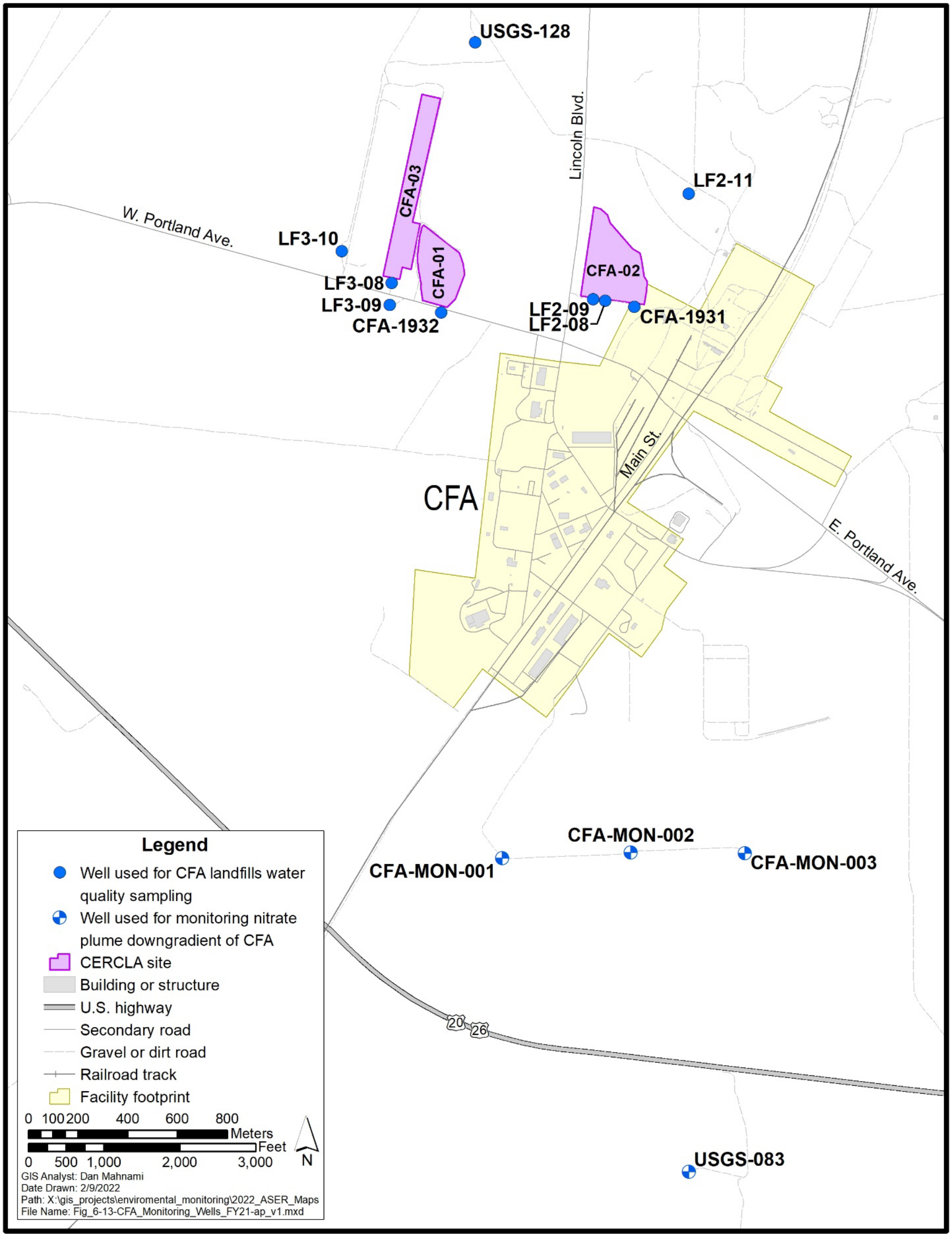

Figure 6-13. Locations of WAG 4/CFA monitoring wells.

Table 6-9. Comparison of CFA landfill groundwater sampling results to regulatory levels (August 2022).

COMPOUND	MCL OR SMCL	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
CENTRAL FACILITIES AREA NITRATE PLUME WELLS			
Chloride (mg/L)	*250*[a]	72.9	0
Sulfate (mg/L)	*250*	33.2	0
Nitrate/nitrite (mg-N/L)	10	**14.0**[b]	0
CENTRAL FACILITIES AREA LANDFILL WELLS			
ANIONS			
Chloride (mg/L)	*250*	52.9	0
Sulfate (mg/L)	*250*	41.9	0
Nitrate/nitrite (mg-N/L)	10	2.32	0
COMMON CATIONS			
Calcium (µg/L)	None	51,700	NA[c]
Magnesium (µg/L)	None	22,900	NA
Potassium (µg/L)	None	6,480	NA
Sodium (µg/L)	None	28,200	NA
INORGANIC ANALYTES			
Antimony (µg/L)	6	ND[d]	0
Aluminum (µg/L)	*50–200*	ND	0
Arsenic (µg/L)	10	ND	0
Barium (µg/L)	2,000	92.4	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	30.5	0
Copper (µg/L)	*1,300/1,000*	1.39	0
Iron (µg/L)	*300*	102	2
Lead (µg/L)	15	ND	0
Manganese (µg/L)	50	18.4	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	93.5	NA
Selenium (µg/L)	50	2.12	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0

Table 6-9. continued.

COMPOUND	MCL[a] OR SMCL[b]	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
Vanadium (µg/L)	None	6.50	NA
Zinc (µg/L)	*5,000*	20.4	0
DETECTED VOLATILE ORGANIC COMPOUNDS			
Chloroform (µg/L)	80	0.90	0

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

Water level measurements taken in the CFA area decreased an average of 1.29 ft from August 2021 to August 2022. A water level contour map based on August 2022 water levels showed groundwater gradients and flow directions consistent with previous maps (DOE-ID 2023d).

6.5.5 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from 12 monitoring wells near and downgradient of RWMC in May 2022 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 92 aquifer analytical results (excluding field blanks), 22 met reportable criteria established in the *Field Sampling Plan for Operable Unit 7-13/14 Aquifer Monitoring* (DOE-ID 2021c). Table 6-10 summarizes the reportable contaminants of concern in 2022, and a discussion of those results follows. Figure 6-14 depicts the WAG 7 aquifer well monitoring network.

- *Carbon tetrachloride* – Carbon tetrachloride was reportable at seven monitoring locations in May 2022, one of which was detected above the MCL at Well M15S. The carbon tetrachloride concentrations increased slightly in most wells nearby, as shown in Figures 6-15 and 6-16.

Table 6-10. Summary of WAG 7 aquifer analyses for May 2022 sampling.

ANALYTE	NUMBER OF WELLS SAMPLED	NUMBER OF SAMPLES ANALYZED[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	12	14	8	6.00 µg/L	M15S	1	5 µg/L
Trichloro-ethylene	12	14	6	3.69 µg/L	M15S	0	5 µg/L
Nitrate (as nitrogen)	12	14	8	2.64 mg/L	M6S	0	10 mg/L

a. Includes field duplicate samples collected for quality control purposes and samples collected from wells with multiple ports.
b. Results that exceeded reporting criteria as established in the Operable Unit 7-13/14 Field Sampling Plan (DOE-ID 2021c).
c. MCLs are from “National Primary Drinking Water Regulations” (40 CFR 141).

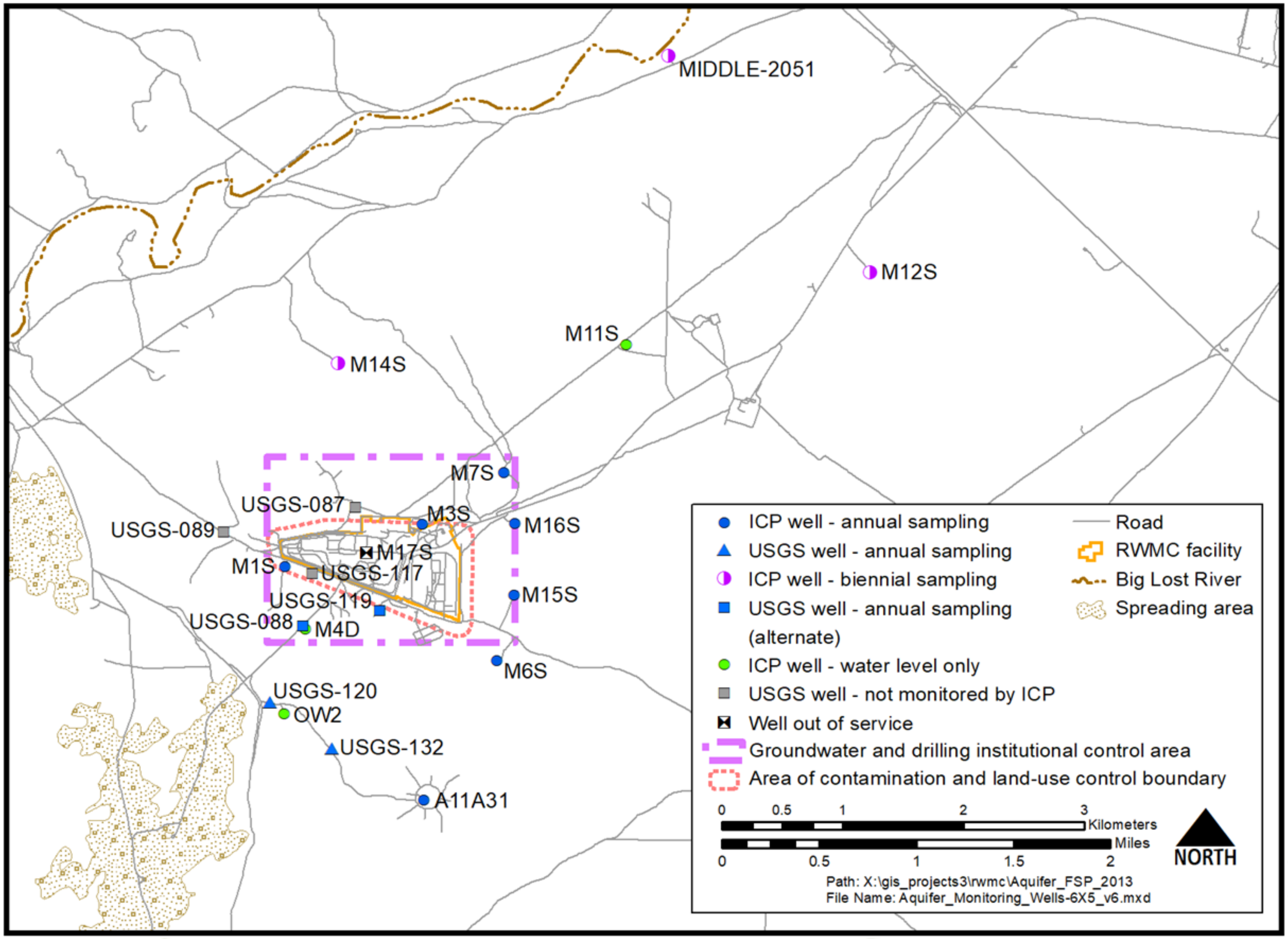

Figure 6-14. The WAG 7 aquifer well monitoring network at the RWMC (DOE-ID 2021c).

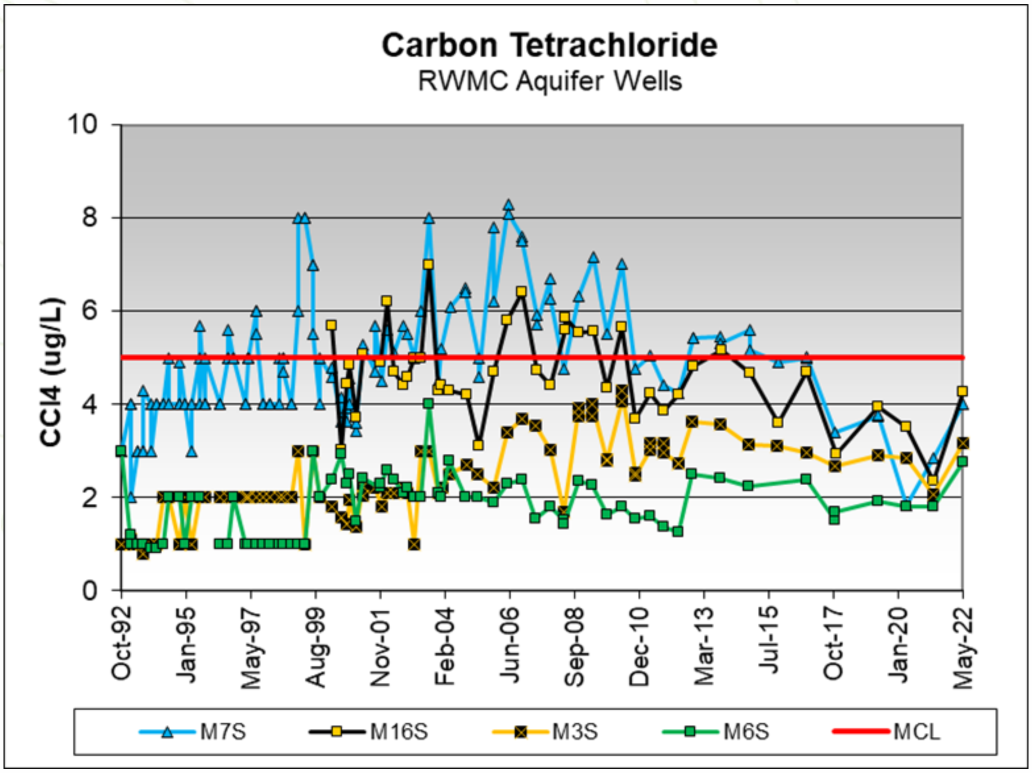

Figure 6-15. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells M7S, M16S, M3S, and M6S.

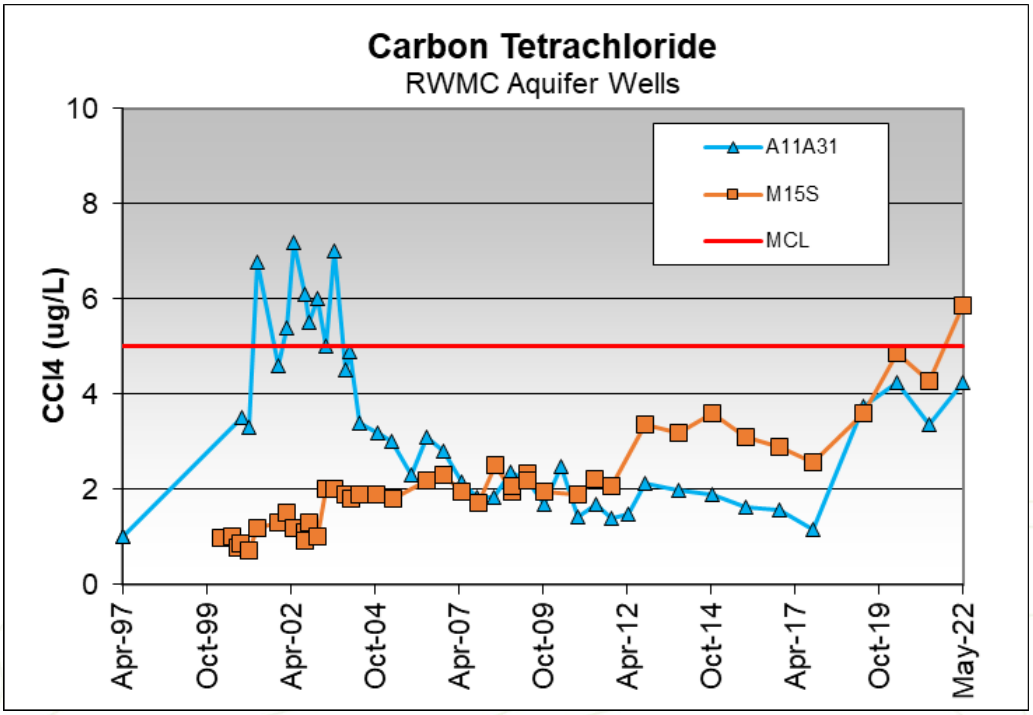

Figure 6-16. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells A11A31 and M15S.

- *Trichloroethylene* – In May 2022, the concentrations of reportable TCE either increased or remained steady in wells near and downgradient of RWMC, as shown in Figure 6-17. No TCE concentrations were detected above the MCL of 5 µg/L.
- *Radiological analytes* – Radiological analytes were not detected above reporting thresholds in groundwater samples collected from the WAG 7 monitoring network in 2022.
- *Inorganic analytes* – Nitrate (as nitrogen) was the only inorganic analyte detected above its reporting threshold (background concentration of 1.05 mg/L) in 2022, which was calculated based on maximum concentrations in upgradient background wells (DOE-ID 2021c). All detections were below the MCL of 10 mg/L.

As in previous years, groundwater-level measurements in RWMC-area monitoring wells were taken prior to the sample collection for the May 2022 event. The groundwater-level contour map for the 2022 sampling indicates groundwater flow toward the south-southwest beneath the RWMC, as shown in Figure 6-18.

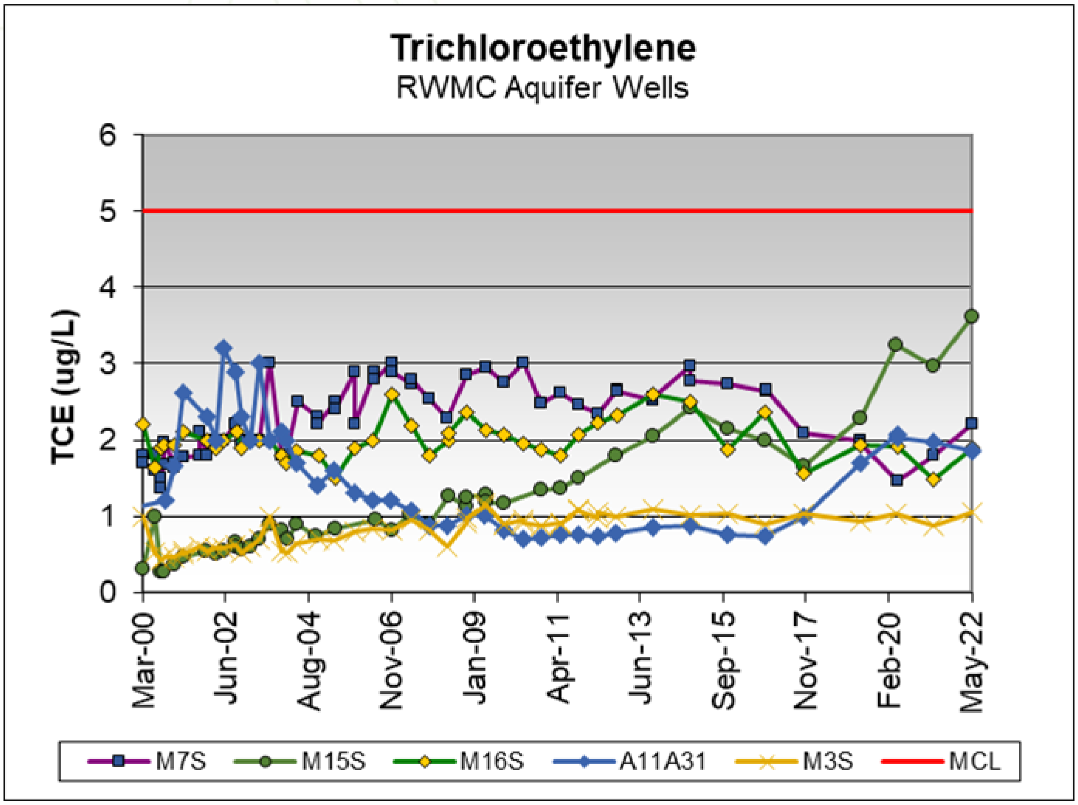

Figure 6-17. Concentration history of TCE in aquifer Wells M7S, M15S, M16S, A11A31, and M3S.

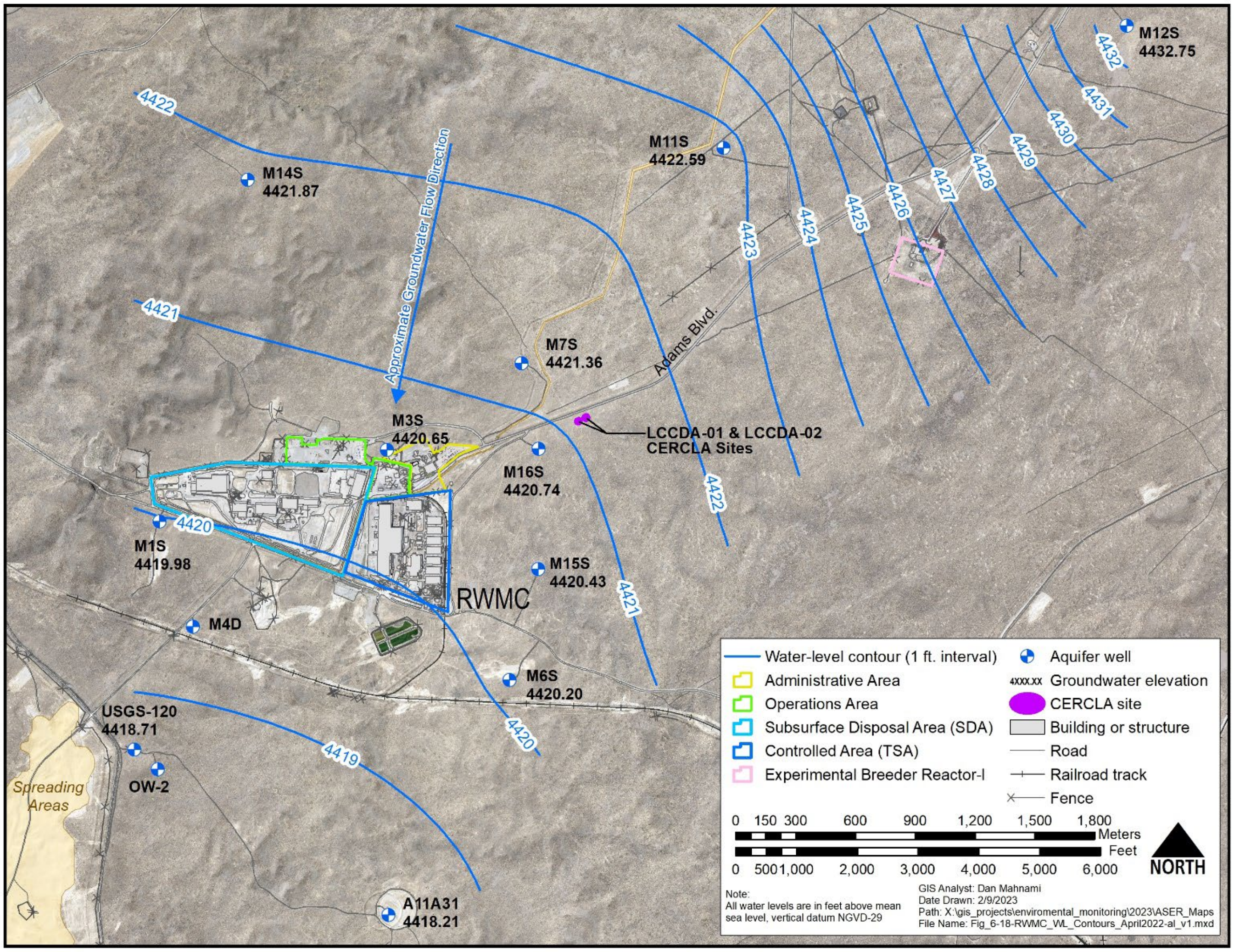

Figure 6-18. Groundwater-level contours in the aquifer near the RWMC based on 2022 measurements.

6.5.6 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC were sampled twice in 2022 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 2022 results are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

Groundwater monitoring performed to meet the CERCLA requirements of the WAG 9 Record of Decision began in 1998 and was discontinued at the end of 2022. The *Operable Unit 9-04 Operations and Maintenance Report for Fiscal Years 2008–2014* (DOE-ID 2015) indicates the groundwater monitoring data:

- Demonstrate that concentrations of organic, inorganic, and radionuclide constituents have never exceeded groundwater or drinking water standards at WAG 9
- Show the remedies have achieved their expected outcomes
- Show no discernible impact from previous or current activities at MFC.

Termination of CERCLA semiannual groundwater monitoring in 2022 was formalized in the *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site – Fiscal Years 2015 – 2019* (DOE-ID 2021e). While CERCLA-specific groundwater monitoring ended in 2022, groundwater monitoring for certain metals, inorganics, and radionuclides will continue at MFC monitoring Wells ANL-MON-A-012, ANL-MON-A-013, and ANL-MON-A-014 to meet the MFC reuse permit and DOE environmental surveillance monitoring requirements.

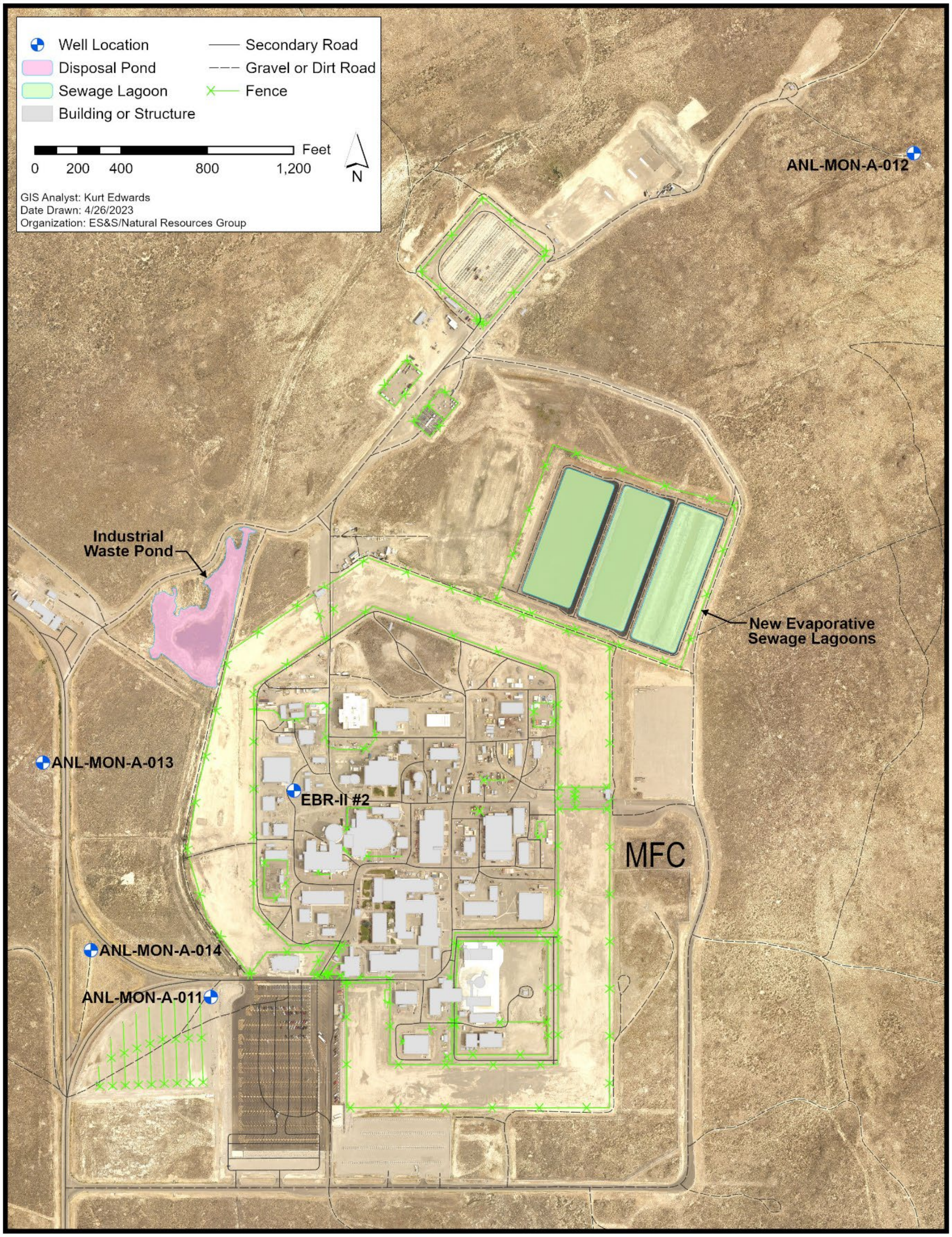

Figure 6-19. Locations of WAG 9 wells sampled in 2022.

Table 6-11. Comparisons of detected analytes to groundwater standards at WAG 9 monitoring wells (2022).

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:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
RADIONUCLIDES[c]											
Gross alpha (pCi/L)	ND[d]	ND	2.07 ± 0.492 (2.07 ± 0.545)[e]	ND	ND	ND	3.64 ± 0.687	1.70 ± 0.337	ND	1.04 ± 0.329	15 pCi/L
Gross beta (pCi/L)	4.11 ± 0.516	3.51 ± 0.259	2.33 ± 0.498 (2.50 ± 0.351)	4.03 ± 0.265	3.86 ± 0.597	2.43 ± 0.237	3.29 ± 0.426	2.74 ± 0.286	2.12 ± 0.419	2.89 ± 0.286	4 mrem/yr[f]
Cesium-137 (pCi/L)	ND	ND	1.87 ± 0.471 (ND)	ND	ND	ND	ND	ND	ND	ND	NA[g]
Uranium-233/234 (pCi/L)	1.24 ± 0.202	1.05 ± 0.150	1.39 ± 0.219 (1.13 ± 0.174)	1.28 ± 0.222	1.22 ± 0.184	1.25 ± 0.181	1.25 ± 0.199	1.28 ± 0.201	1.39 ± 0.222	1.60 ± 0.226	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.886 ± 0.161	0.623 ± 0.110	0.537 ± 0.126 (0.692 ± 0.129)	0.488 ± 0.128	0.788 ± 0.138	0.511 ± 0.108	0.487 ± 0.115	0.587 ± 0.128	0.690 ± 0.146	0.581 ± 0.124	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND (ND)	ND	ND	ND	ND	ND	ND	ND	NA
METALS[h]											
Arsenic (mg/L)	0.00227	0.00202	0.00201 (0.002U)	0.00208	0.00245	0.00202	0.00228	0.002U[d]	0.00213	0.00207	0.05
Barium (mg/L)	0.0383	0.0373	0.0370 (0.0370)	0.0391	0.0367	0.0363	0.0390	0.0364	0.0383	0.0372	2
Calcium (mg/L)	38.6	37.2	37.3 (38.0)	35.4	36.5	34.0	39.5	34.7	42.0	38.2	NA
Chromium (mg/L)	0.003U	0.003U	0.003U (0.003U)	0.003U	0.00373	0.00325	0.00408	0.003U	0.003U	0.003U	0.1
Copper (mg/L)	0.000335	0.000638	0.000314 (0.000300)	0.000335	0.000646	0.000613	0.000432	0.000467	0.0125	0.00371	1.3
Iron (mg/L)	0.0826	0.283J[d]	0.03U (0.03U)	0.03U	0.03U	0.0364	0.03U	0.03U	0.03U	0.03UJ[d]	0.3

Table 6-11. 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:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
Lead (mg/L)	0.0005U	0.0005U	0.0005U (0.0005U)	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.00299U	0.00103	0.015
Magnesium (mg/L)	12.4	12.5	11.6 (11.8)	11.5	12.2	11.7	12.9	11.5	13.2	12.6	NA
Manganese (mg/L)	0.001U	0.001U	0.001U (0.001U)	0.001U	0.001U	0.00202	0.001U	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.000664	0.000617	0.0006U (0.0006U)	0.0006U	0.000685	0.00104	0.0006U	0.0006U	0.00743	0.00445	NA
Potassium (mg/L)	3.48	3.30	3.49 (3.46)	3.42	3.42	3.24	3.41	3.30	3.58	3.36	NA
Sodium (mg/L)	18.4	17.8	16.8 (17.1)	17.3	19.7	18.1	19.3	17.3	19.1	18.2	NA
Vanadium (mg/L)	0.00529	0.00486	0.00572 (0.00557)	0.00492	0.00930	0.00639	0.00516	0.00503	0.00531	0.00494	NA
Zinc (mg/L)	0.0033U	0.0033U	0.0033U (0.0033U)	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0389	0.0210	5
ANIONS											
Chloride (mg/L)	17.3J	16.9J	15.8J (15.6J)	15.8J	18.8	16.9J	17.1J	15.9J	17.5	16.5J	250
Nitrate-as nitrogen (mg/L)	2.37J	2.44	2.40J (2.37J)	2.39J	2.44J	2.39J	2.36	2.45J	2.59	2.44	10
Phosphorus (mg/L)	0.0375U	0.0146U	0.0877J (0.0696J)	0.099	0.0934J	0.106	0.0354U	0.0678	0.0508UJ	0.0213J	NA
Sulfate (mg/L)	18.1	19.0	18.2J (18.3J)	17.7	21.7J	19.6	18.8	19.3	19.6	18.2	250

Table 6-11. 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:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
WATER QUALITY PARAMETERS											
Alkalinity (mg/L)	134	136	136 (91.8)	147	152	145	135	139	133	136	NA
Bicarbonate alkalinity (mg/L)	134	135	136 (91.8)	147	152	145	135	139	133	135	NA
Total dissolved solids (mg/L)	206	227	227 (226)	212	244	221	223	224	249	216	500

a. EBR-II = Experimental Breeder Reactor II. Also known as ANL 2.

b. PCS = primary constituent standard; SCS = secondary constituent standard, as specified in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

c. Result ± 1σ uncertainty. Only analytes with at least one statistically positive result greater than 3σ uncertainty are shown. Samples were analyzed for gross alpha; gross beta; tritium; gamma-emitting radionuclides including 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; and alpha-emitting radionuclides including americium-241, uranium-233/234, uranium-235, and uranium-238.

d. ND = not detected; J = associated value is an estimate and may be inaccurate or imprecise; U = 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 five times the highest positive amount in any laboratory blank; UJ = the sample was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

e. Results for field duplicate samples shown in parentheses.

f. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/yr effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

g. NA = not applicable. A primary or secondary constituent standard has not been established for this constituent in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

h. Metals reported as non-filtered unless noted.

6.5.7 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2021d), groundwater samples are collected every two years. In 2022, groundwater samples were not collected for WAG 10. WAG 10 monitoring wells will be sampled in 2023.

6.6 Remote-Handled Low-Level Waste Disposal Facility

The INL contractor monitors groundwater at the RHLLW Disposal Facility to demonstrate compliance with DOE O 435.1, "Radioactive Waste Management," and IDAPA 58.01.11, "Ground Water Quality Rule." Samples were collected from three monitoring wells in 2022 and analyzed for gross alpha, gross beta, carbon-14 (^{14}C), ^{129}I, ^{99}Tc, and tritium in accordance with PLN-5501, "Monitoring Plan for the INL RHLLW Disposal Facility," as shown in Figure 6-20. Results for analytes with positive detections are summarized in Table 6-12. Tritium and gross beta were detected in all three wells, while gross alpha was positively detected in two of the three wells. Carbon-14, ^{129}I, and ^{99}Tc were not detected in any samples. All results are consistent with concentrations in the aquifer established prior to facility completion (INL 2017). The 2022 results show no discernable impacts to the aquifer from RHLLW Disposal Facility operations.

Table 6-12. Radioactivity detected in surveillance groundwater samples collected at the RHLLW Facility (2022).

WELL:	USGS-136		USGS-140		USGS-141		PCS/SCS[a]
SAMPLE DATE:	4/18/2022	9/16/2022	4/19/2022	9/21/2022	4/19/2022	9/21/2022	
RADIONUCLIDES[b]							
Gross alpha (pCi/L)	ND[c]	1.62 ± 0.535	ND	ND	ND (1.04 ± 0.295)[d]	ND	15 pCi/L
Gross beta (pCi/L)	1.92 ± 0.184	3.45 ± 0.556	3.80 ± 0.277	4.02 ± 0.552	1.59 ± 0.270 (2.96 ± 0.264)	2.54 ± 0.489	4 mrem/yr[e]
Tritium (pCi/L)	1,110 ± 171	535 ± 145	992 ± 161	842 ± 182	877 ± 154 (773 ± 145)	874 ± 186	20,000 pCi/L

a. PCS = primary constituent standard, SCS = secondary constituent standard, as specified in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

b. Result ± 1σ. Only analytes with at least one statistically positive result greater than 3σ uncertainty are shown. Samples were analyzed for gross alpha, gross beta, carbon-14, iodine-129, technecium-99, and tritium.

c. ND = not detected.

d. Duplicate sample results are shown in parentheses.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/yr effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes only, the EPA also specifies MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

In addition to compliance monitoring of groundwater at the RHLLW Disposal Facility, facility performance is monitored by collecting and analyzing soil-pore water samples, where sufficient water is present, from vadose-zone lysimeters installed in native materials adjacent to and below the base of the vault arrays. Development of the baseline for the soil-pore water samples was intended to include the 2019–2021 samples; however, due to the persistent lack of soil-pore water volume available for sampling at some locations in 2019–2021, the 2022 data will also be included in the development of the baseline. Additional baseline data collection may continue in 2023 and beyond to address data gaps at locations where insufficient soil-pore water for sampling persists. Future soil-pore water sample results will be compared to the baseline measurements, where established, and used as early indicators of facility operations and key assumptions. For establishment of the baseline, soil-pore water samples are analyzed for the same target and indicator analytes as the aquifer compliance samples (e.g., gross alpha, gross beta, tritium, ^{14}C, ^{129}I, and ^{99}Tc).

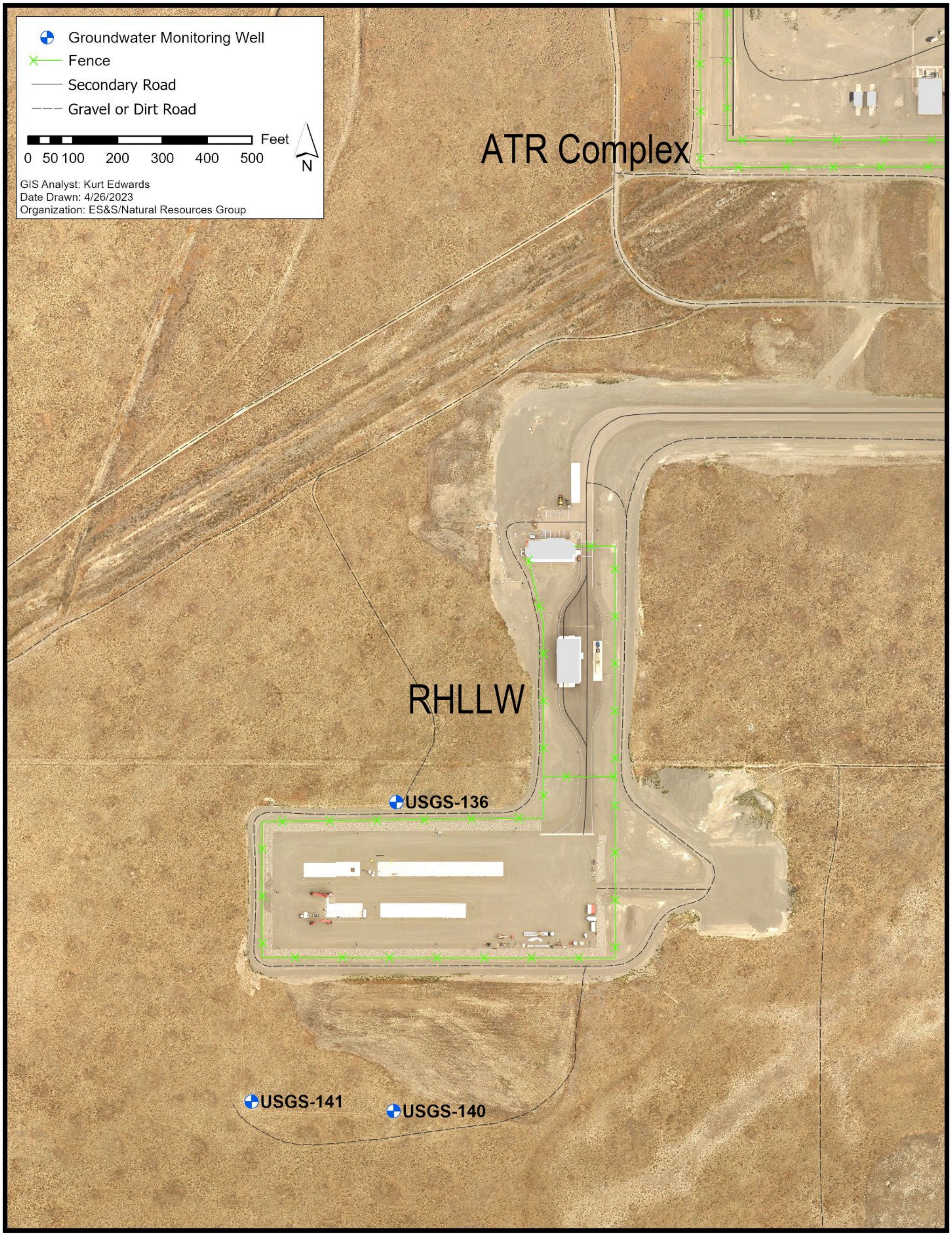

Figure 6-20. Well locations sampled for RHLLW Facility.

6.7 Onsite Drinking Water Sampling

The INL and ICP contractors monitor drinking water to ensure that 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 are sampled according to a 9-year monitoring cycle, which identifies the frequency and the specific classes of contaminates to monitor at each drinking water source (https://www2.deq.idaho.gov/water/monitoringschedulereport). 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.

The INL Site has 11 drinking water systems that are monitored by the INL and ICP contractors. The INL contractor monitors eight of these drinking water systems, and the ICP contractor monitors three. 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 Reactors Facility Environmental Monitoring Report for Calendar Year 2022* (FMP 2022). 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 four INL contractor transient, non-community water systems are located at the CITRC, EBR-I, Gun Range, and Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems and are located at ATR Complex, CFA, MFC, and TAN/CTF. Two of the ICP contractor systems, INTEC and RWMC, are classified as non-transient, non-community and the NRF Deactivation and Decommissioning (D&D) Facility is classified as transient, non-community.

As required by the state of Idaho, INL and the ICP 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. Idaho DEQ oversees the certification program and maintains a list of approved laboratories.

The INL and ICP contractors monitor certain parameters more frequently than required by regulation because of low volume usage on weekends. For example, bacterial analyses are conducted monthly rather than quarterly at all eight INL contractor drinking water systems and at the three ICP contractor drinking water systems during months of operation. Because of known groundwater plumes near one ICP contractor drinking water well, additional sampling is conducted for carbon tetrachloride at RWMC.

6.7.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2022, the INL contractor collected 66 routine/compliance samples and 10 quality control samples in the form of blanks from the eight INL-operated drinking water systems. Semiannual sampling was conducted at all eight water systems for gross alpha, beta, and tritium. CFA was also sampled for ^{129}I due to its location downgradient of the plume around INTEC. Table 6-13 lists results of routine/compliance and radiological surveillance monitoring. In addition to routine samples, the INL contractor collected 211 surveillance bacteriological, lead and copper, and perfluoroalkyl substances (PFAS) samples.

The ICP contractor collected 15 routine/compliance samples and five quality control samples from the ICP drinking water systems. ICP also collected 87 surveillance bacteriological, synthetic organic compounds, and VOCs samples. Two gross alpha/beta samples were collected semiannually from both ICP drinking water systems (INTEC and RWMC). One tritium sample was also collected from each drinking water system, as shown in Table 6-13.

All INL Site water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 2.77 mg/L at CFA and 2.19 mg/L at MFC. Samples for total trihalomethanes and haloacetic acids were collected at ATR Complex, CFA, INTEC, MFC, RWMC, and TAN/CTF, as seen in Table 6-1.3

All INL Site drinking water systems were well below regulatory limits for drinking water or there were no detections. Since all the water systems are public water systems (PWS); their data are listed on the Idaho DEQ’s PWS Switchboard (www.deq.idaho.gov).

The EPA is actively researching and beginning to establish regulations for a class of very widely used and dispersed man-made-chemicals called PFAS, which are considered to be an emerging contaminant of concern and have been used in

Table 6-13. Summary of INL Site drinking water results (2022).

CONSTITUENT	MCL (units)	ATR COMPLEX 6120020	CFA 6120008	CITRC 6120019	EBR-I 6120009	GUN RANGE 6120025	INTEC PWS 6120012	MAIN GATE 6120015	MFC 6060036	NRF D&D 6120031	RWMC PWS 6120018	TAN CTF 6120013
RADIOLOGICAL SURVEILLANCE MONITORING												
Gross Alpha[a] (pCi/L)	15	ND[b]	ND	ND	ND	ND	ND	ND	ND	NA[b]	ND-2.99	ND
Gross Beta[a] (pCi/L)	50 screening or 4 mrem	ND-3.43	4.19-5.54	2.81-4.59	ND-2.88	ND	ND	ND-3.87	ND-4.34	NA	ND-3.01	ND-2.74
Tritium[a] (pCi/L)	20,000	ND	1,770-2,260	ND	ND	ND	ND	ND	ND	NA	ND	ND
Iodine-129[c] (pCi/L)	1	—[d]	ND	—	—	—	NA	—	—	NA	NA	—
Radium-226 (pCi/L)	5 combined	0.08	0.14/ND[a]	—	—	—	NA	—	0.05	NA	NA	ND
Radium-228 (pCi/L)		0.06	1.63/ND[a]	—	—	—	NA	—	2.29	NA	NA	ND
Uranium (µg/L)	30	1.26	2.37/2.38[a]	—	—	—	NA	—	1.67	NA	NA	2.26
COMPLIANCE MONITORING												
Nitrate (mg/L)	10	ND	2.75/2.77[a]	ND	ND	ND	ND	ND	2.18/2.19[a]	NA	ND	ND
Total trihalomethanes (ppb)	80	ND	5.39	NA[c]	NA	NA	ND	NA	5.13	NA	10.6	3.68
Total coliform	2 or more present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
E. coli	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Haloacetic acids (ppb)	60	ND	ND	NA	NA	NA	ND	NA	ND	NA	ND	ND
SOCs/VOCs[e] (ppb)	SOCs varies, 5 for most VOCs	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	NA

a. Range of results (minimum – maximum) presented.
b. ND = not detected.
c. NA = not applicable based on water system classification.
d. — = not analyzed.
e. SOCs = synthetic organic compounds and VOCs = volatile organic compounds.

industry and consumer products worldwide since the 1950s in non-stick cookware, water-repellent clothing, stain resistant fabrics and carpets, some cosmetics, some firefighting foams, and products that resist grease, water, and oil. Many of the common PFAS have been phased out of production. These chemicals do not degrade in the environment. During production and use, PFAS can migrate into the soil, water, and air. Because of their widespread use and their persistence in the environment, PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and the environment. Some PFAS can build up in people and animals with repeated exposure over time. Research involving humans suggests that high levels of certain PFAS may lead to numerous health impacts. A common pathway for humans to be potentially impacted by PFAS is through drinking contaminated water.

In 2022, INL sampled three wells and one manifold associated with two drinking water systems as a follow-up to a 2021 voluntary state of Idaho initiative to explore the potential for the existence of PFAS in Idaho's drinking water sources. ICP did not sample for PFAS in 2022. In 2021, ICP collected PFAS samples from two drinking water wells at INTEC and one well at RWMC. No PFAS constituents were identified at detectable concentrations in these wells.

INL and ICP will continue to monitor PFAS based on the DOE PFAS Strategic Roadmap: DOE Commitments to Action 2022–2025 (DOE 2022), the pending INL PFAS Implementation Plan, and the ICP PFAS Implementation Plan (SPR-190). CFA was the only sample location with any detections of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which are the two primary constituents of concern. These results have not exceeded any regulatory limits, as there are no drinking water MCLs as of 2022.

6.7.1.1 Advanced Test Reactor Complex, PWS 6120020

There are over 500 employees assigned to the ATR Complex. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. A new potable well was completed for the ATR Complex in September 2019. This gives the ATR Complex two drinking water wells. Since both are approximately 600 feet deep and less than 100 feet apart, they are designated as a wellfield. Compliance samples are collected from the wellfield at TRA-696 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples. These wells can pump over 200 gpm. Water is also supplied to the RHLLW Disposal Facility, which is outside the fence of the ATR Complex.

6.7.1.2 Central Facilities Area, PWS 6120008

The CFA water system has two wells that serves over 500 people daily. The two wells are 639 and 681 feet deep, and they pump over 600 gpm. The water system is continuously disinfected on a voluntary basis as an added protection. Compliance samples are collected from the manifold at CFA-1603 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all constituents sampled were below the MCL, which includes the monthly bacteriological samples (i.e., total coliform and E. coli).

6.7.1.3 Critical Infrastructure Test Range Complex Facility, PWS 6120019

At present, there are no permanent employees at CITRC. The water system has a continuous chlorination system to disinfect the water. CITRC #1 well is located at PBF-602, is 653 feet deep and can pump 400 gpm. CITRC #2 well is located at PBF-614. The well is 1,217 feet deep and can pump 800 gpm. Compliance samples are collected from the manifold, located at PBF-638. In 2022, all compliance samples were below the MCL, which includes the monthly bacteriological samples (i.e., total coliform and E. coli).

6.7.1.4 Experimental Breeder Reactor-I, PWS 6120009

EBR-I has a public water system that is open to the public from Memorial Day to Labor Day with scheduled tours throughout the year. There are no personnel stationed at this facility. The well is 1,075 feet deep. EBR-I is one of four water systems at INL that does not automatically disinfect. The water system and well were constructed in 1949. In 2022, all compliance samples, including the monthly bacteriological samples (i.e., total coliform and E. coli), were below the MCL.

6.7.1.5 Gun Range Facility, PWS 6120025

There is one employee permanently stationed at the Gun Range Facility. In 2010 continuous chlorination was discontinued due to an ongoing history of no bacteria (i.e., total coliform and E. coli). The well is located at B21-607 and was completed in January 1990. The well is 626 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B21-607 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2022, all sampled constituents were below the MCL, which includes the monthly bacteriological samples.

6.7.1.6 Idaho Nuclear Technology and Engineering Center, PWS 6120018

Drinking water for the INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. In 2022, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system.

Five compliance samples were collected from various buildings throughout the distribution system at INTEC and were analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.7 Main Gate Badging Facility, PWS 6120015

There are three employees permanently stationed at the Main Gate Badging Facility. The well is located at B27-605 and was completed in January 1985. The well is 644 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B27-605 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2022, all constituents sampled were below the MCL, which includes the monthly bacteriological samples.

6.7.1.8 Materials and Fuels Complex, PWS 6060036

There are 1,200 employees located at MFC. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. Well #1 is located at MFC-754 and Well #2 at MFC-756. Well #1 was completed in 1958 and is 747 feet deep. Well #2 was completed in 1959 and is 755 feet deep. Most compliance samples are collected from both wells. Other compliance samples, such as lead/copper, total trihalomethanes/haloacetic acids, and bacteria (i.e., total coliform and E. coli), are collected from the distribution system as required by the regulations. In 2022, all sampled constituents were below the MCL, which includes the two monthly bacteriological samples.

6.7.1.9 Naval Reactors Facility Deactivation and Decommissioning Facility, PWS 6120031

The NRF D&D Facility is made up of two comfort stations and two shower trailers that serve approximately 50 people. These trailers each have their own individual storage tanks. The source water is transported from Idaho Falls public water system and dispersed to each individual storage tank.

Four compliance samples (total coliform and E. coli) were collected from each location and analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.10 Radioactive Waste Management Complex, PWS 6120012

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (e.g., 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 the point of entry to the distribution system (WMF-603). 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 2022, drinking water samples were collected from the point of entry to the distribution system (WMF-603) and from various buildings throughout the distribution system.

Six compliance samples were collected from various buildings throughout the distribution system at RWMC and analyzed for the contaminants identified by the state of Idaho per the monitoring schedule. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.11 Test Area North/Contained Test Facility, PWS 6060021

There are more than 300 employees located at TAN/CTF. The water system has a continuous chlorination system to disinfect the water on a voluntary basis for added protection. TAN/CTF #1 Well is located at TAN-632 and was constructed in November 1957. The well is 339 feet deep. The well can pump 1,000 gpm. TAN/CTF #2 Well is located at TAN-639 and was completed in April 1958. The well is 462 feet deep and can pump 1,000 gpm. Compliance samples are collected from the manifold at TAN-1612 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all sampled constituents, including the monthly bacteriological (i.e., total coliform and E. coli) samples, were below the MCL.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program, drinking water samples were collected off the INL Site for radiological analyses in 2022. 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 2022. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. Samples were also collected 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 results are shown in Table 6-14. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Table 6-14. Gross alpha, gross beta, and tritium concentrations in offsite drinking water samples collected by the INL contractor in 2022.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING	FALL	EPA MCL[b]
Atomic City	1.6 ± 0.54	1.4 ± 0.40	15 pCi/L
Control (bottled water)[c]	0.36 ± 0.16	0.12 ± 0.12	15 pCi/L
Craters of the Moon	2.2 ± 0.32	3.0 ± 0.51	15 pCi/L
Howe	1.3 ± 0.28	1.6 ± 0.38	15 pCi/L
Idaho Falls	2.5 ± 0.57	0.46 ± 0.46	15 pCi/L
Minidoka	0.64 ± 0.35	1.5 ± 0.58	15 pCi/L
Mud Lake (Well #2)	0.43 ± 0.19	0.20 ± 0.25	15 pCi/L
Rest Area (Highway 20/26)	1.2 ± 0.29	1.4 ± 0.42	15 pCi/L
Shoshone	2.0 ± 0.39	2.8 ± 0.57	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Atomic City	4.1 ± 0.48	3.2 ± 0.48	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	0.18 ± 0.42	0.01 ± 0.31	4 mrem/yr (50 pCi/L)
Craters of the Moon	3.5 ± 0.36	2.7 ± 0.44	4 mrem/yr (50 pCi/L)
Howe	7.7 ± 0.40	2.0 ± 0.44	4 mrem/yr (50 pCi/L)

Table 6-14. continued.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
Idaho Falls	4.7 ± 0.41	3.4 ± 0.50	4 mrem/yr (50 pCi/L)
Minidoka	2.1 ± 0.41	4.7 ± 0.49	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.3 ± 0.33	4.6 ± 0.43	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	3.2 ± 0.35	3.0 ± 0.44	4 mrem/yr (50 pCi/L)
Shoshone	3.5 ± 0.35	4.2 ± 0.48	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Atomic City	-19 ± 26	-11 ± 34	20,000 pCi/L
Control (bottled water)	-13 ± 33	-19 ± 22	20,000 pCi/L
Craters of the Moon	30 ± 26	-4.9 ± 22	20,000 pCi/L
Howe	10 ± 24	-15 ± 23	20,000 pCi/L
Idaho Falls	0.80 ± 26	-49 ± 22	20,000 pCi/L
Minidoka	17 ± 34	-53 ± 21	20,000 pCi/L
Mud Lake (Well #2)	-35 ± 33	-26 ± 22	20,000 pCi/L
Rest Area (Highway 20/26)	26 ± 34	35 ± 23	20,000 pCi/L
Shoshone	17 ± 34	-26 ± 22	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.

Gross alpha activity was detected statistically (above 3σ) in 10 of 18 samples collected in 2022. The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 3.0 ± 0.51 pCi/L, as measured at Craters of the Moon in November.

Gross beta activity was detected statistically in all but two drinking water samples collected during 2022. Gross beta activity was not detected in the bottled water samples (control) collected in May and November. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 7.7 ± 0.4 pCi/L, measured at Howe 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 2012 in past Annual Site Environmental Reports was 8.8 ± 1.0 pCi/L at Atomic City in fall of 2021.

Tritium was not statistically detected in any of the drinking water samples collected in 2022.

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2022 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman shown in Figure 6-21. Results are summarized in Table 6-15.

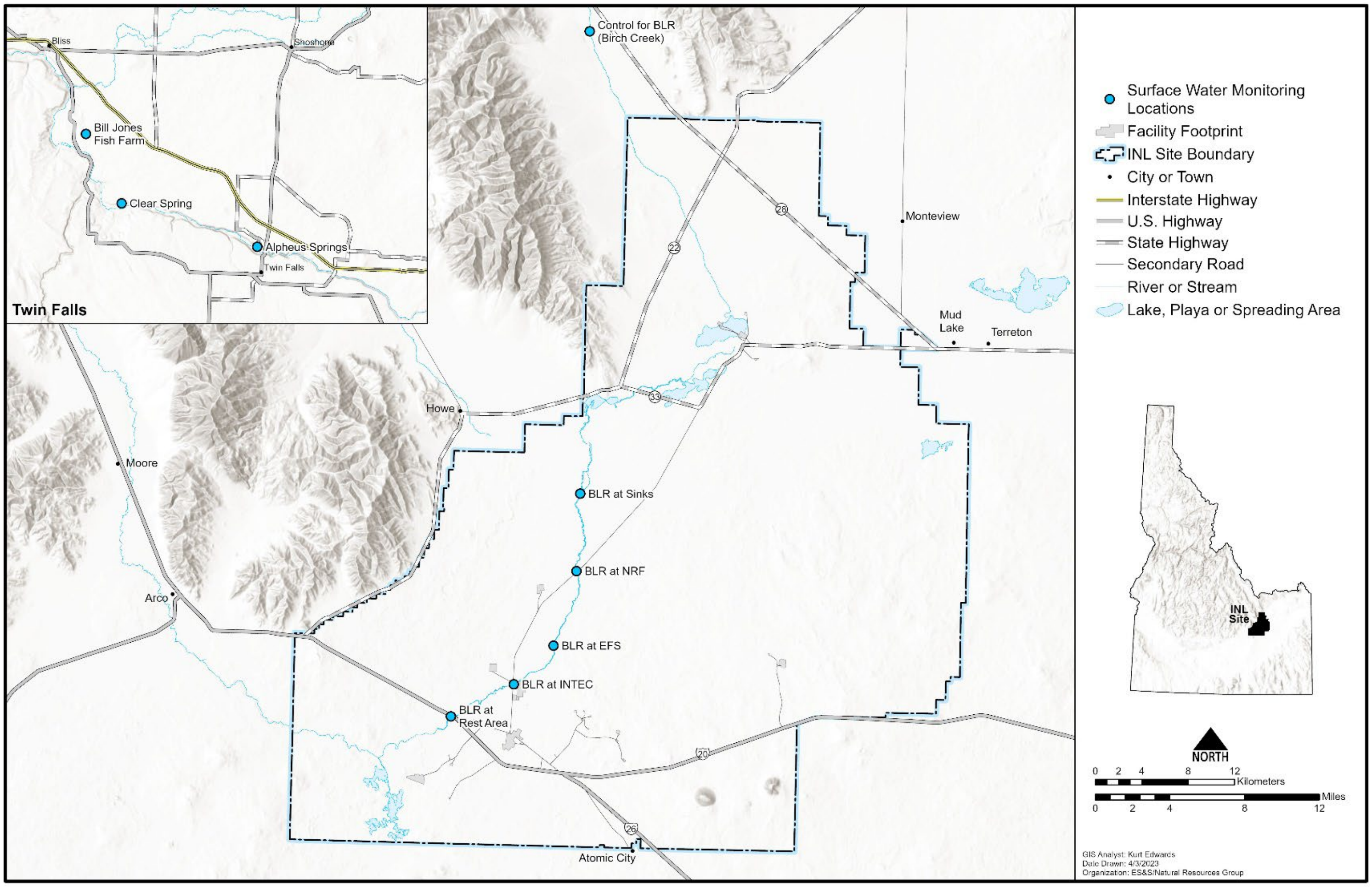

Figure 6-21. Detailed map of INL program surface water monitoring locations.

Gross alpha activity was detected in one sample collected in November for the sample collected as Alpheus Springs in May. For comparison, the maximum concentration measured since 2012 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 results were measured in the Clear Springs sample (4.9 ± 0.40 pCi/L) collected in May and the Alpheus Springs sample (4.9 ± 0.64 pCi/L) collected in November. The maximum result measured since 2012 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

Tritium was not detected in any of the surface water samples collected in 2022.

Table 6-15. Gross alpha, gross beta, and tritium concentrations in surface water samples collected along the Big Lost River by the INL contractor in 2022.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING[b]	FALL[b]	EPA MCL
Alpheus Springs-Twin Falls	4.0 ± 0.85	1.5 ± 0.55	15 pCi/L
Clear Springs-Buhl	1.0 ± 0.35	1.6 ± 0.67	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	1.4 ± 0.49	1.4 ± 0.39	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	1.9 ± 0.52	4.9 ± 0.64	4 mrem/yr (50 pCi/L)[c]
Clear Springs-Buhl	4.9 ± 0.40	4.6 ± 0.52	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	4.7 ± 0.48	2.3 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	36 ± 33	-30 ± 34	20,000 pCi/L
Clear Springs-Buhl	18 ± 33	-30 ± 34	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.43 ± 33	-7.7 ± 33	20,000 pCi/L

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

b. The springs and trout farm were sampled on May 9, 2022, and on November 14, 2022.

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.

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 the Big Lost River Sinks (see Figure 6-21). 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. The INL contractor did not collect surface water samples from the Big Lost River on the INL Site because water demands upstream at the Mackay Reservoir inhibited river flow onto the INL Site from March to May 2022 and flow never went as far as the Lincoln Blvd bridge. No river samples were collected during 2022 at INL because of the lack of surface water flow in the Big Lost River.

6.10 USGS 2022 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 and the eastern Snake River Plain 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://usgs-r.github.io/inlpubs/articles/inl-bibliography.html. Two reports, Bartholomay (2022) and Treinen and Bartholomay (2022), and one software package (Fisher 2022) were published by the USGS INL Project Office in 2022. The abstracts of these studies and the publication information associated with each study are presented below.

6.10.1 Evaluation of Sample Preservation Methods for Analysis of Selected Volatile Organic Compounds in Groundwater at Idaho National Laboratory, Idaho (Treinen and Bartholomay 2022)

During 2020, water samples were collected from 25 wells completed in the eastern Snake River Plain Aquifer and from 1 well completed in perched groundwater above the aquifer at INL to determine the effect of different sample preservation methods on the laboratory determinations of concentrations of VOCs. Paired-sample sets were collected at each well. One sample in each set was preserved with hydrochloric acid, and one sample was preserved without it. Both samples were chilled after collection and during shipping to the laboratory for analysis. The samples were analyzed for 61 VOCs at the U.S. Geological Survey National Water Quality Laboratory in cooperation with the DOE. A comparison of the reproducibility of the analyses of co-located unpreserved and preserved samples by a relative percent difference method determined that all sample pairs were statistically equivalent. Using a normalized absolute difference method, 81 percent of the analyses were found to be statistically equivalent. This study confirms that the results of analyses of historical collected samples, which were preserved by chilling only, are statistically comparable to the analyses of samples being currently collected and preserved by both hydrochloric acid and chilling, and thus are valid for use in future geochemical evaluations.

6.10.2 Historical Development of the U.S. Geological Survey Hydrological Monitoring and Investigative Programs at Idaho National Laboratory, Idaho, 2002–2020 (Bartholomay 2022)

Long-term monitoring of water quality data collected from wells at INL have provided essential information for delineating the movement of radiochemical and chemical wastes in the eastern Idaho Snake River Plain Aquifer. In cooperation with DOE, the USGS has maintained as many as 200 wells in the INL water quality monitoring network since 1949. A network design tool, distributed as an R package, was developed to evaluate and optimize groundwater monitoring in the existing network based on water quality data collected at 153 sampling sites since January 1, 1989. The objective of the optimization design tool is to reduce well monitoring redundancy while retaining sufficient data to reliably characterize water quality conditions in the aquifer. A spatial optimization was used to identify a set of wells whose removal leads to the smallest increase in the deviation between interpolated concentration maps using the existing and reduced monitoring networks while preserving significant long-term trends and seasonal components in the data. Additionally, a temporal optimization was used to identify reductions in sampling frequencies by minimizing the redundancy in sampling events (Fisher et al. 2021).

Spatial optimization uses an islands genetic algorithm to identify near-optimal network designs removing 10, 20, 30, 40, and 50 wells from the existing monitoring network. With this method, choosing a greater number of wells to remove results in greater cost savings and decreased accuracy of the average relative difference between interpolated maps of the reduced dataset and the full dataset. The genetic search algorithm identified reduced networks that best capture the spatial patterns of the average concentration plume while preserving long-term temporal trends at individual wells. Concentration data for 10 analyte types are integrated in a single optimization so that all datasets may be evaluated simultaneously. A constituent was selected for inclusion in the spatial optimization problem when the observations were sufficient to (1) establish a two-range variability model, (2) classify at least one concentration time series as a continuous record block, and (3) make a prediction using the quantile-kriging interpolation method. The selected constituents include sodium, chloride, sulfate, nitrate, carbon tetrachloride, 1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, tritium, ^{90}Sr, and plutonium-238.

In temporal optimization, an iterative-thinning method was used to find an optimal sampling frequency for each analyte-well pair. Optimal frequencies indicate that for many of the wells, samples may be collected less frequently and still be able to characterize the concentration over time. The optimization results indicated that the sample collection interval may be increased by an average of 273 days owing to temporal redundancy.

6.10.3 inlpubs—Bibliographic Information for the U.S. Geological Survey Idaho National Laboratory Project Office (Fisher 2022)

The R package (inlpubs) may be used to search and analyze 363 publications that cover the 73-year history of the USGS, Idaho Water Science Center, Idaho National Laboratory Project Office (INLPO). The INLPO publications were authored by 251 researchers trying to better understand the effects of waste disposal on water contained in the eastern Snake River Plain Aquifer and the availability of water for long-term consumptive and industrial use. Information contained within these publications is crucial to the management and use of the aquifer by the INL and the state of Idaho. USGS geohydrologic studies and monitoring, which began in 1949, were done in cooperation with the DOE Idaho Operations Office (Bartholomay 2017). Access to the inlpubs repository can be found at https://rconnect.usgs.gov/INLPO/inlpubs-main/.

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

CHAPTER 7

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 was detected in 2 of 14 milk samples at concentrations that are consistent with past measurements; this is likely due to the presence of fallout radionuclides in the environment. The results were well below the Derived Concentration Standard established for strontium-90 in milk by the U.S. Department of Energy (DOE) for the protection of human health. Human-made radionuclides were not detected in any of the other agricultural products (e.g., lettuce, grain, potatoes, alfalfa) collected in 2022 except strontium-90 in one alfalfa sample.

No human-made radionuclides were detected in road-killed animal samples collected in 2022. Three human-made radionuclides (e.g., cobalt-60, strontium-90, zinc-65) were detected in some tissue samples of waterfowl collected on ponds in the vicinity of the Advanced Test Reactor Complex and Test Area North 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. Three human-made radionuclides (e.g., cobalt-60, strontium-90, and cesium-137) were detected in 2022 in some of the bats sampled. While cesium-137 and strontium-90 may be of fallout origin, the presence of cobalt-60 may indicate that the bats have visited radioactive effluents ponds on the INL Site.

Soil samples were collected on and off the INL Site in 2022. Samples were collected from 13 offsite and 17 onsite locations. Results for the monitoring locations were consistent with previous measurements and were less than the background values.

Direct radiation measurements made at boundary and offsite locations were consistent with background levels. The average annual dose equivalent from external exposure was estimated from dosimeter measurements to be 118 mrem off the INL Site. The total background dose from natural sources to an average individual living in southeast Idaho was estimated to be approximately 384 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 INL Site during 2022. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021). INL and the Idaho Cleanup Project (ICP) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable DOE orders and other requirements. The focus of the monitoring conducted by INL and ICP contractors is on the INL Site, particularly on and around facilities, as shown in Table 7-1. The INL contractor's primary responsibility is to monitor the presence of contaminants in environmental media, which may originate from INL Site releases, as can be seen in Table 7-1. To improve the readability of this chapter, INL contractor data tables are included when monitoring results exceed three sigma (3σ) and/or background upper threshold limits. Media results for 2022 are provided in quarterly surveillance reports (INL 2023a, INL 2023b, INL 2023c, and INL 2023d).

Table 7-1. Environmental monitoring of agricultural products, biota, soil, and direct radiation on and around the INL Site.

AREA/FACILITY[a]	MEDIA				
	AGRICULTURAL PRODUCTS	BIOTA	ECOLOGICAL	SOIL	DIRECT RADIATION
IDAHO NATIONAL LABORATORY CONTRACTOR					
INL Site/Regional	•	•	•	•	•
IDAHO CLEANUP PROJECT CONTRACTOR					
ICDF[b]	—[d]	—	—	—	•
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.
d. — = media not sampled.

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the INL contractor because of the potential transfer of radionuclides to people through food chains, as was shown in Chapter 4, Figure 4-1. Figure 7-1 shows the locations where agricultural products were collected in 2022.

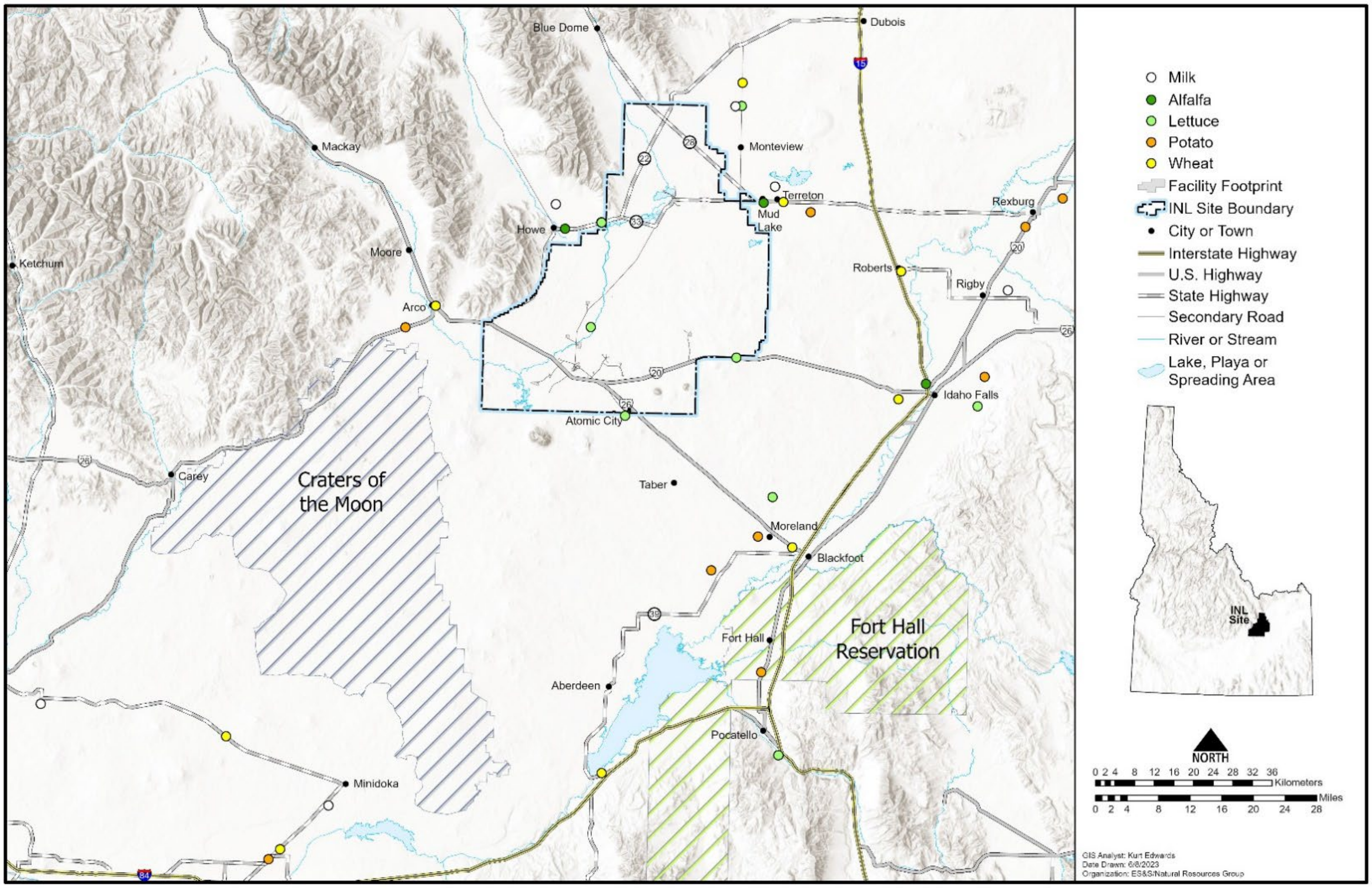

Figure 7-1. Locations of agricultural product samples collected (2022).

7.2 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). Additionally, 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 Surveillanc*e (DOE 2015), representative samples of the pathway-significant agricultural products grown within 16 km (10 miles) of the INL Site should be collected and analyzed for radionuclides potentially present from INL Site operations. These samples should be collected in at least two locations: (1) the place of expected maximum radionuclide concentrations and (2) a "background" location unlikely to be affected by radionuclides released from the INL 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 the 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 wind patterns typical of the INL Site. Prevailing winds at most INL Site locations are from the southwest during daytime hours. During evening hours, the winds will sometimes shift direction and blow from the north or northeast but at a lower velocity. Model results show the location of maximum offsite deposition is located between the southwest INL Site boundary and Big Southern Butte. Because there are no agricultural activities in this region, sampling is focused on other agricultural areas west and northeast of the INL Site. In addition, the sampling design considers locations of interest to the public as well as those of historical interest, which is why some samples are collected at extended distances from the INL Site.

7.2.1 Methods

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

7.2.2 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 2022, the INL contractor collected 184 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 Rigby and Terreton, Idaho, and monthly at other locations around the INL Site.

All milk samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine is an essential nutrient and is readily assimilated by cows 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) in Ukraine or the 2011 accident at Fukushima in Japan. The ingestion of milk pathway is the main route of internal ^{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 2022 was from the Materials and Fuels Complex (approximately 0.09 Ci). None was detected in air samples collected at or beyond the INL Site boundary (see Chapter 4). Iodine-131 was not detected in any milk sample collected during 2022.

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 a 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. Three milk samples collected during 2022 indicated ^{137}Cs was present, however, further review of the data determined these were false positives and that a confirming peak for ^{137}Cs was not present in the samples. Cesium-137 was not detected in any milk sample collected in 2022.

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 either from nuclear reactors or from detonations of nuclear weapons. It has a half-life of about 29 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 two of the 14 milk samples analyzed. Concentrations ranged from -0.04 ± 0.16 pCi/L at Terreton to 0.55 ± 0.13 pCi/L at Minidoka, as observed in 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 the ingestion of grass. Results from EPA Region 10, which includes Idaho, for a limited dataset of seven samples collected from 2007 through 2016, ranged from 0 to 0.54 pCi/L (EPA 2017). 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 2021) for radionuclides in air, water, and milk. A DCS is the concentration of a radionuclide in air, water, or milk that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. The DCS for ^{90}Sr in milk is 5,800 pCi/L. Therefore, the maximum observed value in milk samples (0.55 ± 0.13 pCi/L) is approximately 0.009% of the DCS for milk.

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 and from plants that contain water. Tritium was detected in one of the milk samples analyzed during 2022, as observed in Table 7-2. Concentrations varied from -72.00 ± 23.50 pCi/L in a sample from Monteview in November 2022 to 123.00 ± 25.70 pCi/L in the control sample collected in May 2022. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in milk is 12,000,000 pCi/L.

Table 7-2. Strontium and tritium concentrations[a] in milk samples collected offsite in 2022.

STRONTIUM-90 (pCi/L)		
LOCATION	MAY 2022	NOVEMBER 2022
Dietrich	0.13 ± 0.10	0.06 ± 0.11
Howe	0.52 ± 0.19	0.09 ± 0.06
Minidoka	**0.55 ± 0.13**	0.12 ± 0.11
Monteview	0.05 ± 0.13	0.19 ± 0.08
Rigby	0.15 ± 0.13	0.08 ± 0.08
Terreton	-0.04[b] ± 0.16	0.35 ± 0.12
Control (Colorado)	**0.46 ± 0.13**	0.22 ± 0.13
TRITIUM (pCi/L)		
LOCATION	MAY 2022	NOVEMBER 2022
Dietrich	58.60 ± 24.80	-12.50 ± 24.80
Howe	-9.98 ± 24.00	15.90 ± 26.00
Minidoka	34.60 ± 25.40	-36.90 ± 24.50
Monteview	2.72 ± 24.20	-72.00 ± 23.50
Rigby	23.90 ± 25.30	48.00 ± 25.20
Terreton	3.87 ± 25.10	-25.10 ± 24.10
Control (Colorado)	**123.00 ± 25.70**	-26.70 ± 24.10

a. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected and are indicated with a **bold** value.

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

7.2.3 Lettuce Results

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people, as shown in Figure 4-1. The uptake of radionuclides by plants may occur through root uptake from soil and from 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, such as lettuce, have higher concentration ratios of radionuclides to soil than other kinds of plants. The INL contractor collects lettuce samples every year from areas on and adjacent to the INL Site, as observed in Figure 7-1. The number and locations of gardens have changed from year to year, depending on whether vegetables were available. Home gardens have been replaced with portable lettuce planters, as shown in Figure 7-2, because the availability of lettuce from home gardens was unreliable at some key locations.

Figure 7-2. Portable lettuce planter.

In addition, planters can be placed, and the 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 the 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.

Five lettuce samples were collected from portable planters at Atomic City, the Experimental Field Station, the Federal Aviation Administration Tower, Howe, and Monteview. In 2022, 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 Ammon, Blackfoot, and Pocatello, Idaho, and a control sample was purchased at the grocery store from an out-of-state location (California).

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was not detected in the lettuce samples collected during 2022. 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.

7.2.4 Grain Results

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2022, the INL contractor collected grain samples at 10 locations from areas surrounding the INL Site (Figure 7-1); an additional duplicate sample was collected from American Falls. 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).

7.2.5 Potato Results

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 INL contractor at nine locations in the vicinity of the INL Site and an additional duplicate sample was collected from Moreland (Figure 7-1). A control sample was purchased from outside the state of Idaho. None of the potato samples (including duplicates) collected during 2022 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.

7.2.6 Alfalfa Results

In addition to analyzing milk, the INL contractor began collecting data in 2010 on alfalfa consumed by milk cows. A sample of alfalfa was collected in June 2022 from locations in the Mud Lake area, Howe, and Idaho Falls. Mud Lake is an agricultural area with a high potential for offsite contamination via the air pathway are shown in Figure 8-6. (Note: The highest offsite air concentration used for estimating human doses was located southeast of the INL Site's east entrance; however, there is limited agriculture near that location.) The samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. Strontium-90 was detected in the Mud Lake (90.8 ± 19.5 pCi/kg) sample collected in 2022. Concentrations for ^{90}Sr ranged from -8.5 ± 17.1 pCi/kg to 90.8 ± 19.5 pCi/kg. No gamma-emitting radionuclides were detected in the alfalfa samples collected during 2022.

7.2.7 Big Game Animals Results

Muscle, liver, and thyroid samples were collected, under a scientific collection permit, from five big game animals. The muscle and liver samples were analyzed for ^{137}Cs because it is an analog of potassium and is readily incorporated into muscle and organ tissues. Thyroids are analyzed for ^{131}I because they selectively concentrate in the thyroid gland when assimilated by many animal species, thus they are an excellent bio-indicator of atmospheric releases.

Iodine-131 was not detected in the thyroid samples. No ^{137}Cs or other human-made, gamma-emitting radionuclides were found in any of the muscle or liver samples.

7.2.8 Waterfowl Results

Waterfowl are collected, under a scientific collection permit, each year at ponds on the INL Site and at a location offsite. Three waterfowl collected from wastewater ponds located at the Advanced Test Reactor (ATR) Complex, one waterfowl from INTEC, one waterfowl from Test Area North (TAN), and three control waterfowl collected from Swan Valley 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 subsamples: (1) edible tissue (e.g., muscle, gizzard, heart, liver), (2) external portion (e.g., feathers, feet, head), and (3) all remaining tissue.

Three human-made radionuclides were detected in edible, exterior, and remainder subsamples from the ducks collected at the ATR Complex ponds and TAN. The radionuclides were cobalt-60 (^{60}Co), ^{90}Sr, and ^{65}Zn. An American Wigeon collected from the sewage lagoons at ATR Complex had one of these radionuclides in edible tissue identified in Table 7-3.

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, it is likely the ducks also spent time at the evaporation pond. The hypothetical dose to a hunter who eats a contaminated duck from the ATR Complex ponds is presented in Chapter 8, Section 8.3.1.

Table 7-3. Radionuclide concentrations detected in waterfowl collected in 2022.

RADIONUCLIDES DETECTED IN WATERFOWL TISSUE (pCi/kg)				
LOCATION	SPECIES	PORTION	RADIONUCLIDE	CONCENTRATION
ATR Complex	American Wigeon	Edible	^{90}Sr	38.7 ± 6.74
		Exterior	^{60}Co	18.5 ± 2.15
			^{90}Sr	89.6 ± 5.86
		Remainder	^{90}Sr	113.0 ± 6.96
	Gadwall	Remainder	^{90}Sr	17.2 ± 5.42
	Blue-Winged Teal	Exterior	^{60}Co	18.4 ± 5.36
		Remainder	^{90}Sr	25.5 ± 3.95
TAN	Ruddy Duck	Exterior	^{65}Zn	4.32 ± 0.57

7.2.9 Bats Results

Bat carcasses have been collected on the INL Site since the summer of 2015 under a scientific collection permit. Bat carcasses are used to identify if the death is related to a particular species and needs to be examined. Since bat carcasses are discovered in facility buildings or outside in areas near facilities, the carcasses may be sent to a qualified laboratory to assess the presence of radionuclides. The analysis results can be used to calculate the potential dose bats receive. Bats are typically desiccated when received and generally weigh about a few grams each. The samples collected in 2022 were analyzed for gamma-emitting radionuclides, for specific alpha-emitting radionuclides (plutonium isotopes and ^{241}Am), and for ^{90}Sr (a beta-emitting radionuclide).

The bat carcasses were divided and composited by the following areas in 2022: TAN, Naval Reactors Facility, Materials and Fuels Complex, Central Facilities Area, and ATR Complex/INTEC.

The bat analysis results are summarized in Table 7-4. The following radionuclides were detected in at least one sample during 2022: ^{137}Cs, ^{60}Co, and ^{90}Sr. Cesium-137 is ubiquitous in the environment because of fallout from historical nuclear weapons tests. Strontium-90 is another fallout radionuclide. Cobalt-60, which is a fission product, may indicate that the bats visited radioactive effluent ponds on the INL Site such as at the ATR Complex ponds. The potential doses received by bats are discussed in Chapter 8, Section 8.8.2.

Table 7-4. Radionuclide concentrations measured in bats collected in 2022.

BAT TISSUE CONCENTRATIONS (pCi/kg)			
RADIONUCLIDE	MINIMUM[a]	MAXIMUM[b]	NUMBER OF DETECTIONS[c]
Americium-241	ND[d]	ND	0
Cesium-137	1,510 ± 134	2,870 ± 153	2
Cobalt-60	667 ± 130	5,450 ± 229	3
Plutonium-238	ND	ND	0
Plutonium-239/240	ND	ND	0
Strontium-90	182 ± 46	9,200 ± 117	5

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

7.3 Soil Sampling

In the early 1970s, the DOE Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface and subsurface soils (0–5 cm and 5–10 cm deep) on and around the INL Site. At that time, RESL established extensive onsite soil sampling grids outside INL Site 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 while 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 ATR Complex). Surface soils were sampled at offsite and boundary locations 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. Sampling occurred in 2022 and is next scheduled for 2027. 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).

7.3.1 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 2022b). The data quality objectives used historical data, current emissions data, and soil-deposition modeling for establishing the quality and quantity of data needed to support decision making for protecting human health and the environment. Figure 7-3 shows the INL Site soil monitoring locations for 2022, most of which are near the Radioactive Waste Management Complex (RWMC).

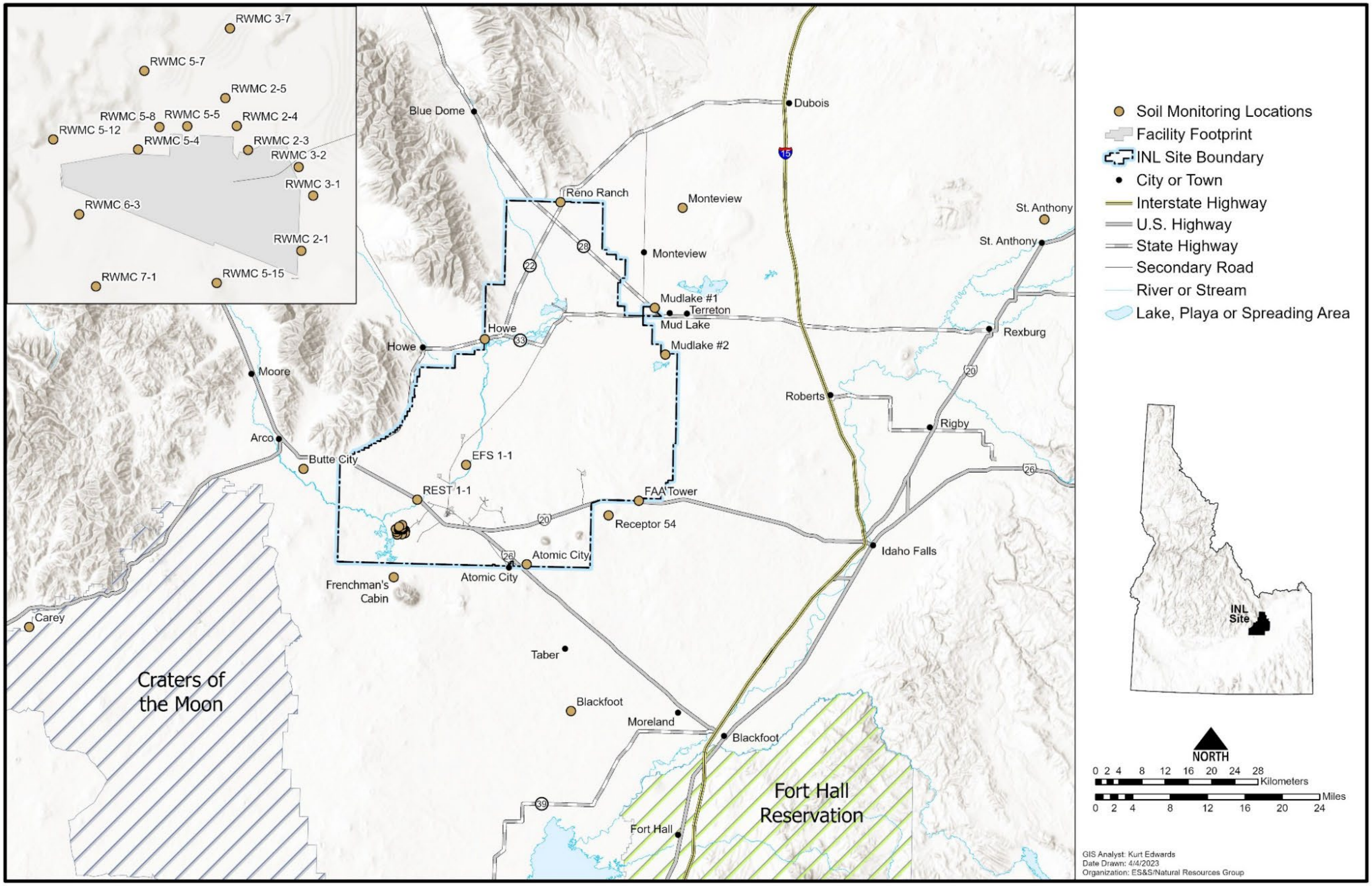

Figure 7-3. Soil sampling locations in 2022.

To determine the need for soil sampling, potential releases from each INL facility were modeled using CALPUFF, a non-steady-state Lagrangian puff dispersion model (Rood and Sondrup 2014), and estimated particulate deposition rates (INL 2016). The results showed that for the onsite facilities, only the RWMC has the potential for soil accumulations to be detectable in less than a decade. Results for the other facilities (e.g., Idaho Nuclear Technology and Engineering Center and Materials and Fuels Complex) showed the potential for surface accumulations to be detectable only after hundreds to thousands of years (INL 2016). In addition, at best, soil sampling is of questionable value in attempting to estimate small increments of deposition over a period of a few years or less because of the large uncertainties in sampling itself and the inherent variability in soil (EML 1997). Accordingly, the INL contractor uses a graded approach that considers extensive historical knowledge about soil conditions from past releases and current knowledge about facility emissions (INL 2016).

The INL contractor began performing near-facility monitoring at the RWMC in 2017 on a five-year rotation focusing on radionuclides that could be detectable in the relative near term (i.e., plutonium isotopes, ^{90}Sr, and gamma emitters). The original sampling points established by RESL were selected as logical monitoring locations for data comparisons. Of the approximately 50 sampling points established by RESL, historical data were collected mostly southwest and northeast of the facility, with the highest radionuclide concentrations being in the prevalent wind direction to the northeast. For the current sampling, a systematic, random sampling design was used to determine which of these points would be used as routine monitoring locations, as shown in Figure 7-3.

Additional soil monitoring away from RWMC includes two INL Site ambient air-monitoring locations (U.S. Highway 20/26 Rest Stop [REST] and the Experimental Field Station [EFS]) that were chosen so that soil, ambient air, and direct radiation data can be compared. These locations were also chosen because they have higher modeled deposition potential from major facility emissions than other ambient air monitor locations.

7.3.2 Methods

Soil is collected near each sampling post in an undisturbed area in a 100-m^2 area. Using techniques and equipment similar to those developed by RESL, each sample is a composite of five cores. Using a hammer, samplers force a metal ring that resembles a 10-cm-diameter and 5-cm-deep cookie cutter into the ground at the corners and center of the 100 m^2 area. Discreet samples are collected from each of the two depths: 0–5 cm and 5–10 cm. The soil inside each subsample is sieved through a 35-mesh screen, mixed in a pan, and composited into a single jar for that location.

7.3.3 Soil Sampling Results

Samples were collected from locations described in Figure 7-3. Background values for EFS, REST, Frenchmans Cabin, and Receptor 54 have not been determined since the minimum number of data points have not been met to calculate the INL site specific background values. As more data are collected from these sites, background values will be computed and comparisons will be made. For the remaining sampling locations, sitewide background values are available (INL 2017), and the radionuclides and concentrations at these locations are similar to those documented in Rood et al. (1996). Results obtained from monitoring sites were consistent with previous results and all the measured activities were less than the background values in Table 7-5.

7.4 Direct Radiation

7.4.1 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, whereas the last set of Environmental Surveillance, Education, and Research (ESER) TLD results were from November 2021.

Table 7-5. 2022 Soil results compared to background.

LOCATIONS	^{241}Am RESULTS (pCi/kg)	^{241}Am BACKGROUND (pCi/kg)	^{137}Cs RESULTS (pCi/kg)	^{137}Cs BACKGROUND (pCi/kg)	^{238}Pu RESULTS (pCi/kg)	^{238}Pu BACKGROUND (pCi/kg)	$^{239/240}$Pu RESULTS (pCi/kg)	$^{239/240}$Pu BACKGROUND (pCi/kg)	^{90}Sr RESULTS (pCi/kg)	^{90}Sr BACKGROUND (pCi/kg)
BOUNDARY										
Butte City	1.11E+01	9.42E+01	**4.18E+02**[a]	1.25E+03	3.83E+00	3.37E+01	**2.45E+01**	4.87E+01	**1.83E+02**	5.60E+02
FAA Tower	9.09E+00	3.56E+01	**4.81E+02**	1.62E+03	3.63E+00	7.43E+01	**1.88E+01**	8.29E+01	**1.37E+02**	8.06E+02
Frenchmans Cabin	4.92E+00	—[b]	**2.03E+02**	—	0.00E+00	—	**2.37E+01**	—	5.82E+01	—
Monteview	6.84E+00	1.94E+01	**2.93E+02**	1.11E+03	-8.91E-07	3.50E+01	**1.42E+01**	4.77E+01	4.29E+01	2.68E+02
Mud Lake[c]	6.76E+00	8.75E+01	**1.36E+02**	6.24E+02	4.72E+00	5.14E+01	**1.35E+01**	8.92E+01	1.60E+00	3.35E+02
Receptor 54	**2.06E+01**	—	**8.19E+02**	—	3.10E+00	—	**4.72E+01**	—	**1.38E+02**	—
OFFSITE										
Blackfoot	2.37E+00	4.05E+01	**1.43E+02**	2.70E+03	0.00E+00	1.54E+02	5.79E+00	2.39E+02	3.90E+01	3.98E+02
Carey	1.57E+01	5.56E+01	**5.47E+02**	9.63E+02	5.90E+00	4.47E+01	**2.85E+01**	6.71E+01	**8.68E+01**	5.34E+02
St. Anthony	8.98E+00	4.22E+01	**4.65E+02**	1.76E+03	3.68E+00	8.57E+01	**1.69E+01**	9.54E+01	**1.31E+02**	9.48E+02
ONSITE										
Atomic City	5.89E+00	2.78E+01	**2.90E+02**	1.01E+03	5.13E+00	2.27E+01	**2.05E+01**	5.73E+01	**7.63E+01**	7.34E+02
EFS	9.39E+00	—	**6.20E+02**	—	4.94E+00	—	**1.90E+01**	—	**2.11E+02**	—
Howe	4.95E+00	1.00E+01	**3.37E+02**	7.00E+02	1.53E+00	1.19E+01	**1.91E+01**	3.53E+01	-1.06E+01	6.70E+02
Reno Ranch	8.89E+00	2.68E+01	**6.09E+02**	1.58E+03	6.36E+00	1.44E+01	**2.85E+01**	6.77E+01	9.37E+01	9.11E+02
Hwy 26 Rest Area	**1.25E+01**	—	**3.34E+02**	—	4.45E+00	—	**2.03E+01**	—	**1.06E+02**	—
RWMC[c]	**1.53E+02**	8.40E+03	**3.72E+02**	3.54E+03	7.10E+00	5.80E+01	**1.51E+02**	2.57E+03	**9.69E+01**	2.47E+03

a. Results greater than 3σ uncertainty are considered statistically detected and are indicated with a **bold** value.
b. — = Insufficient amount of data to calculate background values.
c. Average of all sample locations.

Following the October 1, 2021, ESER transition to BEA their dosimetry sample locations were incorporated into the INL Environmental Dosimetry program with the first set of dosimeters being placed in the field on May 1, 2022. Offsite and boundary dosimeter locations are shown in Figure 7-4. The sampling periods for 2022 were from November 2021 to April 2022 and May 2022 to October 2022.

INL contractor was notified of plans to move radiological work occurring at IF-670 Bonneville County Technology Center to a new location. Beginning May 2022 dosimetry was established around the new location at IF-652A Lindsay Building (Figure B-16).

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.

7.4.2 Methods

Environmental OSLDs are placed in the field for six months. After the six-month period, the OSLDs are collected and returned to the supplier 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 5% 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 (Table 7-7), 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 2022a). The method for computing the background value as the upper tolerance limit (UTL) is described in EPA (2009) and EPA (2016). The ProUCL Version 5.1 software (EPA 2016) has been used to compute UTLs, given all available data in the area since 2012.

7.4.3 Results

The INL contractor OSLD data measured at boundary and offsite locations around the INL Site in 2022 are shown in Table 7-6. Using OSLD data collected by the INL contractor, the mean annual ambient dose was estimated at 118 mrem (1,180 µSv) for boundary and 118 mrem (1,180 µSv) for offsite locations. The mean annual ambient dose for all locations combined is 118 mrem (1,180 µSv). The annual mean ambient dose for all groups is consistent with past data (Table 7-6).

The 2022 direct radiation results collected by the INL contractor at boundary, offsite, and onsite locations are provided in Appendix B. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2022 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. It should be noted that the UTLs for each six-month collection period are different since the *Data Quality Objectives Supporting the Environmental Direct Radiation Monitoring Program for the Idaho National Laboratory* (INL 2022a) was updated in July 2022. The UTLs for the May collection period were calculated using results measured from 2009 through 2018 (INL 2019). UTLs for the November collection period were calculated using results measured from 2012 through 2021 (INL 2022a). As discussed in Section 7.4.2, a result greater than the background level UTL does not necessarily mean that radiation levels have increased since 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.

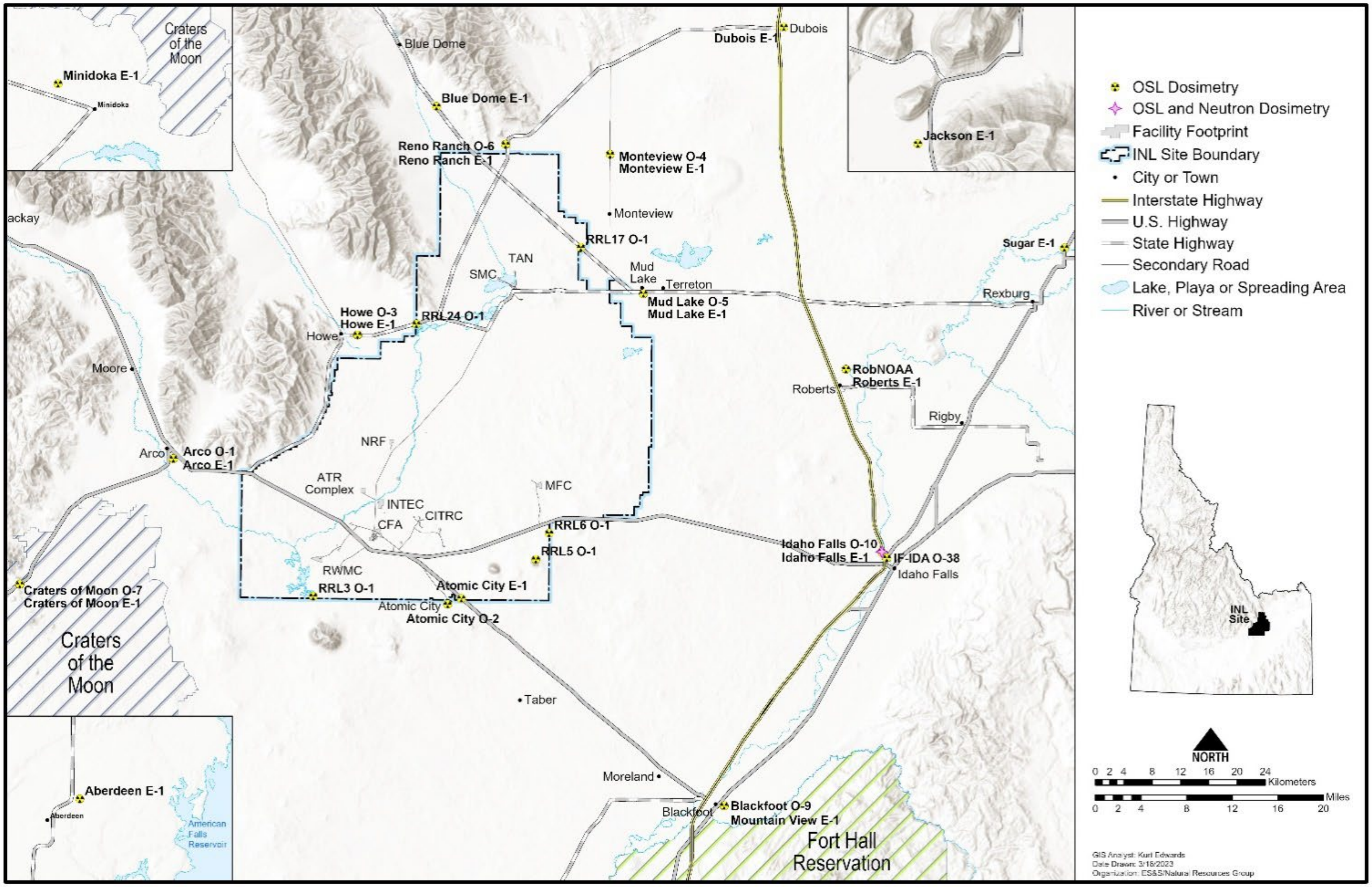

Figure 7-4. Offsite and boundary direct radiation monitoring locations (2022).

Table 7-6. Annual environmental radiation doses using OSLDs at all offsite locations (2018–2022).

LOCATION	2018		2019		2020		2021		2022
	ESER[a] (mrem)	INL[b] (mrem)	ESER (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)	INL[c] (mrem)
OFFSITE									
Aberdeen	123	NA[d]	134	NA	125	NA	134	NA	130
Blackfoot (Mountain View Middle School)	110	125	116	113	115	121	109	115	111[e]
Craters of the Moon	118	132	122	116	118	133	118	132	118[e]
Dubois	103	NA	110	NA	102	NA	106	NA	99
Idaho Falls	118	126	134	114	115	134	127	121	117[e]
IF-IDA	NA	119	NA	106	NA	112	NA	106	102
Jackson	109	NA	113	NA	108	NA	113	NA	114
Minidoka	109	NA	118	NA	111	NA	113	NA	110
Roberts[f]	130	145	134	133	129	138	134	128	134[e]
Sugar City	151	NA	156	NA	144	NA	149	NA	134
MEAN	**119**	**129**	**126**	**116**	**119**	**128**	**122**	**120**	**118**
BOUNDARY									
Arco	122	134	127	118	122	127	128	128	114[e]
Atomic City	122	132	135	112	124	125	130	130	124[e]
Birch Creek Hydro[g]	110	119	114	110	105	113	113	108	112[e]
Blue Dome	106	NA	111	NA	99	NA	109	NA	94
Howe	119	129	121	119	117	117	120	111	111[e]
Monteview	119	130	127	119	125	134	125	118	124[e]
Mud Lake	132	143	131	130	133	139	128	129	138[e]
MEAN	**119**	**131**	**124**	**120**	**118**	**126**	**122**	**121**	**118**

a. ESER = Environmental Surveillance, Education, and Research Program.
b. INL = Idaho National Laboratory.
c. The ESER program was transitioned to the INL contractor in October 2021. The first set of dosimeters, under the INL Environmental Dosimetry program, were placed in the field on May 1, 2022.
d. NA = Not applicable. Neither contractor samples at this location.
e. The value was calculated by averaging the annual dose for both the former ESER location and the INL contractor location (Appendix B, Figure B-12).
f. INL contractor calls this location RobNOAA.
g. INL contractor calls this location Reno Ranch.

Table 7-7. Dosimetry locations above the six-month background UTL (2022).

LOCATION	MAY 2022 SAMPLE RESULT (mrem)	BACKGROUND LEVEL UTL[a] (mrem)	NOV. 2022 SAMPLE RESULT (mrem)	BACKGROUND LEVEL UTL[a] (mrem)
ANL O-21	88.1	86.3	—	87.5
EBR I O-2	91.9	91.0	—	91.0
Hwy22 T28 O-1	—[b]	67.6	77.8	68.1
ICPP O-20	293.5	197.1	—	347.0
ICPP O-27	—	197.1	232.9	230.2
ICPP O-30	218.6	197.1	—	347.0
IF-638S O-3	74.2	66.9	—	66.4
RWMC O-13A	98.10	86.7	90.6	88.0
RWMC O-9A	—	86.7	93.5	88.0

a. The UTL is the value such that 95% of all the doses in the area are less than that value with 95% confidence. That is, only 5% of the doses should exceed the UTL.
b. — = Sample did not exceed the UTL for the collection period.

The facility perimeter dosimeters that exceeded the background level UTL in 2022 are listed in Figure 7-7. The exceedances at Argonne National Laboratory (ANL) (Figure B-6), Experimental Breeder Reactor I (EBR I) (Figure B-14), and Highway 22 T28 (Hwy22 T28) (Figure B-11) are only slightly above their UTLs. Locations at Idaho Nuclear Technology and Engineering Center (listed as Idaho Chemical Processing Plant [ICPP]), (Figure B-4), specifically ICPP O-20 appears to follow a pattern of elevated measurements. It should be noted with the UTL updates in June 2022 the location did not exceed the limit at the November collection. ICPP O-27 only slightly exceeded the UTL during the November collection. ICPP O-30 did exceed the UTL during the May collection, but when the UTL was recalculated, the November result did not exceed the UTL. It is anticipated the elevation is due to the work being performed in the area. Locations IF-638S (Figure B-5), RWMC O-13A, and RWMC O-9A (Figure B-9) are only slightly above the UTL. All 2022 environmental dosimetry results were provided to the Radiation Control Department for their consideration.

Neutron dose monitoring is conducted around buildings in Idaho Falls, Idaho, where sources may emit or generate neutron radiation. These buildings include IF-675 Portable Isotopic Neutron Spectroscopy Laboratory, IF-670 Bonneville County Technology Center, and IF-638 Physics Laboratory. Additional neutron dosimeters are placed at the INL Research Center along the south perimeter fence and at the background location Idaho Falls O-10. Onsite locations with neutron badges include Transient Reactor Test Facility and Remote-Handled Low-Level Waste Facility. All neutron dosimeters collected in 2022 were reported as “M,” which denotes the dose equivalents are 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 dosimetry by wrapping each in aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed.

Table 7-8 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (e.g., 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).

Table 7-8. Calculated effective dose from natural background sources (2022).

SOURCE OF RADIATION DOSE	TOTAL AVERAGE ANNUAL DOSE	
	CALCULATED (mrem)	MEASURED[a] (mrem)
EXTERNAL IRRADIATION		
Terrestrial	70[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	**127**	**118**
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	**384**	**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.

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 indicate 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 equivalents received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose that Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2022, this resulted in a reduction in the effective dose from soil to a value of 70 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 2022 was estimated to be 127 mrem/yr. This is similar to the 118 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 offsite locations in 2022.

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 on 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 the 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 387 mrem/yr, as identified in Table 7-8. This value was used to calculate background radiation dose to the population living within 50 miles of INL Site facilities, shown in Table 8-6.

7.5 Waste Management Surveillance Sampling

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

7.5.1 Vegetation Sampling at the Radioactive Waste Management Complex

At the RWMC, vegetation was historically collected from four major areas, identified in Figure 7-5, and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Russian thistle was collected in even-numbered years. Crested wheatgrass and rabbitbrush were collected in odd-numbered years. In 2018, the ICP contractor decided, 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.

7.5.2 Soil Sampling at the Radioactive Waste Management Complex

Waste management surveillance soil sampling has been conducted triennially at the SDA at the 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* (INL 1986). All results were well below their respective environmental concentration guide.

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

In 2017, a decision was made to discontinue soil monitoring based on several factors: (1) the limited availability of undisturbed soils, (2) sufficient historical data being collected previously to satisfy the characterization objectives, and (3) the conclusion that planned activities in the SDA do not have the potential to change surface soil contaminant concentrations prior to the installation of the surface cover over the entire SDA under the CERCLA program.

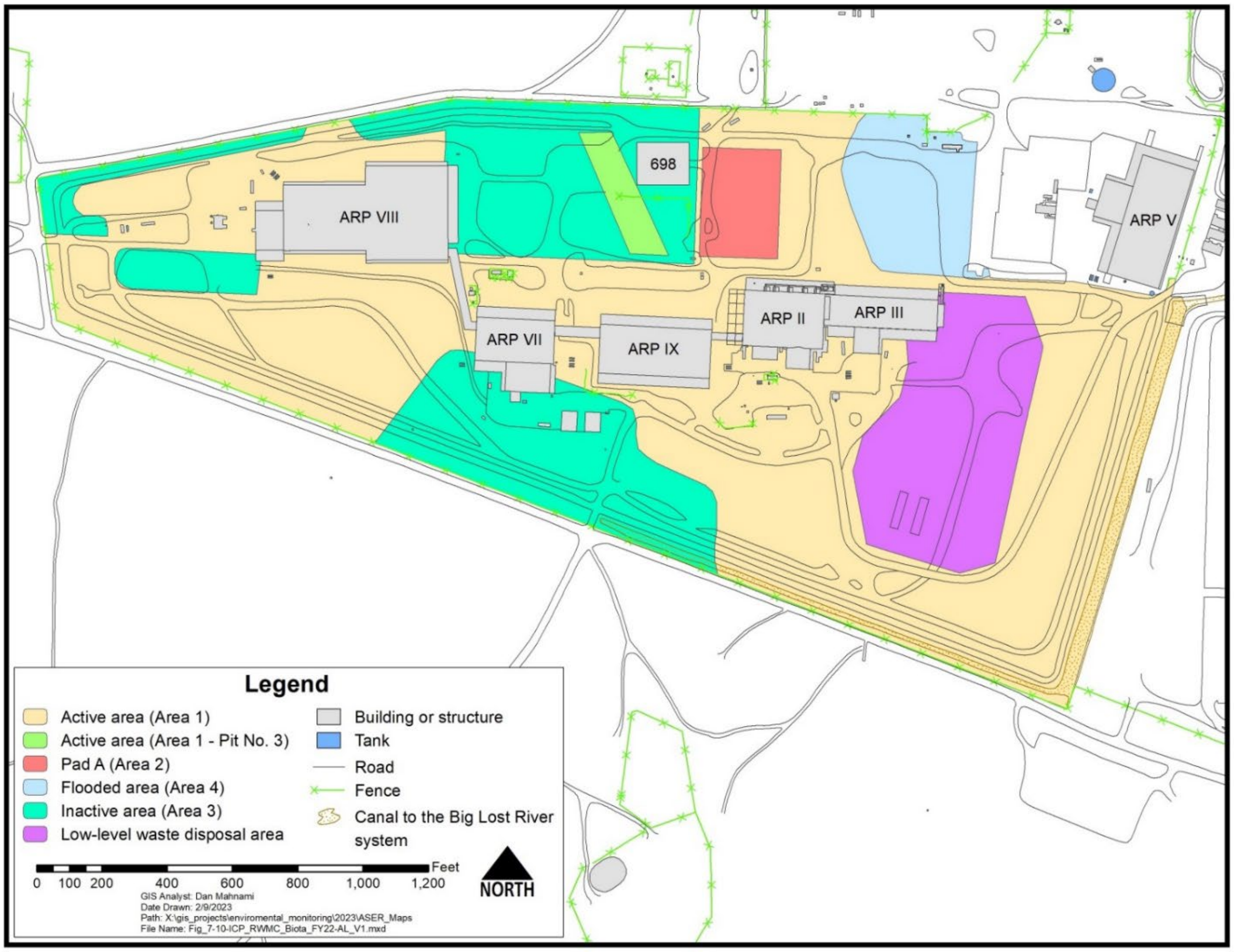

Figure 7-5. Historical vegetation sampling areas at the RWMC.

7.5.3 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 SDA at RWMC and at the ICDF to complement air sampling. The SDA contains legacy waste, of which some is in the process of being removed for repackaging and shipment to an offsite 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 inches 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 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 2022 in comparison to previous years.

Figure 7-6 shows a map of the area that was surveyed at RWMC in 2022. 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 2022 results are comparable to measurements in previous years. Most of 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 2022 RWMC gross gamma radiation measurements were at or near background levels. The 2022 maximum gross gamma radiation measurement on the SDA was 40,152 counts per second, as compared to the maximum 2021 measurement of 27,874 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 2022. The maximum readings in 2022 were observed directly north of the Accelerated Retrieval Project Storage Enclosure (WMF-698). This is likely attributed to waste operations and waste storage located within the building during the time of the survey.

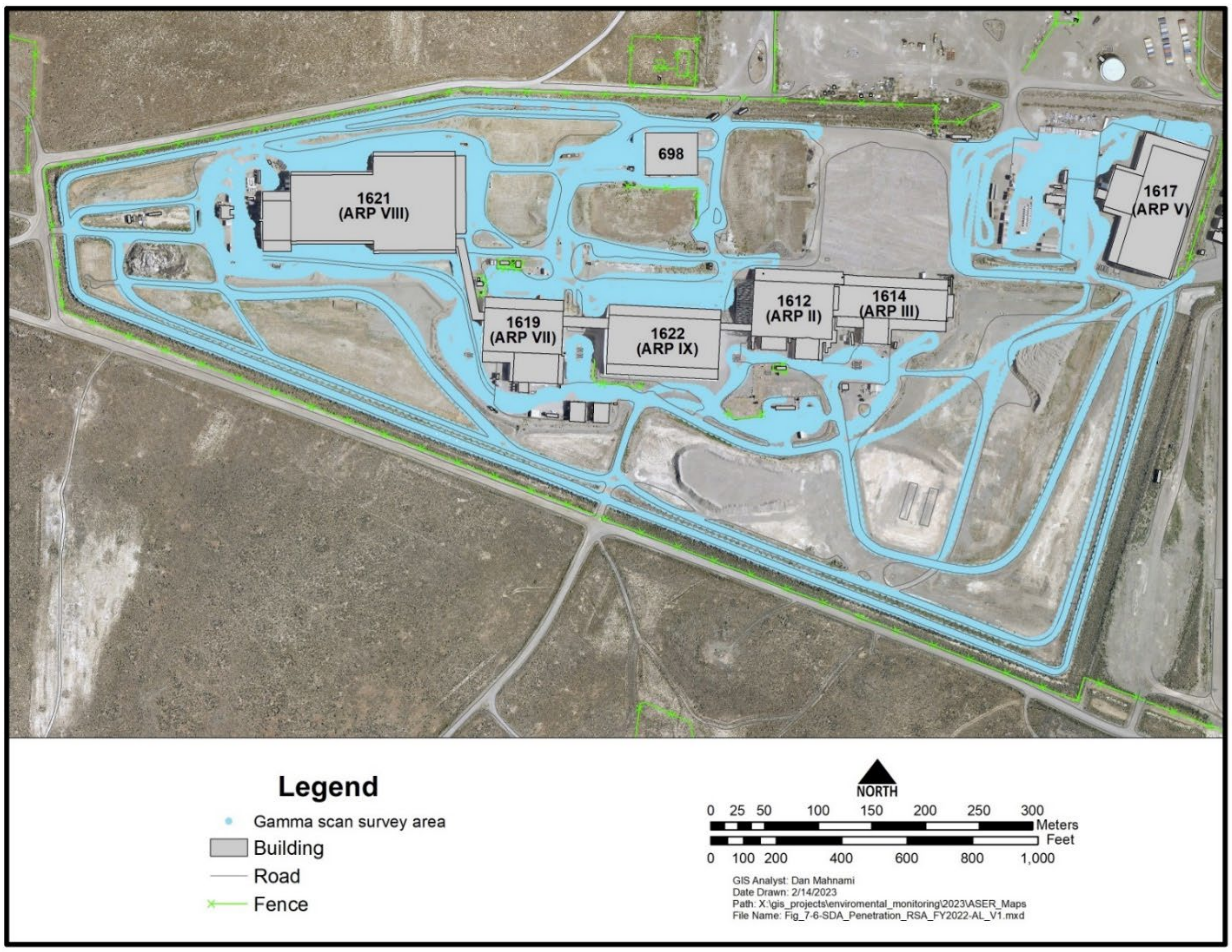

Figure 7-6. SDA surface radiation survey area (2022).

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 2022, the readings were either at background levels or slightly above background levels (approximately 3,000 counts per second), which is expected until the facility is closed and capped.

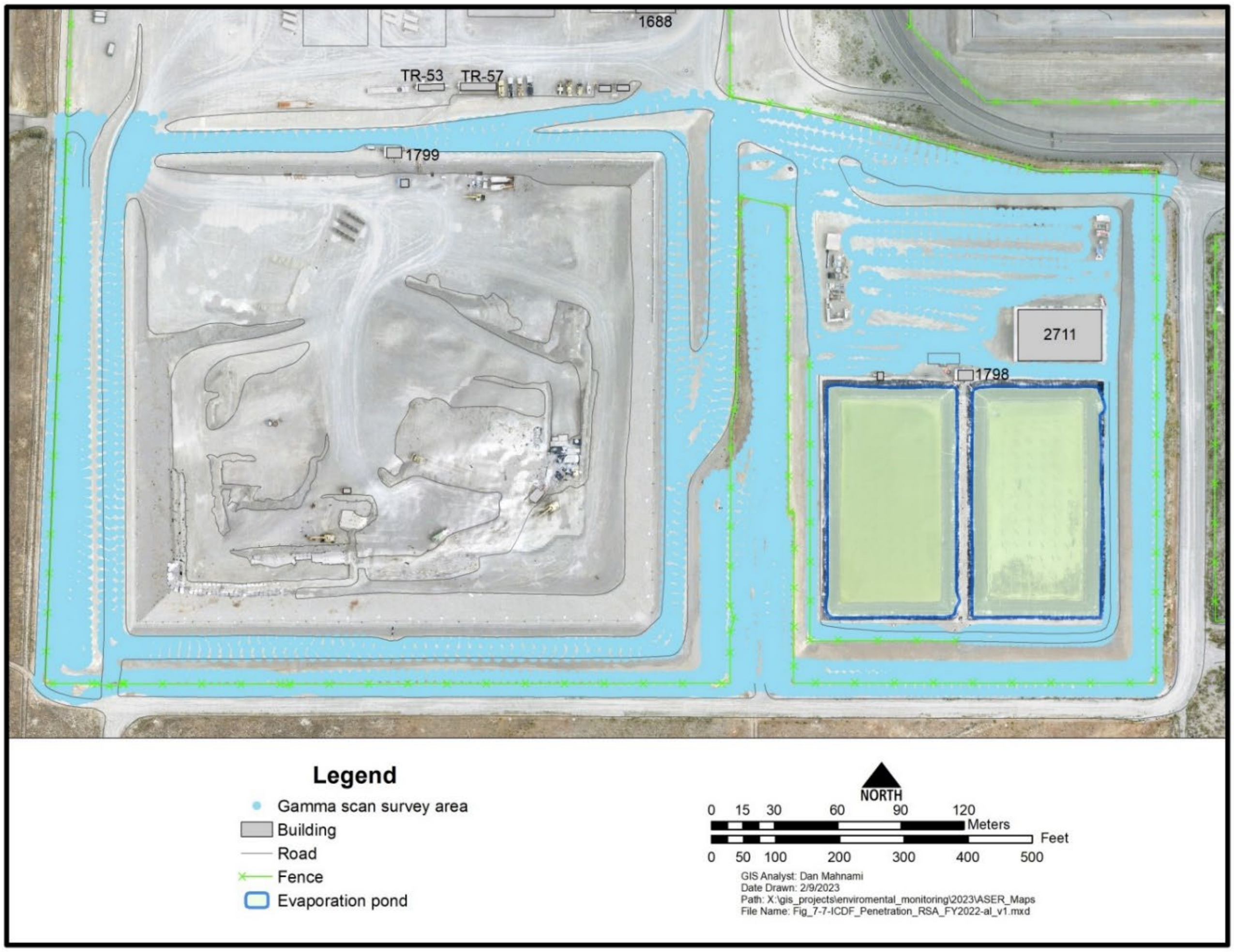

Figure 7-7. ICDF surface radiation survey area (2022).

7.6 References

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Chapter 8: Dose to the Public and Biota

CHAPTER 8

Airborne emissions from Idaho National Laboratory (INL) Site operations were used to determine potential radiological dose to members of the public using the Clean Air Act Assessment Package 88-PC computer program. The annual dose to the maximally exposed individual in 2022, as determined using Clean Air Act Assessment Package 88-PC, was 0.018 mrem (0.18 µSv), which was well below the applicable standard of 10 mrem (100 µSv) per year. A maximum potential dose from ingestion of game animals was also estimated using the highest radionuclide concentrations in the edible tissue of waterfowl collected at Advanced Test Reactor ponds in 2022. The maximum potential dose to an individual who consumes waterfowl was calculated to be 0.0009 mrem (0.009 µSv). It was determined there is no dose associated with the consumption of big game animals. Therefore, the total dose (from air emissions and ingestion of the waterfowl) to the maximally exposed individual during 2022 was estimated to be 0.019 mrem (0.19 µSv). This dose is also well 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 353,435 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 Special Operations and Research Division, and a dose calculation model. For 2022, the estimated potential population dose was 1.91×10^{-2} person-rem (1.91×10^{-4} person-Sv). This is approximately 0.00001 percent of the expected dose from exposure to natural background radiation of 134,109 person-rem (1,341 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. Additionally, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds and in bats, which were collected at or near INL facilities, were used to estimate internal doses to the waterfowl and bats. These calculations indicate the potential doses to waterfowl and bats do not exceed the DOE limits for biota.

No reportable unplanned radiological effluent or emission releases occurred from the INL Site in 2022; therefore, no doses or impacts were manifested.

8. DOSE TO THE PUBLIC AND BIOTA

DOE O 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 DOE control. 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 protecting the environment against ionizing radiation, DOE also developed the technical standard DOE-STD-1153-2019, “A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota” (DOE 2019). The standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

Title 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities," establishes federal radiation dose limits for the maximally exposed member of the public from all airborne emissions and pathways. It requires that doses to members of the public from airborne releases are calculated using U.S. Environmental Protection Agency (EPA)-approved sampling procedures, computer models, or other procedures.

This chapter describes the estimated potential dose to members of the public and biota from operations at the INL Site, based on 2022 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, as shown in 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 the ingestion of meat from wild game animals that access the INL Site. Ingestion doses were calculated from the concentrations of radionuclides measured in game animals killed by vehicles on INL Site roads 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 radionuclides associated with INL Site releases have not 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 be released by the facilities. The 2022 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2023) 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 four large operating stacks were modeled explicitly and included the Advanced Test Reactor (ATR) main stack (TRA-770), 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 near ground-level releases from a single location within the facility. These other releases include other non-fugitive releases from stacks, ducts, and vents, and also include fugitive releases from ponds, soil, or other sources. Figure 8-1 shows the location of all sources modeled in the dose assessment. Emissions from the Safety and Tritium Applied Research facility (TRA-666) at the ATR Complex are typically routed to and out of the Material Test Reactor stack. During calendar year 2022, TRA-666 began a building ventilation system modification project, and emissions were routed to a much shorter temporary stack for most of the year. Therefore, all TRA-666 emissions for calendar year 2022 were conservatively reported as a ground-level release and no emissions were reported for the Material Test Reactor stack.

The radionuclides and source terms used in the dose calculations were presented previously in Table 4-2 of Chapter 4 and are 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 most to the overall estimated dose to the maximally exposed individual (MEI) were uranium-238 (^{238}U), chlorine-36 (^{36}Cl), uranium-234 (^{234}U), americium-241 (^{241}Am), strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), and tritium (^{3}H). These radionuclides are a very small fraction of the total amount of radionuclides reported.

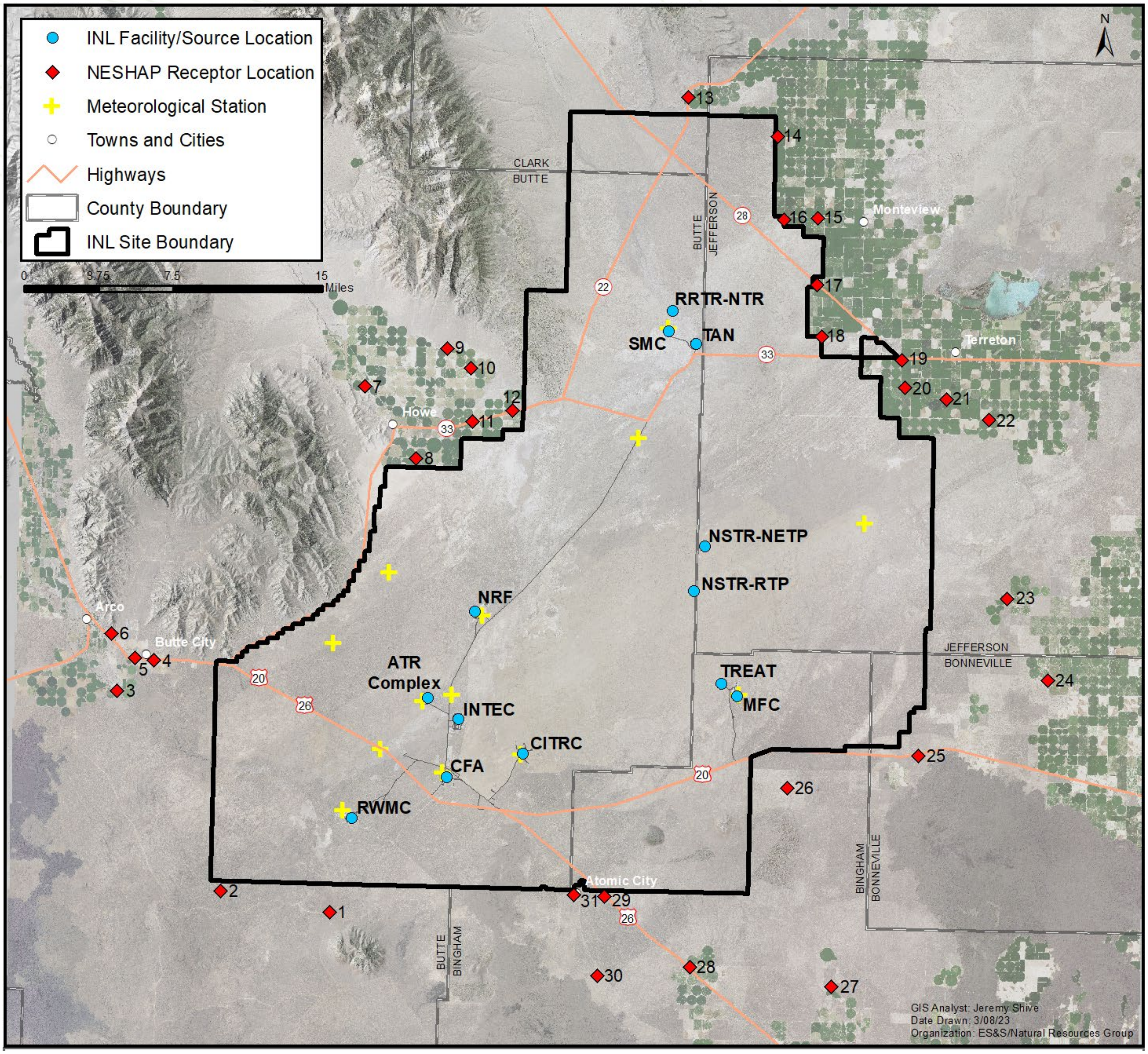

Figure 8-1. INL Site major facility airborne source locations. *TRA-770, CPP-708, TREAT, and MFC-764 were modeled as stack releases. The remaining sources were modeled as ground-level releases. Newer facilities including the Radiological Response Training Range - New Explosive Test Pad (RRTR-NTR), National Security Test Range - Radiological Training Pad (NSTR-RTP), and National Security Test Range - New Explosive Test Pad (NSTR-NETP) reported no releases in the calendar year 2022; therefore were not included in the analysis. Thirty-one specific receptor locations are also shown, including the MEI (location 26), modeled by Clean Air Act Assessment Package-1988 personal computer (CAP88-PC).*

Table 8-1. Summary of radionuclide composition of INL Site airborne effluents (2022).

	TOTAL CURIES[a] RELEASED										
FACILITY[b]	TRITIUM	NOBLE GASES[c] ($T1/2$ > 40 DAYS)	NOBLE GASES[d] ($T1/2$ < 40 DAYS)	FISSION AND ACTIVATION PRODUCTS[e] ($T1/2$ < 3 HOURS)	FISSION AND ACTIVATION PRODUCTS[f] ($T1/2$ > 3 HOURS)	TOTAL RADIOIODINE[g]	TOTAL RADIOSTRONTIUM[h]	TOTAL URANIUM[i]	PLUTONIUM[j]	OTHER ACTINIDES[k]	OTHER[l]
ATR Complex	9.88E+00	1.48E-19	2.92E-04	1.04E-05	1.24E-02	4.33E-06	2.75E-02	2.07E-09	8.46E-06	2.21E-05	3.06E-10
CFA	5.39E-01	6.68E-06	1.77E-01	1.90E-03	9.40E-07	8.47E-11	3.32E-11	2.47E-10	9.10E-1212	3.05E-11	4.41E-15
CITRC	0.00E+00	0.00E+00	0.00E+00	4.40E-08	0.00E+00	0.00E+00	0.00E+00	8.82E-10	0.00E+00	0.00E+00	0.00E+00
INTEC	2.33E-01	1.09E+00	0.00E+00	0.00E+00	4.50E-04	7.93E-05	2.99E-03	4.77E-07	4.34E-04	5.79E-04	0.00E+00
MFC	3.82E-01	7.97E-02	2.26E+02	3.62E+01	6.57E-02	8.94E-02	8.31E-03	1.05E-01	3.05E-07	2.16E-03	0.00E+00
NRF	1.10E-02	4.20E-03	0.00E+00	0.00E+00	3.20E-01	1.44E-05	5.50E-05	0.00E+00	2.70E-06	0.00E+00	0.00E+00
RRTR	0.00E+00	3.35E-06	8.53E-11	5.02E-11	3.32E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWMC	4.81E+01	0.00E+00	0.00E+00	0.00E+00	2.22E-02	0.00E+00	4.31E-08	1.67E-08	4.78E-05	1.03E-04	0.00E+00
TAN	1.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.01E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-07	0.00E+00	0.00E+00	0.00E+00
Total	5.92E+01	1.17E+00	2.26E+02	3.62E+01	3.36E+01	8.94E-02	3.88E-02	1.05E-01	4.94E-04	2.86E-03	3.06E-10

a. One curie (Ci) = 3.7×10^{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; RRTR = Radiological Response Training Range-Northern Test Range; RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project); TAN = Test Area North; and SMC = Specific Manufacturing Capability.

c. Noble gases ($T_{1/2}$ > 40 days) released in 2022 = ^{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 2022 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{89}Kr, ^{90}Kr, ^{91}Kr, ^{92}Kr ^{219}Rn, ^{220}Rn, ^{127}Xe, ^{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 2021 = ^{106}Ag, ^{109m}Ag, ^{110}Ag, ^{78}As, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{211}Bi, ^{80}Br, ^{83}Br, ^{84}Br, ^{117}Cd, ^{60m}Co, ^{138}Cs, ^{139}Cs, ^{140}Cs, ^{165}Dy, ^{158}Eu, ^{68}Ga, ^{70}Ga, ^{75}Ge, ^{78}Ge, ^{114}In, ^{117}In, ^{142}La, ^{56}Mn, ^{97}Nb, ^{149}Nd, ^{65}Ni, ^{150}Pm, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, ^{90}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{126m}Sb, ^{128m}Sb, ^{130}Sb, ^{81}Se, ^{81m}Se, ^{127}Sn, ^{128}Sn, ^{129}Te, ^{131}Te, ^{133}Te, ^{134}Te, ^{208}Tl, ^{89m}Y, ^{91m}Y, and ^{69}Zn.

f. Fission products and activation products ($T_{1/2}$ > 3 hours) released in 2022 = ^{108m}Ag, ^{110m}Ag, ^{111}Ag, ^{112}Ag, ^{73}As, ^{76}As, ^{77}As, ^{133}Ba, ^{140}Ba, ^{10}Be, ^{207}Bi, ^{210}Bi, ^{210m}Bi, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{113m}Cd, ^{115}Cd, ^{115m}Cd, ^{139}Ce, ^{141}Ce, ^{143}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{58m}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{135}Cs, ^{136}Cs, ^{137}Cs, ^{64}Cu, ^{67}Cu, ^{159}Dy, ^{166}Dy, ^{169}Er, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{157}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{72}Ga, ^{73}Ga, ^{153}Gd, ^{159}Gd, ^{68}Ge, ^{71}Ge, ^{77}Ge, ^{175}Hf, ^{178m}Hf, ^{179m}Hf, ^{180m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{166}Ho, ^{166m}Ho, ^{114m}In, ^{115m}In, ^{190}Ir, ^{192}Ir, ^{194}Ir, ^{40}K, ^{42}K, ^{140}La, ^{141}La, ^{177}Lu, ^{177m}Lu, ^{52}Mn, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{92m}Nb, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{95m}Nb, ^{96}Nb, ^{147}Nd, ^{57}Ni, ^{59}Ni, ^{63}Ni, ^{66}Ni, ^{185}Os, ^{189m}Os, ^{191}Os, ^{191m}Os, ^{193}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{210}Pb, ^{107}Pd, ^{109}Pd, ^{146}Pm, ^{147}Pm, ^{148}Pm, ^{148m}Pm, ^{149}Pm, ^{151}Pm, ^{210}Po, ^{143}Pr, ^{145}Pr, ^{189}Pt, ^{191}Pt, ^{193}Pt, ^{193m}Pt, ^{195m}Pt, ^{197}Pt, ^{83}Rb, ^{84}Rb, ^{86}Rb, ^{87}Rb, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{102}Rh, ^{102m}Rh, ^{105}Rh, ^{103}Ru, ^{105}Ru, ^{106}Ru, ^{35}S, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{126}Sb, ^{127}Sb, ^{128}Sb, ^{129}Sb, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{79}Se, ^{32}Si, ^{151}Sm, ^{153}Sm, ^{156}Sm, ^{113}Sn, ^{117m}Sn, ^{119m}Sn, ^{121}Sn, ^{121m}Sn, ^{123}Sn, ^{125}Sn, ^{126}Sn, ^{179}Ta, ^{180}Ta, ^{182}Ta, ^{183}Ta, ^{184}Ta, ^{157}Tb, ^{158}Tb, ^{160}Tb, ^{161}Tb, ^{97m}Tc, ^{99}Tc, ^{99m}Tc, ^{123m}Te, ^{125m}Te, ^{127}Te, ^{127m}Te, ^{129m}Te, ^{131m}Te, ^{132}Te, ^{204}Tl, ^{168}Tm, ^{170}Tm, ^{171}Tm, ^{48}V, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{93}Y, ^{65}Zn, ^{69m}Zn, ^{71m}Zn, ^{72}Zn, ^{93}Zr, ^{95}Zr, and ^{97}Zr.

g. Radioiodine released in 2022 = ^{125}I, ^{126}I, ^{128}I, ^{129}I, ^{130}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I, and ^{135}I.

h. Radiostrontium released in 2022 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr, and ^{92}Sr.

i. Uranium isotopes released in 2022 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, and ^{238}U.

j. Plutonium isotopes released in 2022 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, and ^{244}Pu.

k. Other actinides released in 2022 = ^{227}Ac, ^{241}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{252}Cm, ^{237}Np, ^{239}Np, ^{231}Pa, ^{233}Pa, ^{234}Pa, ^{234m}Pa, ^{227}Th, ^{228}Th, ^{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 2022. These are typically heavy elements that are decay chain members of actinides. They include ^{212}Bi, ^{214}Bi, ^{211}Pb, ^{212}Pb, ^{214}Pb, ^{212}Po, ^{215}Po, ^{216}Po, ^{223}Ra, ^{224}Ra, ^{226}Ra, and ^{207}Tl.

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 CAP88-PC model Version 4.1 (EPA 2020) 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 Dose Multi-Media (DOSEMM) model (Rood 2019) using dispersion and deposition factors calculated by HYSPLIT to comply with DOE O 458.1.

The dose estimates considered the 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 (previously shown in Figure 4-1). The CAP88-PC computer model uses dose and risk tables developed by the EPA. Population dose calculations were made using (1) DOE effective dose coefficients for inhaled radionuclides (DOE 2021), (2) EPA dose conversion factors for ingested radionuclides (EPA 2002), and (3) 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 the 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 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 the National Oceanic and Atmospheric Administration (NOAA).

In calendar year 2022, NESHAP receptor locations were revised to ensure the currently selected locations are still occupied by the public and to capture new residences, schools, or offices that were constructed since the last receptor location evaluation. Receptor locations were last updated in 1995 when 62 locations were identified during a helicopter fly-over inspection of the INL Site boundary (Ritter 1997). This updated analysis employed high-resolution aerial imagery to identify suitable receptor locations quickly and easily. The use of aerial imagery instead of in-person helicopter surveys ensures this process can be completed at a reasonably frequent interval and at minimum cost. Additionally, a defensible strategy for identifying receptor locations was established to eliminate selecting redundant receptor locations. The analysis resulted in a total of 31 NESHAP receptor locations. The calendar year 2022 MEI remains at the same location as previous years; however, it is now identified as Receptor 26 rather than Receptor 54. References to the MEI prior to 2019 (Receptor 1) continue to be referred to as Receptor 1 in the new arrangement (INL 2023).

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 2022 INL Report for Radionuclides* (DOE-ID 2023). To identify the MEI, the doses at 31 offsite locations shown in 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 26, a farmhouse and cattle operation located 3.1 km south of Highway 20 and 3 km from INL Site's east entrance. This is the same MEI location as the previous year, but it is different from the MEI location prior to 2019 which was location 1 (i.e., Frenchmans Cabin). Location 1 is located 2.3 km south of the INL boundary, south of RWMC. An effective annual dose of 0.018 mrem (0.18 µSv) was calculated for a hypothetical person living at location 26 during 2022. The 2022 dose at the former MEI (location 1) was 0.0097 mrem/yr and it was the fourth highest receptor location in terms of dose.

Figure 8-2 compares the MEI doses calculated for years 2013–2022. 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 2021.

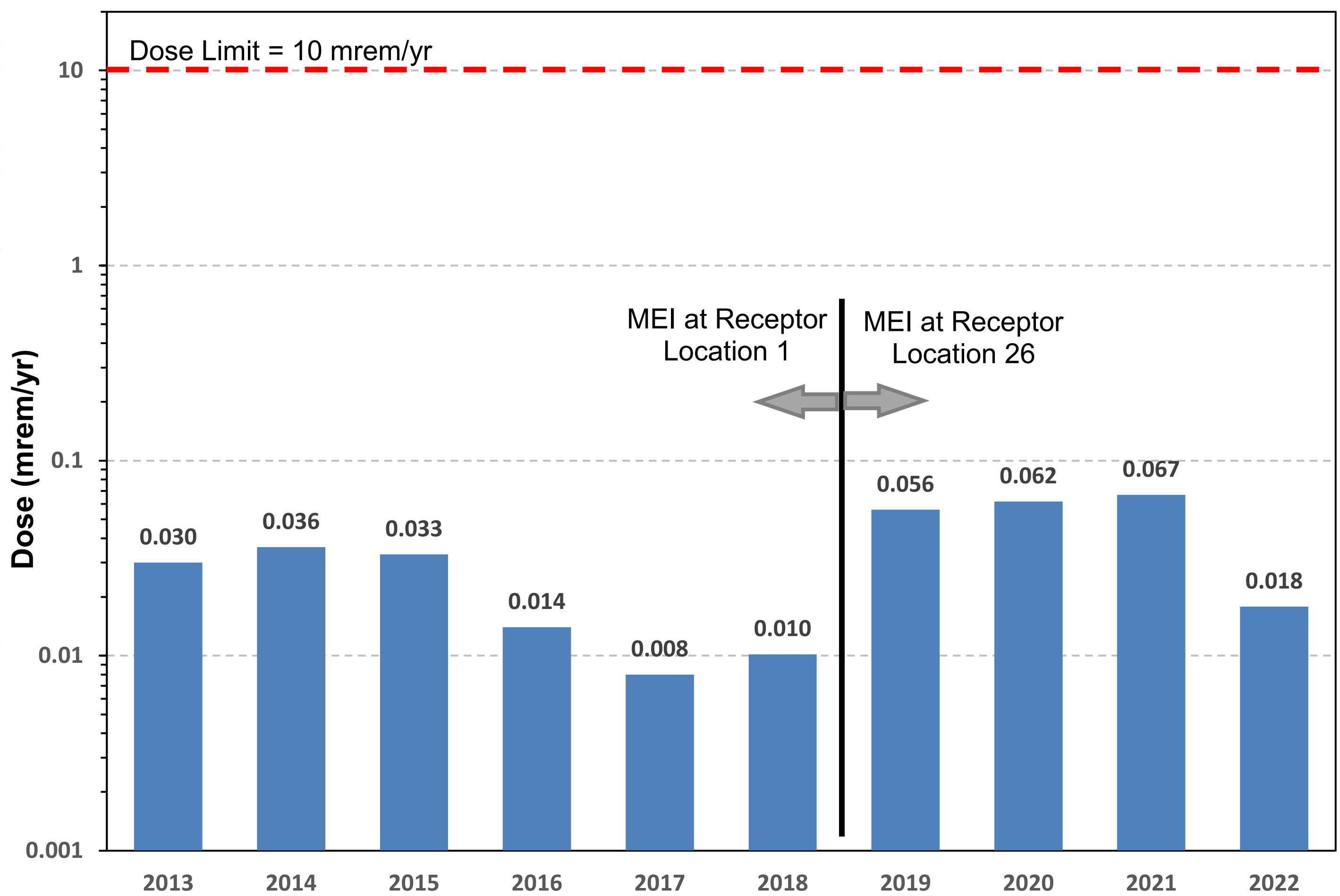

Figure 8-2. MEI dose from INL Site airborne releases estimated for 2013–2022. *See Figure 8-1 for INL Site receptor locations.*

Although noble gases were the radionuclides that were released in the largest quantities in 2022, they accounted for less than 3.5% of the cumulative MEI dose from all pathways 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 26% of the total INL activity released was argon-41 (^{41}Ar) as shown in Table 4-2 of Chapter 4, yet ^{41}Ar accounted for less than 2% of the estimated MEI dose. In contrast, radionuclides typically associated with airborne particulates, such as ^{241}Am, ^{238}U, ^{234}U, and ^{36}Cl, comprised only a small fraction (e.g., less than 0.04%) of the total amount of radionuclides reported to be released in Table 4-2 of Chapter 4, yet the radionuclides resulted in approximately 82.11% of the estimated MEI dose, as shown in Figure 8-3. 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 a small health hazard, mostly from 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. Americium-241 has a half-life of 432.2 years and is a strong alpha emitter; ingestion and inhalation of ^{241}Am being the pathways of greatest concern.

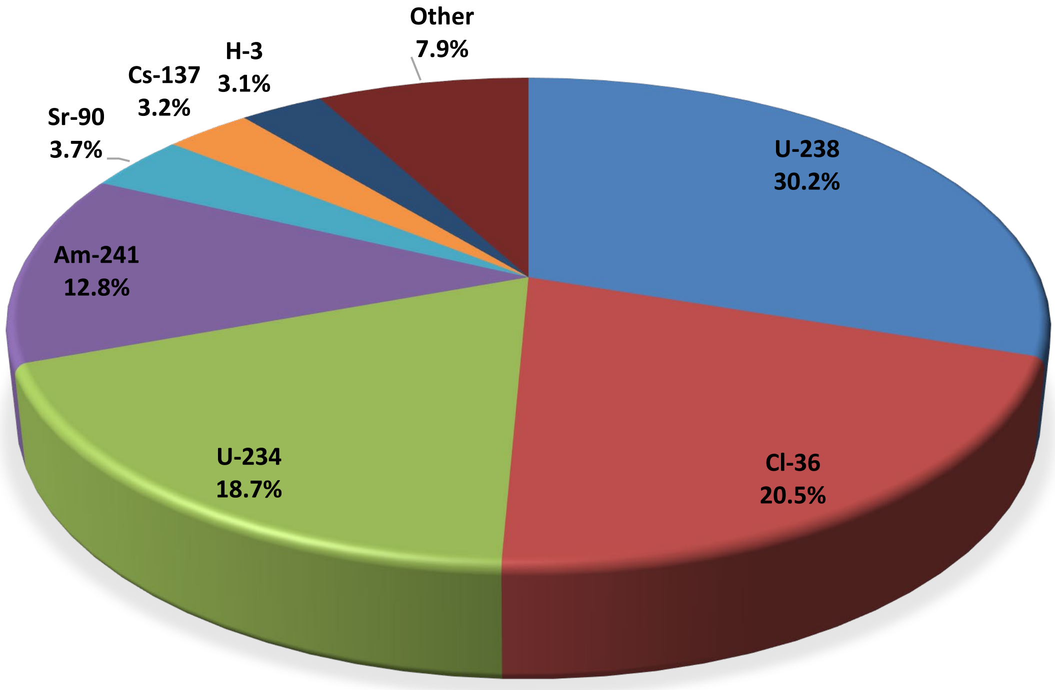

Figure 8-3. Radionuclides contributing to dose to MEI from INL Site airborne effluents as calculated using the CAP88-PC Model (2022).

Primary sources of the major radionuclides used to estimate the dose to the MEI, identified in Figure 8-3 were identified during the preparation of the annual NESHAP report (DOE-ID 2023) as follows:

- ^{238}U and ^{234}U account for 30.2% and 18.7% of the MEI dose, respectively; the majority of which came from the Electron Microscopy Laboratory (MFC-774) at MFC.
- The second largest dose contribution was from ^{36}Cl (20.5%), most of which originated at the Electron Microscopy Laboratory (MFC-774) at MFC.
- ^{241}Am contributed 12.8% to the MEI dose, which primarily came from MFC's Experimental Fuels Facility-West (MFC-794-002).
- Tritium accounts for 3.1% of the MEI dose with 96.1% coming from the RWMC Beryllium Blocks, 1.3% coming from the Warm Waste Evaporation Pond, 0.5% from the ATR stack, and the rest from other sources.
- ^{90}Sr and ^{137}Cs contributed 3.7% and 3.2%, respectively. The remaining 7.9% came from other radionuclides.

The largest contribution by facility to the MEI dose overwhelmingly came from MFC at 70.37%, followed by the RWMC at 15.23%, and the ATR Complex at 3.14% as shown in Figure 8-4. This is expected for location 26 given the proximity to MFC. Additionally, primary wind directions at the INL Site are from the southwest and northeast; thus, emissions from Test Area North, the Naval Reactors Facility, INTEC, ATR Complex, and RWMC are off axis from a receptor near MFC.

The dose to the MEI is lower than in 2021 at 0.018 mrem/year, which is far below the regulatory standard of 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H).

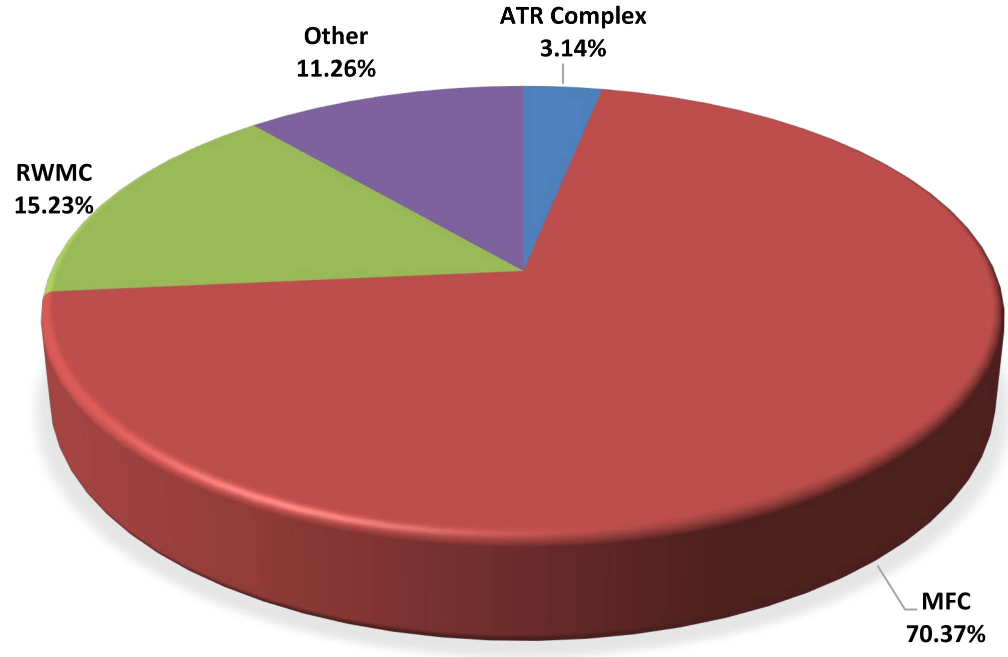

Figure 8-4. Percent contributions, by facility, to MEI dose from the INL Site airborne effluents as calculated using the CAP88-PC Model (2022).

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The total effective population dose from airborne releases was calculated using air dispersion modeling performed by the NOAA Air Research Laboratory Special Operations and Research Division using their HYSPLIT model (Stein et al. 2015; Draxler et al. 2013), and the DOSEMM v 190926 (Rood 2019) dose assessment model. The HYSPLIT model and its capabilities are described on the NOAA Air Resources Laboratory website (see https://www.arl.noaa.gov/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, as observed in Figure 8-5. In addition to INL Site sources, releases from the Idaho Falls facilities located at the INL Research Center (IRC) within 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 2020) modeling performed for the annual NESHAP report (DOE-ID 2022). These sources and radionuclides were included in the HYSPLIT/DOSEMM modeling. Radionuclides and facilities that yielded greater than 0.01% of the total dose at the location of the INL Site MEI were selected to be modeled, as observed in 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, Idaho, were included. The radionuclide source term used for the Idaho Falls facilities modeling is shown in Table 8-4.

During 2022, the NOAA Air Resources Laboratory Special Operations and Research Division continuously gathered meteorological data at 34 meteorological stations on and around the INL Site (see *Meteorological Monitoring*, a supplement to this Annual Site Environmental Report). The transport and dispersion of contaminants by winds and deposition onto the ground was projected by the HYSPLIT model using hourly averaged observations from the meteorological stations throughout 2022 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, as shown in 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.

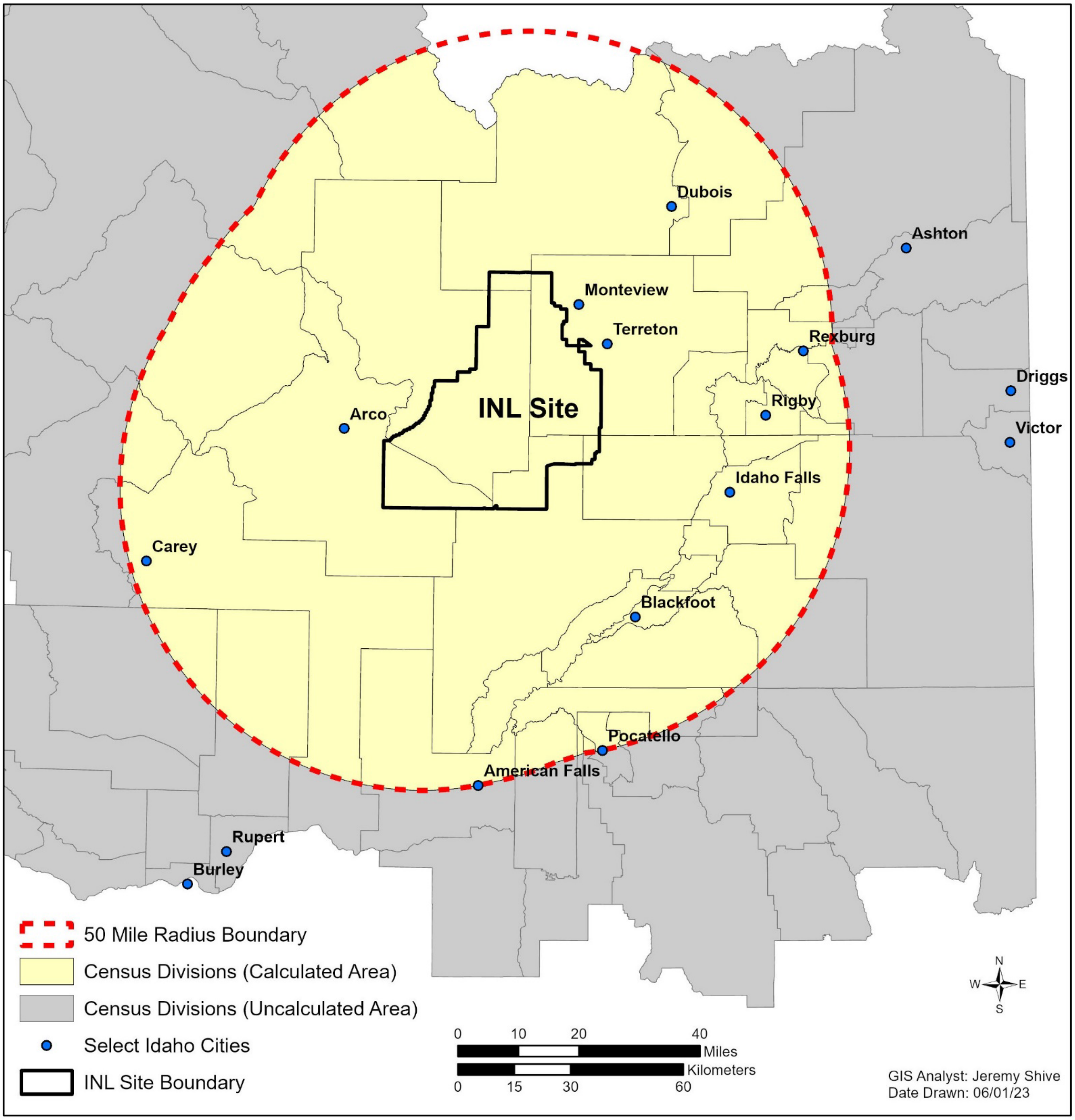

Figure 8-5. Region within 80 km (50 miles) of INL Site facilities. *Census divisions used in the 50-mile population dose calculation are shown.*

Table 8-2. Particulate radionuclide source term (Ci yr^{-1}) for radionuclide-facility combinations that contributed greater than 0.01% of the total dose for INL Site facilities at the MEI location (2023).

RADIONCULIDE	ATRC[a]	ATRC-ATR[a]	ATRC-MTR[a]	CFA[a]	INTEC[a]	INTEC-MS[a]	MFC[a]	MFC-MS[a]	MFC-TREAT[a]	NRF[a]	RRTR[a]	RWMC[a]	SMC[a]	TAN[a]	TOTAL (Ci yr^{-1})[b]
Americium-241	2.19E-05	—[c]	—	—	—	5.79E-04	—	2.11E-03	—	—	—	—	1.03E-04	—	2.81E-03
Bromine-82	—	—	—	—	—	—	—	—	—	—	—	6.02E+00	—	—	6.02E+00
Cadmium-109	—	—	—	—	—	—	—	5.28E-03	—	—	—	—	—	—	5.28E-03
Californium-252	—	—	—	—	—	—	—	5.00E-05	—	—	—	—	—	—	5.00E-05
Cesium-134	—	—	—	—	—	—	—	6.31E-05	—	—	—	—	—	—	6.31E-05
Cesium-137	5.35E-03	—	—	—	—	3.39E-04	—	3.55E-03	—	—	—	—	—	—	9.24E-03
Chlorine-36	—	—	—	—	—	—	—	7.17E-03	—	—	—	—	—	—	7.17E-03
Cobalt-60	6.31E-03	—	—	—	—	—	—	—	—	—	—	—	—	—	6.31E-03
Copper-64	—	—	—	—	—	—	—	—	—	—	—	2.70E+01	—	—	2.70E+01
Plutonium-239	—	—	—	—	—	2.14E-04	—	—	—	—	—	—	3.75E-05	—	2.52E-04
Plutonium-240	—	—	—	—	—	2.14E-04	—	—	—	—	—	—	8.61E-06	—	2.23E-04
Stronium-90	2.75E-02	—	—	—	—	2.99E-03	—	1.97E-03	—	—	—	—	—	—	3.24E-02
Tellurium-129	—	—	—	—	—	—	—	2.71E+01	—	—	—	—	—	—	2.71E+01
Tellurium-129m	—	—	—	—	—	—	—	3.93E-02	—	—	—	—	—	—	3.93E-02
Uranium-234	—	—	—	—	—	—	—	4.32E-02	—	—	—	—	—	—	4.32E-02
Uranium-235	—	—	—	—	—	—	—	2.44E-03	—	—	—	—	—	—	2.44E-03
Uranium-238	—	—	—	—	—	—	—	5.98E-02	—	—	—	—	—	—	5.98E-02

a. ATRC = Advanced Test Reactor Complex, ATRC-ATR = Advanced Test Reactor Complex-Advanced Test Reactor, ATRC-MTR = Advanced Test Reactor Complex-Material Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, INTEC-MS = Idaho Nuclear Technology and Engineering Center-Main Stack, MFC = Materials and Fuels Complex, MFC-MS = Materials and Fuels Complex-Main Stack, MFC-TREAT = Materials and Fuels Complex-Transient Reactor Test Facility, NRF = Naval Reactors Facility, RRTR = Radiological Response Test Range, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), SMC = Specific Manufacturing Capability, TAN = Test Area North (including Technical Support Facility).

b. Total curies may be less than the originally reported amounts due to changes in total activity associated with conversion from short-lived radionuclides into progeny with half-lives long enough to be modeled and for dose to be calculated.

c. A long dash signifies no emissions reported in 2022.

Table 8-3. Noble gases, iodine, tritium and carbon-14 source term (Ci yr^{-1}) for radionuclide-facility combinations that contributed greater than 0.01% of the total dose for INL Site facilities at the MEI location (2023).

RADIONUCLIDE	ATRC[a]	ATRC-ATR[a]	ATRC-MTR[a]	CFA[a]	INTEC[a]	INTEC-MS[a]	MFC[a]	MFC-TREAT[a]	NRF[a]	RWMC[a]	SMC[a]	TAN[a]	TOTAL (Ci yr^{-1})[b]
Argon-41	—[c]	—	—	—	—	—	—	—	—	8.19E+01	—	—	8.19E+01
Carbon-14	—	—	—	—	—	—	—	—	—	—	3.20E-01	—	3.42E-01
Hydrogen-3	3.14E+00	6.74E+00	—	5.39E-01	—	—	—	3.82E-01	—	—	—	—	5.92E+01
Krypton-85m	—	—	—	—	—	—	—	—	—	1.01E+01	—	—	1.01E+01
Krypton-87	—	—	—	—	—	—	—	—	—	1.06E+01	—	—	1.06E+01
Krypton-88	—	—	—	—	—	—	—	—	—	9.63E+00	—	—	9.64E+00
Krypton-89	—	—	—	—	—	—	—	—	—	3.47E+01	—	—	3.47E+01
Iodine-129	—	—	—	—	—	—	—	4.94E-05	—	—	—	—	1.38E-04
Iodine-131	—	—	—	—	—	—	—	8.93E-02	—	—	—	—	8.93E-02
Xenon-135	—	—	—	—	—	—	—	—	—	2.65E+00	—	—	2.80E+00
Xenon-138	—	—	—	—	—	—	—	—	—	1.64E+01	—	—	1.64E+01

a. ATRC = Advanced Test Reactor Complex, ATRC-ATR = Advanced Test Reactor Complex-Advanced Test Reactor, ATRC-MTR = Advanced Test Reactor Complex-Material Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, INTEC-MS = Idaho Nuclear Technology and Engineering Center-Main Stack, MFC = Materials and Fuels Complex, MFC-TREAT = Materials and Fuels Complex-Transient Reactor Test Facility, NRF = Naval Reactors Facility, RRTR = Radiological Response Training Range, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), SMC = Specific Manufacturing Capability, TAN = Test Area North (including Technical Support Facility).

b. Total curies may be less than the originally reported amounts due to changes in total activity associated with conversion from short-lived radionuclides into progeny with half-lives long enough to be modeled and for dose to be calculated.

c. A long dash signifies no emissions reported in 2022.

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 (2022).

RADIONUCLIDE	IF-603[a]	IF-683 (RESL)[a]	ANNUAL RELEASE (Ci yr^{-1})
Actinium-227	—[b]	5.23E-12	5.23E-12
Americium-241	—	1.04E-10	1.04E-10
Americium-243	—	2.09E-12	2.09E-12
Barium-133	—	3.36E-10	3.36E-10
Cobalt-60	3.90E-13	3.92E-11	3.96E-11
Cesium-134	—	1.76E-11	1.76E-11
Cesium-137	—	7.54E-11	7.54E-11
Europium-152	—	4.26E-11	4.26E-11
Europium-154	—	1.73E-10	1.73E-10
Lead-210	—	2.24E-11	2.24E-11
Neptunium-237	—	6.48E-12	6.48E-12
Protactinium-231	—	1.15E-12	1.15E-12
Plutonium-238	—	7.77E-11	7.77E-11
Plutonium-239	—	1.32E-10	1.32E-10
Radium-226	—	7.52E-11	7.52E-11
Sodium-22	—	9.14E-11	9.14E-11
Strontium-90	—	6.87E-11	6.87E-11
Uranium-232	—	3.15E-11	3.15E-11
Uranium-233	—	1.64E-10	1.64E-10
Xenon-133	6.57E-01	—	6.57E-01

a. IF-683 = Radiological and Environmental Sciences Laboratory (RESL) and IF-603 = INL Research Complex Laboratory (IRC-L).
b. A long dash signifies no emissions reported in 2022.

Outputs from the NOAA HYSPLIT model were radionuclide air 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).

The dispersion factor, often referred to as the X/Q value (concentration divided by source), was calculated by dividing the concentration in the 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), then dividing that total 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 the doses calculated from the modeling of all releases from the facilities (including INL in-town facilities) as isopleths, ranging in value from 0.0008 to 0.8 mrem (0.008 to 8 µSv). The highest dose to an INL Site boundary receptor was estimated to be 0.00349 mrem (0.0349 µSv) at a farmhouse and cattle operation (Receptor location 26, which is the same Receptor location in Figure 8-1). The farmhouse and cattle operation are also the location of the MEI used for the NESHAP dose assessment in 2022, which reported an estimated dose of 0.018 mrem (0.18 µSv) to the MEI (see Section 8.2.1). The lower dose of the HYSPLIT/DOSEMM model are attributed to the generally lower HYSPLIT dispersion factors when compared to those from CAP88-PC and to the one-year buildup time in soil in DOSEMM for external exposure compared to 100-year buildup time in CAP88-PC (Rood 2022). The HYSPLIT dispersion factors reflect differences in plume trajectory, turbulent diffusion, terrain complexities, plume depletion, and sector averaging between the HYSPLIT and CAP88-PC models.

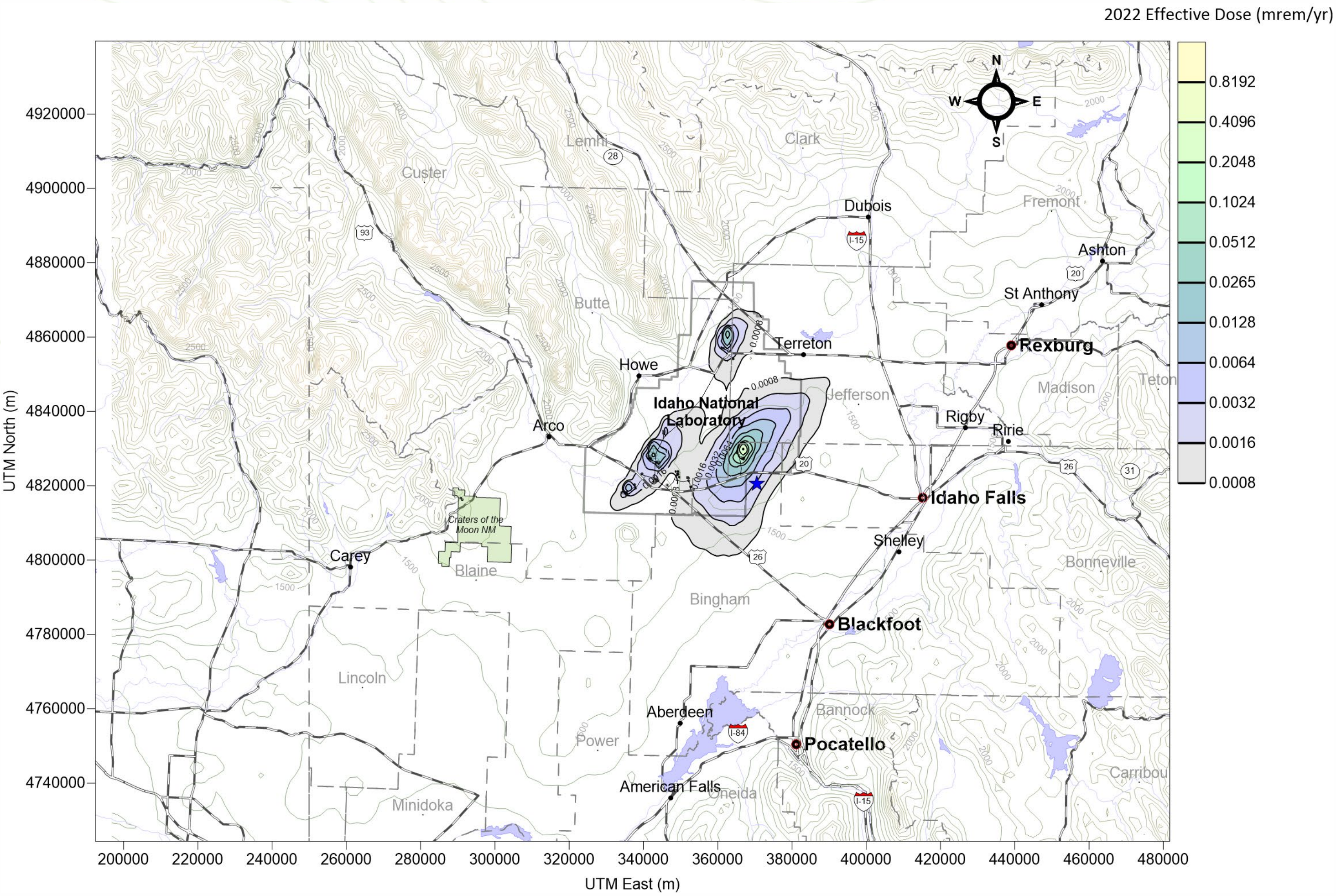

Figure 8-6. Effective dose (mrem) isopleth map with boundary receptor locations displayed (2022). *The maximum receptor dose is projected at Receptor 6, which is a farmhouse and cattle operation, as depicted as a blue star east of the INL east entrance. This is the same location as Receptor 54 in Figure 8-1.*

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 2020 census and extrapolated to 2022. The extrapolation of the population for each census division was performed by calculating the change in the population during the last ten-year period between censuses (i.e., 2010–2020), then the result was divided by ten to yield the rate of change per year. The rate of change per year was adjusted for the 2022 time period and applied to the 2020 population to estimate the number of people living in each census division. 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. The doses within each census division were averaged and multiplied by the population within each of the divisions or division portions within the 80 km (50 mi) area defined in Figure 8-5. These doses were then summed over all census divisions to obtain the 80 km (50 mi) population dose. The estimated potential population dose was 1.91 $\times 10^{-2}$ person-rem (1.91 $\times$ 10^{-4} person-Sv) to a population of approximately 349,242. When compared with the approximate population dose of 134,109 person-rem (e.g., 1,341 person-Sv) estimated to be received from natural background radiation, as observed in Table 8-5, this represents an increase of about 0.00001 percent.

The estimated population dose for 2022 is lower than that calculated for 2021 (2.85 x 10^{-2} person-rem).

Table 8-5. Contribution to estimated annual dose from INL Site facilities by pathway (2022).

PATHWAY	ANNUAL DOSE TO MEI		PERCENT OF DOE 100 mrem/yr LIMIT[a]	ESTIMATED POPULATION DOSE		POPULATION WITHIN 80 km	ESTIMATED BACKGROUND RADIATION POPULATION DOSE (PERSON-rem)[b]
	(mrem)	(µSv)		(PERSON -rem)	(PERSON -Sv)		
Air	0.018	0.18	0.018	0.019	0.00019	349,242	134,109
Waterfowl	0.0009	0.009	0.0009	NA[c]	NA	NA	NA
Big Game Animals	0.000	0.00	NA	NA	NA	NA	NA
TOTAL, ALL PATHWAYS	**0.019**	**0.19**	**0.019**	**0.019**	**0.00019**	**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 384 mrem or 0.384 rem in 2022, as shown previously in 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.

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

The potential dose that 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 may 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 0.0009 mrem (0.009 µSv) calculated for an individual consuming contaminated waterfowl based on 2022 sample results is lower than the dose estimated for 2021 (0.002 mrem [0.02 µSv]). As in the past, the 2022 samples were not collected directly from the warm wastewater evaporation ponds at the ATR Complex but from sewage lagoons adjacent to them. The dose calculation assumes the waterfowl resided at all the ponds while they were in the area.

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 2022, none of the game samples collected (e.g., four elk and one pronghorn) had a detectable concentration of ^{137}Cs or other human-made radionuclides. Therefore, no dose from human-made radionuclides would be associated with the consumption of these animals.

The contribution of game animal consumption to the population dose is calculated because only a limited percentage of the population hunts game, few animals killed have spent time on the INL Site, and most of the animals that 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 the inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

8.4 Dose to the Public from Drinking 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; Twining et al. 2021). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration from all the wells on the INL Site (3,970 ± 130 pCi/L) in 2022 is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). An individual drinking water from a well with the maximum concentration would hypothetically receive a dose of 0.184 mrem (0.00184 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 luminescent dosimeters, as previously shown in Figure 7-4.

In 2022, 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 direct exposure pathways (Figure 8-7). For 2022, 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, and 3 km from INL Site's east entrance presented in Figures 8-1 and Figure 8-6, would receive a calculated dose from INL Site airborne releases reported for 2022 (Section 8.2.1) and from consuming a duck contaminated by the ATR Complex wastewater ponds (Section 8.3.1). No dose was calculated from eating big game animals in 2022 (Section 8.3.2).

The dose estimate for an offsite MEI is presented in Table 8-5. The total all-pathways dose was conservatively estimated to be 0.019 mrem (0.19 μSv) for 2022. This represents about 0.005 percent of the annual dose expected to be received from background radiation (384 mrem [3.8 mSv], as shown in Table 7-7) and is well below the 100 mrem/yr (1 mSv/yr) public dose limit above the background radiation dose 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 1.91×10^{-2} person-rem (1.91×10^{-4} person-Sv), as identified in Table 8-5. This is approximately 0.00001 percent of the dose (134,109 person-rem, [1,341 person-Sv], Table 8-5) expected from exposure to natural background radiation in the region.

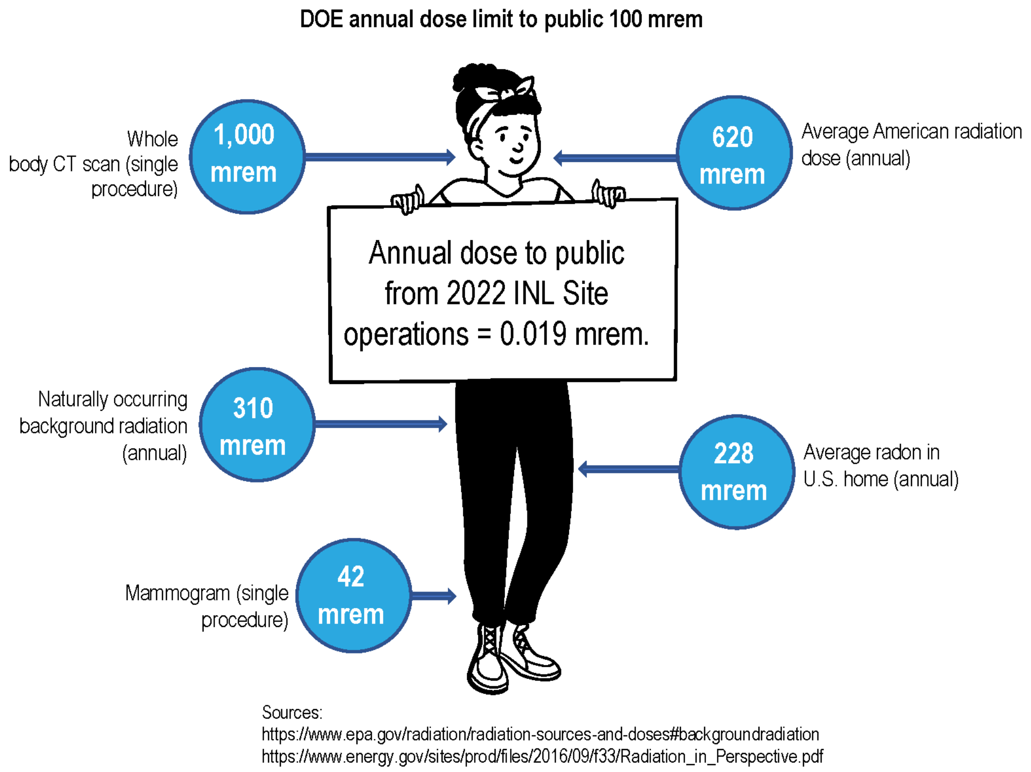

Figure 8-7. Radiation doses associated with some common sources.

8.7 Dose to the Public from Operations on the INL Research and Education Campus

Facilities in Idaho Falls that reported potential radionuclide emissions for inclusion in the 2022 NESHAP report include the IRC Laboratory (IF-603), DOE Radiological and Environmental Sciences Laboratory (RESL, IF-683), and the National Security Laboratory (IF-611). However, due to software limitations, releases from IF-603 and IF-611 were modeled as collocated releases from IF-603. These facilities are located contiguously at the IRC, which is part of the Research and Education Campus on the north side of the city of Idaho Falls. Though programs and operations at the IRC are affiliated with INL, the IRC is located within the city limits of Idaho Falls and is not contiguous with the INL Site. The nearest boundary of the INL Site is approximately 35 km (22 mi) west of Idaho Falls. For this reason, the 2022 INL NESHAP evaluation (DOE-ID 2023) includes a dose calculation to a member of the public that is separate from the INL Site MEI. (Note: The Research and Education Campus source term was, however, included in the population dose calculation reported in Section 8.2.2.) The IRC MEI for calendar year 2022 is approximately 323 meters north of IF-683. The effective dose equivalent to the MEI was conservatively calculated, using CAP88-PC, to be 0.004 mrem/yr (0.040 μSv/yr), which is less than 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 2019) and the associated software, RESRAD-Biota 1.8 (DOE 2019). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for the 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 of less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or of 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 (i.e., the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. Doses are not calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organism populations. Instead, it is an indication that more realistic model assumptions may be necessary.

If the screening process indicates the need for a more site-specific analysis, an analysis is performed using site-representative parameters (e.g., distribution coefficients, bioconcentration factors) instead of the more conservative default parameters. This is Level 2 in RESRAD-Biota.

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters that represent contributions to the organism internal dose (e.g., body mass, consumption rate of food/soil, inhalation rate, lifespan, biological elimination rates) can be modified to represent site- and organism-specific characteristics. The kinetic model 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 the 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 2022 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 the facilities shown in Figure 1-4 and include the following:

- 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, as discussed in Table 8-6. The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, 2015, 2022 (soil samples were not collected on the INL Site in 2016, 2018, 2019, 2020, or 2021).

Using the maximum radionuclide concentrations for all locations in Table 8-6, a screening level analysis was made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in ponds at the INL Site were for the MFC Industrial Waste Pond presented in Table A-17. The results for uranium-233/234 ($^{233/234}U$) and ^{238}U in Table A-17 (in Appendix A), 0.273 pCi/L and 0.241 pCi/ respectively, were used to represent surface water concentrations. When $^{233/234}U$ was reported, it was assumed that the radionuclide present was ^{233}U since doses due to ingestion and inhalation are more conservative for ^{233}U than for ^{234}U (EPA 2002).

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, as pointed out in Table 8-7. Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

Tissue data from bats collected at or near INL facilities were also available and were previously presented in Table 7-4 (in Chapter 7). 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 their tissue are shown in Table 8-8. The maximum dose received by bats at the INL Site was estimated to be 0.0006 rad/d (0.006 mGy/d) in 2022. The calculated doses are well below the threshold 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 the protection of terrestrial animals.

8.8.3 Aquatic Evaluation

Maximum radionuclide concentrations reported in Table A-17 of Appendix A (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 2022 calculations. The results shown in Table 8-9 indicate that INL Site-related radioactivity in ponds and liquid effluents is not harming aquatic biota. The combined sum of fractions was less than one for both aquatic animals (0.002) and riparian animals (0.0007).

Table 8-6. Concentrations of radionuclides in INL Site soils, by area.

LOCATION[a]	RADIONUCLIDE	DETECTED CONCENTRATION (pCi/g)[b]	
		MINIMUM	MAXIMUM
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	—[c]	3.9E-03
	Plutonium-239/240	1.3E-02	1.8E-02
	Americium-241	5.5E-03	8.5E-03
ATR Complex	Cesium-137	2.0E-1	6.1E-01
	Strontium-90	—	5.8E-02
	Plutonium-238	5.9E-03	4.3E-02
	Plutonium-239/240	1.7E-02	2.2E-02
EFS	Cesium-137	1.7E-01	6.2E-01
	Strontium-90	—	2.1E-01
	Plutonium-239/240	—	1.9E-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
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
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
Rest Area	Cesium-137	2.3E-01	3.3E-01
	Strontium-90	—	1.1E-01
	Plutonium-239/240	—	2.0E-02
	Americium-241	—	1.3E-02
RWMC	Cesium-137	8.0E-02	6.2E-01
	Strontium-90	5.6E-02	2.3E-01
	Plutonium 238	9.9E-03	2.4E-02

Table 8-6. continued.

LOCATION[a]	RADIONUCLIDE	DETECTED CONCENTRATION (pCi/g)[b]	
		MINIMUM	MAXIMUM
	Cesium-134	—	6.0E-02
	Cesium-137	—	3.3E-01
	Plutonium-239/240	1.6E-02	1.6E+00
	Americium-241	1.4E-02	1.2E+00
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. ATR Complex = Advanced Test Reactor Complex, ARA/CITRC = Auxiliary Reactor Area/Critical Infrastructure Test Range Complex, EFS = Experimental Field Station, MFC = Materials and Fuels Complex, INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, TAN/SMC = Test Area North/Specific Manufacturing Capability. See Figure 1-4.

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 2022.

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 8-7. RESRAD Biota assessment (screening level) of terrestrial ecosystems on the INL Site (2022).

TERRESTRIAL ANIMAL						
	WATER			SOIL		
NUCLIDE	CONCENTRATION (pCi/l)	BCG[a] (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Americium-241	—	2.02E+05	—	1.2	3.89E+03	3.08E-04
Cobalt-60	—	1.19E+06	—	0.05	6.92E+02	7.23E-05
Cesium-134	—	3.26E+05	—	0.09	1.13E+01	7.97E-03
Cesium-137	—	5.99E+05	—	3.5	2.08E+01	1.69E-01
Plutonium-238	—	1.89E+05	—	0.043	5.27E+03	8.16E-06
Plutonium-239	—	2.00E+05	—	1.6	6.11E+03	2.62E-04
Strontium-90	—	5.45E+04	—	0.71	2.25E+01	3.16E-02
Uranium-233	0.27	4.01E+05	6.81E-07	—	4.83E+03	—
Uranium-238	0.24	4.06E+05	5.94E-07	—	1.58E+03	—
SUMMED	**—**	**—**	**1.27E-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	—	7.04E+08	—	1.2	2.15E+04	5.57E-05
Cobalt-60	—	1.49E+07	—	0.05	6.13E+03	8.16E-06
Cesium-134	—	2.28E+07	—	0.09	1.09E+03	8.28E-05
Cesium-137	—	4.93E+07	—	3.5	2.21E+03	1.59E-03
Plutonium-238	—	3.95E+09	—	0.043	1.75E+04	2.46E-06
Plutonium-239	—	7.04E+09	—	1.6	1.27E+04	1.26E-04
Strontium-90	—	3.52E+07	—	0.71	3.58E+03	1.98E-04
Uranium-233	0.27	1.06E+10	2.58E-11	—	5.23E+04	—
Uranium-238	0.24	4.28E+07	5.62E-09	—	1.57E+04	—
SUMMED	**—**	**—**	**5.65E-09**	**—**	**—**	**2.06E-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 8-8. RESRAD Biota assessment (Level 3 analysis) of terrestrial ecosystems on the INL Site using measured bat tissue data (2022).

BAT DOSE (rad/d)					
NUCLIDE	WATER	SOIL	SEDIMENT	TISSUE[a]	SUMMED
Americium-241	—	2.87E-05	—	2.72E-05	2.87E-05
Cobalt-60	—	—	—	4.78E-05	4.78E-05
Cesium-134	—	1.05E-04	—	9.77E-05	1.05E-04
Cesium-137	—	9.91E-05	—	3.77E-05	1.37E-04
Plutonium-238	—	7.99E-07	—	7.98E-07	7.99E-07
Plutonium-239/240	—	2.57E-05	—	2.57E-05	2.57E-05
Strontium-90	—	4.27E-06	—	4.75E-04	4.80E-04
Uranium-233/234	6.80E-08	—	—	6.80E-08	6.80E-08
Uranium-238	5.35E-08	—	—	5.28E-08	5.35E-08
TOTAL	**1.21E-07**	**2.63E-04**	**—**	**7.12E-04**	**8.24E-04**

a. Calculated using maximum concentrations measured in bat tissues.

Table 8-9. RESRAD Biota assessment (screening level) of aquatic ecosystems on the INL Site (2022).

AQUATIC ANIMAL						
	WATER			SEDIMENT		
NUCLIDE	CONCENTRATION (pCi/l)	BCG[a] (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Uranium-233	0.27	2.00E+02	1.37E-03	0.014	1.06E+07	1.29E-09
Uranium-238	0.24	2.23E+02	1.08E-03	0.012	4.28E+04	2.81E-07
Summed	**—**	**—**	**2.45E-03**	**—**	**—**	**2.83E-07**
RIPARIAN ANIMAL						
	WATER			SEDIMENT		
NUCLIDE	CONCENTRATION (pCi/l)	BCG (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Uranium-233	0.27	6.76E+02	4.04E-04	0.014	5.28E+03	2.59E-06
Uranium-238	0.24	7.56E+02	3.19E-04	0.012	2.49E+03	4.84E-06
SUMMED	**—**	**—**	**7.23E-04**	**—**	**—**	**7.43E-06**

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.

Tissue data from waterfowl collected on the ATR Complex wastewater ponds in 2022 were also available, as shown previously in Table 7-3 of Chapter 7. 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 from Table 7-3. 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 uranium concentrations in water. The concentrations of uranium in sediment were estimated by the RESRAD-Biota code from the concentrations in water.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-10. The estimated dose to waterfowl was calculated by RESRAD-Biota to be 1.72×10^{-4} rad/d (1.72×10^{-2} 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 water held in ponds at the INL Site is harming aquatic biota.

Table 8-10. RESRAD Biota assessment (Level 3 analysis) of aquatic ecosystems on the INL Site using measured waterfowl tissue data (2022).

WATERFOWL DOSE (rad/d)					
NUCLIDE	WATER[a]	SOIL[b]	SEDIMENT	TISSUE[c]	SUMMED
Americium-241	—	8.45E-07	—	—	8.45E-07
Cobalt-60	—	4.97E-06	—	6.20E-07	1.12E-05
Cesium-134	—	5.37E-06	—	—	5.37E-06
Cesium-137	—	7.58E-05	—	—	7.58E-05
Plutonium-238	—	1.76E-10	—	—	1.76E-10
Plutonium-239	—	3.27E-09	—	—	3.27E-09
Strontium-90	—	5.14E-07	—	6.44E-06	6.95E-06
Uranium-233	4.03E-05	NA	2.57E-07	4.06E-05	4.06E-05
Uranium-238	3.13E-05	NA	2.09E-07	3.15E-05	3.15E-05
Zinc-65	—	—	—	3.13E-08	3.13E-08
TOTAL	**7.16E-05**	**8.75E-05**	**4.66E-07**	**8.48E-05**	**1.72E-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 in soil.

c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Table 7-3. Note: NA=uranium isotopes were not analyzed for in tissue samples.

8.9 Unplanned Releases

In 2022, the INL Site did not have any events that resulted in emissions exceeding reporting thresholds. All radiological emissions were accounted for in the dose received by the MEI.

8.10 References

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Chapter 9: Natural and Cultural Resources Conservation and Monitoring

CHAPTER 9

Natural resource information is used to demonstrate compliance with applicable rules and regulations and to ensure that the Idaho National Laboratory (INL) Site mission and goals can be achieved with few-to-no impacts to natural resources. There are four key areas of emphasis: (1) special status species (2) conservation planning; (3) natural resource monitoring and research; and (4) land stewardship.

The U.S. Department of Energy's Idaho Operations Office (DOE-ID) addresses conservation by continually evaluating the regulatory rankings, abundance, and distribution of special status plant and animal species. For some species of elevated concern or with extensive populations and key habitats on the INL Site, DOE-ID has developed conservation plans to protect species and the valuable ecosystems they inhabit. These efforts include (1) the Candidate Conservation Agreement for Greater Sage-grouse (*Centrocercus urophasianus*) on the INL Site, (2) the INL Site Bat Protection Plan, (3) the Sagebrush Steppe Ecosystem Reserve, (4) the Migratory Bird Conservation Plan and Avian Protection Planning documents, and (5) the implementation of the U.S. Department of Energy (DOE) Conservation Action Plan.

Natural resource monitoring and research has been conducted for more than 70 years on the INL Site, with some studies dating back to the 1950s. The focus of this work is to better understand the INL Site's ecosystem and biota and to determine the impact on these species' populations from activities conducted at the INL Site. Natural resource monitoring activities include (1) breeding bird surveys, (2) midwinter raptor survey, (3) long-term vegetation transects, and (4) vegetation mapping. Additionally, the INL Site was designated as a National Environmental Research Park in 1975 and serves as an outdoor laboratory for environmental scientists to study Idaho's native plants and wildlife in an intact and relatively undisturbed ecosystem. Ongoing National Environmental Research Park (NERP) activities include (1) documenting ants and associated arthropods on the INL Site, (2) tracking rattlesnake movements through gestation and dispersal of young, (3) addressing ecohydrology in sagebrush steppe, (4) evaluating beta diversity within the context of fire severity, and (5) identifying high quality foodscapes critical to greater sage-grouse.

Land stewardship involves managing ecosystems on the INL Site through planning, assessment, restoration, and rehabilitation activities. Areas where DOE-ID is actively employing land stewardship activities include (1) wildland fire protection planning, management, and recovery; (2) restoration and revegetation; (3) weed management; and (4) ecological support for National Environmental Policy Act (NEPA).

The INL Cultural Resource Management Office (CRMO) coordinates cultural resource-related activities at the INL Site and implements the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Cultural resource identification and evaluation studies in fiscal year 2022 included (1) archaeological field surveys, (2) cultural resource monitoring and site record updates related to INL Site project activities and research, (3) comprehensive evaluations of pre-1980 built environment resources, and (4) meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

9. NATURAL RESOURCES CONSERVATION AND MONITORING

The INL Site is in the Upper Snake River Plain, near the southern extent of the Beaverhead Mountains and the Lemhi and Lost River Ranges. It is host to a variety of wildlife species including, but not limited to, large ungulates, such as elk (*Cervus canadensis*) and pronghorn (*Antilocapra americana*); ten species of bats, commonplace being the western small-footed bat (*Myotis ciliolabrum*); and sagebrush obligates, such as the sagebrush lizard (*Sceloprus* graciosus) and the greater sage-grouse (*Centrocercus urophasianus*). Herpetofauna, such as the Great Basin rattlesnake (*Crotalus oreganus lutosus*) and the Great Basin spadefoot (*Spea intermontana*), use locally appropriate habitats, as do over 100 species of birds (e.g., raptor, waterfowl, passerine, and upland game species). The natural vegetation of the INL Site consists of an overstory of shrubs and an understory of grasses and forbs, or wildflowers. Big sagebrush (*Artemisia tridentata*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) are the most common shrubs, while perennial grasses, such as needle and thread (*Hesperostipa comata*), Sandberg bluegrass (*Poa secunda*), and thickspike wheatgrass (*Elymus lanceolatus*), are generally the most abundant understory species. A diversity of flowering herbaceous forbs occurs in most plant communities, especially under favorable precipitation conditions.

The primary ecosystem of the INL Site is characterized as sagebrush steppe. Approximately 94% of the land on the INL Site is undeveloped (DOE-ID and USFWS 2014), with approximately 60% open to livestock grazing. Over the past two decades, wildland fire has affected natural resources across a substantial portion of the INL Site. Because of threats like these, the sagebrush ecosystem is considered one of the most imperiled ecosystems in the United States (Noss et al. 1995), and these ecosystems are being lost at an alarming rate. In fact, by the early 2000s, only about 56% of their historic range was occupied (Knick et al. 2003; Schroeder et al. 2004). Consequently, natural resources on the INL Site are a high conservation priority for the survival of species that are dependent upon sagebrush steppe, some of which may be at the risk of local extirpation or even regional loss (Davies et al. 2011). As such, effective natural resource monitoring and land stewardship are imperative to executing the INL Site's mission with minimal impacts to the local flora and fauna.

Natural resources conservation, monitoring, and land stewardship activities on the INL Site can be organized in four categories: (1) frequently evaluating the regulatory rankings, distribution, and populations for special status species; (2) planning and implementing conservation efforts for high-priority natural resources; (3) ongoing monitoring and research to provide baseline and trend data for specific taxa and broader ecological communities; and (4) conducting land stewardship activities to minimize impacts to natural resources and restore ecological condition, where appropriate. Natural resource data collected on vegetation and key wildlife species provide DOE-ID with an understanding of how species use the INL Site and context for analyzing trends. These data are often used in NEPA analyses and enable DOE-ID to make informed decisions for project planning and to maintain up-to-date information on potentially sensitive species on the INL Site. The data are also summarized and reported to support DOE-ID's compliance with environmental regulations, agreements, policies, and executive orders. Finally, conservation management, wildland fire recovery, and vegetation management plans are developed and maintained to provide land management guidance for a variety of land stewardship concerns.

9.1 Special Status Species

9.1.1 Wildlife

The INL Site provides breeding and foraging habitat for a variety of species, including 24 species of birds and 12 species of mammals that are of elevated conservation concern by state or federal agencies. Several of these species are sagebrush obligates, while others use habitats that are very localized on the INL Site such as juniper woodlands or surface water features. Many of these species are detected or monitored during annual survey efforts, including the midwinter raptor counts, sage-grouse lek counts, breeding bird surveys, and bat acoustical monitoring.

9.1.1.1 Federally Listed Species

Several species currently listed in the Endangered Species Act of 1973 (ESA) have been documented in the state of Idaho, including the bull trout (*Salvelinus confluentus*) and the Canada lynx (*Lynx canadensis*); however, due to habitat requirements of these and other listed species, they are not likely to occur on the INL Site. Several species that have either been proposed for listing under the ESA or have been recovered and delisted occur seasonally or are considered residents of the INL Site. The bald eagle (*Haliaeetus leucocephalus*), delisted in 2007, is commonly seen during the winter months on or near the INL Site. Species associated with sagebrush habitats, such as the pygmy rabbit (*Brachylagus idahoensis*) and the greater sage-grouse, were proposed for listing under the ESA in recent years. However, findings by the U.S. Fish and Wildlife Service (USFWS) deemed these listings unwarranted except for a distinct population segment of pygmy rabbits in Washington State.

While no wildlife species currently listed under the ESA are known to occur on the INL, there are at least 24 wildlife species of conservation concern identified by the Bureau of Land Management (BLM) as special status species (Type 2) that have been documented on the INL Site (Table 9-1). A BLM ranking of Type 2 indicates that a species is a candidate, was delisted within the past five years, is an experimental population, or has a proposed critical habitat by the USFWS (BLM 2008). Some of these species would also be considered sensitive if they were assigned a global or state conservation status ranking of three or less by NatureServe (2023). Of these BLM Type 2 species, some of the most common at the INL Site include the sage thrasher (*Oreoscoptes montanus*), the loggerhead shrike (*Lanius ludovicianus*), the ferruginous hawk (*Buteo regalis*), and the greater sage-grouse. Currently, DOE-ID and the USFWS are signatories on a Candidate Conservation Agreement for the sage-grouse and sage-grouse habitat; details of this agreement are discussed in Section 9.2.1.

9.1.1.2 State Sensitive Species

A minimum of 20 wildlife species identified in the Draft Statewide Wildlife Action Plan (2023) by the Idaho Department of Fish and Game (IDFG) as Species of Greatest Conservation Need (SGCN) have been documented on the INL Site (Table 9-1). These include occasional sightings of species, such as the American white pelican (*Pelecanus erythrorhynchos*) and the ring-billed gull (*Larus delawarensis*), to more commonly observed species, such as the greater sage-grouse and the burrowing owl (*Athene cunicularia*). As with BLM special status species, many SGCN species are detected or monitored during annual survey efforts at the INL Site; additional details of these survey efforts are discussed in Sections 9.2 and 9.3.

9.1.2 Plants

During the establishment of the INL Site research facilities in the 1950s, the flora and fauna were required to be monitored by the Atomic Energy Commission (Singlevich et al. 1951). Plant specimen collections were made during field surveys and founded the Plants of the Idaho National Laboratory herbarium. The herbarium contributes to the knowledge of species historically present across the INL Site. When the ESA (1973) was enacted, a list of proposed plant species for conservation protection was developed for the state of Idaho, but botanical professionals indicated there were state-specific data gaps (Henderson et al. 1977). On the INL Site, a concerted effort to survey rare and sensitive plant species was undertaken in the early 1980s, and another similar effort was completed during the early 1990s to fill the data gaps and to inform both state and federal assessments (Cholewa and Henderson 1984; Anderson et al. 1996). The INL contractor continues to conduct special status plant surveys to support federal conservation efforts, to provide information for NEPA assessment, and to facilitate mission critical activities in a manner that minimizes impacts to sensitive species (Atwood 1969; Cholewa and Henderson 1984; Anderson et al. 1996; Forman 2015).

There are currently 20 special status plant species that have been documented to occur on the INL Site. Many of those species are rare and occur very infrequently within their optimal habitats. Others may have slightly larger population sizes but are restricted by unique habitat requirements. A few special status plants have a widespread distribution across the INL Site.

Table 9-1. Special status animal taxa documented to occur onsite.

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK†	STATE RANK†	BLM RANK‡	SGCN RANK*	USESA STATUS	SEASONAL OCCURRENCE	ABUNDANCE
American white pelican	*Pelecanus erythrorhynchos*	G4	S3B	-[a]	Tier 2	Species of Concern	Migrant	Rare
bald eagle	*Haliaeetus leucocephalus*	G5	S5	Type 2	-	Delisted / Recovery	Migrant, Winter	Uncommon
big brown bat	*Eptesicus fuscus*	G5	S3	Type 2	-	species of concern	Year-round	Common
black-throated sparrow	*Amphispiza bilineata*	G5	S2B	Type 2	-	Species of Concern	Migrant, Summer	Rare
Brewer's sparrow	*Spizella breweri*	G5	S3B	Type 2	-	Species of Concern	Migrant, Breeding	Common
burrowing owl	*Athene cunicularia*	G4	S2B	Type 2	Tier 2	Species of Concern	Migrant, Breeding	Common
California gull	*Larus californicus*	G5	S2B, S5N	-	Tier 2	Not Listed	Migrant	Uncommon
California myotis	*Myotis californicus*	G5	S3	Type 2	-	Species of Concern	Unknown	Unknown
Caspian tern	*Hydroprogne caspia*	G5	S1B	-	Tier 2	Species of Concern	Migrant, Summer	Rare
Clark's nutcracker	*Nucifraga columbiana*	G5	S3	-	Tier 3	Species of Concern	Year-round	Uncommon
common nighthawk	*Chordeiles minor*	G5	S4B	-	Tier 3	Species of Concern	Migrant, Breeding	Common
ferruginous hawk	*Buteo regalis*	G4	S3B	Type 2	Tier 2	Resolved	Migrant, Breeding	Uncommon
flammulated owl	*Psiloscops flammeolus*	G4	S3B	Type 2	-	-	Migrant	Rare
Franklin's gull	*Leucophaeus pipixcan*	G4/G5	S3B	-	Tier 3	Species of Concern	Migrant	Rare
fringed myotis	*Myotis thysanodes*	G4	S3	Type 2	-	Species of Concern	Summer	Uncommon
golden eagle	*Aquila chrysaetos*	G5	S3	Type 2	Tier 2	Species of Concern	Migrant, Summer, Winter	Uncommon
grasshopper sparrow	*Ammodramus savannarum*	G5	S3B	Type 2	Tier 3	Species of Concern	Migrant, Breeding	Common
greater sage-grouse	*Centrocercus urophasianus*	G3G4	S3	Type 2	Tier 1	Resolved	Year-round, Breeding	Common
green-tailed towhee	*Pipilo chlorurus*	G5	S4B	Type 2	-	Species of Concern	Summer	Rare
hoary bat	*Lasiurus cinereus*	G3G4	S3	Type 2	Tier 2	-	Summer, Migratory	Common
little brown myotis	*Myotis lucifugus*	G3	S3	Type 2	Tier 3	Petitioned for Listing	Summer	Common
loggerhead shrike	*Lanius ludovicianus*	G4	S3	Type 2	-	Species of Concern	Migrant, Breeding	Common
long-billed curlew	*Numenius americanus*	G5	S2B	Type 2	Tier 2	Resolved	Migrant, Breeding	Uncommon
long-legged myotis	*Myotis volans*	G4G5	S3	Type 2	-	Species of Concern	Summer	Uncommon
Piute ground squirrel	*Urocitellus mollis*	G5	S4	Type 2	-	-	Resident	Common

Table 9-1. continued.

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK†	STATE RANK†	BLM RANK‡	SGCN RANK*	USESA STATUS	SEASONAL OCCURRENCE	ABUNDANCE
pronghorn	*Antilocapra americana*	G5	S4	-	*	-	Resident	Abundant
pygmy rabbit	*Brachylagus idahoensis*	G4	S3	Type 2	Tier 2	Resolved	Resident	Uncommon
ring-billed gull	*Larus delawarensis*	G5	S2B, S5N	-	Tier 3	Species of Concern	Migrant	Rare
sage thrasher	*Oreoscoptes montanus*	G5	S3B	Type 2	Tier 2	Species of Concern	Migrant, Breeding	Abundant
short-eared owl	*Asio flammeus*	G5	S3	Type 2	Tier 3	Species of Concern	Year-round, Breeding	Common
silver-haired bat	*Lasionycteris noctivagans*	G3G4	S3	Type 2	Tier 2	Species of Concern	Summer, Migratory	Common
Townsend's big-eared bat	*Corynorhinus townsendii*	G4	S3	Type 2	Tier 3	-	Winter	Common
western grebe	*Aechmophorus occidentalis*	G5	S2B	-	Tier 2	Species of Concern	Migrant, Summer, Winter	Rare
western long-eared myotis	*Myotis evotis*	G5	S3	Type 2	-	-	Year-round	Uncommon
western small-footed myotis	*Myotis ciliolabrum*	G5	S3	Type 2	Tier 3	-	Migratory	Uncommon
white-faced ibis	*Plegadis chihi*	G5	S2B	-	Tier 2	Species of Concern	Migrant, Summer	Rare
willow flycatcher	*Empidonax traillii*	G5	S4B	Type 2	-	Species of Concern	Unknown	Rare
Yuma myotis	*Myotis yumanensis*	G5	S3	Type 2	-	-	Year-round	Rare

*Proposed SGCN 2023 Draft SWAP; see SWAP for a description of rankings (IDFG 2023)
†See NatureServe for a description of rankings (NatureServe 2023)
‡See BLM Manual 6840 – Special Status Species Management for a description of rankings (BLM 2008)
a. - = Not applicable

9.1.2.1 Federally Listed Species

The state of Idaho is host to five federally listed plant species under the ESA. None of the federally listed species are known to occur on the INL Site. Ute ladies'-tresses (*Spiranthes diluvialis*) and whitebark pine (*Pinus albicaulis*) have population occurrences within proximity to the INL Site but require specific key habitats, which are negligible or nonexistent within the cold desert steppe site. Although appropriate slickspot peppergrass (*Lepidium papilliferum*) habitat is available on the INL Site, the only known populations do not occur on the INL Site and are located hundreds of miles to the west.

9.1.2.2 State Sensitive Species

In addition to those species that receive federal regulatory support, state agencies also maintain a list of sensitive species. The list is a tool for agencies to prioritize conservation efforts and to promote a unified conservation approach statewide, which can be used proactively to avoid potential ESA listings. The Idaho Natural Heritage Program (IDFG 2023) and the Idaho Native Plant Society established this list of state sensitive species for Idaho in the 1980s at the Idaho Rare Plant Conference (e.g., INPS 2023). The conference brings together experts from many organizations to evaluate state sensitive species using the National NatureServe Network framework (NaureServe 2023). The state of Idaho manages the data within the Idaho Fish and Wildlife Information Systems program and disseminates species' specific information to make species account evaluations possible for assessing potential environmental impacts for project activities. Additionally, the special status plant list is made publicly available after each biennial list revision. Species are assigned a global and subnational ranking (State Rank). Vulnerable (S3), imperiled (S2), and critically imperiled (S1) are considered rare and denoted as special status plant species. There have been 20 special status species documented on the INL Site within its diverse composition of sagebrush steppe habitats (Table 9-2).

Table 9-2. Special status plant taxa documented to occur onsite.

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK†	STATE RANK†	BLM RANK‡	HABITAT	ABUNDANCE
white sand verbena	*Abronia mellifera*	G4	S1	-[a]	Sandy substrates in scrub	Rare
Lemhi milkvetch	*Astragalus aquilonius*	G3	S3	Type 2	Talus, gravelly, sandy substrates	Rare
painted milkvetch*	*Astragalus ceramicus* var. *apus*	G4T3	S3	-	Sandy substrates in sagebrush	Widespread
plains milkvetch	*Astragalus gilviflorus*	G5	S2	Type 4	Talus, gravelly, sandy substrates	Rare
wingfruit suncup	*Camissonia pterosperma*	G4	S2	Type 4	Talus, gravelly substrates	Localized
rosy pussypaws	*Cistanthe rosea*	G5	S2	-	Gravelly substrates	Rare
desert dodder	*Cuscuta denticulata*	G4G5	S1	-	Parasitic; shrub and grass hosts	Rare
smooth larkspur	*Delphinium glaucescens*	G3G4	S3	-	Sagebrush to bunchgrass rocky slopes	Rare
Hooker's buckwheat	*Eriogonum hookeri*	G5	S1	-	Slopes of lose sandy, rocky, talus substrates	Localized
nakedstem gymnosteris	*Gymnosteris nudicaulis*	G4	S3	-	Open, dry sandy substrates	Localized
fineleaf Hymenopappus*	*Hymenopappus filifolius* var. *idahoensis*	G5T3	S3	-	Slopes of talus, gravelly, sandy substrates	Localized
manybranched ipomopsis	*Ipomopsis polycladon*	G4	S2	Type 3	Slopes of talus, gravelly, sandy substrates	Localized
King bladderpod	*Lesquerella kingii*	G5	S3	-	Open rocky areas with silty substrates	Rare
Middle Butte bladderpod	*Lesquerella obdeltata*	G2	S2	-	Open rocky areas with silty substrates	Rare
Torrey's desert dandelion	*Malacothrix torreyi*	G4	S2	-	Coarse rocky substrates on slopes	Rare
shortflower monkeyflower	*Mimulus breviflorus*	G4	S2	-	Ephemerally damp swales	Rare
narrowleaf oxytheca	*Oxytheca dendroidea*	G4	S3	-	Dry, sandy to rocky flats	Rare
mountain ball cactus	*Pediocactus simpsonii*	G5?	S3	-	Cobblestone, clayey loam substrates	Localized
hidden phacelia+	*Phacelia inconspicua*	G2	S1S2	Type 2	Loose sandy soils near persistent snowbanks	Rare
green princesplume	*Stanleya viridiflora*	G4	S3	-	Large rocky areas with clayey to volcanic substrates	Widespread

*USESA Resolved
+USESA Species of Concern
†See NatureServe for a description of rankings (NatureServe 2023)
‡See BLM Manual 6840 – Special Status Species Management for a description of rankings (BLM 2008)
a. - = Not applicable.

9.2 Conservation Planning

9.2.1 Candidate Conservation Agreement for Greater Sage-grouse Onsite

Populations of the greater sage-grouse (*Centrocercus urophasianus*; 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 historical distribution (Schroeder et al. 2004, Connelly et al. 2011a). Healthy stands of sagebrush (*Artemisia* spp.) are necessary for sage-grouse to survive throughout the year; however, young sage-grouse also require a diverse understory of native forbs and grasses during the summer months. Sagebrush habitats that consist of a diversity of vegetation provide protection from predators and supply high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011b). Sagebrush habitats have been greatly altered during the past 150 years and are currently at risk from a variety of pressures (Connelly et al. 2004; Davies et al. 2011; Knick et al. 2011). Because of sage-grouse reliance on broad expanses of sagebrush, there is concern about the trajectory of sage-grouse populations.

When sage-grouse were petitioned for listing under the ESA, DOE-ID recognized the need to reduce the potential for impact to existing and future mission activities. In 2014, DOE-ID entered into the Candidate Conservation Agreement (CCA) with the USFWS to identify threats to the species and their habitat and develop conservation measures and objectives to avoid or minimize threats to sage-grouse. This voluntary agreement established a Sage-Grouse Conservation Area (SGCA) (see 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 (DOE-ID and USFWS 2014).

To evaluate sage-grouse population declines with respect to their natural range of variation, the CCA established population and habitat triggers. The baseline value for the sage-grouse population trigger for the INL Site equals the number of males counted in 2011 during peak male attendance on 27 active leks within the SGCA (i.e., 316 males). The population trigger will be tripped if the three-year running average of males on those 27 baseline leks decreases ≥ 20% (i.e., ≤ 253 males). The baseline value of the habitat trigger is equivalent to the amount of area within the SGCA that was characterized as a sagebrush-dominated (*Artemisia* spp.) habitat at the beginning of 2013. The habitat trigger will trip if there is a reduction of ≥ 20% (15,712 ha [38,824 ac]) of sagebrush habitat within the SGCA. The total sagebrush habitat area and distribution are monitored using aerial imagery and a Geographic Information System. If a trigger is tripped, an automatic response by both DOE and USFWS would be initiated, as described in the CCA (DOE-ID and USFWS 2014).

The INL contractor biologists monitor sage-grouse populations, sagebrush habitats, and activities that are considered threats to sage-grouse survival on the INL Site. For details about the most recent annual results, refer to *Implementing the Candidate Conservation Agreement for Greater Sage-Grouse on the Idaho National Laboratory Site 2022 Full Report* (INL 2023).

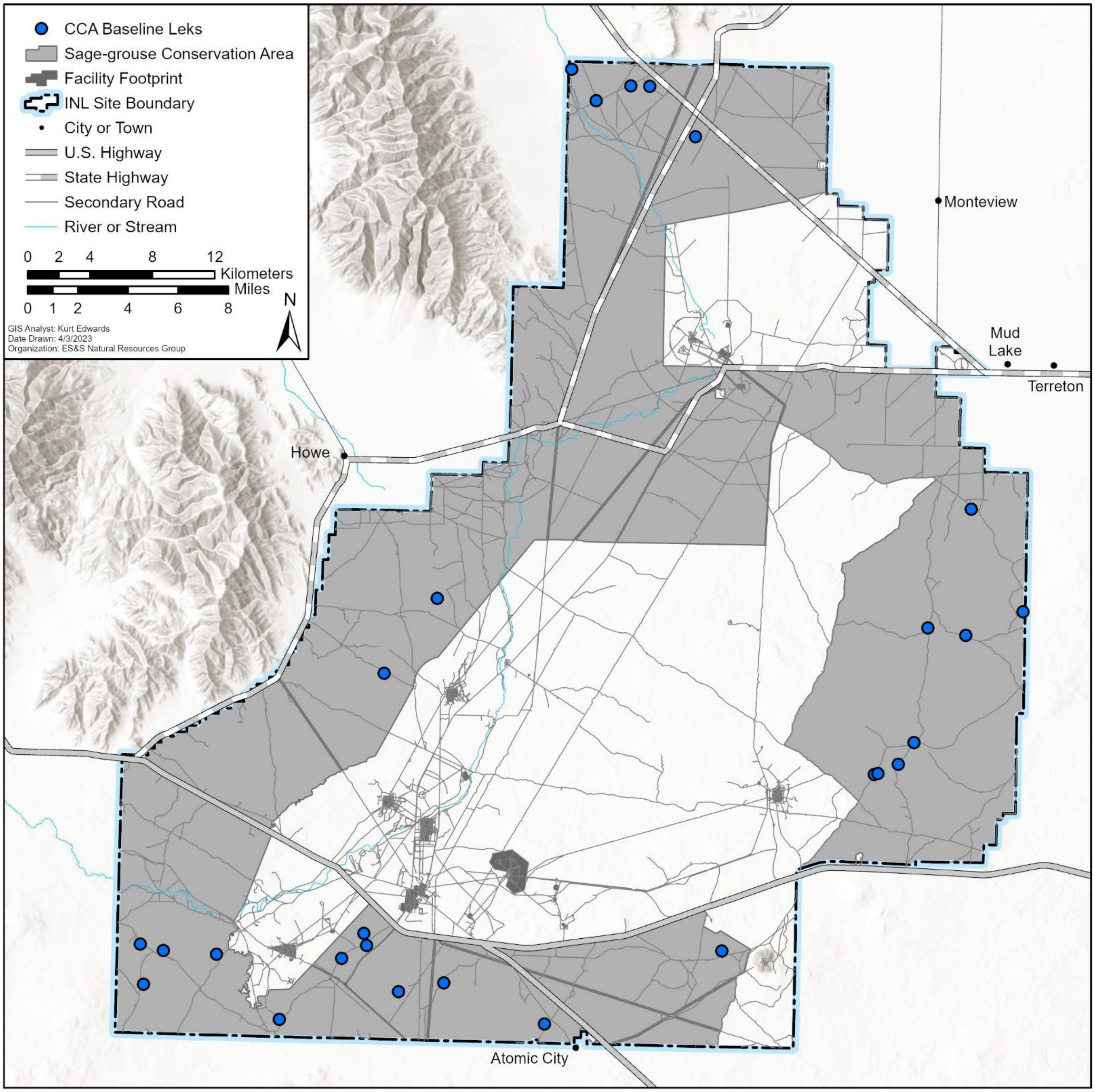

Figure 9-1. Area defined by the CCA for greater sage-grouse onsite as a SGCA and location of baseline leks used for determining the population trigger.

9.2.1.1 Population and Habitat Status

Each spring, crews monitor sage-grouse that have congregated on leks for breeding purposes. Baseline and all other active leks are monitored multiple times from March 20 until peak male attendance has been determined and recorded. Inactive leks are also surveyed every five years to determine if the lek status has changed. During 2022, the peak male abundance on baseline leks was 246—an 8.4% increase of males observed in 2021. Due to the overall declining trend in peak male attendance since 2016, the population trigger has been tripped for the first time based on the three-year running average, as stipulated in the CCA. However, the population decline observed on the INL Site is consistent with those observed statewide by the IDFG (Kemner 2022). Per the CCA (DOE-ID and USFWS 2014), additional cooperative action has been initiated between DOE and USFWS.

Two monitoring tasks are designed to identify vegetation changes across the landscape and assist in maintaining an accurate record of the condition and distribution of the sagebrush habitat within the SGCA to facilitate annual evaluation of the habitat trigger: (1) sagebrush habitat condition and (2) sagebrush habitat amount and distribution. Monitoring sagebrush condition provides data used to track annual changes in sagebrush habitat on the INL Site. Data collected to support this task may also be used to document gains in habitat as non-sagebrush map polygons transition back into sagebrush classes or to document losses when compositional changes occur within sagebrush polygons that may require a change in the assigned map class. Sagebrush habitat amount and distribution tracks losses to sagebrush habitat following events that alter vegetation communities, such as wildlife fires and land development. As updates are made to map classes (e.g., vegetation polygon boundaries), the total area of the sagebrush habitat available is compared to the baseline value established for the habitat trigger to determine the status with respect to the habitat threshold.

Together, these two monitoring tasks provide the basis for maintaining an accurate map and estimate of the condition and quantity of sagebrush habitat on the INL Site. The condition of sagebrush habitat remained high in 2022. Sagebrush cover was within its historical range of variability. Herbaceous cover exceeded its range of variability, and the abundance of non-natives was generally low. The total area of sagebrush habitat in the SGCA on the INL Site remained unchanged from 2021 to 2022, with 71,358.8 ha (176,331.4 ac). To date, a total loss of sagebrush habitat in the SGCA of approximately 1.3% has been reported.

9.2.1.2 Threats and Associated Conservation Measures

The CCA identifies and rates eight threats that potentially impact sage-grouse and their habitats on the INL Site, including wildland fire, infrastructure development, and raven predation. Conservation measures have been assigned to each threat and consist of actions aimed toward mitigating impacts to the sage-grouse and its habitat by INL Site activities. This is accomplished through the avoidance and minimization of threats by using best management practices (BMPs) such as setting seasonal and time-of-day restrictions. DOE-ID also recognizes that sagebrush-dominated communities outside of the SGCA serve as important habitats for sage-grouse, so BMPs were developed and applied to the entire INL Site, which guide infrastructure development and other land-use decisions.

9.2.2 Bat Protection Plan

Over the past several decades, newly identified threats to bat populations (e.g., white-nose syndrome and large-scale commercial wind energy development) have caused widespread mortality events in bats and resulted in precipitous declines of numerous common bat species and elevated conservation concern for bats across the United States, including additional listings under the ESA. Bats represent over 30% of mammal species described for the INL Site. Large undisturbed areas of shrub-steppe habitat, basalt outcrops, lava caves, juniper uplands, and ponds and landscape trees at industrial facilities provide complex and abundant foraging and roosting habitat for a variety of resident and transient bat species. Beginning in the early 1980s, the INL Site has supported bat research either through program funding or through outside-funded projects managed under the NERP. These efforts promoted general bat conservation and provided critical conservation data to DOE-ID decision makers state and federal resource agencies. The result of numerous publications, reports, conservation assessments, and theses has been the recognition of the INL Site and surrounding desert as crucial bat habitat.

In 2011, DOE-ID and the Naval Reactors Laboratory Field Office/Idaho Branch Office decided to increase the attention they give to bat resources and initiate the development of a comprehensive INL Site-wide bat protection and monitoring program. In 2018, the INL Site Bat Protection Plan was finalized (DOE-ID 2018). The Bat Protection Plan provides a framework for eliminating mission impacts associated with protected bat species, monitoring the status of bat populations, providing current data for environmental analyses, and engaging resource agency stakeholders such as the USFWS, BLM, and IDFG on bat issues. The *Idaho National Laboratory Site Bat Protection Plan Annual Report 2022* provides the most current INL Site bat data (Bybee et al. 2022).

During 2022, work performed under the INL Site Bat Protection Program scope included the following activities: there were 1,993,794 total files collected from acoustic monitoring stations, five caves were monitored year-round, four additional caves were monitored during the winter (November–April), two additional caves were monitored during the summer (May–October), and eight facilities were monitored during the summer. Of the total number of files, 288,800 files (104,648 identifiable as bat files) were from facilities and 1,702,839 files (286,339 identifiable as bat files) were from caves. Ongoing monitoring efforts show consistent patterns in seasonal bat distribution. The summer resident bat community consists predominantly of western small-footed myotis (*Myotis ciliolabrum*), Townsend's big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), and western long-eared myotis (*Myotis evotis*) with some little brown myotis (*Myotis lucifugus*) and silver-haired bat (*Lasionycteris noctivagans*) detected at moderate levels at a few locations. Low levels of summer activity of hoary bat (*Lasiurus cinereus*) were detected during the summer at many monitoring locations. Western small-footed myotis was the most detected bat species at all surveyed features (facilities and caves). Little brown myotis are more commonly detected at facilities than at cave sites. Tree bats (hoary bats and silver-haired bats) were detected more frequently at facilities than caves. The results of the passive monitoring program are providing critical information regarding bat distribution, ecology, and conservation on the INL Site. The INL Site also participated in the North American Bat Monitoring program, facilitated by the United States Geological Survey (USGS) in 2022, collecting acoustic data in two priority grid cells as part of a nationwide sampling framework. These data were provided to IDFG.

In addition to the acoustical bat monitoring at the INL Site, several other activities were performed to address bat conservation. To support surveillance for white-nose syndrome (a disease impacting hibernating bats), humidity/temperature dataloggers were installed in eight monitored hibernacula during the summer of 2022. Five live bats were found in areas of facilities that were disrupting work and were relocated to safe areas. There were two other bats that were not interfering with work activities and left on their own. Thirty-four bat carcasses were recovered from facilities and submitted for radiological testing. Additionally, multiple public events were held at the Idaho Falls Zoo and Museum of Idaho.

9.2.3 Sagebrush Steppe Ecosystem Reserve

On July 19, 2004, DOE-ID signed a Finding of no Significant Impact for an Environmental Assessment (EA) and Management Plan that outlined a framework to collaboratively manage the Idaho National Engineering and Environmental Laboratory (INEEL) Sagebrush Steppe Ecosystem Reserve (SSER) with the BLM, USFWS, and IDFG. The SSER includes 29,945 ha (74,000 ac) of high desert land in the north central portion of the INL Site. In the 1999 Proclamation establishing the SSER, then Secretary of Energy Bill Richardson recognized that the "Reserve is a valuable ecological resource unique to the Intermountain West and contains lands that have had little human contact for over 50 years. The sagebrush steppe ecosystem across its entire range was listed as a critically endangered ecosystem by the National Biological Service in 1995, having experienced greater than a 98% decline since European Settlement." Because the SSER represents a unique ecological resource, "conservation management of the area is intended to maintain the current plant community and provide the opportunity for study of an undisturbed sagebrush steppe ecosystem." The Proclamation also specified that traditional rangeland uses will be allowed to continue under the SSER management designation and that the Public Land Orders, which withdrew INEEL lands, would supersede SSER management objectives if the land was needed to support INEEL's nuclear energy research mission (DOE-ID 2004).

Specific actions to guide the SSER management according to its mission and management goals were provided in the INEEL Sagebrush Steppe Ecosystem Reserve Final Management Plan (DOE-ID 2004). The primary actions included in the preferred alternative for managing the SSER were as follows: (1) establishment of a Reserve Management Committee, (2) reduction in road access and use, (3) implementation of an integrated weed management plan, (4) limitation of restoration actions to locally collected plant materials, (5) no changes in livestock class or increase in stocking levels, (6) no construction of wells for livestock watering purposes, (7) minimization of anthropogenic structures for raptor perching, and (8) responding to wildland fire suppression and post-fire restoration in a manner that is consistent with INL's Wildland Fire EA.

Implementation of the SSER Management Plan and associated actions were contingent on funding allocations from the cooperating agencies because those agencies recognized that innovative funding sources would likely be required for timely implementation. To date, the cooperating agencies have been unable to identify funding resources sufficient to establish the SSER managing committee and fully implement the SSER Management Plan. As such, DOE-ID is currently evaluating actions to improve the management of the SSER. However, DOE-ID and the INL contractor continue to consider the mission and goals of the SSER Management Plan in their planning processes and land management decisions on the INL Site. When federal actions are proposed by DOE-ID on or including portions of the SSER, the restrictions on travel, infrastructure development, and other activities described in the SSER Management Plan are documented and applied to any proposed actions through the INL NEPA process.

9.2.4 Migratory Bird Conservation and Avian Protection Planning

Most activities at the INL Site are conducted within fenced, industrial complexes that are up to several hundred acres in size. General actions from day-to-day operations that may affect migratory birds include mowing vegetated areas for wildland fire protection, maintenance of utilities and infrastructure, and moving equipment such as trailers and nuclear fuel casks. Therefore, it is not unusual to encounter a variety of animals, including migratory birds, while conducting these activities. As directed in Executive Order (EO) 13186 (2001) and outlined in a 2013 Memorandum of Understanding between the DOE and USFWS, DOE-ID has developed a Migratory Bird Conservation Plan (DOE-ID 2022) that provides a framework for protecting and conserving migratory birds and their habitat in accordance with the Migratory Bird Treaty Act of 1918 and the Bald and Golden Eagle Protection Act of 1940 while accomplishing critical DOE-ID and Naval Reactors Laboratory Field Office/Idaho Branch Office missions.

DOE-ID maintains a Special Purpose Permit issued by USFWS that allows for the destruction or relocation of a pre-determined number of migratory bird nests, when permit conditions are met. Additionally, a Scientific Collection Permit issued by IDFG allows for the capture of certain migratory birds for the intent of using them for scientific and monitoring purposes. All practicable minimization and avoidance efforts identified in the Migratory Bird Conservation Plan are to be implemented before parties exercise their ability to take migratory birds under these permits. The conservation plan identifies measures that are designed to eliminate or minimize impacts on migratory birds and to protect their habitat. These measures include the protection of native vegetation, avoiding disturbing nesting birds, reducing the potential for conflicts with missions, and enhancing native habitat as practical. Conservation measures are identified through the NEPA process, which assesses the potential impacts on migratory birds during the implementation of a project or activity. The plan also identifies BMPs that are implemented across the INL Site. BMPs include routine surveys of structures, equipment, and vegetated areas conducted during nesting season (i.e., April 1 to October 1) to ensure project activities do not disturb or otherwise interfere with active nests. If an active nest with eggs or chicks is discovered, all work that could result in abandonment or destruction of the nest is suspended and the appropriate environmental personnel are contacted for assistance and guidance. Until a determination is made whether to remove the nest, actions are conducted to ensure the nest is not abandoned due to work activities.

On July 14, 2022, an unauthorized removal of swallow nests occurred at a bus stop at the Central Facilities Area resulting in the take of seven nests with viable eggs and 10 hatchlings. This unauthorized take was committed by one or more individuals and was immediately reported to the USFWS for further investigation.

Immediate actions taken after the incident included:

- The area was secured to preserve the scene in anticipation of a USFWS investigation. Photos were taken of the scene.

- Carpenters built and installed two bird boxes to help protect the chicks that survived. Adults were observed entering one of the boxes with food the following morning, indicating the success of the box. Chicks in the second box were placed in the first box which had been accepted by the adults.
- Materials and carcasses have been collected by DOE for USFWS review
- iNote was developed to reinforce expectations to protect migratory birds.

During 2019, DOE-ID established a Migratory Bird/Wildlife Conservation Working Group to provide a forum for discussing, resolving, and collaborating on all activities related to migratory bird and other wildlife matters arising on the INL Site. A primary task of this group is to promote the conservation of migratory birds, share ideas to minimize the impact of nesting birds to operations, and ensure compliance with permit requirements. Accomplishments to date include the development of online Migratory Bird Awareness Training for environmental staff, facility maintenance, operations, and program managers; mitigation actions, such as incorporating critical equipment inspections into daily operations orders to identify nesting activities; use of window dressings to reduce mortality from window collisions; and effectively exchanging information regarding the use of relocating bird eggs or young to licensed rehabilitators are used as options in lieu of unavoidable destruction and take situations.

In 2022, two dead birds (a raven and a red-tailed hawk) were found along powerlines. The INL contractor has developed an Avian Protection Plan and Bird Management Policy (MCP-3367) in accordance with Avian Power Line Interaction Committee requirements (Avian Power Line Interaction Committee 2006). This plan includes documenting, tracking, and correcting conditions that resulted in a migratory bird's death. When birds are electrocuted, power poles are either retrofitted or modified with avian protection devices during the next scheduled power outage. These efforts help to reduce future electrocutions. Avian interactions are also considered when siting new line locations and when replacing existing poles to reduce risks to migratory birds through proactive and innovative resolutions.

9.2.5 Conservation Action Plan

EO 14008, "Tackling the Climate Crisis at Home and Abroad" (2021), establishes the need for the United States to increase the speed and scale of necessary actions to mitigate the effects of the climate crisis. This EO states, "The United States will also move quickly to build resilience, both at home and abroad, against the impacts of climate change that are already manifest and will continue to intensify according to current trajectories." Additionally, it requires federal agencies to identify strategies that will encourage broad participation in the goal of conserving 30% of the Nation's lands and waters by 2030.

To address EO 14008 and its requirements, the *Conserving and Restoring America the Beautiful* report (2021) was developed by federal resource agencies and the Council on Environmental Quality. The report outlines seven focus areas for early action, and DOE developed a Conservation Action Plan (2021) to summarize ongoing and planned conservation projects within each of those focus areas that are broadly applicable across DOE lands. The focus areas that are specifically addressed at each DOE site are related to the complexity and sensitivity of the mission at that site. The following are long-term and ongoing projects that are conducted on the INL Site to address some of these focus areas:

- ***Support Tribal Led Conservation and Restoration Priorities*** – The lands now designated as the INL Site are included in the ancestral homelands of the Shoshone and Bannock people. Archaeological sites on the INL Site and far beyond are held by the Shoshone-Bannock Tribes as evincing their cultural heritage and a reflection of their ancestors. Landmarks, such as Middle Butte, define home and territory, figure in oral histories that tell how the world came to be the way it is, and provide a living link between contemporary Shoshone and Bannock people and their ancestral homelands. This landscape is part of the tribe's past subsistence and settlement, seasonal round for hunting (e.g., buffalo), plant gathering, travel and trade routes, tool sources (i.e., obsidian), and features many areas that are of great importance or are sacred to them. As a signatory to the *Memorandum of Understanding Regarding Interagency Coordination and Collaboration for the Protection of Indigenous Sacred Sites Among the U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of Transportation, U.S. Department of Energy, U.S. Environmental Protection Agency, White House Council on Environmental Quality, Advisory Council on Historic Preservation, Tennessee Valley Authority,* DOE-ID works to provide access to and protection of such sites.

DOE-ID's long-term relationship with the Shoshone-Bannock Tribes is documented in an Agreement in Principle that formalizes tribal involvement in DOE-ID planning and implementation of environmental restoration, long-term stewardship, cultural resources protections, waste management operations, and nuclear energy programs. For example, the tribes, DOE-ID, the INL contractor, and BLM staff began planning restoration efforts at the Birch Creek site to stabilize soils and vegetation in the area. In 2022, soil samples were collected and analyzed so that nutrient deficiencies can be addressed prior to planting. Weed management activities at Middle Butte Cave and Aviator's Cave reduced weed propagation, which allows other beneficial vegetation to establish in the area and stabilizes the soil. Weed management projects also improved access to the caves by humans and bats. Additionally, the tribes, DOE-ID, and the INL contractor collaborated to plant approximately 11,000 sagebrush seedlings where sagebrush had been lost to wildland fire near Middle Butte.

- ***Expand Collaborative Conservation of Fish and Wildlife Habitats and Corridors*** – IDFG has identified sagebrush steppe as one of the most important ecosystems for wildlife in Idaho (IDFG 2023) and the INL Site remains one of the best remaining examples of an intact sagebrush steppe ecosystem in the region. DOE-ID is working to restore these important habitats that were impacted by fires or other disturbances by planting sagebrush seedlings (Section 9.2.2), reducing invasive species (Section 9.2.4), and developing conservation plans for key species such as sage-grouse (Section 9.1.1) and bats (Section 9.1.2). DOE-ID has also set aside 29,945 ha (74,000 ac) of sagebrush steppe habitat as an ecosystem reserve (Section 9.1.3). In many cases, these conservation efforts are undertaken in collaboration with federal and state stakeholders, such as USFWS, BLM, IDFG, and the Idaho State Office of Species Conservation. In addition to these ongoing efforts, several new conservation opportunities were identified in the Climate Vulnerability and Resilience Planning for INL (see Other Actions Supportive of the America the Beautiful Campaign in this section below).
- ***Increase Access for Outdoor Recreation Opportunities*** – DOE-ID and the INL Site facilitate outdoor recreation opportunities to the public via big game hunting. Hunting zones for elk and pronghorn were established by DOE-ID and are administered by the IDFG on 8,704 ha (21,508 ac) along the Site boundary in northern portions of the INL Site. A valid hunting license and an IDFG-issued INL Site hunting permit are required to access these areas.
- ***Incentivize and Reward Voluntary Conservation Efforts of Fishers, Ranchers, Farmers, and Forest Owners*** – Livestock grazing permits for cattle and sheep are administered by BLM on eight allotments that overlap the INL Site boundary, resulting in approximately 60% of the INL Site that is open to ranching operations. DOE-ID and the INL contractor collaborate with BLM and allotment permittees by attending allotment reviews, providing vegetation monitoring data, reviewing EAs for activities that may impact the INL Site, and sharing resources for fire recovery of sagebrush ecosystems and sagebrush habitat restoration. These parties also cooperate to ensure that conservation measures, such as ensuring that fences are wildlife compatible and water troughs are located to minimize impacts to vegetation, are implemented and yield the desired outcome. In many cases, these conservation measures have the potential to reduce impacts from livestock operations on natural resources and increase efficiencies for permittees.
- ***Other Actions Supportive of the America the Beautiful Campaign*** – In addition to the Conservation Action Plan (DOE 2021), DOE also developed the Climate Adaptation and Resilience Plan (CARP) (DOE 2021) in response to EO 14008. The CARP provides a framework for developing a Vulnerability Assessment and Resilience Plan for each DOE site. The INL Vulnerability Assessment and Resilience Plan, or *Climate Vulnerability Assessment and Resilience Planning for Idaho National Laboratory* (Ischay and Nate 2022), identifies programmatic and technological solutions to increase resilience to climate change across INL Site facilities (see Chapter 3), and it also includes opportunities to increase climate resilience across the natural landscape through inventory, monitoring, and resource management plans. Finally, DOE-ID and the INL contractor are participating in DOE's Sustainable Climate-Ready Sites program, which is a voluntary recognition program designed to foster excellence in sustainability, climate resilience, and natural resource protection. This program supports implementation of the Conservation Action Plan and the CARP.

9.3 Natural Resource Monitoring and Research

9.3.1 Breeding Bird Surveys

The North American Breeding Bird Survey (BBS) was developed by the USFWS and 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, included all North America (Sauer and Link 2011). The BBS program in North America is managed by the USGS and currently consists of over 5,100 routes, with approximately 2,500 of these being sampled each year (Sauer and Link 2011).

BBS data provide long-term species abundance and distribution trends for more than 420 species of birds across a broad-geographic extent (Sauer and Link 2011). These data have been used to estimate population changes for hundreds of bird species, and they are the primary source for regional conservation programs and modeling efforts for birds (Sauer and Link 2011). The BBS provides a wealth of information about population trends of birds in North America and is the foundation for broad conservation assessments extending beyond local jurisdictional boundaries (Sauer and Link 2011).

Five official USGS BBS routes (i.e., remote routes) are on the INL Site and have been surveyed nearly each year since 1985 (except 1992 and 1993). In 1985, DOE-ID also established eight additional routes around INL Site facilities to monitor birds near human activity centers (i.e., facility routes; see Figure 9-2). These routes are also surveyed annually using the same techniques and methods as those indicated by USGS. Surveys are conducted from late May until early July and are scheduled to be conducted as close to the same day each year. All birds seen and heard during the survey are recorded regardless of breeding status (e.g., flyovers). BBS data can directly benefit INL Site managers by providing information on local breeding bird populations, which may be useful as they consider new activities and comply with the NEPA assessment process.

A total of 7,125 birds and 58 species were documented during the 2022 surveys. Total observations were 58.8% higher than the 36-year mean of 4,598 birds (1985–1991 and 1994–2022). The total number of species recorded was also higher than the 36-year mean of 55 species.

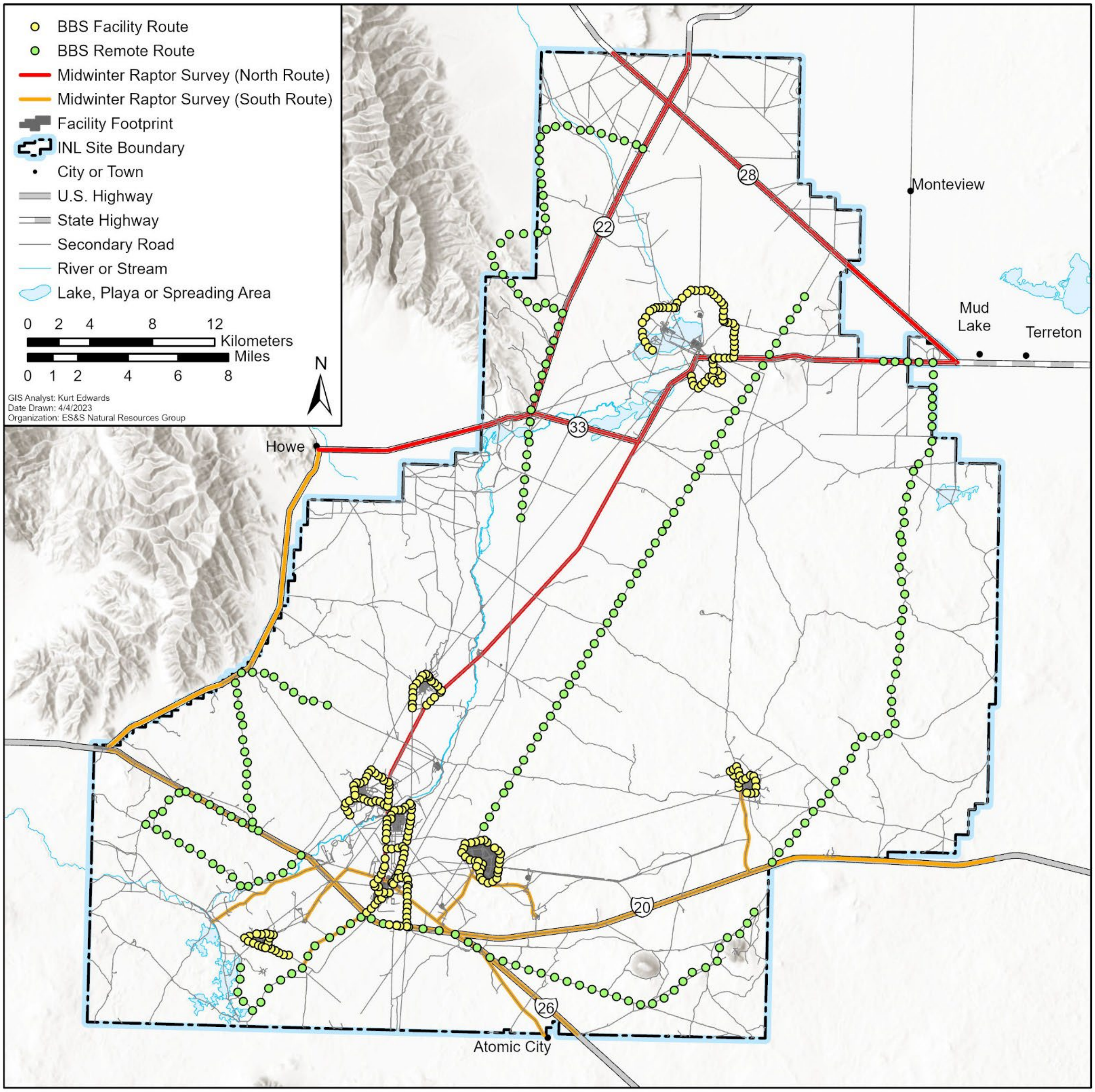

Figure 9-2. Remote and facility BBS routes and north and south midwinter raptor survey routes onsite.

Five species observed during the 2022 BBS are considered by the IDFG as SGCN, which includes the Franklin's gull (*Leucophaeus pipixcan*, n=880), California gull (*Larus californicus*, n=419), sage thrasher (*Oreoscoptes montanus*, n=313), sagebrush sparrow (*Artemisiospiza nevadensis*, n=250), and burrowing owl (*Athene cunicularia*, n=5). When Franklin's gulls and California gulls are observed, they are often in large flocks foraging on the INL Site, and it is unlikely they are nesting on Site.

The five most abundant bird species across all routes were horned lark (*Eremophila alpestris*, n=2,733), Franklin's gull, western meadowlark (*Sturnella neglecta*, n=666), Brewer's sparrow (*Spizella breweri*, n=474), and the California gull. Horned lark, western meadowlark, sage thrasher, sagebrush sparrow, and Brewer's sparrow were observed on every route (Bybee and Williams 2023).

9.3.2 Midwinter Raptor Survey

Midwinter eagle surveys were initiated during 1979 by the USGS 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 wintering habitat. In 1983, two midwinter eagle survey routes were established on the INL Site, one that encompasses the northern portion of the INL Site and one that encompasses the south (Figure 9-2). Initially, the counts focused on eagle populations; however, biologists recognized the importance of collecting data on raptor abundance during this survey and started recording all raptors, including owls, hawks, and falcons in 1985. In 1992, the list of recorded species expanded to include corvids and shrikes.

In early January of each year, teams of biologists survey along the two established routes to detect any target species perched, hovering, or soaring. The number of individuals per species is counted for each of the target species detected. A total of 403 birds representing eight species were observed during the 2022 midwinter raptor surveys. Common ravens and rough-legged hawks are typically the most observed species during this survey and made up 76% and 15% of the observations in 2022, respectively.

9.3.3 Long-term Vegetation Transects

The long-term vegetation (LTV) transects and associated permanent plots were established on what is now the INL Site in 1950 for the purposes of assessing impacts of nuclear energy research and production on surrounding ecosystems (Singlevich et al. 1951). Initial sampling efforts focused on potential fallout from nuclear reactors and the effects of radionuclides on the flora and fauna of the Upper Snake River Plain. After several years of sampling, however, the concentrations and any related effects of radionuclides on the sagebrush steppe ecosystem of the INL Site were determined to be negligible (Harniss 1968). Because the LTV plots were widely distributed across two transects that bisect the INL Site, as shown in Figure 9-3, and vegetation abundance data had been collected periodically since their establishment, the LTV plots' utility as a basis for monitoring vegetation trends in terms of species composition, abundance, and distribution was eventually recognized. Regular vegetation data collection has continued on the LTV plots—occurring about once every five years. Eighty-nine LTV plots are still accessible, and most have been sampled consistently between 1950–2022, making the resulting dataset one of the oldest, largest, and most comprehensive for sagebrush steppe ecosystems in North America.

As the mission of the INL Site has grown and changed over the past 70 years, so too has the purpose and utility of the LTV project. Although the LTV project was initiated to address energy development at the INL Site, it is unique in its capacity to allow investigators to observe long-term vegetation change and the potential impacts of that change at the INL Site and across the region. Abiotic and biotic conditions (e.g., conditions created by the physical environment and by other living organisms) have been characterized by rapid change over the past few decades. These changes include shifts in land cover, land use, and weather patterns. Several wildland fires have removed sagebrush from a large portion of the Upper Snake River Plain over the past few decades; approximately 99,000 ha (250,000 ac) have burned on the INL Site since 1994. Soil disturbance associated with fighting wildland fires and disturbance associated with general increases in the use of remote backcountry areas are notable at INL and throughout the Intermountain West. Concurrently, many of the hottest and driest years during the 70-year INL Site weather record occurred during the past decade. All these factors contribute to increasing stress on native plant communities and potentially set the stage for a period of dramatic change in vegetation across the region. The LTV project is documenting this change and may provide some context for understanding resistance and resilience in local sagebrush steppe.

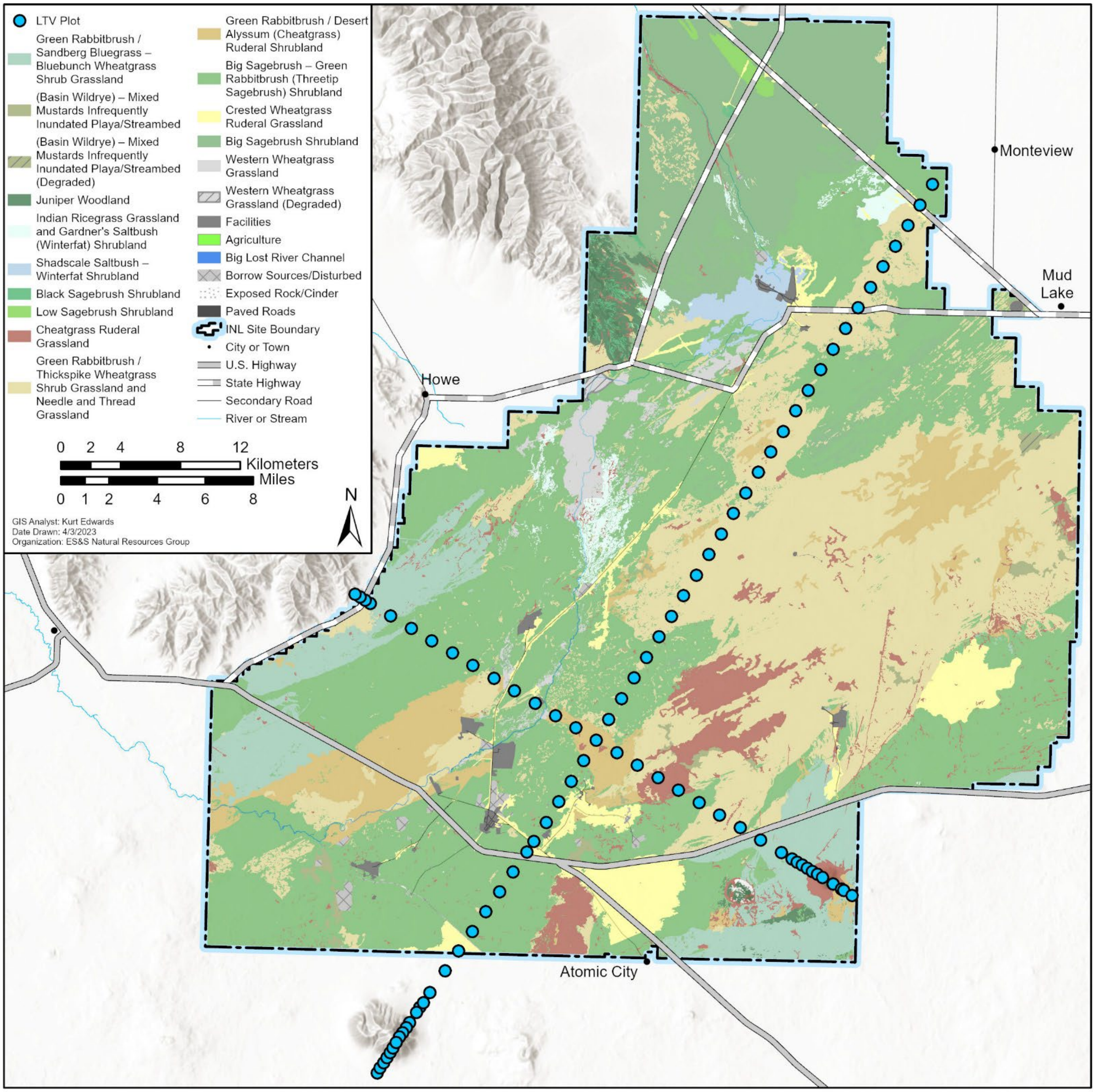

Figure 9-3. Locations for the LTV plots established onsite in 1950 and sampled regularly over the past 70 years shown with the INL Site vegetation community classification map published in 2019.

Data were collected across the 89 active LTV plots for the fourteenth time between June and August of 2022. Plots were sampled for cover and density by species according to methodologies developed in 1950, with supplemental sampling protocols added in 1985 (see Forman and Hafla [2018] for details of the project sample design). The 2022 data will be integrated into the larger LTV dataset, and summary results will be presented in a technical report scheduled to be released in 2024. Notable changes between the 2011 and 2016 sample periods (the most recent sample periods for which data have been published) include decreases in shrub cover and particularly big sagebrush, increases in native grass cover, and declines in the densities of introduced annual grasses and forbs. In terms of long-term trends, big sagebrush cover was at its lowest point in the 66-year history of the dataset, and native, perennial grasses were near the upper end of their historical range of variability. Introduced annuals, primarily cheatgrass (*Bromus tectorum*), exhibited fluctuations with greater magnitudes of change from one sample period to the next over the past two decades when compared with earlier sample periods.

9.3.4 Vegetation Map

The vegetation map published in 2011 represented a substantial improvement over previous maps of the INL Site in terms of resolution, accuracy, and statistical rigor (Shive et al. 2011). Since completion, the vegetation map has been used extensively to support the inventory and monitoring of ecological resources, prioritizing potential habitat for other sensitive species, identifying restoration and weed control opportunities, and characterizing affected environments for NEPA analyses. There have been many changes in vegetation distribution and composition since the map was completed. The most discrete changes were caused by four relatively large wildland fires that burned approximately 52,820 ha (130,521 ac) from 2010–2012, representing approximately 23% of the INL Site. More gradual changes in plant community composition, such as increases in the abundance and distribution of non-native annual grasses and forbs, have also been occurring over the past decade.

A comprehensive update to the current vegetation map was initiated in 2017 and involved three steps: (1) a plant community classification to define vegetation classes, (2) manual map delineations of those classes, and (3) an accuracy assessment of the completed map. A total of 16 unique vegetation classes resulted from the plant community classification, in which 12 represented natural vegetation classes and 4 were ruderal classes (e.g., classes dominated by non-native species; Shive et al. 2019). Within the native classes, there was one woodland class, six shrubland classes, two shrub grasslands, and three grasslands. Within the ruderal classes, there was one shrubland, two grasslands, and a class characterized by mixed weedy forbs that tend to dominate areas with a specific hydrologic regime, namely playas.

The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class contained the largest amount of total area of the INL Site mapped, with 851.2 km^2 (210,330.9 ac), and the greatest number of map polygons with 2,388 (Figure 9-3). The second largest mapped area was the combined Green Rabbitbrush/Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland class with 570.8 km^2 (141,035 ac). The three largest map classes cover 73.2% of the vegetated area on the INL Site, suggesting most vegetation communities are dominated by big sagebrush or species most commonly associated with post-fire communities where big sagebrush was previously present. The Cheatgrass Ruderal Grassland contained the second largest number of polygons with 1,435. However, the mean area for the Cheatgrass Ruderal Grassland class was much smaller at 0.06 km^2 (15.9 ac) and many of the polygons mapped were isolated individual patches rather than larger contiguous areas.

Some plant community classes were combined prior to the map accuracy assessment because those classes were known to be hard to map with imagery. This resulted in 13 map classes that were evaluated through an independent map accuracy assessment. Overall map accuracy across all classes was 77.3% with a Kappa value of 0.75. These results indicate the new vegetation map is not only the highest spatial resolution (i.e., 1:6,000), but also the most accurate map ever produced for the INL Site. The Juniper Woodland class had the highest individual class accuracy (i.e., user's and producer's accuracy) of 100%, but was limited in distribution and spatial extent. The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class contained the largest amount of mapped area and was the second most accurate map class with a user's accuracy of 93.9%. For more information about vegetation classification and mapping results, visit the Vegetation Community Classification and Mapping of the INL Site 2019.

9.3.5 National Environmental Research Park

The INL Site was designated as a NERP in 1975 through a NERP Charter, the Energy Reorganization Act, and Non-nuclear Energy Research and Development Act. The Idaho NERP and NERPs at other DOE sites are outdoor laboratories that provide opportunities for environmental studies on protected lands that act as buffers around DOE facilities. The objective of the NERP system is to facilitate research and education, particularly to demonstrate the compatibility of energy technology development and a quality environment. INL's NERP designation has allowed the INL Site to host environmental scientists to study Idaho's native plants and wildlife in an intact and relatively undisturbed ecosystem (Figure 9-4). The Idaho NERP provides exceptional opportunities for research because of its established facilities, a security buffer that protects research areas, extensive historical data, and partnerships with universities. In 2022, the INL contractor facilitated university-led research on five ecological research projects through the NERP: (1) documenting ants and associated arthropods on the INL Site, (2) tracking rattlesnake movements through gestation and dispersal of young, (3) addressing ecohydrology in sagebrush steppe, (4) evaluating beta diversity within the context of fire severity, and (5) identifying high quality foodscapes critical to greater sage-grouse.

Figure 9-4. Researchers studying the flora and fauna of the Idaho NERP.

Entomological studies facilitated through the Idaho NERP include an array of research on taxa relationships, new species descriptions, and documentation of species new to the INL Site. A list of ants found at the INL Site was developed by Clark and Blom (2007) and has been used as a basis for studying ecological relationships between some of the ant taxa and a variety of ant guests. In the ecological context, guests are generally defined as animals living within the nest or colony of another species. One ant guest taxon, a desert beetle (*Philolithus elatus*), was not previously known from the INL Site (Stafford et al. 1986) but has recently been collected from harvester ant (*Pogonomyrmex salinus)* nests; it is currently the subject of study and description. An undescribed species of the Jerusalem cricket (*Stenopelmatus* sp.) has also been found in ant nests at the INL Site; work to formally describe this species continues. Field observations indicate a predatory crab spider (*Xysticus* sp.) that has not been documented previously on the INL Site was noted to be feeding on *Pogonomyrmex salinus*. Additionally, researchers continued to make incidental observations and field records for flea beetles (*Disonycha latifrons)* that feed on green rabbitbrush (*Chrysothamnus viscidifloris*) and *Moneilema* sp. (not previously found at the Site), a rare cactus feeding beetle. Voucher specimens collected at the INL Site have been deposited in the insect collection at the Orma J. Smith Museum of Natural History and College of Idaho and are available for research. The principal investigator leading this research effort is William Clark from the College of Idaho; his work on invertebrates at the INL Site spans several decades and will continue into the foreseeable future.

More ecological studies have been conducted on the Great Basin rattlesnake (*Crotalus oreganus* ssp. *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, Great Basin rattlesnakes make a lengthy migration away from and back to a hibernaculum. While adult male and non-pregnant female rattlesnakes travel several kilometers 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, and to provide proper thermoregulatory opportunities because embryonic development is influenced by temperature. In 2018 and 2019, a project was conducted on the INL Site to locate gestation rocks used by pregnant Great Basin rattlesnakes and to measure their attributes to determine if pregnant rattlesnakes were selecting specific rocks. Initial 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. 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. The principal investigator for this project is Dr. Vincent Cobb from Middle Tennessee State University and he is working on manuscripts that describe the results from this study.

The INL Site and other landscapes with sagebrush steppe vegetation are experiencing a simultaneous change in climate and plant community composition that is impacting habitat for wildlife, wildfire risks, and ecosystem services such as forage. Determining the separate and combined/interactive effects of climate and vegetation change is important for assessing future changes on the landscape and for hydrologic processes. Since the early 2000s, investigators have used an existing INL ecohydrology research facility, the former Protective Cap/Biobarrier Experiment, to study vegetation change with respect to precipitation regime, vegetation type, and soil depth. The focus of current research is to compare the impacts of grass invasion and shifts in timing of precipitation to the function of the whole ecosystem, including biogeochemistry, carbon storage, and other attributes that relate to resistance and resilience in a changing environment. The experiment site was burned in its entirety by the 2019 Sheep Fire, which created an exceptional opportunity to test the underlying basis for the theory on resistance to exotic annual-grass invasion (cheatgrass) and resilience of sagebrush steppe. The long-term treatments conveniently create a gradient of pre-fire climate differences, and the cessation of treatment application has induced large differences in simulated drought conditions on the experiment. Researchers continue to sample the differences in cheatgrass among the treatments along with the corresponding soil nutrients and water. The research team includes Dr. Matthew Germino from the USGS Forest and Rangeland Ecosystem Science Center and Dr. Toby Maxwell and Dr. Marie-Anne DeGraff from Boise State University; their research continues to use a facility that has been in operation since 1994. They will continue to collect data for at least the next few years.

In 2017, vegetation abundance data were collected from over three hundred plots across the INL Site to support an update to the INL Site vegetation map. These plots were used to classify plant communities into mappable units and were therefore distributed across a range of representative vegetation types. The plant communities sampled during this survey effort included intact sagebrush steppe and recovering post-fire assemblages from areas that burned at various times and intensities prior to data collection. In 2022, an effort to revisit these data and summarize them for publication in the peer-reviewed literature was initiated. The purpose is two-fold. The first objective of this research effort is to document and describe the methodologies used to develop the INL Site plant community classification. The second objective is to evaluate changes to beta diversity in the context of fire severity across the INL Site. The principal investigator for this project is Dr. Ken Aho from Idaho State University, and his work to complete analyses and develop manuscripts related to this study is ongoing.

The Idaho NERP is collaborating in a multiagency research project focused on identifying high quality foodscapes critical to sage-grouse habitat conservation across the sagebrush steppe ecosystem. The project has been conducted for several years and spans across multiple western states. The research team aims to identify the chemical phenotype (or chemotype) of sagebrush species linked with high sage-grouse forage fidelity to identify which habitats are crucial dietary hotspots for sage-grouse that should be prioritized for conservation and where seed collection should occur for local restoration of plants that are palatable to local sage-grouse populations. Field research is conducted during the winter and spring months to identify the seasonal changes in chemotypes of sagebrush consumed by sage-grouse. Browsed vegetation and excreta of sage-grouse are collected and used to determine diet quality using Near Infrared Spectroscopy and analytical chemistry of plants, diet composition using DNA barcoding of feces, digestibility of food using a particle size analysis of feces, and detoxification capacity by analyzing renal metabolites in uric acid. Overall, the project is focused on supporting preventative management actions, protecting functional biodiversity and palatable sagebrush, and improving the availability of locally adapted seed sources most appropriate in habitat restoration projects that aim to promote health populations of sage-grouse. The principal investigator is Boise State University researcher, Dr. Jennifer Forbey, and her work is anticipated to continue on the INL Site.

9.4 Land Stewardship

9.4.1 Wildland Fire Protection Planning, Management, and Recovery

The INL fire department provides wildland fire suppression services on the rangeland within the Site boundary as well as a five-mile buffer outside of the INL Site boundary. The fire department employs pre-incident strategies, such as the identification of special hazards, mitigation procedures, and mapping necessary to facilitate response to fires. DOE-ID maintains mutual aid agreements with regional agencies, including the BLM, to assist in response to high challenge wildland fires. Additionally, the INL contractor implements PLN-14401, “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. The INL contractor has established a Wildland Fire Management Committee (WFMC) to review seasonal fuel management activities and the potential impact of all fires greater than 40.5 ha (100 ac).

A primary responsibility of the WFMC is to determine if a post-fire recovery plan is warranted for a given fire. Once an ecological resources post-fire recovery plan is requested, the INL Natural Resources Group completes an ecological resource assessment to evaluate the resources potentially impacted by a wildland fire and drafts a recovery plan for treatment prioritization and implementation by the WFMC. After the 2019 Sheep Fire, WFMC members expressed an interest in a recovery plan where implementation is phased over five years and is flexible, in that actions can be implemented individually depending on specific resource concerns and funding availability. The resulting plan was organized into four natural resource recovery objectives: (1) soil stabilization for erosion, (2) cheatgrass and noxious weed control, (3) native herbaceous recovery, and (4) sagebrush habitat restoration. Multiple treatment options were provided in the plan for improving post-fire recovery. Because the structure and organization of the plan, as well as the options of prioritizing treatment actions, were useful to the WFMC, subsequent post-fire ecological recovery plans continue to use this framework. There are two post-fire ecological resource recovery plans that are actively being implemented on the INL Site—one plan for four fires that burned in 2020 and one plan for the 2019 Sheep Fire.

In 2020, the WFMC requested an ecological assessment and fire recovery plan for four fires ranging in size from 11 ha (27 ac) to 678 ha (1,675 ac): the Howe Peak Fire, the Telegraph Fire, the Cinder Butte Fire, and the Lost River Fire. Under approved emergency stabilization actions listed in the existing Wildland Fire EA (DOE 2003), the INL contractor completed several activities during the fall of 2020, including recontouring containment lines on the fires where they were used, reseeding containment lines with native grass seed, and spraying noxious weeds, especially in disturbed soils on and around containment lines. Upon completion and review of the ecological resource recovery plan (Forman et al. 2021), additional recovery actions were prioritized by INL’s WFMC, including (1) monitoring temporary fire suppression access roads for natural recovery, (2) installing signs, and (3) replanting those roads, if necessary, and (4) ongoing noxious weed inventory and treatment across all four fires. Additionally, sagebrush restoration was recommended on the Telegraph Fire because it would improve habitat value in proximity to an active sage-grouse lek, and it would provide some habitat connectivity across the burned area. A total of 41,300 sagebrush seedlings were planted in the Telegraph Fire footprint in October 2022.

The Sheep Fire burned more than 40,000 ha (98,842 ac) of land on the INL Site in July 2019. Under the direction of the WFMC, several restoration efforts outlined in the Sheep Fire Ecological Resources Post-Fire Recovery Plan (Forman et al. 2020) were completed. Soil stabilization efforts were finished on the Sheep Fire containment lines in 2020, and the WFMC prioritized additional restoration/treatment actions within two post-fire recovery objectives: noxious weed/cheatgrass control and big sagebrush habitat restoration. Noxious weed treatment continued throughout the Sheep Fire footprint in 2022. Cheatgrass treatments were completed adjacent to approximately 13.7 km (8.5 mi) of a two-track road in 2021 and was revisited to assess treatment efficacy in 2022. DOE-ID and agency stakeholders collaborated to seed sagebrush on portions of the Sheep Fire during the winter of 2019/2020. The seeding was completed across a target area of approximately 10,100 ha (25,000 ac) in and adjacent to the SGCA. Because of poor initial germination and establishment from the aerial seeding, a total of 45,000 seedlings were planted in the Sheep Fire in October 2021, and an additional 45,000 seedlings were planted in October 2022. Except for ongoing noxious weed treatment, all post-fire recovery activities prioritized by the WFMC for the Sheep Fire were completed by the end of fiscal year (FY) 2022.

Emergency wildland fire response and associated soil stabilization actions are addressed in the INL Wildland Fire EA (DOE 2003). Because there have been changes in fire frequency and land cover over the past twenty years, updates to the wildland fire management and recovery plans are necessary. The INL contractor is currently in the process of updating wildland fire management plans and the framework for post-fire recovery plans. These updates are based on the recommendations by the WFMC after the Sheep Fire and the 2020 fires. DOE will perform the necessary NEPA analysis to assess any potential impacts attributed to the implementation of updated plans. Updated plans and additional NEPA analysis will facilitate a more comprehensive and effective response to wildland fire management and post-fire restoration in the future.

9.4.2 Restoration and Revegetation

9.4.2.1 Revegetation for Soil Stabilization

Revegetation with native species is required on the INL Site for activities that disturb or remove soil and vegetation where the area will not be physically stabilized and maintained as sterile. These areas are left exposed and vulnerable to erosion and invasive or noxious weed infestation. Areas requiring revegetation are evaluated for appropriate revegetation methods based on site condition and disturbance size. The baseline condition of areas that may be disturbed are characterized prior to disturbance, partly to assess the native species present. The native species observed inform an appropriate seed mix that is to be used during revegetation efforts following the disturbance. Revegetation strategies on the INL Site include but are not limited to hand broadcasting seed, seedbed preparation, soil augmentation, drill seeding, and planting nursery stock.

In 2022, one revegetation project was initiated by INL's Facility and Site Services on approximately 0.13 ha (0.33 ac) to address soil stabilization. The project occurred in disturbed areas containing little to no vegetation along a recently built power line. Initial germination and establishment of native grass seed that was hand broadcast and raked in will be assessed in 2023.

Revegetation projects on the INL Site are revisited at least one growing season after the revegetation attempt, and revegetation assessments involve a two-step process to monitor success and determine if further actions need to be taken. The first step includes collecting qualitative data to provide a rapid assessment of the area. This initial assessment is used to determine if a more rigorous quantitative assessment is warranted or if the revegetation actions are obviously unsuccessful and further revegetation actions are needed. The second step is a quantitative assessment, which is used to assess the ground cover by species of the revegetated area for comparison to the background vegetative cover of the surrounding plant community. Revegetation is considered successful if the vegetative cover of desirable species is within an acceptable threshold of background values.

There were three revegetation projects evaluated in 2022 with an initial qualitative assessment. The first revegetation project was for an area used for road improvements along Nile Avenue near Test Area North (TAN) and the Specific Manufacturing Capability facility. The initial assessment of this area indicated that vegetative cover was sparse, and the area has continued to be utilized for staging by multiple projects in the vicinity. Efforts to maintain the area as a stabilized and sterilized construction laydown area would be a better use of resources than continued revegetation efforts, and it would prevent the establishment of additional staging areas in previously undisturbed vegetation. The second project was for revegetation on an area where excess soil was placed at TAN in support of the TAN Fire and Potable Water Line Replacement project. The initial assessment of this area indicated that vegetative cover was sparse and patchy, and the most abundant plant species were undesirable, introduced species. It was recommended a new revegetation plan be developed and implemented for this area. The third project was the revegetation of disturbed areas in support of the construction and operation of a Remote-Handled Low-Level waste disposal facility project. This project was revegetated in the 2016–2017 timeframe, but the 2022 assessment was the first assessment completed for the area. This initial qualitative assessment indicated there was a reasonable diversity of native species, and they were well distributed across the revegetation area. There were no further revegetation actions recommended at the time, and the quantitative second step in assessing this project shall be conducted to evaluate progress toward background conditions.

9.4.2.2 Sagebrush Habitat Restoration

Sagebrush habitat restoration on the INL Site is conducted in response to DOE-ID's goal of no net loss of sagebrush. The potential to lose sagebrush habitat on the INL Site occurs in two instances. The first is due to wildland fire, as discussed in Section 9.4.1, which has the potential to remove large tracts of sagebrush habitat and can take more than 100 years to recover naturally (Blew and Forman 2010). The second instance where sagebrush habitat is lost is due to infrastructure expansion and mission critical project activities. The INL contractor implements multiple BMPs to minimize sagebrush habitat loss, such as co-locating infrastructure, but in some cases, removal of sagebrush habitat is necessary to support the INL mission. The INL contractor carries out a compensatory sagebrush mitigation strategy for projects that must remove sagebrush habitat. This strategy outlines an approach for projects to provide funds for sagebrush to be restored in designated priority areas where they can provide the greatest habitat benefit.

Sagebrush habitat restoration has been conducted using containerized sagebrush seedlings (Figure 9-5) and aerially applying sagebrush seed. Due to the semiarid nature of the local ecosystem, the INL contractor has found that planting sagebrush seedlings results in higher survivorship than trying to establish sagebrush from seed. Therefore, current efforts focus on containerized planting, but DOE-ID and the INL contractor continue to partner with agencies to test and develop additional planting methods.

Figure 9-5. Planters using hoedads to install big sagebrush seedlings onsite.

In 2022 a total of 100,000 sagebrush seedlings were planted. The seedlings were distributed as follows: 45,000 sagebrush seedlings were planted in the Sheep Fire burned area, 41,300 sagebrush seedlings were planted in the Telegraph Fire burned area, and 13,700 seedlings were planted in the Twin Buttes Fire and Middle Butte Fire burned areas. The areas planted in the Sheep and Telegraph Fires were to address fire recovery priorities for those areas, and the planting in the Twin Buttes and Middle Butte Fires were to provide compensatory mitigation for infrastructure development. As a result of sagebrush habitat restoration on the INL Site since 2015, 255,750 sagebrush seedlings have been planted across 988.7 ha (2,443.1 ac). Seedlings planted on the INL Site are monitored one year and five years after planting to assess survivorship, and planting strategies are adjusted according to past survivorship data.

9.4.3 Weed Management

The INL contractor maintains and funds a noxious and invasive weed management program to address requirements of federal agencies described in *EO 13112, Invasive Species*, as amended by EO 13751, *Safeguarding the Nation from the Impacts of Invasive Species.* The Noxious and Invasive Weed Species Management program on the INL Site fulfills these requirements by first ensuring that prevention of the introduction, establishment, and spread of invasive species is prioritized during all activities. The risks from noxious weeds and invasive species are also minimized by discouraging unnecessary actions that can create spreading vectors or new introductions. Another strategy the INL contractor uses to prevent the introduction of noxious weeds to unaffected areas is focusing treatment efforts along potential vectors such as perimeter roads, along highways, interior two-track roads, and within facility footprints.

Trained INL Applicators can detect, identify, mark, and in most cases, treat invasive weed species quickly in cooperation with the Natural Resource Group. Each time noxious and invasive weeds are encountered, INL Applicators use integrated pest management principles that determine whether treatment actions are required and what type of treatment is needed (biological, cultural, physical, mechanical, or chemical). Noxious weed species and invasive species are typically treated differently from one another on the INL Site. INL Applicators generally treat noxious weeds with pesticide application when the pesticide label allows but, in some cases, certain species are treated using manual or mechanical treatments. Most treatments targeting invasive species without a noxious weed designation take place in the form of mechanical removal such as mowing or trimming. These treatments are often conducted for defensible space around infrastructure. In some cases, following the removal of large infestations of noxious weeds, the INL contractor will revegetate the area with appropriate native species to prevent invasive weeds from returning and promote soil stabilization.

INL Applicators are also able to monitor known noxious weed and invasive species locations along with any treatments conducted. This capability allows INL Applicators to understand where, how, and which noxious weeds are spreading on the INL Site so they can more effectively allocate time and resources. This information can be used to determine if additional treatments are necessary and identify which treatment methods can be applied to achieve greater control and to ensure they are the most effective, cost-efficient, and present little to no risk to people or the environment.

Along with directly targeting and treating weeds, INL has implemented programmatic strategies to reduce the potential introduction and spread of weeds. These include both employee education and work controls. Every year employees are provided briefings and training material about how to identify, report, and minimize the spread of weeds. Work controls to limit risks of weed introduction and spread during work activities are implemented through the Biological Resource Review (BRR) process. During the BRR process, a natural resource scientist reviews and identifies projects with the potential to create weed vectors or that may require monitoring for noxious weeds and invasive species and provides strategies for addressing those concerns.

Because invasive species do not recognize ownership boundaries, INL Applicators participate in invasive species management with surrounding land management agencies and municipalities by participating in Cooperative Weed Management Area (CWMA) activities. The INL Site is located within three different CWMAs designated by the Idaho State Department of Agriculture, and CWMA activities often include joint spray days in which adjacent landowners, county employees, or federal and state employees who maintain a state of Idaho issued Pesticide Applicator License collaborate to treat large infestations. In 2022 INL Applicators attended two joint spray days hosted by regional CWMAs to treat noxious weeds in regions adjacent to INL, and INL hosted a CWMA spray day on the INL Site where Applicators treated nearly 150 acres in the Big Lost River Spreading Area that was infested mostly by leafy spurge (*Euphorbia esula*).

All pesticide applications on the INL Site are conducted in accordance with the specific pesticide label instructions in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (1996). All records associated with pesticide applications on the INL Site are kept for a minimum of three years in accordance with Idaho Administrative Procedures Act 02.03.03, "Rules Governing Pesticide and Chemigation Use and Application" (Idaho State Department of Agriculture 2022). In 2022, 1778 noxious weed observations were made, and 119 pesticide applications were conducted. Additionally, weeds were controlled via shoveling and hand-pulling when appropriate. Noxious weed species targeted and controlled in 2022 were rush skeletonweed (*Chondrilla juncea*), scotch thistle (*Onopordum acanthium*), musk thistle (*Carduus nutans*), Russian knapweed (*Acroptilon repens*), spotted knapweed (*Centaurea stoebe*), black henbane (*Hyoscyamus niger*), leafy spurge, houndstounge (*Cynnoglassum officinale*), sowthistle (*Sonchus arvensis*), and Canada thistle (*Cirsium arvense*).

9.4.4 Ecological Support for National Environmental Policy Act

Individual actions performed under Categorical Exclusions at the INL Site are addressed in Environmental Compliance Permits (ECPs). These are the lowest level of NEPA review. There were 70 new ECPs initiated in 2022. Ecological support for ECPs is carried out predominantly through Technical Point of Contact review and the BRR process for activities outside of facility footprints with the potential to disturb wildlife, vegetation, or soils. There were 25 BRRs initiated in support of ECPs in 2022. The BRR is intended to assess the biological impacts and fulfill any regulatory compliance requirements associated with the project. The first part of the BRR process is collecting a baseline condition of the project site prior to conducting activities. The second part is conducting a follow-up survey of project activities to assess project impacts. The BRR also acts as a tracking mechanism for multiple monitoring requirements that must be reported at the end of the year. Some monitoring requirements that are documented in the BRR include identifying noxious weed locations, evaluating areas requiring soil stabilization, quantifying areas where compensatory sagebrush mitigation may be required, completing nesting bird surveys, and identifying native plant species that should be used for revegetation.

9.5 INL Site Cultural Resource Management

The INL CRMO resides within the INL Management and Operating contractor, Battelle Energy Alliance. Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Provisions to protect the unique cultural resources of the land and facilities at the INL Site are included in environmental policies issued by Battelle Energy Alliance and other INL Site contractors and in company procedures that guide work completion. Cultural resource identification and evaluation studies in 2022 included archaeological field surveys, monitoring, and site updates related to INL Site project activities, and the studies supported DOE-ID in facilitating meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

9.5.1 INL Section 106 Project Reviews

During 2022, the INL CRMO reviewed approximately 500 projects under Section 106 of the National Historic Preservation Act. Increased efficiencies in the review process grew from CRMO integration into the NEPA review process via the rollout of the new Environmental Review Process system and the issuance of a Timely Order that clarified the use of exempted activities and property types. These changes to the CRMO Section 106 review process streamlined sharing project information and communication, resulting in shorter review times and integration of information required to support decisions. Approximately 200 of these Section 106 reviews were issued CRMO project numbers. Of these, three projects resulted in No Adverse Effects to historic properties and two required hold points for further review. The remainder of the projects resulted in findings of No Historic Properties Affected. Section 106 reviews that did not involve exempt activities and property types were provided to the DOE-ID Cultural Resource Coordinator for review and approval as the 36 CFR 800 agency official prior to completion of the NEPA reviews.

9.5.2 INL Section 110 Research

Cultural resource identification and evaluation studies in FY 2022 were many and varied. Class III inventories for Section 110 surveys related to areas identified by the Shoshone-Bannock Tribes and INL CRMO research interests. These interests include the acquisition of data to support the ongoing development of the Precontact Context and other active research proposals. There are currently two active multi-year Section 110 research proposals, including “Pluvial Lake Terreton: Building a Multidisciplinary Dataset to Understand Human Land Use During the Terminal Pleistocene” (INL 2017a) and “Decoding the Southern Idaho Cultural Landscape Through Volcanic Glass Source Analysis” (INL 2017b). The INL CRMO staff is coordinating these research efforts with the Shoshone-Bannock Tribes.

9.5.2.1 Precontact Context Initiation

As part of DOE-ID commitments to strengthen the INL Site historic preservation program, the INL CRMO, DOE-ID, and Shoshone-Bannock Heritage Tribal Office (HeTO) initiated efforts on the Precontact Context (PCC). Precontact refers to the period when the Shoshone and Bannock Tribes occupied North America prior to contact with Europeans and Euroamericans. The Precontact Context identifies the time span as roughly 13,000 years before the present to contact with Lewis and Clark in 1805. A draft proposal was prepared and is currently under review by the HeTO staff. The proposal includes the following themes (along with associated research questions): Shoshone and Bannock ethnohistory, changes in the landscape and environment, projectile point chronology, settlement and subsistence, volcanic glass transport and trade.

Because the INL Site only covers 569,600 acres of the ancestral territory of the Shoshone and Bannock people, it was necessary to consider cultural resources beyond those on DOE-managed lands. The draft proposal includes an 8-million-acre study area, with the understanding that this area represents only a small portion of the Shoshone and Bannock ancestral territories.

The INL CRMO and HeTO are currently in the “Assessing, Synthesizing and Identification” phase of the PCC. Given that much of the study area includes lands managed by the Idaho Falls BLM, the agency has agreed to share their existing cultural resource information and will assist in the identification process. Preliminary property types, based on previous eastern Snake River Plain research, have been refined during 2022, with guidance from HeTO staff.

During the summer of 2022, the CRMO staff, HeTO, and the BLM archaeologist rerecorded ten previously recorded precontact sites within the study area thought to represent specific property types. Most of these sites had not been visited by Shoshone-Bannock Tribal representatives before 2022. During the summer of 2023, the rerecording of other sites in the study area will continue.

Work has also been initiated on context themes, including the generation of Accelerator Mass Spectrometry assays to refine the eastern Snake River Plain point chronology and characterize environmental changes over the past 13,000 years. Previously collected projectile points from excavated sites within the study area, including Weston Canyon Rock Shelter, Jackknife Cave, the Wasden Site, and the Birch Creek Rock Shelters, have been analyzed via X-ray Fluorescence Spectroscopy (XRF). These efforts will continue into 2023 and involve XRF analysis of existing surface collections from the study area.

Assignment of property types in the PCC geospatial database will take place in 2023. Once this task is complete, the INL CRMO and HeTO staff will work to characterize the locational patterns of property types and characterize the current condition of property types. This task will assist in defining physical integrity guidelines and provide the necessary information for evaluating National Register eligibility.

9.5.2.2 Owl Cave Research

To better understand the Shoshone and Bannock peoples' use of the landscape within the Pioneer Basin, the physiographic region encompassing the INL Site, INL CRMO archaeologist graduate interns began investigations at the oldest and only stratigraphic site in the region. Working in conjunction with Museum of Idaho collection managers, INL researchers inventoried and classified the entire stone tool collection for the purpose of establishing the collection's extent and potential for future research. In addition to organizing lithic artifacts, INL researchers reviewed and digitized notes on features, units, and layers to evaluate the potential for undisturbed stratigraphic sections of the site, resulting in a three-dimensional model of excavations, artifacts, and features at Owl Cave. Finally, a selection of obsidian stone tools of differing functional type and stratigraphic context were subjected to X-ray fluorescence analysis. The results of all these efforts will be published in a peer-reviewed journal article in 2023.

9.5.2.3 Decoding the Southern Idaho Cultural Landscape Through Volcanic Glass Source Analysis

Over the past two years, researchers at the INL CRMO and HeTO have undertaken a massive, collaborative study of obsidian source use on the Upper Snake River Plain to understand how mobility, trade, and lithic resource use may have changed over time. By comparing the trace-element composition of obsidian artifacts to a comprehensive reference collection of geologic obsidian from across the state, archaeologists at the CRMO can determine the provenance or "source" of each artifact. Drawing on legacy collections of artifacts held at the Idaho Museum of Natural History (IMNH), CRMO and HeTO staff have thus far selected over 1,200 temporally diagnostic obsidian projectile points for non-destructive analysis via XRF at the CRMO lab. Combined with data from prior analyses of early projectile point types found in association with Lake Terreton, a large Late Pleistocene lake that once covered much of the INL Site, the data will provide a rich new source of information on how the changing environment of the eastern Snake River Plain conditioned patterns of landscape use and subsistence over the past 13,000 years. Development of the CRMO Idaho obsidian reference collection was made possible through a Memorandum of Understanding between DOE-ID, the BLM, and the United States Forest Service. Analysis of collections held at the IMNH was permitted by the IMNH as well as DOE-ID and the BLM and in coordination with the Shoshone-Bannock Tribes.

9.5.2.4 Built Environment Comprehensive Inventory

In 2021, the INL CRMO contracted the Center for the Environmental Management of Military Lands (CEMML), housed at Colorado State University, to complete a comprehensive survey of built environment resources at the INL Site constructed prior to 1980. While select INL Site campuses were surveyed in the late 1990s, those records did not capture the necessary depth of detail to provide sound evaluations of eligibility for the National Register of Historic Places. As the years passed, additional resources have reached 50 years of age, a requirement for listing on the National Register of Historic Places. For the past two decades, historic-age resources were surveyed on a project-by-project basis only. CEMML's comprehensive inventory will provide both an up-to-date record of historic-age built resources across the INL Site and a planning document for future growth. During 2022, CEMML completed draft reports and site forms for Central Facilities Area, Critical Infrastructure Test Range Complex, Materials and Fuels Complex, Idaho Nuclear Technology and Engineering Center, and Advanced Test Reactor Complex. INL CRMO architectural historians reviewed the drafts and provided comments before submitting the reports to DOE-ID and Idaho State Historic Preservation Office for review. Final comments and concurrence are expected during 2023.

To support the needs of the evolving INL Site campuses, the INL CRMO continued updating the Historic and Post-World War II Contexts to provide a fuller understanding of the human history of what would become the INL Site and to better situate the resources preserved within their temporal and thematic contexts.

9.5.3 Cultural Resource Monitoring

Field work in 2022 also included a broad, annual program involving routine visits to monitor current conditions at select previously recorded archaeological resources across the INL Site. In 2022, INL CRMO, Shoshone-Bannock Tribes HeTO, and DOE-ID staff monitored site conditions at seven locations on the INL Site. The data acquired during the 2022 monitoring efforts of these sites allowed for a complete evaluation of their current condition as compared to previous recordings. No impact to historic properties were observed during these monitoring visits in 2022. Based on prior monitoring efforts, stabilization and restoration activities at three sites occurred within 2022. One such activity included the replacement of a fence designed to protect the area from unauthorized use. Furthermore, weed control was completed at two sites to enable appropriate site conditions to preserve cultural resources.

9.5.4 Stakeholder, Tribal, Public, and Professional Outreach

In 2022, the CRMO staff continued public outreach, combining virtual opportunities to expand reach and accommodate schedules with in-person meetings and site visits as COVID-19 restrictions eased. Educational exhibits at the Experimental Breeder Reactor I (EBR-I) National Historic Landmark within the boundaries of the INL Site are important tools for public outreach, and in-person employee and public tours resumed during the summer of 2022. There was a total of 9,164 visitors in 2022. Even with the resumption of in-person tours, EBR-I has maintained the infrastructure necessary for self-guided tours of the facility available through a free app. Following the success of the virtual tours of the EBR-I museum, the INL CRMO developed and conducted three virtual archaeology tours for over 100 INL employees and members of the public. These tours included discussions of DOE-ID’s archaeological responsibilities, eastern Idaho precontact history, and specific examples of historic sites and nuclear history at the INL Site.

In addition to tours, INL CRMO archaeologists visited three local schools to give presentations on archaeology in southern Idaho, reaching over 200 hundred elementary, middle, and high school students. CRMO staff also assisted the Shoshone-Bannock HeTO with a presentation on cultural resource management to about 30 students at the Shoshone-Bannock Junior-Senior High School and presented a lecture to a group of students attending the Pacific Northwest Historic Preservation Field School.

DOE-ID and CRMO staff hosted the Idaho State Historical Society Board of Trustees and members of Idaho State Historic Preservation Office (SHPO) at INL. The meetings consisted of presentations from Suzann Henrikson (CRMO) and Taylor Haskett (Shoshone-Bannock Tribes) on precontact archaeology of INL. Jon Grams (CRMO) and Shelly Norman (Tours) discussed the reactors’ history at the INL, and Tricia Canaday of Idaho SHPO and Betsy Holmes of DOE-ID discussed the importance of the consultation process and Section 106 success stories. Later, the group visited EBR-II and the original control room, and they discussed how adaptive reuse and repurposing of the structure will host new microreactors. This highlights DOE-ID’s dedication and ability to balance historic preservation and lab mission at highly scientific facilities. Eastern Idaho legislators joined the group for the afternoon tours and offered additional support of the historic reuse of these buildings. Staff also gave a presentation to local government officials focused on how INL CRMO supports INL Site missions. This included highlights on our working relationship with the Shoshone-Bannock Tribes and Idaho SHPO and a brief history of the INL Site from the precontact period to the naval and nuclear period. Approximately 12 people were in attendance.

In 2022, CRMO staff participated in a site-wide long-term stewardship tour organized by DOE-ID for environmental and cultural resource staff of the Shoshone-Bannock Tribes. The group visited Radioactive Waste Management Complex, Idaho Nuclear Technology and Engineering Center, and Central Facilities Area to discuss goals and strategies for environmental remediation and monitoring at these and other INL Site Waste Area Groups. The group also stopped at important Native American sites near Radioactive Waste Management Complex and Critical Infrastructure Test Range Complex, where CRMO and HeTO staff led discussions regarding complementary efforts to preserve and protect cultural resources as an aspect of long-term stewardship of the INL desert Site.

On April 22, 2022, the Shoshone-Bannock Tribes held an Earth Day celebration for students from the Shoshone-Bannock Junior-Senior High School at the INL Site. The event was organized by the Shoshone-Bannock Heritage Tribal Office and the INL K-12 Science, Technology, Engineering, and Mathematics (STEM) Education Program with logistical support from the CRMO, INL Facilities and Site Services, and the INL Fire Department. Activities included a morning visit to Middle Butte cave followed by a ceremony at Central Facilities Area. Over sixty students were able to visit Middle Butte cave, where tribal elder Darrell Shay, Fort Hall Business Council member Ladd Edmo, and HeTO staff underscored the enduring importance of the cave and other lands of the INL Site to the Shoshone-Bannock Tribes. In the afternoon, a ceremony and demonstration of traditional dances were held at Central Facilities Area. In addition to the students, the event was attended by members of the Fort Hall Business Council, senior leadership and staff from DOE-ID and BEA, and HeTO staff.

The CRMO staff continue to support the DOE-ID with the Shoshone-Bannock relationship by supporting and facilitating attendance at Language and Cultural Committee Meetings, Cultural Resource Working Group Meetings, and an annual update to the Fort Hall Business Council.

9.5.5 INL Archives and Special Collections

During 2022, the INL Archives and Special Collections retained one full-time intern and added a second to assist the INL archivist. Together, archives staff completed the scanning, editing, and metadata entry for 3,535 large format architectural drawings, photographs, and slides requested by CEMML. Furthermore, archives staff completed 16 accessions for the INL Archives and Special Collections, including 1,171 architectural and engineering drawings, 960 archival photographs, 378 INL specific booklets and articles, 5 maps, 44 slides, and 13 archival objects, including the original wooden Zero Power Plutonium Reactor road sign, which was autographed by the scientists.

Archives staff also completed five itemized inventories of 2,337 contractor newsletters (1968–1999), historical publications, external news publications (1989–1999), EBR-I visitor logbooks (1989–2006), Stationary Low-Power Plant Number 1 newspaper clippings, reports, booklets, factsheets, journal articles, correspondence, historical photographs, area plot plans, contractor magazines, leaflets, books, engineering drawings, compact disks, video home system tapes, film reel, slides, pamphlets, brochure, newsletters, project plan, photograph narrative sheets, and negatives (1956–2005). Repairs were completed for 70 damaged architectural drawings.

Archives staff surveyed all institutional objects at West One and updated the Special Collections inventory with photographs of the items and INL property numbers for each. Metadata for more than 6,000 inventoried architectural and engineering drawings was standardized.

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Chapter 10: Quality Assurance of Environmental Surveillance Programs

CHAPTER 10

Quality assurance (QA) consists of planned and systematic activities that give confidence in effluent monitoring and environmental surveillance programs results (NCRP 2012). Environmental surveillance programs should provide data of known quality for assessments and decision making. QA and quality control (QC) programs were maintained by Idaho National Laboratory (INL) contractors and laboratories performing environmental analyses.

GEL and Southwest Research Institute laboratories were rigorously assessed and audited in 2022 by the U.S. Department of Energy Consolidated Audit Program-Accreditation Program (DOECAP-AP), an approved third-party accrediting body. ALS-Fort Collins decided not to continue with the DOECAP-AP audit for 2022. Idaho State University's Environmental Assessment Laboratory and the Prime Laboratory are listed in their respective environmental program's approved vendor lists.

In 2022, GEL, Southwest Research Institute, ALS, and Idaho State University's Environmental Assessment Laboratory (ISU-EAL) participated in the Mixed Analyte Performance Evaluation Program (MAPEP) (performance test [PT] samples). Results are presented in Section 10.3.1.

In 2022, the environmental surveillance programs sent QC samples to the laboratories for the purpose of demonstrating that a laboratory can successfully analyze samples within performance criteria, as specified in respective contractor quality project plans. Results are summarized in Section 10.3.2. Data quality reviews were performed by the laboratories and any unusual conditions were addressed, identified, and, when necessary, corrective actions were prepared to improve processes.

The multifaceted approach to QA and QC used by the INL contractors provide confidence that all laboratory data reported for 2022 are reliable and of acceptable quality.

10. QUALITY ASSURANCE OF ENVIRONMENTAL SURVEILLANCE PROGRAMS

This chapter describes specific measures taken to ensure adequate data quality and summarizes performance.

10.1 Quality Assurance Policy and Requirements

The primary policy, requirements, and responsibilities for ensuring QA in U.S. Department of Energy (DOE) activities are provided in the following resources:

- DOE O 414.1D, Chg 2 (LtdChg), "Quality Assurance"
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- U.S. Environmental Protection Agency (EPA) QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objective (DQO) Process*
- EPA Intergovernmental Data Quality Task Force, *Uniform Federal Policy for Implementing Quality Systems: Evaluating, Assessing, and Documenting Environmental Data Collection/Use and Technology Programs* (EPA 2005)

- American Society of Mechanical Engineers NQA-1-2012, *Quality Assurance Requirement for Nuclear Facility Applications*.

These regulations specify 10 criteria of a quality program (presented in the gray text box). Additional QA program requirements in 40 CFR 61, Appendix B, Method 114, must be met for all new point sources of radiological air emissions, as required by 40 CFR 61, Subpart H.

Each INL Site contractor incorporates appropriate QA requirements to ensure that environmental samples are representative and complete and that data are reliable and defensible.

Required Criteria of a Quality Program

- Quality assurance program
- Personnel training and qualification
- Quality improvement process
- Documents and records
- Established work processes
- Established standards for design and verification
- Established procurement requirements
- Inspection and acceptance testing
- Management assessment
- Independent assessment

10.2 Program Elements and Supporting QA Process

According to the National Council on Radiation Protection and Measurements (NCRP 2012), QA is an integral part of every aspect of an environmental surveillance 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 surveillance process can lead to the misinterpretation of data and errors in decisions based on the 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.

Meeting requirements of state regulations, EPA, and DOE orders are an important part of developing a successful and defensible environmental sampling surveillance program. Gathering quantitative and qualitative environmental surveillance data is unique to each surveillance program. All data from planning, sample collection and handling, sample analysis, data review and evaluation, and reporting is accurate, precise, complete, and representative to ensure defensibility. Approved, detailed procedures are maintained, adequate training is given, and documents are controlled by the INL contractors and analytical laboratories to ensure that data are of acceptable precision and accuracy.

The main elements of environmental surveillance programs implemented at the INL Site as well as the QA processes/activities that support them are shown in Figure 10-1 and discussed below.

10.2.1 Planning

Environmental surveillance activities are conducted by the following:

- INL contractor
- Idaho Cleanup Project (ICP) contractor
- U.S. Geological Survey (USGS).

Each INL Site contractor determines sampling requirements using the EPA 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.

Sitewide Monitoring Plans. The *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021) summarize the various monitoring programs at the INL Site, including surveillance monitoring for air, water (surface, drinking, and ground), soil, biota, agricultural products, external radiation, ecological, and meteorological monitoring on and near the INL Site; and surveillance/compliance monitoring for effluent on the INL Site. The plans include the rationale for monitoring, the types of media monitored, where the monitoring is conducted, and information regarding access to analytical results.

QA Project Plan. Implementation of QA elements for sample collection and data assessment activities are documented by each INL Site contractor using EPA's recommended approach. 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*. DQOs are project-dependent and are determined based on the needs of the data users' and the purpose for which data are generated. DQOs, sampling and analysis plans, and

Technical Basis for Environmental Monitoring and Surveillance at the INL Site (DOE/ID-11485) are integrated into the INL Site contractors QA project plans. Quality elements applicable to environmental surveillance and decision making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans* (EPA 2001).

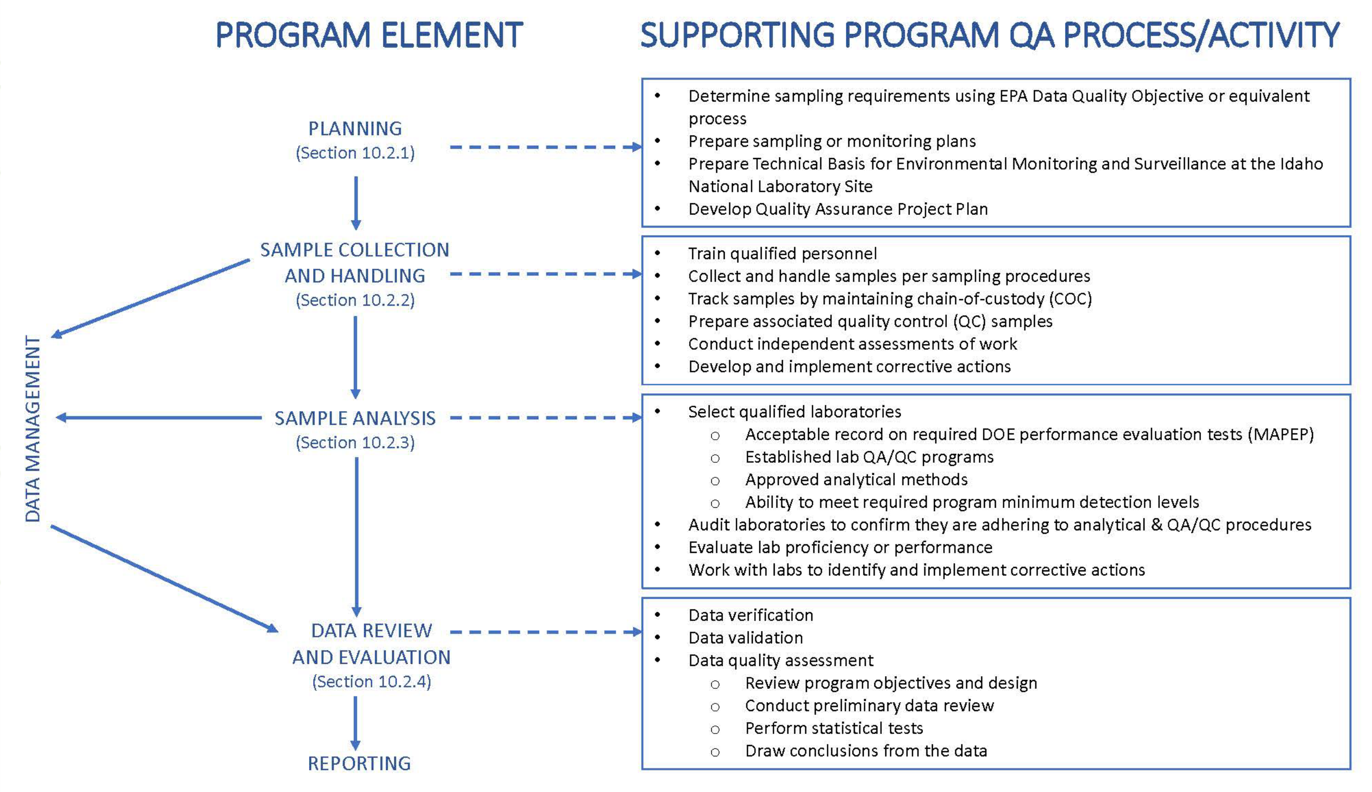

Figure 10-1. Flow of environmental surveillance program elements and associated QA processes and activities.

A QA project plan serves to ensure that all data collected are of known and defensible quality and meet the requirements of all applicable federal and state regulations and DOE orders. These plans include the following:

- INL contractor
  - *Environmental Monitoring Services Quality Assurance Project Plan* (PLN-6690)
  - *Quality Assurance Program Description* (PDD-13000)
- ICP contractor
  - *Quality Assurance Project Plan* (PLN-5199)
- USGS
  - *Field Methods, Quality Assurance, and Data Management Plan for Water-Quality Activities and Water-Level Measurements, INL, Idaho* (DOE/ID-22253).

10.2.2 Sample Collection and Handling

Defensible laboratory data is a critical component of any environmental program. Field sample collection and handling coupled with a chain-of-custody that shows unique sample identification, weight, sample preservation, volume, holding time, approved procedures, and request of laboratory analysis are important steps of good defensible quality data.

Strict adherence to program procedures is an implicit foundation of QA. In 2022, samples were collected and handled by trained personnel according to documented program procedures. Sample integrity was maintained through a system of sample custody records. Work execution assessments were routinely conducted by personnel independent of the work activity. Deficiencies were addressed by follow-up and corrective actions. Quality assessments are tracked in contractor-maintained systems.

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.

QC sampling elements, as shown in Figure 10-2, are used by the contractor to validate the collection process and verify the quality of laboratory preparation and analysis. These included the collection of trip blanks, field blanks, equipment blanks, split samples, sample duplicates, and PE samples.

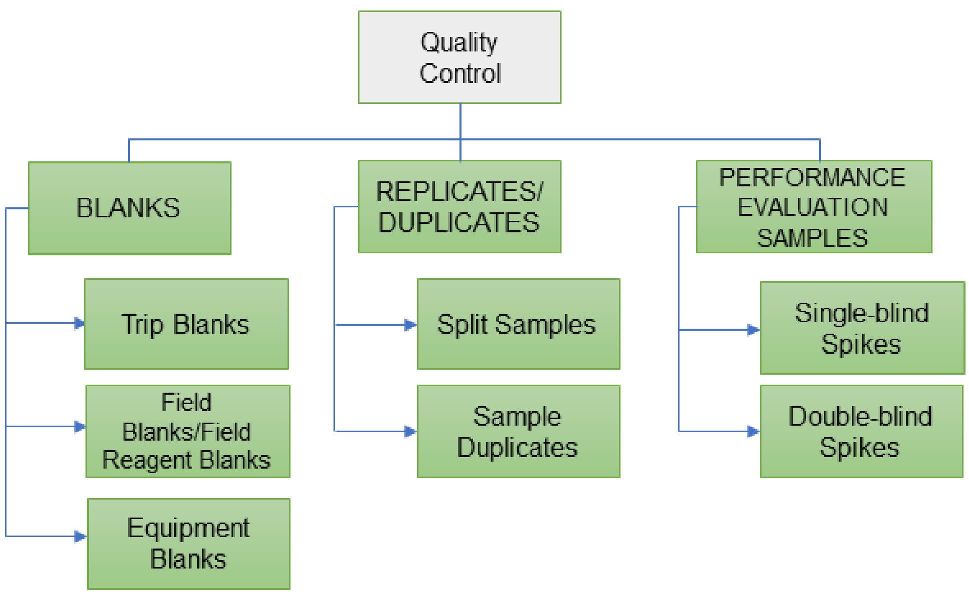

Figure 10-2. QC sampling elements.

10.2.3 Sample Analysis

Laboratories used for routine analyses of radionuclides in environmental media were selected by INL contractors based on each laboratory's capabilities to meet program objectives, such as the ability to meet required detection levels, and past results in PT programs. 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 DOECAP-AP, accredits laboratories in meeting the requirements outlined in the Quality System Manual (QSM 2021). No major findings were identified by DOECAP-AP for GEL Laboratory and Southwest Research Institute (SwRI) Laboratory that would influence the defensibility or quality of laboratory data in 2022. ALS Laboratory closed in 2022 and will not be participating in the DOECAP-AP.

For more information on DOECAP-AP, visit the DOE Analytical Services Program webpage at www.energy.gov/ehss/analytical-services-program.

Laboratory data quality is continually verified by QC samples, as observed in Figure 10-3, and includes calibration verifications, blanks, replicates/duplicates, intra-laboratory, and PT samples.

The analytical laboratory may use several of the laboratory QC measurement elements identified in Figure 10-3. Results of the laboratory QC are presented to the INL Site contractors as a data package and provide assurance that the reported data are usable and defensible.

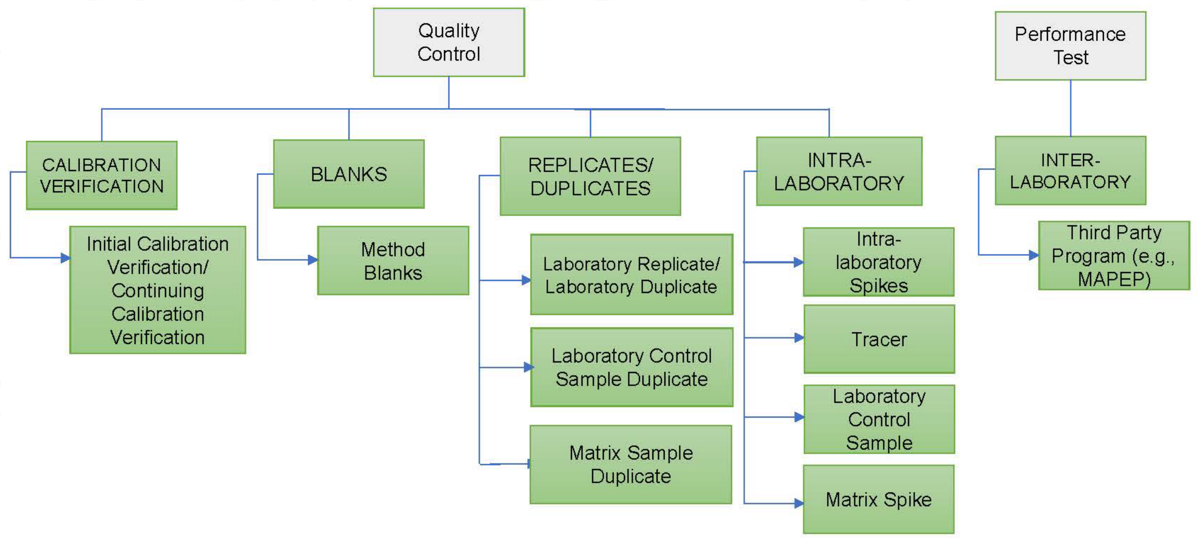

Figure 10-3. Laboratory measurement elements.

10.2.4 Data Review and Evaluation

Data INL Site contractors generate are routinely evaluated to understand and sustain the data quality. This enables the program to determine whether the DQO's established in the planning phase were achieved and whether the laboratory is performing within its 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.

The INL Site contractors send media-specific QC samples to the laboratories for the purpose of testing the laboratories' ability to successfully analyze samples within performance criteria as specified in each respective contractor quality project plans. These are compared with PT results and can provide valuable indicators that further QC testing may be required.

10.2.4.1 QC Review

Figure 10-4 shows a visual decision tree of the process used for reviewing QC sample results along with sample data from the elements listed in Figure 10-2. When QC sample results fall within the acceptable range for the INL Site contractors, review of the remaining data continues. If no issues are identified, the data package is approved. If the QC result is identified as a nonagreement, the INL Site contractor reviews all available QC data to determine the course of action needed.

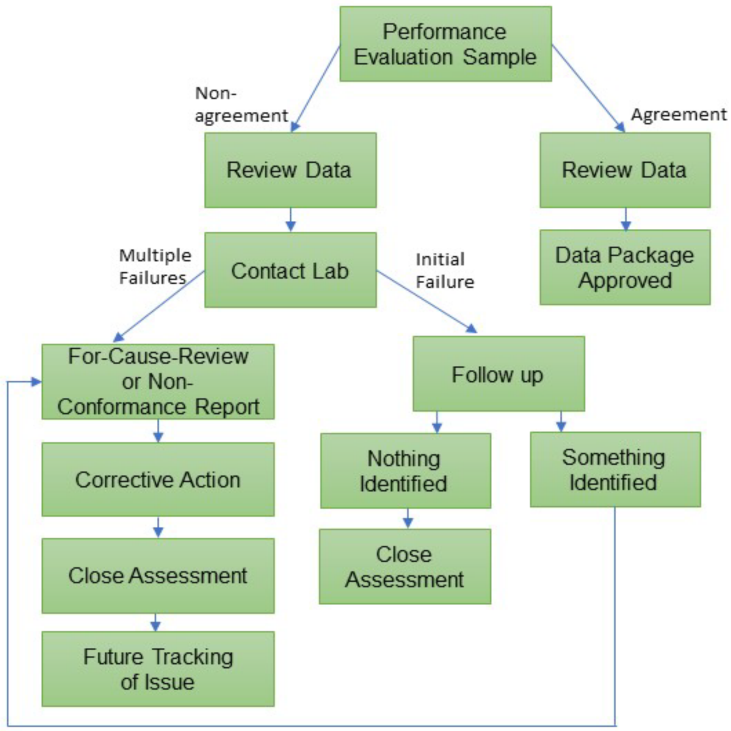

Figure 10-4. Environmental surveillance field sampling data QA review process.

A variety of items that may be considered for review include (but is not limited to) the following questions:

- Did the PE sample provider prepare the sample (single-blind or double-blind) within the range specified by their customer? If yes, begin looking into the other QC data reported by the laboratory. If not, the PE sample may not be an accurate representation of the project-specific field conditions or field results. If the equipment is calibrated for the field concentration range, and the PE sample is not within that range, then the accuracy and representativeness of the PE sample may be called into question.
- Did the laboratory perform all the required program- and method-specific QC analyses? Are these QC results within acceptable parameters?
- What does a review of the long-term project results indicate? Are all project-specific and analytic-method-specific QC results within specification? If not, does the laboratory have a history of out-of-specification QC results for a specific analyte or is the new result a one-time anomaly?

Upon review of the entire body of QC evidence, using both objective and subjective professional judgement, the INL Site contractor will determine if the nonagreement result is a one-time anomaly or if the laboratory needs to implement any “Follow up” or “Corrective Actions.”

A “For-Cause-Review” or “Non-Conformance Report” is requested when multiple blind QC sample issues occur consecutively (e.g., a nonagreement evaluation for the same radionuclide in the same matrix) or as a result of a “Follow up” action. The “For-Cause-Review” would review laboratory data to investigate anything that may have been misreported (e.g., sample units, weights, calculations), whereas a “Non-Conformance Report” would generate a more rigorous laboratory review. Both the “For-Cause-Review” and “Non-Conformance Report” could result in a “Corrective Action” being issued, which will resolve the problem and prevent future issues from occurring. Upon acceptance of the “Corrective Action,” the assessment would be closed, and the issues discussed in the “Corrective Action” will be monitored in future data packages.

A "Follow up” action occurs after a single failure and may result in the laboratory not identifying any issues leading to the nonagreement result. At this point, the data package is good defensible data if the laboratory passed all their qualifying criteria for the data package and if the following are within the laboratory quality criteria, as applicable: initial calibration verification, continuing calibration verification, method blank, laboratory control sample, matrix spike, laboratory replicate, radioactive tracer recovery, and field blank(s). If a laboratory qualifying criterion is not met, the laboratory will re-prepare and re-analyze the samples. However, if enough of a sample is not available, the laboratory may flag their data if their radioactive tracer, laboratory control sample, laboratory replicate, or matrix spike are not within their criteria. When the "Follow up" action identifies issue(s), either a "For-Cause-Review" or "Non-Conformance Report" may be requested.

If a laboratory were to have two consecutive sets of PE samples that were not within the acceptable criteria, the specific environmental laboratory project manager would be asked to demonstrate whether the issue in question was investigated, corrective measures were implemented, and additional PE samples were analyzed with results within the acceptable criteria. If the laboratory cannot identify any issues, the INL Site contractor will work with the laboratory to assist in the investigative process. For example, whether additional PE samples may be provided to the analytical laboratory to determine if any problems arise from sample preparation, data calculations, data entry into a database, etc. As a result, the laboratory will provide an acceptable "Corrective Action" to the INL Site contractor. The issue will be monitored for future PE samples. Depending on the severity, the contractor may hold onto samples until the issue is resolved and then may send a letter-of-concern to the laboratory. Based on the outcome of the investigation, the INL Site contractors may terminate the contract and seek another laboratory.

10.2.4.2 Performance Testing

The programs include results of individual program QC data as well as the MAPEP PT. Individual QC programs include the use of several elements, as shown in Figure 10-2 and Figure 10-3, respectively, to evaluate the performance of a laboratory. Not all QC measurement elements are required unless specifically called out in each INL Site contractor program's contract with the laboratory, or as required by the specific analytical method.

The MAPEP is an inter-laboratory program that uses PT evaluations to test the ability of the laboratories to correctly analyze radiological, non-radiological, stable organic, and stable inorganic constituents' representative of those at DOE sites.

The following section presents results and discussions for each environmental surveillance program's quality program.

10.3 QC and PT Sample Results

Laboratories used for routine analyses of radionuclides in environmental media were selected by each INL Site contractor based on each laboratory's capabilities to meet program objectives (such as the ability to meet required detection limits) and past results in PT programs. 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. Table 10-1 lists the analytical laboratories used by the INL Site contractors to analyze surveillance media in 2022.

Table 10-1. 2022 analytical laboratories used to analyze surveillance media.

ANALYTICAL LABORATORY	MEDIA					
	AIR	WATER	AGRICULTURAL PRODUCTS	BIOTA	ECOLOGICAL	SOIL
ALS Laboratory[a]	X[b]					
GEL Laboratories, LLC	X[b]	X[c]	X	X	X	X
ISU - EAL	X[b]	X[c]	X	X	X	X
Prime Laboratory		X				
RESL Laboratory		X				
SwRI	X					

a. ALS closed their Fort Collins location in the summer of 2022.
b. Includes atmospheric moisture.
c. Includes precipitation.

10.3.1 2022 MAPEP PT Results

In 2022, ALS, GEL Laboratories, ISU-EAL, and SwRI participated in the MAPEP PT (Series 46 and 47) program. ALS only participated in Series 46 due to their laboratory closure. Analyte nonagreement results were evaluated by the INL Site contractors based on their respective media and analyte tested. Following a similar process as identified in Figure 10-4, INL Site contractors requested reviews to be conducted by the laboratory to determine why the nonagreement occurred. MAPEP analyte results that were within criteria for the participating laboratories are presented in Figure 10-5. Two or more consecutive nonagreement MAPEP evaluations for the same radionuclide in the same matrix requiring additional review/discovery from the laboratory are indicated in footnotes in Figure 10-5, with a numbered list detailing the review/discovery below the figure. The results were then compared with the INL contractors' internal QC results. PT results for the water, air filter, and produce were acceptable; therefore, future MAPEP results will continue to be monitored and evaluated.

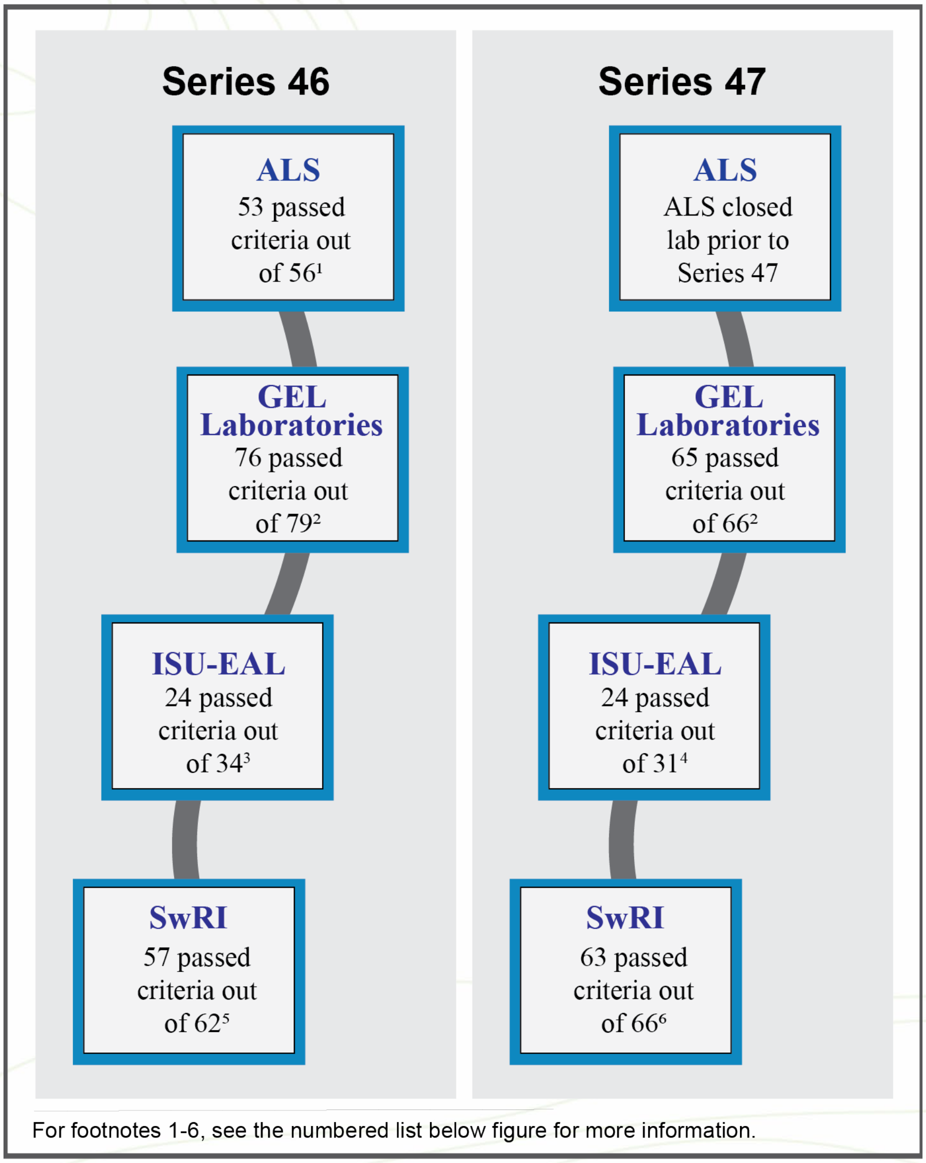

Figure 10-5. 2022 MAPEP PT analyte performance.

1. ALS received nonagreement evaluations for several matrices and radioanalytes that were a single event and does not require additional review/discovery.
2. GEL received nonagreement evaluations for several matrices and radioanalytes that were a single event and does not require additional review/discovery.
3. ISU-EAL received nonagreement evaluations for several matrices and radioanalytes of interest in the MAPEP Series 46. The matrices and respective radioanalytes include air filter (^{57}Co), soil (^{57}Co), water (^{57}Co, ^{54}Mn, ^{3}H, and ^{40}K), and vegetation (^{60}Co).

   ISU-EAL identified a few issues in the MAPEP Series 46: (1) a reporting issue with false negatives, (2) incorrect entry of the reference date, and (3) miscalculation of uncertainty values. The "Corrective Action" was to provide laboratory additional training with respect to calculating, analyzing, and reporting results to the MAPEP Program. ISU-EAL performance will be monitored for future MAPEP PT program samples to identify consecutive nonagreement evaluations.

4. ISU-EAL received nonagreement evaluations for several matrices and radioanalytes of interest in the MAPEP Series 47. The matrices and respective radioanalytes include air filter (^{65}Zn), soil (^{60}Co, ^{65}Zn), water (tritium), and vegetation (^{137}Cs, ^{57}Co, ^{60}Co).

   A review of the evaluation results for Series 47 identified potential trends with a few matrices/analytes not meeting the acceptable criteria. As a result, a request was submitted to ISU-EAL to perform a “For-Cause-Review.” The ISU-EAL addressed the “For-Cause-Review” and identified a few issues in the MAPEP Series 47: (1) reporting issue with false negatives, (2) selection of incorrect sample geometry, and (3) not following protocol for reporting results to MAPEP. The “Corrective Actions” included: posting a copy of the analysis protocol with a follow up discussion of the importance of following the protocol, and a visit to the laboratory from the MAPEP program personnel to provide additional training on the MAPEP process. ISU-EAL performance will be monitored for future trends.

5. SwRI received nonagreement evaluations for several matrices and radioanalytes of interest in the MAPEP Series 46. The matrices and respective radioanalytes include air filter (gross alpha, ^{90}Sr), soil (^{65}Zn), water (^{226}Ra), and vegetation (^{234}U). Sample matrices and analytes will be followed for future trending.
6. SwRI received nonagreement evaluations for several matrices and radioanalytes of interest in the MAPEP Series 47. The matrices and respective radioanalytes include soil (^{241}Am, and ^{63}Ni), and water (^{90}Sr). Sample matrices and analytes will be followed for future trending.

10.3.2 2022 Field QC Elements

Field QC samples are sent to the laboratories along with routine environmental samples to be analyzed in tandem. The samples are prepared in a way that the QC samples are analogous to the field samples. The laboratory is not aware of which samples are blanks, duplicates or PE samples. PE samples can be either a single-blind or a double-blind sample. A PE sample activity known by the INL contractor but not the analytical laboratory is called a single-blind PE sample; whereas a PE sample where the activity is unknown to both the INL contractor and the analytical laboratory is a double-blind PE sample. The laboratory is being evaluated on these samples to determine laboratory capabilities. Discussions of results and any unexpected results are discussed in the following sections.

10.3.2.1 INL Contractor QC Results

In 2022, the INL contractor used ALS, GEL, and ISU-EAL laboratories to provide analytical results for air (air filters, quarterly composites, and charcoal cartridges), atmospheric moisture, precipitation, drinking water, surface water, effluents, groundwater, milk, produce (i.e., alfalfa, lettuce, potato, wheat), big game, soil, and bats. Figure 10-6 presents the results for the laboratories with corresponding numbered list (below the figure) to provide additional information regarding items of concern to the INL contractor. Criteria for these results are identified in quality assurance project plans. The process identified in Figure 10-4 was followed, issues of concern were evaluated, and assessments were conducted on data usability. The 2022 QC results for the INL contractor indicate that the data is reliable and of acceptable quality.

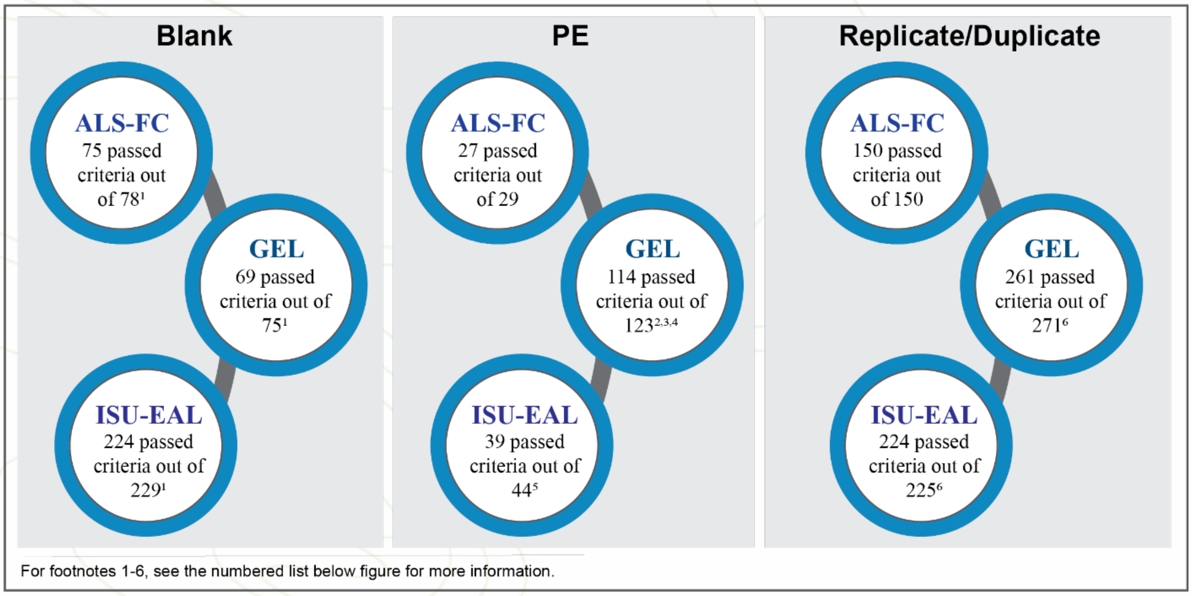

Figure 10-6. INL contractor 2022 QC analyte results.

1. The objective of the INL contractor sending blanks to the laboratories was to show acceptable laboratory precision. The QA program establishes that sample results should agree within 3σ of zero for 98% of samples submitted. ALS and ISU-EAL met this criterion in 2022. GEL did not meet this 2022 criterion, mainly caused by gross beta analysis of blanks. Some possible causes for this could be long laboratory count time and/or blank correction. GEL will be monitored to meet future expectations for blank sample criteria.

2. A total of 36 analytes for various media were analyzed by GEL Laboratories in 2022. GEL received a nonagreement for ^{90}Sr in lettuce and ^{57}Co and ^{54}Mn in soil. GEL was informed of the nonagreement and performed additional review/discovery.

   The laboratory determined that a fraction of the lettuce sample was used for analysis instead of the entire sample. Since the distribution of ^{90}Sr was not homogenous in the sample, a note was included on the chain of custody to use the entire sample. The fraction of sample used for analysis did not contain any of the ^{90}Sr resulting in a statistically zero value. GEL added additional comments for the project to prevent a similar incident from happening in the future.

   The two nonagreements for ^{57}Co and ^{54}Mn in soil were reviewed and the lab determined the issue was due to the relatively short half-lives of the radionuclides, and the amount of time elapsed between the sample collection date and the known activity reference date. Reviews were conducted for the previous soil PE samples and the two MAPEP series for 2022. GEL received agreement evaluations for the two analytes. Since two or more consecutive nonagreement evaluations were not identified, the INL contractor will continue to monitor GEL's performance on these analytes in the future.

3. In 2022, the INL contractor requested an internal evaluation to be performed due to GEL Laboratories, LLC receiving nonagreement for ^{90}Sr analysis of air filter composite samples for consecutive PE samples. As part of the evaluation, the INL contractor requested an internal evaluation be performed and then shipped two filter sets with known activities. Results of the filter sets were within the agreement criteria. No findings were reported by GEL Laboratories, LLC; however, the laboratory concluded that an undetermined error occurred during the preparation process of the sample submitted in 2021. The INL contractor will continue to monitor GEL's performance for ^{90}Sr analysis of air filter composite samples.

4. A total of 83 effluent and groundwater PE analytes were analyzed by GEL in 2022. GEL received a nonagreement for six gamma spectrometry results, including two ^{241}Am and four ^{226}Ra. All six received a nonagreement from the

PE provider for being reported by GEL as non-detected results. Americium-241 and ^{226}Ra are primarily alpha radiation emitters. Gamma spectrometry results for ^{241}Am and ^{226}Ra are used as a screening tool for these specific projects where these analytes are not expected. Additional analysis of field samples for ^{241}Am and ^{226}Ra, using analyte-specific methods, can be performed if the program determines the gamma spectrometry screening results exceed certain thresholds. The thresholds were not exceeded in the associated field samples. Review of the ^{241}Am and ^{226}Ra PE results indicate the PE sample provider prepared all six PE nonagreement analytes at levels less than the contractual minimum detection limits of the laboratory; therefore, the PE provider's nonagreement conclusion (due to the lab reporting the results as non-detects) is considered correct. The 2022 PE provider's nonagreement results were submitted to GEL for evaluation. No findings or gamma spectroscopy QC deficiencies requiring corrective actions have been reported by GEL. Based on review and evaluation of all the quality data presented, the projects have determined the nonagreement conclusions for the six PE sample analytes did not affect the accuracy or defensibility of the field sample results.

5. A total of 43 analytes for various matrices were analyzed by ISU-EAL. ISU-EAL received a nonagreement for five gamma spectroscopy results. Four of the nonagreements were: ^{57}Co, ^{134}Cs, ^{54}Mn, and ^{65}Zn in milk; and one nonagreement was for ^{134}Cs in wheat.

   All four analytes in milk received a nonagreement for not reporting the results. A request to perform a "For-Cause-Review" was submitted to ISU-EAL and determined there was a breakdown in the internal communication of the positive results. The "Corrective Action" was an update to the gamma analysis procedure with an emphasis on reviewing data and communication of positive results.

   Regarding the nonagreement for ^{134}Cs in wheat, ISU-EAL determined that sample positioning on the detector for one of the analyses led to the nonagreement. ISU-EAL rejected the results from the analysis and recalculated the average value for the analyte. The updated average, when compared to the known value, met the criteria of ± 30%. The INL contractor will continue to monitor these analytes in the future.

6. The objective of the INL contractor sending replicate/duplicate samples to the laboratories was to have data close enough to conclude that there was minor sampling bias between the samplers and acceptable laboratory precision. The QA program establishes that duplicate sample results should agree within 3σ for 98% of submitted samples. In 2022 all laboratories met this criterion. The INL contractor wastewater effluent and groundwater program require 90% of duplicate pairs meet a relative percent difference of less than 35%, GEL met this criterion in 2022.

10.3.2.2 ICP Contractor QC Results

In 2022, the ICP contractor used ALS, GEL, and SwRI laboratories to provide analytical results for air and water. Figure 10-7 presents the results for the laboratories with a corresponding numbered list (below the figure) to provide additional information regarding items of concern to the ICP contractor. Criteria for these results are identified in quality assurance project plans. The process identified in Figure 10-4 was followed by ICP, issues of concern were evaluated, and assessments were conducted on data usability. The 2022 results indicate that there were no problems identified with sample collection or laboratory analysis techniques.

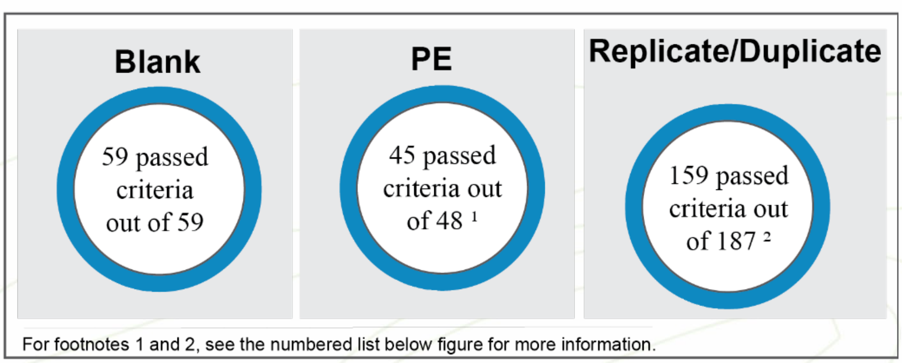

Figure 10-7. ICP contractor 2022 QC analyte results.

1. A total of 48 analytes were analyzed in 2022 for GEL Laboratories. GEL Laboratories received a nonagreement for ^{90}Sr, ^{238}Pu, and Pu for water samples in 2022. At ICP, when a laboratory has a nonagreement assigned, the Sample and Analysis Management Office informs the project managers and participating laboratories of the results and requests the laboratory to investigate. For the discrepancies in agreement for 2022, GEL investigated the results and reported back that there were no errors in GEL's processes found. When it was possible, GEL repeated the analysis during the investigation. GEL reported that for the ^{90}Sr nonagreements, one case of cross contamination was suspected due to significantly high beta activity in the analyzed batch, and in the other case, the laboratory concluded that "an indeterminate error occurred during the preparation process." In the case of ^{238}Pu and ^{239}Pu, the error was either due to an insufficient number of counts or an initial dilution or final platting issue. GEL did pass the MAPEP Series, which was conducted before and after the time these PE results were analyzed. It was concluded that methods are under control, but that GEL and the ICP contractor will continue to monitor these analytes in future evaluations.
2. In 2022, the ICP contractor requested the analysis of 134 field duplicate pairs for the environmental surveillance air program, of which 109 were determined to be acceptable. Accordingly, total precision for air samples across all projects was 81.3%, which, while lower than the previous year, is likely the result of mechanical issues that have been corrected with the air sampler at location SDA 4.3B/4.

10.3.2.3 USGS QC Results

In 2022, the USGS used RESL and Prime laboratories to provide analytical results for groundwater monitoring wells. Figure 10-8 summarizes the QC program results. A footnote is included in Figure 10-8. The 2022 results indicate that there were no problems identified with sample collection or laboratory analysis techniques.

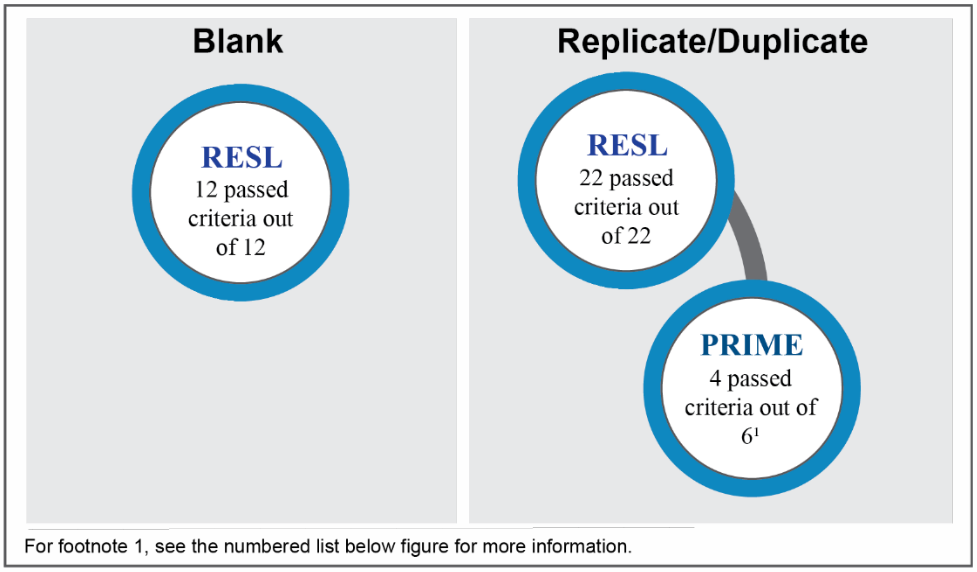

Figure 10-8. USGS 2022 QC analyte results.

1. Utilizing the process as identified in Figure 10-4, PRIME was questioned regarding results above 3σ for duplicate samples and were calculated to have a normalized absolute difference <1.96.

10.4 Conclusions

The quality elements presented in Figure 10-1 were implemented in 2022. Field sampling elements (as provided in Figure 10-2), laboratory measurements (as outlined in Figure 10-3), and QC samples were reviewed and evaluated for each INL Site contractor and are summarized in Section 10.3. It has been determined that all laboratory data presented in this report are reliable and of applicable quality.

10.5 References

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Woollypod Milkvetch

Appendix A:
Chapter 5 Addendum

Table A-1. Advanced Test Reactor Complex cold waste pond effluent permit-required monitoring results (2022).[a,b]

PARAMETER	MINIMUM	MAXIMUM	MEDIAN
pH (standard units)	6.08	7.55	6.98
Conductivity (µS/cm)	402	419	410
Chromium, filtered (mg/L)	0.003U[c]	0.00487	0.00346
Chromium, total (mg/L)	0.00324	0.00392	0.00346
Iron, filtered (mg/L)	0.033U	0.0407	0.033U
Iron, total (mg/L)	0.033U	0.0515	0.033U
Nitrate + nitrite as nitrogen (mg/L)	0.905	1.01	0.932
Solids, total dissolved (mg/L)	204	266	221
Sulfate (mg/L)	21.1	30.1	25.5J[d]

a. Reuse Permit I-161-03 does not specify maximum effluent constituent loading or concentration limits.
b. Duplicate samples collected in July 2022 are included in the statistical summary.
c. U qualifier indicates the result was below the detection limit.
d. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table A-2. Hydraulic loading rates for the Advanced Test Reactor Complex cold waste pond (2022).

	YEARLY TOTAL FLOW
2022 flow[a]	279.21 MG[b]
Annual permit limit[c]	375 MG
5-yr moving annual average permit limit	300 MG

a. Annual flow is reported for the 2022 permit reporting year. The 2022 flow is estimated due to the flowmeter failing its annual calibration in 2022.
b. MG = million gallons.
c. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1 through October 31.

Table A-3a. Advanced Test Reactor Complex cold waste pond industrial wastewater reuse permit monitoring well results (2022).[a]

WELL NAME	USGS-098 (GW-0161-01)		USGS-065 (GW-161-02)		USGS-076 (GW-161-04)		TRA-08 (GW-161-05)		MIDDLE-1823 (GW-161-06)		USGS-136 (GW-161-08)		STANDARD[b] PCS/SCS
SAMPLE DATE:	04/20/22	09/14/22	04/26/22	09/15/22	04/21/22	09/16/22	04/21/22	09/15/22	04/20/22	09/15/22	04/27/22	09/16/22	
Water table depth (ft) bls[c]	429.28	430.74	475.97	477.25	484.52	486.22	489.72	492.08	494.30	495.93	489.93	491.55	NA[d]
Water table elevation (ft)[e]	4,459.93	4,458.47	4,452.60	4,451.32	4,448.69	4,446.99	4,449.34	4,446.98	4,448.57	4,446.94	4,448.80	4,447.18	NA
Borehole correction factor (ft)[f]	2.53	2.53	NA	NA	NA	NA	0.63	0.63	NA	NA	0.22	0.22	NA
pH (s.u.)	6.74	7.39	6.53	7.34	6.25	7.88	7.04	7.47	6.87	7.25	6.85	7.48	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	398	393	611	586	428	423	414	414	431	422	449	435	NA
Temperature (ºF)	52.3	57.4	53.1	58.1	53.8	55.6	55.8	56.3	53.4	56.1	54.0	55.0	NA
Nitrite + nitrate as nitrogen (mg/L)	1.16 (1.17)[g]	1.22	1.51	1.44	1.09	1.24J[h]	1.05	1.02	1.03	1.01	1.21	1.25J	10 (PCS)
Sulfate (mg/L)	21.4 (21.4)	21.7J	136J	129	32.3	32.1J	41.7	40.9	30.6	31.0J	32.3J	31.9J	250 (SCS)
Solids, total dissolved (mg/L)	257 (256)	214	359	372	240	222	239	224	270	222	250	232	500 (SCS)
Chromium, total (mg/L)	0.00646 (0.00667)	0.00677	0.0754	0.0752	0.0103	0.0108	0.0182	0.0191	0.00955	0.00995	0.0162	0.0170	0.1 (PCS)
Chromium, filtered (mg/L)	0.00622 (0.00616)	0.00647	0.0742	0.0744	0.0108	0.0107	0.0181	0.0186	0.0099	0.00951	0.0158	0.0163	0.1 (PCS)
Iron, filtered (mg/L)	0.03U[i] (0.03U)	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)

Table A-3a. continued.

WELL NAME	USGS-098 (GW-0161-01)		USGS-065 (GW-161-02)		USGS-076 (GW-161-04)		TRA-08 (GW-161-05)		MIDDLE-1823 (GW-161-06)		USGS-136 (GW-161-08)		STANDARD[b] PCS/SCS
SAMPLE DATE:	04/20/22	09/14/22	04/26/22	09/15/22	04/21/22	09/16/22	04/21/22	09/15/22	04/20/22	09/15/22	04/27/22	09/16/22	

a. Reuse Permit I-161-03 was issued October 30, 2019.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01 a and b.

c. bls = below land 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. The borehole correction factors were determined from gyroscopic surveys conducted by U.S. Geological Survey to reconcile discrepancies in water level measurements from well deviations.

g. Results shown in parenthesis are from the field duplicate samples.

h. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

i. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit but the value is not more than 5 times the highest positive amount in any laboratory blank and is U qualified as a result of data validation.

Table A-3b. Advanced Test Reactor Complex cold waste pond industrial wastewater reuse permit monitoring well results (2022).

WELL NAME	USGS-058[a] (GW-161-07)		STANDARD (PCS/SCS)[b]
SAMPLE DATE:	04/26/22	09/26/222	
Water table depth (ft) bgs[c]	472.59	474.16	NA[d]
Water table elevation (ft)[e]	4,449.30	4,447.73	NA
Borehole correction factor (ft)[f]	NA	NA	NA
pH (s.u.)	6.77	7.65	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	473	424	NA
Temperature (°F)	53.6	54.7	NA
Solids, total dissolved (mg/L)	250	223	500 (SCS)
Sulfate (mg/L)	34.3J[g]	31.2	250 (SCS)

a. Reuse permit I-161-03 only requires water table elevation, water table depth, pH, conductivity, temperature, total dissolved solids and sulfate reported for USGS-058.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Idaho 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. The borehole correction factors were determined from gyroscopic surveys conducted by U.S. Geological Survey to reconcile discrepancies in water level measurements from well deviations.

g. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table A-4. Idaho Nuclear Technology and Engineering Center sewage treatment plant influent monitoring results at CPP-769 (2022).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Biochemical oxygen demand (5-day) (mg/L)	10.6	213	106
Nitrate + nitrite, as nitrogen (mg/L)	0.01320 U[a]	0.99	0.164
Total kjeldahl nitrogen (mg/L)	15.0	130	63.0
Total phosphorus (mg/L)	3.59	11.1	6.09
Total suspended solids (mg/L)	19.6	215	100.3

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table A-5. Idaho Nuclear Technology and Engineering Center sewage treatment plant effluent monitoring results at CPP-773 (2022).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Biochemical oxygen demand (5-day) (mg/L)	7.92 U[a]	132.0	28.6
Nitrate + nitrite, as nitrogen (mg/L)	0.00147	2.09	0.95
pH (standard units)[b]	7.52	9.91	8.54
Total coliform (MPN[c]/100 mL)[b]	55.0	2,419	1,153.2
Total kjeldahl nitrogen (mg/L)	4.00	52	23.1
Total phosphorus (mg/L)	1.40	7.0	4.22
Total suspended solids (mg/L)	1.0	61	29

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 A-6. Idaho Nuclear Technology and Engineering Center new percolation ponds effluent monitoring results at CPP-797 (2022).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Chloride (mg/L)	11.5	81.5	36.2
Chromium (mg/L)	0.00560	0.00848	0.00656
Coliform, fecal (MPN/100 mL)[a]	1	4	1
Coliform, total (MPN/100 mL)[a]	47.1	2,419.2	1,809.6
Fluoride (mg/L)	0.193	0.277	0.233
Manganese, total (mg/L)	0.00200U[b]	0.00213U	0.00201U
Nitrate + nitrite, as nitrogen (mg/L)	0.675	2.34	1.36
pH (standard units)[a]	7.05	9.64	8.39
Selenium (mg/L)	0.00150U	0.00150U	0.00150U
Total dissolved solids (mg/L)	197	326	252
Total phosphorus (mg/L)	0.413	1.070	0.837

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 A-7. Hydraulic loading rates for the Idaho Nuclear Technology and Engineering Center new percolation ponds (2022).

	MAXIMUM DAILY FLOW	YEARLY TOTAL FLOW
2022 flow	1,038,630 gallons	166,153,015 gallons
Permit limit	3,000,000 gallons	1,095 MG[a]

a. MG = million gallons.

Table A-8. Idaho Nuclear Technology and Engineering Center new percolation ponds aquifer monitoring well groundwater results (2022).

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:	04/20/22	09/20/22	04/20/22	09/20/22	04/18/22	09/19/22	
Water table depth (ft below brass cap)	508.39	509.83	514.51	516.03	506.68	509.51	NA[b]
Water table elevation (at brass cap in ft)[c]	4,447.88	4,446.44	4,447.8	4,445.81	4,448.46	4,445.63	NA
Chloride (mg/L)	30.5J[d]	30.0	17.5J[d]	16.6	9.39J[d]	10.3	250
Chromium (mg/L)	0.0153	0.00934	0.00531	0.00677	0.0107	0.0132	0.1
Coliform, fecal (MPN[e]/100 mL)	<1	<1	<1	<1	<1	<1	<1 CFU[f]/100 mL
Coliform, total (MPN/100 mL)	<1	<1	<1	<1	<1	<1	1 CFU/100 mL[g]
Dissolved oxygen (mg/L)	7.75	8.25	6.33	5.82	7.30	7.93	NA
Electrical conductivity (µmhos/cm)	424	406	316	293	381	370	NA
Fluoride (mg/L)	0.244	0.164	0.353	0.221	0.22	0.137	4
Manganese, dissolved (mg/L)[h]	NR[i]	NR	NR	NR	NR	NR	0.05
Manganese, total (mg/L)	ND (<0.001)[j]	0.00165J[k]	0.00826	0.0404	ND (<0.001)	ND (<0.001)	0.05
Nitrate/nitrite, as nitrogen (mg/L)	1.13	1.11	0.338	0.368	0.909	1.02	10
pH (standard units)	7.75	7.94	7.62	7.82	7.74	7.74	6.5–8.5
Selenium (mg/L)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	0.05
Temperature (°F)	53.87	54.46	53.22	53.81	54.41	55.34	NA
Total dissolved solids (mg/L)	279	248	197	181	251	221	500
Total phosphorus (mg/L)	0.12J[k]	0.0360	0.0932J[k]	0.129	0.142J[k]	0.0426	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.
b. NA = not applicable.
c. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
d. 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.
e. MPN = most probable number.
f. CFU = colony forming unit.
g. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.
h. The result of the dissolved concentrations of this parameter are used for SCS compliance determinations.
i. NR = parameter was not a monitoring requirement since the analytical result for total manganese did not exceed the standard in Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.b manganese standard of 0.05 mg/L.
j. ND = Parameter not detected in sample. Value in parentheses is the detection limit.
k. 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 A-9. Idaho Nuclear Technology and Engineering Center new percolation ponds perched water monitoring well groundwater results (2022).

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:	04/18/22	09/19/22	04/18/22	09/19/22	04/18/22	09/19/22	
Depth to water (ft below brass cap)	Dry[b]	Dry	113.34	119.81	239.19	238.89	NA[c]
Water table elevation (at brass cap in ft)[d]	NA	NA	4,842.23	4,835.79	4,722.12	4,722.52	NA
Chloride (mg/L)	NA	NA	75.1J[e]	68	81.8J[e]	73.4	250
Chromium (mg/L)	NA	NA	0.00658	0.00700	0.0318	0.0254	0.1
Coliform, fecal (MPN[f]/100 mL)	NA	NA	<1	<1	<1	<1	<1 CFU[g]/100 mL
Coliform, total (MPN/100 mL)	NA	NA	<1	<1	<1	<1	1 CFU/100 mL[h]
Dissolved oxygen (mg/L)	NA	NA	7.21	6.64	6.78	5.44	NA
Electrical conductivity (µmhos/cm)	NA	NA	572	517	569	497	NA
Fluoride (mg/L)	NA	NA	0.274	0.188	0.263	0.180	4
Manganese, dissolved (mg/L)[i]	NA	NA	NR[j]	NR	NR	NR	0.05
Manganese, total (mg/L)	NA	NA	ND (<0.001)[k]	0.00441J[l]	0.00569	0.0152	0.05
Nitrate/nitrite, as nitrogen (mg/L)	NA	NA	1.89	1.04	1.42	1.87	10
pH (standard units)	NA	NA	7.63	7.55	9.66	8.93	6.5–8.5
Selenium (mg/L)	NA	NA	0.00171J[l]	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	0.05
Temperature (°F)	NA	NA	60.62	59.79	61.12	62.79	NA
Total dissolved solids (mg/L)	NA	NA	350	309	374	313	500
Total phosphorus (mg/L)	NA	NA	0.537J[l]	0.466	0.132J[l]	0.0643J[l]	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.
b. ICPP-MON-V-191 was dry in April and September 2022.
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 United States Environmental Protection Agency Method Recovery Criteria.
f. MPN = most probable number.
g. CFU = colony forming units.
h. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.
i. The results of dissolved concentrations of this parameter are used for SCS compliance determinations.
j. NR = not required since the analytical result for total manganese did not exceed the standard in Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.b for manganese of 0.05 mg/L.
k. ND = Parameter not detected in sample. Value in parentheses is the detection limit.
l. J flag indicates that 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 A-10. Materials and Fuels Complex industrial waste pond effluent monitoring results for the reuse permit (2022).[a,b,c]

PARAMETER	MINIMUM	MAXIMUM	MEDIAN
pH (standard units)	6.78	8.22	7.09
Conductivity[d] (µS/cm)	401	587	451
Chloride[d] (mg/L)	5.35J[e]	53.8J	19.7J
Nitrate + nitrite as nitrogen (mg/L)	2.66	3.53	2.87
Iron (mg/L)	0.03U[f]	0.0638	0.03U
Iron, filtered (mg/L)	0.03U	0.03U	0.03U
Manganese (mg/L)	0.002U	0.0052J	0.002U
Manganese, filtered (mg/L)	0.002U	0.00453J	0.002U
Sodium[d] (mg/L)	18.7	42.7	21.5
Sodium,[d] filtered (mg/L)	18.6	41.2	21.8
Solids, total dissolved (mg/L)	204	356	260

a. Liquid effluent results for permit-required constituents collected at the sampling station located on the Industrial Wastewater Collection System (IWCS) primary line prior to discharge into the pond. The results represent effluent contributions from both the IWCS Primary Line (PL) and Southwestern Branch Line (SBL), which are combined upstream of the sampling station.

b. Duplicate samples were collected in July 2021. The duplicate results are included in the data summary.

c. Reuse permit I-160-02 does not specify maximum constituent loading or concentration limits.

d. Conductivity, chloride and sodium are not required effluent monitoring parameters in the reuse permit.

e. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

f. U qualifier indicates the result was below the detection limit.

Table A-11. Materials and Fuels Complex effluent hydraulic loading to the industrial waste pond (2022).

	YEARLY TOTAL FLOW
2022 flow[a]	10.188 MG[b]
Annual permit limit[c]	17 MG

a. Annual flow is reported for the 2022 permit reporting year. The annual flow is an estimate due to adjustments during instances when the flow rate exceeded the maximum measurable flow rate of the flow meter.

b. MG = million gallons.

c. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1 through October 31.

Table A-12. Materials and Fuels Complex industrial waste pond summary of groundwater quality data collected for the reuse permit (2022).

WELL NAME	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		PCS/SCS[a]
SAMPLE DATE:	04/28/22	09/19/22	04/28/22	09/19/22	05/03/22	09/19/22	
Water table depth (ft bls)[b]	659.60	662.86	647.95	651.18	647.36	650.39	NA[c]
Water table elevation (ft above mean sea level)[d]	4,473.10	4,469.84	4,472.42	4,469.19	4,470.72	4,467.69	NA
Temperature (°F)	54.14	55.40	54.32	56.12	53.60	57.56	NA
pH (s.u)	6.90	7.48	6.99	7.60	6.63	7.62	6.5 to 8.5 (SCS)
Conductivity (µmhos/cm)	375 (379)[e]	325	400	335	381	328	NA
Nitrite + nitrate as N (mg/L)	2.73 (2.72)	2.48	2.63	2.50	2.74	2.55	10 (PCS)
Nitrate nitrogen (mg/L)[f]	2.40J[g] (2.37J)	2.39J	2.44J	2.39J	2.36	2.45J	10 (PCS)
Total dissolved solids (mg/L)	227 (226)	212	244	221	223	224	500 (SCS)
Iron, total (mg/L)	0.03U[h] (0.03U)	0.03U	0.03U	0.0364	0.03U	0.03U	0.3 (SCS)
Iron, filtered (mg/L)	0.03U (0.03U)	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)
Manganese, total (mg/L)	0.001U (0.001U)	0.001U	0.001U	0.00202	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) specified in the Ground Water Quality Rule, Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

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. Nitrate nitrogen is not required by the reuse permit. It was analyzed for surveillance and historical trending purposes.

g. J qualification 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 five times the highest positive amount in any laboratory blank.

Table A-13. Advanced Test Reactor Complex cold waste ponds effluent surveillance monitoring results (2022).[a]

PARAMETER	MINIMUM	MAXIMUM	DCS[b] (pCi/L)
Gross alpha (pCi/L ± 1s)[c,d]	1.46 (± 0.419)	2.41 (± 0.503)	NA[e]
Gross beta (pCi/L ± 1s)[f]	0.886 (± 0.259)	4.52 (± 0.845)	NA

a. Monthly samples were analyzed for gross alpha, gross beta, tritium, and gamma-emitting radionuclides including 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. DOE Derived Concentration Standards for ingested water.

c. Result ± 1σ. Results are shown only for statistically positive detections greater than 3σ.

d. Gross alpha was positively detected in May and November 2022. Results were non-detect for the other ten months of 2022.

e. NA = not applicable. Derived Concentration Standards values are not established.

f. Gross beta was positively detected in March, May, July, October, and November 2022. Results were non-detect for the other seven months of 2022.

Table A-14. Radioactivity detected in surveillance groundwater samples collected at the Advanced Test Reactor Complex (2022).

MONITORING WELL	SAMPLE DATE	GAMMA EMITTERS[a] (pCi/L)	GROSS ALPHA (pCi/L)	GROSS BETA (pCi/L)	STRONTIUM-90 (pCi/L)	TRITIUM (pCi/L)
PCS/SCS[b]		NA	15	4 mrem/yr[c]	8	20,000
USGS-098	04/20/2022	ND[d]	0.848 (±0.271)[e] [1.35 (±0.323)][f]	2.34 (±0.215) [2.53 (±0.237)]	ND	ND
	09/14/2022	ND	ND	1.81 (±0.242)	ND	ND
USGS-058	04/26/2022	ND	ND	2.02 (±0.490)	ND	403 (±126)
	09/16/2022	ND	ND	1.37 (±0.222)	ND	ND
USGS-065	04/26/2022	ND	ND	4.27 (±0.521)	ND	1,070 (±192)
	09/15/2022	ND	3.51 (±0.660)	3.32 (±0.419)	ND	1,490 (±223)
TRA-08	04/21/2022	ND	ND	3.15 (±0.574)	ND	723 (±141)
	09/15/2022	ND	1.55 (±0.471)	2.18 (±0.337)	1.13 (±0.331)	721 (±146)
USGS-076	04/21/2022	ND	ND	2.28 (±0.558)	ND	ND
	09/16/2022	ND	1.84 (±0.350)	1.97 (±0.218)	ND	ND
MIDDLE-1823	04/20/2022	ND	ND	2.15 (±0.216)	ND	ND
	09/15/2022	ND	1.15 (±0.346)	1.58 (±0.257)	ND	403 (±114)
USGS-136	04/27/2022	ND	ND	2.45 (±0.508)	ND	890 (±173)
	09/16/2022	ND	1.52 (±0.319)	1.62 (±0.203)	ND	910 (±133)

a. Gamma-emitting radionuclides including 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. Primary Constituent Standards (PCS) in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a, are provided for perspective.

c. Gross Beta PCS = 4 mrem/yr effective dose, Ground Water Quality Rule, IDAPA 58.01.11.200.01.a. For perspective, the U.S. Environmental Protection Agency public drinking water system regulations also specify a maximum contaminant limit of 4 mrem/yr for gross beta and use a screening level of 50 pCi/L to determine when speciation of individual beta/photon emitters is necessary.

d. ND = not detected.

e. Results shown are for statistically positive detections greater than 3σ, along with the reported 1σ uncertainty.

f. Results from field duplicate samples shown in brackets.

Table A-15. Liquid effluent radiological monitoring results for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds CPP-797 (2022).

SAMPLE DATE	GAMMA EMITTERS[a] (pCi/L)	GROSS ALPHA[b] (pCi/L)	GROSS BETA[b] (pCi/L)	TOTAL STRONTIUM (pCi/L)
PCS/SCS[b]	NA	15	4 mrem/yr[c]	8
January 2022	ND[e]	ND	5.01 (±0.738)	ND
February 2022	ND	ND	4.45(±0.799)	ND
March 2022	ND	ND	4.71 (±0.902)	ND
April 2022	ND	ND	4.55 (±0.859)J[f]	ND
May 2022	ND	ND	7.11 (±0.892)	ND
June 2022	ND	ND	6.07 (±0.911)J[f]	ND
July 2022	ND	ND	5.23 (±0.868)	ND
August 2022	ND	ND	8.69 (±0.863)	ND
September 2022	ND	ND	4.57 (±0.902)	ND
October 2022	ND	ND	5.81 (±0.870)	ND
November 2022	ND	ND	6.36 (±9.25)	ND
December 2022	ND	ND	5.61 (±7.09)	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 1σ uncertainty.

c. Primary constituent standards (PCS) in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a, are provided for perspective.

d. Gross Beta PCS = 4 mrem/yr effective dose, IDAPA 58.01.11.200.01.a. For perspective, the U.S. Environmental Protection Agency public drinking water system regulations also specify a maximum contaminant limit of 4 mrem/yr for gross beta and use a screening level of 50 pCi/L to determine when speciation of individual beta/photon emitters is necessary.

e. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

f. J flag indicates the associated value is an estimate.

Table A-16. Groundwater radiological monitoring results for the Idaho Nuclear Technology and Engineering Center (2022).

MONITORING WELL	SAMPLE DATE	GROSS ALPHA[a] (pCi/L)	GROSS BETA[a] (pCi/L)
ICPP-MON-A-165	04/20/2022 09/20/2022	ND[b] ND	4.85 (±0.900) 2.84 (±0.745)
ICPP-MON-A-166	04/20/2022 09/20/2022	ND ND	3.03 (±0.797) ND
ICPP-MON-V-200	04/20/2022 09/19/2022	ND ND	5.90 (±0.874) 7.98 (±0.986)
ICPP-MON-V-212	04/18/2022 09/19/2022	ND 7.76 (±1.48)	24.0 (±1.38) 15.6 (±1.25)

a. Detected results are shown along with the reported 1σ uncertainty.
b. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table A-17. Radiological Monitoring Results for Materials and Fuels Complex industrial waste pond (2022).[a]

PARAMETER[b] (pCi/L)	MINIMUM	MAXIMUM	DCS[c] (pCi/L)
Gross alpha	ND[d]	3.96 (±1.15)	NA[e]
Gross beta	ND	10.8 (± 0.902)	NA
Uranium-238[f]	0.241 (± 0.0624)	0.241 (± 0.0624)	1,400
Uranium-233/234[f]	0.273 (± 0.0731)	0.273 (± 0.0731)	1,200

a. Samples were analyzed for gross alpha; gross beta; plutonium-241; strontium-90; tritium; gamma-emitting radionuclides, including 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, zirconium-95; alpha-emitting radionuclides including americium-241, uranium-233/234, uranium-235, uranium-238, plutonium-236, plutonium-238, plutonium-239/240, and plutonium-242.
b. Results shown are for statistically positive detections greater than 3σ, along with the reported 1σ uncertainty. Only parameters with at least one positively detected result are shown.
c. DCS = DOE Derived Concentration Standard for ingested water (DOE-STD-1196-2022).
d. ND indicates the result was below the detection limit.
e. NA = not applicable. DCS values are not established.
f. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

Appendix B: Dosimeter Measurements and Locations

Table B-1. Results of environmental radiation measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2022).

LOCATION	mrem[a]	
	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022
ARA[b] I&II O-1	62	70
PBF[c] SPERT O-1	70	67

a. Millirem (mrem) in ambient dose equivalent.
b. Auxiliary Reactor Area (ARA).
c. Power Burst Facility Special Power Excursion Reactor Test (PBF SPERT).

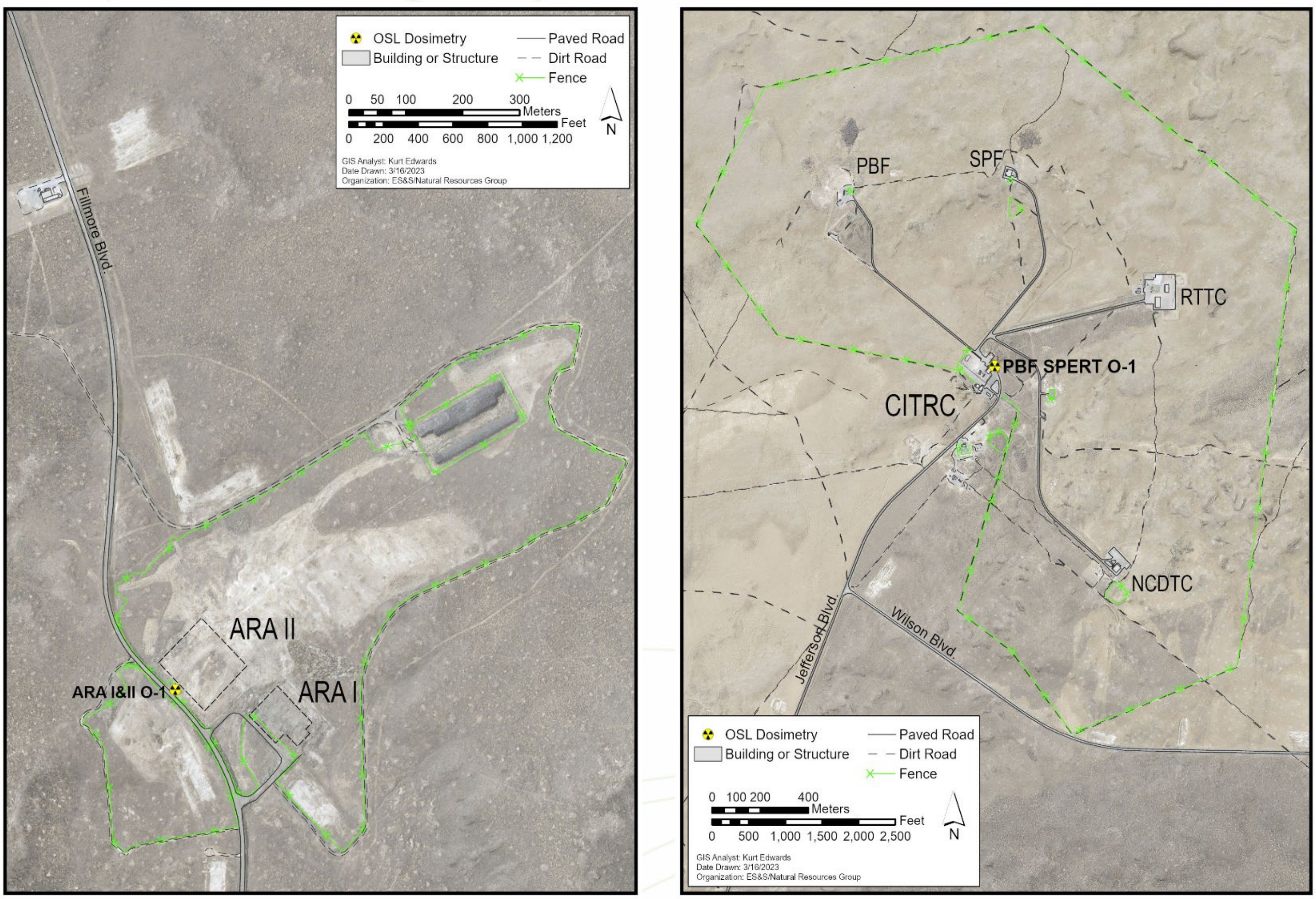

Figure B-1. Environmental radiation measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2022).

Table B-2. Results of environmental radiation measurements at Advanced Test Reactor (ATR) Complex and Remote-Handled Low-Level Waste Disposal Facility (RHLLW) (2022).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022		NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022
RHLLW[b] O-1	67	80	TRA O-14	69	69
RHLLW O-2	67	65	TRA O-15	69	66
RHLLW O-3	69	63	TRA O-16	77	69
RHLLW O-4	74	72	TRA O-17	74	66
RHLLW O-5	68	74	TRA O-18	75	74
RHLLW O-6	70	66	TRA O-19	89	82
TRA[c] O-1	72	79	TRA O-20	70	67
TRA O-6	71	66	TRA O-21	75	70
TRA O-7	83	77	TRA O-22	63	71
TRA O-8	78	77	TRA O-23	66	69
TRA O-9	82	81	TRA O-24	70	75
TRA O-10	140	116	TRA O-25	73	78
TRA O-11	138	118	TRA O-26	70	77
TRA O-12	81	82	TRA O-27	71	70
TRA O-13	77	85	TRA O-28	73	66

a. Millirem (mrem) in ambient dose equivalent.
b. Remote-Handled Low-Level Waste (RHLLW).
c. Test Reactor Area (TRA).

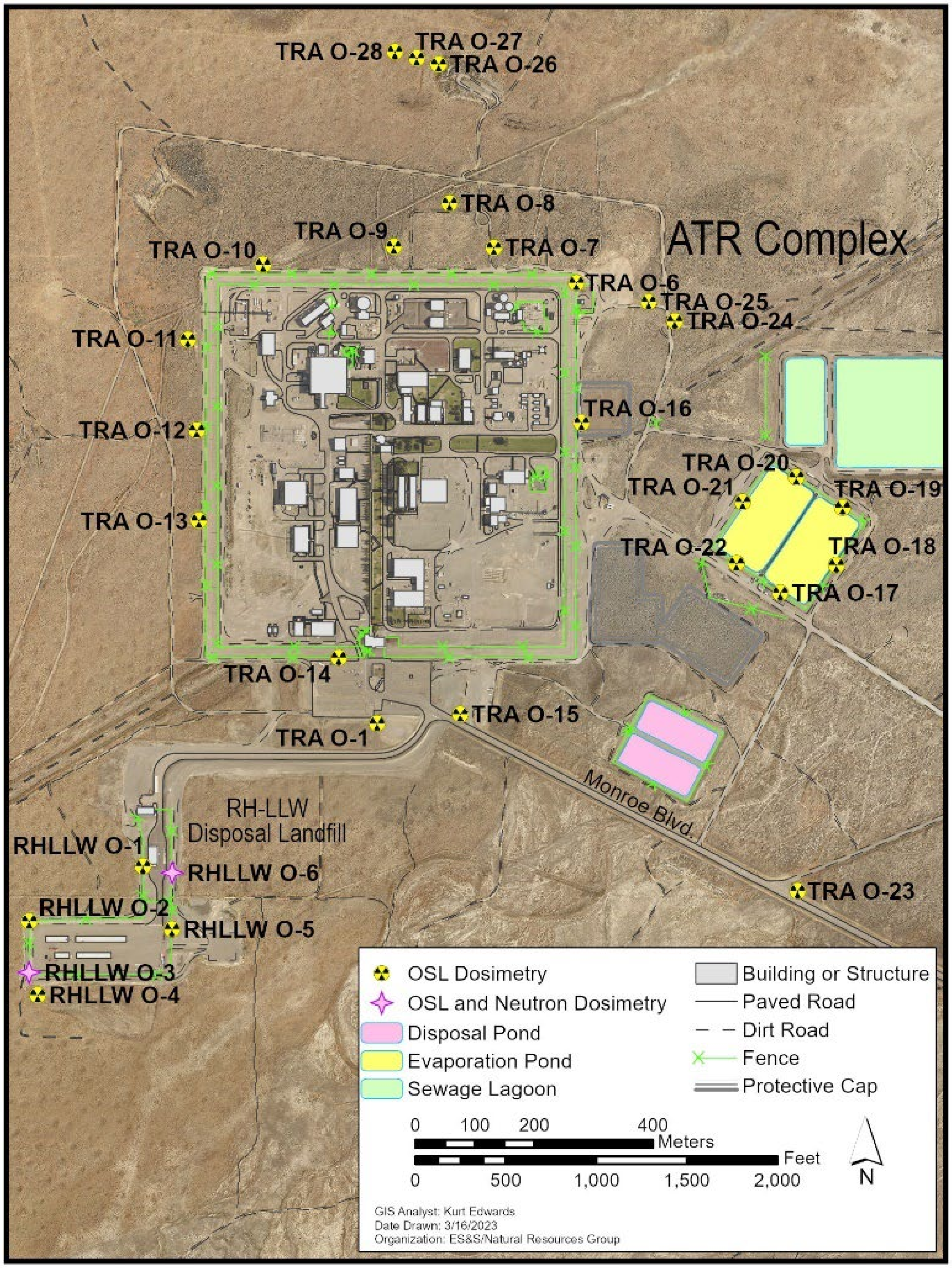

Figure B-2. Environmental radiation measurements at Advanced Test Reactor (ATR) Complex and Remote-Handled Low-Level Waste Disposal Facility (RHLLW) (2022).

Table B-3. Results of environmental radiation measurements at Central Facilities Area (CFA) and Lincoln Boulevard (2022).

LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
CFA[b] O-1	66	73
LincolnBlvd[c] O-1	71	63

a. Millirem (mrem) in ambient dose equivalent.
b. Central Facilities Area (CFA).
c. Lincoln Boulevard (LincolnBlvd).

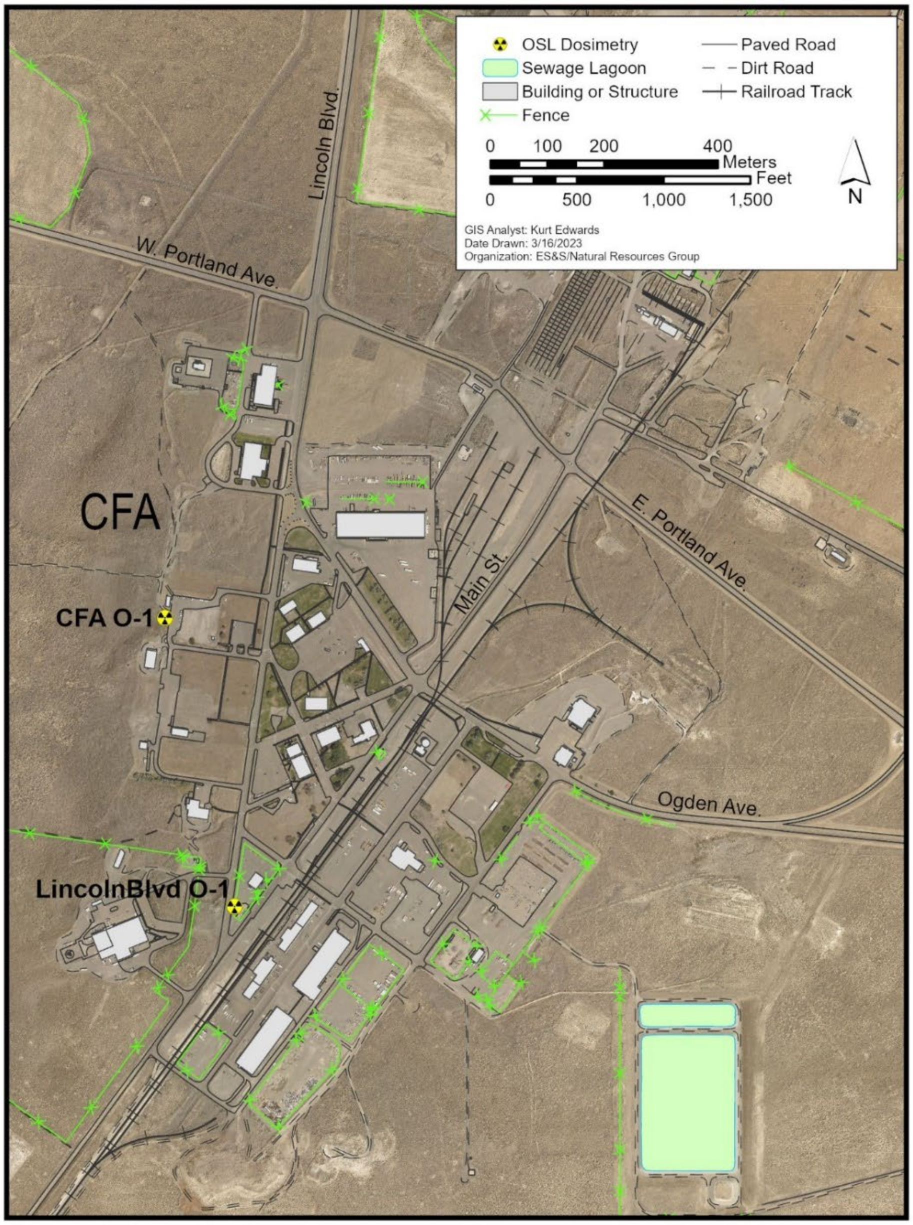

Figure B-3. Environmental radiation measurements at Central Facilities Area (CFA) and Lincoln Boulevard (2022).

Table B-4. Results of environmental radiation measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2022).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022		NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
ICPP[b] O-9	86	86	ICPP O-26	72	72
ICPP O-14	107	101	ICPP O-27	184	233
ICPP O-15	160	145	ICPP O-28	196	183
ICPP O-17	70	78	ICPP O-30	219	206
ICPP O-19	101	93	TreeFarm O-1	119	138
ICPP O-20	294	325	TreeFarm O-2	78	91
ICPP O-21	84	95	TreeFarm O-3	86	98
ICPP O-22	98	92	TreeFarm O-4	126	140
ICPP O-25	82	92			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Chemical Processing Plant (ICPP).

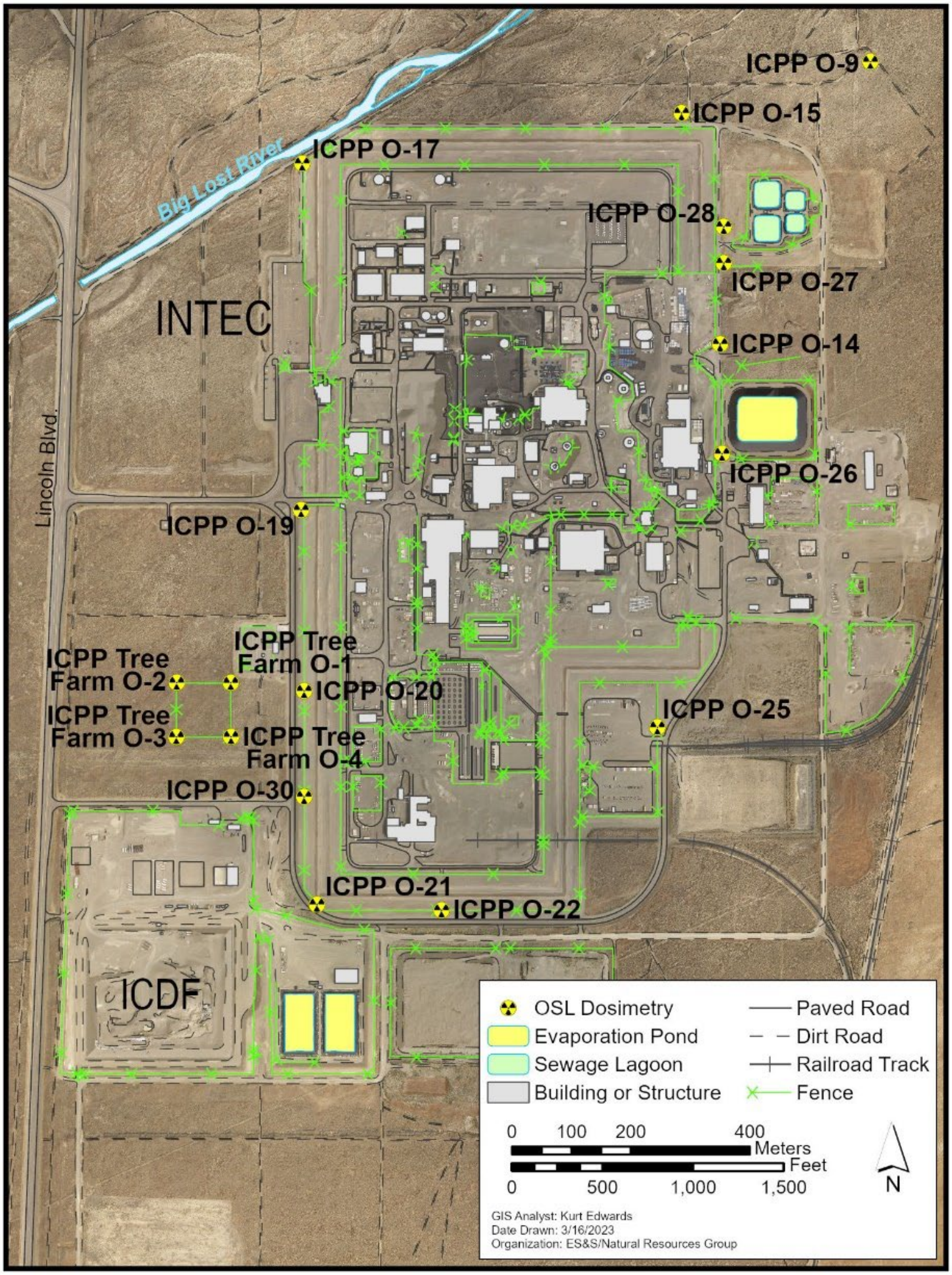

Figure B-4. Environmental radiation measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2022).

Table B-5. Results of environmental radiation measurements at Idaho National Laboratory Research Center Complex (IRC) (2022).

LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022– OCT. 2022	LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022
IF[b]-603N O-1	57	56	IF-670N O-31	57	53
IF-603E O-2	54	47	IF-670E O-32	53	45
IF-603S O-3	53	52	IF-670S O-33	63	57
IF-603W O-4	61	56	IF-670D O-34	58	53
IF-627 O-30	54	52	IF-670W O-35	63	63
IF-638N O-1	57	59	IF-689 O-7	56	57
IF-638E O-2	56	53	IF-689 O-8	50	53
IF-638S O-3	74	58	IF-IRC[c] O-39	59	59
IF-638W O-4	57	57			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).
c. INL Research Center (IRC).

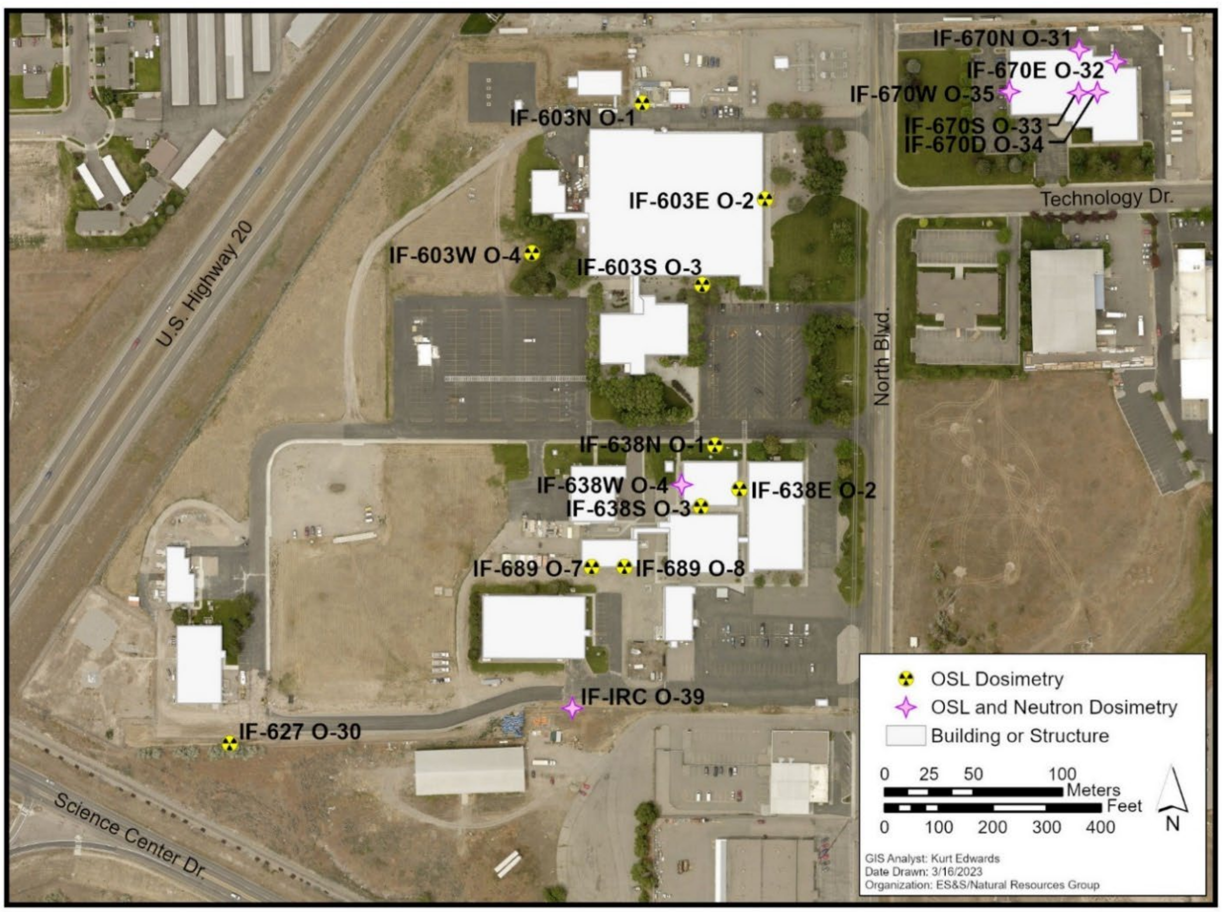

Figure B-5. Environmental radiation measurements at Idaho National Laboratory Research Center Complex (IRC) (2022).

Table B-6. Results of environmental radiation measurements at Materials and Fuels Complex (MFC) and Transient Reactor Test (TREAT) Facility (2022).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022		NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
ANL[b] O-7	70	64	ANL O-24	68	68
ANL O-8	67	62	ANL O-25	71	68
ANL O-12	57	56	ANL O-26	68	72
ANL O-14	60	71	TREAT[c] O-1	61	62
ANL O-15	66	77	TREAT O-2	66	68
ANL O-16	66	62	TREAT O-3	69	71
ANL O-18	65	62	TREAT O-4	73	71
ANL O-19	59	55	TREAT O-5	63	68
ANL O-20	74	63	TREAT O-6	69	63
ANL O-21	88	88	TREAT O-7	67	71
ANL O-22	81	76	TREAT O-8	66	66
ANL O-23	74	69			

a. Millirem (mrem) in ambient dose equivalent.
b. Argonne National Laboratory (ANL).
c. Transient Reactor Test (TREAT) Facility.

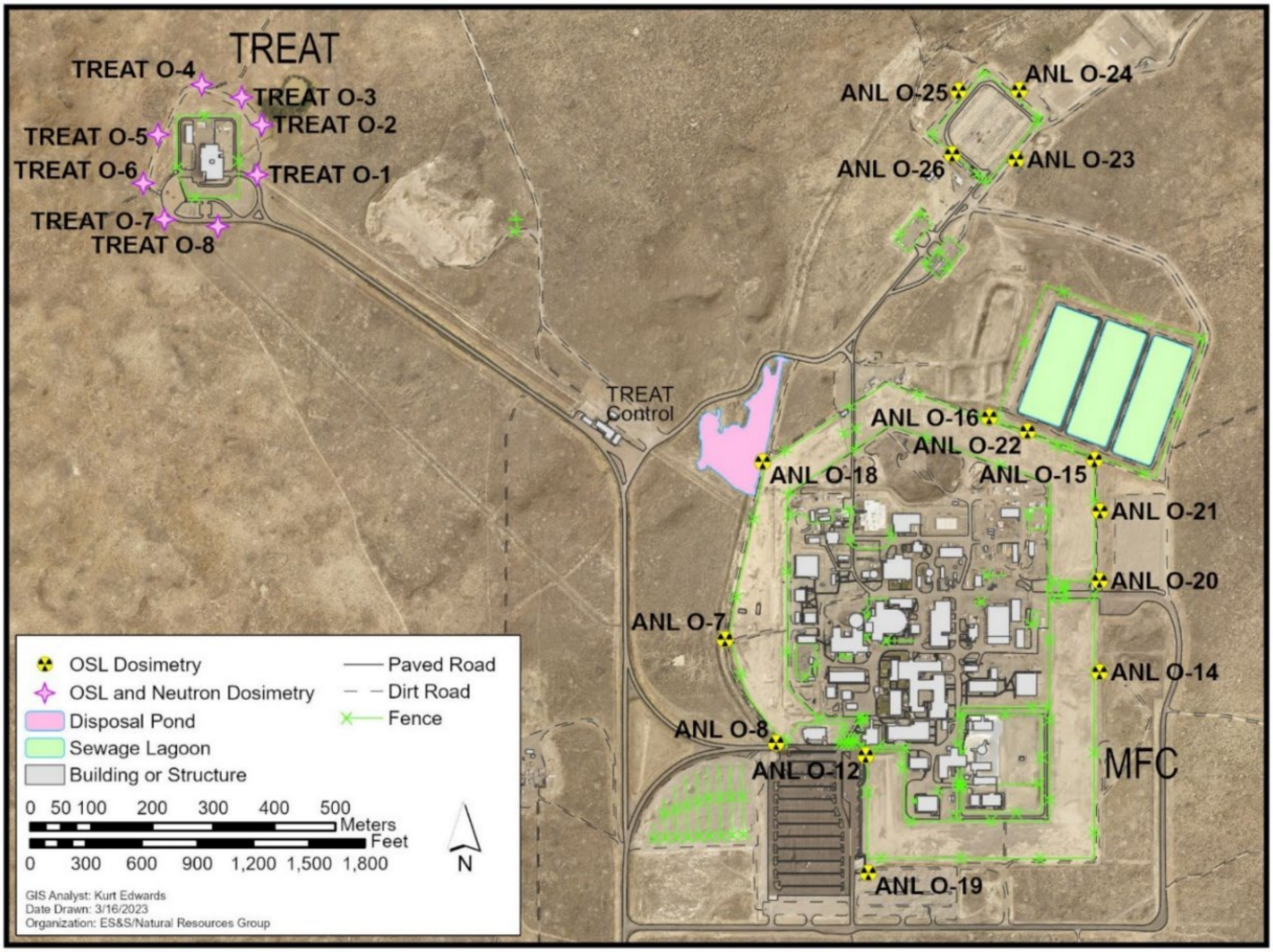

Figure B-6. Environmental radiation measurements at Materials and Fuels Complex (MFC) and Transient Reactor Test (TREAT) Facility (2022).

Table B-7. Results of environmental radiation measurements at Naval Reactors Facility (NRF) (2022).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022		NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
NRF[b] O-11	66	64	NRF O-21	65	57
NRF O-16	63	65	NRF O-22	60	60
NRF O-18	69	72	NRF O-23	58	57
NRF O-19	69	69	NRF O-24	67	65
NRF O-20	73	64			

a. Millirem (mrem) in ambient dose equivalent.
b. Naval Reactors Facility (NRF).

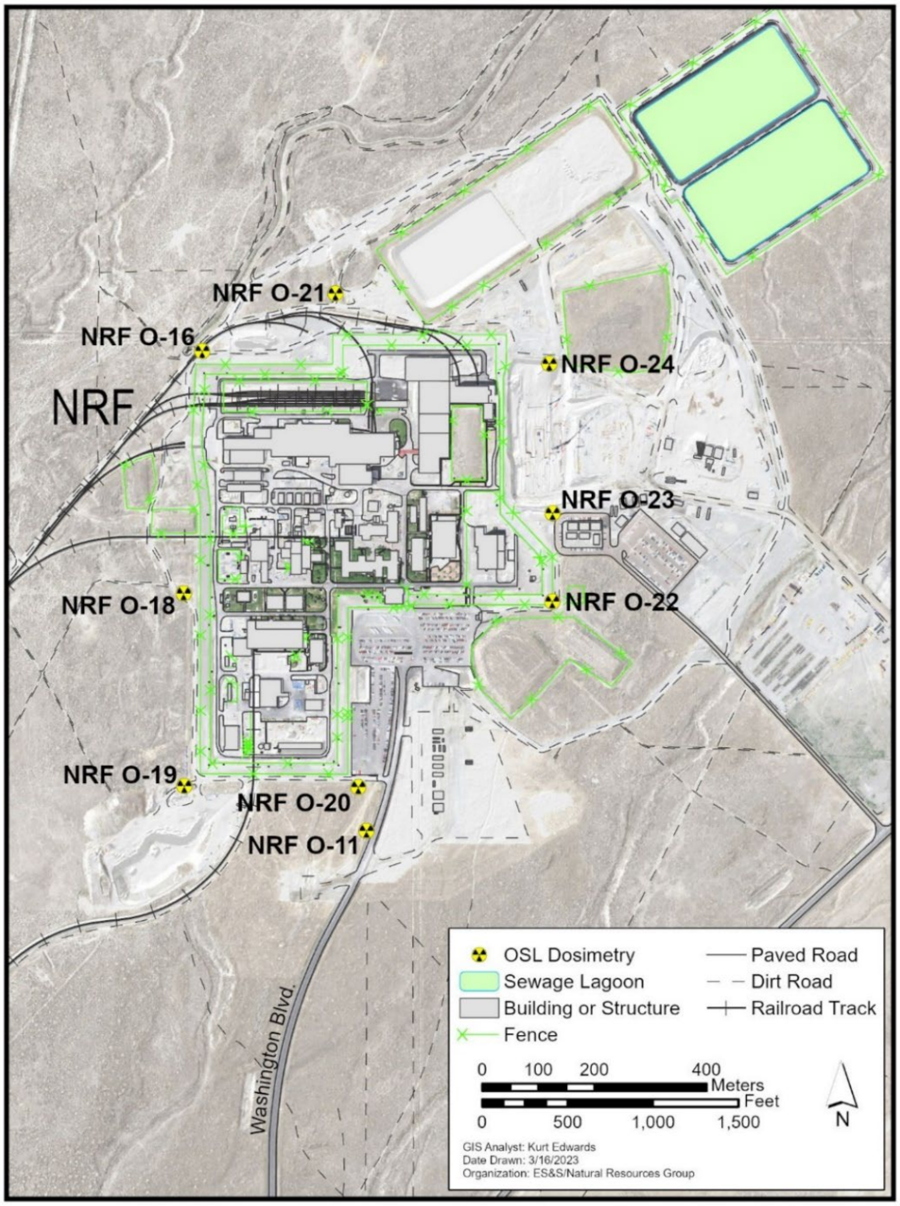

Figure B-7. Environmental radiation measurements at Naval Reactors Facility (NRF) (2022).

Table B-8. Results of environmental radiation measurements at IF-675 Portable Isotopic Neutron Spectroscopy (PINS) Laboratory (2022).

LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
IF[b]-675E O-31	48	55
IF-675D O-33	55	49
IF-675S O-34	62	58
IF-675W O-35	56	54

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

Figure B-8. Environmental radiation measurements at IF-675 Portable Isotopic Neutron Spectroscopy (PINS) Laboratory (2022).

Table B-9. Results of environmental radiation measurements at Radioactive Waste Management Complex (RWMC) (2022).

LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022	LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022
RWMC[b] O-3A	68	61	RWMC O-25A	61	67
RWMC O-5A	64	63	RWMC O-27A	67	72
RWMC O-7A	62	58	RWMC O-29A	65	71
RWMC O-9A	85	94	RWMC O-39	68	72
RWMC O-11A	74	73	RWMC O-41	143	154
RWMC O-13A	98	91	RWMC O-43	65	72
RWMC O-19A	72	58	RWMC O-46	64	70
RWMC O-21A	76	61	RWMC O-47	66	61
RWMC O-23A	66	78			

a. Millirem (mrem) in ambient dose equivalent.
b. Radioactive Waste Management Complex (RWMC).

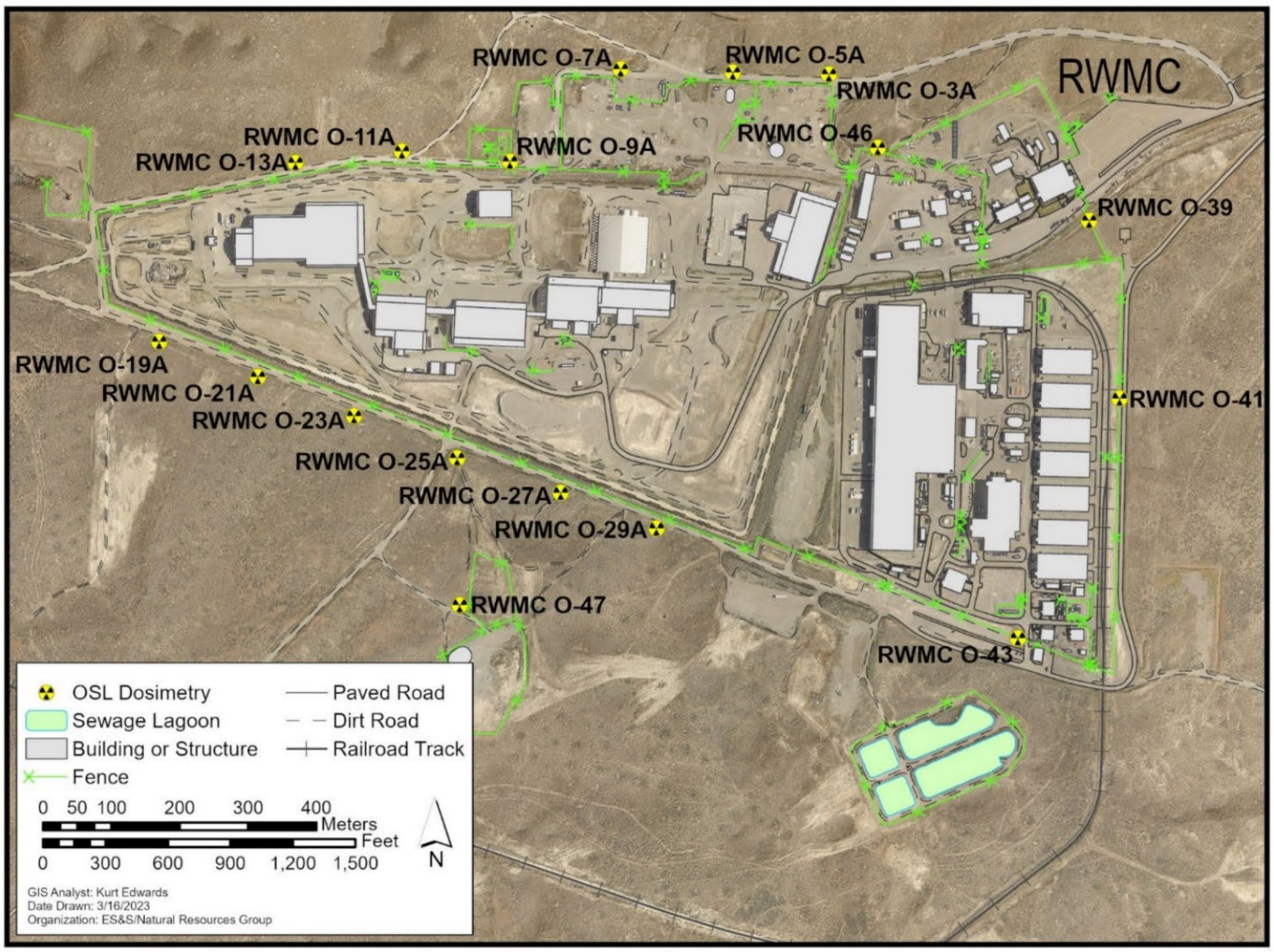

Figure B-9. Environmental radiation measurements at Radioactive Waste Management Complex (RWMC) (2022).

Table B-10. Results of environmental radiation measurements at Specific Manufacturing Capability (SMC) (2022).

LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022	LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022
TAN LOFT[b] O-6	62	73	TAN LOFT O-10	72	71
TAN LOFT O-7	72	69	TAN LOFT O-11	66	68
TAN LOFT O-8	61	59	TAN LOFT O-12	55	61
TAN LOFT O-9	52	60	TAN LOFT O-13	71	62

a. Millirem (mrem) in ambient dose equivalent.
b. Test Area North, Loss-of-Fluid Test (TAN LOFT).

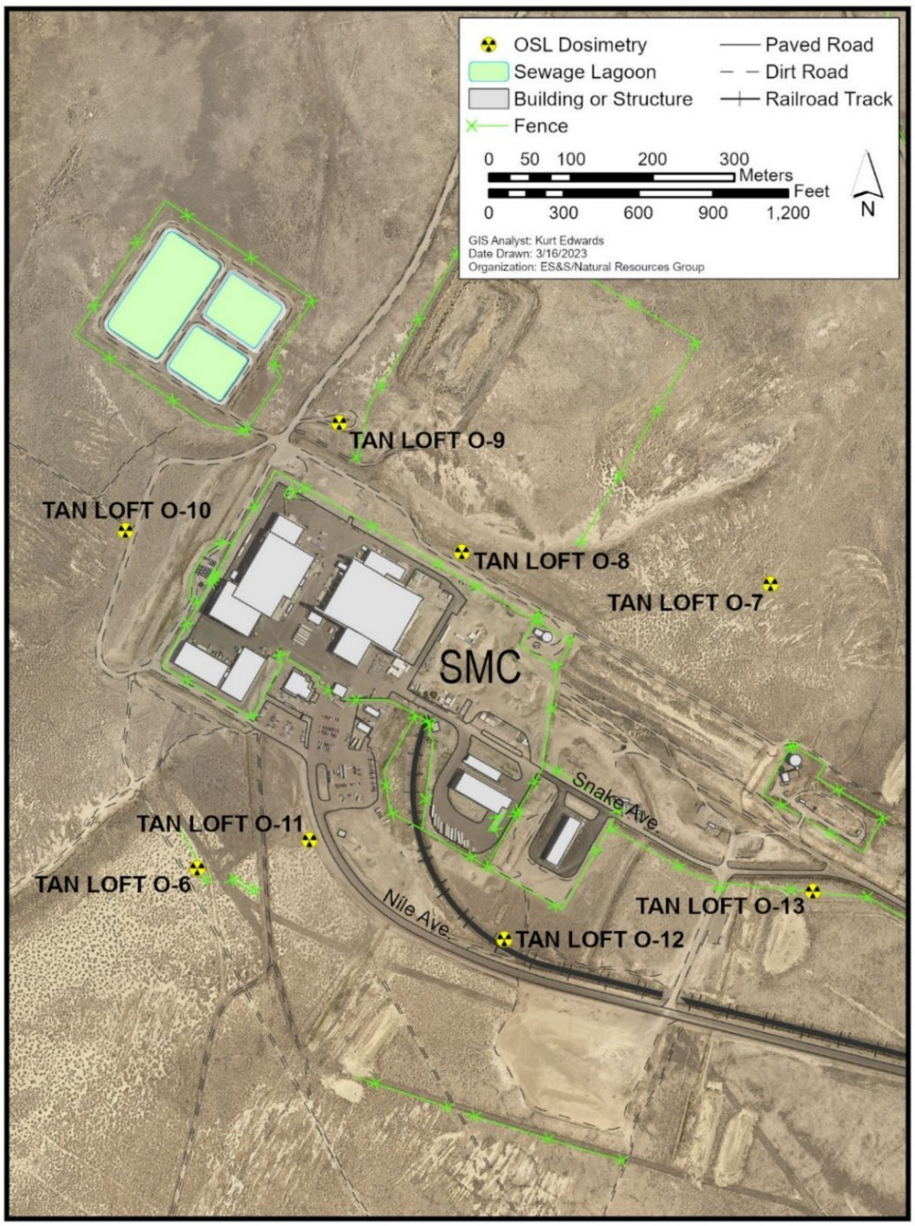

Figure B-1. Environmental radiation measurements at Specific Manufacturing Capability (SMC) (2022).

Table B-11. Results of environmental radiation measurements at sitewide locations (2022).

	mrem[a]			mrem[a]	
LOCATION	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022	LOCATION	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022
EFS[b] O-1	64	72	Hwy33 T17 O-3	59	61
Gate4 O-1	59	63	LincolnBlvd[d] O-3	71	62
Haul E O-1	62	64	LincolnBlvd O-5	72	69
Haul W O-2	70	65	LincolnBlvd O-9	70	74
Hwy[c]20 Mile O-266	64	64	LincolnBlvd O-15	74	78
Hwy20 Mile O-270	Lost	59	LincolnBlvd O-25	64	68
Hwy20 Mile O-276	64	68	Main Gate O-1	64	66
Hwy22 T28 O-1	59	78	Rest[e] O-1	62	62
Hwy28 N2300 O-2	53	51	VanB[f] O-1	66	71

a. Millirem (mrem) in ambient dose equivalent.
b. Experimental Field Station (EFS).
c. Highway (Hwy).
d. Lincoln Boulevard (LincolnBlvd).
e. Rest Area Highway 26 (Rest).
f. Van Buren (VanB).

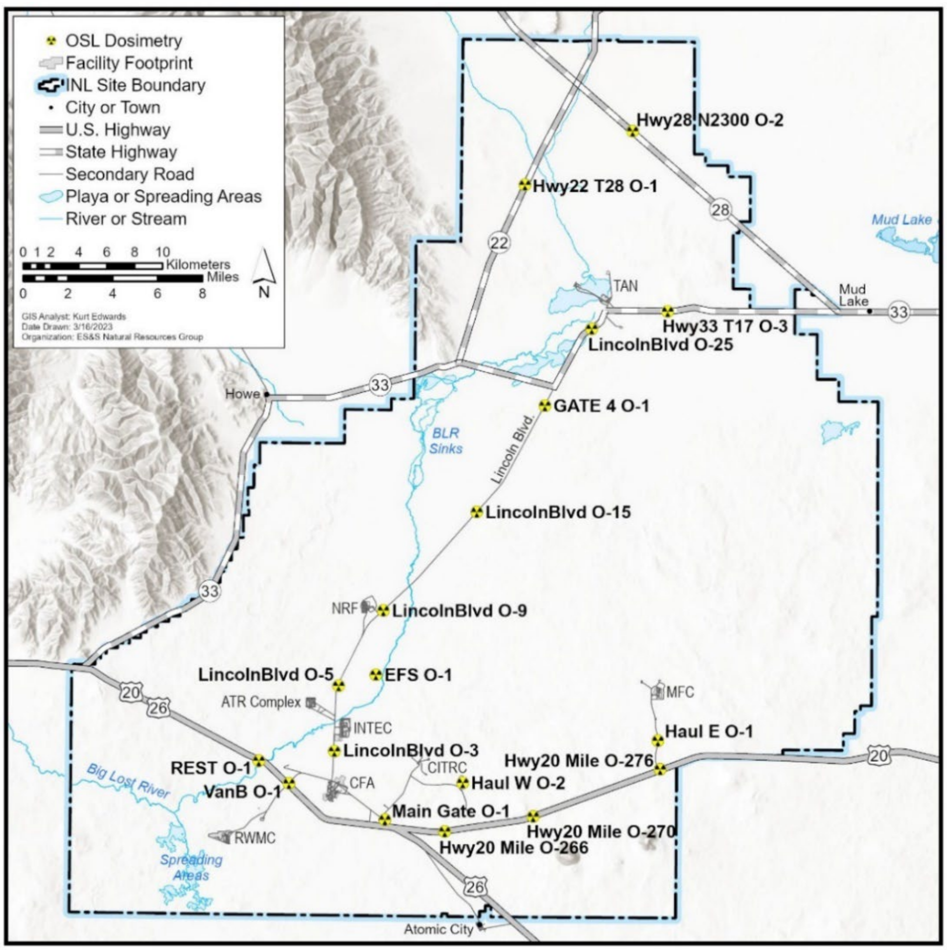

Figure B-11. Environmental radiation measurements at sitewide locations (2022).

Table B-12. Environmental radiation measurements at regional locations (2022).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022		NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022
Aberdeen E-1	58[e]	72	Minidoka E-1	54[e]	56
Arco E-1	57[e]	58	Monteview E-1	56[e]	63
Arco O-1	55	58	Monteview O-4	63	67
Atomic City E-1	58[e]	67	Mountain View E-1	51[e]	58
Atomic City O-2	60	63	Mud Lake E-1	62[e]	73
Blackfoot O-9	57	55	Mud Lake O-5	67	74
Blue Dome E-1	47[e]	47	Reno Ranch E-1	55[e]	58
Craters[b] E-1	53[e]	64	Reno Ranch O-6	56	55
Craters O-7	56	63	Roberts E-1	64[e]	74
Dubois E-1	49[e]	50	RobNOAA[c]	66	63
Howe E-1	58[e]	59	RRL[d]3 O-1	63	60
Howe O-3	54	51	RRL5 O-1	75	78
Idaho Falls E-1	54[e]	65	RRL6 O-1	67	62
Idaho Falls O-10	59	56	RRL17 O-1	63	59
Idaho Falls-IDA O-38	50	52	RRL24 O-1	60	57
Jackson E-1	56[e]	58	Sugar City E-1	71[e]	64

a. Millirem (mrem) in ambient dose equivalent.
b. Craters of Moon (Craters).
c. Roberts National Oceanic and Atmospheric Administration (RobNOAA).
d. Resident Receptor Location (RRL).
e. Past Environmental Surveillance, Education and Research Program location that was incorporated into the INL Environmental Dosimetry program. The first dosimeter for this location, under the INL contractor, was placed in the field on May 1, 2022. These locations are identified with an E- and corresponding number.

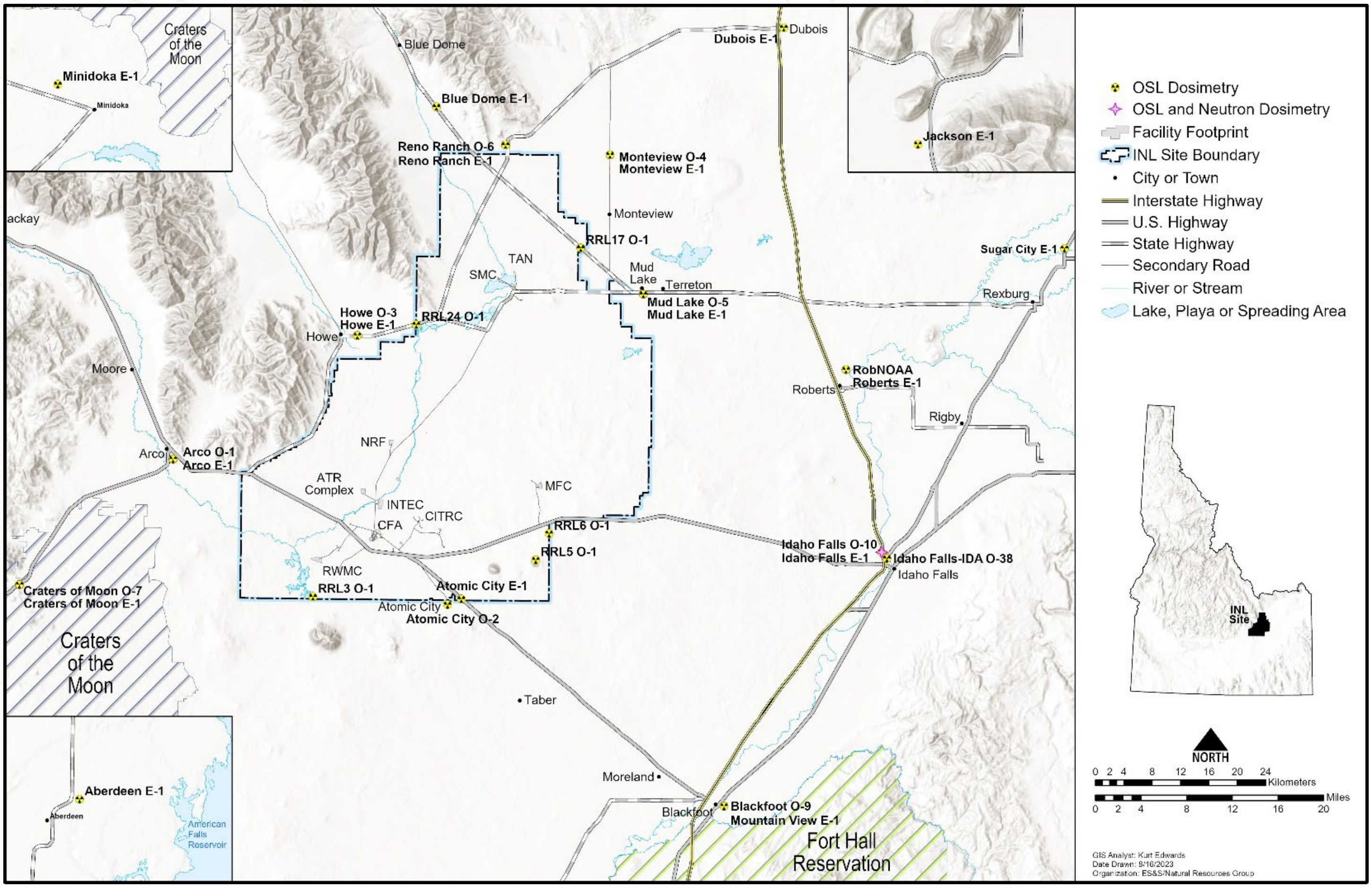

Figure B-12. Environmental radiation measurements at regional locations (2022).

Table B-13. Results of environmental radiation measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2022).

LOCATION	mrem[a] NOV. 2021–APRIL 2022	mrem[a] MAY 2022–OCT. 2022	LOCATION	mrem[a] NOV. 2021–APRIL 2022	mrem[a] MAY 2022–OCT. 2022
IF[b]-616N O-36	53	57	IF-665 O-4	49	59
IF-665 O-1	44	47	IF-665 O-5	52	56
IF-665 O-2	56	58	IF-665W O-37	60	50
IF-665 O-3	52	54			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

Figure B-13. Environmental radiation measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2022).

Table B-14. Results of environmental radiation measurements at Experimental Breeder Reactor I (EBR-I) (2022).

LOCATION	mrem[a]	
	NOV. 2021 – APRIL 2022	MAY 2022 – OCT. 2022
EBR1[b] O-1	63	56
EBR1 O-2	92	87
EBR1 O-3	263	235

a. Millirem (mrem) in ambient dose equivalent.
b. Experimental Breeder Reactor I (EBR-I).

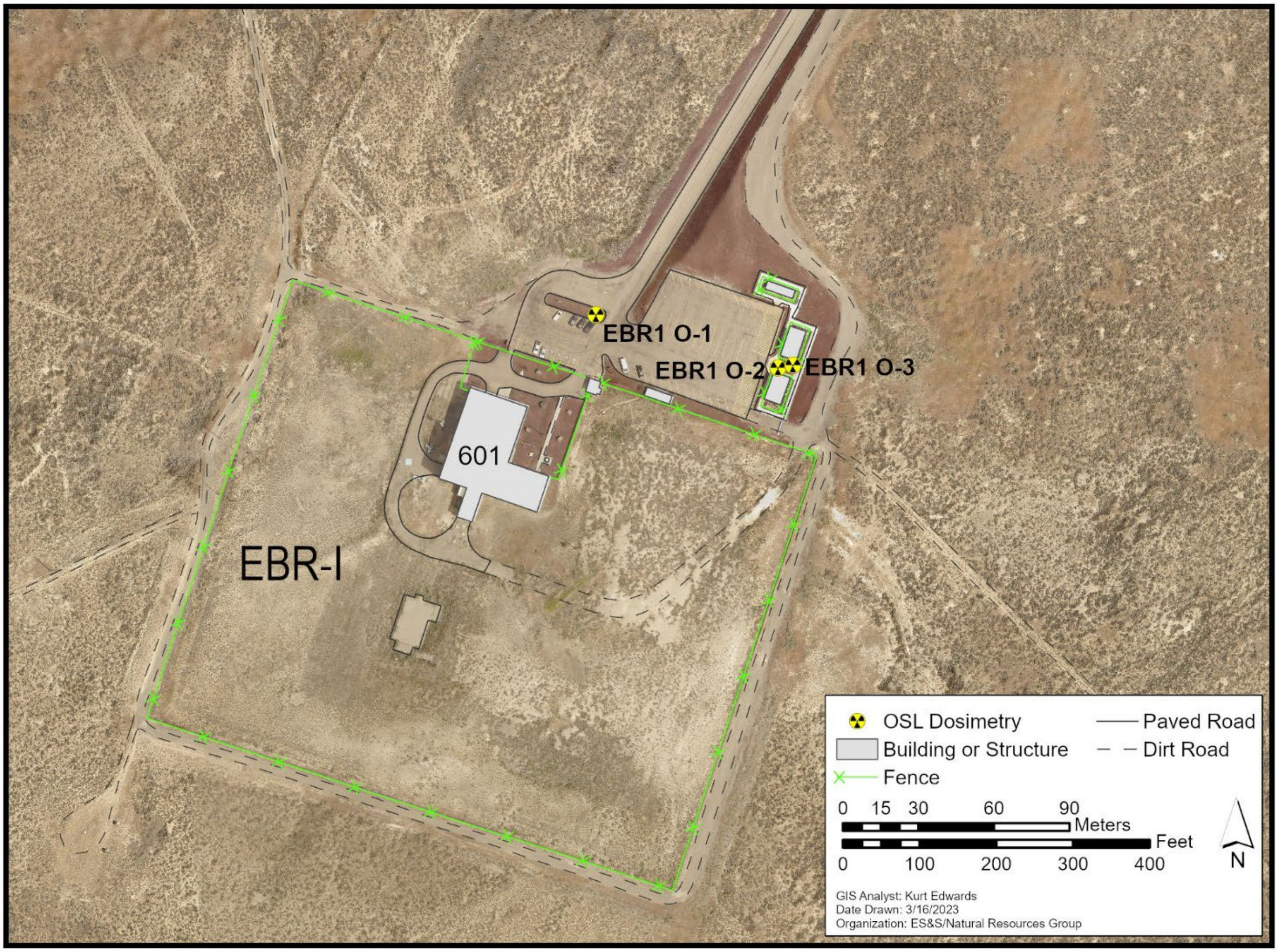

Figure B-14. Environmental radiation measurements at Experimental Breeder Reactor I (EBR-I) (2022).

Table B-15. Results of environmental radiation measurements at Energy Innovation Laboratory (EIL) (2022).

LOCATION	mrem[a] NOV. 2021 – APRIL 2022	mrem[a] MAY 2022 – OCT. 2022
IF[b]-688B O-1	54	49
IF-688B O-2	52	50

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

Figure B-15. Environmental radiation measurements at Energy Innovation Laboratory (EIL) (2022).

Table B-16. Results of environmental radiation measurements at Lindsay Building IF-652A.

LOCATION	mrem[a]	
	NOV. 2021–APRIL 2022	MAY 2022–OCT. 2022
IF-652A[b] O-1	new location	67
IF-652A O-2	new location	Lost
IF-652A O-3	new location	67
IF-652A O-4	new location	76

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

Figure B-16. Environmental radiation measurements at Lindsay Building IF-652A (2022).

Appendix C: Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the ‘true’ value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium to lawrencium, including the naturally occurring radionuclides thorium and uranium and the human-made radionuclides plutonium and americium.

alpha radiation: The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of approximately an inch. Despite its low penetration ability, alpha radiation is densely ionizing and, therefore, very damaging when ingested or inhaled.

ambient dose equivalent: Since the effective dose cannot be measured directly with a typical survey instrument or a dosimeter, approved simulation quantities are used to approximate the effective dose (see **dose, effective**). The ambient dose equivalent is the quantity recommended by the International Commission on Radiation Units and Measurements to approximate the effective dose received by a human from external exposure to ambient ionizing radiation.

anthropogenic radionuclide: Radionuclide produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the U.S. 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 gray, 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 the protection of populations of aquatic and terrestrial biota to be exceeded.

blank: The primary purpose of blanks (e.g., a sample of analyte-free media) is to trace sources of artificially introduced contamination. Laboratory blanks assess the potential of contamination being introduced during the analytical laboratory process whereas field blanks are used to identify potential contamination that occurred during sample collection. 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.

calibration verification: The calibration verification is used to check that the instrument is within the original calibration of the instrumentation being used for analyses of the samples sent to the laboratory for the requested method and analytes requested on the chain of custody.

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 dataset 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.

continuing calibration verification (CCV) (also known as initial calibration verification [ICV]): The primary purpose of the CCV/ICV is to check the original calibration of the instrumentation being used to analyze samples for that method and targeted analytes. The CCV/ICV is from an external source different than that used in calibration.

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 **becquerel**.

D

data gap: A lack or inability to obtain information despite good faith efforts to gather desired information.

data quality assessment: Data quality assessment includes reviewing data for accuracy, representativeness, and, if available, consistency 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.

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 act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements. The data verification process involves checking for common errors associated with analytical data. A review is first conducted to ensure all data and sample documentation are present and complete. In addition, the following also may be reviewed: sample preservation and temperature, defensible chain-of-custody documentation and sample integrity, analytical hold-time compliance, correct test method application, 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).

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 prepared the dispersion coefficients for this report, using data gathered continuously at meteorological stations on and around the INL Site and the HYSPLIT transport and dispersion model.

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.

double-blind PE samples: The value of a double-blind PE sample is unknown to both the laboratory receiving the sample and the INL contractor. While the program specifies PE sample matrix and boundaries of the value's range (i.e., the known value must fall between a predetermined minimum and maximum value that corresponds to the specific project or program), the actual value is unknown to both the INL Site contractor and the laboratory.

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. See **replicate sample**.

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 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, 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 samples are collected, preserved, and shipped to the laboratory with field samples. Results include relevant ambient conditions during sampling and laboratory sources of contamination. See **field reagent blank**.

field replicates: 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 estimating the precision resulting from the sampling process. See **sample duplicate (collocated 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.

floodplain: Lowlands that border a river and are subject to flooding. A floodplain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, such as 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: Any hazardous chemical as defined under 29 CFR 1910.1200, "Hazard Communication," and 40 CFR 370.2, "Definitions." See **hazardous substance**.

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 (e.g., 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.

initial calibration verification (ICV): The primary purpose of the CCV/ICV is to check the original calibration of the instrumentation being used to analyze samples for that method and targeted analytes. The CCV/ICV is from an external source different than that used in calibration. See **continuing calibration verification (CCV).**

inter-laboratory PT samples: This is an external PT and inter-laboratory comparison program accredited under the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC 17043:2010[E]). *The Department of Defense (DOD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (QSM 2021) requires that laboratories receiving and analyzing samples for DOE contracts successfully participate in a PT program for one year before becoming an accredited laboratory to receive samples for analyses for all analytes, matrices, and methods included in the laboratory's scope of work. The inter-laboratory program requires that participating laboratories must analyze at least two sets of samples during a calendar year.

intra-laboratory PE: This is an internal laboratory quality program using their own known value sample program to test their laboratory for method performance.

intra-laboratory samples: Intra-laboratory known value samples can be used to verify competency of the laboratory analysis method and of the analyst performing the sample preparation and analysis.

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 has 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.

laboratory control sample: The primary purpose of the laboratory control sample (accuracy) is to demonstrate that the laboratory can perform the overall analytical approach in a matrix free of interferences (e.g., reagent water, clean sand, or another suitable reference matrix), and its analytical system is in control but does not reflect analytical performance on analyzing real world samples.

laboratory control sample duplicate analysis (accuracy and precision): The laboratory control sample duplicate is used to determine the accuracy and precision as well as the bias of a method in each sample matrix.

laboratory matrix spike: The purpose of the matrix spike (accuracy) sample is to determine if the method is applicable to the sample matrix in question.

laboratory replicate/duplicate: Two aliquots from the same field sample are prepared by the laboratory and analyzed separately using identical procedures to assess the precision of a method in a given sample matrix.

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.

matrix spike duplicate analysis (accuracy and precision): The matrix spike duplicate is used to determine the accuracy and precision as well as the bias of a method in each sample matrix.

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.

method blank: A method blank is an analyte-free matrix, such as distilled water, for liquids or cleaned sand for solids and/or soils that is processed in the same way as the INL Site contractor program samples. The main function of the method blank is to document contamination resulting from the analytical laboratory process.

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 as follows:

- ***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.

non-community water system: A public water system that is not a community water system. A non-community water system is either a transient non-community water system or a non-transient non-community water system.

non-transient non-community water system: A public water system that is not a community water system and that regularly serves at least 25 of the same people for more than 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 (PE) sample: PE samples are prepared samples that contain known values of analyte(s) of interest to the specific project, INL Site contractor program, or laboratory. PE samples are used to assess analytical method specific laboratory performance and to check that the laboratory can be within the criteria set by the specific project or program for known value sample recovery. The samples are matched as closely as possible to the specific media, analytes of interest, and expected concentration or activity levels appropriate for the specific project, program, or use in decision making. In some cases, the PE sample matrix may differ from the field samples (i.e., using deionized water with a known amount of analyte to simulate an atmospheric moisture sample). The PE samples are generally submitted with batches of field samples so they are processed simultaneously in the laboratory.

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 that 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 the 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 for 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 non-community 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. QA includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then QA is the 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 using 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 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 following equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

replicate samples: 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. See **duplicate samples**.

reportable quantity: Any hazardous substance under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 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 occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, considering the possible harmful effects on individuals or society from 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

sample duplicate: 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 estimating the precision resulting from the sampling process. See **field replicates.**

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; for example, 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).

single-blind PE sample: The value of a single-blind PE sample is known to the INL contractor sending the sample but unknown to the laboratory receiving the sample.

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 (often abbreviated as 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: Surface radiation is monitored at the INL Site at or near waste management facilities and at the perimeter of Site facilities. See **direct radiation**.

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 action is not required by a permit or regulation.

T

thermoluminescent dosimeter: 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: 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: A chemical that can have toxic effects on the public or environment above the 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.

Tracer: Tracers are added to samples to determine the overall chemical yield for the analytical preparation steps. Tracers are made of the same element with a different isotope that is chemically similar. An example would be using ^{242}Pu as a tracer when analyzing ^{238}Pu and ^{239}Pu.

transient non-community water system: A water system that is not a community water system and serves an average of 25 individuals for less than six months per year. These systems are typically campgrounds or highway rest stops.

transuranic: 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.

trip blank*:* 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.

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 body of water 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 which under normal circumstances does 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.

Sagebrush habitat flowers


Idaho National Laboratory