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Idaho National Laboratory Site

Site Environmental Report

Environmental Surveillance, Education, and Research Program

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IDAHO NATIONAL LABORATORY

SITE ENVIRONMENTAL REPORT

CALENDAR YEAR 2013

Environmental Surveillance, Education, and Research Program

U.S. Department of Energy, Idaho Operations Office

September 2014

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Under Contract DE-NE0000300
By Gonzales-Stoller Surveillance, LLC
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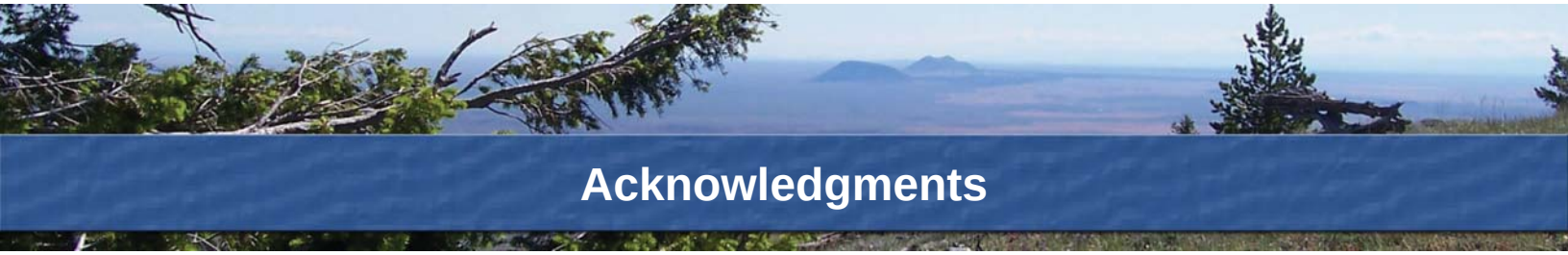

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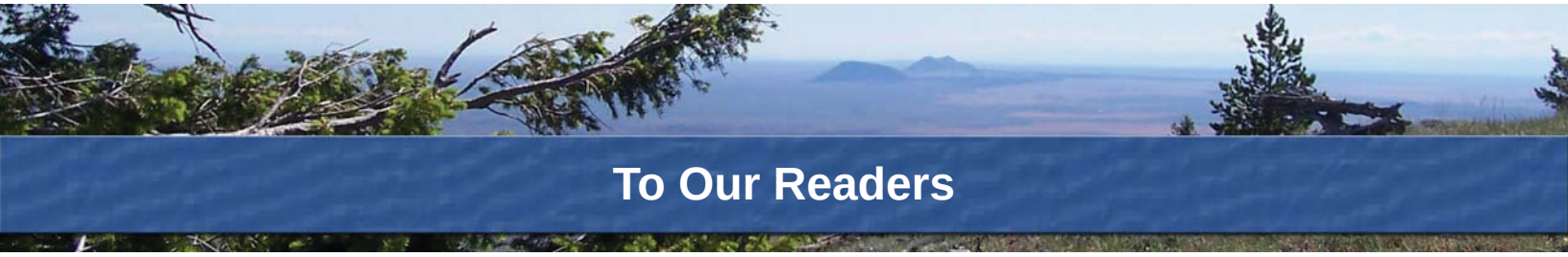


To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2013 is an overview of environmental management activities conducted on and in the vicinity of the Idaho National Laboratory (INL) Site from January 1 through December 31, 2013. This report includes:

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

The report addresses three general levels of reader interest:

- The first is a brief summary with a “take-home” conclusion. This is presented in the “Chapter Highlights” text box at the beginning of each chapter. There are no tables, figures, or graphs in the highlights. A lay person with little knowledge of science may comfortably read the Chapter Highlights.
- 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 on this page or in the CD provided with the hard copy of this report.

In addition to the Environmental Surveillance, Education, and Research Program, which is managed by Gonzales-Stoller Surveillance, LLC, the contributors to the annual report include Battelle Energy Alliance (BEA), CH2M-WG Idaho (CWI), Department of Energy, Idaho Operations Office (DOE-ID), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS). Links to their websites may be found on this page or in the CD provided with the hard copy of this report.

- Idaho National Laboratory (https://inlportal.inl.gov/portal/server.pt/community/home/255)
- Idaho Cleanup Project (https://idahocleanupproject.com/)
- Department of Energy, Idaho Operations Office (http://www.id.doe.gov/)
- Field Research Division of NOAA’s Air Resources Laboratory (http://www.noaa.inel.gov/)

- U.S. Geological Survey (http://id.water.usgs.gov/)

Included in the chapter headings of this report are historic photographs of INL Site facilities and environmental surveillance activities during the early decades of operation. A description of each photograph is provided at the end of every chapter.

Prickly Pear Cactus (*Opuntia polyacantha*)

Executive Summary

Introduction

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

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

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

The INL mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems and unique national and homeland security capabilities. In order to clear the way for the facilities required for the new nuclear energy research mission, the Idaho Cleanup Project (ICP) has been charged with the environmental cleanup of the legacy wastes generated from World War II-era conventional weapons testing, government-owned reactors, spent fuel reprocessing, and nuclear and alternative energy research. The overarching aim of the project is to reduce risks to workers, the public, and the environment and to protect the Snake River Plain aquifer. A great deal of this cleanup has occurred since 2005. Significantly, the ICP Decontamination and Decommissioning Project was officially closed out in 2012 with the safe decontamination and decommissioning of 223 buildings and structures for a total footprint reduction of over 1.6 million square feet.

Purpose of the INL Site Environmental Report

The INL Site's operations, as well as the ongoing cleanup, necessarily involve a commitment to environmental stewardship and full compliance with environmental protection laws. As part of this commitment, the INL Site Environmental Report is prepared annually to inform the public, regulators, stakeholders, and other interested parties of the INL Site's environmental performance during the year.

This report is published for the U.S. Department of Energy, Idaho Operations Office (DOE-ID) in compliance with DOE Order 231.1B, "Environment, Safety and Health Reporting." Its purpose is to:

- Present the INL Site, mission, and programs
- Report compliance status with all applicable, federal, state, and local regulations
- Describe the INL Site environmental programs and activities
- Summarize results of environmental monitoring
- Discuss potential radiation doses to the public residing in the vicinity of the INL Site
- Report on ecological monitoring and research conducted at the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data.

Major INL Site Programs and Facilities

There are three primary programs at the INL Site: the INL, the ICP, and the Advanced Mixed Waste Treatment Project (AMWTP). DOE is committed to safely retrieve, characterize, treat, and package transuranic waste for shipment out of Idaho to permanent disposal at the Waste Isolation Pilot Plant in New Mexico. Characterized waste containers that need further treatment before they can be shipped are sent to the AMWTP Treatment Facility where the waste can be

size-reduced, sorted, and repackaged. The prime contractors at the INL Site are: Battelle Energy Alliance, the management and operations contractor for the INL; CH2M-WG Idaho, LLC, which manages ongoing cleanup operations under the ICP; and Idaho Treatment Group, LLC, which operates AMWTP. The INL Site consists of several primary facilities situated on an expanse of otherwise undeveloped terrain. Buildings and structures at the INL Site are clustered within these facilities, which are typically less than a few square miles in size and separated from each other by miles of undeveloped land. In addition, DOE-ID owns or leases laboratories and administrative offices in the city of Idaho Falls, some 25 miles east of the INL Site border. About 30 percent of employees work in administrative, scientific support, and non-nuclear laboratory programs and have offices in Idaho Falls.

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

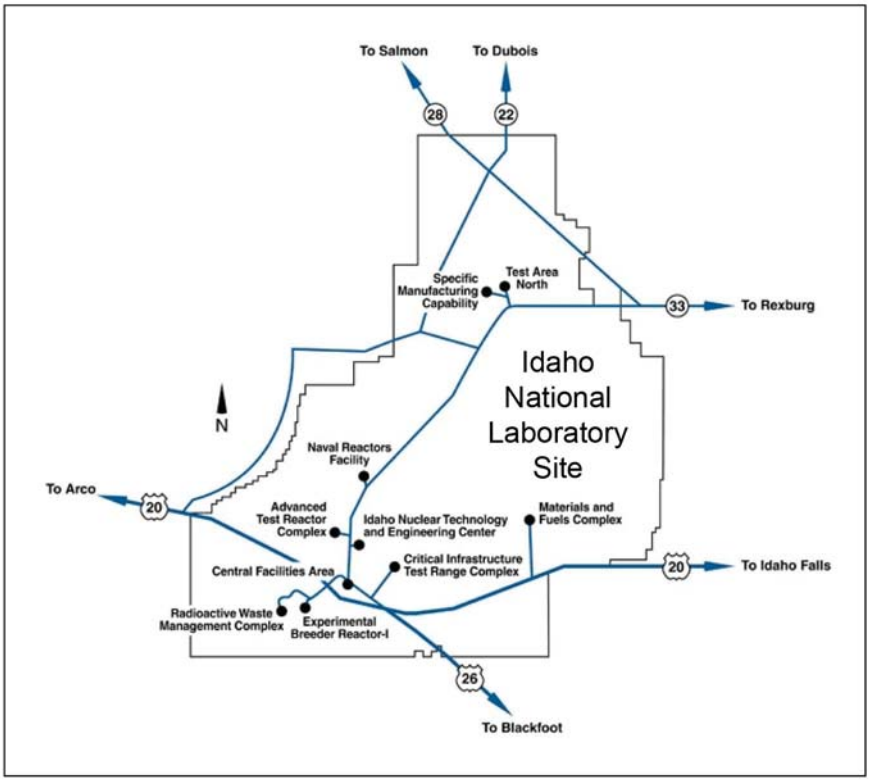


Figure ES-2. Idaho National Laboratory Site Facilities.

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

Major INL Site Area[a]	Operated By	Mission
Advanced Test Reactor (ATR) Complex	INL	Research and development of nuclear reactor technologies. Home of the ATR, a DOE National Scientific User Facility and the world's most advanced nuclear test reactor.
Central Facilities Area (CFA)	INL	Support for the operation of other INL Site facilities.
Critical Infrastructure Test Range Complex (CITRC)	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 (INTEC)	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 (MFC)	INL	Focuses on research and development of nuclear fuels. Pyroprocessing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Nuclear batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex (RWMC)	ICP	Environmental remediation; and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. Advanced Mixed Waste Treatment Project (AMWTP), operated by Idaho Treatment Group, LLC, and co-located with RWMC, characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities.
Research and Education Campus (REC)	INL	Located in Idaho Falls, is home to INL administration, the INL Research Center (IRC), the Center for Advanced Energy Studies (CAES), and other energy and security research programs. Research is conducted at IRC in robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. CAES is a research and education partnership between Boise State University, INL, Idaho State University, and University of Idaho to conduct energy research and address the looming nuclear energy work-force shortage.
Test Area North (TAN)/Specific Manufacturing Capability (SMC)	INL	Several historic nuclear research and development projects were conducted at TAN. Major cleanup and demolition of the facility was completed in 2008 and the current mission is manufacture of tank armor for the U.S. Army's battle tanks at the SMC for the U.S. Department of Defense.

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

Environmental Protection Programs

Directives (orders, guides, and manuals) are DOE's primary means of establishing policies, requirements, responsibilities, and procedures for DOE offices and contractors. Among these are a series of orders directing each DOE site to implement sound stewardship practices that are protective of the public and the environment. These orders require the implementation of an environmental management system (EMS), a Site Sustainability Plan, radioactive waste management, and radiation protection of the public and biota.

Battelle Energy Alliance, CH2M-WG Idaho, LLC, and Idaho Treatment Group have each established and implemented an EMS and contribute to the INL Site Sustainability Plan, as required by DOE and executive orders. Each EMS integrates environmental protection, environmental compliance, pollution prevention, and waste minimization into work planning and execution throughout all work areas. The INL Sustainability Plan contains strategies and activities that will lead to continual greenhouse gas reductions as well as energy, water, and transportation fuels efficiency at the INL Site. Plan requirements are integrated into each INL Site contractor's Integrated Safety Management System and EMS. In 2013, the INL Site as a whole achieved reductions in energy, water, and fossil fuel usage, decreased greenhouse gas emissions, and increased alternative fuels usage.

An essential element for the successful implementation of the INL Site EMSs is the Pollution Prevention Program, which incorporates national and DOE requirements to reduce, reuse, and recycle wastes and pollutants as an integral part of the site's operating philosophy. INL Site radioactive waste management involves four types of radioactive wastes: low-level, mixed (hazardous and radioactive), transuranic, and high-level radioactive wastes. Significant accomplishments during 2013 include the shipment of treated transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, for disposal. The mixed low-level waste and low-level waste were sent to Nevada Test Site or to commercial facilities.

The INL Site met all DOE public and biota dose limits for radiation protection in 2013.

Environmental Restoration

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

Comprehensive remedial investigation/feasibility studies have been conducted at all WAGs and closeout activities have been implemented at five WAGs. In 2013, all institutional controls and operational and maintenance requirements were maintained and active remediation continued on WAGs 1, 3, 7, and 6/10.

Radiation Dose to the Public and Biota from INL Site Releases

Humans, plants, and animals potentially receive radiation doses from various INL Site operations. The DOE sets dose limits for the public and biota to ensure that exposure to radiation from site operations are not a health concern. Potential radiological doses to the public from INL Site operations were calculated to determine compliance with pertinent regulations and limits (Table ES-2). The calculated dose to the maximally exposed individual in 2013 was 0.03 mrem (0.30 µSv), well below the 10-mrem standard established by the Clean Air Act. The maximally exposed individual is a hypothetical member of the public who could receive the maximum possible dose from INL Site releases. This person was assumed to live just south of the INL boundary. For comparison, the dose from natural background radiation was estimated in 2013 to be 386 mrem to an individual living on the Snake River Plain. The maximum potential population dose to the approximately 314,069 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.499 person-rem (0.005 person-Sv), below that expected from exposure to background radiation (121,231 person-rem or 1,212 person-Sv).

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2013).

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (µSv)	Percent of DOE 100-mrem/yr Dose Limit[a]	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	0.0302	0.302	0.0302	0.5	0.005	314,069	121,321
Waterfowl ingestion	0.0355	0.355	NA[c]	NA	NA	NA	NA
Big game animals	0.0002	0.002	NA	NA	NA	NA	NA
Total pathways	**0.0659**	**0.659**	**0.0659**	**NA**	**NA**	**NA**	**NA**

a. The EPA regulatory standard for the air pathway is 10 mrem/yr effective dose equivalent. The DOE limit for all pathways is 100 mrem/yr total effective dose equivalent.

b. The individual dose from background was estimated to be 386 mrem (3860 µSv) in 2013 (Table 7-6).

c. NA = Not applicable

The maximum potential individual dose from consuming waterfowl at the INL Site, based on the highest concentrations of radionuclides measured in samples of these animals, was estimated to be 0.036 mrem (0.36 µSv). The maximum dose from consumption of big game animals was estimated at 0.0002 mrem (0.002 µSv). When the dose from waterfowl and big game ingestion were summed with the dose estimated for the air pathway, the maximally exposed individual could potentially receive a total dose of 0.066 mrem (0.66 µSv) in 2013. This is 0.066 percent of the DOE health-based dose limit of 100 mrem/yr (1 mSv/yr) from all pathways for the INL Site.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located along the southern INL Site boundary. A hypothetical individual drinking water from these wells would receive a dose of less than 0.2 mrem (0.002 mSv) in one year. This is an unrealistic pathway to humans as there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for tritium corresponds to a dose of approximately 4 mrem (0.04 mSv).

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Maximum concentrations of radionuclides measured in waterfowl tissue were used to estimate doses to those wildlife accessing ATR Complex ponds. Ducks were estimated to receive less than the standard of 1 rad/d (1 mGy/d) established by DOE for aquatic biota. Based on the 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. Overall, the INL Site met all federal, state, and local regulatory commitments in 2013. INL Site compliance with major federal regulations established for the protection of human health and the environment is presented in Table ES-3. There were no reportable environmental occurrences or unplanned releases in 2013.

Environmental Monitoring of Air

Airborne releases from INL Site operations are reported annually in a document prepared in accordance with the Code of Federal Regulations, Title 40, “Protection of the Environment,” Part 61, “National Emission Standards for Hazardous Air Pollutants,” Subpart H, “National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities.” An estimated total of 2,890 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2013. The highest releases were from the ATR Complex (57.6 percent of total), INTEC (39.5 percent of total), and RWMC (2.8 percent of total.)

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

Regulator/ Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA/ 40 CFR 61, Subpart H	The Clean Air Act (CAA) is the basis for national air pollution control. Emissions of radioactive hazardous air pollutants are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutants (NESHAPs), (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2013.*	2.1.1 4.2 8.2.1
DOE/ Order 458.1, Change 2	The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires the preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment.	The INL Site maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions does not present risk to the public, workers, or environment. Environmental monitoring plans are well documented and the results are published annually in the INL Site Environmental Report	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/ 40 CFR 300	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites.	Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. In 1991, the INL Site entered into a tri-party agreement, the Federal Facility Agreement and Consent Order, with EPA, the state of Idaho, and DOE-ID. INL Site remediation is conducted by the Idaho Cleanup Project (ICP).	3.2
EPA/ 40 CFR 109–140	The Clean Water Act (CWA) establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two CWA permits – the National Pollution Discharge Elimination System (NPDES) permits and Storm Water Discharge Permits for Construction Activity.	2.4.1
EPA/ 40 CFR 141–143	The Safe Drinking Water Act (SDWA) establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site has 12 active drinking water systems which are routinely sampled and analyzed as required by the state of Idaho and EPA.	5.4

The INL Site environmental surveillance programs, conducted by the INL, ICP, and the Environmental Surveillance, Education, and Research (ESER) contractors, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2013, the INL contractor monitored ambient air outside 17 INL Site facilities and at four locations off the INL Site. The ICP contractor focused on ambient air monitoring of waste management facilities, namely INTEC and the RWMC. The ESER contractor sampled ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at six locations distant from the INL Site.

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

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

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

Environmental Monitoring of Groundwater, Drinking, and Surface Water for Compliance Purposes

The INL and ICP contractors monitor liquid effluents, drinking water, groundwater, and storm water runoff at the INL Site, primarily for nonradioactive constituents, to comply with applicable laws and regulations, DOE orders, and other requirements. Wastewater is typically discharged from INL Site facilities to the ground surface. Wastewater discharges occur at percolation ponds southwest of INTEC, a cold waste pond at the ATR Complex, and a sewage treatment facility at CFA. These effluents are regulated by the state of Idaho groundwater quality and wastewater rules through wastewater reuse permits, which require monitoring of the wastewater and, in some instances, groundwater in the area. During 2013, liquid effluent and groundwater

monitoring were conducted in support of wastewater reuse permit requirements. An annual report for each permitted facility was prepared and submitted to the Idaho Department of Environmental Quality. No permit limits were exceeded.

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

Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Drinking water was sampled in nine drinking water systems at the INL Site in 2013. Results were below limits for all relevant drinking water standards. The CFA distribution system serves 500 workers daily and is downgradient from an historic groundwater plume of radionuclides resulting from wastewater injection by INTEC and the ATR Complex directly into the aquifer. Because of this, a dose was calculated to a worker who might obtain all their drinking water from the CFA drinking water system during 2013. The dose, 0.2 mrem (2.0 μSv), is below the EPA standard of 4 mrem/yr (40 μSv/yr) for public drinking water systems.

Surface water flows off the 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-238, plutonium-239/240, and ^{90}Sr were detected within historical levels. The detected concentrations are well below standards established by DOE for radiation protection of the public and the environment.

Environmental Monitoring of the Eastern Snake River Plain Aquifer

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

The USGS began to monitor the groundwater below the INL Site in 1949. Currently, the USGS performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain aquifer under and adjacent to the INL Site. These activities utilize an extensive network of strategically placed monitoring wells on and around the INL. In 2013, the USGS continued to monitor localized areas of chemical and radiochemical contamination beneath the INL Site produced by past waste disposal practices, in particular the direct injection of wastewater into the aquifer at INTEC and the ATR Complex. Results for monitoring wells sampled within the plumes show decreasing concentrations of tritium and ^{90}Sr over time.

Several purgeable organic compounds were detected by USGS in 27 groundwater monitoring wells sampled at the INL Site in 2013. The concentration of tetrachloromethane (carbon

tetrachloride) was above the EPA maximum contaminant level (MCL) during all 12 months of 2013 in the production well at the RWMC. Concentrations of most other organic compounds and trace elements detected were below their respective primary contaminant standards. Groundwater surveillance monitoring continued for the CERCLA WAGs on the INL Site in 2013. At TAN (WAG 1), results of groundwater monitoring indicated that in situ bioremediation of the plume of trichloroethene has been effective. Data from groundwater in the vicinity of the ATR Complex (WAG 2) show no concentrations of chromium, ^{90}Sr, and tritium above MCLs.

Groundwater samples collected from aquifer and perched water monitoring wells at and near INTEC (WAG 3) indicate ^{90}Sr exceeded the MCL at seven well locations, had three constituents which exceeded drinking water maximum contaminant levels: strontium-90, technetium-99, and nitrate. The source of ^{90}Sr is past disposal of service waste to the injection well at INTEC. Technicium-99 is from past releases from the INTEC Tank Farm. The presence of elevated nitrate is attributed to past Tank Farm releases and has remained relatively constant over the past few years at INTEC. Strontium-90, technicium-99, and nitrate show stable or declining trends. Monitoring of groundwater for the CFA landfills (WAG-4) consists of sampling wells for metals, volatile organic compounds, and anions. Five organic compounds were detected in groundwater downgradient of the CFA, at levels well below the established EPA maximum concentrations levels. Nitrate exceeded its maximum contaminant level in 2013, but the concentration was within historic levels. None of the organic compounds exceeded any EPA maximum contaminant level. At the RWMC (WAG 7), carbon tetratchloride slightly exceeded its maximum contaminant level in one aquifer well north of the facility in 2013. Wells at the MFC (WAG 9) are sampled for radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters. Overall, the results show no evidence of impacts from MFC activities.

Drinking water and surface water samples were sampled downgradient of the INL Site and analyzed for gross alpha and beta activity and tritium. Tritium was detected in some samples at levels within historical measurements and below the EPA maximum contaminant level. Gross alpha and beta results were within historical measurements.

Monitoring of Agricultural Products, Wildlife, and Direct Radiation Measurements

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, grain, and potatoes) and wildlife were sampled and analyzed for radionuclides in 2013. The agricultural products were collected on, around and distant from the INL Site by the ESER contractor.

Wildlife sampling included collection of ducks from wastewater ponds in the vicinity of the ATR Complex and the MFC, as well as big game animals killed by vehicles on roads within the INL Site. In addition, direct radiation was measured on and off the INL Site in 2013.

Some human-made radionuclides were detected in agricultural product, waterfowl and big game samples. However, measurements were consistent with those made historically.

Strontium-90, a radionuclide measured in fallout, was detected at low levels in some lettuce samples. Cesium-137, another fallout radionuclide, was detected in the liver of one big game animal sampled in 2013. Cesium-137, cobalt-60, ^{90}Sr, and zinc-65 were measured in the edible tissue of waterfowl accessing ATR Complex wastewater ponds.

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

Monitoring of Wildlife Populations

Field data are routinely collected on several key groups of wildlife at the INL Site for information that can be used to prepare National Environmental Policy Act documents and to enable DOE to make informed decisions for planning projects and compliance with environmental policies and executive orders related to protection of wildlife. Surveys are routinely conducted on bird, big game, and bat populations on the INL Site. Monitoring in 2013 included the midwinter eagle survey, sage-grouse lek surveys, and a breeding bird survey. During 2013 permanent bat monitoring stations were monitored at the INL Site.

Environmental Research at the Idaho

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

The Idaho National Environmental Research Park maintains several regionally and nationally important long-term ecological data sets. It is home to one of the largest data sets on sagebrush steppe vegetation anywhere. In 1950, 100 vegetation plots were established on the INL Site and were originally designed to look for the potential effects of nuclear energy research on native vegetation. Since then the plots have been surveyed about every 5 to 7 years. In 2013, six major ecological research projects took place on the Idaho National Environmental Research Park. The researchers were from Idaho State University; Boise State University; Montana State University; Texas A&M; Washington State University; Environmental Surveillance, Education, and Research Program; Wildlife Conservation Society; and U.S. Department of Agriculture.

USGS Research

The USGS INL Project Office drills and maintains research wells which provide information about subsurface water, rock and sediment, and contaminant movement in the eastern Snake River Plain aquifer at and near the INL Site. In 2013, the USGS published seven research reports.

Quality Assurance

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

Adherence to procedures and quality assurance project plans was maintained during 2013. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP and ESER contractors during 2013 were addressed with the laboratories and have been or are being resolved.

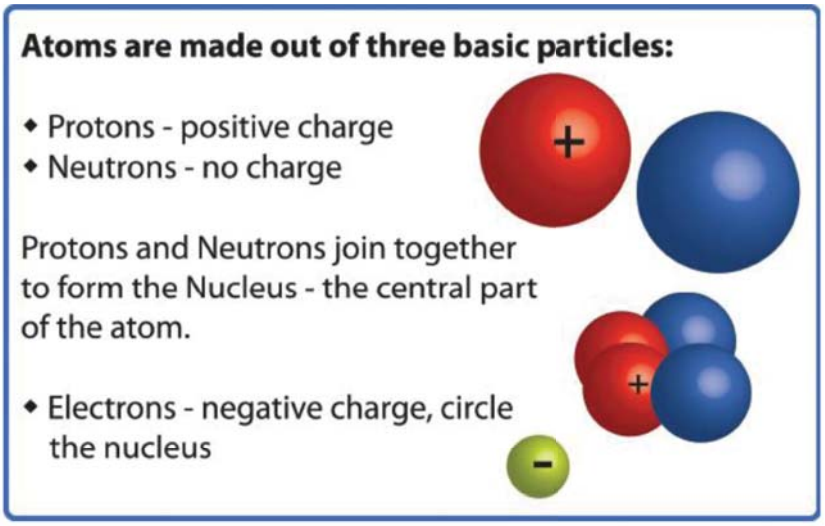
Big Southern Butte

Helpful Information

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

What is Radiation?

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



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

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

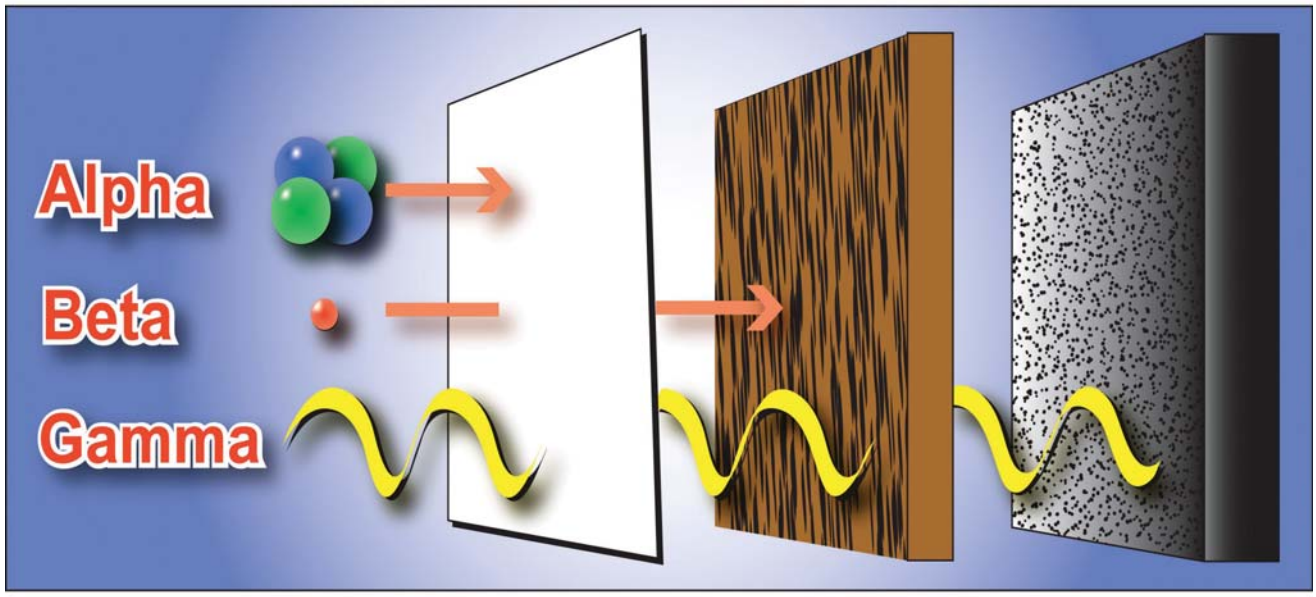


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

X-Rays and Gamma-Rays. X-rays and gamma-rays are photons that have very short wavelengths compared to other electromagnetic waves, such as visible light, heat rays, and radio waves. Gamma-rays and X-rays have identical properties, behavior, and effects, but differ only in their origin. Gamma-rays originate from an atomic nucleus, and X-rays originate from interactions with the electrons orbiting around atoms. All photons travel at the speed of light. Their energies, however, vary over a large range. The penetration of X-ray or gamma-ray photons depends on the energy of the photons, as well as the thickness, density, and composition of the shielding material. Concrete is a common material used to shield people from gamma-rays and X-rays (Figure HI-1). Examples of gamma-emitting radionuclides include radioactive atoms of iodine and cesium. X-rays may be produced by medical X-ray machines in a doctor's office.

How are Radionuclides Designated?

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

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

Symbol	Radionuclide	Half-life[a,b]	Symbol	Radionuclide	Half-life
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.5 d
^{243}Am	Americium-243	7,380 yr	^{59}Ni	Nickel-59	7.5×10^4 yr
^{125}Sb	Antimony-125	2.77 yr	^{63}Ni	Nickel-63	96 yr
^{41}Ar	Argon-41	1.827 hr	^{238}Pu	Plutonium-238	87.74 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.4065×10^4 yr
^{140}Ba	Barium-140	12.74 d	^{240}Pu	Plutonium-240	6.537×10^3 yr
^{7}Be	Beryllium-7	53.3 d	^{241}Pu	Plutonium-241	14.4 yr
^{14}C	Carbon-14	5,730 yr	^{242}Pu	Plutonium-242	3.763×10^5 yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.28×10^9 yr
^{144}Ce	Cerium-144	284.3 d	^{226}Ra	Radium-226	1.62×10^3 yr
^{134}Cs	Cesium-134	2.062 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.0 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.704 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.271 yr	^{103}Ru	Ruthenium-103	39.28 d
^{152}Eu	Europium-152	13.33 yr	^{106}Ru	Ruthenium-106	368.2 d
^{154}Eu	Europium-154	8.8 yr	^{90}Sr	Strontium-90	29.12 yr
^{3}H	Tritium	12.35 yr	^{99}Tc	Technetium-99	2.13×10^5 yr
^{129}I	Iodine-129	1.57×10^7 yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.04 d	^{233}U	Uranium-233	1.585×10^5 yr
^{55}Fe	Iron-55	2.7 yr	^{234}U	Uranium-234	2.445×10^5 yr
^{59}Fe	Iron-59	44.529 d	^{235}U	Uranium-235	7.038×10^8 yr
^{85}Kr	Krypton-85	10.72 yr	^{238}U	Uranium-238	4.468×10^9 yr
^{87}Kr	Krypton-87	1.27 hr	^{90}Y	Yttrium-90	64.0 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	243.9 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	63.98 d

a. From EPA (1999).

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

How are Radioactivity and Radionuclides Detected?

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

Air and water samples are often analyzed to determine the total amount of alpha and beta-emitting radioactivity present. This is referred to as a "gross" measurement, because the radiation from all alpha-emitting and beta-emitting radionuclides in the sample is quantified. Such sample analyses measure both human-generated and naturally occurring radioactive material. Gross alpha and beta analyses are generally considered screening measurements, since specific radionuclides are not identified. The amount of gross alpha and beta-emitting radioactivity in air samples is frequently measured to screen for the 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 (G-M) counter. However, detection of specific beta-emitting radionuclides, such as ^{3}H and strontium-90 (^{90}Sr), requires chemical separation first.

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

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

How are Results Reported?

Scientific Notation. Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very large. A very small number may be expressed with a negative exponent, for example, 1.3×10^{-6}. To convert this number to its decimal form, the decimal point is moved left by the number of places equal to the exponent (six, in this case). The number 1.3×10^{-6} may also be expressed as 0.0000013.

When considering large numbers with a positive exponent, such as 1.0×10^{6}, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0×10^{6} represents one million and may also be written as 1,000,000.

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

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

Table HI-2. Multiples of Units.

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

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

The Système International (SI) is the official system of measurement used internationally to express units of radioactivity and radiation dose. The basic SI unit of radioactivity is the Becquerel (Bq), which is equivalent to one nuclear disintegration per second. The number of curies must be multiplied by 3.7×10^{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 and sievert (Sv) for effective dose, where 1 Sv equals 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.

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

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

Table HI-4. Units of Radioactivity.

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

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the "true value" of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value which is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). There is a 68-percent probability that the true concentration is in the range of the reported concentration plus or minus the analytical uncertainty (i.e., 8 - 12 pCi/L for the example). Some labs report the analytical uncertainty as two times the uncertainty value at which there is a 95-percent probability that the true concentration is in the range of 6 - 14 pCi/L for the example. In the laboratory, radionuclide concentrations that equal three times the analytical uncertainty represent a measurement of the minimum detectable concentration. For concentrations of greater than or equal to three times the uncertainty, there is 95-percent or more probability of correctly concluding that a selected radionuclide was detected in a sample. For example, if a radionuclide is reported for a sample at a concentration of 10 ± 2 pCi/L, it is concluded that that radionuclide was 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 it is concluded that the sample probably does not contain that radionuclide; i.e., 10 is less than 3 × 6 or 18.

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

of results is the median. If there is an even number of results, the median is the average of the two central values. The maximum and the minimum results represent the range of the measurements.

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

How are Data Represented Graphically?

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

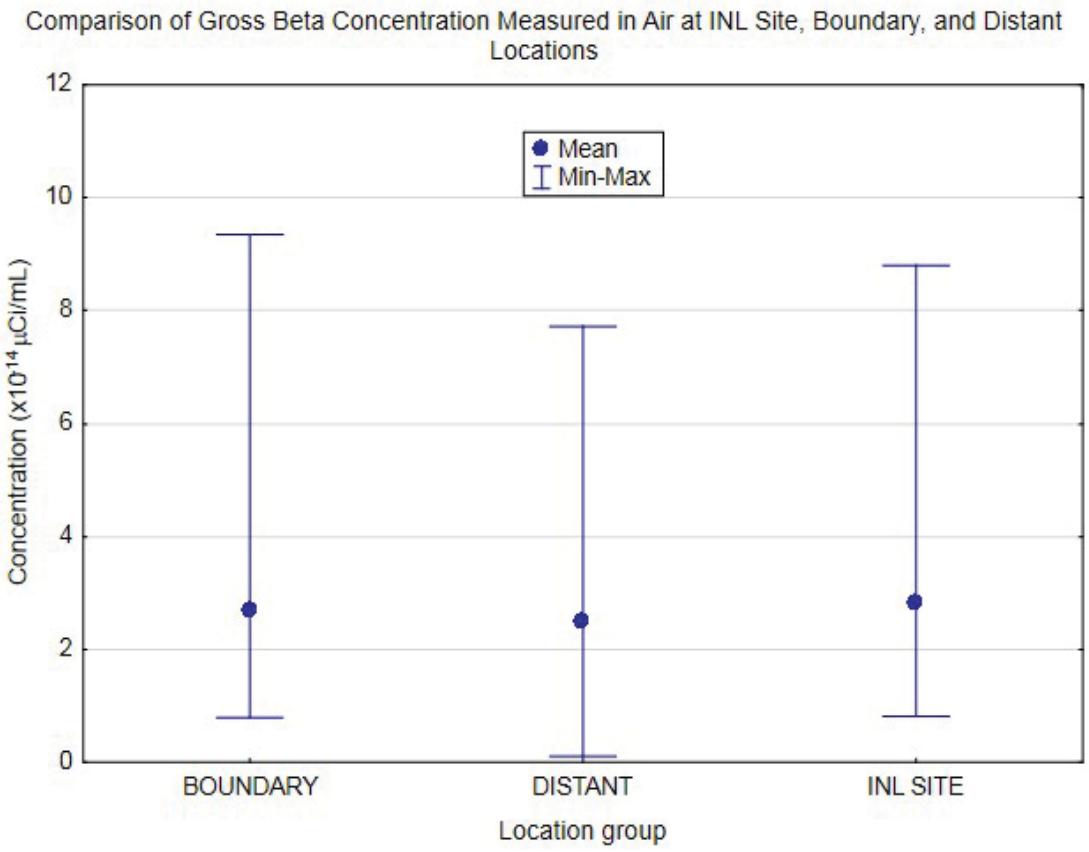


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.

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 upper right-hand corner of the figure. The medical, consumer, and occupational/industrial portions are from National Council on Radiation Protection and Measurements Report No. 160 (NCRP 2009). The contribution from background (natural radiation, mostly radon) is estimated in Table 7-5 of this report.

A **column or bar chart** can show data changes over a period of time or illustrate comparisons among items. Figure HI-4 illustrates the contribution of radionuclides released into air from INL Site operations from 1975 through 1984 to the dose (mrem) calculated for the maximally exposed individual. The maximally exposed individual is a hypothetical member of the public who is exposed to radionuclides from airborne releases through various environmental pathways and the media through which the radionculides are transported (i.e., air, water, and food). One column (red) represents the annual dose from krypton-88 (^{88}Kr) released. The second column (green) plots the annual dose from all radionuclides released into the air. The chart shows the general decreasing trend of the dose as well as the relative contribution to dose from the ^{88}Kr. The relative contribution to the total dose from ^{88}Kr varies over time. For example, it represents approximately one-third of the total dose in 1975 and a little over one-half of the dose in 1976.

A **plot** can be useful to visualize differences in results over time. Figure HI-5 shows the median, minimum, and maximum results of gross beta measurements in all air filters collected by the Environmental Surveillance, Education, and Research contractor for ten years (2003

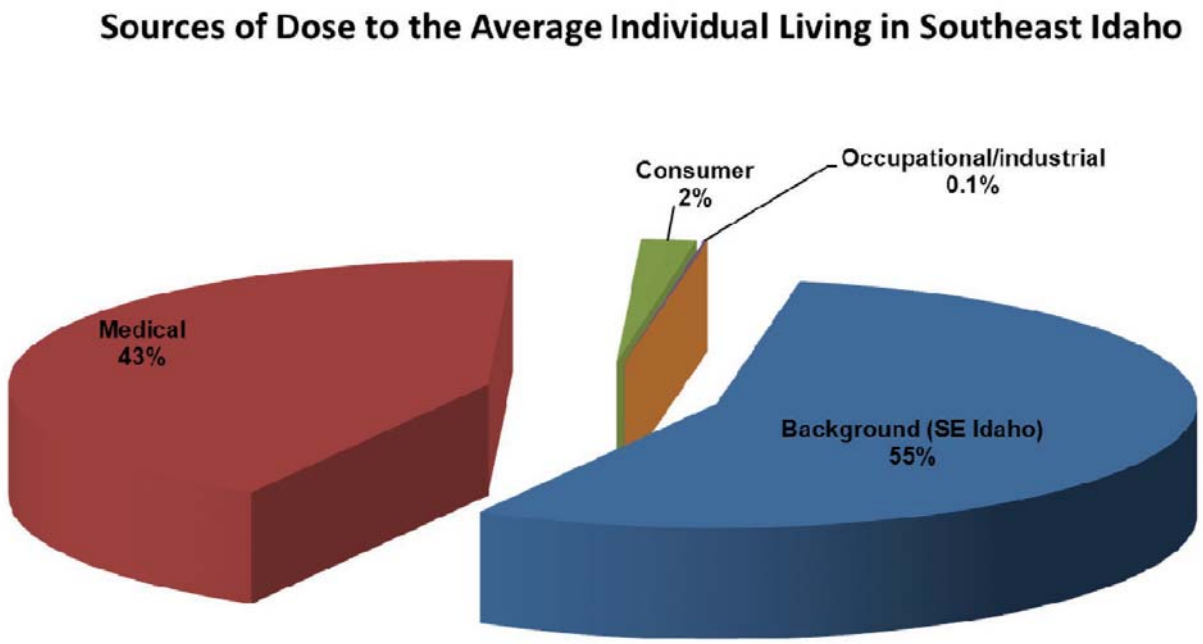


Figure HI-3. Data Presented Using a Pie Chart.

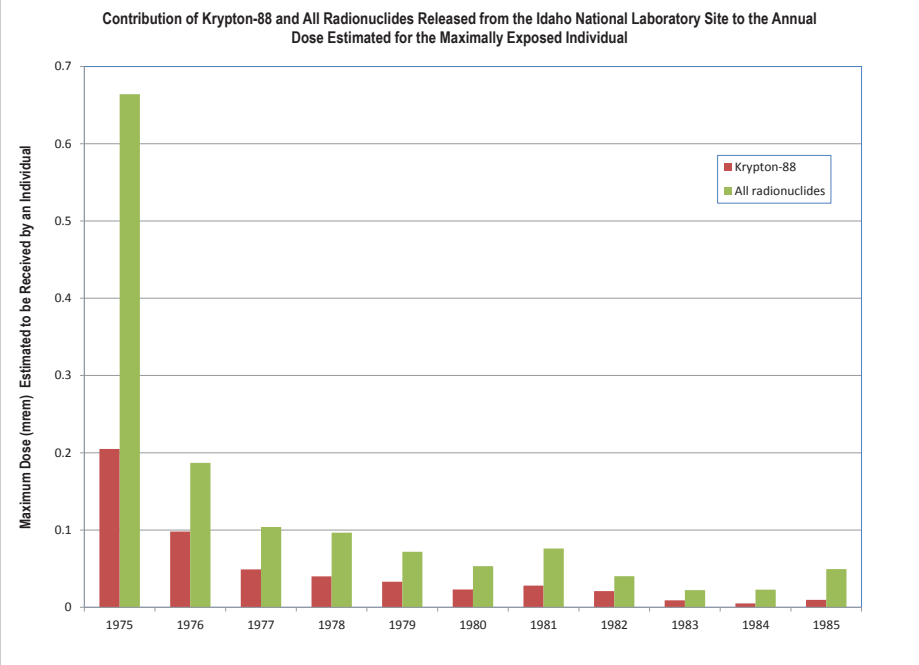


Figure HI-4. Data Plotted Using a Column Chart.

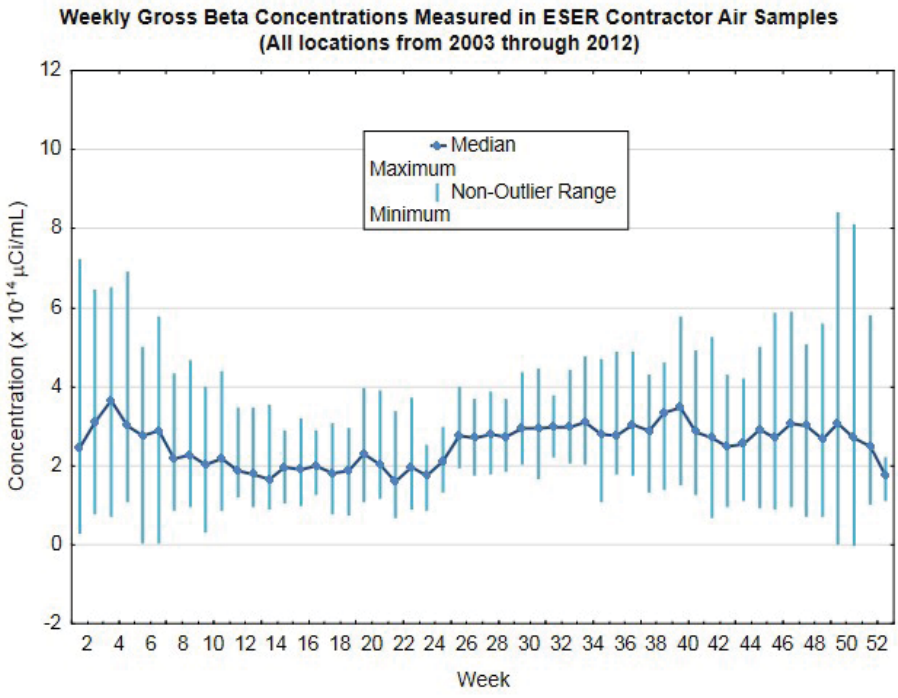


Figure HI-5. Data Plotted Using a Linear Plot.

through 2012). The results are plotted by the week of the year. Thus, the median for each week represents the midpoint of measurements made at all locations during the ten-year period for that week. The plot shows that the results can vary greatly, particularly during the winter.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of ^{3}H in groundwater around the Idaho Nuclear Technology and Engineering Center (INTEC). Each contour line, or isopleth, represents a specific concentration of the radionuclide in groundwater. It was estimated from measurements of samples collected from wells around INTEC. Each contour line separates areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

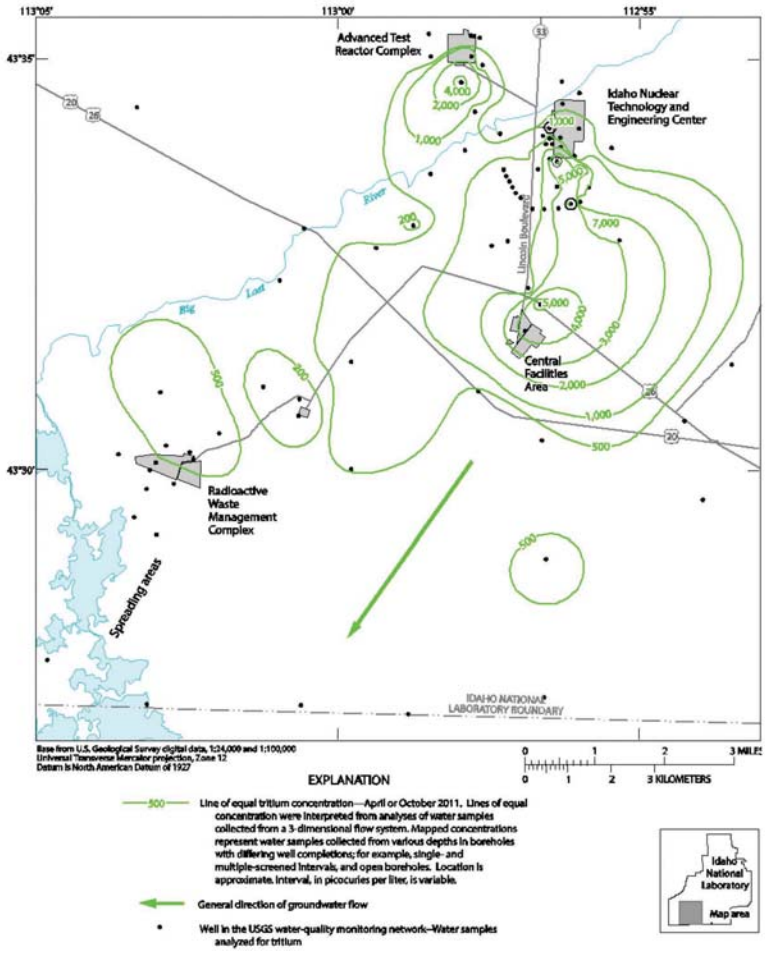


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal tritium concentration in water samples collected at the same depth from wells on the INL Site.

How are Results Interpreted?

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

- **Comparison of results collected at different locations.** For example, measurements made at INL Site locations are compared with those made at locations near the boundary of the INL Site and distant from the INL Site to find differences that may indicate an impact (Figure HI-2).
- **Trends over time or space.** Data collected during the year can be compared with data collected at the same location or locations during previous years to see if concentrations are increasing, decreasing, or remaining the same with time. See, for example, Figure HI-4, which shows a general decrease in dose over time. Figure HI-6 illustrates a clear spatial pattern of radionuclide concentrations in groundwater decreasing with distance from the source.
- **Comparison with background measurements.** Humans are now, and always have been, continuously exposed to ionizing radiation from natural background sources. Background sources include natural radiation and radioactivity as well as radionuclides from human activities. These sources are discussed in the following section.

What is Background Radiation?

Radioactivity from natural and fallout sources is detectable as “background” in all environmental media. Natural sources of radiation include: radiation of extraterrestrial origin (called cosmic rays), radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides), and radionuclides present at the time of the formation of the earth (called primordial radionuclides). Radiation that has resulted from the activities of modern man is primarily fallout from past atmospheric testing of nuclear weapons. One of the challenges to environmental monitoring on and around the INL Site is to distinguish between what may have been released from the INL Site and what is already present in background from natural and fallout sources. These sources are discussed in more detail below.

Natural Sources. Natural radiation and radioactivity in the environment, that is natural background, represent a major source of human radiation exposure (NCRP 1987, NCRP 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 2013 to receive an average dose of about 386 mrem/yr (3.9 mSv/yr) from natural background sources of radiation on earth (Figure HI-7). These sources include cosmic radiation and naturally occurring radionuclides.

Cosmic radiation is radiation that constantly bathes the earth from extraterrestrial sources. The atmosphere around the earth absorbs some of the cosmic radiation, so doses are lowest at sea level and increases 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.

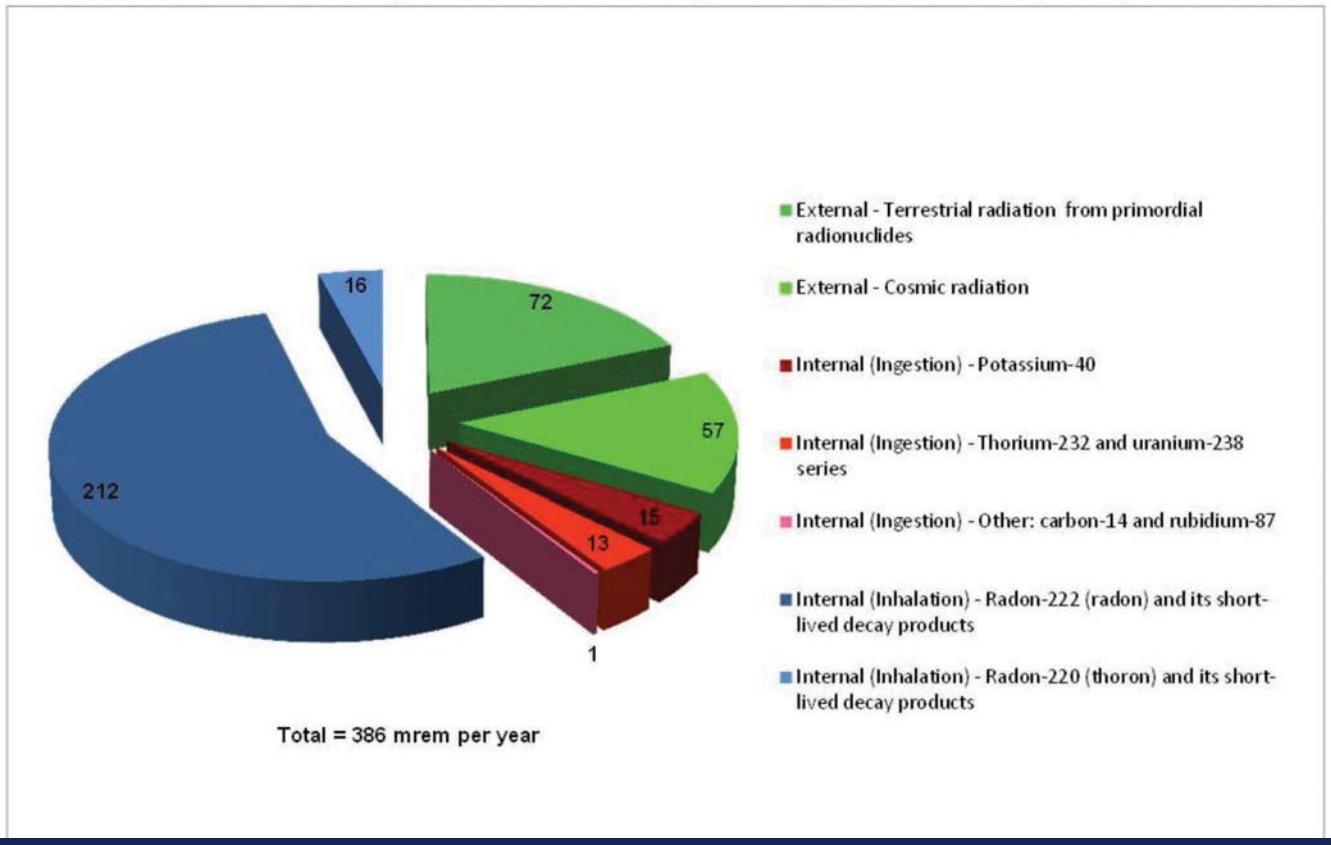


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2013).

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

Primordial radionuclides are those that were present when the earth was formed. The primordial radionuclides detected today are billions of years old. The radiation dose to a person from primordial radionuclides comes from internally deposited radioactivity, inhaled radioactivity, and external radioactivity in soils and building materials. Three of the primordial radionuclides,

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)	2.7×10^{6} yr	Cosmic rays	Rain, air
Tritium (^{3}H)	12.3 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.26×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.4×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.5×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.5×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,620 yr	^{238}U progeny	Water

potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th), are responsible for most of the dose received by people from natural background radioactivity. They have been detected in environmental samples collected on and around the INL Site (Table HI-5). The external dose to an adult living in southeast Idaho from terrestrial natural background radiation exposure (76 mrem/yr or 0.76 mSv/yr) has been estimated using concentrations of ^{40}K, ^{238}U, and ^{232}Th measured in soil samples collected from areas surrounding the INL Site from 1976 through 1993. Uranium-238 and ^{232}Th are also estimated to contribute 13 mrem/yr (0.13 mSv/yr) to an average adult through ingestion (NCRP 2009).

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

Uranium-238 and ^{232}Th each initiate a decay chain of radionuclides. A radioactive decay chain starts with one type of radioactive atom called the “parent” that decays and changes into another type of radioactive atom called a “progeny” radionuclide. This system repeats, involving several different radionuclides. The parent radionuclide of the uranium decay chain is ^{238}U. The most familiar element in the uranium series is radon, specifically radon-222 (^{222}Rn). This is a gas that can accumulate in buildings. Radon and its progeny are responsible for most of the inhalation dose (an average of 200 mrem/yr [2.0 mSv/yr] nationwide) produced by naturally occurring radionuclides (Figure HI-7). The parent radionuclide of the thorium series is ^{232}Th. Another isotope of radon (^{220}Rn), called thoron, occurs in the thorium decay chain of radioactive atoms. Uranium-238, ^{232}Th, and their progeny often are detected in environmental samples (Table HI-5).

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

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

The deposition of these radionuclides on the earth’s surface varies by latitude, with most occurring in the northern hemisphere at approximately 40°. 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 over 30 years since that estimate, so the current dose is even lower.

What Are the Risks of Exposure to Low Levels of Radiation?

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

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

It is difficult to estimate risks from low levels of radiation. Low-dose effects are those that might be caused by doses of less than 20 rem (0.2 Sv), whether delivered acutely or spread

out over a period as long as a year (Taylor 1996). Most of the radiation exposures that humans receive are very close to background levels. Moreover, many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its effects. For this reason, government agencies make the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of health effects. Cancer is considered by most scientists to be the primary health effect from long-term exposure to low levels of radiation.

Each radionuclide represents a somewhat different health risk. However, health physicists (radiation protection professionals) currently estimate that overall, if each person in a group of 10,000 people is exposed to 1 rem (0.01 Sv) of ionizing radiation in small doses over a lifetime, we would expect five or six more people to die of cancer than would otherwise (EPA 2013). In this group of 10,000 people, about 2,000 would be expected to die of cancer from all non-radiation causes. A lifetime exposure to 1 rem (0.01 Sv) of radiation would increase that number to about 2,005 or 2,006. For perspective, most people living on the eastern Snake River Plain receive over one-third of a rem (390 mrem or 3.9 mSv) every year from natural background sources of radiation.

Health physicists generally agree on limiting a person's exposure beyond background radiation to about 100 mrem/yr (1 mSv) from all sources (EPA 2013). Exceptions are occupational, medical, or accidental exposures. DOE limits the dose to a member of the public from all sources and pathways to 100 mrem (1 mSv) and the dose from the air pathway only to 10 mrem (0.1 mSv) (DOE Order 458.1). The doses estimated to maximally exposed individuals from INL Site releases are typically well below 1 mrem (0.01 mSv or 10 μSv) per year.

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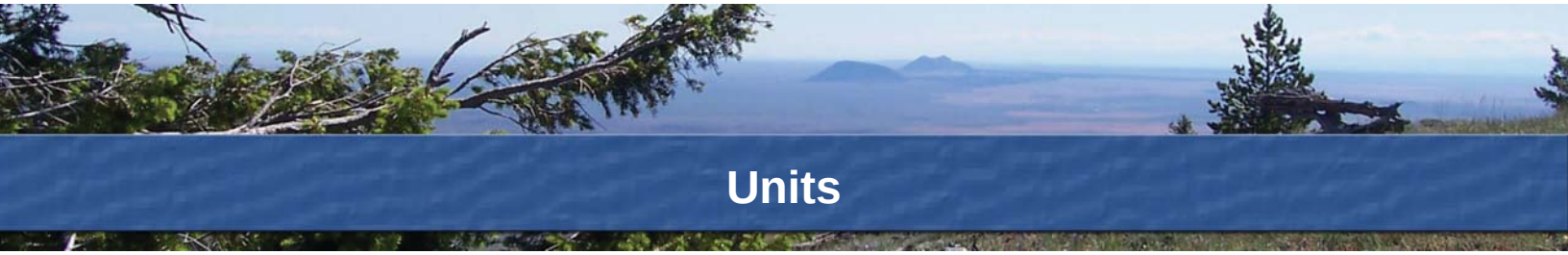
Acronyms

AIP	Agreement in Principle
ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
ARA	Auxiliary Reactor Area
ARP	Accelerated Retrieval Project
ARPA	Archaeological Resource Protection Act
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance
BBS	Breeding Bird Survey
BLM	Bureau of Land Management
BLS	Below Land Surface
CAA	Clean Air Act
CAP88-PC	Clean Air Act Assessment Package, 1988 Personal Computer
CCA	Candidate Conservation Agreement
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CRM	Cultural Resource Management
CRMO	Cultural Resource Management Office
CTF	Contained Test Facility
CWA	Clean Water Act
CWI	CH2M-WG Idaho, LLC
CWP	Cold Waste Pond
CY	Calendar Year
D&D	Decontamination and Decommissioning
DCS	Derived Concentration Standard
DCG	Derived Concentration Guide
DEQ	Department of Environmental Quality (state of Idaho)
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DOE-ID	U.S. Department of Energy, Idaho Operations Office
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor-I
EBR-II	Experimental Breeder Reactor-II
EC	Environmental Checklist
EFS	Experimental Field Station
EIC	Electret Ionization Chamber
EIS	Environmental Impact Statement

EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EO	Executive Order
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Register
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GHG	Greenhouse Gas
GP	Guiding Principles
GPS	Global Positioning System
GSS	Gonzales-Stoller Surveillance, LLC
HIP	Hot Isostatic Pressing
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
IEC	International Electrotechnical Commission
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IOP	INL Oversight Program (state of Idaho DEQ)
ISB	In Situ Bioremediation
ISO	International Organization for Standardization
ISU	Idaho State University
ISU-EAL	Idaho State University-Environmental Assessment Laboratory
IWTU	Integrated Waste Treatment Unit
LOFT	Loss-of-Fluid Test
LSD	Least Significant Difference
LTV	Long-Term Vegetation
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MD	Mean Difference
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MESODIF	Mesoscale Diffusion Model
MFC	Materials and Fuels Complex
NA	Not Applicable
NAPL	Non-aqueous Phase Liquid
NCRP	National Council on Radiation Protection and Measurements
ND	Not Detected

NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIS	Non-indigenous Plant Species
NIST	National Institute of Standards and Technology
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory - Field Research Division
NPDES	National Pollutant Discharge Elimination System
NRF	Naval Reactors Facility
OMB	Office of Management and Budget
OP	Oversight Program
OSLD	Optically Stimulated Luminescence Dosimeters
PCB	Polychlorinated Biphenyls
PLN	Plan
PT	Proficiency Testing
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RPD	Relative Percent Difference
RPS	Rare Plant Species
ROD	Record of Decision
RSD	Relative Standard Deviation
RSWF	Radioactive Scrap and Waste Facility
RWMC	Radioactive Waste Management Complex
SCS	Secondary Constituent Standards
SDA	Subsurface Disposal Area
SHPO	State Historic Preservation Office
SI	Système International
SMC	Specific Manufacturing Capability
SNF	Spent Nuclear Fuel
TAN	Test Area North
TCE	Trichloroethylene
TIC	Time Integrated Concentration
TLD	Thermoluminescent Dosimeter
TMI	Three Mile Island
TOC	Total Organic Carbon
TSF	Technical Support Facility
TRU	Transuranic (waste)
TSCA	Toxic Substances Control Act
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
WAG	Waste Area Group
WNS	White-nose Syndrome



Units

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

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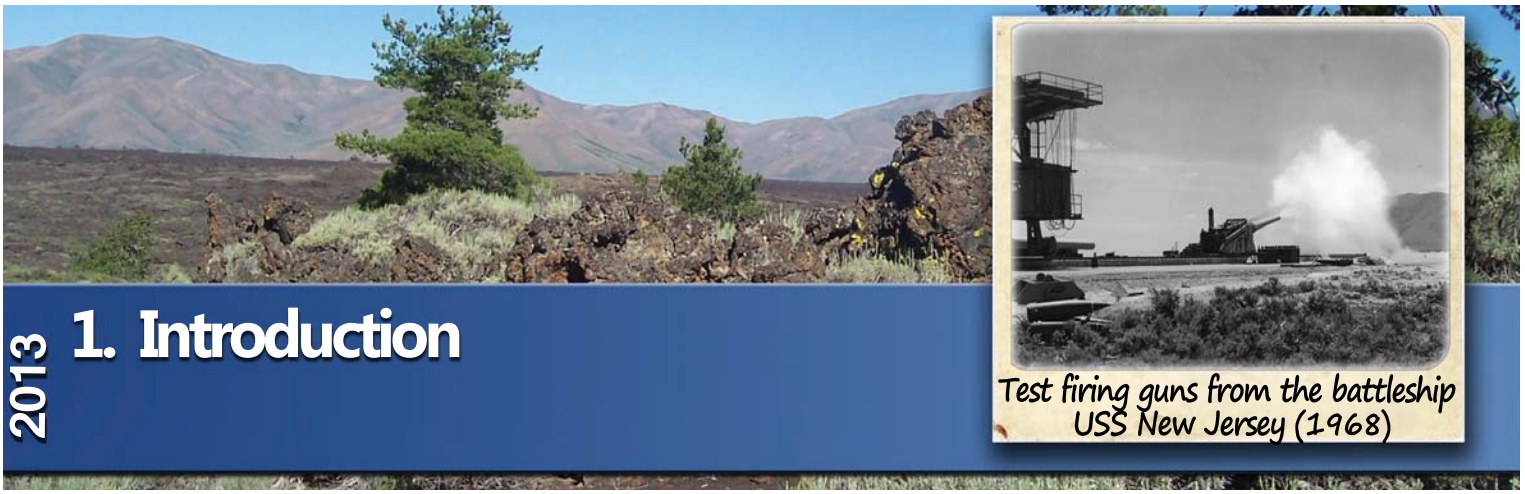
Big Southern Butte on the INL Site



1. INTRODUCTION

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

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

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

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

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

1.1 Site Location

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

Federal lands surround much of the INL Site, including Bureau of Land Management lands and Craters of the Moon National Monument to the southwest, Challis National Forest to the west, and Targhee National Forest to the north. Mud Lake Wildlife Management Area, Camas

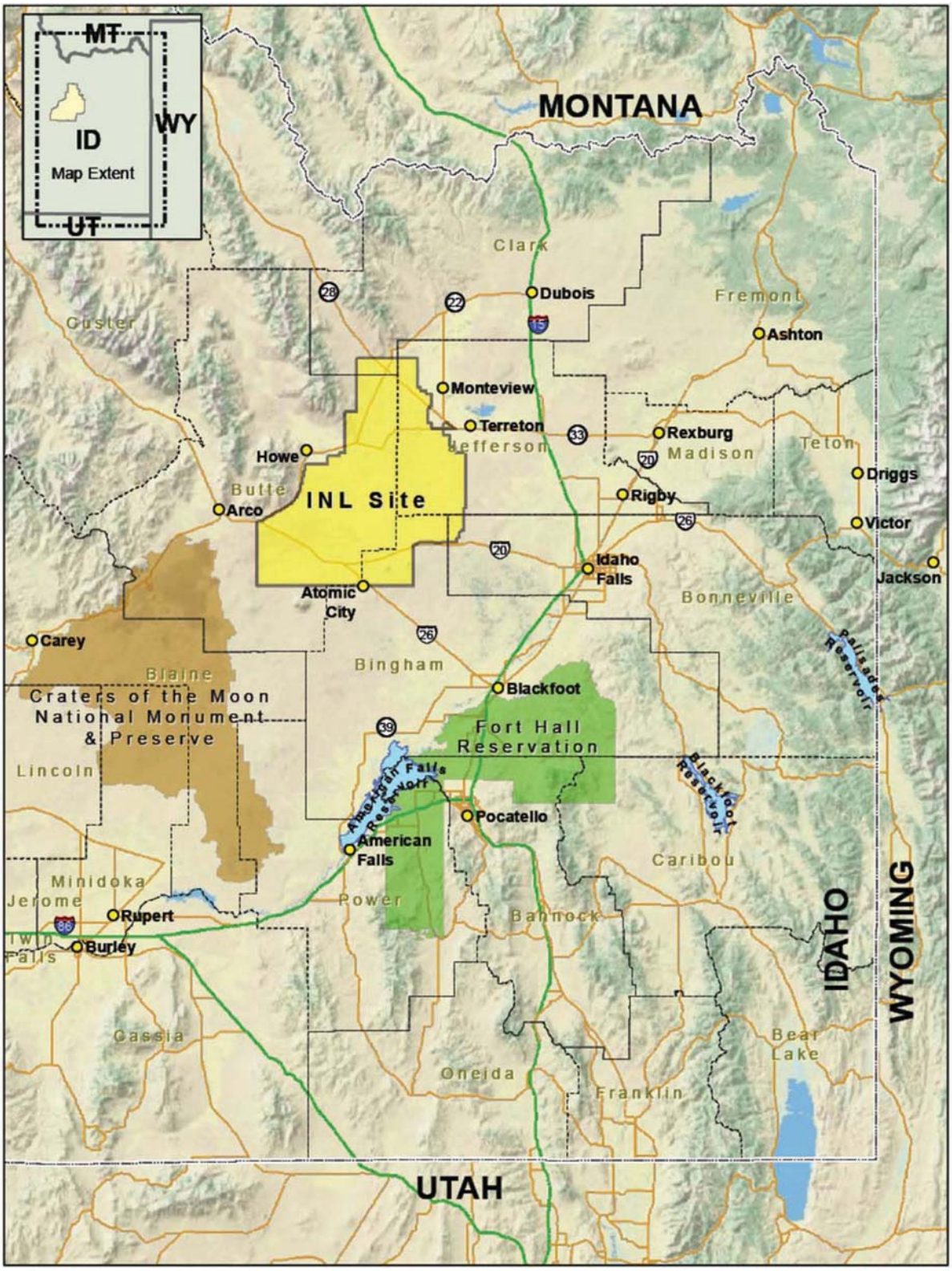


Figure 1-1. Location of the Idaho National Laboratory Site.

National Wildlife Refuge, and Market Lake Wildlife Management Area are within 80 km (50 mi) of the INL Site. The Fort Hall Indian Reservation is located approximately 60 km (37 mi) to the southeast.

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94 percent of the land on the INL Site is open and undeveloped. The INL Site has an average elevation of 1,500 m (4,900 ft) above sea level and is bordered on the north and west by mountain ranges and on the south by volcanic buttes and open plain. Lands immediately adjacent to the INL Site are open sagebrush steppe, foothills, or agricultural fields. Agriculture is concentrated in areas northeast of the INL Site.

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

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.6 cm/yr [8.5 in./yr]), warm summers (average daily temperature of 18.2°C [64.8°F]), and cold winters (average daily temperature of -6.2°C [20.8°F]), with all averages based on observations since 1950. The altitude, intermountain setting, and latitude of the INL Site combine to produce a semiarid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain (DOE-ID 1989). 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 plain, producing rolling topography. Vegetation is visually dominated by big sagebrush (*Artemisia tridentata*). Beneath these shrubs are grasses and wild flowers adapted to the harsh climate. A total of 409 plant species have been recorded on the INL Site (Anderson et al. 1996).

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

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

The fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-2), which stretches 320 km (199 mi) from Island Park to King Hill, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 247 to 370 billion m^3 (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from the Henry's Fork and the South Fork of the Snake River, and to a lesser extent by the Big Lost River, Little Lost River, Birch Creek, and irrigation. Beneath the INL

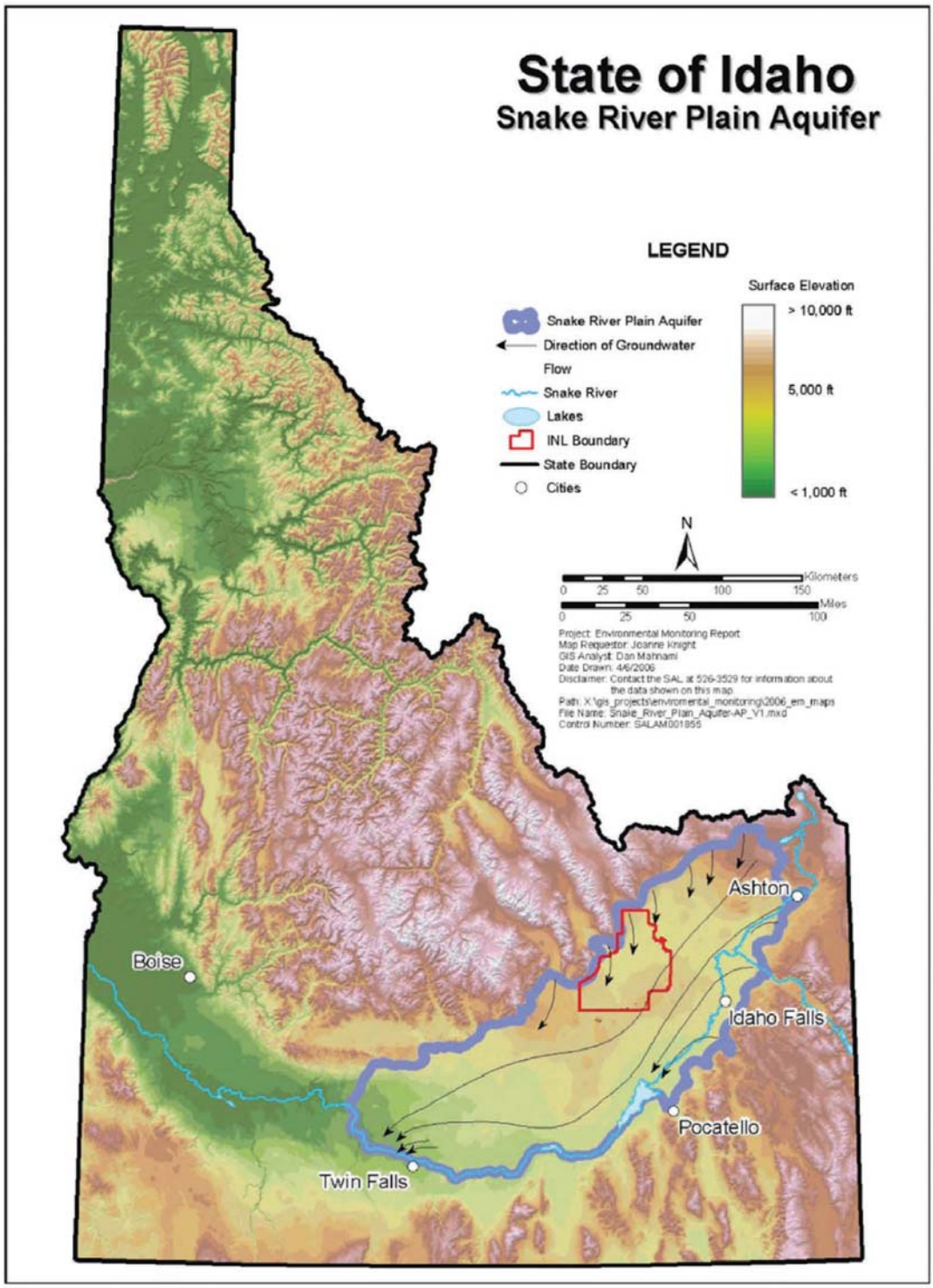


Figure 1-2. Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

Site, the aquifer moves laterally southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The eastern Snake River Plain aquifer emerges in springs along the Snake River between Milner and Bliss, Idaho. Crop irrigation is the primary use of both surface water and groundwater on the Snake River Plain.

1.3 Idaho National Laboratory Site Primary Program Missions and Facilities

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

1.3.1 Idaho National Laboratory

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

1.3.2 Idaho Cleanup Project

The Idaho Cleanup Project (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 is led by CH2M-WG Idaho, LLC, and funded through the DOE Office of Environmental Management. 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.

The ICP involves treating a million gallons of sodium-bearing waste, removing targeted transuranic waste from the Subsurface Disposal Area (SDA), placing spent nuclear fuel in dry storage, selecting a treatment for high-level waste calcine, and demolishing more than 200 structures, including reactors, spent nuclear fuel storage basins, and laboratories used for radioactive experiments.

1.3.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) prepares and ships contact-handled transuranic waste out of Idaho. AMWTP is managed and operated by Idaho Treatment Group, LLC. Operations at AMWTP retrieve, characterize, treat, and package transuranic waste currently stored at the INL Site. The project's schedule is aligned with court-mandated milestones in the 1995 Settlement Agreement (DOE 1995) among the state of Idaho, U.S. Navy, and DOE to remove waste from Idaho. The majority of waste AMWTP processes resulted from the manufacture of nuclear weapons components at DOE's Rocky Flats Plant in Colorado. This waste was shipped to Idaho in the 1970s and early 1980s for storage and contains industrial debris, such as rags, work clothing, machine parts, and tools, as well as soil and sludge, and is contaminated with transuranic radioactive elements (primarily plutonium). Most of the waste is "mixed waste" that is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents. Since 1999, more than 52,903 m^3 (69,195 yd^3) of transuranic waste has been shipped off the INL Site.

1.3.4 Primary Idaho National Laboratory Site Facilities

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

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

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

Critical Infrastructure Test Range Complex – The Critical Infrastructure Test Range Complex (CITRC) 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. CITRC provides open landscape, technical employees, and specialized facilities for performing work in three main areas – physical security, contraband detection, and infrastructure testing. It is operated by the INL contractor.

Idaho Nuclear Technology and Engineering Center – The Idaho Chemical Processing Plant was established in the 1950s to recover usable uranium from spent nuclear fuel used in DOE and Department of Defense reactors. Over the years, the facility recovered more than

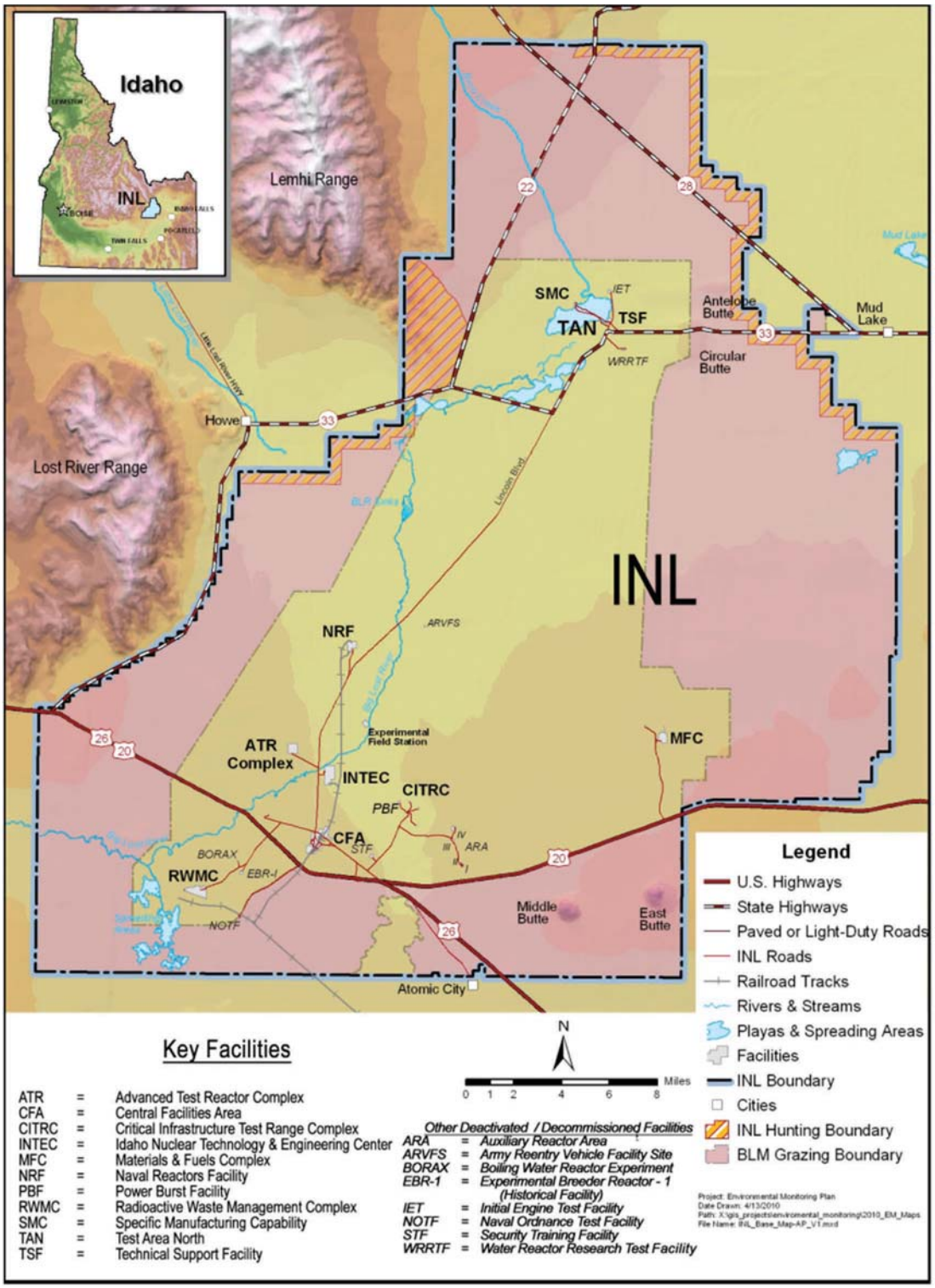


Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

$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 management of sodium-bearing waste, spent nuclear fuel storage, environmental remediation, and disposing of excess facilities.

Materials and Fuels Complex – The Materials and Fuels Complex (MFC) 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 increasingly efficient reactor fuels and the important work of nonproliferation – harnessing more energy with less risk. Facilities at MFC also support manufacturing and assembling components for use in space applications. It is operated by the INL contractor.

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

As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 436.1, 458.1, and 414.1C. Therefore, NRF is excluded from this report. The director, Naval Nuclear Propulsion Program, establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2014).

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 manages solid transuranic and low-level radioactive waste. RWMC provides treatment, temporary storage and transportation of transuranic waste destined for the Waste Isolation Pilot Plant. Management of stored wastes at RWMC is the responsibility of the AMWTP contractor.

The SDA 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 INL and weapons production at other DOE facilities. A Comprehensive Environmental Response, Compensation and Liability Act Record of Decision (OU-7-13/14) was signed in 2008 (DOE-ID 2008) that includes exhumation and off-site disposition of targeted waste. Through December 2013, 3.17 of the required 5.69 acres (1.28 of 2.30 hectares) have been exhumed and 5,594 m^3 (7,317 yd^3) of waste have been shipped out of Idaho. Cleanup of RWMC is managed by the ICP contractor.

Advanced Test Reactor Complex – The Advanced Test Reactor (ATR) Complex was established in the early 1950s and has been the site for operation of three major test reactors

– the Materials Test Reactor (1952 – 1970), the Engineering Test Reactor (1957 – 1982), and the Advanced Test Reactor (1967 – present). The current primary mission at the ATR Complex is operation of the Advanced Test Reactor, the world's premier test reactor used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The ATR Complex also features the Advanced Test Reactor – Critical Facility, Test Train Assembly Facility, Radiation Measurements Laboratory, Radiochemistry Laboratory, and the Safety and Tritium Applied Research Facility – a national fusion safety user facility. The ATR Complex will design, test, and prove the new technologies of the nuclear renaissance. It is operated by the INL contractor. The ATR is a national scientific user 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, and the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. As the name implies, the Research and Education Campus uses both basic science research and engineering to apply new knowledge to products and processes that improve quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. The Center for Advanced Energy Studies, designed to promote education and world-class research and development, is also located at the Research and Education Campus. Two new laboratory facilities, the Energy Systems Laboratory and the Energy Innovation Laboratory were recently constructed, and other facilities envisioned over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure close to current campus buildings. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory. The DOE Radiological and Environmental Sciences Laboratory (RESL) is located within the REC. RESL provides an unbiased technical component to DOE oversight of contractor operations at DOE facilities and sites. As a reference laboratory, RESL conducts cost-effective measurement quality assurance programs that help assure key DOE missions are completed in a safe and environmentally responsible manner. By assuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, RESL assures the reliability of data on which decisions are based. RESL's core scientific capabilities are in analytical chemistry and radiation calibrations and measurements.

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

small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island (TMI) in Pennsylvania. In October 2006, the LOFT reactor and facilities were decontaminated, decommissioned, and demolished.

Additionally, TAN housed the TMI Unit 2 Core Offsite Examination Program that obtained and studied technical data necessary for understanding the events leading to the TMI-2 reactor accident. Shipment of TMI-2 core samples to the INL Site began in 1985, and the program ended in 1990. INL 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 and the TAN Hot Shop and LOFT reactor. Environmental monitoring continues at TAN.

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

1.4 History of the INL Site

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

The volcanic history of the Yellowstone-Snake River Plain volcanic field is based on the time-progressive volcanic origin of the region characterized by several large calderas in the eastern Snake River Plain, with dimensions similar to those of Yellowstone's three giant Pleistocene calderas. These volcanic centers are located within the topographic depression that encompasses the Snake River drainage. Over the last 16 Ma, there was a series of giant, caldera-forming eruptions, with the most recent at Yellowstone National Park 630,000 years ago. The youngest silicic volcanic centers correspond to the Yellowstone volcanic field that are less than 2.0 Ma old and are followed by a sequence of silicic centers at about 6 Ma ago, southwest of Yellowstone. A third group of centers, approximately 10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the Snake River Plain are approximately 16 Ma, are distributed across a 150-km-wide (93-mi-wide) zone in southwestern Idaho and northern Nevada, and are the suspected origin of the Yellowstone-Snake River Plain (Smith and Siegel 2000).

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

People of European descent began exploring the Snake River Plain between 1810 and 1840; these explorers were trappers and fur traders seeking new supplies of beaver pelts. Between 1840 (by which time the fur trade was essentially over) and 1857, an estimated 240,000

immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed forcing the native populations onto the reservation at Fort Hall. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

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

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

After the war ended, the nation turned to peaceful uses of atomic power. DOE's predecessor, the U.S. Atomic Energy Commission, needed an isolated location with ample groundwater supply on which to build and test nuclear power reactors. The relatively isolated Snake River Plain was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station in 1949.

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

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

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

1.5 Populations Near the INL Site

The population of the region within 80 km (50 mi) of the INL Site is estimated, based on the 2010 census and projected growth, to be 314,069. Over half of this population (171,757) resides

in the census divisions of Idaho Falls (101,117) and northern Pocatello (70,640). Another 25,730 live in the Rexburg census division. Approximately 18,126 reside in the Rigby census division and 15,161 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

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Header photo notes: From 1968 to 1970, during the Vietnam War, the Navy test-fired sixteen-inch guns from the battleship USS New Jersey. The firing point, named the Naval Ordnance Test Facility, was south of the Experimental Breeder Reactor I complex, and the target was the northern flank of Big Southern Butte. Sixteen-inch guns were the only World War II-era naval weapons used during the Vietnam War.

2013

2. Environmental Compliance Summary

Idaho Chemical Processing Plant (1956)

Chapter 2 Highlights

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of non-permitted hazardous materials to the environment must be documented. Overall, the INL Site met all its regulatory commitments in 2013, and programs are in place to address areas for continued improvement.

The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2013 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2014, in compliance with the Clean Air Act. All Emergency Planning and Community Right-to-Know Act and Resource Conservation and Recovery Act reports were submitted as scheduled.

There was one reportable environmental release at the INL Site in 2013 when a small quantity (about 1.6 pounds) of hazardous waste sludge was spilled to soil at the Radioactive Waste Management Complex. The spilled sludge and contaminated soil were recovered and managed as required by the Resource Conservation and Recovery Act permit.

With respect to the National Environmental Policy Act, the DOE, Idaho Operations Office (DOE-ID) issued the *Draft Environmental Assessment for the Resumption of Transient Testing of Nuclear Fuels and Materials* for public comment on November 12, 2013. DOE-ID also prepared a Supplement Analysis for the Disposition of Mixed Low-Level Waste and Low-Level Waste from the Advanced Mixed Waste Treatment Project at Commercial Facilities.

The 2013 Site Sustainability Plan with the Annual Report was completed in compliance with the new Department of Energy Order 436.1, “Departmental Sustainability.” The document provides plans for providing continual energy efficiency, greenhouse gas reductions, environmental improvements, and transportation fuels efficiency at the INL Site.

The 2013 Idaho Hazardous Waste Generator Annual Report was submitted to the state of Idaho, which is authorized by Environmental Protection Agency (EPA) to regulate hazardous waste under the Resource Conservation and Recovery Act. The Idaho Department of Environmental Quality (DEQ) issued a Hazardous Waste Management Act/Resource Conservation and Recovery Act Compliance Inspection Warning Letter to DOE and an INL Site contractor stating that three apparent violations of the Idaho Rules and Standards for

Hazardous Waste were documented in association with the INL Site inspection conducted by DEQ on April 29 – May 2, 2013. A corrective action plan was submitted to DEQ.

The eastern Snake River Plain aquifer is the source for the 12 drinking water systems at all the facilities on the INL Site. In 2013, DEQ performed sanitary surveys on 11 of the 12 INL Site public water systems and the systems were found to be in compliance with the Idaho Drinking Water Rules and Regulations.

In 2013, 19 field studies were completed to identify and evaluate archaeological sites and 38 cultural resource localities were visited and monitored. Twelve cultural resource reviews were also conducted for projects that had the potential to impact INL historic architectural properties. Twenty-one INL properties that would be impacted by the projects were determined to be eligible to the National Register of Historic Places (National Register). One project would result in adverse effects to five historic architectural properties.

There are 40 active permits for air emissions, groundwater, wastewater, and hazardous waste compliance that have been granted to the INL Site from the city of Idaho Falls, state of Idaho, Environmental Protection Agency, and the Corps of Engineers.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (INL) Site with environmental protection requirements. Operations at the INL Site are subject to numerous federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders, and Department of Energy (DOE) orders. These are listed in Appendix A. The programs in place to comply with environmental protection requirements are discussed in Chapter 3.

2.1 Air Quality and Radiation Protection

2.1.1 Clean Air Act

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

- **National Ambient Air Quality Standards** – The National Ambient Air Quality Standards establish permissible exposure levels for six pollutants (criteria air pollutants) identified as primary contributors to health-related deaths and illnesses. The six pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, particulates, and sulfur oxides.

- **State Implementation Plans** – A state may assume responsibility for the CAA by developing an Environmental Protection Agency (EPA)-approved state implementation plan. A state implementation plan contains the laws and regulations a state will use to administer and enforce the provisions of the CAA. The state of Idaho has been delegated authority for the CAA through an approved state implementation plan.
- **New Source Performance Standards** – The New Source Performance Standards Program is a permitting performance standard for specific industry source categories. The standard targets sources that contribute significantly to air pollution and ensures the sources pay to meet ambient air quality standards. The criteria air pollutants are the focus of the New Source Performance Standards Program.
- **Prevention of Significant Deterioration** – The Prevention of Significant Deterioration program applies to new major sources or major modifications to existing sources where the source is located in an area that is designated as attainment or unclassifiable with the National Ambient Air Quality Standards. An attainment area is one that meets the national primary or secondary ambient air quality standards. An unclassifiable area is one that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standards.
- **National Emissions Standards for Hazardous Air Pollutants (NESHAPs)** – The NESHAPs Program regulates emissions of hazardous air pollutants from a published list of industrial sources. The source categories must meet control technology requirements for these hazardous air pollutants. The state of Idaho has added to the federal NESHAPs list of hazardous air pollutants with the State List of Toxic Air Pollutants.

  The state of Idaho has not been delegated authority for one key subpart of the NESHAPs Program. Specifically, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 Code of Federal Regulations [CFR] 61, Subpart H) is regulated by EPA. Subpart H applies to facilities owned or operated by DOE, including the INL Site. The Department of Energy, Idaho Operations Office (DOE-ID) submits an annual NESHAPs Subpart H report to EPA and the Idaho Department of Environmental Quality (DEQ). The latest report is *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2013 INL Report for Radionuclides* (DOE-ID 2014). The annual NESHAPs Subpart H report uses an EPA-approved computer model to calculate the hypothetical maximum individual effective dose equivalent to a member of the public resulting from INL Site airborne radionuclide emissions. The calculations for this code are discussed further in Chapter 8, "Dose to the Public and Biota."
- **Stratospheric Ozone Protection Program** – The Stratospheric Ozone Protection Program limits emissions of chlorofluorocarbons, halons, and other halogenic chemicals that contribute to the destruction of stratospheric ozone.
- **Enforcement Provisions** – Enforcement provisions establish maximum fines and penalties for CAA violations.

- **Operating Permit Program** – The Operating Permit Program provides for states to issue federally enforceable operating permits to applicable stationary sources. The permits aid in clarifying operating and control requirements for stationary sources.

The Idaho Air Quality Program is primarily administered through a permitting process that sets conditions under which facilities that generate air pollutants may operate. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is exempt from permitting. If the source is not exempted, the type of permit required depends on the type of emission or emitting source or both. Two primary types of air permits have been issued to the INL Site (Table 2-1):

- **Permit to Construct** – An air quality permit to construct is required of new or modified stationary sources, such as buildings, structures, or equipment that may emit pollutants into the air. State of Idaho air regulations and guidelines are used to apply for all permits to construct

Table 2-1. Environmental Permits for the INL Site (2013).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	13
Title V Operating Permit	1
Groundwater:	
Injection Well	10
Well construction	1
Surface Water:	
Wastewater Reuse Permits	4
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2
Part B	7[a]
Ecological:	
Migratory Bird Treaty Act Special Purpose Permit	1
Cultural Resources:	
Permit for Archaeological Investigation	1

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

- **Title V Operating Permit** – A Title V operating permit, also known as a Tier I operating permit, is required for major sources. Major sources emit, or have the potential to emit, 10 tons or more of one hazardous air pollutant or 25 or more tons per year of any combination of hazardous air pollutants. EPA promulgated regulations in July 1992 that established the Tier I requirements for state programs. Through the state implementation plan, Idaho has approved one Tier I operating permit for the INL Site.

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

DOE Order 458.1, "Radiation Protection of the Public and the Environment," establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The objectives of this Order are:

- To conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in this Order
- To control the radiological clearance of DOE real and personal property
- To ensure that potential radiation exposures to members of the public are as low as reasonably achievable
- To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public
- To provide protection of the environment from the effects of radiation and radioactive material.

DOE Order 458.1 was issued in February 2011, and replaced DOE Order 5400.5 by the same title. 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 2013.

DOE Standard DOE-STD-1196-2011, Derived Concentration Technical Standard, was issued in April 2011, and defines the quantities used in the design and conduct of radiological environmental protection programs at DOE facilities and sites. These quantities, derived concentration standards (DCSs), represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year via each of the following pathways: ingestion of water, submersion in air, and inhalation. They replace the Derived Concentration Guides (DCGs), which were previously published by DOE in 1993 in DOE Order 5400.5 and represented the best available information on doses at that time. Since that publication, the radiation protection framework on which DCSs are based has evolved with more sophisticated biokinetic and dosimetric information provided by the International Commission on Radiological Protection (ICRP), thus enabling consideration of age and gender. The purpose of DOE-STD-1196-2011 is to establish DCS values reflecting the current state of knowledge and practice in radiation protection. These DCSs are based on age-specific effective dose coefficients, revised gender specific physiological parameters for the Reference Man (ICRP 2002), and the latest information

on the energies and intensities of radiation emitted by radionuclides (ICRP 2008). Previous versions of the Annual Site Environmental Report used DCGs, as defined in DOE Order 5400.5, to evaluate environmental monitoring results for the INL Site. With the issuance of DOE Order 458.1 and DOE-STD-1196-2011, this report will now evaluate environmental monitoring results according to the corresponding DCSs.

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

- personal items or materials
- documents, mail, diskettes, compact disks, and other office media
- paper, cardboard, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- office trash
- non-radiological area housekeeping materials and associated waste
- break-room, cafeteria, and medical wastes
- medical and bioassay samples
- other items with an approved release plan.

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

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

All contractors complete material surveys prior to release and transport to the state-permitted landfill at Central Facilities Area. The only exception is for items that could be internally

contaminated; these items are submitted to Waste Generator Services for disposal using one of the offsite treatment, storage, and disposal facilities that can accept low level contamination. All INL Site contractors continue to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is recycled.

2.2 Environmental Protection and Remediation

2.2.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release of chemically hazardous or radioactive substances or both. Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. The INL Site was placed on the National Priorities List under CERCLA on November 29, 1989. DOE-ID, the state of Idaho, and EPA Region 10 signed the Federal Facility Agreement and Consent Order in December 1991 (DOE 1991). The Idaho Cleanup Project (ICP) contractor, in accordance with the Federal Facility Agreement and Consent Order, is conducting environmental restoration activities at the INL Site. Specific environmental restoration activities are discussed in Chapter 3.

2.2.2 DOE Order 436.1, Departmental Sustainability

The purpose of DOE Order 436.1, "Departmental Sustainability," is to provide requirements and responsibilities for managing sustainability within DOE to:

- Ensure 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
- Institute wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions
- Ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable laws, regulations and Executive Orders, related performance scorecards, and sustainability initiatives.

These programs are summarized in this chapter and elsewhere in this report. DOE Order 436.1 was issued in May 2011 and replaces most of the requirements of DOE Order 450.1A "Environmental Program Protection," and DOE Order 430.2B, "Departmental Energy, Renewable Energy and Transportation Management."

2.2.3 Emergency Planning and Community Right-to-Know Act

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

Table 2-2. INL Site EPCRA Reporting Status (2013).

EPCRA Section	Description of Reporting	2013 Status
Section 304	Extremely Hazardous Substance release notification	Not Required
Section 311-312	Material Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

Section 304 – Section 304 requires owners and operators of facilities where hazardous chemicals are produced, used, or stored to report releases of CERCLA hazardous substances or extremely hazardous substances that exceed reportable quantity limits to state and local authorities (i.e., state emergency response commissions and local emergency planning committees). There were no CERCLA-reportable chemicals released at the INL Site during 2013.

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make material safety data sheets describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities also are required to report, to state and local officials and local fire departments, inventories of all chemicals that have material safety data sheets. The INL Site satisfies the requirements of Section 311 by submitting quarterly reports 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 was 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 INL Site and Idaho Falls facilities that exceed regulatory thresholds.

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

Reportable Environmental Releases – There was one reportable environmental release at the INL Site during calendar year 2013:

- On August 20, 2013, approximately 1.6 lb. (0.73 kg.) of hazardous waste sludge was spilled to soil inside WMF-1617 at the Radioactive Waste Management Complex. The spilled sludge and contaminated soil were recovered and managed as required by the Resource

Conservation and Recovery Act (RCRA) permit. The quantity of hazardous waste sludge spilled exceeded the reportable limit of 1.0 lb. (0.45 kg) therefore notification was made to the DEQ.

2.2.4 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider and analyze potential environmental impacts of proposed actions and explore appropriate alternatives to mitigate those impacts, including a "no action" alternative. Agencies are required to inform the public of the proposed actions, impacts, and alternatives and consider public feedback in selecting an alternative. DOE implements NEPA according to procedures in the CFR (40 CFR 1500; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Order 451.1B, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. DOE-ID issued the Annual NEPA Planning Summary on January 29, 2013. The summary is a requirement of DOE Order 451.1B, and is prepared to inform the public and other DOE elements of:

- The status of ongoing NEPA compliance activities
- Environmental assessments expected to be prepared in the next 12 months
- EISs expected to be prepared in the next 24 months
- The planned cost and schedule for completion of each NEPA review identified.

DOE-ID prepared the Draft Environmental Assessment for the Resumption of Transient Testing of Nuclear Fuels and Materials. The environmental assessment evaluated the potential of restarting the Transient Reactor Test Facility Reactor at the INL Site or modifying the Annular Core Research Reactor at Sandia National Laboratories in New Mexico, to conduct high-power radiation testing on nuclear fuels and materials. The Draft EA was issued for public comment on November 12, 2013. DOE will address any public comments received in early 2014 and make a determination of whether the proposed action has the potential for significant environmental impacts.

DOE-ID also prepared a Supplement Analysis for the Disposition of Mixed Low-Level Waste and Low-Level Waste from the Advanced Mixed Waste Treatment Project at Commercial Facilities. DOE analyzed using commercial facilities in addition to DOE facilities for treatment and disposal of low-level and mixed low-level waste from the Advanced Mixed Waste Treatment Project. On March 26, 2013, DOE-ID determined that based on the Supplement Analysis the proposed changes to the location for waste disposal were covered by existing NEPA documentation.

2.2.5 Endangered Species Act

The Endangered Species Act (ESA):

- Provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved

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

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

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

There are several species categorized under the ESA which occur or may occur on the INL Site. Table 2-3 presents a list of those species and the likelihood of their occurrence on the INL Site. Several species have been removed from the list based on the limited likelihood they would occur on the INL Site. The wolverine (*Gulo gulo luscus*) has been added to the list.

In March 2010, the USFWS classified the Greater sage-grouse (*Centrocercus urophasianus*) as a candidate for listing under the ESA. This means that although the species warrants protection under the ESA, it is currently precluded from being listed due to higher agency priorities. However, in a recent (2011) U.S. district court lawsuit settlement, the USFWS agreed to make a final listing decision on all candidate species by 2016. A resulting agency work plan commits the USFWS to make a determination by 2015 to either list sage-grouse as threatened or endangered, or to remove it from the candidate list.

Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves. This disease is caused by a cold-adapted fungus (*Geomyces destructans*)

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

Species	Designation	Presence on INL Site
Greater sage-grouse (Centrocercus urophasianus)	Candidate	Large populations present on INL Site.
Yellow-billed cuckoo (*Coccyzus americanus*)	Candidate	Documented occasionally on south border of INL Site.
Wolverine (Gulo gulo luscus)	Candidate	Not documented but may pass through the INL Site.

and has killed at least 5.5 to 6.7 million bats in seven species. WNS has been labeled by some as the greatest wildlife crisis of the past century, and many species of bats could be at risk of significant declines or extinction due to this disease. At least two species of bats that occupy the INL Site could be affected by WNS if this disease arrives in Idaho – the little brown myotis (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*). In 2010, the little brown myotis was petitioned for emergency listing under the ESA, and the USFWS is collecting information on both species to determine if, in addition to existing threats, this disease may be increasing the extinction risk of these bats. Currently, biologists from the Environmental Surveillance, Education, and Research Program have initiated a monitoring program using acoustical detectors set at hibernacula and important habitat features (caves and facility ponds) used by these mammals on the INL Site. The results of our monitoring program will provide critical information regarding bat ecology on the INL Site.

2.2.6 Migratory Bird Treaty Act

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

DOE-ID did not have to use the permit to relocate or destroy any active migratory bird nests in 2013. DOE-ID is required to submit an annual report to USFWS by January 31st of each year detailing reportable activities related to migratory birds.

2.2.7 Executive Order 11988 – Floodplain Management

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

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

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

2.2.8 Executive Order 11990 – Protection of Wetlands

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

The only area of the INL Site identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The USFWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2013, no actions took place or impacted potentially jurisdictional wetlands on the INL Site.

2.2.9 Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance

Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” was signed by President Obama on October 5, 2009. This Executive Order expands on the energy reduction and environmental performance requirements for federal agencies identified in Executive Order 13423, “Strengthening Federal Environmental, Energy, and Transportation Management.”

The goal of Executive Order 13514 is “to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of GHG emissions a priority for Federal agencies.” Towards meeting that goal, federal agencies are required to meet a series of deadlines critical to achieving the GHG reduction goals of the Executive Order.

- On November 5, 2009, each agency submitted the name of their Senior Sustainability Officer to the Council on Environmental Quality (CEQ) Chair and Office of Management and Budget (OMB) Director
- On January 4, 2010, a percentage reduction target for agency-wide reductions of Scope 1 and 2 GHG emissions, in absolute terms, by fiscal year 2020, relative to a fiscal year 2008 baseline of the agency’s Scope 1 and 2 GHG, was due to the CEQ Chair and OMB Director
- On June 2, 2010, Scope 3 targets and the Strategic Sustainability Performance Plan were submitted to the CEQ Chair and the OMB Director

- On January 31, 2011, the comprehensive GHG inventory was due from each of the agencies to the CEQ Chair and OMB Director.

In addition to guidance, recommendations, and plans that are due by specific dates, Executive Order 13514 specifies numerical and non-numerical targets for agencies to reach in areas such as sustainable buildings, water efficiency, electronic products, and transportation management. Beyond targets, Executive Order 13514 requires agencies to follow specific management strategies to improve sustainability.

On May 22, 2011, DOE issued DOE Order 436.1 "Departmental Sustainability." The order defines requirements and responsibilities for managing sustainability at DOE to ensure that the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future; institutes wholesale cultural change to factor sustainability and GHG reductions into all DOE corporate management decisions; and ensures that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan. This order combined, added to and cancels DOE Order 450.1A "Environmental Protection Program" and DOE Order 430.2B "Departmental Energy, Renewable Energy, and Economic Performance."

DOE-ID submitted the *FY 2014 INL Site Sustainability Plan with the FY 2013 Annual Report* to DOE Headquarters in December, 2013 (DOE-ID 11383) (DOE-ID 2013a). This plan contains strategies and activities for 2014 that are leading to continual energy efficiency, GHG reductions, environmental improvements, and transportation fuels efficiency to facilitate the INL Site in meeting the goals and requirements of Executive Order 13514, and DOE Order 436.1 before the end of fiscal year 2020.

A more detailed discussion of environmental management systems including the sustainability program, and pollution prevention programs is provided in Chapter 3.

2.3 Waste Management

2.3.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The DEQ is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE orders, regulates radioactive wastes and the radioactive part of mixed wastes. A RCRA hazardous waste permit application contains two parts – Part A and Part B. Part A of the RCRA hazardous waste permit application consists of EPA Form 8700-23, along with maps, drawings, and photographs, as required by 40 CFR 270.13. Part B of the RCRA hazardous waste permit application contains detailed, site-specific information as described in applicable sections of 40 CFR 270.14 through 270.27. The INL Site currently has two RCRA Part A permit volumes and seven Part B permit volumes. The Parts A and B are considered a single RCRA permit and are comprised of several volumes.

RCRA Reports – As required by the state of Idaho, the INL Site submitted the 2013 Idaho Hazardous Waste Generator Annual Report on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remaining in storage. The INL Site also submitted the 2013 RCRA Biennial Report as required by EPA on the quantities, types, and management of hazardous wastes generated and received from offsite.

RCRA Closure Plan – There were no RCRA closure plans completed in 2013.

RCRA Inspection – From April 29 through May 2, 2013, DEQ conducted an annual RCRA inspection of the INL Site. On July 25, 2013, DEQ issued a Hazardous Waste Management Act/ RCRA Compliance Inspection Warning Letter to DOE and an INL Site contractor stating that three apparent violations of the Idaho Rules and Standards for Hazardous Waste were documented in association with the INL Site annual inspection. The apparent violations had been self-reported to DEQ; however, self-disclosure does not constitute a defense or shield to any enforcement action. As agreed upon by all parties, a corrective action plan that addresses all three apparent violations was submitted to DEQ. No financial penalty was assessed for the apparent violations.

2.3.2 Federal Facility Compliance Act

The Federal Facility Compliance Act requires the preparation of site treatment plans for the treatment of mixed wastes stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The INL Site Proposed Site Treatment Plan was submitted to the state of Idaho and EPA on March 31, 1995. This plan outlined DOE-ID's proposed treatment strategy for INL Site mixed-waste streams, called the "backlog," and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities. The Federal Facility Compliance Act Consent Order and Site Treatment Plan was finalized and signed by the state of Idaho on November 1, 1995 (DEQ 1995). A status of Site Treatment Plan milestones for 2013 is provided in Chapter 3.

2.3.3 Toxic Substances Control Act

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

2.3.4 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1, "Radioactive Waste Management," was issued to ensure that all DOE radioactive waste is managed in a manner that protects the environment and worker and public safety and health. Change 1 was added to the Order in August 2001. INL Site activities related to this Order are discussed in Chapters 3 and 6.

2.3.5 1995 Settlement Agreement

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

The INL Site continues to ship transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, in compliance with the Settlement Agreement requirement to ship a running average of no fewer than 2,000 m^3 (2,616 yd^3) of transuranic waste per year out of Idaho. The running average over the past three years is 3,450 m^3 (4,512 yd^3). In calendar year 2013, 9 m^3 (11.7 yd^3) of remote-handled transuranic waste was shipped out of Idaho. In addition, 1,022 m^3 (1,337 yd^3) of mixed low level waste historically managed as transuranic was shipped.

In 2013, 70 m^3 (91.5 yd^3) of buried transuranic waste was shipped.

2.4 Water Quality and Protection

2.4.1 Clean Water Act

The Clean Water Act (CWA), passed in 1972, 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 and water quality standards set by states. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES) permit program, requiring permits for discharges into regulated surface waters.

The INL Site complies with a CWA permit through the implementation of procedures, policies, and best management practices. The permit covers discharges from Idaho Falls facilities to the city of Idaho Falls publicly-owned treatment works. The city of Idaho Falls is authorized by the NPDES permit program to set pretreatment standards for nondomestic discharges to publicly-owned treatment works. This program is set out in the Municipal Code of the city of Idaho Falls regulations in Chapter 1, Section 8. The INL Research Center is the only facility that is required to have an Industrial Wastewater Acceptance Permit. The Industrial Wastewater Acceptance Permit contains special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters. All discharges from Idaho Falls facilities in 2013 were within compliance levels established in the INL Research Center Wastewater Acceptance Permit.

2.4.2 Safe Drinking Water Act

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

The eastern Snake River Plain aquifer is the source for the 12 active public water systems at all the facilities on the INL Site. In 2013, DEQ performed Sanitary Surveys on the INL Site public water systems and the systems were found to be in compliance with the Idaho Drinking Water Rules and Regulations. All INL Site public water systems sample their drinking water as required by the state of Idaho. Chapter 5 contains details on drinking water monitoring.

2.4.3 State of Idaho Wastewater Reuse Permits

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

To protect public health and prevent pollution of surface and ground waters, the state of Idaho requires anyone wishing to land-apply wastewater to obtain a Wastewater Reuse Permit. The DEQ issues the Reuse permits in accordance with IDAPA 58.01.17 Recycled Water Rules, IDAPA 58.01.16 Wastewater Rules, and IDAPA 58.01.11 Ground Water Quality Rule (http://adminrules.idaho.gov/rules/current/58/0111.pdf). All Wastewater Reuse Permits consider site-specific conditions and incorporate water quality standards for ground water protection. The following INL Site facilities have Wastewater Reuse Permits to land apply wastewater:

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

2.4.4 Corrective Action/Monitoring Plan for Petroleum Release Associated with Well ICPP-2018

The Corrective Action/Monitoring Plan for Well ICPP-2018 Petroleum Release at the Idaho Nuclear Technology and Engineering Center was written to address a release of petroleum hydrocarbons detected in 2007 in perched water monitoring well ICPP-2018 at Idaho Nuclear Technology and Engineering Center (ICP 2012). The removal of petroleum product and the sampling and analysis of groundwater for benzene, toluene, ethylbenzene and xylenes compounds and polynuclear aromatic hydrocarbons are required per IDAPA 58.01.02 Water Quality Standards, Subsection 852, “Petroleum Release Response and Corrective Action.” The plan identifies activities for removing petroleum product from perched water well ICPP-2018, as well as any other monitoring well where product is found, and outlines the proposed perched water and groundwater monitoring schedule.

The insertion of SoakEase® absorbent socks into Well ICPP-2018 has been effective in removing petroleum product. During 2013, approximately 9.25 L of petroleum product was recovered from Well ICPP-2018. The thickness of product in the well generally has shown a declining trend. Product thickness decreased to approximately 0.18 ft in early 2013. No product

was measured in the well during monthly well monitoring activities performed in March, April, and May 2013. Due to the decreasing product thickness in Well ICPP-2018, CWI requested and received approval from DEQ to reduce the frequency of well monitoring activities at Wells ICPP-2018 and CPP-33-4-1 from monthly to quarterly.

2.5 Cultural Resources Protection

INL cultural resources are numerous and represent at least 13,000 years of human land use. They include prehistoric and historic archaeological resources, important historic World War II, post-war, and nuclear facilities like Experimental Breeder Reactor I, which was the first reactor in the world to produce usable electrical power and is recognized as a National Historic Landmark, places and resources of importance to the Shoshone-Bannock Tribes, and a myriad of original historical data such as 1949 aerial photographs, as-built engineering and architectural drawings, and early technical reports.

Protection and preservation of cultural resources under the jurisdiction of federal agencies, including DOE, are mandated by a number of federal laws and their implementing regulations. Primary among them are the:

- National Historic Preservation Act (NHPA) of 1966, as amended – requires federal agencies to establish programs to locate, evaluate, and nominate to the National Register of Historic Places, historic properties under their jurisdiction and to do so in consultation with State Historic Preservation Offices (SHPO), tribes, and stakeholders and to invite the Advisory Council on Historic Preservation to participate in the consultation. Federal agencies must inventory all of their cultural resources, minimize impacts to them, involve Tribes and stakeholders in decisions, and inform and educate the public about the resources. The Act also requires that this work and persons who complete this work meet certain professional standards.
- National Environmental Policy Act (NEPA) of 1969, as amended – outlines the federal policy of general environmental protection and requires the use of natural and social sciences in planning and decision-making processes with regard to project impacts on the environment including historical, cultural, and natural resources that are important to national heritage.
- Archaeological Resource Protection Act (ARPA) of 1979, as amended – establishes permit requirements and felony-level penalties for unauthorized excavation, removal, damage, alterations or defacement of any archaeological resource that is more than 100 years old and that is located on public or tribal lands. It also fosters increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals.
- American Indian Religious Freedom Act of 1978 – prompts federal agencies to avoid interfering with access to sacred locations and traditional resources and to consult with interested tribes to aid in the protection and preservation of cultural and spiritual traditions and sites.

Many INL cultural resources remain protected and undisturbed as a result of the area's closure to the general public beginning in 1942, and an active, comprehensive cultural resource management program. Through contract, DOE-ID has tasked BEA's Cultural Resource Management Office (CRMO) with implementation of the program.

2.5.1 Compliance with Cultural Resource Management Requirements

The *Idaho National Laboratory Cultural Resource Management Plan* (DOE-ID 2013b) was written specifically for INL Site resources. The Plan provides a tailored approach to comply with NHPA, NEPA, ARPA, American Indian Religious Freedom Act, and other federal and state laws and regulations and to implement DOE cultural resource policies and goals while meeting the unique needs of the INL. The Plan is reviewed annually, updated as needed, and is legitimized through a 2004 Programmatic Agreement, *Concerning Management of Cultural Resources on the INL Site* (DOE-ID 2004). The Agreement is between DOE-ID, the Advisory Council on Historic Preservation (Advisory Council), and the Idaho SHPO.

The INL is an active facility where thousands of work orders for projects ranging from lawn care to new facility construction are processed each year. The *INL Cultural Resource Management Plan* (DOE-ID 2013b) contains an approach for assessing and, when necessary, mitigating adverse impacts to cultural resources as a consequence of all activities large or small (NHPA Section 106). Under INL procedures, a cultural resource review is prompted whenever ground disturbance or major structural or landscape modifications are proposed. In 2013, 44 INL projects were reviewed for potential impacts to cultural resources. Table 2-4 provides a summary of the cultural resource reviews performed.

In 2013, 19 field studies were completed to identify and evaluate archaeological sites. All of these efforts were associated with NHPA Section 106 project reviews designed to evaluate potential impacts as a result of proposed INL activities and included small archaeological surveys as well as small scale test excavations. Approximately 43 acres on the INL Site and 2 acres at a small facility in the vicinity of Idaho Falls were intensively examined during these project surveys, 14 new archaeological resources were identified at the INL Site and recommended for avoidance or other protective measures, and two prehistoric sites were subject to test excavations. Cumulatively, the total number of acres surveyed for archaeological resources on the INL Site increased to 55,670 with the addition of these surveys (approximately 10 percent of the 890 square mile laboratory) and the total number of known archaeological resources identified rose to 2,755.

Twelve cultural resource reviews were also conducted in 2013 for projects that had the potential to impact INL historic architectural properties. Twenty-one INL properties that would be impacted by the projects were determined to be eligible to the National Register of Historic Places (National Register). Activities associated with five of the projects and seven properties, including four projects at the historic ATR facility, were determined to be exempt from cultural resource review and two proposed projects involved six resources that had been determined ineligible for listing on the National Register. Of the eligible INL properties, three projects would result in no adverse effects to nine INL structures and one would result in adverse effects to five historic architectural properties. The properties that would be adversely affected include World

War II era INL structures that are scheduled for demolition. A Draft Memorandum of Agreement was negotiated with the Idaho SHPO and Advisory Council that outlines stipulations (Historic American Landscape Survey documentation, interpretive signs) to mitigate the adverse impacts of the demolition of these historic properties.

In addition to INL cultural resource reviews, CWI submitted an updated NEPA EC for cultural resource review for the deactivation, decontamination, and demolition of an undisclosed number

Table 2-4. Cultural Resource Reviews Performed at the INL Site (2013).

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
BEA-13-01:	Montana State University Soil Sampling	Environmental Checklist review, limited field survey, and documentation	1	None
BEA-13-02:	Idaho Cleanup Project Routine Maintenance and Small Projects	Environmental Checklist reviews	None	None
BEA-13-03:	Small Wireless projects	Environmental Checklist reviews	None	None
BEA-13-04:	National Oceanic and Atmospheric Administration Wind Studies	Environmental Checklist review, limited field survey, and documentation	1	None
BEA-13-05:	Fire Evaluation and Monitoring/Lava Embayments Surveys	Archaeological survey, monitoring of known resource locations, and documentation	2	2 sites
BEA-13-06:	Naval Reactors Facility Small Projects	Archive reviews, monitoring of known resource locations, and documentation	None	Several previously recorded sites
BEA-13-07:	New Seismic Stations	Environmental Checklist review, limited field survey, monitoring of known resource locations, and documentation	5	1 site
BEA-13-08:	Ordnance Assessments and Remediation	Environmental Checklist review	None	None
BEA-13-09:	Well Abandonment and Monitoring	Environmental Checklist review	None	None
BEA-13-10:	Water Security Test Bed	Environmental Checklist review, monitoring of ground disturbance in sensitive areas, and documentation	None	None

Table 2-4. Cultural Resource Reviews Performed at the INL Site (2013). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
BEA-13-11:	Pioneer Site (10-BT-676) Excavations	Research excavations and analyses	None	1 previously recorded site
BEA-13-12:	New Power Poles at Antelope Substation	Environmental Checklist review, limited field survey, and documentation	2	1 isolate
BEA-13-13:	Magnetometer Research at Materials and Fuels Complex (MFC) and Test Area North	Environmental Checklist review, limited field survey, and documentation	2	None
BEA-13-14:	Trailmix Project Powerline Reconfiguration	Environmental Checklist review, limited field survey, and documentation	None	None
BEA-13-15:	Resumption of Transient Testing at MFC	Environmental Assessment review and preparation, limited field survey, monitoring of known resource locations, and documentation (see also Project #BEA-13-H011)	None	1 previously recorded site
BEA-13-16:	National Security Test Range Sign Replacement	Environmental Checklist review, field survey, and documentation	10	7 isolates 3 sites
BEA-13-17:	Iona Hill Facility Maintenance and Fire Protection	Environmental Checklist review, limited field survey, and documentation	2 (off INL site)	None
BEA-13-18:	INL Fire Department Chainsaw Training Near East Butte	Environmental Checklist review, limited field survey, and documentation	1	None
BEA-13-19:	Fire Protection at Central Facilities Area (CFA) and Experimental Field Station	Environmental Checklist review, limited field survey, and documentation	None	None
BEA-13-20:	U.S. Geologic Survey Well #139	Environmental Checklist review, limited field survey, and documentation	1	None
BEA-13-21:	Spreading Areas Future Expansion of Borrow Pits	Archive review and recommendations for future project	None	Several previously recorded sites
BEA-13-22:	U.S. Geologic Survey Well #140 and #141	Environmental Checklist review, limited field survey, and documentation	2	None
BEA-13-23:	National Oceanic and Atmospheric Administration Dispersion Studies	Environmental Checklist review, limited field survey, monitoring of known resource locations, and documentation	None	Several previously recorded sites

Table 2-4. Cultural Resource Reviews Performed at the INL Site (2013). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
BEA-13-24:	Relocation of Project Trailers and Operations Center to Critical Infrastructure Test Range Complex	Environmental Checklist review, monitoring of ground disturbance in sensitive areas, and documentation	None	None
BEA-13-25:	Field Material Buildup at Trailmix Project	Environmental Checklist review, limited field survey, and documentation	None	None
BEA-13-26:	Idaho Transportation Department-Bureau of Land Management Highway 20 Gravel Pit Expansion	Archive review, field survey, monitoring of known resource locations, and documentation	15	Several previously recorded sites
BEA-13-27:	Minor Ground Disturbance Associated with Willow Creek Building Projects in Idaho Falls	Environmental Checklist review and documentation (see also Project #BEA-13-H004)	None	None
BEA-13-28:	Diversion Dam at MFC	Environmental Checklist review, limited field survey, and documentation	1	None
BEA-13-29:	Minor Ground Disturbance Associated with Demolitions at CFA	Environmental Checklist review and documentation (see also Project #BEA-13-H001)	None	None
BEA-13-30:	East Butte Fiber Optic Cable Installation	Review of cultural resource review and survey completed by Bureau of Land Management	None	None
BEA-13-31:	INL Road Sign Replacement and Upgrade	Environmental Checklist review and documentation	None	None
BEA-13-32:	Fencing and Paving Projects at MFC	Environmental Checklist review and documentation	None	None
BEA-13-H001:	CFA NPG Demolitions (CF606, 607, 613, 632); partial demolition of CF-633	Eligible, NEPA EA and NHPA 106 compliance	NA	NA
Architectural BEA-13-H002:	TRA-670 Housing and Rigging	Eligible; exempt activity	NA	NA
Architectural BEA-13-H003:	Bi-directional Amplifier Installation for Emergency Communications; Misc Facilities (CPP-666, MFC-752, 765, 774, 776, 785, TRA-670)	Eligible, except CPP-666; exempt activity	NA	NA

Table 2-4. Cultural Resource Reviews Performed at the INL Site (2013). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
Architectural BEA-13-H004:	WCB Pedestrian Bridge Replacement	Ineligible	NA	NA
Architectural BEA-13-H005:	TRA-670 Remote Monitoring and Management	Eligible; exempt activity	NA	NA
Architectural BEA-13-H006:	TRA-605, MFC-765, IF-608 In-Kind Roof Repairs	Eligible; no adverse impact	NA	NA
Architectural BEA-13-H007:	TAN-629 In-Kind Roof Repair Project	Eligible; no adverse impact	NA	NA
Architectural BEA-13-H008:	TRA-670 Transition to Commercial Power	Eligible; exempt activity	NA	NA
Architectural BEA-13-H009:	ICP General DD&D 2013-2015 (EC Update)	Eligible; adverse impact, mitigation re: INL CRMP and NHPA Section 106 compliance	NA	NA
Architectural BEA-13-H010:	Wireless Testbed Tower Replacement	Ineligible	NA	NA
Architectural BEA-13-H011:	TREAT Restart (MFC-720, 721, 765, 785, and TRA 670)	Eligible; no adverse impact	NA	NA
	TREAT Restart (MFC-722, 723, 724, and CPP-666)	Ineligible	NA	NA
Architectural BEA-13-H012:	TRA-605 Decontamination Shower Installation	Eligible; exempt activity	NA	NA

of properties. Instructions were provided to CWI to contact the INL CRMO prior to initiation of any activities that would impact properties that may be eligible to the National Register.

The results of project-specific cultural resource reviews are documented in a number of ways per the requirements outlined in the *INL Cultural Resource Management Plan* (DOE-ID 2013b). Recommendations tailored to specific projects and any cultural resources that may require

consideration are delivered in official e-mail notes that become part of the project's NEPA-driven EC and permanent record. For larger projects, technical reports are often prepared to synthesize cultural resource information and recommendations. Two reports were completed for FY 2013 projects:

- "Cultural Resource Investigations for the Resumption of Transient Testing of Nuclear Fuels and Material at the Idaho National Laboratory" (INL/EXT-13-29097, June 2013).
- "Cultural Resource Investigations for Recapitalization of Infrastructure at the Naval Reactors Facility on the INL" (INL/LTD-12-27685, December 2013).

Information gathered during INL cultural resource investigations and reviews is managed as a valuable archive of INL cultural resources and a record of decision-making related to cultural resource compliance. These hard copy and electronic data provide the foundation for archaeological predictive modeling efforts that facilitate land use planning in both the long- and short-term and serve important roles in local and regional archaeological research. Important documents related to the historical development of the INL Site, the ground-breaking scientific research conducted throughout INL history, and inventories to identify historic properties associated with these activities are also preserved.

INL cultural resources field investigations in 2013, were also conducted to further DOE-ID obligations under Section 110 of the NHPA to develop a broad understanding of all INL Site cultural resources, not only those located in active project areas. The INL CRMO continued collaboration with researchers from the Center for the Study of the First Americans at Texas A & M University to pursue ongoing scholarly research on long-term human occupation of the INL Site region. In 2013, for the fourth year the INL CRMO staff mentored a PhD candidate from Texas A & M. The collaborative work included the completion of excavations at an important prehistoric campsite (10-BT-676) located on the banks of the Big Lost River. Deeply stratified cultural deposits at this site extend more than two meters below surface and hold promise for providing information to contribute to a clearer understanding of regional cultural chronology and human adaptations. As required by their INL cultural resource investigation permit, researchers from Texas A & M updated a draft preliminary summary of the excavations. In 2014, analysis of the artifacts and other samples recovered from excavations at this site and the project report will be completed.

Under INL-wide Stop Work Authorities, INL employees are authorized to stop work at all DOE-ID, contractor, and/or subcontractor operations if they believe the work poses an imminent danger to human health and safety, or the environment, including irreplaceable cultural resources. Procedures are in place to make immediate notifications to appropriate parties (INL CRMO, DOE-ID, Shoshone-Bannock Tribes, State of Idaho, local law enforcement) in the event of any discoveries of this nature. Additionally, areas that have previously revealed unanticipated discoveries of sensitive cultural materials are routinely monitored for new finds. No cultural materials were unexpectedly discovered at the INL Site in 2013.

2.5.2 Cultural Resources Monitoring

The INL CRMO conducts yearly cultural resource monitoring that includes many sensitive archaeological, historic architectural, and tribal resources. Under the INL Cultural Resource Management (CRM) monitoring program, there are four possible findings for given monitoring, based on the level of disturbance noted:

Type 1: no visible changes to a cultural resource and/or a project is operating within the limits of cultural resource clearance recommendations.

Type 2: impacts are noted but do not threaten the integrity and National Register eligibility of a cultural resource and/or a project is operating outside of culturally cleared limitations.

Type 3: impacts are noted that threaten the integrity and National Register eligibility of a cultural resource and/or a project has been operating outside of culturally cleared limitations and impacts to cultural resources have occurred.

Type 4: impacts that threaten the integrity and National Register eligibility of a cultural resource are occurring during the monitoring visit, justifying the use of the INL Stop Work Authority.

If Type 2, 3, or 4 impacts are documented during monitoring, notifications are made to project managers, the DOE-ID Cultural Resources Management Coordinator, and various other parties, as appropriate and according to the nature and severity of the disturbance. Typically, Type 2 impacts can be corrected by CRMO personnel or with the cooperation of INL project managers, security personnel, and/or landlord organizations. In these instances, the impacts are only reported in summary fashion in year-end reports. Some Type 2 and all Type 3 or 4 impacts prompt formal investigations initiated by the INL CRMO. INL project managers, security, and/or landlord organizations, DOE-ID, and representatives from the Shoshone-Bannock Heritage Tribal Office (HeTO) may also participate in these investigations.

The INL Cultural Resource Monitoring Plan is contained in Appendix L of the *INL Cultural Resource Management Plan* (DOE-ID 2013b). The Monitoring Plan describes the impact types, purpose of monitoring, process of selecting resources to be monitored each year, and how impacts will be documented.

During the reporting year, 38 cultural resource localities were visited and monitored including:

- Two locations with Native American human remains, one of which is a cave
- Fourteen additional caves, one of which is listed on the National Register
- Seven prehistoric archaeological sites
- Four historic archaeological sites (two homesteads and two stage stations)
- One historic trail

- Experimental Breeder Reactor I (EBR-601) and associated guardhouse (EBR-602)
- Central Facilities Area World War II Signature Properties (CF-606, CF-607, CF-613, CF-632, CF-633, CF-637, CF-638, CF-642, and CF-651).

Representatives from INL projects, DOE-ID, the Idaho SHPO, and the Shoshone-Bannock Tribe's HeTO participated in several of the trips in 2013 (Figure 2-1). The INL CRM staff also took the opportunity to visit select INL caves, some for the first time. This opportunity was offered during the winter months by researchers associated with the Environmental Surveillance, Education, and Research program administered by Gonzales-Stoller Surveillance, LLC, in conjunction with their ongoing bat research. Combining archaeological monitoring with the bat research project served to limit the number of cave entries in the interest of protecting sensitive biological as well as cultural resources. As a result of the multiple cave entries completed in 2013, INL CRM staff have added significant observations to the INL Site cave inventory and established baselines for future monitoring at caves that had not been visited previously.

Throughout the year, most of the cultural resources monitored had no visual adverse changes resulting in Type 1 determinations. However, Type 2 impacts were noted at eight sites. In all of these cases, although impacts were noted or documentation was made of INL projects operating outside of culturally cleared limitations, cultural resources retained integrity and noted impacts did not threaten National Register eligibility. No new Type 3 or any Type 4 impacts that adversely impacted cultural resources and threatened National Register eligibility were observed at the cultural resource locations monitored in 2013.

In an effort to address select recurring Type 2 impacts and Type 3 impacts to prehistoric archaeological sites documented in previous years, INL CRM staff continued to interact with DOE-ID Physical Security and U.S. federal agents experienced in enforcing the ARPA toward successfully prosecuting individuals who have violated the law. It is anticipated that interaction and cooperation between the federal agents, DOE-ID Security, and the INL CRMO will be ongoing through 2014 and beyond, leading to more effective tools to identify unauthorized visitors and protections for sensitive INL cultural resources.

Results of all monitoring and formal impact investigations' reports, if available, are summarized annually in a year-end report to DOE-ID that is due each year at the end of October. The results of FY 2013 INL cultural resource monitoring are documented in the *Idaho National Laboratory Cultural Resource Monitoring Report for 2013* (DOE-ID 2013c). The report is available through the DOE-ID Cultural Resource Management Coordinator or the INL Cultural Resources Management Office.

2.5.3 Stakeholder, Tribal, Public, and Professional Outreach

Outreach and education are important elements in the INL CRM program and efforts are routinely oriented toward the general public, INL employees, important stakeholders such as the Idaho SHPO, Shoshone-Bannock Tribes, and cultural resource professionals. Tools that facilitate communication include activity reports, presentations, newspaper articles and interviews, periodic

tours, regular meetings with Tribal representatives, and various INL-specific internal and external media outlets. Educational exhibits at the Experimental Breeder Reactor I Visitor's Center (a National Historic Landmark) and the Big Lost River Rest Area on U.S. Highway 20/26 are also important public outreach tools. Several legal drivers mandate these efforts, including a 2012 Memorandum of Understanding between the DOE, the Departments of Defense, Interior, and Agriculture, and the national Advisory Council on Historic Preservation to improve the protection of Indian sacred sites along with tribal access to those sites through enhanced interdepartmental coordination and collaboration.

INL CRM staff members spoke on a wide variety of general topics in FY 2013, including regional prehistory and history, World War II, nuclear history, historic preservation, careers, cultural resource management, archaeological resource protection, and Native American resources and sensitivities. Audiences ranged from the general public and students to Idaho Master Naturalists and the Idaho SHPO. Staff also presented unique INL research to professional audiences at the Biennial Great Basin Anthropological Conference and the Annual Conference of the Association of Pacific Coast Geographers. Eight tours were given of select prehistoric and historic INL sites.

Figure 2-1. DOE-ID, Idaho SHPO, ACHP, and BEA Representatives Visit the Central Facilities Area. *(Photo courtesy of Don Watts, Idaho SHPO Preservation Planner)*

The INL Site is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-Bannock Tribes have a government-to-government relationship with DOE-ID that is strengthened and maintained through an Agreement-in-Principle (AIP) (revised and signed in December 2012) between the Tribes and the DOE-ID (DOE-ID 2012). The AIP defines working relationships between the Shoshone-Bannock Tribes and DOE-ID and fosters a mutual understanding and commitment to addressing a variety of tribal concerns regarding protection of health, safety, and environment, including cultural resources of importance to the Tribes. To aid with implementing cultural resource aspects of the AIP, a Cultural Resources Working Group comprised of representatives from the Shoshone-Bannock's HeTO, DOE-ID, and the INL CRMO was established in 1993. It was the first of its kind within the DOE complex and its regular Cultural Resources Working Group meetings enable issues and opportunities to be addressed in an environment of mutual respect and learning. Tribal input is sought for new and ongoing projects and a standing invitation is extended to comment on, visit, observe, and/or assist in INL CRMO field activities (Figure 2-2). The holistic view of cultural resources and cooperative spirit encouraged in this group foster an atmosphere of mutual respect that is conducive to open communication and effective consideration of tribal views in decisions regarding INL cultural resources and overall land management.

Figure 2-2. HeTO Staff Member, LaRae Bill, Assists at an INL Archaeological Excavation Site.

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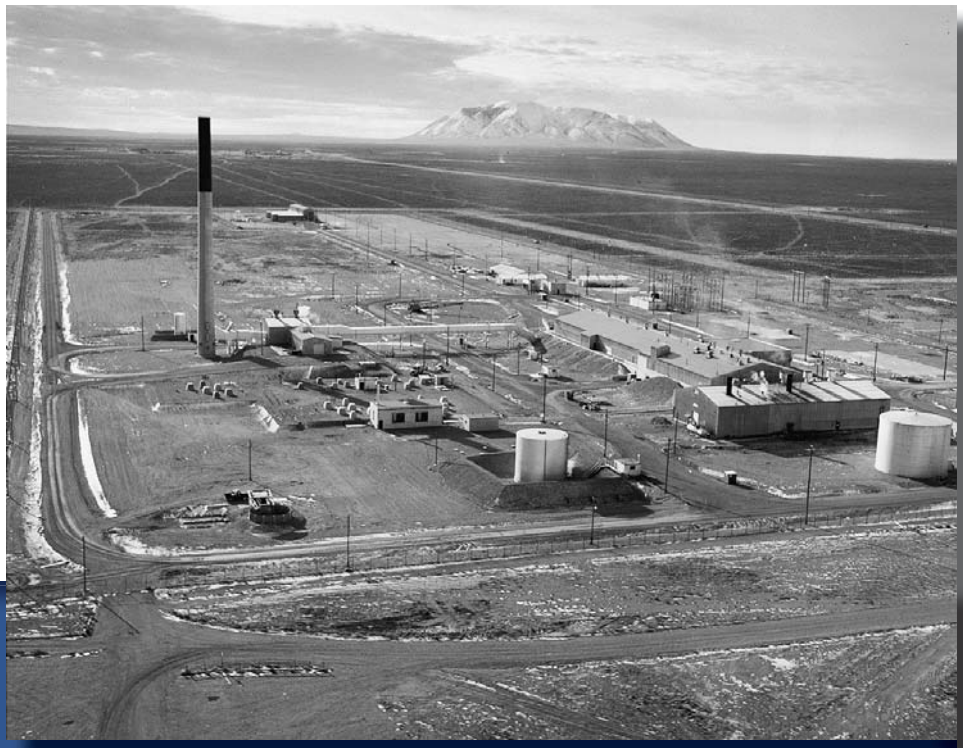
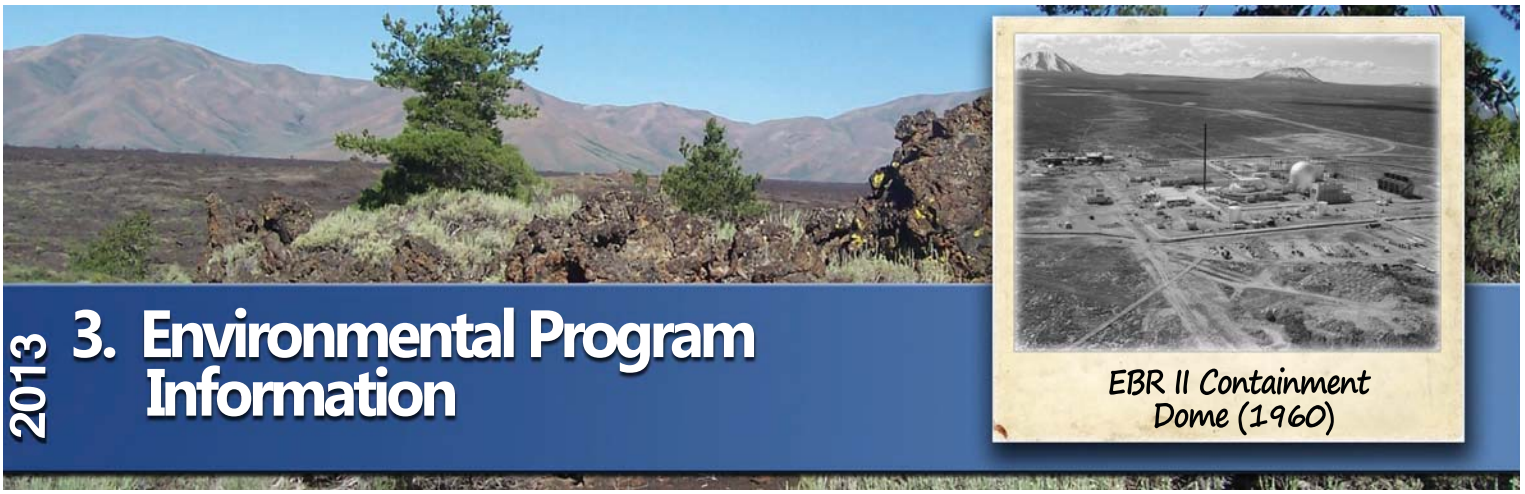


Header Photo Description: The 82-acre Chemical Processing Plant or Chem Plant was where spent nuclear fuels with different types of cladding– aluminum, zirconium, stainless steel – were stored and processed. Construction of facilities to house these activities began in 1950. The fuel processing mission was ended by the DOE in 1992.



2013

3. Environmental Program Information

EBR II Containment Dome (1960)

Chapter 3 Highlights

Environmental monitoring programs at the Idaho National Laboratory (INL) Site involve sampling environmental media, including ambient air, drinking water, surface water, and groundwater, soils, vegetation, agricultural products and wildlife, and measuring direct radiation. More than 6,100 samples were collected and analyzed in 2013 for a wide array of constituents, including pH, inorganics, volatile organics, gases, gross alpha and beta activity, and specific radionuclides, such as tritium, strontium, americium, and plutonium isotopes.

Significant progress continues on INL Site cleanup activities. Among the 2013 accomplishments are:

- 2,487 m^3 (3,253 yd^3) of stored transuranic waste was sent from the Advanced Mixed Waste Treatment Project to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, for disposal
- 1,022 m^3 (1,337 yd^3) of mixed low-level waste, historically managed as stored transuranic waste, was also shipped off the INL Site from the Advanced Mixed Waste Treatment Project
- 351 m^3 (459 yd^3) of mixed low-level waste and 749 m^3 (980 yd^3) of low-level waste were shipped off the INL Site from the Radioactive Waste Management Complex (RWMC) for treatment and/or disposal. Approximately 37.26 m^3 (49 yd^3) of newly generated, low-level waste was disposed of at the RWMC.

Contractors in charge of nuclear energy and cleanup operations at the INL Site had environmental management systems in place that were compliant with Department of Energy Order 436.1 (“Departmental Sustainability”) requirements. The INL Site energy usage was reduced by 11.5 percent in 2013 from the 2003 baseline. Water usage in 2013 was reduced by 2.8 percent from the 2007 baseline. Greenhouse gas emissions produced at the INL Site have been reduced by 36.7 percent from the 2008 baseline. In 2013, the Pollution Prevention Program successfully accomplished the goals of the INL Site Pollution Prevention Plan through projects such as the Federal Electronics Challenge, Earth Day, and the INL’s recycling initiative.

In 2013, removal of sodium from piping in MFC-766 (Sodium Boiler Building) was initiated and will be completed in 2014. Four shipments of spent nuclear fuel from the deactivated Experimental Breeder Reactor II were transferred from the Fuel Storage Facility at the Idaho Nuclear Technology and Engineering Center to the MFC for processing in 2013.

3. ENVIRONMENTAL PROGRAM INFORMATION

This chapter highlights the Idaho National Laboratory (INL) Site environmental programs that help maintain compliance with major acts, agreements, and orders. Much of the regulatory compliance activity is performed through the various environmental monitoring programs (Section 3.1), environmental restoration (Section 3.2), waste management and disposition (Section 3.3), and the Environmental Management System (EMS) (Section 3.4). Section 3.5 summarizes other significant INL Site environmental programs and activities.

3.1 Environmental Monitoring Programs

Facility effluents and environmental media are monitored for radioactive and nonradioactive constituents to ensure INL Site operations protect human health and the environment and comply with applicable environmental protection laws, regulations, and permits. INL Site environmental monitoring consists of effluent monitoring and environmental surveillance, which are defined as follows:

- Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents for the purpose of:
  - Characterizing and quantifying contaminants
  - Assessing radiation exposure of members of the public
  - Providing means to control effluents at or near the point of discharge
  - Demonstrating compliance with applicable standards and permit requirements.
- Environmental surveillance is the measurement of contaminants in the environment to assess any potential incremental effects that INL Site operations may have on human health and the environment. Routine surveillance of all exposure pathways (Figure 3-1) is performed on specific environmental media (air, water, agricultural products, animal tissue, soil, and direct radiation).

At the INL Site, several organizations conduct environmental monitoring:

- The INL contractor (Battelle Energy Alliance, LLC [BEA]) and the Idaho Cleanup Project (ICP) contractor (CH2M-WG Idaho, LLC [CWI]) perform monitoring activities on the INL Site.

- The Environmental Surveillance, Education, and Research (ESER) contractor, Gonzales-Stoller Surveillance, LLC (GSS), performs monitoring activities off the INL Site.
- Two federal agencies also perform monitoring activities on and around the INL Site under interagency agreements with the Department of Energy, Idaho Operations Office (DOE-ID). The National Oceanic and Atmospheric Administration conducts meteorological monitoring and research, and the U.S. Geological Survey (USGS) conducts groundwater monitoring and research.

Tables 3-1 through 3-6 present a summary of the environmental surveillance programs conducted by the ESER, INL and ICP contractors, and the USGS in 2013. In addition to the monitoring constituents listed in Table 3-6, the USGS collected samples twice a year from nine wells in cooperation with the Naval Reactors Facility (NRF), and collected an expanded list of constituents from 11 multi-depth sampling wells. This expanded constituent list changes from year to year in response to USGS program remedial investigation/feasibility study requirements. The constituents collected during 2013 for the multi-depth wells were major anions and cations, trace elements, nutrients, selected radionuclides, and selected stable isotopes. These data are available from the USGS by request. For a more detailed description of INL Site monitoring activities, see the Idaho National Laboratory Site Environmental Monitoring Plan (DOE-ID 2014).

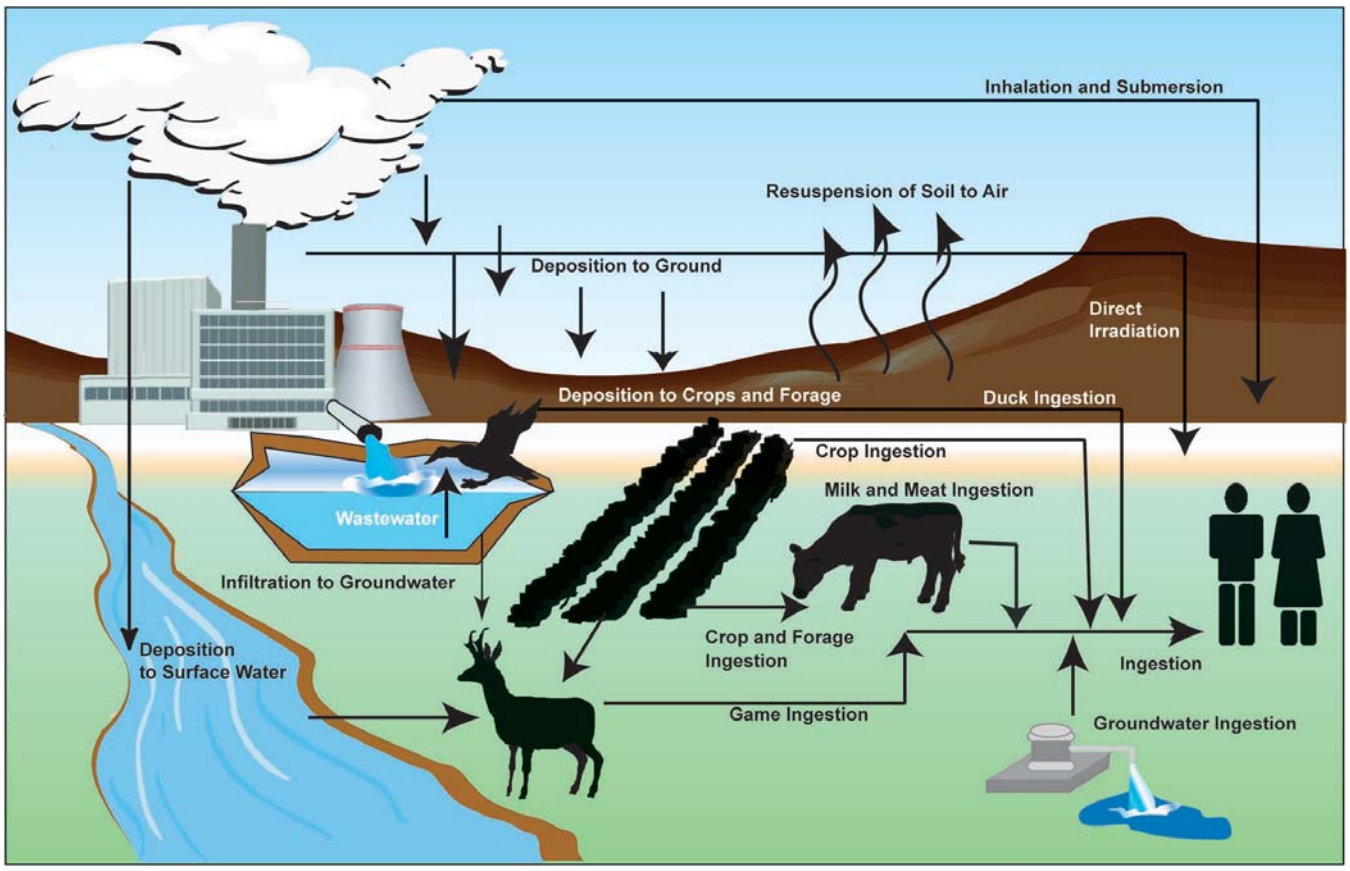


Figure 3-1. Potential Exposure Pathways to Humans from the Idaho National Laboratory Site.

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2013).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	3 weekly[a]	15 weekly[a]	1×10^{-15} µCi/mL
	Gross beta	3 weekly	15 weekly	2×10^{-15} µCi/mL
	Specific gamma[b]	3 quarterly	15 quarterly	2×10^{-16} µCi/mL
	Plutonium-238	2 quarterly	5-6 quarterly	3.5×10^{-18} µCi/mL
	Plutonium-239/240	2 quarterly	5-6 quarterly	3.5×10^{-18} µCi/mL
	Americium-241	2 quarterly	5-6 quarterly	4.6×10^{-18} µCi/mL
	Strontium-90	2 quarterly	5-6 quarterly	3.4×10^{-17} µCi/mL
	Iodine-131	3 weekly	15 weekly	1.5×10^{-15} µCi/mL
	Total particulates	3 quarterly	15 quarterly	10 µg/m^3
Air (high volume)[c]	Gross beta	None	1, twice per week	1×10^{-15} µCi/mL
	Gamma scan	None	If gross $\beta > 1$ pCi/m^3	1×10^{-14} µCi/mL
	Isotopic U and Pu	None	1 annually	2×10^{-18} µCi/mL
Air (atmospheric moisture)	Tritium	None	4 locations, 3 - 6 per quarter	2×10^{-13} µCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[d]	1 monthly	150 pCi/L
Animal tissue (big game and waterfowl)[e]	Specific gamma	Varies annually	Varies annually	2 pCi/g
	Iodine-131	Varies annually	Varies annually	2 pCi/g
Alfalfa	Specific gamma	None	1 annually	0.1 pCi/g
	Strontium-90	None	1 annually	0.02 pCi/g
Agricultural products (milk)	Cesium-137	None	1 weekly	1 pCi/L
	Iodine-131	None	1 weekly/9 monthly	1 pCi/L
	Strontium-90	None	9 semiannually	0.2 pCi/L
	Tritium	None	9 semiannually	150 pCi/L
Agricultural products (potatoes)	Specific gamma	None	8 –10 annually	0.1 pCi/g
	Strontium-90	None	8 –10 annually	0.02 pCi/g
Agricultural products (grain)	Specific gamma	None	10 –12 annually	0.1 pCi/g
	Strontium-90	None	10 –12 annually	0.02 pCi/g
Agricultural products (lettuce)	Specific gamma	1 annually	7 – 9 annually	0.1 pCi/g
	Strontium-90	1 annually	7 – 9 annually	0.02 pCi/g
Drinking Water[f]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	150 pCi/L
Surface Water[g]	Gross alpha	6 annually	4 semiannually	3 pCi/L
	Gross beta	6 annually	4 semiannually	2 pCi/L
	Tritium	6 annually	4 semiannually	150 pCi/L

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2013). (cont.)

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Soil	Specific gamma	None	14 biennially[h]	0.01 pCi/g
	Plutonium-238	None	14 biennially	0.01 pCi/g
	Plutonium-239/240	None	14 biennially	0.01 pCi/g
	Americium-241	None	14 biennially	0.03 pCi/g
	Strontium-90	None	14 biennially	0.1 pCi/g
Direct radiation exposure (thermoluminescent dosimeters and optically stimulated luminescence dosimeters)	Ionizing radiation	None	17 semiannually	5 mR

a. Onsite includes three locations and a duplicate sampler at one location; off INL Site includes 13 locations and a duplicate sampler at one location.
b. The minimum detectable concentration shown is for Cesium-137.
c. Filters are collected by Environmental Surveillance, Education, and Research personnel for the Environmental Protection Agency (EPA) RadNet program and sent to the EPA for analysis. Data are reported by the Environmental Protection Agency's RadNet at http://www.epa.gov/narel/radnet/.
d. A portion of the monthly sample collected at Idaho Falls is sent to the Environmental Protection Agency for analysis, and data are reported by RadNet.
e. Only big game animals (pronghorn, elk, or mule deer) that are victims of road kills or natural causes are sampled on the INL Site. No big game animal controls are collected. Waterfowl are usually collected on ponds within the Advanced Test Reactor Complex, Materials and Fuels Complex, and control areas.
f. Samples are co-located with the State of Idaho Department of Environmental Quality (DEQ) INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.
g. Onsite locations are the Big Lost River (if running) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at EFS, and at the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ INL Oversight Program at Alpheus Spring, Clear Springs, and at a fish hatchery at Hagerman. A duplicate sample is also collected at one location.
h. A duplicate sample is also collected at one location.

Results of the environmental monitoring programs for 2013 are presented in Chapter 4 (air), Chapter 5 (compliance monitoring for liquid effluents, groundwater, drinking water, and surface water), Chapter 6 (eastern Snake River Plain aquifer), and Chapter 7 (agricultural, wildlife, soil, and direct radiation). Chapter 8 discusses radiological doses to humans and biota. Chapter 9 summarizes wildlife population monitoring at the INL Site, and Chapter 10 presents abstracts of ecological and USGS research studies conducted at the INL Site. Quality assurance activities of the various organizations conducting environmental monitoring are described in Chapter 11. A summary of historical environmental monitoring activities, meteorological monitoring, and statistical methods used in this report are provided as supplemental reports.

Table 3-2. Idaho National Laboratory Contractor Air and Environmental Radiation Surveillance Summary (2013).

Medium Sampled	Type of Analysis	Locations and Frequency		Detectable Concentration
		Onsite[a]	Offsite[a]	
Air (low volume)	Gross alpha	18 weekly	5 weekly	1×10^{-15} µCi/mL
	Gross beta	18 weekly	5 weekly	5×10^{-15} µCi/mL
	Specific gamma	18 quarterly	5 quarterly	Varies by analyte[b]
	Iodine-131	18 weekly	5 weekly	2×10^{-15} µCi/mL
Air (atmospheric moisture)	Tritium	2 to 4 per quarter	2 to 4 per quarter	1×10^{-11} µCi/mL (water)
Soil	In situ gamma	Varies annually	None	Varies by analyte
Direct radiation exposure (optically stimulated luminescence dosimeters)	Ionizing radiation	54 annually	17 annually	5 mR
Direct radiation exposure (mobile radiation surveys)	Gamma radiation	Facilities and INL Site roads[b]	Not collected	Not applicable

a. Low volume air sampling locations onsite include ARA, ATR Complex CFA, EBR-I, Gate 4, INTEC, PBF, RWMC, SMC, MFC, EFS, Highway 26 Rest Area, Van Buren and two duplicate locations. Locations offsite include Blackfoot, Craters of the Moon, Idaho Falls, IRC, and Sugar City. A blank also is analyzed. (ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CFA = Central Facilities Area; EBR-I = Experimental Breeder Reactor; PBF = Power Burst Facility; RWMC = Radioactive Waste Management Complex; SMC = Specific Manufacturing Capability; MFC = Materials and Fuel Complex; EFS = Experimental Field Station).

b. The perimeter at each INL Site facility and an area outside the northeast corner of INTEC are surveyed each year.

Table 3-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2013).

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

Table 3-4. Idaho Cleanup Project Contractor Environmental Surveillance Program Air, Surface Water, Vegetation, and Radiation Survey Summary (2013).

Medium Sampled	Type of Analysis	Location and Frequency		Minimum Detectable Concentration[c]
		RWMC[a]	INTEC[b]	
Air (low volume)	Gross alpha	8 bimonthly	1 bimonthly	7×10^{-13} µCi/mL
	Gross beta	8 bimonthly	1 bimonthly	2×10^{-12} µCi/mL
	Specific gamma	8 monthly	1 monthly	Varies by analyte
	Specific alpha	8 quarterly	1 quarterly	8×10^{-18} µCi/mL
	Strontium-90	8 quarterly	1 quarterly	1×10^{-16} µCi/mL
Surface water runoff	Specific gamma	1 quarterly	None	Varies by analyte
	Plutonium isotopes	1 quarterly	None	0.02 pCi/L
	Uranium-233/234	1 quarterly	None	0.06 pCi/L
	Uranium-235	1 quarterly	None	0.04 pCi/L
	Uranium-238	1 quarterly	None	0.04 pCi/L
	Americium-241	1 quarterly	None	0.02 pCi/L
	Strontium-90	1 quarterly	None	0.3 pCi/L
Vegetation[d]	Specific gamma	4 annually	None	Varies by analyte
	Plutonium isotopes	4 annually	None	0.0006 pCi/g
	Uranium-233/234	4 annually	None	0.002 pCi/g
	Uranium-235	4 annually	None	0.001 pCi/g
	Uranium-238	4 annually	None	0.001 pCi/g
	Americium-241	4 annually	None	0.0006 pCi/g
	Strontium-90	4 annually	None	0.012 pCi/g
Mobile radiation surveys	Gamma radiation	1 annually	None	Not applicable

a. RWMC = Radioactive Waste Management Complex.
b. INTEC = Idaho Nuclear Technology and Engineering Center.
c. Detection limits vary with each laboratory analysis, but approximate values are provided.
d. Crested wheatgrass was sampled in 2013.

3.1.1 Sitewide Monitoring Committees

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

Table 3-5. Idaho Cleanup Project Contractor Drinking Water Program Summary (2013).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha	2 annually	15 pCi/L
Gross beta	2 annually	4 mrem/yr
Tritium	2 annually	20,000 pCi/L
Strontium-90	2 annually	8 pCi/L
Nitrate	2 annually	10 mg/L (as nitrogen)
Microbes	6 to 8 monthly	If <40 samples/month, no more than one positive for total coliform
Volatile organic compounds	2 quarterly	Varies

Table 3-6. U.S. Geological Survey Monitoring Program Summary (2013).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	49	49	4	4	1.5 pCi/L
Gross beta	49	49	4	4	3.4 pCi/L
Tritium	143	142	7	5	200 pCi/L
Gamma-ray spectroscopy	89	87	4	4	—[b]
Strontium-90	91	89	—[c]	—	2 pCi/L
Americium-241	23	22	—[c]	—	0.03 pCi/L
Plutonium isotopes	23	22	—[c]	—	0.02 pCi/L
Iodine-129	0	0	—[c]	—	<1aCi/L
Specific conductance	143	142	7	5	Not applicable
Sodium ion	137	134	—[c]	—	0.1 mg/L
Chloride ion	143	141	7	5	0.1 mg/L
Nitrates (as nitrogen)	114	115	—[c]	—	0.05 mg/L
Fluoride	4	4	—[c]	—	0.1 mg/L
Sulfate	124	121	—[c]	—	0.1 mg/L
Chromium (dissolved)	73	72	—[c]	—	0.005 mg/L
Purgeable organic compounds[d]	27	38	—[c]	—	Varies
Trace elements	10	10	—[c]	—	Varies

a. Number of samples does not include 12 replicates and 3 blanks collected in 2013. Number of samples was different than the number of sites because one site was sampled twice, and one site had pump problems and was not sampled. Number of sites does not include 54 zones from 11 wells sampled as part of the multi-level monitoring program.

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

c. No surface water samples collected for this constituent.

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

The INL 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 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, USGS and NRF, and serves as a forum for coordinating water-related activities across the INL and exchanging technical information, expertise, regulatory issues, data, and training.

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

3.1.2 DOE Headquarters Independent Assessment

In 2010, at DOE-ID's request, the Department of Energy (DOE) Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security conducted an independent assessment of the INL Site environmental monitoring program (HSS 2010). The scope for the assessment included:

- Review of INL Site environmental monitoring activities to ensure that the sitewide environmental monitoring program as a whole is comprehensive and meets the objectives of DOE Order 450.1A, Sections 4(c)(2)(a-d), which address protection of public health and the environment for specific media, and (c)(5-6), which address monitoring and meeting data quality objectives
- Review of the INL (BEA), ICP (CWI), and ESER (GSS) contractor environmental monitoring activities to ensure compliance with the requirements of DOE Order 450.1A, Sections 4(c)(2)(a-d) and (c)(5-6) and DOE Order 5400.5 for their contract responsibilities
- Determination of whether current monitoring activities meet selected stakeholder (Idaho Department of Fish and Game, state of Idaho, INL Oversight) expectations
- Review of the effectiveness of communication and timely access to monitoring data between site contractors and with DOE-ID on monitoring activities
- Review of the effectiveness of INL self-assessments of environmental monitoring activities
- Confirmation of the effectiveness of data storage and access, including foreseeable technological issues related to data storage, retrievability, and contractor planning to address such issues
- Confirmation that data quality objectives are appropriate and are being met
- Determination of whether monitoring is adequate for the expanding research and development activities of INL in the city of Idaho Falls
- Review of the INL Site Annual Site Environmental Report production process to ensure that the information reported is comprehensive, technically sound, written in a manner that is

understandable to the public and site stakeholders, and that appropriate efforts are being made to ensure the quality and defensibility of data reported.

The Office of Health, Safety, and Security Assessment Team issued a final report detailing positive attributes of the existing program and recommended program enhancements. Recommended program enhancements have been developed and are ongoing. The full Assessment Report is available at http://energy.gov/iea/downloads/independent-oversight-assessment-idaho-national-laboratory-site-may-2010.

3.2 Environmental Restoration

Environmental restoration at the INL Site is conducted under the Federal Facility Agreement and Consent Order (FFA/CO) (DOE 1991). The FFA/CO outlines how the INL Site will comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). It sets up a process for DOE-ID to work with its regulators to safely execute cleanup of past release sites at the INL Site.

The INL Site is divided into ten waste area groups (WAGs) (Figure 3-2) as a result of the FFA/CO, and each WAG is further divided into smaller cleanup areas called operable units. Field investigations are used to evaluate potential release sites within each WAG and operable unit when existing data are insufficient to determine the extent and nature of contamination. After each investigation is completed, a determination is made whether a “No Action” or “No Further Action” listing is possible, or if it is appropriate to proceed with an interim cleanup action, the Operable Unit-10-08 Plug-In Remedy action, or further investigation using a remedial investigation/feasibility study. The remedial investigation/feasibility study is used to determine the nature and extent of the problem presented by the past release of contamination and to develop and evaluate options for remedial action. Results from the remedial investigation/feasibility study 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. Proposed plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments, DOE, the Environmental Protection Agency, and the state of Idaho develop a record of decision (ROD) selecting a cleanup approach from the alternatives evaluated. Cleanup activities then can be designed, implemented, and completed.

Since the FFA/CO was signed in December 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials. All twenty-four RODs that were scheduled have been signed and are being implemented. Comprehensive remedial investigation/feasibility studies have been completed for WAGs 1, 2, 3, 4, 5, 7, 8, 9, and 6/10 (6 is combined with 10). Closeout activities at WAGs 1 (excluding Operable Unit 1-07B), 2, 4, 5, and 8 have been completed. The WAG 10, Operable Unit 10-08 ROD (Sitewide Groundwater, Miscellaneous Sites and Future Sites [DOE-ID 2009]) was the last ROD and was finalized in September 2009.

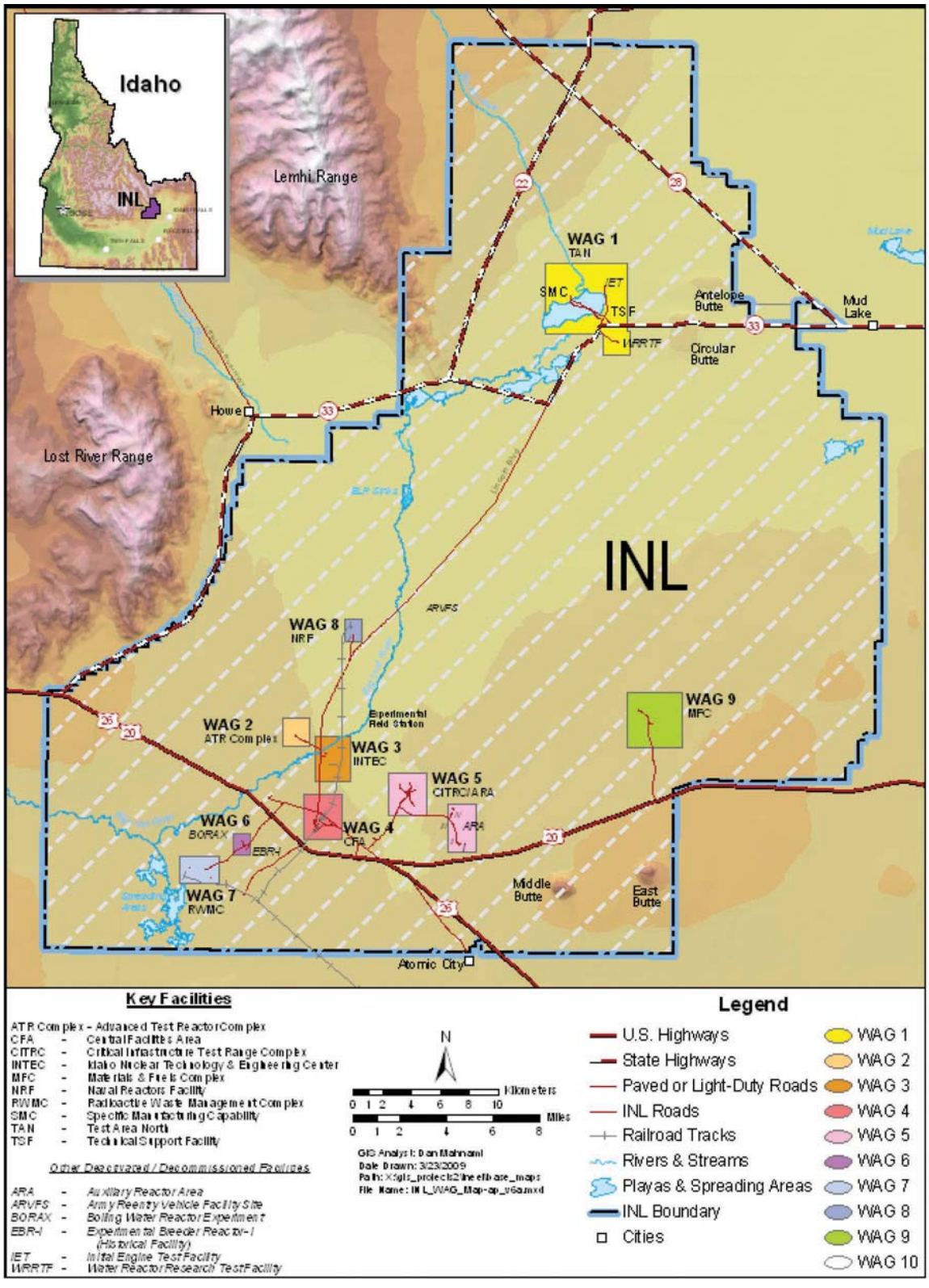


Figure 3-2. Map of the Idaho National Laboratory Site Showing Locations of the Facilities and Corresponding Waste Area Groups.

Documentation associated with the FFA/CO is publicly available in the CERCLA Administrative Record and can be accessed at http://ar.inel.gov/. The location of each WAG is shown in Figure 3-2. Cleanup progress for each WAG is summarized in the following subsections.

3.2.1 Waste Area Group 1 – Test Area North

Groundwater cleanup for Operable Unit 1-07B continued throughout 2013. The New Pump and Treat Facility generally operated four days per week, except for downtime due to maintenance, to maintain trichloroethylene concentrations in the medial zone below specified targets. The in situ bioremediation transitioned into a rebound test in 2012 to determine the effectiveness of the remedy to date. The rebound test continued through 2013. All institutional controls were maintained in 2013.

3.2.2 Waste Area Group 2 – Advanced Test Reactor Complex

All active remediation in WAG 2 is complete. Some elements of the remedy, including monitoring perched water and groundwater under the facility area and maintenance of caps and covers, will continue until the risk posed by contamination left in place is acceptable. Residual soil contamination in the vicinity of the demolished Engineering Test Reactor and Materials Testing Reactor and hot cell facilities is being evaluated as a new site under operable unit 10-08. All institutional controls and operations and maintenance requirements were maintained in 2013.

3.2.3 Waste Area Group 3 – Idaho Nuclear Technology and Engineering Center

The Idaho CERCLA Disposal Facility (ICDF) disposes of contaminated soils and debris from CERCLA remediation operations to reduce risk to the public and the environment. During 2012, the ICDF was put in a standby mode until shipments of contaminated soil requiring disposal are resumed. The facility continues to receive small amounts of liquid and solid waste periodically for disposal in the ICDF evaporation ponds and disposal cells, respectively.

Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately 9 million gallons of anthropogenic recharge to the northern perched water zones. Remedial actions were taken at the Tank Farm Facility to reduce water infiltration that potentially could transport contaminants from the perched water to the underlying aquifer. Perched and groundwater monitoring under and near the facility will continue until the risk posed by contamination left in place is below target levels. All institutional controls and operations and maintenance requirements were maintained in 2013.

3.2.4 Waste Area Group 4 – Central Facilities Area

Remediation of WAG 4 was completed in 2004. Groundwater monitoring and maintenance of caps and covers will continue until the risk posed by contamination left in place is acceptable. All institutional controls were maintained in 2013.

3.2.5 Waste Area Group 5 – Critical Infrastructure Test Range/Auxiliary Reactor Area

Cleanup activities at WAG 5 are complete. The Remedial Action Report (DOE-ID 2005) was completed in 2005. All institutional controls and operations and maintenance requirements were maintained in 2013.

3.2.6 Waste Area Group 6/10 – Experimental Breeder Reactor I/Boiling Water Reactor Experiment, Miscellaneous Sites, Eastern Snake River Plain Aquifer

The WAG 10, Operable Unit 10-08 ROD (Sitewide Groundwater, Miscellaneous Sites, and Future Sites) was the last INL Site ROD identified and was finalized in September 2009 (DOE-ID 2009). Operable Unit 10-08 addresses eastern Snake River Plain aquifer concerns not covered by other WAGs and future sites that may be discovered. Groundwater monitoring continued in 2013 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary. Remediation of unexploded ordnance, in accordance with the Operable Units 6-05 and 10-04 ROD (DOE-ID 2002), continued in 2013, including surveying two World Ware II-era practice bombing ranges. Active field work planned to address unexploded ordnance is now essentially complete. All institutional controls and operations and maintenance requirements were maintained in 2013.

3.2.7 Waste Area Group 7 – Radioactive Waste Management Complex

WAG 7 includes the Subsurface Disposal Area (SDA), a 39-hectare (97-acre) radioactive waste landfill that is the major focus of remedial response actions at the Radioactive Waste Management Complex (Figure 3-3). Waste is buried in approximately 14 of the 39 hectares (35 of the 96 acres) within 21 unlined pits, 58 trenches, 21 soil vault rows, and on Pad A, an above-grade disposal area. Disposal requirements have changed in accordance with laws and practices current at the time of disposal. Initial operations were limited to shallow, landfill disposal of waste generated at the INL Site. Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the Radioactive Waste Management Complex for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. A variety of radioactive waste streams was disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of transuranic waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste was disposed of in the SDA. Disposal of waste from offsite generators was discontinued in the early 1990s, and disposal of contact-handled waste was discontinued at the end of Fiscal Year (FY) 2008. Currently, only remote-handled, low-level waste is being disposed of in the SDA.

The Operable Unit 7-13/14 ROD (DOE-ID 2008) was signed in 2008. The ROD is consistent with DOE's obligations for removal of transuranic waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the state of Idaho and DOE, effective July 3, 2008 (DOE 2008). The ROD calls for exhuming and packaging a minimum of 6,238 m^3 (8,159 yd^3) (7,485 m^3 [9,790 yd^3] packaged) of targeted waste from a minimum combined area

of 2.3 hectares (5.69 acres). Targeted waste for retrieval contains transuranic elements (e.g., plutonium), uranium, and collocated organic solvents (e.g., carbon tetrachloride). Targeted waste retrievals in specific areas of the SDA commenced in 2005. The retrieved targeted waste is packaged, certified, and shipped out of Idaho. As of December 2013, 5,864 m^3 (7,670 yd^3) of targeted waste has been retrieved and packaged from a combined area of 1.28 hectares (3.17 acres).

In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of continued vapor-vacuum extraction and treatment of solvent vapors from the subsurface, in situ grouting of specified waste forms containing mobile contaminants (completed 2010), constructing an evapotranspiration surface barrier over the entire landfill, and long-term management and control following construction. Construction will be complete by 2028.

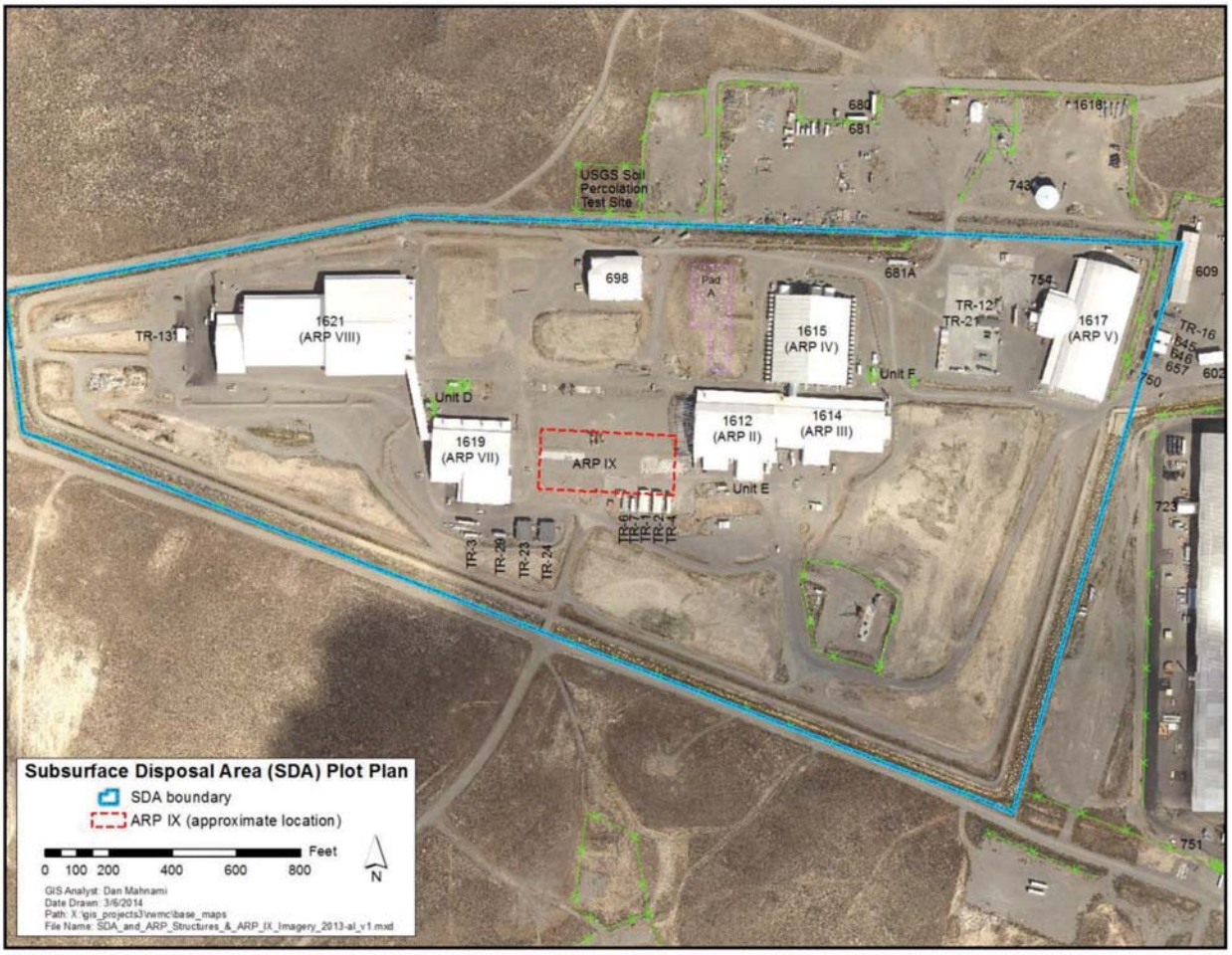


Figure 3-3. Radioactive Waste Management Complex Subsurface Disposal Area (2013).

3.2.8 Waste Area Group 8 – Naval Reactors Facility

NRF environmental program updates are discussed in the NRF environmental monitoring reports and are not included in this report.

3.2.9 Waste Area Group 9 – Materials and Fuels Complex

All WAG 9 remediation activities have been completed; however, the industrial waste pond (ANL-01) and interceptor canal (ANL-09) remain under institutional controls. The Industrial Waste Pond has elevated levels of chromium in the sediment and will be re-evaluated when it is no longer in use. Cesium-137 levels at the interceptor canal ditch and mound are below action levels, but above background. The site will remain under control until the cesium naturally decays to background levels.

Three sites at Materials and Fuels Complex (MFC) were administratively assigned to WAG 10 and remain under institutional controls:

1. The sewage lagoons (ANL-04) pose an ecological risk because of mercury levels in the sludge. In 2012, the lagoons were replaced with new HDPE-lined evaporation ponds. Closure options for the sewage lagoons will be evaluated after the sludge dries and additional samples are collected, analyzed, and compared with remedial action levels.

2. The buried remains of buildings MFC-767 and MFC-795 (ANL-67) are controlled because of asbestos associated with piping left in place when the buildings were removed.

3. The steel shot area north of MFC (ANL-65) is contaminated with metals. This site was remediated in 2013 by removal and disposal of 98 m^3 (128 yd^3) of lead-contaminated soil.

3.3 Waste Management and Disposition

Waste management and disposition covers a variety of operations and functions, including: (1) storage of waste pending disposition; (2) characterization of waste to allow it to be placed in storage or to be transported, treated, or disposed of; (3) transportation of waste to locations on or off the INL Site for treatment or disposal or both; (4) treatment of waste prior to disposal; and (5) disposal. Safe operations and compliance with applicable federal, state, and local regulations are the highest priorities, along with meeting the commitments made in the Idaho Settlement Agreement (DOE 1995) and the 2013 Idaho National Laboratory Site Treatment Plan (INL-STP) (ICP 2013).

3.3.1 Federal Facility Compliance Act

The Federal Facility Compliance Act requires preparation of a site treatment plan for the treatment of mixed wastes at the INL Site. Mixed wastes contain both radioactive and Resource Conservation and Recovery Act (RCRA)-regulated hazardous components. A backlog of mixed waste is being managed in RCRA-permitted storage units at the INL Site. During 2013, the INL Site treated or processed 4,125 m^3 (5,395 yd^3) of legacy mixed waste, of that total, 1,171 m^3 (1,532 yd^3) was mixed low-level waste shipped offsite for treatment/disposal, and 2,954 m^3

(3,864 yd^3) was mixed transuranic waste that was shipped offsite to the Waste Isolation Pilot Plant for disposition.

In accordance with the INL Site Treatment Plan (ICP 2013), the INL Site began receiving mixed waste from offsite locations for treatment in January 1996. Mixed waste has been received from other sites within the DOE complex, including Hanford, Los Alamos, Paducah, Pantex, Sandia, Savannah River, Argonne, and six locations managed by the Office of Naval Reactors. All off-site mixed waste was treated and shipped offsite within the specified timeframes established in the INL Site Treatment Plan in 2013.

During 2013, six INL Site Treatment Plan milestones were met and two milestones associated with the sodium-bearing waste treatment were modified. The (P-5) milestone to commence operations was modified from third quarter FY 2013 to third quarter FY 2014, and the (P-6) milestone to submit a schedule for system backlog was modified from fourth quarter FY 2013 to fourth quarter FY 2014. The following milestones were completed:

- Calcine Disposition Project – (P-5) Schedule for Table 5-1 (Table 2-1 Milestones/Planning dates)
- Calcine Disposition Project – (P-7) Submit RCRA Part B application for calcine retrieval, treatment (if necessary), and packaging
- Radioactive Waste Disposition Project – (P-1) Submit RCRA Part B Permit Modification Request
- Commercial Backlog Treatment/Disposal – 80 m^3 (104.6 yd^3)
- Sodium Component Maintenance Shop/Commercial Treatment Facility Backlog Treatment/Disposal – 2 m^3 (2.6 yd^3)
- Original volume Transuranic-contaminated Waste Backlog Treatment/Processing – 4,500 m^3 (5,886 yd^3).

3.3.2 Advanced Mixed Waste Treatment Project

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

After the waste containers have been retrieved from waste storage, they are examined in the AMWTP Characterization Facility. During characterization, each container is examined to determine its contents. Characterized waste containers that need further treatment before they can be shipped offsite for disposal are either sent to the AMWTP Treatment Facility or to the Drum Treatment Tent in WMF-628. The AMWTP Treatment Facility treats the waste by size-reducing, sorting, and repackaging the waste. Waste sent to the Treatment Facility is transported

to different areas within the facility by an intricate system of conveyers, and all waste is handled remotely. The Treatment Facility houses a supercompactor and a shredder for major size-reduction of the waste. Any restricted items, such as liquids or compressed gas cylinders, are removed, and the waste is repackaged. The Drum Treatment Tent primarily treats drums that contain sludge waste with excess liquids by adding liquid absorbent. The Drum Treatment Tent may also repackage old drums into new drums.

There are two loading areas at the AMWTP. In both loading facilities, the waste containers go through two major steps: payload assembly and TRUPACT II loading. Payload assembly includes grouping the waste into four different configurations consisting of 55-gallon drums, 100-gallon pucks drums (i.e., drums of compacted waste), waste over-packed into Standard Waste Boxes, and waste over-packed into Ten Drum Overpacks. Then, the waste is loaded into the TRUPACT II containers for shipping. A TRUPACT II container is a special double-containment vessel that is approved for waste transport. After the payloads are placed in the TRUPACT II containers, the containers are visually and mechanically inspected before they are certified for travel. Once a TRUPACT II container is certified for travel, the waste is sent 2,092 km (1,300 mi) to its final destination at the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

During 2013, the AMWTP shipped 2,487 m^3 (3,253 yd^3) of stored transuranic waste to the Waste Isolation Pilot Plant, for a cumulative total of 42,201 m^3 (55,197 yd^3) of waste shipped off the INL Site. The AMWTP also shipped offsite 1,022 m^3 (1,337 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 10,702 m^3 (13,998 yd^3) of waste shipped offsite. A combined cumulative total of 52,903 m^3 (69,195 yd^3) of stored waste has been shipped offsite. In addition, the AMWTP has shipped a cumulative total of 70 m^3 (92 yd^3) of buried transuranic waste (see 3.2.7, “Waste Area Group 7 – Radioactive Waste Management Complex”) to the Waste Isolation Pilot Plant.

3.3.3 High-Level Waste and Facilities Disposition

In 1953, reprocessing of spent nuclear fuel (SNF) began at the Idaho Nuclear Technology and Engineering Center (INTEC), resulting in the generation of liquid high-level waste and sodium-bearing waste. Those wastes were placed into interim storage in underground tanks at the INTEC Tank Farm. Treatment of those wastes began in 1963 through a process called calcining. The resultant waste form, calcine, was placed in storage in stainless steel bins at the Calcine Solids Storage Facility. DOE announced the decision to stop processing SNF in 1992. Calcining of all nonsodium-bearing, liquid, high-level waste was completed on February 20, 1998, four months ahead of the June 30, 1998, Idaho Settlement Agreement milestone. Calcining of remaining sodium-bearing waste began immediately following completion of nonsodium-bearing, liquid, high-level waste treatment, more than three years ahead of the Idaho Settlement Agreement milestone. All such waste is required to be treated by the end of 2012.

In October 2002, DOE issued the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002) that included alternatives other than calcination for treatment of the sodium-bearing waste. DOE-ID issued a ROD for this Final Environmental Impact Statement on December 13, 2005 (DOE 2005). This ROD specified steam reforming to treat the remaining sodium-bearing waste at the INTEC Tank Farm. This technology will treat the

remaining approximately 3.4 million L (900,000 gal) of liquid, sodium-bearing waste that has been consolidated into three 1.14 million L (300,000 gal) below grade tanks at the INTEC Tank Farm for interim storage.

A new facility, the Integrated Waste Treatment Unit (IWTU) was constructed and approved for operation in 2012. The IWTU is a facility for treatment of the remaining liquid sodium-bearing waste utilizing the steam reforming process. Processing of the sodium-bearing waste by IWTU has not been initiated due to problems that occurred in June 2012 during initial start-up testing. The facility has completed facility hardware and operational modifications to address issues identified during the initial start-up. The facility has completed readiness assessments for restart of testing and is expected to begin processing waste by June 2014. DOE-ID has negotiated with the state of Idaho Department of Environmental Quality a revised completion date for treatment of the sodium-bearing waste. The revised consent order milestone is December 2014.

Seven other 1.14 million L (300,000 gal) INTEC Tank Farm tanks have been emptied, cleaned, and removed from service in preparation for final closure. With regard to tank closures, DOE issued a final Section 3116 Waste Determination and amended ROD in November 2006 (71 Federal Register [FR] 68811-13, 2006). Filling the seven cleaned tanks and their surrounding vaults began in November 2006 and was completed in March 2008.

The Final Environmental Impact Statement also included analysis of alternatives for treating the calcined waste. On December 23, 2009, DOE issued an amended ROD (75 FR 137.40, 75 FR 1615-16) for the treatment of calcine using an industrially mature manufacturing process known as hot isostatic pressing (HIP).

A RCRA Part B permit was submitted to the state of Idaho Department of Environmental Quality on November 27, 2012, for the HIP process. The permit is based upon the utilization of the existing IWTU facility to the extent practicable by retrofitting the IWTU to accommodate the HIP process. Current efforts are focused on Calcine Bin Set conceptual design activities and response to any comments from the State regarding the RCRA Part B Permit application.

3.3.4 Low-Level and Mixed Radioactive Waste

In 2013, more than 351 m^3 (459 yd^3) of mixed low-level waste and 749 m^3 (980 yd^3) of low-level waste was shipped off the INL Site for treatment or disposal or both. Approximately 37.26 m^3 (49 yd^3) of newly generated, low-level waste was disposed of at the SDA in 2013.

3.4 Environmental Management System

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

Executive Order (EO) 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," mandates that all federal agencies implement EMSs at all appropriate organizational levels. DOE Order 436.1, "Departmental Sustainability," requires compliance with this EO, and further requires that DOE sites use their EMS as a platform for Site Sustainability Plan implementation. Sites must maintain their EMS as being certified to or conforming to the International Organization for Standardization's (ISO) 14001:2004 in accordance with the accredited registrar provisions or self-declaration instructions.

The three main INL Site contractors have established EMSs for their respective operations. The ICP and INL contractors maintain ISO 14001 systems certified and registered by accredited registrars. Auditors from the registrars conduct periodic surveillances and full audits of the systems to determine improvement or degradation, and eligibility for recertification. The AMWTP contractor's EMS is self-declared conformant to the ISO standard, based upon conformance audits by independent, external, qualified auditors. DOE strongly supports the management system concept, and its auditors review contractor processes to ensure they meet DOE's requirements.

3.4.1 Sustainability Program

The Site Sustainability Plan and program implemented sustainable practices in facility design operation, procurement, and program operations that meet the requirements of EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," and DOE Order 436.1, "Departmental Sustainability." The goal of EO 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies."

The goal of the INL Site sustainability program is to promote economic, environmental, and social sustainability for the INL Site, helping to ensure its long-term success and viability as a premier DOE national laboratory. The sustainability program focuses on water and GHG reductions, as well as responsible use and disposal of materials and resources; advancing sustainable building designs; exploring the potential use of renewable energy; reducing utility costs across the INL Site; and supporting cost-effective facilities, services, and program management. The challenge is to minimize the impact of operations on the laboratory. The INL Site is integrating environmental performance improvement in the areas that matter most to its stakeholders and the laboratory, including minimizing the environmental footprint, taking a progressive approach to climate change, and championing energy conservation.

Energy Use – The DOE goal for energy usage is a 30 percent reduction of energy intensity by FY 2015, as compared to the FY 2003 energy intensity baseline. Energy intensity is defined as energy use divided by the building area measured in Btu/ft^2.

The INL Site is reducing its energy intensity to help DOE achieve its agency goal. In FY 2013, the INL Site reduced its energy intensity by 11.5 percent compared to the FY 2003 baseline. During FY 2013, the INL Site made progress towards lighting upgrades at several facilities that result in energy and cost savings. In addition, the INL Site has consolidated work from three buildings to other facilities further reducing energy needs.

Water Conservation – The DOE goal for water usage is a 26 percent reduction of usage intensity by FY 2020 as compared to the FY 2007 Water Usage Intensity Baseline. Water intensity is defined as gallons of water used divided by building area (gal/ft^2). The INL Site has reduced its water use by 2.8 percent when compared to the FY 2007 baseline.

Due to the nature of the various INL Site missions, many of the operations can be cyclical and result in varying usages of water throughout the year and from year to year. In addition, as facilities are removed and processes are shut down, the lower square footage can actually result in an increase in water intensity even as overall water usage is reduced.

A number of water-savings projects expected to save 50 million gallons/year were implemented in late FY 2013: elimination of adding water to the sewage lagoons and providing water for wildlife at the Advanced Test Reactor (ATR) Complex; xeriscaping and sprinkler shutdown at ATR Complex and Central Facilities Area. In addition, the INL Site identified and repaired leaks at INTEC that is expected to save 7 million gallons/year.

Achieving greater reductions in water intensity will be very difficult for the INL Site to accomplish. Long payback calculations based on inexpensive water and electric rates make water saving projects cost ineffective. Water usage is also dependent upon process usage and unplanned events such as wildfires as well as additional demolition of existing facilities.

Petroleum Use – DOE's goal for reduced petroleum use is 30 percent by 2020 when compared to the 2005 baseline. Presently, the INL Site has reduced its petroleum use by 36.5 percent. The INL Site has diversified strategies for increasing alternative fuel consumption and reducing carbon emissions associated with light and heavy-duty vehicles.

The INL Site will continue to obtain increasingly fuel-efficient, light-duty vehicles, manage bus idling times, eliminate underutilized bus routes, and continue its use of B20 and E-85 fuels. The INL also converted two buses to duel fuel, and is actively converting a third bus. That conversion allows those buses to run on regular diesel/biodiesel and LNG/CNG. The INL has completed the replacement of the INL bus fleet with 52 new motor coaches that run on B20 and have improved fuel mileage by up to 100 percent.

Greenhouse Gases – EO 13514 mandates that agencies develop specific GHG reductions targets. DOE has set a reduction target of 28 percent for Scope 1 and 2 GHGs and 13 percent reduction in Scope 3 GHG emissions. The EO sets 2008 as the baseline year against which reductions are measured. Scope 1, 2, and 3 are defined as:

- **Scope 1.** Direct or INL Site-owned emissions that are produced onsite, such as stationary combustion (from fuel combustion), mobile combustion (from fleet vehicles), and fugitive emissions (from refrigerants, onsite landfills, and onsite wastewater treatment). These include emissions that may benefit another entity or contractor, but for which the INL Site controls or owns the associated process.
- **Scope 2.** Indirect or shared emissions produced by INL's electricity, heat, and steam purchases.

- **Scope 3.** Indirect or shared emissions generated by outsourced activities that benefit the INL Site (occur outside the INL Site's organizational boundaries, but are a consequence of the INL Site's activities). This can include a large number of activities, so the INL Site focuses on transmission and distribution losses, employee commuting, employee travel, contracted waste disposal and contracted wastewater treatment since these categories were identified in the Technical Support Document for required reporting. Other activities that could be included in Scope 3 include the embodied emissions of purchased materials.

The INL Site combined Scope 1 and 2 GHG emissions are down 30.7 percent from the FY 2008 baseline. The INL Site scope 3 emissions are down 36.7 percent from the FY 2008 baseline. Many factors influence the INL Site's GHG emissions, including the large land area on which the Laboratory's facilities are located. The area requires long commutes, an extensive fleet to provide transportation for desert Site workers, and contains many antiquated inefficient facilities built before the current appreciation for energy efficiency and high-performance design.

INL continues to reduce GHGs by transporting employees with a modernized transportation system. By streamlining the INL mass transit system that provides safe, efficient, and sustainable transportation to work for INL employees throughout the eastern Idaho region, INL encourages travel behavior changes to reduce carbon emissions and fossil fuel consumption and increase highway safety. In doing so, INL models future trends in mass transit to local governments across the region. Other actions include instituting a park and ride system, relocating employees to town offices, use of E-85 and biodiesel fuels (B20), and use of modern buses, vans, and light duty vehicles to reduce carbon emissions.

3.4.2 Pollution Prevention

The INL Pollution Prevention Program incorporates national and DOE requirements to reduce, reuse, and recycle wastes and pollutants by implementing cost-effective techniques, practices, and programs. Such actions are required by various federal statutes, including, but not limited to the Pollution Prevention Act and RCRA. In 2007, EO 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," was issued. It consolidates and strengthens five EOs and two memoranda of understanding, and establishes new and updated goals, practices, and reporting requirements for environmental, energy, and transportation performance and accountability. It also requires more widespread use of EMSs to manage and improve sustainability practices. In 2009, EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," was issued. This EO expands on the energy reduction and environmental performance requirements for federal agencies identified in EO 13423.

The INL Site Pollution Prevention Plan (DOE-ID 2013) describes the pollution prevention practices pursued at the INL Site. This plan reflects the goals and policies for pollution prevention and sustainability at the INL Site and represents an ongoing effort to make pollution prevention and sustainability part of the INL Site's operating philosophy. This plan is a reference and guidance document for INL Site managers, operations personnel, and support staff. It contains the policy, objectives, strategies, goals, and support activities of the INL Site Pollution Prevention and Sustainability Program. Objectives of the Pollution Prevention and Sustainability Program

at the INL Site can be divided into the categories of cultural and technical. Cultural objectives include:

- Foster a philosophy among employees to protect the environment while carrying out the various missions at the INL Site
- Enhance communication of pollution prevention and sustainability objectives, goals, methods, and ideas laterally and vertically among INL Site organizations and contractors
- Promote integration and coordination between waste generators and waste managers on pollution prevention and waste minimization
- Recognize employee and project accomplishments in the area of pollution prevention and waste minimization.

Technical objectives include:

- Comply with federal, state, and local regulations and DOE requirements for pollution prevention
- Reduce or eliminate the generation of waste streams through source reduction and substitution, product reformulation, improved housekeeping, inventory control, process modification, and onsite reuse and recycling of materials to protect the air, water, land, and other natural and cultural resources impacted by the INL Site
- Identify new or modify current methods and technologies to improve pollution prevention and sustainable practices at the INL Site
- Promote the use of nonhazardous materials in plant construction, maintenance, and operations to minimize risks to human and environmental health
- Collect and exchange pollution prevention information from fellow DOE laboratories and other appropriate sites through technology transfer, outreach, and educational networks.

In 2013, INL Site facilities recycled 1,430,579.87 lb. (648.9 metric tons [MT]) of materials, including co-mingled materials, office paper, cardboard, scrap metal, wood, cooking oil, and wood pallets. This accounts for a 41.5 percent diversion of municipal solid wastes collected at INL Site facilities. The INL Site also diverted 26.1 percent of its construction and demolition in 2013 (648 MT).

Federal Electronics Challenge – The Federal Electronics Challenge is a program that encourages federal facilities and agencies to purchase greener electronic products, reduce impacts of electronic products during use, and manage obsolete electronics in an environmentally responsible way. The INL Site Pollution Prevention Program is one of the leaders in the DOE complex in its electronics stewardship program. In 2013, the INL Site received the Federal Electronics Challenge Gold Award for reducing the environmental impacts of electronic equipment. The INL Site has received Silver and Bronze Awards in previous years.

3.5 Other Major Environmental Programs and Activities

3.5.1 Decontamination and Decommissioning Activities

Through September 2012, the ICP decontamination and decommissioning (D&D) project safely decontaminated and decommissioned 223 buildings and structures for a total footprint reduction of over 1.6 million square feet at the INL Site. The project demolished three nuclear reactors, two hot cell facilities, the largest hot shop in the world, a spent fuel reprocessing complex, large laboratory buildings, and numerous warehouses and storage buildings. This effort significantly reduced life-cycle cost and risk by eliminating aging facilities that were no longer needed for the INL Site mission.

In 2013, the ICP funded additional D&D work at MFC. The MFC-799 (Sodium Process Facility) was closed under RCRA. Residual sodium in three tanks and associated lines from that facility were removed, treated, and disposed of on the INL Site. Removal of sodium from piping in MFC-766 (Sodium Boiler Building) was initiated and will be completed in 2014. Additional D&D work will be done in the future as funding allows and as facility missions are completed.

3.5.2 Spent Nuclear Fuel

SNF is fuel that has been irradiated in a nuclear reactor. SNF contains some unused enriched uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. DOE's SNF is from development of nuclear energy technology (including foreign and domestic research reactors), national defense, and other programmatic missions. Several DOE offices manage SNF. Fuel is managed by the ICP contractor at INTEC, the Naval Nuclear Propulsion Program at the NRF, and the INL contractor at the ATR Complex and MFC.

Between 1952 and 1992, SNF was reprocessed at the Idaho Chemical Processing Plant (now called INTEC) to recover fissile material for reuse. However, the need for fuel-grade uranium and plutonium decreased. A 1992 decision to stop reprocessing left a large quantity of SNF in storage pending the licensing and operation of an SNF and high-level waste repository or interim storage facility. Licensing of a repository at Yucca Mountain is being reconsidered, but the Idaho Settlement Agreement requires all INL Site fuel be removed from the state of Idaho by 2035. The Blue Ribbon Commission on America's Nuclear Future, charged with reviewing SNF management policies, issued a report to the Secretary of Energy in January 2012, detailing recommendations for creating a safe, long-term solution for managing and disposing of the nation's SNF and high-level radioactive waste.

In 2012, INL Site SNF was stored in both wet and dry conditions. An effort is underway to put all INL Site legacy SNF in dry storage. The Nuclear Materials Disposition team completed all 3,186 fuel handling units of ICP-assigned SNF to dry storage from 2005 to 2010. Descriptions of SNF storage facilities follow.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666) – This INTEC facility, also called FAST, is divided into two parts, an SNF storage basin area and the Fluorinel

Dissolution Facility, which operated from 1983 to 1992 and is currently being used in remote-handled transuranic waste management. The storage area consists of six storage basins currently storing SNF under about 11 million L (3 MG) of water, which provides protective shielding and cooling. All ICP-managed SNF has been removed from the basins and stored in the INTEC dry storage facilities described below. SNF from the ATR, Experimental Breeder Reactor II (EBR-II), and Naval Nuclear Propulsion Program is stored in the basins. Navy SNF is being transferred to the NRF for dry storage. In 2013, ICP transferred four of 227 shipments of EBR-II SNF to the MFC for processing. A project total of seven EBR-II shipments to MFC has been completed. The Idaho Settlement Agreement requires SNF to be removed from wet storage by December 2023.

Irradiated Fuel Storage Facility (IFSF, CPP-603) – This INTEC dry SNF storage facility has 636 storage positions and has provided dry storage since 1973. In 2008, D&D of the old fuel storage basin (the wet side of the facility) was completed. SNF receipt from foreign and domestic research reactors was suspended in 2013. The suspension will be lifted with satisfaction of the settlement agreement milestone for treatment of the sodium-bearing waste.

Cask Pad (CPP-2707) and Rail Casks – This INTEC facility provides safe dry storage of SNF in transport casks staged on an asphalt pad and on a rail siding.

TMI-2 Independent Spent Fuel Storage Installation (CPP-1774, ISFSI) – This INTEC facility is a U.S. Nuclear Regulatory Commission-licensed dry storage facility for SNF and debris from the Three Mile Island reactor accident. Fuel and debris were transferred to Test Area North on the INL Site for examination, study, and storage following the accident. After the examination, the SNF and debris were transferred to the ISFSI. The ISFSI provides safe, environmentally secure, aboveground storage for the SNF and debris. The facility construction consists of fuel and debris in welded stainless steel canisters, placed in carbon steel casks shielded inside concrete vaults.

Peach Bottom Fuel Storage Facility (CPP-749) – This INTEC facility consists of 193 below-ground vaults of various sizes for dry storage of SNF. The vertical vaults generally are constructed of carbon steel pipe, with some of them containing concrete plugs. All of the pipes are below grade and are accessed from the top using specially designed equipment.

Fort Saint Vrain Independent Spent Fuel Storage Installation – DOE-ID manages this U.S. Nuclear Regulatory Commission-licensed dry storage facility located in Colorado. It contains about two-thirds of the SNF generated over the operational life of the Fort Saint Vrain reactor. The rest of the SNF from the Fort Saint Vrain reactor is stored in the Irradiated Fuel Storage Facility, described previously. The Nuclear Regulatory Commission granted a 20-year license extension for material possession in this storage facility (2011-2031).

Advanced Test Reactor (TRA-670) – The ATR is located at the ATR Complex. The ATR is a research reactor that performs materials testing for domestic and foreign customers. During routine maintenance outages, spent fuel elements are removed and placed in underwater racks in the ATR canal, also located in Building TRA-670. Fuel elements are allowed to cool before

being transferred to the Fluorinel Dissolution Process and Fuel Storage Facility, as described previously. The ATR canal is designated as a working facility rather than a storage facility. The ultimate disposition of ATR or spent fuel may be either recycle or disposition in the repository.

Radioactive Scrap and Waste Facility (MFC-771) – The Radioactive Scrap and Waste Facility (RSWF) has operated since 1964 for the dry storage of SNF and solid radioactive wastes resulting from nuclear energy research and development. This facility is located at MFC. It is a fenced outdoor compound with over 1,000 steel pipe storage vaults set into the ground. The storage vaults are typically 0.6 m (24 in.) in diameter and just over 3.7 m (12 ft) long. The pipe storage vaults have concrete or steel shield plugs inserted into their tops to protect workers from radiation fields and to prevent water intrusion. The storage vaults also are cathodically protected from corrosion. Currently, 19.6 metric tons (43,120 lb) of SNF, mostly from the deactivated EBR-II, is stored in the steel pipe storage vaults.

Since 1996, 3.84 metric tons (8,360 lb) of the original EBR-II inventory has been removed from the RSWF and processed using a dry electrometallurgical process. This process operates at the MFC Fuel Conditioning Facility and results in extracted, fairly pure, low-enriched, uranium metal and also a ceramic and a stainless steel, solid, high-level waste. The extracted low-enriched uranium metal is stored at the Transient Reactor Test Facility Warehouse at MFC. DOE is seeking to provide this extracted uranium to the commercial nuclear fuel fabrication industry for reuse. The two high-level waste forms are expected to be disposed of at a national geologic repository. The RSWF also stores mixed waste (primarily steel reactor components waste contaminated with sodium metal) and is managed under a RCRA hazardous waste storage permit. The RSWF formerly stored legacy (pre-1996) transuranic radioactive waste. The last container of this legacy waste was removed from RSWF in October of 2013, and sent to the INTEC for characterization and packaging prior to disposal at the Waste Isolation Pilot Plant facility.

3.5.3 Environmental Oversight and Monitoring Agreement

The 2010 Environmental Oversight and Monitoring Agreement (DOE-ID 2010) between DOE-ID; DOE Naval Reactors, Idaho Branch Office; and the state of Idaho maintains the state's program of independent oversight and monitoring established under the first agreement in 1990 that created the state of Idaho INL Oversight Program. The main objectives of the current five-year agreement are to:

- Assess the potential impacts of present and future DOE activities in Idaho
- Assure citizens that all present and future DOE activities in Idaho are protective of the health and safety of Idahoans and the environment
- Communicate the findings to citizens in a manner that provides them the opportunity to evaluate these potential impacts.

The INL Oversight Program's main activities include environmental surveillance; emergency coordination, planning, preparedness and response; impact analyses and public information; and education. More information can be found on the INL Oversight Program website at http://www.deq.idaho.gov/.

3.5.4 Citizens Advisory Board

The INL Site Environmental Management Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on ICP activities to DOE-ID. The Citizens Advisory Board consists of 12 members who represent a wide variety of key perspectives on issues of relevance to Idaho citizens. They come from a wide variety of backgrounds, including environmentalists, natural resource users, previous INL Site workers, and representatives of local government, health care, higher education, business, and the general public. Their diverse backgrounds assist the ICP Environmental Management program in making decisions and having a greater sense of how the cleanup efforts are perceived by the public. Additionally, one board member represents the Shoshone-Bannock Tribes. Members are appointed by the DOE Environmental Management Assistant Secretary and serve voluntarily without compensation. Three additional liaisons (nonvoting) include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality. The liaisons provide information to the Citizens Advisory Board on their respective agencies' policies and views.

The Citizens Advisory Board is chartered by DOE through the Federal Advisory Committee Act. The Citizens Advisory Board's charter is to provide input and recommendations to DOE on topics such as cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of nonstockpile nuclear materials, excess facilities, future land use and long-term stewardship, risk assessment and management, and cleanup science and technology activities. The Citizens Advisory Board has provided over 148 recommendations during its tenure. More information about the Board's recommendations, membership, and meeting dates and topics can be found at http://www.inlcab.energy.gov.

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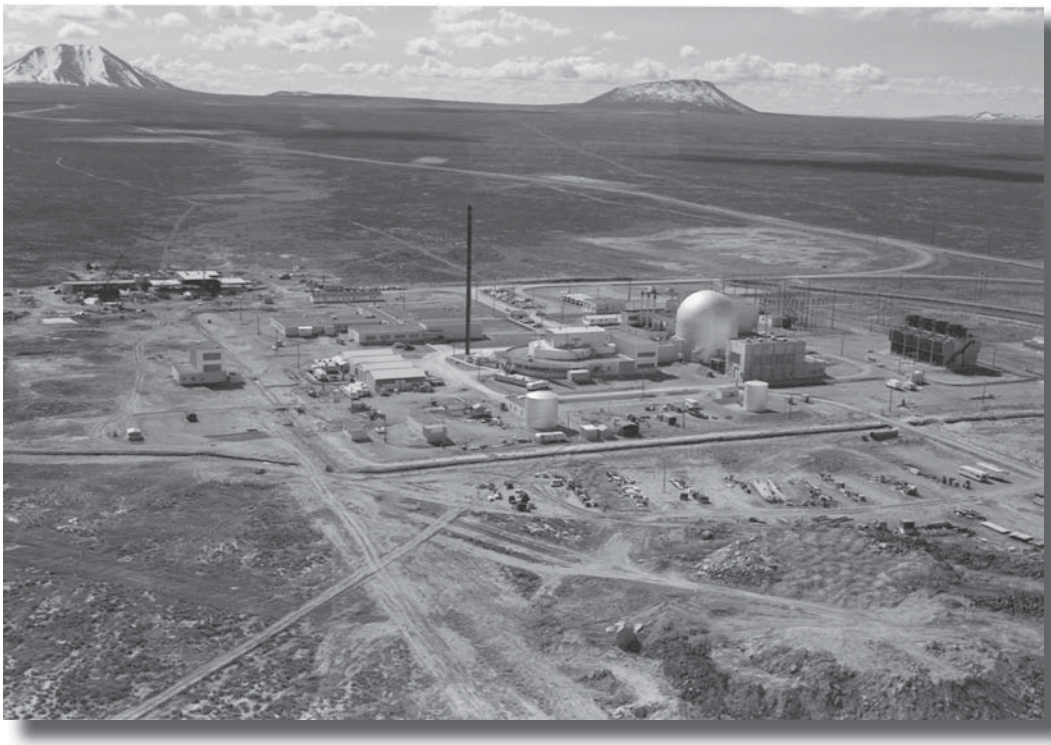


Header Photo Description: The investigation of fast neutron breeding reactors began at Experimental Breeder Reactor I or EBR-I in 1950. Beginning in 1964 the work was continued inside the silver-domed containment shell at EBR-II. The EBR-II reactor operated with an ahead-of-its-time closed fuel cycle, efficiently providing electricity for most INL Site operations for a number of years.

2013

4. Environmental Monitoring Programs - Air

Air sampler at EBR I (1973)

Chapter 4 Highlights

An estimated total of 2,890 Ci (1.07×10^{14} 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 2013. The highest contributors to the total release were the Advanced Test Reactor Complex at 57.6 percent, Idaho Nuclear Technology and Engineering Center at 39.5 percent, and the Radioactive Waste Management Complex at 2.8 percent of the total.

The INL Site environmental surveillance programs emphasize measurements of airborne contaminants because air is the most important transport pathway from the INL Site to receptors living outside the INL Site boundary. Because of this, samples of airborne particulates, atmospheric moisture, and precipitation were collected on the INL Site, at INL Site boundary locations, and at distant communities and were analyzed for radioactivity in 2013.

More than 1,900 charcoal cartridges, collected weekly using a network of low-volume air samplers maintained by the INL contractor and the Environmental Surveillance, Education, and Research contractor, were analyzed for radioiodine during 2013. Iodine-131 was not detected in any samples collected during the year.

Particulates were filtered from air using the same network of low-volume air samplers, and the filters were analyzed for gross alpha activity, gross beta activity, and specific radionuclides, primarily strontium-90, cesium-137, plutonium-239/240, and americium-241. (The INL contractor only analyzes samples for gamma-emitting radionuclides.) Gross alpha and gross beta activities were used primarily for trend analyses and indicated that there were no statistically significant differences between onsite, boundary, and distant locations. Seasonal variations were also observable in the concentrations.

Strontium-90 was reported on one air filter composite per quarter at distant or boundary stations near detection levels. Plutonium-238 was reported on two composites (one onsite and one boundary location) at values near the lower limit of detection. Plutonium-239/240 was detected at low levels in four air samples collected at boundary and distant locations. All results were within historical measurements and below health-based regulatory levels.

Airborne particulates were also collected biweekly around the perimeters of the Subsurface Disposal Area of the Radioactive Waste Management Complex and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility at the Idaho Nuclear Technology and Engineering Center. Gross alpha and gross beta activities measured on the filters were comparable with historical results, and no new trends were identified in 2013. Detections of americium and plutonium isotopes were comparable to past measurements and are likely due to resuspended soils contaminated from past burial practices at the Subsurface Disposal Area.

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

4. ENVIRONMENTAL MONITORING PROGRAMS - AIR

Idaho National Laboratory (INL) Site facilities have the potential to release radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations (Figure 3-1). Air is the most important radionuclide transport pathway to members of the general public (EG&G 1993). The INL Site air monitoring programs emphasize measurement of airborne radioactive contaminants because air has the potential to transport measureable amounts of radioactive materials to receptors in a relatively short period and can directly expose human receptors located off the INL Site.

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

4.1 Organization of Air Monitoring Programs

The INL contractor monitors airborne effluents at individual INL facilities to comply with the Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAPs). Section 4.2 summarizes the results of radiological airborne effluent monitoring.

Ambient air monitoring is conducted by the INL contractor, the ESER contractor, and the ICP contractor to ensure that the INL Site remains in compliance with the U.S. Department of Energy (DOE) Orders 435.1, “Radioactive Waste Management,” and 458.1, “Radiation Protection of the Public and the Environment.” The INL contractor collected about 2,000 air samples (primarily

on the INL Site) for various radiological analyses in 2013. The INL contractor also collects air moisture samples at four sites to determine tritium concentrations. Results of ambient air monitoring by the INL contractor and ICP contractor are summarized in Section 4.3.

Table 4-1. Air Monitoring Activities by Organization.

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

a. INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex, INL = INL Site facilities as shown in Table 4-2, Regional = locations outside of the INL Site as shown in Table 4-3.
b. Facilities that required monitoring during 2013 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Hazardous Air Pollutants."
c. Gamma-emitting radionuclides are measured by the ICP contractor monthly, by the ESER contractor quarterly, and by the INL contractor quarterly. Strontium-90, plutonium-238, plutonium-239/240, and americium-241 are measured by the ICP and ESER contractors quarterly and by the INL contractor when anomalous gross alpha or beta results exceed threshold levels.
d. The ICP contractor monitors waste management facilities.
e. The INL contractor monitors airborne effluents at MFC and ambient air outside INL Site facilities.
f. The ESER contractor collects samples on, around, and distant from the INL Site.

The ESER contractor collects air samples from an area covering approximately 23,309 km^2 (9,000 mi^2) of southeastern Idaho, Jackson, Wyoming, as well as at locations on, around, and distant from the INL Site. The ESER contractor collected approximately 2,000 air samples, primarily off the INL Site, for radiological analyses in 2013. The ESER contractor also collects air moisture and precipitation samples at selected locations for tritium analysis. Results of ambient air monitoring by the ESER contractor are discussed in Section 4.3.

The ICP contractor monitors waste management activities on the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) and at the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF). Section 4.4 discusses air sampling by the ICP contractor in support of waste management activities.

The INL Oversight Program, conducted by the state of Idaho Department of Environmental Quality, collects air samples from a series of air monitoring stations, many of which are collocated with the INL and ESER contractors' monitoring stations. The INL Oversight Program reports their data independently at http://www.deq.idaho.gov/inl-oversight/monitoring/reports.aspx.

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

4.2 Airborne Effluent Monitoring

Radiological effluent monitoring results are used to estimate doses to members of the public from INL Site airborne releases. Because of this, they are a major component of determining compliance with regulatory dose standards. Each regulated INL Site facility determines its airborne effluent concentrations as required under state and federal regulations. Criteria air pollutants and hazardous air pollutant effluent data for the INL Site are contained in the National Emission Inventory database and can be obtained from the U.S. Environmental Protection Agency (EPA) Clearinghouse for Inventories and Emission Factors website (http://www.epa.gov/ttn/chief/index.html). Information on radiological effluents is contained in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2013*, referred to hereafter as the NESHAPs Report (DOE-ID 2014b).

The NESHAPs Report describes three categories of airborne emissions:

- The first category includes sources that require continuous monitoring under the NESHAPs regulation
- The second category consists of releases from other point sources
- The final category is comprised of nonpoint, or diffuse, sources, which include radioactive waste ponds and contaminated soil areas and decontamination and decommissioning of facilities by ICP.

INL Site emissions include all three of these categories, as represented in Table 4-2. During 2013, an estimated 2,890 Ci (1.07×10^{14} Bq) of radioactivity were released to the atmosphere from all INL Site sources, which was within the range of releases from previous years, and continued the downward trend observed over the last ten years.

Approximately 79 percent of the radioactive effluent was from the noble gases argon, krypton, and xenon. A noble gas is inert, which means that it exists in a gaseous state and does not enter into chemical combination with other elements. Most of the remaining effluent was tritium (Table 4-2 and Figure 4-1). The following facilities were contributors to the total emissions:

- **Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (39.5 percent of total)** – Radiological air emissions from INTEC sources are primarily associated with liquid waste operations, including effluents from the Tank Farm Facility, Process Equipment Waste Evaporator, and Liquid Effluent Treatment and Disposal, which are exhausted through the Main Stack. These radioactive emissions include particulates and gaseous radionuclides. Additional radioactive emissions are associated with wet-to-dry spent nuclear fuel movements, remote-handled transuranic waste management, radiological and hazardous waste storage facilities, and contaminated equipment maintenance.

  The ICDF is located on the southwest corner of INTEC. Radiological emissions from this facility are estimated from waste disposal in the landfill, evaporation pond operations, and waste treatment operations. There were also minor emissions from the EPA Radiological Dispersion Device Decontamination Project in CPP-653.

  Most of the INTEC emissions contained krypton-85 (^{85}Kr). Krypton-85 is a radionuclide commonly associated with the nuclear fuel cycle and has a 10-yr half-life. The dose potentially received from ^{85}Kr is primarily external exposure from immersion in a contaminated plume.

- **Advanced Test Reactor (ATR) Complex Emissions Sources (57.6 percent of total)** – Radiological air emissions from ATR Complex are primarily associated with operation of ATR. These emissions include noble gases, iodines, and other mixed fission and activation products, but are primarily relatively short-lived noble gases. Other radiological air emissions are associated with sample analysis, site remediation, and research and development activities. Another emission source is the INL Radioanalytical Chemistry Laboratory, which began operation in the first quarter of 2011. Activities at the lab include wet chemical analysis to determine trace radionuclides, higher level radionuclides, inorganic, and general purpose analytical chemistry. High-efficiency particulate air filtered hoods are located in the laboratory including the radiological control room used for analysis of contaminated samples.

- **Radioactive Waste Management Complex (RWMC) Emissions Sources (2.8 percent of total)** – Emissions from RWMC result from various activities associated with the facility's mission to manage the low-level radioactive site and to temporarily store contact-handled and remote-handled transuranic waste for shipment to other designated facilities for disposal. In addition, various activities are being conducted in the SDA at RWMC to complete environmental cleanup of the area under CERCLA. These include waste retrieval activities (Accelerated Retrieval Projects [ARPs]) and operation of several units that extract volatile organic compounds from the subsurface.

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a].

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Ac-228	6.15 h	-- [f]	1.83E-12	--	--	--	--	1.83E-12
Ag-110m	432.2 y	1.96E-06	--	1.96E-13	--	--	--	1.96E-06
Am-241	16 h	7.03E-05	1.59E-09	5.67E-08	2.31E-11	1.13E-04	--	1.83E-04
Am-242	7380 y	--	--	--	--	2.84E-17	--	2.84E-17
Am-243	269 y	4.34E-15	1.60E-09	--	3.39E-07	--	--	3.41E-07
Ar-39	1.827 h	1.48E-19	--	--	--	--	--	1.48E-19
Ar-41	10.5 y	1.14E+03	--	--	--	--	--	1.14E+03
Ba-133	2.552 m	5.67E-12	1.91E-12	--	6.03E-10	--	--	6.11E-10
Ba-137m	432.2 y	--	--	--	1.14E-07	--	--	1.14E-07
Ba-139	82.7 m	1.18E-02	--	--	--	--	--	1.18E-02
Ba-140	12.74 d	2.34E-06	--	--	--	--	--	2.34E-06
Ba-141	18.3 m	2.58E-09	--	--	--	--	--	2.58E-09
Be-7	53.3 d	--	--	--	--	1.19E-12	--	1.19E-12
Be-10	1.36E06 y	5.43E-20	--	--	--	--	--	5.43E-20
Bi-207	31.55 y	--	7.50E-12	--	--	--	--	7.50E-12
Bi-210	120 h	7.68E-22	--	--	--	--	--	7.68E-22
Bi-210m	3E6 y	5.73E-28	--	--	--	--	--	5.73E-28
Bi-212	60.6 m	--	1.83E-12	--	--	4.48E-18	--	1.83E-12
Br-83	2.40 h	1.04E-05	--	--	--	--	--	1.04E-05
C-14	5730 y	6.28E-11	5.83E-07	1.33E-05	9.16E-04	3.43E-01	--	1.07E+00
Ca-45	162.61 d	3.27E-14	--	--	--	--	--	3.27E-14
Cd-109	462.6 d	3.33E-14	4.98E-19	--	1.62E-11	--	--	1.62E-11
Ce-139	137.64 d	--	4.61E-10	--	--	--	--	4.61E-10
Ce-141	32.5 d	1.02E-10	--	--	--	6.42E-11	--	1.66E-10
Ce-144	284.3 d	6.96E-04	--	--	3.19E-11	5.84E-08	--	6.96E-04

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Cl-36	3.01E5 y	--	--	8.72E-07	--	--	--	8.72E-07
Cm-242	162.8 d	6.60E-15	--	--	--	--	--	6.60E-15
Cm-243	28.5 y	1.24E-14	--	--	--	--	--	1.24E-14
Cm-244	18.11 y	9.79E-14	1.46E-08	3.65E-17	5.36E-12	9.08E-17	--	1.46E-08
Cm-248	3.48E05 y	--	--	--	5.22E-10	--	--	5.22E-10
Co-57	270.9 d	1.03E-11	3.87E-21	--	1.62E-11	2.20E-16	--	2.65E-11
Co-58	70.8 d	2.51E-05	1.10E-14	--	6.40E-11	1.22E-09	--	2.51E-05
Co-60	5.271 y	2.45E-02	2.45E-02	4.50E-05	2.40E-08	1.47E-09	--	4.91E-02
Co-60m	10.5 m	1.03E-19	--	--	--	--	--	1.03E-19
Cr-51	27.704 d	6.03E-03	2.02E-13	--	6.56E-11	--	--	6.03E-03
Cs-134	2.062 y	3.16E-05	4.06E-13	1.20E-07	2.36E-09	1.53E-09	--	3.17E-05
Cs-137	30.0 y	2.06E-02	2.73E-11	1.71E-02	1.14E-05	1.37E-07	--	3.78E-02
Cs-138	32.2 m	2.78E-01	--	--	--	--	--	2.78E-01
Eu-152	13.33 y	4.08E-04	4.81E-13	4.25E-15	--	9.88E-14	--	4.08E-04
Eu-154	8.8 y	3.46E-04	1.68E-09	3.59E-05	6.08E-09	4.82E-09	--	3.82E-04
Eu-155	4.96 y	6.29E-05	--	9.98E-06	3.14E-10	7.00E-09	--	7.29E-05
Eu-156	15.185 d	3.48E-11	--	--	--	--	--	3.48E-11
Fe-55	2.7 y	3.79E-09	3.87E-14	--	1.02E-09	2.52E-11	--	4.84E-09
Fe-59	44.4529 d	6.42E-08	--	--	5.08E-11	--	--	6.43E-08
Fe-60	1.5E06 y	1.03E-19	--	--	--	--	--	1.03E-19
Gd-153	241.6 d	--	1.67E-09	--	--	--	--	1.67E-09
Ge-71	11.43 d	3.21E-19	--	--	--	--	--	3.21E-19
H-3	12.35 y	3.78E+02	9.20E-01	1.41E+02	2.00E-01	8.10E+01	3.26E-02	6.01E+02
Hf-175	70 d	4.43E-07	--	--	--	--	--	4.43E-07
Hf-178m	3.94 s	2.35E-20	--	--	--	--	--	2.35E-20
Hf-179m	25.05 d	5.34E-20	--	--	--	--	--	5.34E-20
Hf-181	42.39 d	5.51E-05	4.10E-14	--	--	--	--	5.51E-05

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Hf-182	9E06 y	2.55E-23	--	--	--	--	--	2.55E-23
Hg-203	46.6 d	3.14E-06	--	--	--	--	--	3.14E-06
Ho-166m	1.20e03 y	--	1.77E-10	--	--	--	--	1.77E-10
I-128	24.99 m	2.05E-02	--	--	--	--	--	2.05E-02
I-129	1.57 E07 y	1.08E-07	1.99E-09	2.50E-02	1.59E-07	--	--	2.50E-02
I-131	8.04 d	3.43E-03	--	--	5.06E-03	--	--	8.49E-03
I-132	2.3 h	1.68E-04	--	--	--	--	--	1.68E-04
I-133	20.8 h	1.07E-03	--	--	--	--	--	1.07E-03
I-134	52.8 m	1.98E-04	--	--	--	--	--	1.98E-04
I-135	6.61 h	3.84E-04	--	--	--	--	--	3.84E-04
Ir-192	74.02 d	5.76E-21	--	--	--	--	--	5.76E-21
K-40	1.277E08 y	4.05E-14	--	--	--	1.59E-12	--	1.63E-12
Kr-85	10.72 y	1.60E-08	--	1.00E+03	8.27E-03	1.16E-18	--	1.00E+03
Kr-85m	4.48 h	8.12E+00	--	--	--	--	--	8.12E+00
Kr-87	76.3 m	2.69E+01	--	--	--	--	--	2.69E+01
Kr-88	2.84 m	2.37E+01	--	--	--	--	--	2.37E+01
La-140	40.27 h	4.43E-07	--	--	--	--	--	4.43E-07
La-142	92.5 m	1.20E-12	--	--	--	--	--	1.20E-12
Mn-53	3.7 E06 y	7.20E-23	--	--	--	--	--	7.20E-23
Mn-54	312.5 d	3.45E-05	8.39E-13	--	2.10E-10	1.23E-09	--	3.45E-05
Mn-56	2.5785 h	1.14E-11	--	--	--	--	--	1.14E-11
Mo-93	3.5E03 y	1.01E-09	--	--	--	--	--	1.01E-09
Mo-99	66.0 h	8.10E-05	--	--	--	--	--	8.10E-05
Na-22	2.60 y	--	6.00E-10	--	1.19E-08	--	--	1.25E-08
Na-24	15.0 h	1.86E-03	--	--	--	--	--	1.86E-03
Nb-93m	16.1 y	6.48E-13	--	--	--	--	--	6.48E-13
Nb-94	2.03E04 y	3.21E-14	--	--	--	--	--	3.21E-14

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Nb-95	35.15 d	1.23E-06	1.96E-14	--	8.24E-12	3.08E-16	--	1.23E-06
Nb-97	1.23 h	--	--	--	4.80E-12	--	--	4.80E-12
Ni-59	7.5E04 y	3.05E-10	6.03E-15	--	1.18E-10	--	--	4.23E-10
Ni-63	96 y	4.84E-08	1.78E-12	1.10E-04	6.36E-08	1.60E-13	--	1.10E-04
Np-237	2.14E06 y	6.11E-10	2.27E-12	5.95E-17	--	6.79E-09	--	7.40E-09
Np-239	2.355 d	9.94E-05	--	--	--	--	--	9.94E-05
Os-185	93.6 d	4.44E-21	--	--	--	--	--	4.44E-21
Os-191	15.4 d	1.67E-05	--	--	--	--	--	1.67E-05
P-32	14.262 d	5.88E-18	3.00E-10	--	--	--	--	3.00E-10
P-33	25.34 d	3.15E-21	--	--	--	--	--	3.15E-21
Pa-233	27.0 d	--	2.55E-13	--	--	--	--	2.55E-13
Pb-205	1.53E07 y	1.72E-21	--	--	--	--	--	1.72E-21
Pb-210	22.3 y	1.11E-13	--	--	--	3.59E-13	--	4.70E-13
Pb-212	13.6 h	--	1.83E-12	--	--	4.48E-18	--	1.83E-12
Pm-147	2.6234 y	--	4.29E-11	1.10E-05	--	1.03E-12	--	1.10E-05
Po-210	138.38 d	3.03E-21	--	--	--	--	--	3.03E-21
Po-212	0.305 m	--	1.17E-12	--	--	2.86E-18	--	1.17E-12
Po-216	0.15 s	--	1.83E-12	--	--	4.48E-18	--	1.83E-12
Pr-144	17.3 m	--	--	--	2.29E-11	4.58E-18	--	2.29E-11
Pr-144m	7.2 m	--	--	--	--	8.66E-15	--	8.66E-15
Pu-236	2.9 y	1.60E-14	--	--	--	--	--	1.60E-14
Pu-238	87.74 y	4.06E-14	4.98E-16	5.91E-05	1.42E-17	2.86E-18	--	5.91E-05
Pu-239	24065 y	2.67E-05	2.40E-11	2.60E-04	3.43E-07	4.48E-18	--	2.90E-04
Pu-240	6537 y	1.29E-14	6.09E-17	1.30E-04	1.42E-11	4.58E-18	--	1.30E-04
Pu-241	14.4 y	2.45E-14	1.80E-13	4.60E-03	3.61E-10	8.66E-15	--	4.60E-03
Pu-242	3.8E05 y	1.25E-13	9.58E-11	--	--	2.71E-09	--	2.81E-09
Ra-224	3.66 d	--	1.83E-12	--	--	4.48E-18	--	1.83E-12

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Ra-226	1600 y	3.12E-10	1.83E-12	--	--	2.63E-11	--	3.40E-10
Rb-88	17.8 m	3.15E-01	--	--	--	--	--	3.15E-01
Rb-89	15.2 m	1.79E-01	--	--	--	--	--	1.79E-01
Re-184	38.0 d	3.06E-18	--	--	--	--	--	3.06E-18
Re-184m	165 d	2.35E-18	--	--	--	--	--	2.35E-18
Re-186	3.77 d	8.28E-20	--	--	--	--	--	8.28E-20
Re-186m	2.0E05 y	8.28E-20	--	--	--	--	--	8.28E-20
Re-187	5E10 y	3.45E-17	--	--	--	--	--	3.45E-17
Re-188	17.005 h	6.87E-04	--	--	--	--	--	6.87E-04
Rh-106	368.2 d	--	--	--	5.07E-12	--	--	5.07E-12
Rn-220	55.6 s	--	1.83E-12	--	--	--	--	1.83E-12
Ru-106	373.59 d	--	--	--	5.07E-12	1.01E-09	--	1.02E-09
Sb-122	2.7238 d	1.66E-06	--	--	--	--	--	1.66E-06
Sb-124	60.2 d	3.16E-06	7.21E-14	--	--	4.06E-10	--	3.16E-06
Sb-125	2.77 y	2.28E-11	1.33E-13	1.00E-06	7.29E-08	3.66E-10	--	1.07E-06
Sc-46	83.83 d	1.90E-07	1.84E-14	--	--	--	--	1.90E-07
Si-32	100 y	5.34E-18	--	--	--	--	--	5.34E-18
Sm-151	90 y	--	--	1.90E-04	--	--	--	1.90E-04
Sn-113	115.09 d	5.76E-12	--	--	1.62E-11	--	--	2.20E-11
Sr-85	64.84 d	3.00E-10	--	1.50E-11	--	--	--	3.15E-10
Sr-89	50.5 d	2.17E-06	--	--	7.35E-09	--	--	2.18E-06
Sr-90	29.12 y	4.24E-02	4.32E-13	9.55E-03	5.38E-06	1.51E-07	1.02E-06	5.20E-02
Sr-91	9.5 h	1.30E-10	--	--	--	--	--	1.30E-10
Sr-92	2.7 h	1.02E-10	--	--	--	--	--	1.02E-10
Ta-179	1.8 y	1.34E-14	--	--	--	--	--	1.34E-14
Ta-180m	7.1E15 y	5.01E-33	--	--	--	--	--	5.01E-33
Ta-182	114.43 d	1.20E-05	--	--	--	--	--	1.20E-05

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Ta-183	5.1 d	5.94E-10	--	--	--	--	--	5.94E-10
Tc-99	2.13E05 y	2.08E-11	1.70E-10	2.20E-07	--	--	--	2.20E-07
Tc-99m	6.02 h	3.71E-04	3.48E-71	--	--	--	--	3.71E-04
Te-123m	119.7 d	1.32E-15	--	--	--	--	--	1.32E-15
Te-125m	58.0 d	--	--	--	2.11E-12	--	--	2.11E-12
Te-129	1.16 h	--	--	--	1.20E-12	--	--	1.20E-12
Th-228	1.9116 y	2.12E-11	1.83E-12	--	--	4.48E-18	--	2.30E-11
Th-229	7340 y	3.60E-16	--	--	--	--	--	3.60E-16
Th-230	7.7E04 y	2.77E-14	--	--	--	--	--	2.77E-14
Th-232	1.4E10 y	3.03E-11	1.86E-12	--	--	1.23E-18	--	3.22E-11
Tl-204	3.77 y	3.81E-21	--	--	--	--	--	3.81E-21
Tl-208	3.05 m	--	6.57E-13	--	--	1.61E-18	--	6.57E-13
U-232	72 y	6.86E-15	4.44E-17	--	--	4.74E-12	--	4.75E-12
U-233	1.585E05 y	1.95E-11	7.55E-08	3.72E-08	6.87E-06	7.92E-06	--	1.49E-05
U-234	2.457E05 y	2.64E-13	2.58E-12	2.67E-07	2.64E-08	5.13E-09	5.03E-09	3.04E-07
U-235	7.038E08 y	5.43E-12	1.20E-13	4.72E-09	8.43E-10	1.59E-09	3.52E-10	7.51E-09
U-236	4.468E09 y	7.20E-16	--	2.48E-10	--	--	--	2.48E-10
U-238	4.5E09 y	1.69E-09	8.57E-11	2.69E-08	5.40E-11	6.04E-08	2.80E-08	1.17E-07
V-49	330 d	3.21E-19	--	--	--	--	--	3.21E-19
W-181	121.2 d	4.08E-09	--	--	--	--	--	4.08E-09
W-185	75.1 d	6.87E-08	--	--	--	--	--	6.87E-08
W-187	23.9 h	2.46E-04	--	--	--	--	--	2.46E-04
W-188	69.78 d	2.59E-08	--	--	--	--	--	2.59E-08
Xe-133	5.245 d	3.80E+00	--	--	--	--	--	3.80E+00
Xe-135	9.09 h	2.74E+01	--	--	--	--	--	2.74E+01
Xe-135m	15.29 m	1.19E+01	--	--	--	--	--	1.19E+01
Xe-138	14.17 m	4.60E+01	--	--	--	--	--	4.60E+01

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2013)[a]. (cont.)

Radionuclide	Half Life[d]	Airborne Effluent (Ci)[b,c] ATR Complex[e]	CFA[e]	INTEC[e]	MFC[e]	RWMC[e]	TAN	Total
Y-88	106.64 d	1.05E-14	3.00E-10	--	--	--	--	3.00E-10
Y-90	64.0 h	2.14E-03	--	--	1.30E-07	--	--	2.14E-03
Y-92	3.54 h	1.56E-12	--	--	--	--	--	1.56E-12
Zn-65	243.9 d	1.30E-04	2.34E-12	--	--	2.56E-16	--	1.30E-04
Zr-95	63.98 d	6.58E-06	1.50E-10	--	8.44E-12	--	--	6.58E-06
Zr-97	16.9 h	1.14E-11	--	--	--	--	--	1.14E-11
Totals		1.67E+03	9.45E-01	1.14E+03	2.14E-01	8.13E+01	3.26E-02	2.89E+03

a. Radionuclide release information provided by the INL contractor.
b. One curie (Ci) = 3.7 x 10^{10} becquerels (Bq).
c. Includes only those radionuclides with a total INL Site release that potentially contribute > 1E-05 mrem (1E-07 mSv) dose.
d. d = days, h = hours, m = minutes, ms = milliseconds, s = seconds, y = years.
e. ATR = Advanced Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, RWMC = Radioactive Waste Management Complex, including Advanced Mixed Waste Treatment Project, TAN = Test Area North, including Specific Manufacturing Capability.
f. A long dash signifies the radionuclide was not reported to be released to air from the facility in 2013.

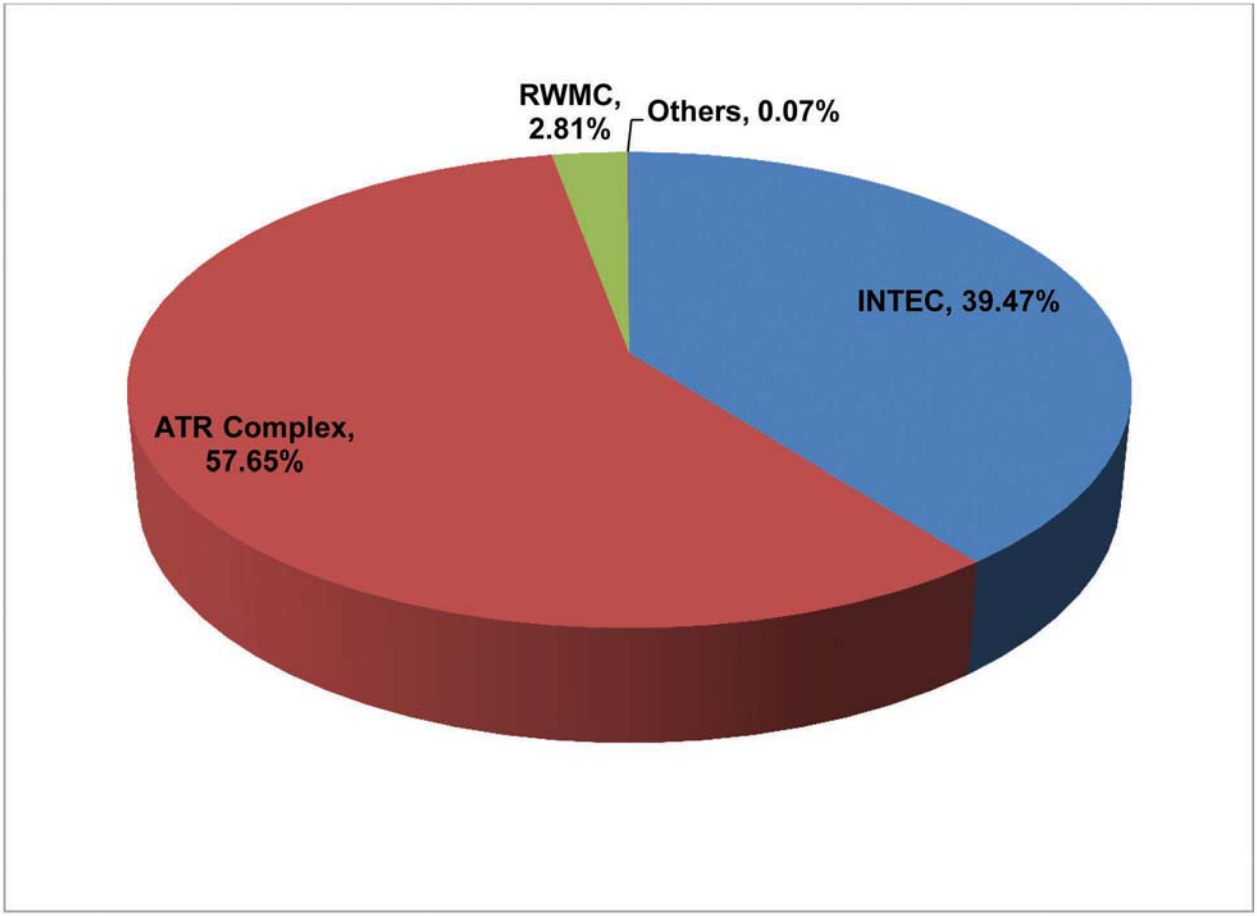


Figure 4-1. Percent Contributions, by Facility, to Total INL Site Airborne Radionuclide Releases (2013).

Potential unabated emissions from the ARP exceed 0.1 mrem/yr (0.001 mSv/yr). By agreement with EPA, the ARP used ambient air monitoring as an alternative to air dispersion calculations to verify compliance with the standard during ARP operation. Real-time monitoring is still conducted using continuous air monitors for detection of off-normal emissions.

RWMC processed (retrieved, sorted, and repackaged) radionuclide-contaminated soils and sludge within the ARP-V enclosure as part of the ARP CERCLA remediation. Exhumation of waste from the ARP-V area within WMF-1617 was completed in August of 2011. As of November 2012, the ARP-V facility (i.e., WMF-1617) was excessed from CERCLA, and a Resource Conservation and Recovery Act (RCRA) permit was completed that allowed processing of RCRA waste from the Advanced Mixed Waste Treatment Project (AMWTP) facility in WMF-1617. Processing of 6,000 drums of sludge from AMWTP under the RCRA permit was continued in 2013.

The AMWTP sludge processing activity is designed to ensure contact-handled stored transuranic waste is compliant with off-site disposal facility waste acceptance criteria by removing prohibited waste items (e.g., free liquids). The emissions from RWMC were estimated to be almost exclusively tritium.

- **Materials and Fuels Complex (MFC) Emissions Sources (0.01 percent of total)** – Radiological air emissions are primarily associated with spent fuel treatment at the Fuel Conditioning Facility, waste characterization at the Hot Fuel Examination Facility, and fuel research and development at the Fuel Manufacturing Facility. These facilities are equipped with continuous emission monitoring systems. On a regular basis, the effluent streams from Fuel Conditioning Facility, Hot Fuel Examination Facility, Fuel Manufacturing Facility, and other non-continuous emission monitoring radiological facilities are sampled and analyzed for particulate radionuclides. Gaseous and particulate radionuclides may also be released from other MFC facilities during laboratory research activities, sample analysis, waste handling and storage, and maintenance operations. Radiological emissions also occurred from ICP decontamination and decommissioning activities in MFC-766, Sodium Boiler Building.
- **Central Facilities Area (CFA) Emissions Sources (0.03 percent of total)** – Minor emissions occur from CFA facilities 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.
- **Test Area North (TAN) Emissions Sources (<0.001 percent of total)** – The main emissions sources at TAN are from the Specific Manufacturing Capability (SMC) project, and the New Pump and Treat Facility. Radiological air emissions from SMC are associated with processing of depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny. The main purpose of the New Pump and Treat Facility is to reduce concentrations of trichloroethylene and other volatile organic compounds in the medial portion of the Operable Unit 1-07B contamination groundwater plume at TAN to below drinking water standards. Low levels of strontium-90 and tritium are also present in the treated water and are released to the atmosphere by the treatment process.

The INL Site dose was calculated using all sources that emitted radionuclides to the environment (DOE-ID 2014b). Radiological dose to the public is discussed further in Chapter 8 of this report.

4.3 Ambient Air Monitoring

The INL, ICP, and ESER contractors' environmental surveillance programs monitor air pathways on and off the INL Site for radionuclides. Figure 4-2 shows the regional ambient air monitoring locations.

Filters generally are collected weekly from a network of low-volume air monitors. At each monitor, a pump pulls air (about 57 L/min [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm membrane filter and a charcoal cartridge. The membrane filters are collected weekly and analyzed in a laboratory for gross alpha and beta activity. Gross alpha and beta results generally are

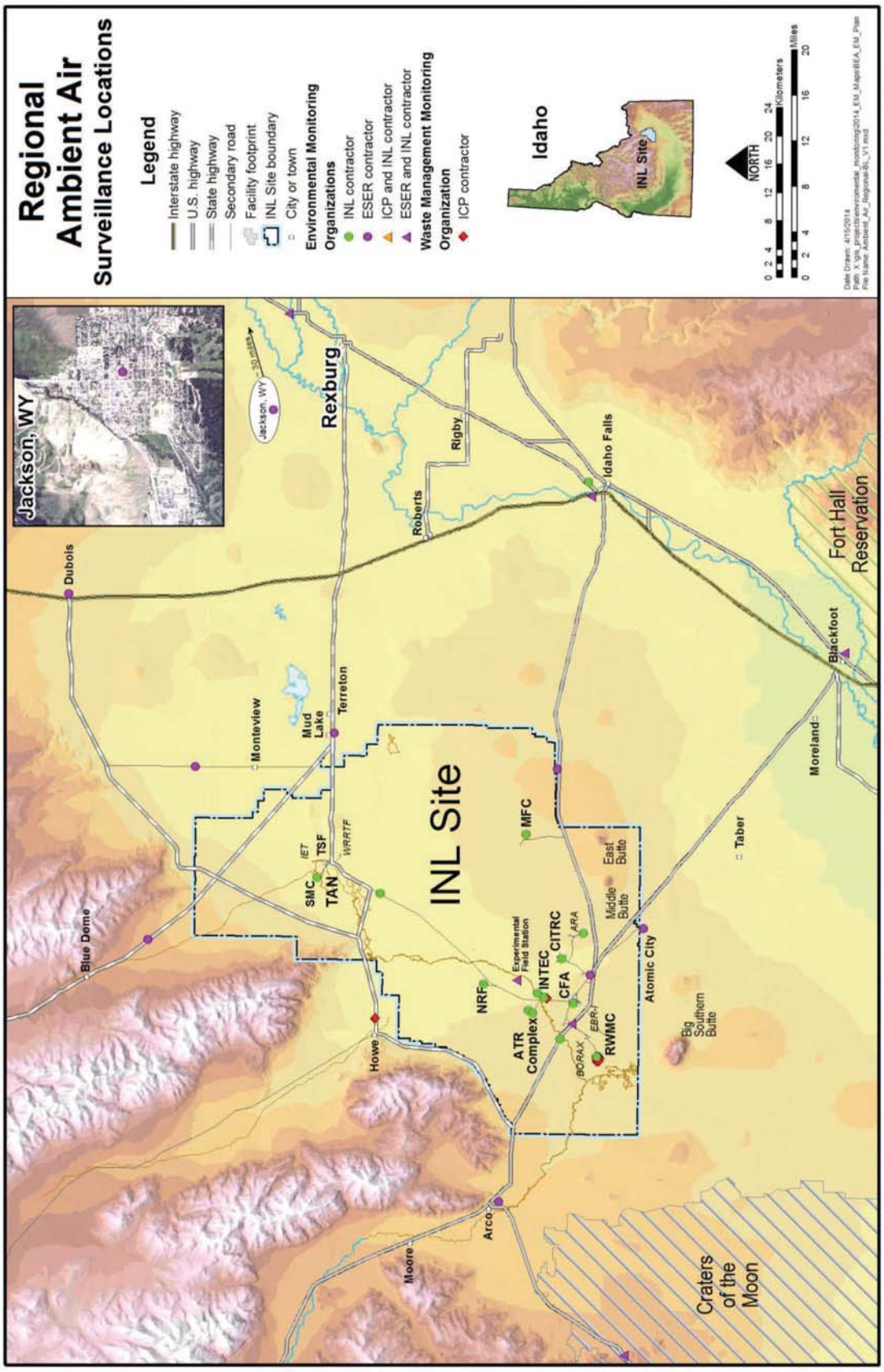


Figure 4-2. INL Site Environmental Surveillance Air Sampling Locations.

considered screenings because specific radionuclides are not identified. Rather, the results reflect a mix of alpha- and beta-emitting radionuclides. Gross alpha and beta radioactivity in air samples are usually dominated by the presence of naturally occurring radionuclides. Because of this, gross alpha and gross beta radioactivity is, with rare exceptions, detected in each air filter collected. If the results are higher than normal, sources other than background radionuclides may be suspected, and then other laboratory techniques can be used to identify specific radionuclides of concern. Gross alpha and beta activity also are examined over time and between locations to detect trends, which might indicate the need for more specific analyses.

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

The ESER and ICP contractors also use laboratories to radiochemically analyze the quarterly and monthly composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and strontium-90 (^{90}Sr). They were selected for analysis because they have been detected historically in air samples and may be present due to resuspension of surface soil particles contaminated by INL Site activities or global fallout. The INL contractor currently screens for certain actinides (uranium-235, uranium-238, and ^{241}Am) using the quarterly gamma spectrometry analysis of the composited air samples and orders additional analyses based on these screening results or in response to requests from the ESER or ICP contractors.

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

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the Experimental Field Station (EFS) and Van Buren Boulevard, and off the INL Site at Atomic City, Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg (Sugar City after July 29). Air passes through a column of molecular sieve, which is an adsorbent material that adsorbs water vapor in the air. Columns are sent to a laboratory for analysis when the material has adsorbed sufficient moisture to obtain a sample. The laboratory extracts water from the material by distillation and determines tritium concentrations by liquid scintillation counting. Tritium typically is present in air moisture due to natural production in the atmosphere, although it also is released by INL Site facilities (Table 4-2).

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

4.3.1 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,000 charcoal cartridges in 2013. There were no statistically positive detections of ^{131}I. During 2013, the ESER contractor analyzed 928 cartridges in batches of ten cartridges, looking specifically for ^{131}I. One batch of ten cartridges from the week of February 27 was initially reported as a statistically positive detection of ^{131}I. The detected value was just above the detection limit. A subsequent recount of this batch found that no ^{131}I was present on the cartridges.

Gross Activity – All air filters were analyzed for gross alpha and gross beta activity. Gross alpha and gross beta measurements were assessed in terms of historical measurements and trends between locations and contractors, as well as over time. All measurements were included in these assessments, even the few that were not considered to be detected, to make the statistical analyses more robust. For more information see the discussion of "less-than-detectable values" in the document entitled *Statistical Methods in the Idaho National Laboratory Annual Site Environmental Report*, which is a supplement to this report.

- **Gross Alpha.** Gross alpha concentrations measured in individual INL contractor samples ranged from a low of $-4.2 \times 10^{-16} \pm 5.4 \times 10^{-16}$ µCi/mL collected at Advanced Test Reactor Complex on March 6, 2013, to a high of $5.9 \times 10^{-15} \pm 1.5 \times 10^{-15}$ µCi/mL collected at Highway 20 Rest Area on July 24, 2013. Gross alpha concentrations measured in weekly ESER contractor samples ranged from a minimum of 0.09×10^{-15} µCi/mL at Dubois during the week ending February 27, 2013, to a maximum of 4.2×10^{-15} µCi/mL during the week of September 11, 2013, at Craters of the Moon. All results were within the range of historical measurements and less than the Derived Concentration Standard (DCS) of 4×10^{-14} µCi/mL for ^{241}Am (see Table A-1 of Appendix A).

  INL and ESER contractor gross alpha activity data differed little when analyzed by location grouping, as illustrated in Figure 4-3. In this figure, median concentrations measured at INL Site and offsite locations (boundary and distant) are plotted for each week of the year. Each median weekly concentration was computed using all measurements, including negative values and statistically undetected results. Both data sets (INL contractor and ESER contractor) indicate that gross alpha concentrations measured at INL Site and offsite locations follow a similar pattern with respect to time.

  Median annual gross alpha concentrations calculated by the INL contractor ranged from 1.1×10^{-15} µCi/mL at Auxiliary Reactor Area to 1.6×10^{-15} µCi/mL at EFS. Median annual gross alpha concentrations calculated by the ESER contractor for each location ranged from 0.9×10^{-15} µCi/mL at Blackfoot and Blue Dome to 1.3×10^{-15} µCi/mL at Rexburg/Sugar City (Table 4-3). The median annual gross alpha concentrations were typical of those detected previously, well within those measured historically, and remarkably consistent between sampling locations.

- **Gross Beta.** Gross beta concentrations in ESER contractor samples were fairly consistent with those of INL contractor samples. Weekly gross beta concentrations in INL contractor samples ranged from a low of $-2.6 \times 10^{-16} \pm 7.3 \times 10^{-16}$ µCi/mL at ATR Complex (south side)

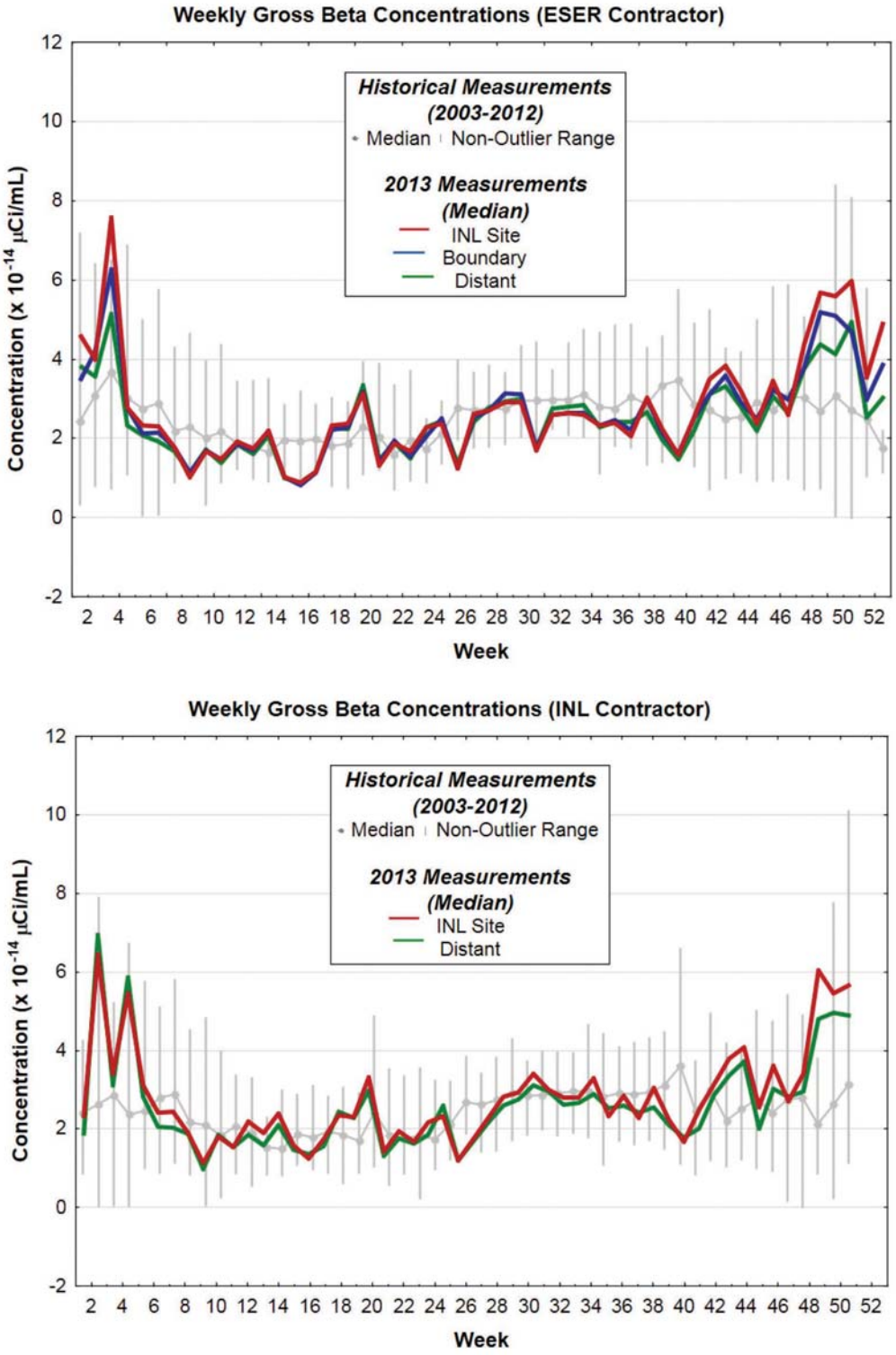


Figure 4-3. Median Weekly Gross Alpha Concentrations in Air (2013).

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2013).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-15} µCi/mL)	Annual Median[c] (× 10^{-15} µCi/mL)
		ESER Contractor		
Distant	Blackfoot	51	0.55 – 2.0	0.9
	Craters of the Moon	53	018 – 4.2	1.0
	Dubois	53	0.09 – 3.0	1.1
	Idaho Falls	53	0.30 – 2.5	1.2
	Jackson	53	0.40 – 2.4	1.2
	Rexburg/Sugar City[d]	53	0.26 – 2.6	1.3
			Distant Median:	1.1
Boundary	Arco	53	0.28 – 3.1	1.2
	Atomic City	53	0.21 – 2.5	1.2
	Blue Dome	53	0.19 – 4.2	0.9
	Federal Aviation Administration Tower	53	0.20 – 2.1	1.0
	Howe	52	0.27 – 3.0	1.2
	Monteview	53	0.28 – 2.8	1.2
	Mud Lake	51	0.24 – 2.7	1.3
			Boundary Median:	1.1
INL Site	EFS	53	0.30 – 2.5	1.1
	Main Gate	42	0.34 – 1.9	1.0
	Van Buren	53	0.22 – 2.7	1.2
			INL Site Median:	1.1
		INL Contractor		
Distant	Blackfoot	51	-0.06– 3.4	1.1
	Craters of the Moon	49	-0.10 – 5.1	1.2
	Idaho Falls	51	0 – 3.1	1.4
	Rexburg	49	-0.02 – 4.5	1.3
			Distant Median:	1.1
INL Site	ARA	50	-0.32 – 4.5	1.1
	ATR Complex (south side)	50	-0.42 – 5.3	1.2
	ATR Complex (NE corner)	51	-0.23 – 5.7	1.4
	CFA	50	-0.2 – 4.3	1.1
	CITRC	51	-0.27 – 4.3	1.4
	INTEC (west side)	51	-0.4 – 4.5	1.3
	EBR-I	51	-0.39 – 2.5	1.1
	EFS	48	-0.37 – 4.4	1.6
	Gate 4	48	-0.18 – 3.9	1.3
	INTEC (NE corner)	51	-0.32 – 4.3	1.4

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2013). (cont.)

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-15} µCi/mL)	Annual Median[c] (× 10^{-15} µCi/mL)
	MFC	49	0 – 5.4	1.3
	NRF	49	-0.09 – 4.9	1.2
	Rest Area	51	-0.13 – 5.9	1.2
	RWMC	51	1.9 – 4.4	1.2
	SMC	51	-0.32 – 5.9	1.4
	TAN	51	-0.20 – 4.2	1.2
	Van Buren	51	-0.41 – 4.4	1.4
			INL Site Median:	1.3

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability, TAN = Test Area North. See Figure 4-2 for locations on INL Site.

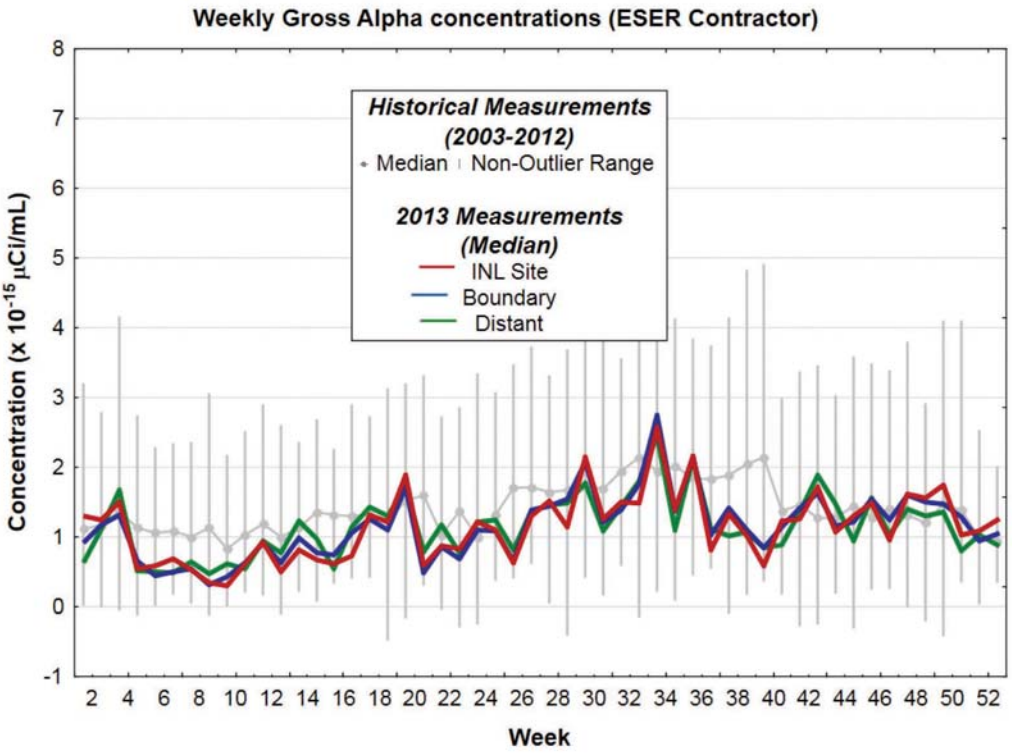
b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements. The maximum possible number of samples collected by the ESER contractor in 2013 was 53, because the first sample included was collected on January 2, 2013, and the last sample was collected on December 31, 2013, for a total of 53 weeks.

c. All measurements, including those <3s, 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. Air sampler was moved from Rexburg to Sugar City on July 29, 2013.

monitoring location on January 9, 2013, to a high of 8.9 x 10^{-14} ± 8.3 x 10^{-15} µCi/mL at TAN on January 23, 2013. Weekly gross beta concentrations detected in individual ESER contractor samples ranged from a low of 1.0 × 10^{-15} µCi/mL on December 24, 2013, at Craters of the Moon to a high of 9.3 × 10^{-14} µCi/mL on January 23, 2013, at Mud Lake. These results are within the range of past measurements.

Figure 4-4 displays the median weekly gross beta concentrations for the ESER and INL contractors at INL Site, boundary, and distant sampling groups in 2013, as well as historical median and range of data measured by the ESER contractor during the 10-year period from 2003 through 2012. In general, median airborne radioactivity levels for the three groups (on INL Site, boundary, and distant locations) tracked each other closely throughout the year. These data are typical of the annual fluctuation pattern for natural gross beta concentrations in air, with higher values typically occurring at the beginning and end of the calendar year



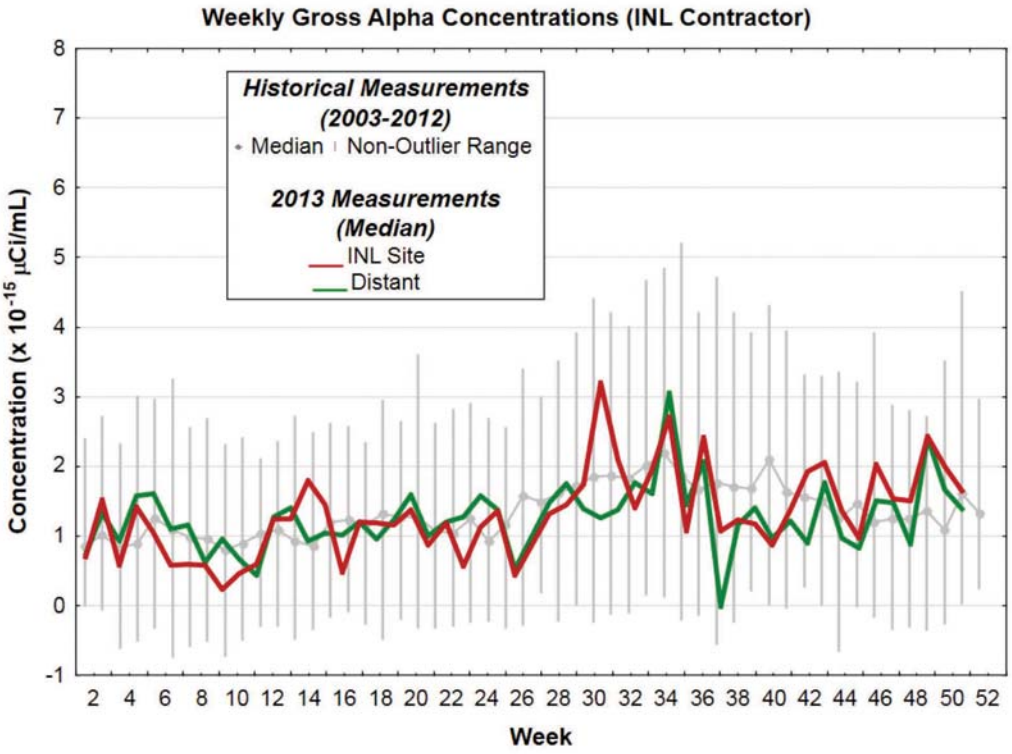


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2013).

during winter inversion conditions (see sidebar). An inversion can lead to natural radionuclides being trapped close to the ground. In 2013, the most prominent inversion periods occurred in January. The maximum median weekly gross beta concentration was 9.3×10^{-14} µCi/mL, which is significantly below the DCS of 240×10^{-14} µCi/mL (see Table A-1 of Appendix A) for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

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.

ESER contractor median annual gross beta concentrations ranged from 2.2×10^{-14} µCi/mL at Craters of the Moon and Idaho Falls to 2.7×10^{-14} µCi/mL at Blackfoot and Rexburg (Table 4-4). INL contractor data ranged from a median annual concentration of 2.3×10^{-14} µCi/mL at EBR-I and Idaho Falls to 2.7×10^{-14} µCi/ mL at TAN. All results detected by the ESER and INL contractors were well within valid measurements taken within the last 13 years (Figure 4-4). This indicates that the fluctuation patterns over the entire sampling network are representative of natural conditions and are not caused by a localized source, such as a facility or activity at the INL Site.

- **Gross Activity Statistical Comparisons.** Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected from the INL Site, boundary, and distant locations (see the supplemental report, *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, for a description of methods used). If the INL Site were a significant source of offsite contamination, contaminant concentrations would be statistically greater at boundary locations than at distant locations. There were no statistical differences among annual concentrations collected from the INL Site, boundary, and distant locations in 2013. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 53 weeks of 2013 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 http://www.gsseser.com/Publications.htm. INL contractor data sets from samples collected on the INL Site and distant locations were compared, and there were no statistical differences.

Specific Radionuclides – The ESER contractor observed four detections of ^{90}Sr throughout 2013. Detectable concentrations ranged from 2.0×10^{-17} µCi/mL at Blackfoot in the fourth quarter to 7.5×10^{-17} µCi/mL at Blue Dome in the second quarter (Table 4-5). All results were within the range of detections for the past several years and near the detection limit. The minimum detection limit reported by the laboratory for ^{90}Sr is approximately 2.0×10^{-17} µCi/mL. The DCS for ^{90}Sr in air is 2.5×10^{-11} µCi/mL.

Table 4.4. Median Gross Beta Concentrations in Air (2013).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-14} µCi/mL)	Annual Median[c] (× 10^{-14} µCi/mL)
		ESER Contractor		
Distant	Blackfoot	51	0.90 – 7.7	2.0
	Craters of the Moon	53	0.10 – 5.7	2.3
	Dubois	53	0.80 – 4.3	2.4
	Idaho Falls	53	0.88 – 5.0	2.3
	Jackson	53	1.02 – 5.8	2.7
	Rexburg/Sugar City[d]	53	0.77 – 6.9	2.5
			Distant Median:	2.4
Boundary	Arco	53	0.83 – 5.9	2.4
	Atomic City	53	0.81 – 7.8	2.6
	Blue Dome	53	0.87 – 4.8	2.4
	Federal Aviation Administration Tower	53	0.80 – 5.4	2.4
	Howe	52	0.81 – 8.6	2.5
	Monteview	53	0.79 – 7.8	2.5
	Mud Lake	51	0.82 – 9.3	2.6
			Boundary Median:	2.5
INL Site	EFS	53	0.81 – 8.8	2.4
	Main Gate	42	0.98 – 8.4	2.3
	Van Buren	53	0.89 – 7.6	2.4
			INL Site Median:	2.4
		INL Contractor		
Distant	Blackfoot	51	0.75 – 6.9	2.4
	Craters of the Moon	49	0.84 – 6.0	2.4
	Idaho Falls	51	1.0 – 8.2	2.3
	Rexburg	49	1.0 – 7.0	2.5
			Distant Median	2.4
INL Site	ARA	50	1.2 – 6.7	2.4
	ATR Complex (south side)	50	-0.03 – 6.0	2.6
	ATR Complex (NE corner)	51	1.0 – 7.1	2.4
	CFA	50	1.1 – 6.5	2.5
	CITRC	51	0.91 – 6.8	2.4
	INTEC (west side)	51	1.1 – 6.5	2.5
	EBR-I	51	0.97– 6.2	2.3
	EFS	48	0.94 – 7.8	2.7
	Gate 4	48	0.99 – 7.7	2.5
	INTEC (NE corner)	51	0.98 – 6.3	2.5

Table 4.4. Median Gross Beta Concentrations in Air (2013). (cont.)

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-14} µCi/mL)	Annual Median[c] (× 10^{-14} µCi/mL)
	MFC	49	0.91 – 6.5	2.4
	NRF	49	0.92 – 6.7	2.6
	Rest Area	51	1.1 – 6.0	2.5
	RWMC	51	1.0 – 8.0	2.4
	SMC	51	1.2 – 8.7	2.7
	TAN	51	1.1 – 8.9	2.7
	Van Buren	51	1.1 – 8.3	2.5
			INL Site Median:	2.5

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability, TAN = Test Area North.
b. Includes valid samples only. Does not include duplicate measurements.
c. All measurements, including those <3s, are included in this table and in computation of median annual values.
d. Air sampler was moved from Rexburg to Sugar City on July 29, 2013.

Plutonium-238 and $^{239/249}$Pu were also reported on a few composites (Table 4-5). All the reported values were just above the minimum detection limits. The maximum reported value of ^{238}Pu (3.3 x 10^{-18} µCi/mL) was 0.009 percent of the DCS for this radionuclide. For $^{239/249}$Pu, the highest measured concentration (4.2 x 10^{-18} µCi/mL) was 0.012 percent of the DCS.

Natural ^{7}Be was detected in numerous ESER and INL contractor composite samples at concentrations consistent with past concentrations. Atmospheric ^{7}Be results from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in earth's atmosphere. No other radionuclides were detected in the quarterly composite samples.

4.3.2 Atmospheric Moisture Monitoring Results

The INL contractor collected atmospheric moisture samples at the EFS and Van Buren Boulevard on the INL Site and at Idaho Falls and Craters of the Moon off the INL Site. During 2013, 37 samples were collected and no statistically positive detections were measured.

During 2013, the ESER contractor collected 60 atmospheric moisture samples. Table 4-6 presents the range of values detected at each station by quarter. Tritium was detected in 41

Table 4-5. Human-made Radionuclides Detected in ESER Contractor Air Samples (2013).

Radionuclide	Result[a] (µCi/mL)	Location	Group	Quarter Detected
Sr-90[b]	$(1.47 \pm 0.46) \times 10^{-17}$	Dubois	Distant	1st
	$(7.45 \pm 0.13) \times 10^{-17}$	Blue Dome	Boundary	2nd
	$(2.33 \pm 0.66) \times 10^{-17}$	Dubois	Distant	3rd
	$(2.00 \pm 0.52) \times 10^{-17}$	Blackfoot	Distant	4th
Pu-238	$(3.34 \pm 1.03) \times 10^{-18}$	Atomic City	Boundary	2nd
	$(3.12 \pm 0.93) \times 10^{-18}$	Van Buren	INL Site	2nd
Pu-239/240	$(4.32 \pm 1.29) \times 10^{-18}$	FAA Tower	Boundary	1st
	$(4.20 \pm 1.31) \times 10^{-18}$	Rexburg	Distant	2nd
	$(2.57 \pm 0.77) \times 10^{-18}$	Arco (QA replicate)	Boundary	2nd
	$(3.66 \pm 1.14) \times 10^{-18}$	Monteview (QA replicate)	Boundary	3rd

a. Results ± 1s. Results shown are ≥ 3s.
b. The original set of air composites analyzed in 2013 had numerous detections of Sr-90 which were later determined to be due to the presence of naturally-occurring radionuclides in the samples and these results were therefore declared invalid. A second set of air composites collected from different locations during 2013 were analyzed for Sr-90 using a modified method which allows the naturally-occurring radionuclides to decay prior to analysis. A full discussion of this finding may be found in Chapter 11 (Quality Assurance), Section 11.5.4.

Table 4-6. Ranges of Tritium Concentrations Detected in ESER Contractor Atmospheric Moisture Samples (2013).[a]

Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		($\times 10^{-13}$ µCi/mL)		
Atomic City	ND[b]	5.0 – 7.2	4.9 – 7.1	4.4 – 9.9
Blackfoot	ND	4.0 – 8.5	5.7 – 13.5	2.9 – 5.8
Idaho Falls	ND	0.9 – 2.3	5.6 – 7.6	4.1 – 5.8
Rexburg/Sugar City[c]	ND	5.2 – 15.4	9.2 – 13.8	9.6[d]

a. Results shown are ≥ 3s.
b. ND = not detected.
c. Sampler was moved to Sugar City on July 29, 2013.
d. When a single value is reported, tritium was detected in only one sample.

samples, ranging from a low of 0.87 × 10^{-13} µCi/mL at Idaho Falls to a high of 15.4 × 10^{-13} µCi/mL at Rexburg. The highest concentration of tritium detected in an atmospheric moisture sample since 1998 was 38 × 10^{-13} µCi/mL at Atomic City. The results are within historical measurements and are probably natural in origin. The highest observed tritium concentration is far below the DCS for tritium in air (as hydrogen tritium oxygen) of 1.4 × 10^{-8} µCi/ mL (see Table A-1 of Appendix A).

4.3.3 Precipitation Monitoring Results

The ESER contractor collects precipitation samples weekly at EFS, when available, and monthly at CFA and off the INL Site in Idaho Falls. A total of 34 precipitation samples were collected during 2013 from the three sites. Tritium concentrations were detected in 20 samples, and detectable results ranged from 70 pCi/L at CFA to 163 pCi/L at Idaho Falls. Table 4-7 shows the concentration ranges by quarter for each location. The highest concentration is well below the DCS level for tritium in water of 1.9 × 10^{6} pCi/L. The concentrations are well within the historical normal range at the INL Site. The maximum concentration measured since 1998 was 553 pCi/L at EFS in 2000. The results are well within measurements made by the EPA in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past ten years (http://www.epa.gov/enviro/html/erams/).

4.3.4 Suspended Particulates Monitoring Results

In 2013, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99 percent efficient for collection of particles greater than 0.3 µm in diameter. That is, they collect the total particulate load greater than 0.3 µm in diameter.

Mean annual particulate concentrations ranged from 5.9 µg/m^3 at Blue Dome to 19.7 µg/m^3 at Blackfoot. In general, particulate concentrations were higher at offsite locations than at the INL Site stations. This is most likely influenced by agricultural activities off the INL Site.

Table 4-7. Ranges of Tritium Concentrations Detected in ESER Contractor Precipitation Samples (2013).[a]

Location[b]	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		(pCi/L)		
CFA	ND[c]	70[d]	91 - 151	94 - 95
EFS	ND	86 - 111	95 - 132	74 - 132
Idaho Falls	ND	71 - 75	94 - 130	83 - 163

a. Results shown are ≥ 3s.
b. CFA = Central Facilities Area, EFS = Experimental Field Station.
c. ND = not detected.
d. When a single value is reported, tritium was detected in only one sample.

4.4 Waste Management Surveillance Monitoring

4.4.1 Gross Activity

The ICP contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, “Radioactive Waste Management.” Currently, ICP waste management operations occur at the SDA at RWMC and the ICDF at INTEC and 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 2013 (Figure 4-5). The ICP contractor also collected samples from a control location at Howe, Idaho (Figure 4-2), to compare with the results of the SDA and ICDF. Samples were obtained using suspended particulate monitors similar to those used by the INL and ESER contractors. The air filters are 4 in. in diameter and are changed out on the closest working day to the 1st and the 15th of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples.

Table 4-8 shows the gross alpha and gross beta monitoring results. The results that were received for the SDA and ICDF are comparable to historical results, and no new trends were identified.

4.4.2 Specific Radionuclides

In 2013, no man-made, gamma-emitting radionuclides were detected at the SDA at RWMC or at the ICDF at INTEC.

Table 4-9 shows man-made specific alpha- and beta-emitting radionuclides detected at the SDA in air samples analyzed using radiochemistry in 2013. These detections are consistent with levels measured in air at RWMC in previous years, and are attributed to resuspension of soils in and adjacent to RWMC. The values and locations for plutonium and americium detections remained consistent from 2012 to 2013. The detections shown in Table 4-9 are likely due to resuspension of contaminated soils as a result of early burial practices (Markham et al. 1978), from previously flooded areas inside or northeast of the SDA, and fugitive emissions from the ARP. Recent studies of radionuclide concentrations in soils (VanHorn et al. 2012) confirm that $^{239/240}$Pu and ^{241}Am still are present in measurable amounts in surface soils surrounding RWMC, with maximum concentrations northeast of the SDA. No man-made specific alpha- or beta-emitting radionuclides were detected in air samples from INTEC or Howe in 2013. The ICP contractor will continue to closely monitor radionuclides to identify trends.

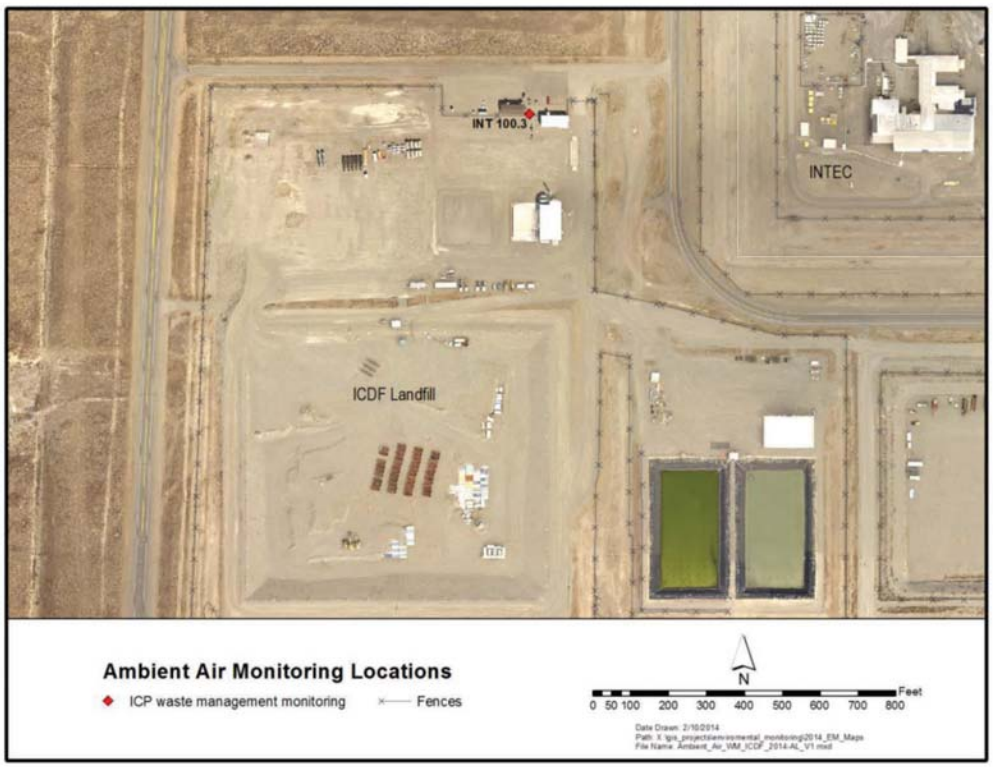


Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas. (RWMC [top] and ICDF [bottom]).

Table 4-8. Gross Activity Concentrations Measured in ICP Contractor Air Samples (2013).[a]

Activity	Low (µCi/mL)	High (µCi/mL)	Annual Mean (µCi/mL)
Subsurface Disposal Area (SDA)			
Gross Alpha	$(1.50 \pm 2.38) \times 10^{-16}$ 2nd half of February at SDA 6.3	$(3.57 \pm 0.35) \times 10^{-14}$ 2nd half of March at SDA 11.3	4.02×10^{-15}
Gross Beta	$(5.29 \pm 0.47) \times 10^{-15}$ 1st half of December at Howe 400.4	$(8.47 \pm 0.72) \times 10^{-14}$ 2nd half of March at SDA 9.3	3.34×10^{-14}
Idaho CERCLA Disposal Facility (INT)			
Gross Alpha	$(1.47 \pm 2.38) \times 10^{-16}$ 2nd half of February at INT 100.3	$(3.28 \pm 0.32) \times 10^{-14}$ 2nd half of March at INT 100.3	4.03×10^{-15}
Gross Beta	$(5.29 \pm 0.47) \times 10^{-15}$ 1st half of December at Howe 400.4	$(7.28 \pm 0.63) \times 10^{-14}$ 2nd half of March at INT 100.3	3.53×10^{-14}

a. Results ± 1s.

Table 4-9. Human-made Radionuclides Detected in ICP Contractor Air Samples (2013).[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Am-241	$(1.45 \pm 0.19) \times 10^{-17}$	SDA[b] 4.3	1st
	$(1.22 \pm 0.18) \times 10^{-17}$	SDA 4.2	1st
	$(1.38 \pm 0.22) \times 10^{-17}$	SDA 4.3	2nd
	$(2.74 \pm 0.39) \times 10^{-17}$	SDA 4.3	3rd
	$(4.40 \pm 1.21) \times 10^{-18}$	SDA 11.3	3rd
	$(9.92 \pm 1.66) \times 10^{-18}$	SDA 4.2	3rd
	$(7.91 \pm 1.34) \times 10^{-18}$	SDA 4.3	4th
	$(5.79 \pm 1.22) \times 10^{-18}$	SDA 4.2	4th
Pu-239/240	$(2.55 \pm 0.76) \times 10^{-18}$	SDA 1.3	1st
	$(2.43 \pm 0.73) \times 10^{-18}$	SDA 9.3	1st
	$(2.44 \pm 0.78) \times 10^{-18}$	SDA 6.3	1st
	$(1.41 \pm 0.21) \times 10^{-17}$	SDA 4.3	1st
	$(5.53 \pm 1.45) \times 10^{-18}$	SDA 1.3	2nd
	$(6.68 \pm 1.41) \times 10^{-18}$	SDA 4.3	2nd
	$(5.91 \pm 1.53) \times 10^{-18}$	SDA 4.2	2nd
	$(4.64 \pm 1.30) \times 10^{-18}$	SDA 2.3	2nd
	$(9.23 \pm 2.22) \times 10^{-18}$	SDA 4.3	3rd
	$(6.59 \pm 1.38) \times 10^{-18}$	SDA 4.2	3rd
	$(4.11 \pm 1.08) \times 10^{-18}$	SDA 4.3	4th
	$(7.24 \pm 1.49) \times 10^{-18}$	SDA 4.2	4th
Sr-90	$(5.86 \pm 1.78) \times 10^{-17}$	SDA 1.3	1st
	$(6.54 \pm 1.35) \times 10^{-17}$	SDA 1.3	4th
	$(5.51 \pm 1.60) \times 10^{-17}$	SDA 2.3	4th

a. Results ± 1s. Results shown are ≥ 3s.
b. SDA = Subsurface Disposal Area.

REFERENCES

40 CFR 61, Subpart H, 2013, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.

DOE Order 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy.

DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," Administrative Change 3, U.S. Department of Energy.

DOE-ID, 2014a, *Idaho National Laboratory Site Environmental Monitoring Plan*, DOE/ID-10-11088, Rev. 4, U.S. Department of Energy Idaho Operations Office, February 2014.

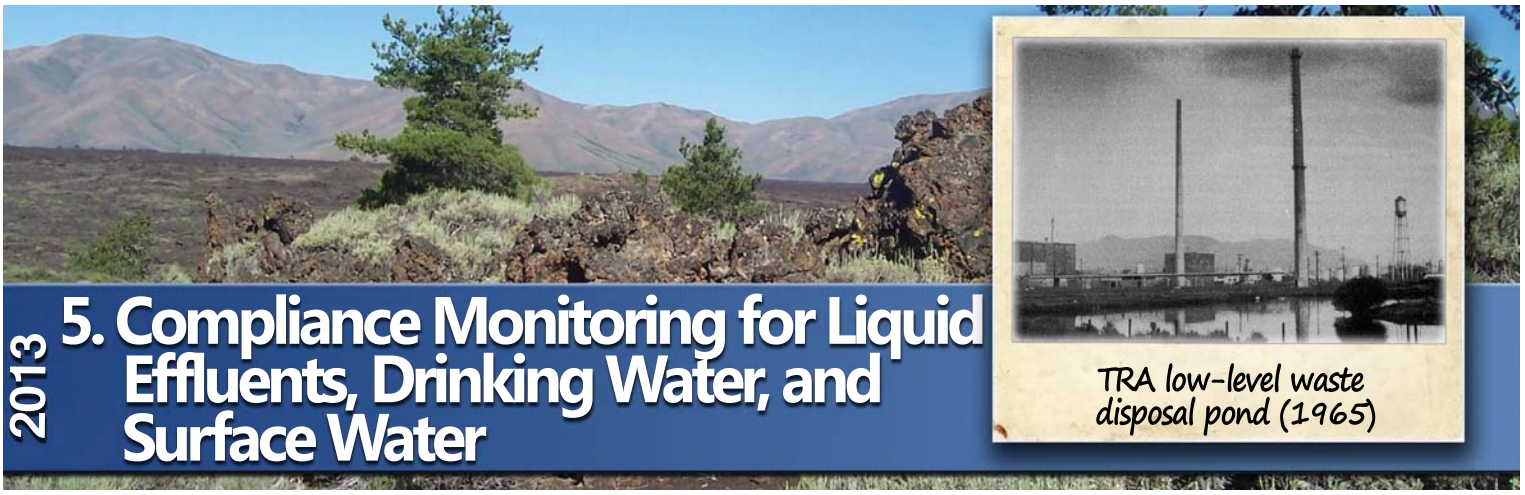
DOE-ID, 2014b, *National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2013*, DOE/ID-10890(13), U.S. Department of Energy Idaho Operations Office.

EG&G Idaho, Inc., 1993, N*ew Production Reactor Exposure Pathways at the Idaho National Engineering Laboratory*, EGG-NPR-8957, Idaho National Engineering Laboratory.

Markham, O. D., K. W. Puphal, and T. D. Filer, 1978, "Plutonium and Americium Contamination Near a Transuranic Storage Area in Southeastern Idaho," *Journal of Environmental Quality*, Vol. 7, No. 3, July – September 1978.

VanHorn R. L., L. S. Cahn, V. M. Kimbro, K. J. Holdren, 2012, *Operable Unit 10-04 Long-Term Ecological Monitoring Report for Fiscal Years 2003 to 2008*, DOE/ID 11390, Rev. 1, U.S. Department of Energy Idaho Operations Office.

Header Photo Description: Air sampling has been conducted routinely since 1952 as part of the environmental surveillance program established at the INL Site to help evaluate the potential for exposing the general public to a release of radioactive materials from INL Site facilities. The first nuclear facility on the INL Site was the Experimental Breeder Reactor I (EBR-I). On Dec. 20, 1951, the reactor achieved an historic first by producing electrical power from nuclear energy. EBR-I is now a registered national landmark open to the public and houses the EBR-I Atomic Museum.



2013

5. Compliance Monitoring for Liquid Effluents, Drinking Water, and Surface Water

TRA low-level waste disposal pond (1965)

Chapter 5 Highlights

Liquid effluents, drinking water, and surface water runoff were monitored in 2013 by the Idaho National Laboratory (INL) contractor and the Idaho Cleanup Project (ICP) contractor for compliance with applicable regulatory standards established to protect human health and the environment.

Wastewater discharged to land surfaces and evaporation ponds at the INL Site is regulated by the state of Idaho groundwater quality and wastewater rules and requires a wastewater reuse permit. During 2013, permitted facilities were:

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

These facilities were sampled for parameters required by their facility-specific permits. No permit limits were exceeded in 2013. Additional liquid effluent and groundwater monitoring were performed in 2013 at these facilities to comply with environmental protection objectives of the U.S. Department of Energy (DOE). All parameters were below applicable health-based standards.

Nine drinking water systems were monitored by the INL contractor in 2013 for parameters required by “Idaho Rules for Public Drinking Water Systems.” Water samples collected from drinking water systems were well below drinking water limits for all relevant regulatory parameters. Because workers are potentially impacted from radionuclides in the CFA distribution system, the dose from ingesting tritium to a CFA worker was calculated. The dose was estimated to be 0.20 mrem (2.0 µSv) for 2013. This is below the Environmental Protection Agency standard of 4 mrem/yr (0.04 mSv/yr) for public drinking water.

Two drinking water systems were monitored by the ICP contractor at the Radioactive Waste Management Complex (RWMC) and INTEC. All parameters were below their respective drinking water limits in 2013.

Surface water runoff from the Subsurface Disposal Area of the RWMC was sampled by the ICP contractor in 2013 for radionuclides in compliance with DOE limits. Results were within historical measurements, with americium-241, plutonium-239/240, and strontium-90 similar to the previous years’ results and well below DOE derived concentration standards.

5. COMPLIANCE MONITORING FOR LIQUID EFFLUENTS, GROUNDWATER, DRINKING WATER, AND SURFACE WATER

This chapter presents analytical results of water samples collected by the Idaho National Laboratory (INL) contractor (Battelle Energy Alliance, LLC) and Idaho Cleanup Project (ICP) contractor (CH2M-WG Idaho, LLC) at the INL Site and the Research and Education Campus (Idaho Falls facilities). Included in this chapter are descriptions and results of liquid effluent and related groundwater monitoring, drinking water monitoring, and surface water runoff monitoring conducted for compliance with regulatory limits and permits.

To improve the readability of this chapter, data tables are only included that compare monitoring results to specified discharge limits, permit limits, or maximum contaminant levels (MCLs). Data tables for other monitoring results are provided in Appendix C.

5.1 Summary of Monitoring Programs

The INL contractor and ICP contractor monitor drinking water, liquid effluent, surface water runoff, and groundwater that could be impacted by INL Site operations and activities. This monitoring is conducted to comply with applicable state and local laws and wastewater reuse permit requirements.

Table 5-1 presents compliance monitoring performed at the INL Site. A comprehensive discussion and maps of environmental monitoring performed by various organizations within and around the INL Site may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014).

5.2 Wastewater and Related Groundwater Compliance Monitoring

Discharge of wastewater to the land surface is regulated by wastewater rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). Wastewater reuse permits require monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater in accordance to the ground water quality standards stipulated in the “Idaho Ground Water Quality Rule” (IDAPA 58.01.11). Some facilities may have specified radiological parameters monitored for surveillance purposes (not required by regulations). The permits specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2014a, 2014b; INL 2014a, 2014b, 2014c, 2014d, 2014e) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2013, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 5-2):

- Central Facilities Area (CFA) Sewage Treatment Plant
- Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds

Table 5-1. Water Monitoring at the INL Site for Regulatory Compliance.

Area/Facility	Media				
	Liquid Effluent (Permitted)[a]	Liquid Effluent (Surveillance)	Groundwater (Permitted)	Drinking Water	Surface Runoff
ICP Contractor					
INTEC	●	●	●	●	
RWMC				●	●
INL Contractor					
ATR Complex	●	●	●	●	
CFA[b]	●	●		●	
MFC	●	●	●	●	
CITRC				●	
TAN/TSF				●	
TAN/CTF (SMC)				●	

a. In 2009, the city of Idaho Falls assumed responsibility for the semiannual liquid effluent monitoring conducted at the Research and Education Campus.
b. Includes Weapons Range, Experimental Breeder Reactor I, and Main Gate.

Table 5-2. Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2013	Explanation
ATR Complex Cold Waste Pond	Renewal Permit application submitted	DEQ[a] issued Permit #LA-000161-01 on February 26, 2008, modified on August 20, 2008, and expires on February 25, 2013. A renewal permit application (INL 2013) was submitted to DEQ.
CFA Sewage Treatment Facility	Permit issued	DEQ issued Permit #LA-000141-03 on March 17, 2010. The permit will expire on March 16, 2015.
INTEC New Percolation Ponds	Permit issued	DEQ issued Permit #LA-000130-05 on March 14, 2012. The permit will expire on March 14, 2017.
MFC Industrial Waste Pond and Industrial Waste Ditch	Permit issued	In 2010, DEQ issued Permit #LA-000160-01, effective May 1, 2010, to April 30, 2015. DEQ issued Permit WRU-I-0160-01 (formerly LA-000160-01), Modification 1 on June 21, 2012.

a. DEQ = Idaho Department of Environmental Quality

- Advanced Test Reactor (ATR) Complex Cold Waste Pond
- Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond.

The following subsections present results of wastewater and groundwater monitored to comply with facility-specific permits.

Additional effluent parameters are monitored to comply with environmental protection objectives of DOE Order 458.1. Section 5.3 discusses the results of liquid effluent surveillance monitoring.

5.2.1 Research and Education Campus

Description – The city of Idaho Falls is authorized by the Clean Water Act, National Pollutant Discharge Elimination System to set pretreatment standards for nondomestic wastewater discharges to publicly owned treatment works. The INL contractor facilities in Idaho Falls are required to comply with the applicable regulations in Chapter 1, Section 8 of the Municipal Code of the city of Idaho Falls.

The Industrial Wastewater Acceptance Permit for the INL Research Center specifies special conditions and compliance schedules, prohibited discharges, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters.

Wastewater Monitoring Results – In 2009, the city of Idaho Falls assumed responsibility for the semiannual monitoring conducted at the Research and Education Campus. The 2013 monitoring results complied with all applicable regulations established in the municipal code. Analytical results are available upon request from the city of Idaho Falls.

5.2.2 Central Facilities Area Sewage Treatment Facility

Description – The CFA Sewage Treatment Facility serves all major buildings at CFA. The treatment facility is southeast of CFA, approximately 671 m (2,200 ft) downgradient of the nearest drinking water well.

A 1,500-L/min (400-gal/min) pump applies wastewater from a 0.2-ha (0.5-acre) lined, polishing pond to approximately 30 ha (74 acres) of sagebrush steppe grassland through a computerized center pivot irrigation system; refer to sections 5.32 and 7.22 for further information.

Wastewater Monitoring Results for the Wastewater Reuse Permit – DEQ issued a permit for the CFA Sewage Treatment Plant on March 17, 2010. The permit requires effluent monitoring and soil sampling in the wastewater land application area (soil samples are required in 2010 and 2013). Effluent samples are collected from the pump pit (prior to the pivot irrigation system) monthly during land application. All samples are 24-hour flow proportional composites, except pH and coliform samples, which are grab samples. All samples collected during 2013 were within the acceptable ranges for pH, salinity, sodium adsorption, nitrogen, and phosphorus. No issues of concern were found in the data.

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

5.2.3 Advanced Test Reactor Complex Cold Waste Pond

Description – The Cold Waste Pond (CWP) is located approximately 137 m (450 ft) from the southeast corner of the ATR Complex compound and approximately 1.2 km (¾ of a mile) southwest of the Big Lost River channel (Figure 5-1). The existing CWP was excavated in 1982. It consists of two cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms, and a depth of 3 m (10 ft). Total surface area for the two cells at the top of the berms is approximately 1.44 ha (3.55 acres). Maximum capacity is approximately 10.22 million gallons (MG).

Figure 5-1. Permit Monitoring Locations for the ATR Complex CWP.

Wastewater discharged to the CWP consists primarily of noncontact cooling tower blowdown, once through cooling water for air conditioning units, coolant water from air compressors, secondary system drains, and other nonradioactive drains throughout the ATR Complex. Chemicals used in the cooling tower and other effluent streams discharged to the CWP include commercial biocides and corrosion inhibitors. DEQ issued a wastewater reuse permit for the pond in February 2008. A permit renewal application was submitted to DEQ on August 21, 2012 (INL 2013).

Wastewater Monitoring Results for the Wastewater Reuse Permit – The industrial wastewater reuse permit requires monthly sampling of the effluent to the CWP. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L), and the results (minimum, maximum, and median) of those permit-limited parameters are shown in Table 5-3. During 2013, neither total suspended solids nor total nitrogen exceeded the permit limit. The minimum, maximum, and median results of all parameters monitored are presented in Table C-1.

Concentrations of sulfate and total dissolved solids are higher during reactor operation because of evaporative concentration of the corrosion inhibitors and biocides added to the reactor cooling water.

Table 5-3. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at ATR Complex CWP (2013).[a]

Parameter	Minimum	Maximum	Median	Permit Level
Total nitrogen[b] (mg/L)	0.1 U	0.519	0.2065	20
Total suspended solids (mg/L)	4 U[c]	4 U	4 U	100

a. Duplicate samples were collected in February, and the results for the duplicate samples are included in the summary.
b. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.
c. U flag indicates the result was below detection limit.

Groundwater Monitoring Results for the Wastewater Reuse Permit – To measure potential impacts from the CWP, the permit requires groundwater monitoring in April and October at five wells (Figure 5-1; Table C-2).

Aluminum, iron, and manganese were elevated in some of the unfiltered samples because of suspended aquifer matrix material or rust in the well water. The metals concentrations in the filtered samples were below the applicable standards.

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

Description – The INTEC New Percolation Ponds are comprised of two unlined ponds excavated into the surficial alluvium and surrounded by bermed alluvial material (Figure 5-2). 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 3 MG per day.

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

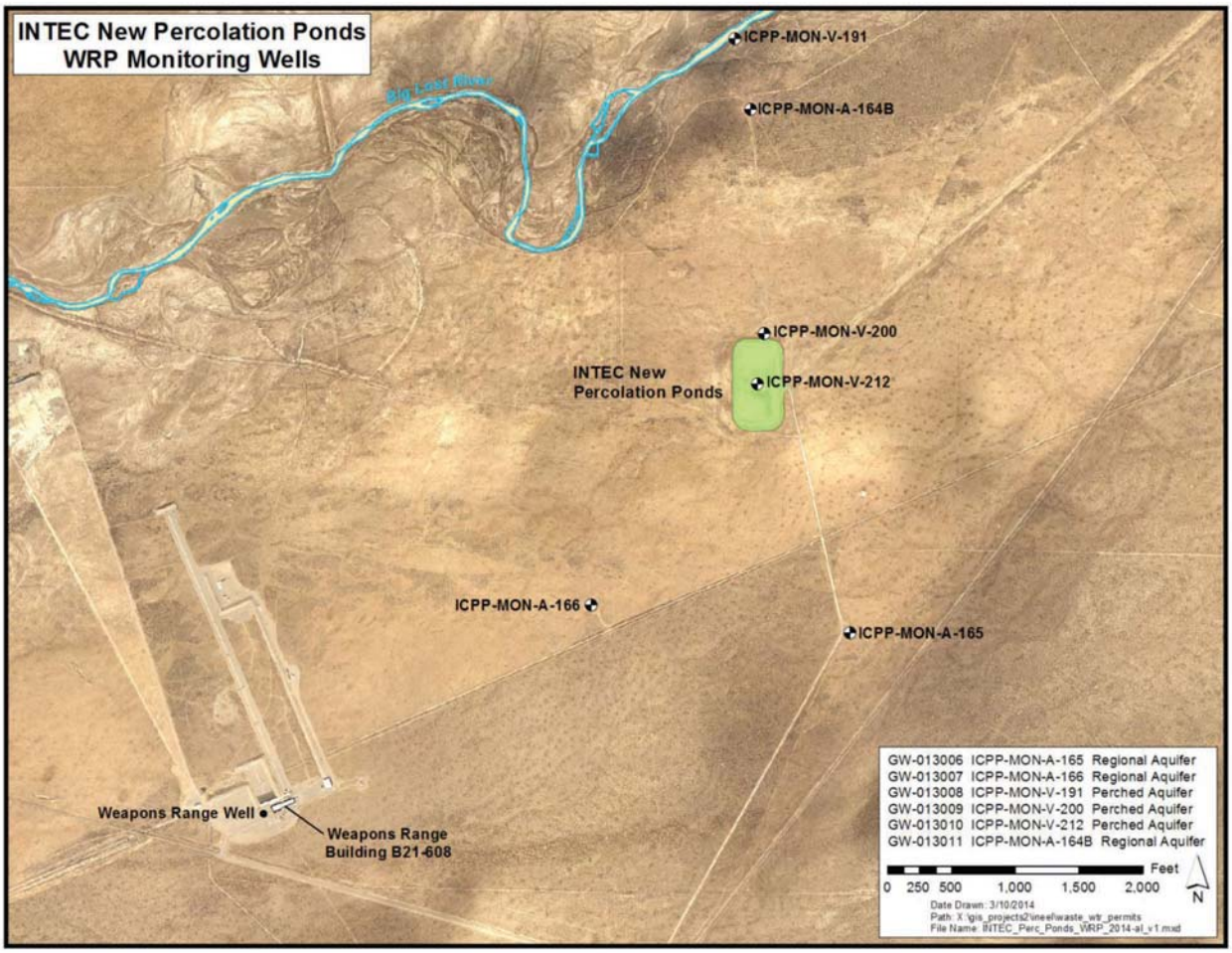


Figure 5-2. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds (Weapons Range Well is not a permitted well and is shown for location reference only).

The Sewage Treatment Plant 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 Sewage Treatment Plant depends on natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) to treat the sanitary waste 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 are permitted by DEQ to operate as a wastewater reuse facility under Wastewater Reuse Permit LA-000130-05 (DEQ 2012). The renewed permit became effective on March 14, 2012.

Wastewater Monitoring Results for the Wastewater Reuse Permit – Monthly samples were collected from:

- CPP-769 – influent to Sewage Treatment Plant
- CPP-773 – effluent from Sewage Treatment Plant prior to combining with service waste
- CPP-797 – combined effluent prior to discharge to the INTEC New Percolation Ponds.

As required by the permit, all samples are collected as 24-hour flow proportional composites, except pH and total coliform, which are collected as grab samples. The permit specifies the parameters that must be monitored for each location, but the permit does not set discharge limits for any of the parameters monitored at CPP-769, CPP-773, or CPP-797. The monitoring results (minimum, maximum, and mean) for CPP-769, CPP-773, and CPP-797 are presented in Tables C-3, C-4, and C-5, respectively.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. Table 5-4 shows the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds. As the table shows, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits during 2013.

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

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

Table C-6 shows the 2013 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all parameters specified by the permit for the

Table 5-4. Hydraulic Loading Rates for INTEC New Percolation Ponds (2013).

	2013 Flow	Permit Limit
Maximum daily (MG)	0.906	3
Yearly total (MG)	195.543	1,095

Table 5-5. INTEC New Percolation Ponds Wastewater Reuse Permit Monitoring Wells.

Wells	Purpose	Location (see Figure 5-2)
Aquifer Wells		
ICPP-MON-A-164B (GW-013011)	Background, noncompliance point	Upgradient of the New Percolation Ponds
ICPP-MON-A-165 (GW-01006)	Permit compliance point	Downgradient of the New Percolation Ponds
ICPP-MON-A-166 (GW-013007)	Permit compliance point	Downgradient of the New Percolation Ponds
Perched Water Wells		
ICPP-MON-V-191 (GW-013008)	Background, noncompliance point	North of the New Percolation Ponds and just south of the Big Lost River
ICPP-MON-V-200 (GW-013009)	Permit compliance point	Adjacent to (north of) the New Percolation Ponds
ICPP-MON-V-212 (GW-013010)	Permit compliance point	Adjacent to (between) the New Percolation Ponds

aquifer wells. Table C-7 presents similar information for the perched water wells. Perched water Well ICPP-MON-V-191 was dry during the 2013 reporting year, and, therefore, samples could not be collected.

As Table C-6 shows, all of the permit-required parameters associated with the aquifer wells were below their respective primary constituent standards and secondary constituent standards during the 2013 reporting year. As Table C-7 shows, all of the permit-required parameters associated with the perched water wells were below their respective primary constituent standards or secondary constituent standards during the 2013 reporting year.

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

Description – The wastewater reuse permit issued by DEQ for the MFC Industrial Waste Ditch and Pond became effective May 1, 2010. The MFC Industrial Waste Pond was first excavated in 1959 and has a design capacity of 285 MG at a maximum water depth of 13 ft (Figure 5-3).

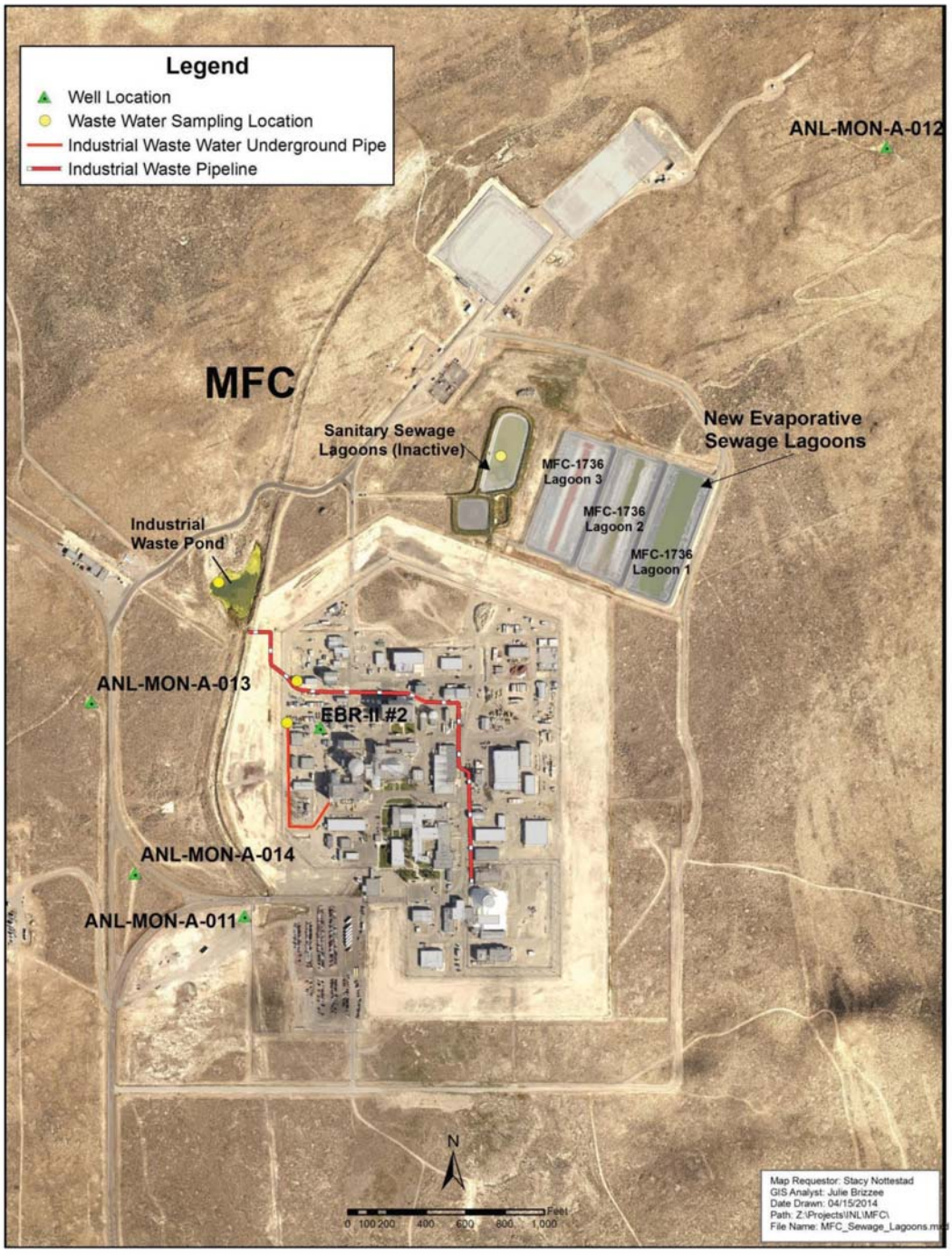


Figure 5-3. Wastewater and Groundwater Sampling Locations at the MFC.

Industrial wastewater discharged to the pond via the Industrial Waste Pipeline consists primarily of noncontact cooling water, boiler blowdown, cooling tower overflow, air wash flows, and steam condensate.

Wastewater composed of mixed cooling tower blowdown, intermittent reverse osmosis effluent, and discharge to a laboratory flows from the MFC-768 Power Plant to Ditch C via the Industrial Wastewater Underground Pipe.

Wastewater Monitoring Results for the Wastewater Reuse Permit – The industrial wastewater reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline. The permit requires quarterly samples of the discharge to Ditch C from the Industrial Wastewater Underground Pipe. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L), and the results of those permit-limited parameters are summarized in Table 5-6. During 2013, neither total suspended solids nor total nitrogen exceeded the permit limit. The minimum, maximum, and median results of all parameters monitored are presented in Tables C-8 and C-9.

Groundwater Monitoring Results for the Wastewater Reuse Permit – To measure potential impacts from the Industrial Waste Pond, the permit requires groundwater monitoring in April/May and September/October at one upgradient and two downgradient wells (Figure 5-3).

The analytical results are summarized in Table C-10. Analyte concentrations in the downgradient wells were essentially indistinguishable from background levels in the upgradient well.

Table 5-6. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at MFC Industrial Waste Pipeline (2013).[a]

Parameter	Minimum	Maximum	Median	Permit Level
Total nitrogen[b] (mg/L)	0.1 U	1.54	0.264	20
Total suspended solids (mg/L)	4 U[c]	13.4	4 U	100

a. Duplicate samples were collected in February, and the results for the duplicate samples are included in the data summary.
b. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.
c. U flag indicates the result was below detection limit.

5.3 Liquid Effluent Surveillance Monitoring

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

5.3.1 Advanced Test Reactor Complex

The effluent to the CWP receives a combination of process water from various ATR Complex facilities. Table C-11 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Radionuclides detected in groundwater samples are summarized in Table C-12. The tritium concentrations are below the Idaho groundwater primary constituent standard for tritium (20,000 pCi/L), which is the same as the Environmental Protection Agency health-based MCL for tritium in drinking water.

5.3.2 Central Facilities Area

The effluent from the CFA Sewage Treatment Facility is monitored according to the wastewater reuse permit. No wastewater was land-applied in 2013, so no effluent samples were collected at the treatment facility.

5.3.3 Idaho Nuclear Technology and Engineering Center

Additional monitoring was conducted during 2013 at the INTEC Sewage Treatment Plant (CPP-769 influent and CPP-773 effluent), prior to discharge into the INTEC New Percolation Ponds (CPP-797 effluent), and the groundwater with respect to the INTEC New Percolation Ponds. Table C-13 summarizes the analytical results for parameters that were detected in at least one sample during the year at these locations. All additional parameters were within their expected historical concentration levels.

Samples were collected from the CPP-773 effluent in March and September 2013 and analyzed for gross alpha and gross beta. Monthly radiological composite samples were also collected from the CPP-797 effluent and analyzed for gamma spectrometry, gross alpha, gross beta, and total strontium. There were no gamma spectrometry detections and no total strontium detections in any of the CPP-797 monthly samples. The gross alpha and gross beta results for CPP-773 and CPP-797 are summarized in Table C-13.

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 and September 2013 and analyzed for gross alpha and gross beta. As shown in Table C-13, the gross alpha activity was below the 15-pCi/L action level, and the gross beta activity was below the 40-pCi/L action level in all four monitoring wells.

5.3.4 Materials and Fuels Complex

The Secondary Sanitary Lagoon and Industrial Waste Pond were sampled prior to November of 2012. However, the Secondary Sanitary Lagoon and Industrial Waste Pond were replaced with new HDPE lined evaporation ponds located east of the existing lagoons in November 2012 (Figure 5-3). The HDPE-lined evaporation ponds are sampled quarterly for gross alpha, gross

beta, gamma spectroscopy, and tritium. Annual samples are collected for selected isotopes of americium, curium, iron, strontium, plutonium, and uranium. In addition, the HDPE-lined evaporation ponds are sampled annually for selected metals, nutrients, and other parameters. Tables C-14 and C-15 summarize the results for analytes detected in at least one sample. Results for the HDPE-lined evaporation ponds are slightly higher than those in the sewage ponds for gross beta and potassium-40, but comparable for the uranium isotopes.

5.4 Drinking Water Monitoring

The INL and ICP contractors monitor drinking water to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Parameters with primary MCLs must be monitored at least once every three years. Parameters with secondary MCLs are monitored every three years based on a recommendation by the Environmental Protection Agency. Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

Currently, the INL Site has 12 drinking water systems. The INL contractor and ICP contractor monitor these systems to ensure a safe working environment. The INL contractor monitors nine of these drinking water systems, ICP contractor monitors two, and NRF has one. According to the “Idaho Rules for Public Drinking Water Systems” (IDAPA 58.01.08), INL Site drinking water systems are classified as either nontransient or transient, noncommunity water systems. The five INL contractor transient, noncommunity water systems are at the Experimental Breeder Reactor I (EBR-I), Gun Range (Live Fire Test Range), Critical Infrastructure Test Range Complex (CITRC), Test Area North/Technical Support Facility (TAN/TSF), and the Main Gate. The four remaining INL contractor water systems are classified as nontransient, noncommunity water systems. These systems are located at CFA, MFC, ATR Complex, and TAN/Contained Test Facility (CTF). The two ICP contractor nontransient, noncommunity water systems are INTEC and the Radioactive Waste Management Complex (RWMC), which also supplies drinking water to the Advanced Mixed Waste Treatment Project facilities.

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

Because of historic or problematic contaminants in the drinking water systems, the INL contractor and the ICP contractor monitor certain parameters more frequently than required by regulation. For example, bacterial analyses are conducted monthly rather than quarterly at all nine INL contractor drinking water systems and at one ICP contractor drinking water system during months of operation. Because of known groundwater plumes near two INL contractor drinking water wells and one ICP contractor drinking water well, additional sampling is conducted for tritium at CFA, for trichloroethylene at TAN/TSF, and for carbon tetrachloride at RWMC.

During 2013, DEQ performed Sanitary Surveys on all of the INL Site drinking water systems (except EBR-I). No deficiencies were identified in any of the systems.

5.4.1 INL Site Drinking Water Monitoring Results

During 2013, the INL contractor collected 245 routine samples and 17 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 15 nonroutine samples after a water main was repaired, a building put into service, or maintenance repairs. Drinking water systems at EBR-I, CITRC, Gun Range, MFC, ATR Complex, and TAN/CTF were well below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report. In addition, all water systems were sampled for nitrates. All water systems results were less than half of the MCL of 5 mg/L. The highest results were 2.56 mg/L at CFA and 2.20 mg/L at MFC. No compliance samples were positive (present) for bacteria in 2013.

5.4.2 Central Facilities Area

The CFA water system serves approximately 500 people daily. Since the early 1950s, wastewater containing tritium was disposed of to the eastern Snake River Plain aquifer through injection wells and infiltration ponds at INTEC and the ATR Complex. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. Disposing of wastewater through injection wells was discontinued in the mid-1980s. In general, tritium concentrations in groundwater have been decreasing (Figure 5-4) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay.

Prior to 2007, compliance samples for the CFA water distribution system were collected semiannually from Well CFA #1 at CFA-651 and Well CFA #2 at CFA-642, and quarterly from the distribution manifold at CFA-1603. Because the results were consistently below the MCL for tritium, the INL contractor decreased the tritium sampling frequency to semiannually at the CFA-1603 manifold and annually at the wells. During 2013, CFA# 1 Well pumped 46.5 million gallons of water and was used 80 percent. CFA# 2 Well pumped 11.4 million gallons of water and was used 20 percent.

CFA Worker Dose – Because of the potential impacts to workers at CFA from an upgradient plume of radionuclides in the eastern Snake River Plain aquifer, the potential effective dose equivalent from radioactivity in water was calculated. For the 2013 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. This assumption overestimates the actual dose because workers typically consume only about half their total intake during working hours and typically work only 240 days rather than 365 days per year. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2013 was 0.20 mrem (2.0 μSv). This value is below the Environmental Protection Agency standard of 4 mrem/yr for public drinking water systems.

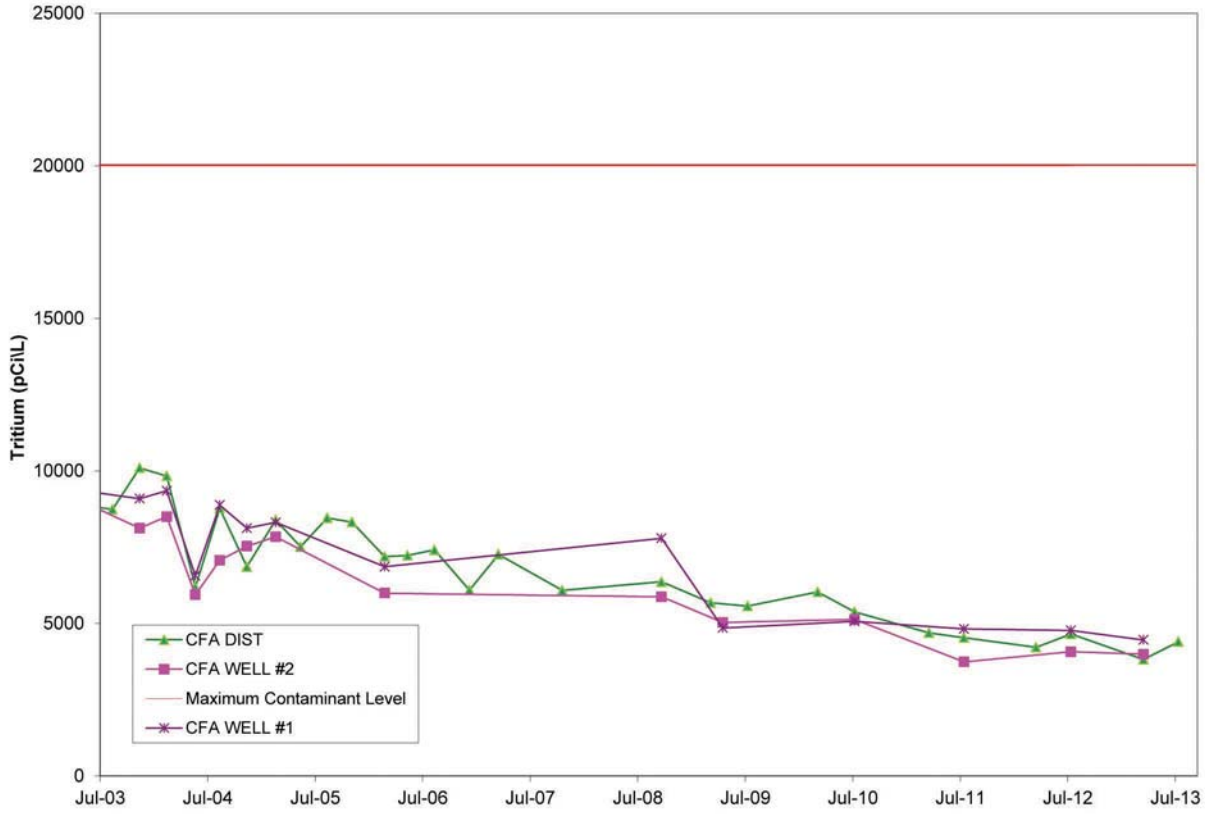


Figure 5-4. Tritium Concentrations in CFA Well and Distribution System (2003 – 2013).
Note: Since October 2011, only CFA #1 Well has been used.

5.4.3 Idaho Nuclear Technology and Engineering Center

Drinking water for INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (chlorine) is maintained throughout the distribution system. In 2013, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system.

Twenty compliance samples and 48 surveillance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for total coliform and E. coli. The results for all 68 samples were reported as absent.

One compliance sample was collected at CPP-614 and analyzed for nitrate. The result was 0.7 mg/L and below the nitrate MCL of 10 mg/L.

One surveillance sample was collected at CPP-614 and analyzed for gross alpha, gross beta, tritium, and strontium-90. Gross alpha was detected at 5.55 pCi/L, but below its MCL of 15 pCi/L. Gross beta, tritium, and strontium-90 were all reported as non-detects.

Two quality control samples (one field duplicate and one performance evaluation sample) were collected. The results are summarized in Section 11.5.3.

5.4.4 Radioactive Waste Management Complex

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

In 2013, drinking water samples were collected from the source (WMF-603), from the point of entry to the distribution system (WMF-604), and from various buildings throughout the distribution system. Samples were also collected from comfort stations WMF-TR-12, WMF-TR-13, WMF-TR-29, and the associated potable water transfer tank PW-TK-RW01.

Four compliance samples and 17 surveillance samples were collected from various buildings at RWMC and analyzed for total coliform and E. coli. The results for all 21 samples were reported as absent.

Seventeen surveillance samples were collected from the comfort stations and potable water transfer tank PW-TK-RW01 and analyzed for total coliform and E. coli. The results for all samples were reported as absent except for total coliform, which was present in one sample collected at WMF-TR-13 in October. This comfort station was taken out-of-service, and its potable water holding tank was flushed, disinfected, and resampled. The results for the resampling were reported as absent for both total coliform and E. coli.

One compliance sample was collected at WMF-604 and analyzed for nitrate. The result was 1.1 mg/L and below the nitrate MCL of 10 mg/L.

One surveillance sample was collected at WMF-604 and analyzed for gross alpha, gross beta, tritium, and strontium-90. Gross alpha was detected at 3 pCi/L (MCL is 15 pCi/L), gross beta was detected at 2.75 pCi/L (MCL is 4 mrem/year), and tritium was detected at 633 pCi/L (MCL is 20,000 pCi/L). Strontium-90 was reported as non-detect.

Four compliance samples were collected at WMF-604 and analyzed for total xylenes. Total xylenes were not detected (<0.5 µg/L) in any of these samples.

Seven surveillance samples were collected at WMF-603, WMF-604, WMF-601, and WMF-620 and analyzed for VOCs, including carbon tetrachloride and total xylenes. No VOCs were detected in any of the samples collected at the WMF-603 sink, WMF-601, or WMF-620. Total xylenes were not detected in any of the samples collected from the WMF-603 Production Well. Carbon tetrachloride was detected in all four samples collected from the WMF-603 Production Well and ranged in concentration from 5.2 µg/L to 6.4 µg/L. Trichloroethylene was also detected

in all four samples collected from the WMF-603 Production Well and ranged in concentration from 2.3 µg/L to 2.9 µg/L.

Seventeen quality control samples (four field blanks, four field duplicates, five trip blanks, and four performance evaluation samples) were collected. The results are summarized in Section 11.5.3.

5.4.5 Test Area North/Technical Support Facility

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

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

Figure 5-5 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system. Table 5-7 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2013 was less than the reporting limit of 0.5 µg/L.

5.5 Waste Management Surveillance Surface Water Sampling

In compliance with DOE Order 435.1, the ICP contractor collects surface water runoff samples at the RWMC Subsurface Disposal Area (SDA) from the location shown in Figure 5-6. Near the end of 2009, a lift station was installed, and the sampling point is now at the lift station. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data. A field blank is also collected for comparison. Because of changes in the area and the change to the lift station as the sampling point, samples were collected monthly the first quarter during 2011 and then quarterly during the remainder of 2011 to more closely monitor these changes. Samples were collected quarterly during all of 2012 and 2013.

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 RWMC. The canal also carries runoff from outside RWMC that has been diverted around the SDA.

Table 5-8 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The americium-241, plutonium-239/240, and strontium-90 concentrations are approximately the same as those detected in previous years and are well below the DOE derived concentration standards. The ICP

contractor will sample quarterly during 2014, when water is available, and evaluate the results to identify any potential abnormal trends or results that would indicate the need to conduct further investigation.

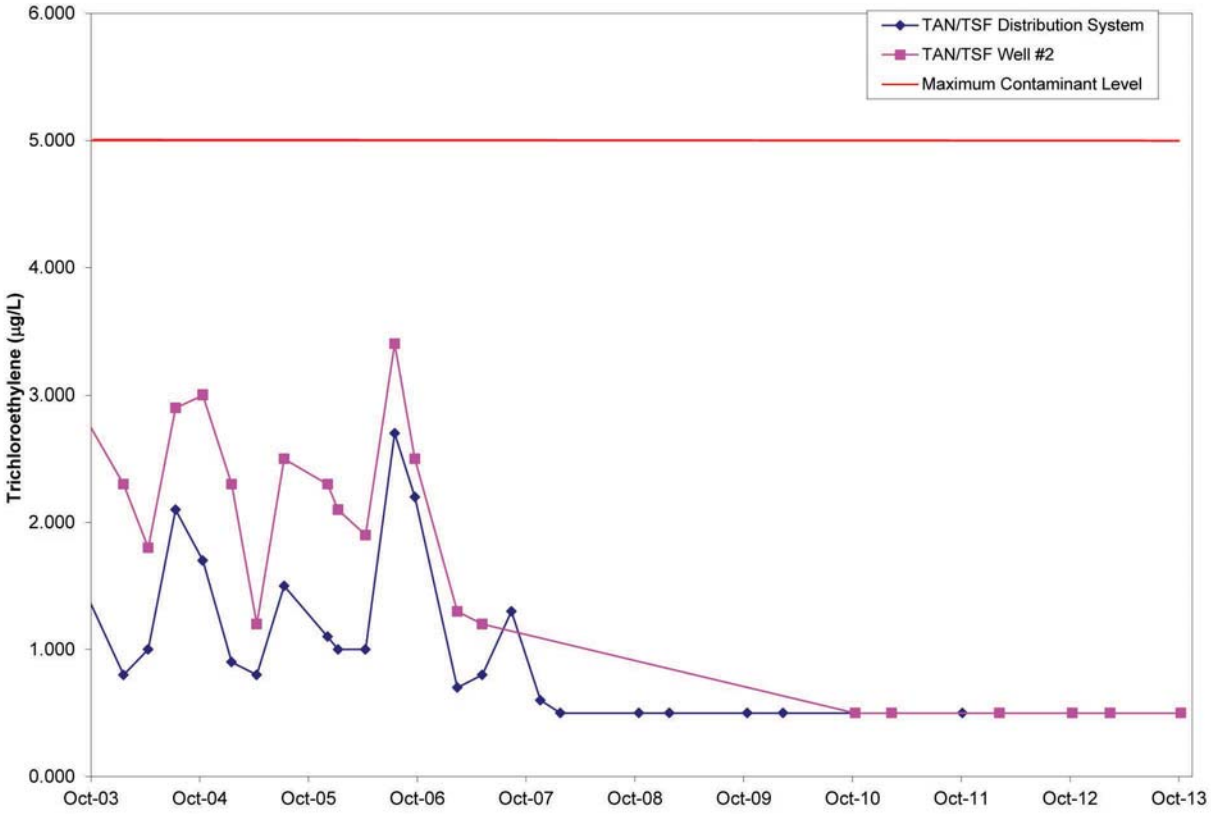


Figure 5-5. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2003 – 2013).

Table 5-7. Trichloroethylene Concentrations at TAN/TSF Well #2 and Distribution System (2013).

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

a. MCL = Maximum contaminant level (see Table A-3).
b. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

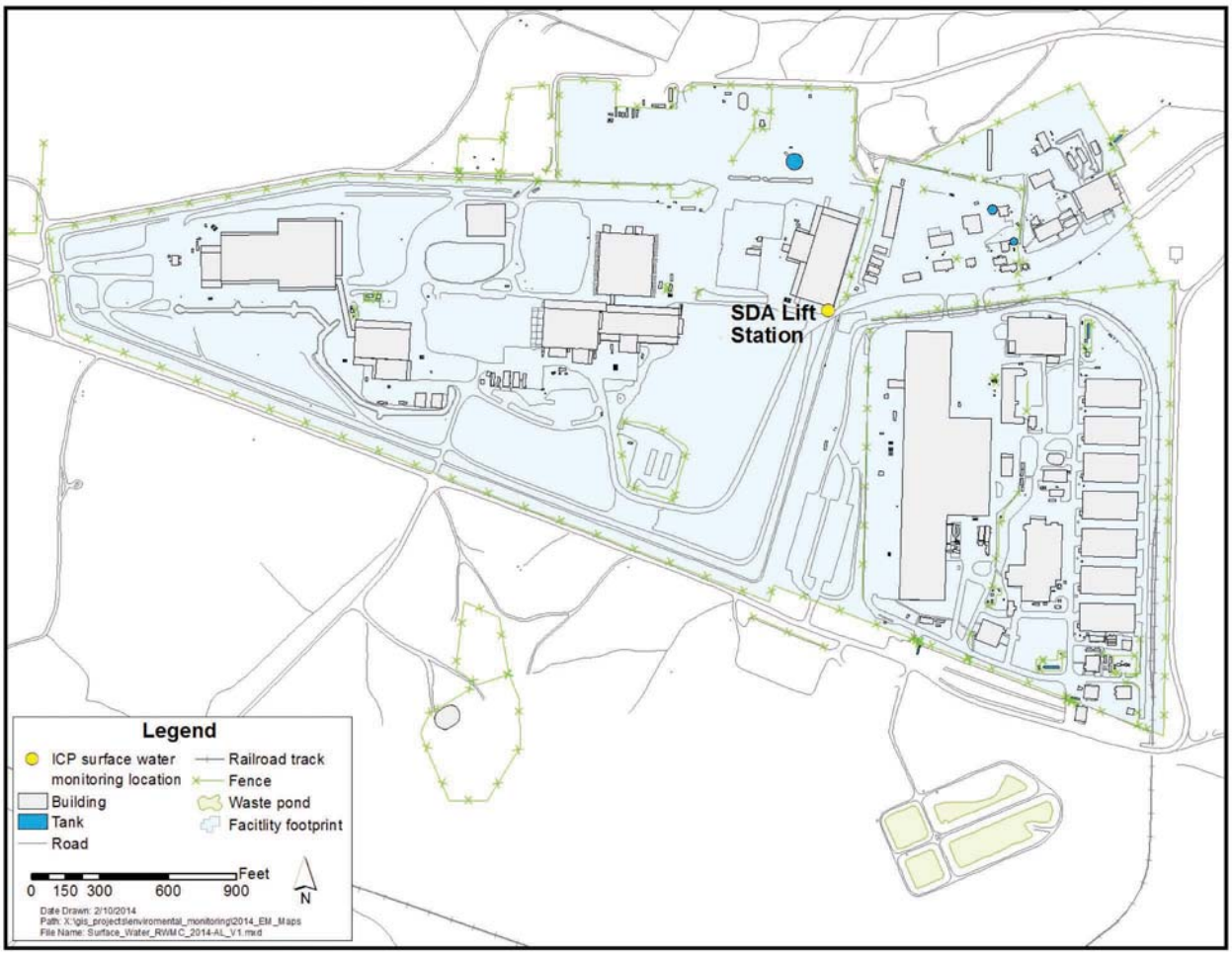


Figure 5-6. Surface Water Sampling Location at RWMC SDA.

Table 5-8. Radionuclides Detected in Surface Water Runoff at the RWMC SDA (2013).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	0.943 ± 0.075	0.18
Plutonium-239/240	(.0349 ± 0.031) x 10^{-1}	0.4
Strontium-90	2.4 ± 0.29	0.46

a. Result ±1s. Results shown are >3s.
b. See Table A-2.

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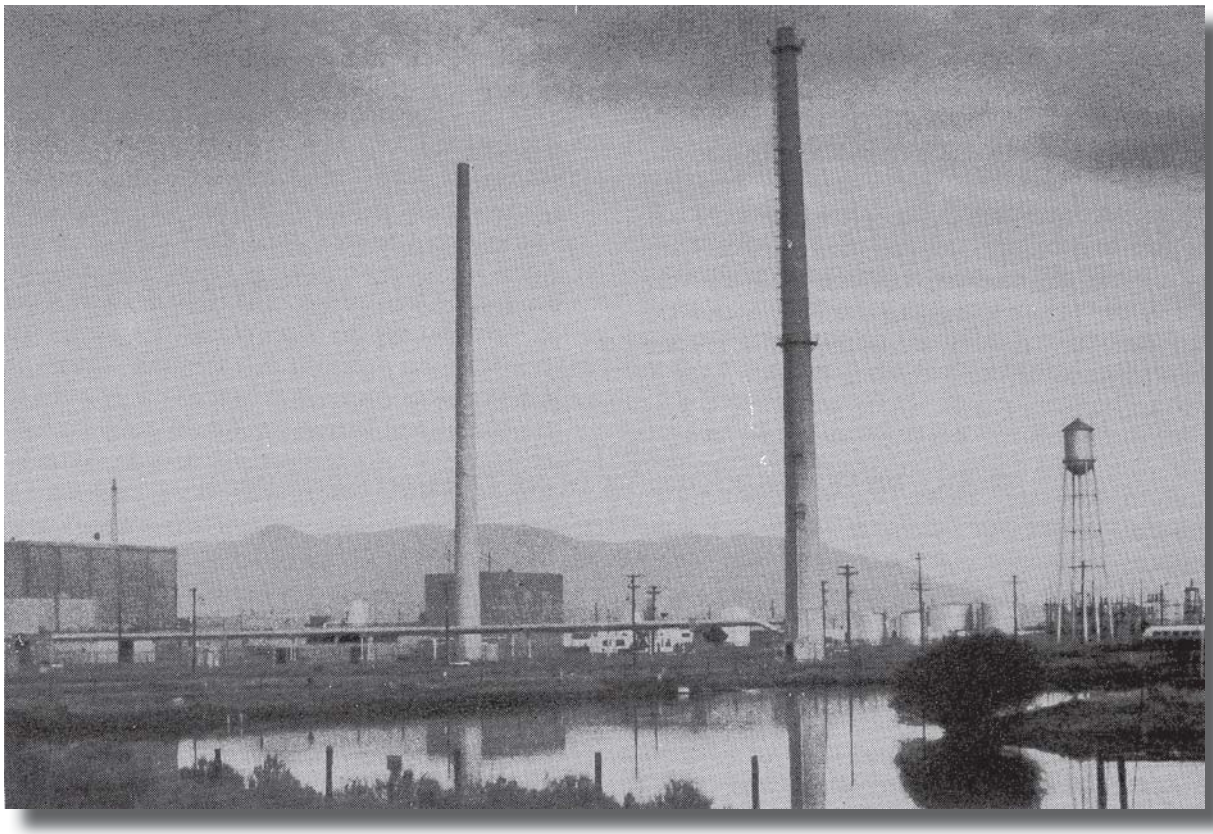
INL, 2014e, *Radiological Monitoring Results for Groundwater Samples Associated with the Industrial Wastewater Reuse Permit for the Materials and Fuels Complex Industrial Waste Ditch and Pond: November 1, 2012 – October 31, 2013*, INL/EXT-13-30966, Idaho National Laboratory.



Header Photo Description: Water containing fission products from reactor testing activities at the Test Reactor Area or TRA (now known as the Advanced Test Reactor Complex) was initially treated at the reactor facilities and then went to man-made ponds after passing through the TRA warm wastewater treatment facility's ion exchange columns (filters). Any solids remaining in the waste water settled to the bottom of the pond and continued their radioactive decay while the water evaporated. The ponds had continuing inflow of water to ensure that the settled solids remained covered by water. The ATR Complex pond was replaced in 1993 by a flexible, plastic-lined evaporative pond, designed to prevent radioactive wastewater from reaching groundwater.

Dry Lost River Channel

2013

6. Environmental Monitoring Programs-Eastern Snake River Plain Aquifer

USGS surveying well (1973)

Chapter 6 Highlights

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site in the eastern Snake River Plain aquifer. These areas are regularly monitored by the U.S. Geological Survey, and reports are published showing the extent of contamination plumes. Results for some 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.

The U.S. Geological Survey sampled 27 groundwater monitoring wells and one perched well for 61 purgeable (volatile) organic compounds in groundwater at the INL Site. Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells, at the INL Site. The concentration of tetrachloromethane (carbon tetrachloride) was above the U.S. Environmental Protection Agency maximum contaminant level (MCL) during all 12 months of 2013 in the production well at the Radioactive Waste Management Complex (RWMC). Concentrations have increased with time in that well. Tetrachloromethane also exceeded the MCL in one annual sample collected from an RWMC well and trichloroethane exceeded the MCL in one annual sample collected at a monitoring well at Test Area North. Concentrations of three other detected purgeable organic compounds were below MCLs and state of Idaho groundwater primary constituent standards for these constituents. Concentrations of chloride, nitrate, sodium, and sulfate are historically above background concentrations in many wells, but are below the applicable standards. The chromium result in one well that had exceeded the MCL in the past was below the MCL in 2013.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed in 2013. At Test Area North, in situ bioremediation (ISB) has been used to reduce the concentration of volatile organic compounds in the aquifer. In 2013 the in situ bioremediation rebound test, which began in July 2012, continued. The anaerobic conditions remain in place, and trichloroethene concentrations are below MCLs in all the former ISB injection wells.

Strontium-90, gamma-emitting radionuclides, tritium, and chromium data collected from seven groundwater wells in the vicinity of the Advanced Test Reactor Complex show no results above their respective MCLs.

Groundwater collected from 18 aquifer monitoring wells at the Idaho Nuclear Technology and Engineering Center indicated strontium-90 concentrations exceeded the MCL at seven well locations sampled. Strontium-90, technitium-99, iodine-129, and nitrate also exceeded the MCL in at least one well each, but continue to show stable or lower concentrations than those observed in previous years. Other constituents measured were all below MCLs.

Monitoring of groundwater for the Central Facilities Area (CFA) landfills consists of two components: CFA landfill monitoring and monitoring of a nitrate plume south of CFA. Groundwater monitoring for the landfills involves sampling seven wells for metals, volatile organic compounds, and anions and two wells for volatile organic compounds. None of the results exceeded MCLs in 2013. The nitrate plume is monitored with four wells sampled downgradient of the CFA. The nitrate concentration in one well continued to exceed its MCL in 2013, and was within its historically observed range. Nitrate concentrations in the three other wells have been consistent or declining.

At the RWMC, 387 analyses were performed on aquifer samples for radionuclides, inorganic constituents, volatile organic compounds, and 1,4-dioxane. Carbon tetrachloride and trichloroethylene were detected above the reporting level of 1 µg/L at several monitoring locations. Carbon tetrachloride was above the MCL in two samples. All other results were below the MCLs. Concentrations show little change relative to 2011 detections and are consistent with historical trends. None of the radionuclides were detected above reporting limits. Nitrate was reported slightly above the regional background level of 2 mg/L.

Drinking water and springs were sampled by the Environmental Surveillance, Education, and Research contractor in the vicinity of the INL Site and analyzed for gross alpha and gross beta activity, and tritium. Some locations were co-sampled with the state of Idaho Department of Environmental Quality INL Oversight Program. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases. The Big Lost River was not sampled in 2013 because the river contained no water at any time during the year.

6. ENVIRONMENTAL MONITORING PROGRAM – EASTERN SNAKE RIVER PLAIN AQUIFER AND OFFSITE SURFACE WATER

This chapter discusses the hydrogeology of the Idaho National Laboratory (INL) Site and presents results from eastern Snake River Plain aquifer studies conducted by the INL contractor, Idaho Cleanup Project (ICP) contractor, and the U.S. Geological Survey (USGS). Results are compared for informational purposes to the following:

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

- U.S. Department of Energy (DOE) Derived Concentration Standards for ingestion of water (DOE Order 458.1).

Results also are reviewed to determine compliance with all the applicable regulatory guidelines, and if exceedances are reported, regulatory agencies are notified so appropriate actions can be addressed.

Finally, this chapter presents the Environmental Surveillance, Education, and Research (ESER) contractor's surface water and offsite drinking water monitoring results.

6.1 Summary of Monitoring Programs

The USGS INL Project Office performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain aquifer under and adjacent to the INL Site. USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site (Figures 6-1 and 6-2) and at locations throughout the eastern Snake River Plain. Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2013, USGS personnel collected and analyzed over 1,200 samples for radionuclides and inorganic constituents, including trace elements and 38 samples for purgeable organic compounds. USGS has the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory analyze samples.

As detailed in Chapter 3, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at the INL Site are divided into 10 Waste Area Groups (WAGs) (Figure 6-3). Each WAG addresses specific groundwater contaminants. WAG 10 has been designated as the INL Site-wide WAG and addresses the combined impact of the individual contaminant plumes. As individual records of decision are approved for each WAG, many of the groundwater monitoring activities are turned over to the Long-Term Stewardship Program to consolidate monitoring activities.

The ESER contractor collects drinking water samples off the INL Site, as well as samples from natural surface waters. This includes the Big Lost River, which occasionally flows through the INL Site, and springs downgradient of the INL Site.

Table 6-1 presents the various groundwater, drinking water, and surface water monitoring activities performed on and around the INL Site. Details may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a) and the *Idaho National Laboratory Groundwater Monitoring Contingency Plan Update* (DOE-ID 2012a).

6.2 Hydrogeology of the Idaho National Laboratory Site

The INL Site occupies approximately 2,300 km^2 (890 mi^2) at the northwestern edge of the eastern Snake River Plain, with the INL Site boundaries coinciding with the Mud Lake sub-basin and the Big Lost Trough. The eastern Snake River Plain aquifer was formed by a unique sequence of tectonic, volcanic, and sedimentologic processes associated with the migration of the North American tectonic plate southwestward across the Yellowstone hot spot, or mantle

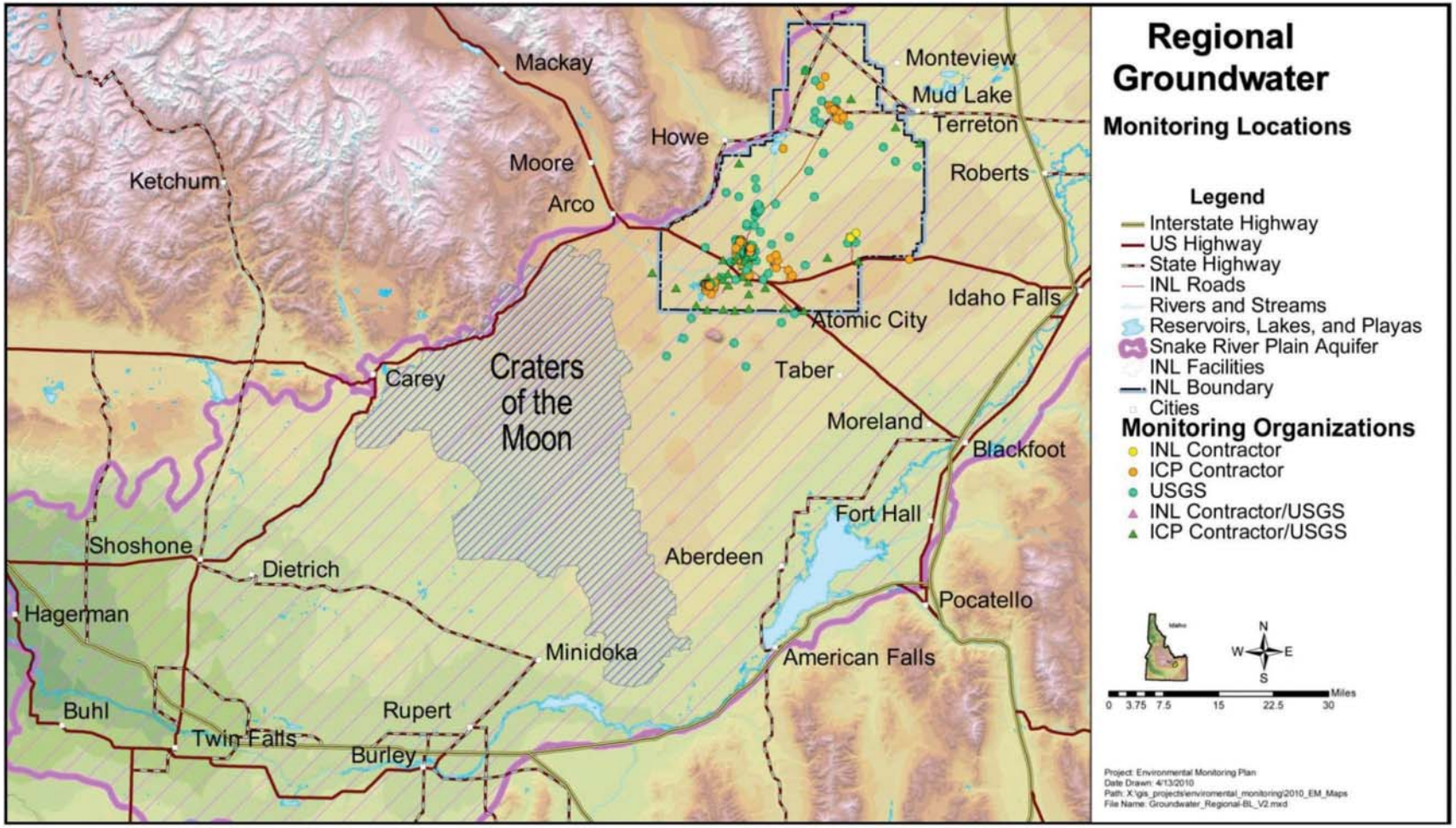


Figure 6-1. Regional Groundwater Monitoring Locations.

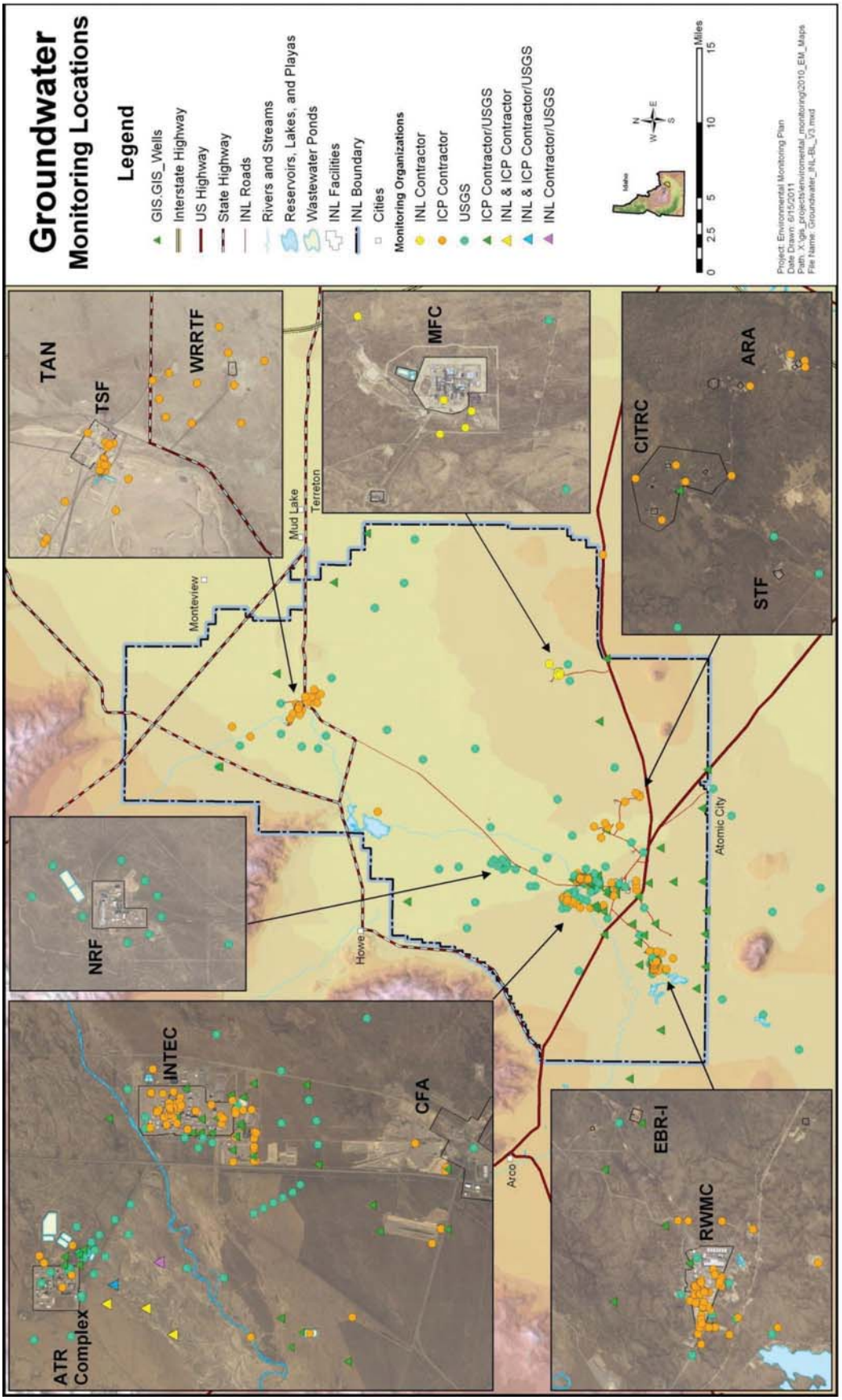


Figure 6-2. INL Site Groundwater Monitoring Locations.

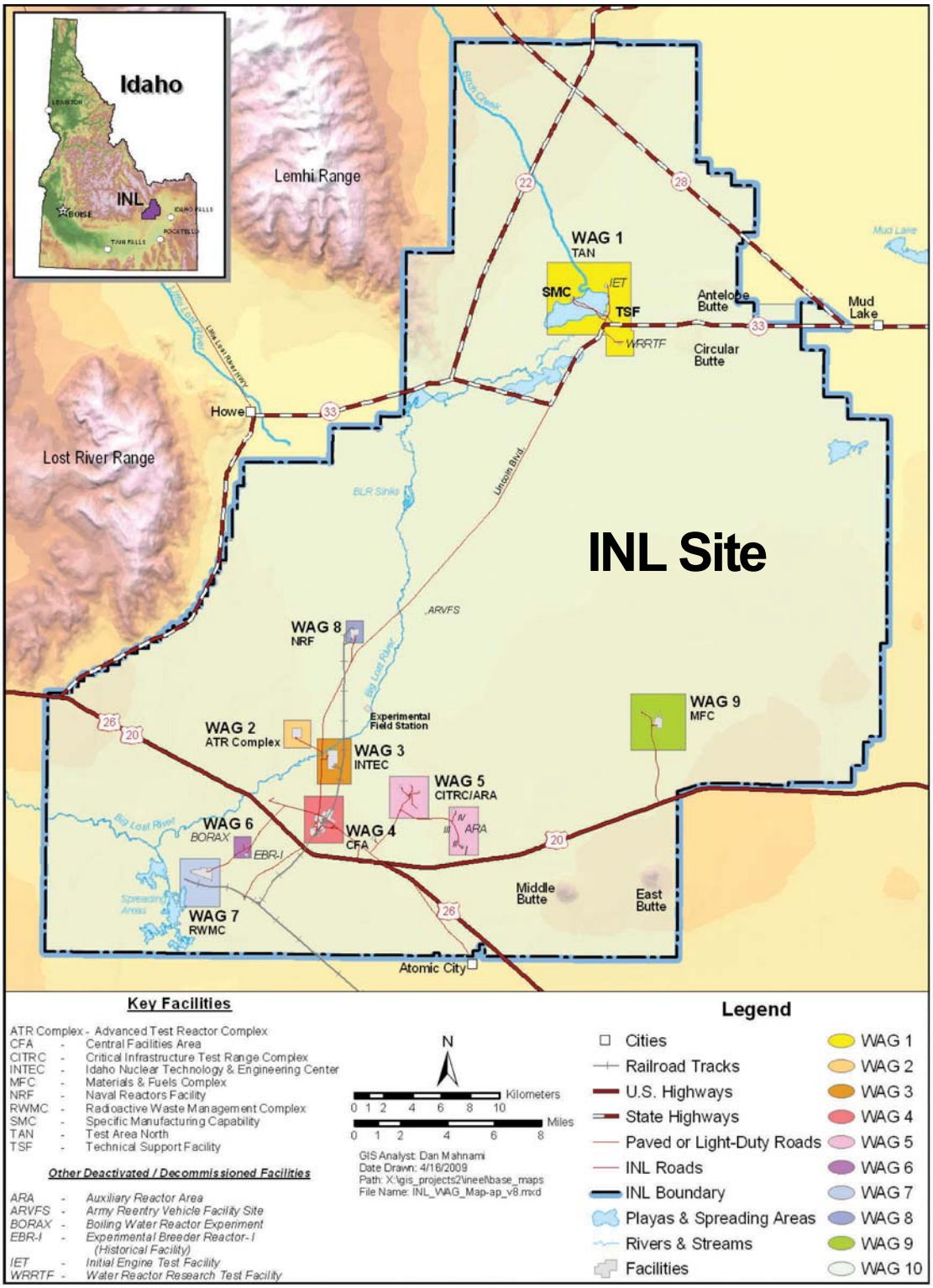


Figure 6-3. Map of the INL Site Showing Locations of Facilities and Corresponding WAGs.

Table 6-1. Monitoring of the Eastern Snake River Plain Aquifer and Surface Water on and Around the INL Site.

Area/Facility	Monitoring Activity				
	Groundwater Quality (Radiological)	Groundwater Quality (Nonradiological)	CERCLA Groundwater Monitoring	Offsite Drinking Water[a]	Surface Water[b]
ICP Contractor					
Advanced Test Reactor Complex			•		
Central Facilities Area			•		
Idaho Nuclear Technology and Engineering Center			•		
Test Area North			•		
Radioactive Waste Management Complex			•		
INL Contractor					
Materials and Fuels Complex			•		
Environmental Surveillance, Education, and Research Program					
INL Site/Distant				•	•
U.S. Geological Survey					
INL Site/Distant	•	•			•

a. Compliance monitoring of INL Site drinking water is discussed in Chapter 5. Results of surveillance of drinking water samples collected off the INL Site are reported in this chapter.

b. Liquid effluent, waste pond, and surface water runoff monitoring is addressed in Chapter 5. Surveillance of natural surface waters (rivers and springs) by the Environmental Surveillance, Education, and Research Program is presented in this chapter. Surface water samples are also collected by the U.S. Geological Survey (see http://id.water.usgs.gov/projects/INL/monitor.html) but are not discussed in this report.

plume (Geslin et al. 1999). Most of the basalt lava flows that host the aquifer and comprise the overlying vadose zone are very porous and permeable due to emplacement processes and fracturing during cooling. Rubble zones between lava flows and cooling fractures allow very rapid flow of water in the saturated zone, rapid infiltration of water and contaminants, and deep penetration of air into the vadose zone. Alluvial, eolian, and lacustrine sediments interbedded within the basalt sequence are generally fine-grained, commonly serving as aquitards below the water table, and affecting infiltration and contaminant transport in the vadose zone (Smith 2004).

The subsiding eastern Snake River Plain and the high elevations of the surrounding recharge areas comprise a large drainage basin that receives enormous amounts of precipitation and feeds high quality groundwater into the aquifer. A northeast–southwest-directed extension of the eastern Snake River Plain produces significant anisotropy to the hydraulic conductivity of the rocks (Smith 2004).

The Big Lost Trough receives sediment primarily from Basin and Range fluvial systems of the Big Lost River, Little Lost River, and Birch Creek. The Big Lost Trough contains a more-than-200-m (650-ft)-thick succession of lacustrine, fluvial, eolian, and playa sediments, recording high-frequency Quaternary climatic fluctuations interbedded with basalt flows. Alternating deposition of clay-rich lacustrine sediments and sandy fluvial and eolian sediments in the central part of the basin was in response to the interaction of fluvial and eolian systems with Pleistocene Lake Terreton, which also, in part, is responsible for the modern day Mud Lake.

Numerous studies suggest the hydraulic gradient of the eastern Snake River Plain aquifer is to the south/southwest (Figure 6-4), with velocities ranging from 0.5 to 6.1 m/day (2 to 20 ft/day). This velocity is much faster than most studied aquifers and is attributed to the eastern Snake River Plain architecture and porous media.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, including USGS, current and past contractors, and other groups. The INL Site Hydrogeologic Data Repository maintains and makes the data generated by these groups available to users and researchers.

The ICP Site Sample and Analysis Management Program was established to provide consolidated environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.

The USGS data management program involves putting all data in the National Water Information System, which is available on the internet at: http://waterdata.usgs.gov/id/nwis/qw.

6.4 Aquifer Studies of the Idaho National Laboratory Site and the Eastern Snake River Plain Aquifer

The eastern Snake River Plain aquifer serves as the primary source for drinking water and crop irrigation in the Upper Snake River Basin. A description of the hydrogeology of the INL Site and water movement in the aquifer is given in Section 6.2. Further information may be found in numerous USGS publications. Some of these publications can be accessed at http://id.water.usgs.gov/projects/INL/pubs.html or requested from the USGS INL Project Office by calling (208) 526-2438. During 2013, USGS INL Project Office personnel published seven documents covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Chapter 10.

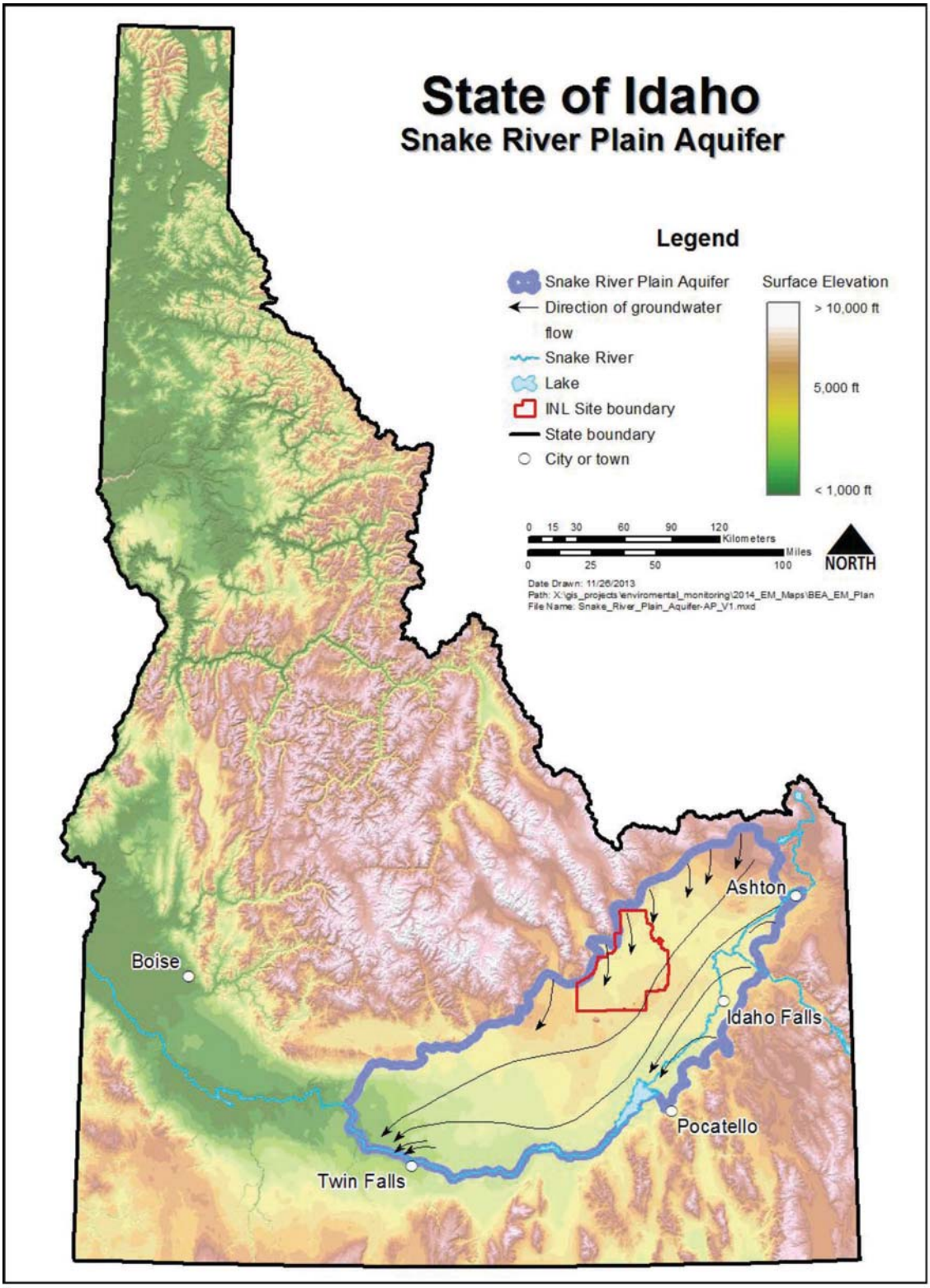


Figure 6-4. Location of the INL Site in Relation to the Eastern Snake River Plain Aquifer.

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

Historic waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain aquifer beneath the INL Site. The Idaho Nuclear Technology and Engineering Center (INTEC) used direct injection as a disposal method up to 1984. This wastewater contained elevated concentrations of tritium, strontium-90 (^{90}Sr), and iodine-129 (^{129}I). Injection at INTEC was discontinued in 1984 and the injection well was sealed in 1989. When direct injection ceased, INTEC wastewater was directed to shallow percolation ponds, where the water infiltrated into the subsurface. Disposal of low- and intermediate-level radioactive waste solutions to the percolation ponds ceased in 1993 with the installation of the Liquid Effluent Treatment and Disposal Facility. The old percolation ponds were taken out of service to be closed, and the new INTEC percolation ponds went into operation in August 2002.

The Advanced Test Reactor (ATR) Complex, formerly known as the Test Reactor Area and the Reactor Technology Complex, also had a disposal well but primarily discharged contaminated wastewater to a shallow percolation pond. The ATR Complex pond was replaced in 1993 by a flexible, plastic (Hypalon®)-lined evaporative pond, designed to prevent radioactive wastewater from reaching groundwater.

The average combined rate of tritium wastewater disposed of at ATR Complex and INTEC was highest from 1952 to 1983 (910 Ci/yr [3.37 × 10^{13} Bq/yr]), decreased during 1984 to 1991 (280 Ci/yr [1.04 × 10^{13} Bq/yr]), and continued to decrease during 1992 to 1995 (107 Ci/yr [3.96 × 10^{12} Bq/yr]). From 1952 to 1998, the INL Site disposed of about 93 Ci (3.44 × 10^{12} Bq) of ^{90}Sr at ATR Complex and about 57 Ci (2.11 × 10^{12} Bq) at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the aquifer at ATR Complex; however, at INTEC, a portion of the ^{90}Sr was injected directly to the aquifer. From 1996 to 1998, the INL Site disposed of about 0.03 Ci (1.11 × 10^{9} Bq) of ^{90}Sr to the INTEC infiltration ponds (Bartholomay et al. 2000). An additional 18,100 Ci (6.70 × 10^{14} Bq) of ^{90}Sr was reported to have leaked at the INTEC Tank Farm (Cahn et al. 2006).

Presently, ^{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 between INTEC and Central Facilities Area (CFA). Other radionuclides (e.g., gross alpha) have been detected above their primary constituent standard in wells monitored at individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen, a key component of water, it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent published USGS data (2011), are shown in Figure 6-5 (Davis et al. 2013). The area of contamination within the 0.5-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000).

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

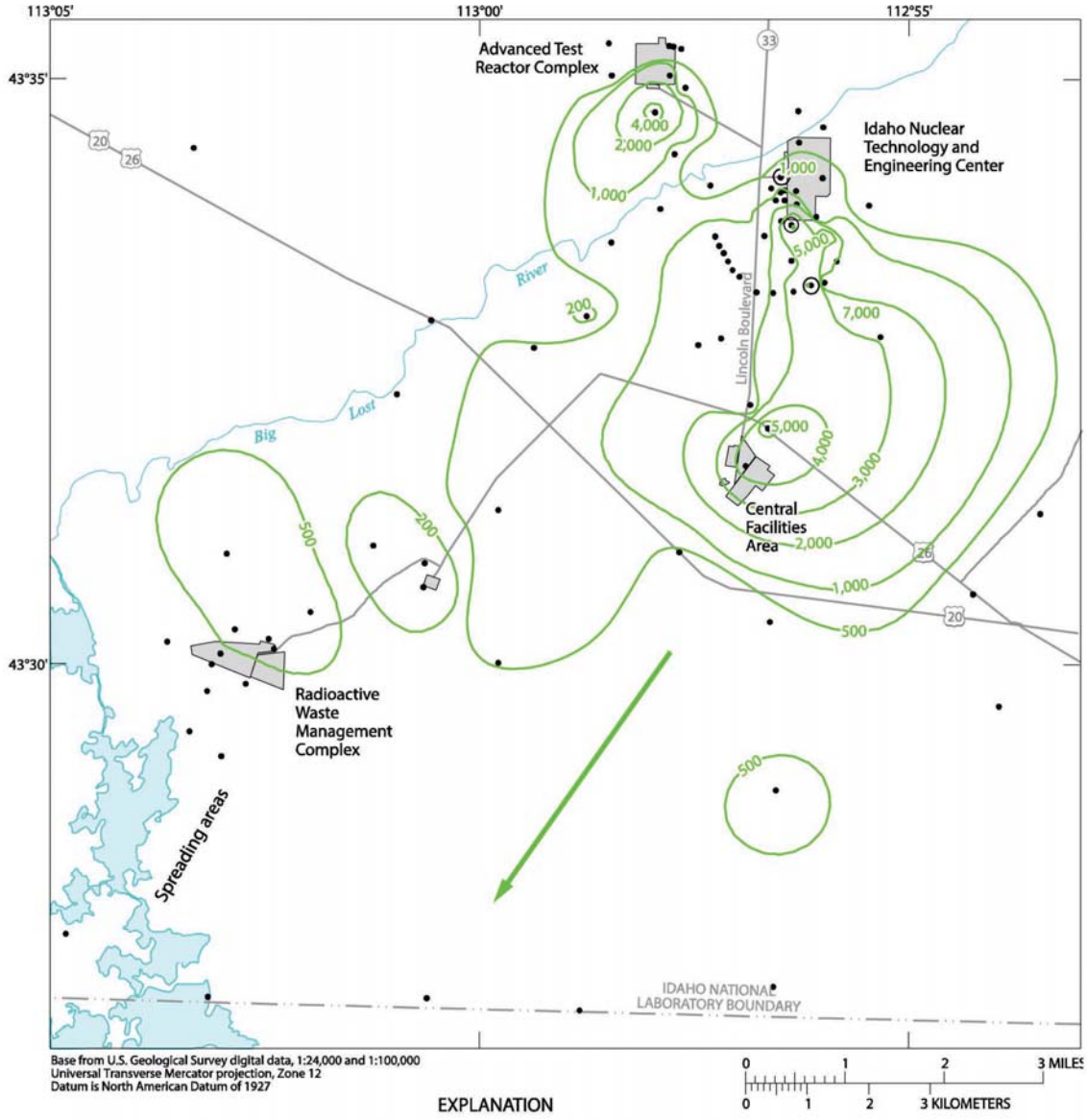


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Figure 6-5. Distribution of Tritium in the Eastern Snake River Plain Aquifer on the INL Site in 2011 (from Davis et al. 2013).

Two monitoring wells downgradient of ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over recent time (Figure 6-6). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in USGS-065 near ATR Complex decreased from 3,550 ± 110 pCi/L in 2012 to 2,760 ± 110 pCi/L in 2013; the tritium concentration in USGS-114 south of INTEC stayed the same at 7,250 ± 160 pCi/L in both 2012 and 2013.

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 both wells USGS-065 and USGS-114 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.3 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer.

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-7 (Davis et al. 2013). The contamination originates from INTEC from historic injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain aquifer near ATR Complex during 2013, the most recent year for which published results are available. All ^{90}Sr at ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

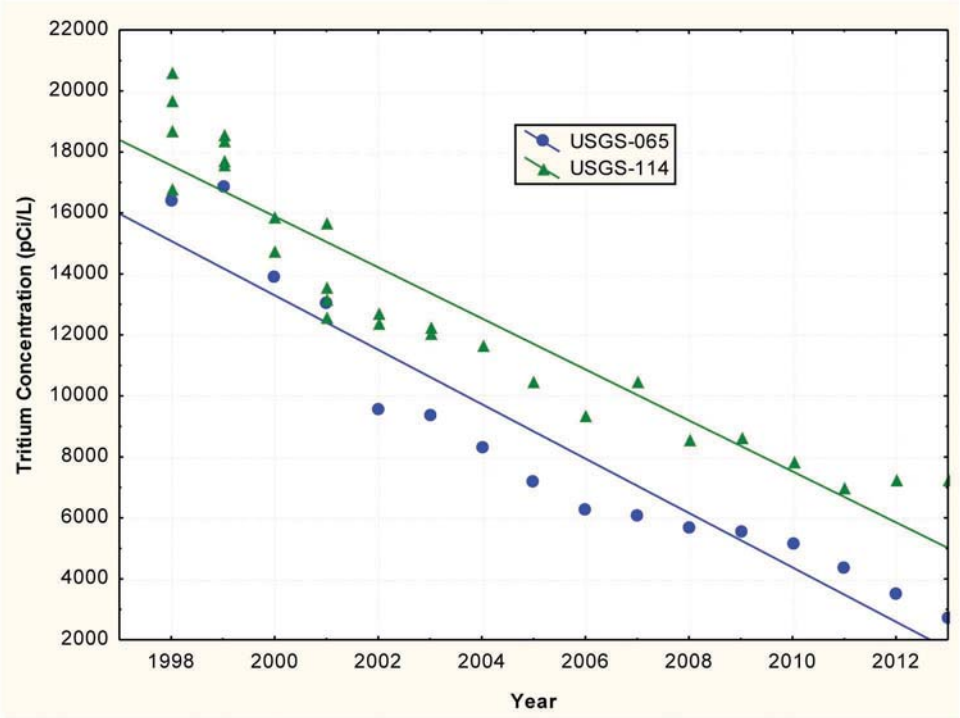

Figure 6-6. Long-term Trend of Tritium in Wells USGS -065 and -114 (1998 – 2013).

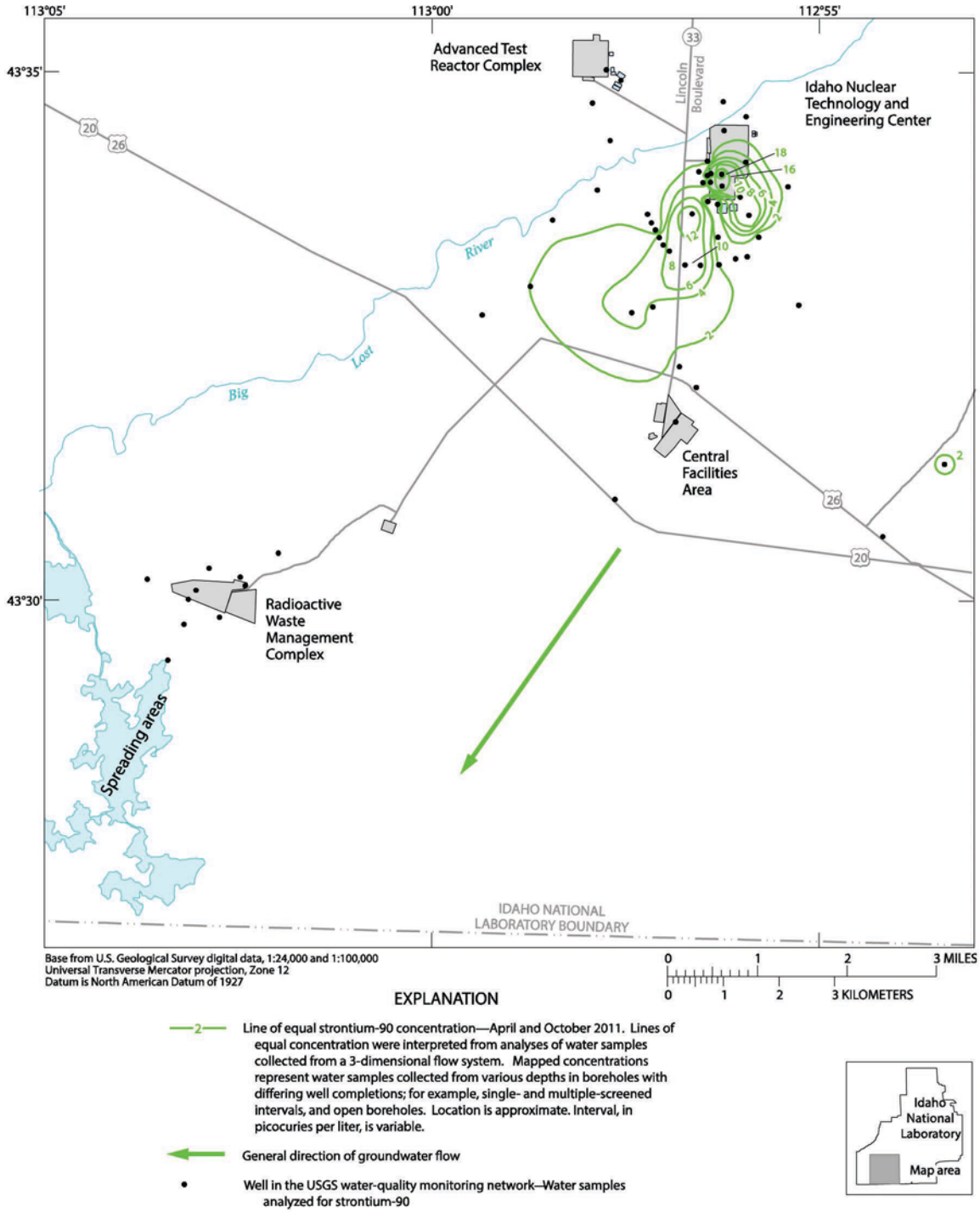

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Figure 6-7. Distribution of ^{90}Sr in the Eastern Snake River Plain Aquifer on the INL Site in 2011 (from Davis et al. 2013).

The ^{90}Sr trend over the past 20 years (1993 – 2013) in Wells USGS-047, USGS-057 and USGS-113 is shown in Figure 6-8. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased through this period. The general decrease is probably the result of radioactive decay (^{90}Sr has a half-life of 29.1 years), discontinued ^{90}Sr disposal, advective dispersion, and dilution within the aquifer. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons also may include increased disposal of other chemicals into the INTEC percolation ponds that may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000).

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes (Table 3-6). Results for wells sampled in 2013 are available at http://waterdata.usgs.gov/id/nwis/. Monitoring results for 2009 – 2011 are summarized in Davis et al. (2013). During 2009 – 2011, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in 8 wells and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all samples analyzed were less than the reporting level. In 2009, reportable concentrations of gross alpha radioactivity were observed in 13 of the 52 wells and ranged from 2.7 ± 0.9 to 4.3 ± 1.4 pCi/L. The change in the amount of reportable concentrations was attributed to increasing the sensitivity of the analyses and changing

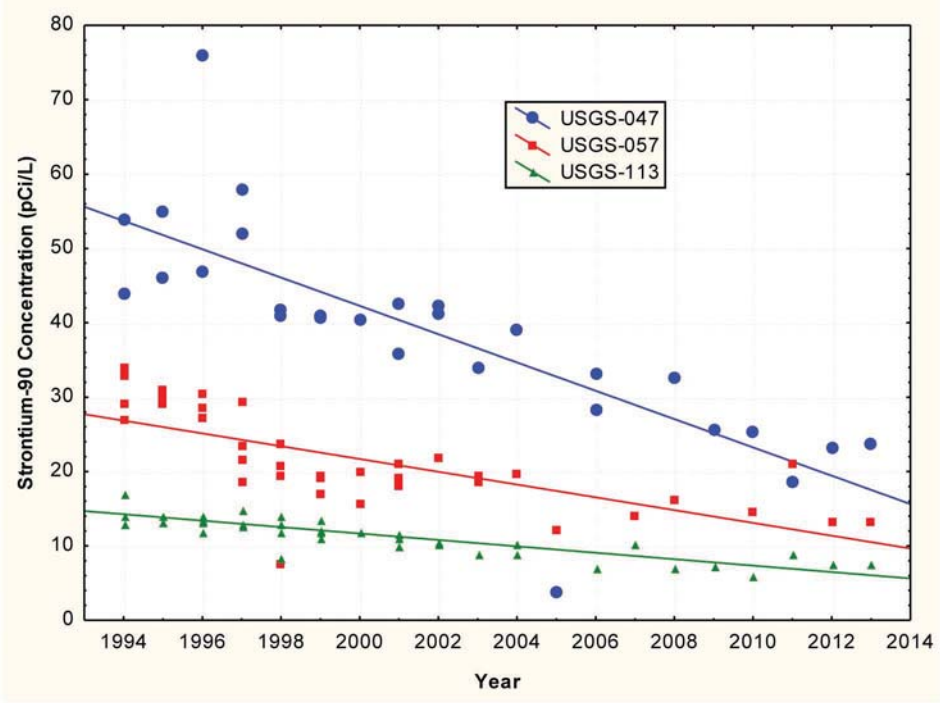

Figure 6-8. Long-term Trend of ^{90}Sr in Wells USGS-047,-057 and -113 (1994 – 2013).

the radionuclide reported for gross alpha radioactivity (Davis et al. 2013). During 2010-11, concentrations of gross-alpha particle radioactivity in 52 wells sampled were less than the reporting level. Beta particle radioactivity exceeded the reporting level in 43 of 52 wells sampled, and concentrations ranged from 1.9 ± 0.0.6 to 19 ± 1.7 pCi/L (Davis et al. 2013).

USGS periodically has sampled for ^{129}I in the eastern Snake River Plain aquifer, and monitoring programs from 1977, 1981, 1986, 1990 – 1991, 2003, and 2007 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2011 and in the spring and summer of 2012, and results were published in Bartholomay (2013). Average concentrations of 15 wells sampled in 1990 – 1991, 2003, 2007, and 2011-12 decreased from 1.15 pCi/L in 1990 – 1991 to 0.173 pCi/L in 2011-12. The maximum concentration in 2011 was 1.02 ± 0.04 pCi/L, which exceeded the drinking water MCL (1 pCi/L). Concentrations around INTEC showed slight decreases from samples collected in previous sample periods and the decreases are attributed to the discontinued disposal and to dilution and dispersion in the aquifer. The configuration and extent of ^{129}I in groundwater, based on the 2011-12 USGS data (most current to date), are shown in Figure 6-9 (Bartholomay 2013).

6.6 U.S. Geological Survey Nonradiological Groundwater Monitoring at the Idaho National Laboratory Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and selected other trace elements, and purgeable organic compounds (Table 3-6). Davis et al. (2013) provides a detailed discussion of results for samples collected during 2009 – 2011. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration was below the MCL in 2013 at 66.4 µg/L. 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 2011 (Davis et al. 2013).

USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2013. Samples from 27 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al. 2003; Knobel et al. 2008). Five purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-2). The production well at the Radioactive Waste Management Complex (RWMC) is monitored monthly, and concentrations of tetrachloromethane (also known as carbon tetrachloride) exceeded the MCL of 5 µg/L during all 12 months in 2013 (Table 6-3). Tetrachloromethane also exceeded the MCL in one sample collected from RWMC M7S. Trichloroethene exceeded the MCL of 5 µg/L from one sample collected from well GIN 2 at Test Area North (TAN) (Table 6-2). None of the other measured constituents were above their respective primary constituent standard. Annual average concentrations of tetrachloromethane in the production well and USGS-87 at RWMC generally have increased through time (Davis et al. 2013).

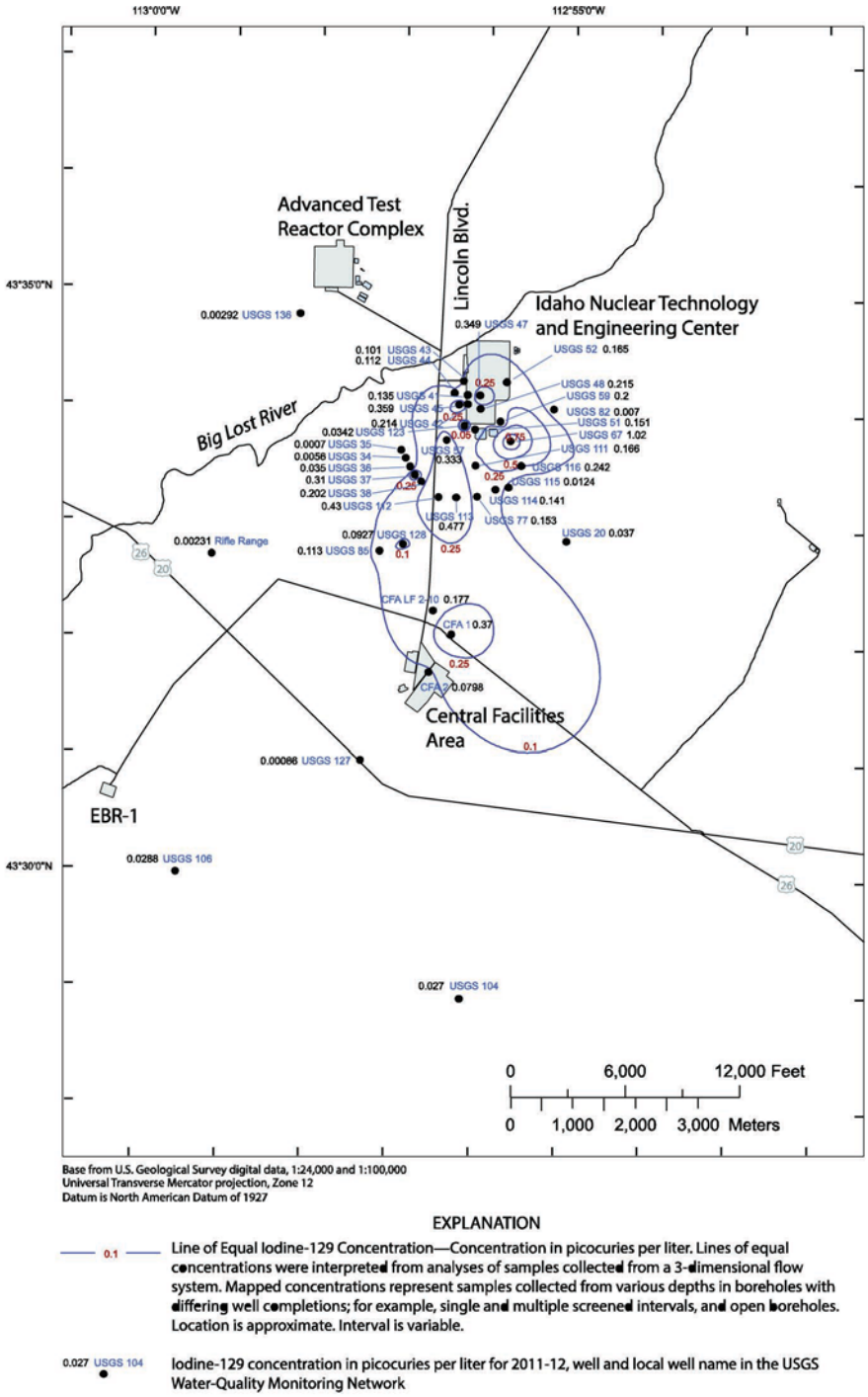

Figure 6-9. Distribution of ^{129}Iodine in the Snake River Plain Aquifer on the INL Site in 2011-12 (from Bartholomay 2013).

Table 6-2. Purgeable Organic Compounds in Annual USGS Well Samples (2013).

Constituent	GIN 2	RWMC-M7S	USGS-087[a]	USGS-88[a]	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[b]	ND[c]	8.53	3.102	1.28/0.994	1.34
Trichloromethane (µg/L) (MCL=100)	0.166	1.31	0.271	0.472/0.582	0.169
1,1,1-Trichloroethane (µg/L) (PCS=200)[d]	ND	0.614	0.146	ND/ND	ND
Tetrachloroethene (µg/L) (MCL=5)	2.55	0.526	0.138	ND/ND	ND
Trichloroethene (µg/L) (PCS=5)	6.532	3.36	0.773	0.576/0.477	0.232

a. USGS 87 also contains 0.334 µg/L toluene and 0.507 µg/L of styrene. RWMC M1SA contains 0.173 µg/L toluene. USGS 88 contains 63.6 and 0.334 µg/L toluene. USGS 140 contains 0.194 µg/L toluene. USGS 141 contains 1.04 µg/L toluene.
b. MCL = maximum contaminant level from Environmental Protection Agency in micrograms per liter (40 CFR 141).
c. ND = not detected.
d. PCS = primary constituent standard values from IDAPA 58.01.11.

6.7 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2013

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 on Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of the CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at http://ar.inel.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.7.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

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

Hot Spot Zone (trichloroethene [TCE] concentrations exceeding 20,000 µg/L) — In situ bioremediation (ISB) was used in the hot spot (TSF-05) to promote bacterial growth by supplying essential nutrients to bacteria that occur naturally in the aquifer and are able to break down contaminants. The hot spot concentration was defined using data from 1997 (Figure 6-10) and is not reflective of current concentrations. With regulatory agency concurrence, an ISB rebound

Table 6-3. Purgeable Organic Compounds in Monthly Production Well Samples at the RWMC (2013).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL=5)[a]	7.01	6.02	7.14	7.14	7.55	7.09	9.23	7.33	8.90	7.49	5.74	6.72
Trichloromethane (µg/L) (MCL=100)[b]	1.93	1.64	2.09	1.78	1.76	2.65	2.22	2.07	2.34	2.09	2.85	2.90
Tetrachloroethene (µg/L) (PCS=5)[c]	0.355	0.333	0.292	0.341	0.359	0.432	0.354	0.377	0.354	0.364	0.436	0.435
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.430	0.387	0.418	0.376	0.435	0.595	0.418	0.474	0.468	0.460	0.585	0.571
Trichloroethene (µg/L) (PCS=5)	3.58	2.99	3.83	3.12	3.23	4.11	3.90	3.58	3.83	3.59	4.37	4.29

a. MCL = maximum contaminant level values from the Environmental Protection Agency (40 CFR 141).
b. The MCL for total trihalomethanes is 100 µg/L This MCL is based on concentrations of bromodichloromethane, dibromochloromethane, tribromomethane and trichloromethane.
c. PCS = primary constituent standard values from IDAPA 58.01.11.

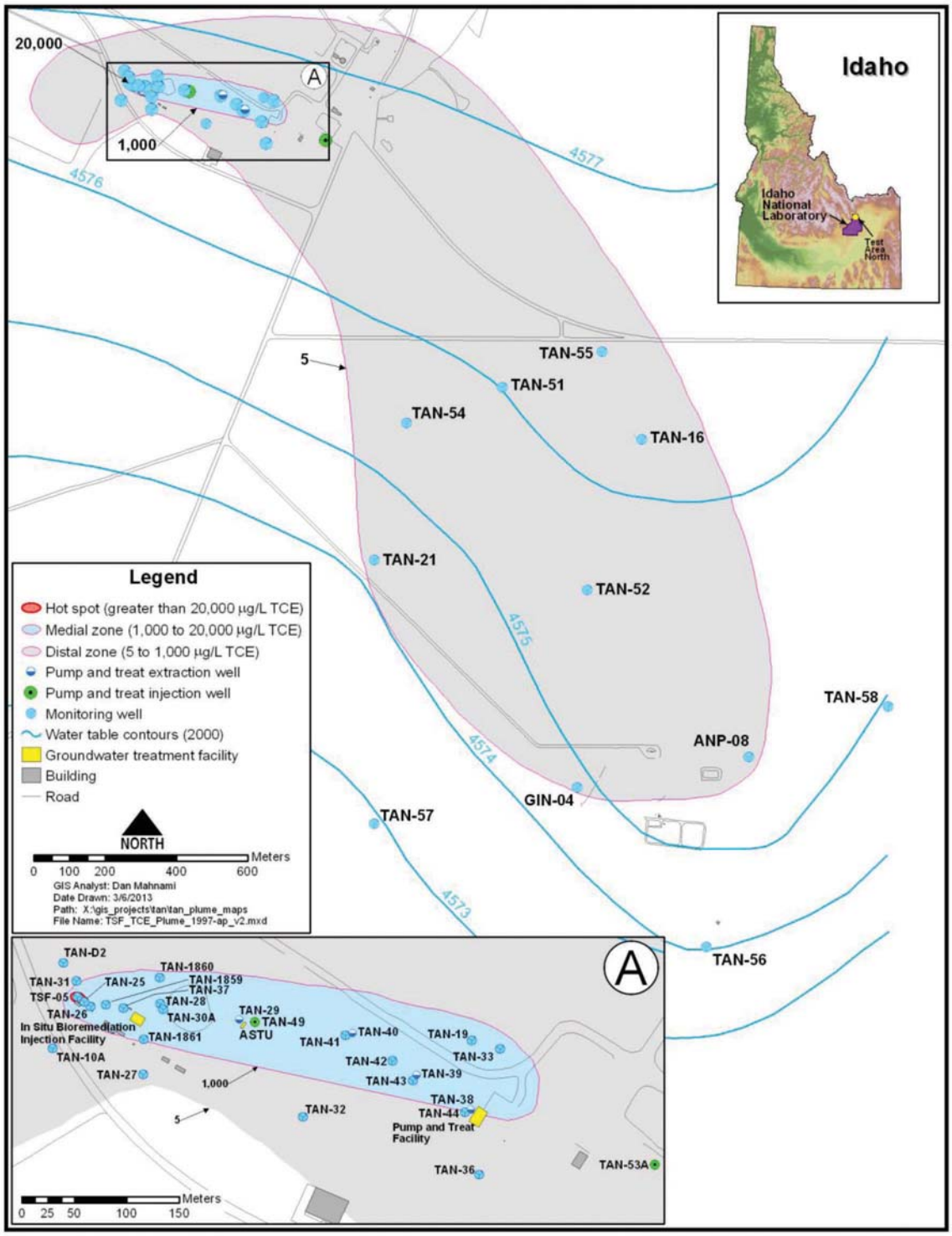

Figure 6-10. TCE Plume at TAN in 1997.

test began in July 2012 because the amount of contactable residual source in the aquifer had declined to the point of diminishing return from ISB injections.

In 2013, an ISB rebound test was in progress. All through 2013, anaerobic conditions created by ISB remained in the hot spot area, and TCE concentrations were below MCLs in all the former ISB injection wells. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2014b).

Data from Wells TAN-28, TAN-30A, TAN-1860, and TAN-1861 located downgradient of the hot spot are used to determine if ISB operations have reduced the downgradient flux of contaminants. Trends in TCE concentrations at Wells TAN-30A and TAN-1861 generally indicate that flux from the hot spot has been reduced at these wells, but the flux has not been reduced sufficiently at Wells TAN-28 and TAN-1860. A goal of the ISB rebound test is to determine the cause of the higher TCE concentrations in TAN-28 and TAN-1860.

Medial Zone (TCE concentrations between 1,000 and 20,000 µg/L) — A pump and treat process has been used in the medial zone. The pump and treat process involves extracting contaminated groundwater, treating through air strippers, and reinjecting treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday through Thursday, except for shut downs due to maintenance. All 2013 Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone are based on data collected in 1997 before remedial actions started (Figure 6-10) and do not reflect current concentrations. Trichloroethene concentrations in the medial zone wells are significantly lower than the historically defined concentration range of 1,000 to 20,000 µg/L. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 are used as an indicator of groundwater TCE concentrations that migrate past the New Pump and Treat Facility extraction wells and were less than 75 µg/L in 2013.

Distal Zone (TCE concentrations between 5 and 1,000 µg/L) — Monitored natural attenuation is the remedial action for the distal zone of the plume as defined by 1997 TCE concentrations (Figure 6-10). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Engineering and administrative 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.

Trichloroethene data collected in 2013 from the distal zone wells indicate that some wells are on track with the model predictions, but additional data are needed to confirm that the monitored natural attenuation part of the remedy is on track for all wells in the distal portion of the plume. The TCE data from the plume expansion wells suggest that plume expansion has occurred but is within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring — Strontium-90 and ^{137}Cs data at wells in the source area show elevated concentrations compared to those before starting ISB. The elevated concentrations are probably due to ISB creating conditions in the aquifer that enhance ^{90}Sr and ^{137}Cs mobility.

Strontium-90 and ^{137}Cs trends will be evaluated after background conditions are established in the aquifer during the ISB rebound test to determine if they will meet the remedial action objective of declining to below MCLs by 2095.

6.7.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells at WAG 2, ATR Complex, during 2013. The locations of the wells sampled for WAG 2 are shown on Figure 6-11. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides, tritium, and chromium (filtered). The data for the October 2013 sampling event will be included in the Fiscal Year 2014 Annual Report for WAG 2 when it is finalized. The October 2013 sampling data are summarized in Table 6-4.

No analyte occurred above its MCL. The highest chromium concentration occurred in Well TRA-07 at 80 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well USGS-065 was also elevated at 66 µg/L. The chromium concentrations in both TRA-07 and USGS-065 show long-term downward trends.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all wells sampled. The highest tritium concentration was 6,840 pCi/L in TRA-07. In the past, Well TRA-08 had detections of ^{90}Sr, but ^{90}Sr has been below detection limits since October 2010.

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

The October 2013 eastern Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing similar groundwater flow directions. Water levels in the vicinity of ATR Complex fell approximately 0.55 feet (0.17 m) on average from October 2012 to October 2013.

6.7.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 18 eastern Snake River Plain aquifer monitoring wells during 2013 (Figure 6-12). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2013 annual report (DOE-ID 2014c). Table 6-5 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, technetium-99 (^{99}Tc), ^{129}I, and nitrate exceeded their respective drinking water MCLs in one or more of the eastern Snake River Plain aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remained above the MCL (8 pCi/L) at seven of the well locations sampled. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events.

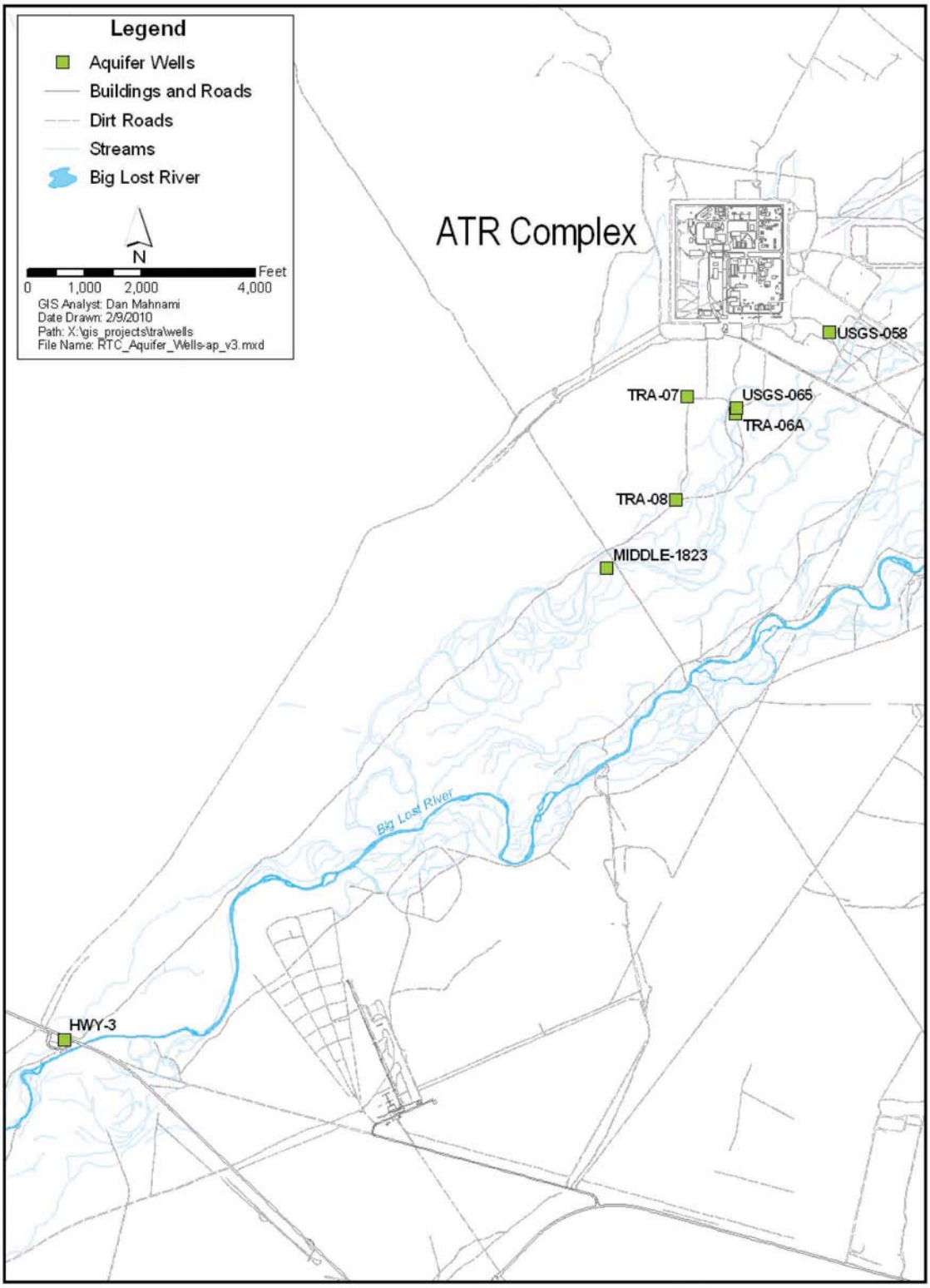

Figure 6-11. Locations of WAG 2 Aquifer Monitoring.

Table 6-4. WAG 2 Aquifer Groundwater Quality Summary for 2013.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2–3	80	1.78	0
Sr-90 (pCi/L)	8	0	ND[c]	ND	0
Tritium (pCi/L)	20,000	75–150	6,840	ND	0

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

As in the past, ^{99}Tc was detected above the MCL (900 pCi/L) in two monitoring wells within INTEC, but concentrations were below the MCL at all other locations. During 2013, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at monitoring 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 (14.5 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 are similar or slightly lower than observed in previous years.

Iodine-129 concentrations were below detection limits at all well locations, and none of the wells showed an increase in ^{129}I levels since the previous reporting period.

Tritium was detected in nearly all of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well USGS-51, near the former percolation ponds (3,850 pCi/L), and Well ICPP-2021, southeast of the tank farm (3,760 ± 415 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotopes were detected in any of the eastern Snake River Plain aquifer groundwater samples.

Uranium-238 (^{238}U)was detected at all eastern Snake River Plain aquifer well locations, with the highest concentration at Well LF3-08 (1.95 ± 0.32 pCi/L) near Central Facilities Area. The ^{238}U results are consistent with background concentrations reported for eastern Snake River Plain aquifer groundwater. Similarly, uranium-234 (^{234}U) also was detected in all groundwater samples, with concentrations as high as 4.31 ± 0.54 pCi/L at Well LF3-08. Uranium-234 is the

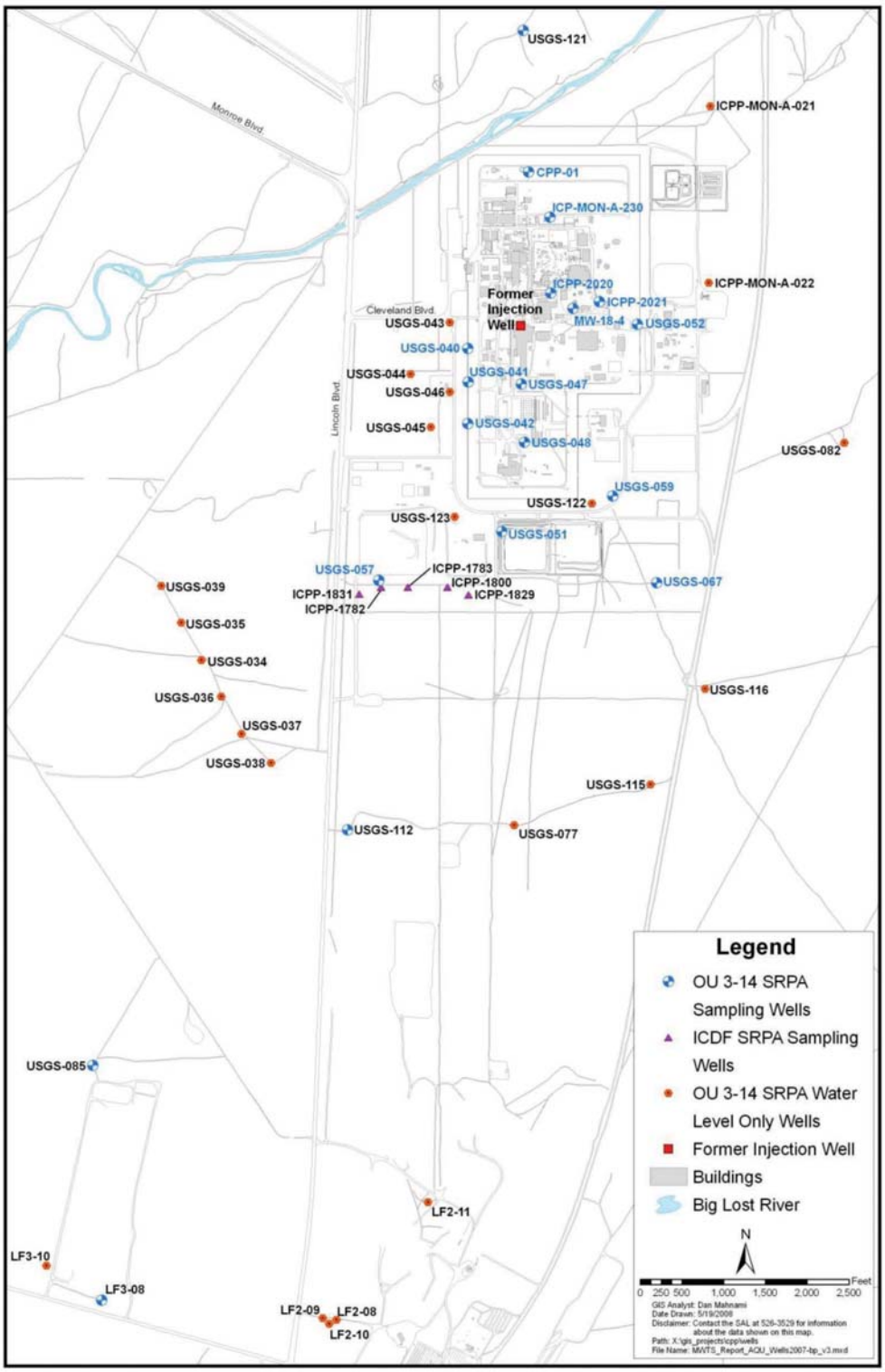

Figure 6-12. Locations of WAG 3 Monitoring Wells.

Table 6-5. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (2013).

Constituent	EPA MCL[a]	Units	Snake River Plain Aquifer Groundwater – March 2013		
			Maximum Reported Value	Number of Results[b]	Results > MCL[b]
Gross alpha	15	pCi/L	6.13 ± 1.59	20	0
Gross beta	NA[c]	pCi/L	840 ± 71.5	20	NA
Cesium-137	200	pCi/L	3.22 ± 1.59 UJ[d]	20	0
Strontium-90	8	pCi/L	**17.9 ± 1.6**[e]	20	9
Technetium-99	900	pCi/L	1,200 ± 68.9	20	3
Iodine-129	1	pCi/L	0.697 ± 0.22 UJ	20	0
Tritium	20,000	pCi/L	3,850 ± 415	20	0
Plutonium-239	15	pCi/L	ND[f]	20	0
Plutonium-239/240	15	pCi/L	ND	20	0
Uranium-233/234	15	pCi/L	4.31 ± 0.542	20	0
Uranium-235	15	pCi/L	0.309 ± 0.138 J	20	0
Uranium-238	15	pCi/L	1.95 ± 0.32	20	0
Alkalinity	NA	mg/L	407	20	NA
Calcium	NA	mg/L	70.9	20	NA
Chloride	250	mg/L	146 J[d]	20	0
Magnesium	NA	mg/L	24.3	20	NA
Nitrate (as N)	10	mg/L	14.5	20	2
Potassium	NA	mg/L	5.56	20	NA
Sodium	NA	mg/L	32.1	20	NA
Sulfate	250	mg/L	41.8 J[d]	20	0
Total dissolved solids	500	mg/L	371	20	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
b. Includes field duplicates.
c. NA = not applicable.
d. Data-qualifier flags: J = estimated value; UJ = not detected, quantitation limit is an estimate.
e. **Bolded** values exceed MCL.
f. ND = constituent not detected in any sample.

daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. Concentrations of ^{234}U and ^{238}U observed in Well LF3-08 were approximately twice those reported for any of the other aquifer wells. The higher uranium concentrations at LF3-08 are believed to be associated with suspended sediment in the unfiltered sample from this location. Because the water table at this location has declined to within approximately 10 ft of the bottom of the well, Well LF3-08 had to be sampled with a bailer (instead of submersible pump), and as a result, the groundwater sample

from LF3-08 was very muddy. The excessive turbidity likely explains the elevated uranium activities, as clay minerals may contain some natural uranium. Aside from Well LF3-08, uranium results for the other wells are consistent with background concentrations reported for SRPA groundwater. Ratios of $^{234}U/^{238}U$ were similar to background $^{234}U/^{238}U$ activity ratios of 1.5 to 3.1 reported for the eastern Snake River Plain aquifer.

Uranium-235 (^{235}U) was reported in two of the groundwater samples: LF3-08 (0.309 ± 0.138J) and USGS-067 (0.135 ± 0.0675J 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 percent upper tolerance limit). Reported ^{235}U concentrations in groundwater at INTEC have historically been slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

The 2013 groundwater contour map is similar in shape to the maps prepared for previous years, although water elevations vary slightly from year to year in response to wet-dry climate cycles. Groundwater levels declined during 2000–2005 as a result of the drought during this period. However, as a result of near normal precipitation during 2005–2013 and corresponding periods of flow of the Big Lost River, groundwater levels have remained relatively constant during this period.

6.7.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: (1) CFA landfill monitoring and (2) monitoring of a nitrate plume south of CFA. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, fluoride, and sulfate) and two wells for VOCs only in accordance with the long-term monitoring plan (DOE-ID 2013). Four wells south of CFA were sampled for nitrate and other anions to monitor a nitrate plume downgradient of CFA. The CFA monitoring well locations are shown on Figure 6-13. Analytes detected in groundwater are compared to regulatory levels in Table 6-6. A complete list of the groundwater sampling results is contained in the 2013 Monitoring Report (DOE-ID 2014d).

In the nitrate monitoring wells, nitrate, at 14.2 mg/L-N, continued to exceed its groundwater MCL of 10 mg/L-N for sensitive populations in Well CFA-MON-A-002, south of CFA. Nitrate concentrations in CFA-MON-A-002 have declined below the 1997 range of 15 to 21 mg/L-N. The decline in nitrate concentrations below the lower limit of the historical concentration range appears to confirm a downtrend. The nitrate concentration of 8.07 mg/L-N in Well CFA-MON-A-003 is below the MCL and within its historic range of 8 to 11 mg/L-N. Except for a 2005 spike, nitrate concentrations in Well CFA-MON-A-003 have been relatively consistent since monitoring started in 1995.

Chloroform and toluene were the VOCs detected downgradient from the CFA landfills in the 2013 sampling event. The source of the chloroform and toluene in the groundwater is uncertain because the soil gas samples do not indicate a source in the landfills for these compounds that appears capable of causing the groundwater contamination.

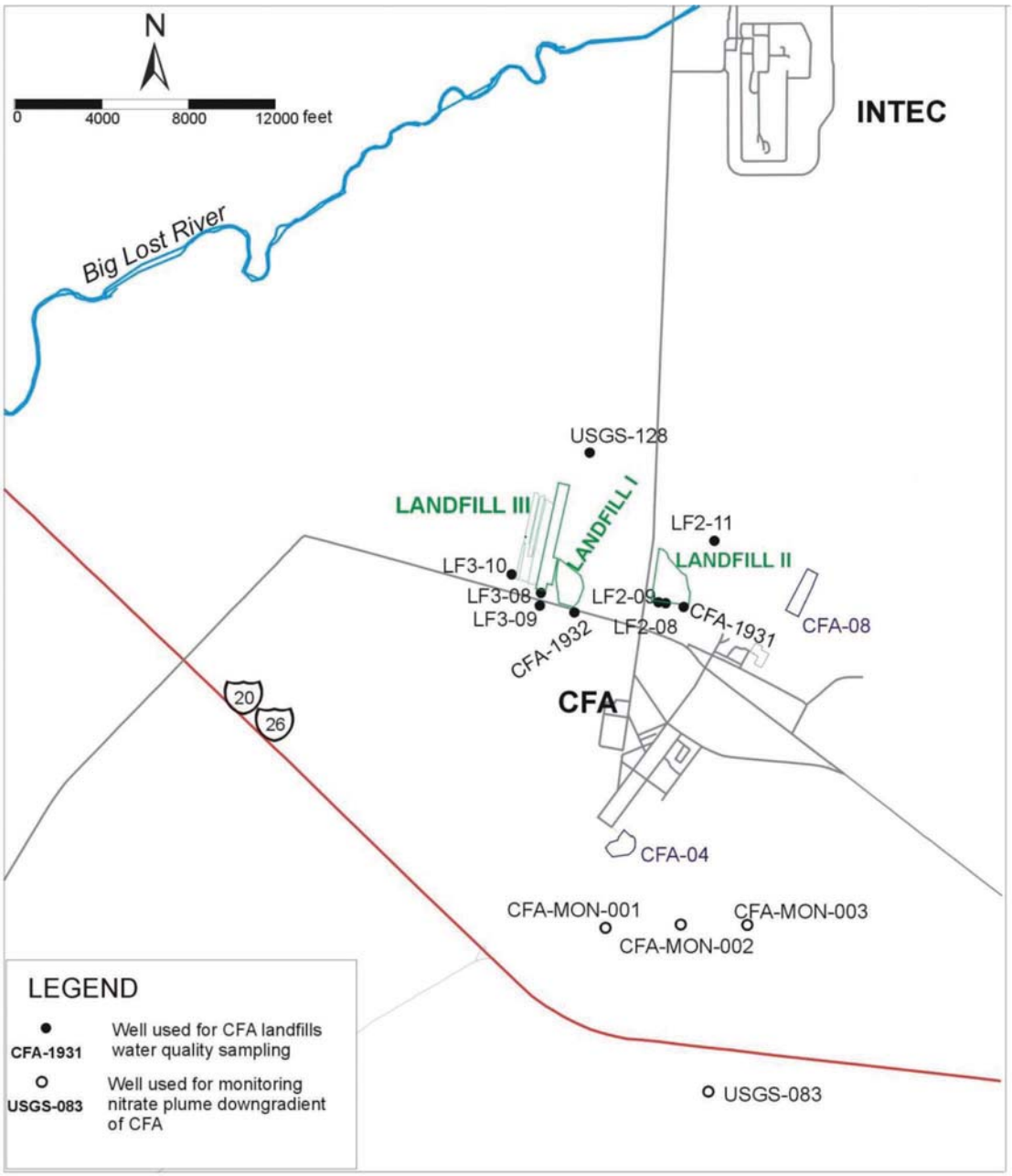

Figure 6-13. Locations of WAG 4/CFA Monitoring Wells Sampled in 2013.

Water-level measurements taken in the CFA area in 2013 suggest that after the sharp drop in water levels from 2000 to 2005, water levels appear to be stabilizing because they have changed little since 2005. A water table map produced from water levels collected in August 2013 was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2014d).

Table 6-6. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2013).

Compound	MCL[a] or SMCL[b]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*[c]	69.6	0
Fluoride (mg/L)	2	0.326	0
Sulfate (mg/L)	*250*	32.4	0
Nitrate/nitrite (mg-N/L)	10	**14.2**	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	79.3	0
Fluoride (mg/L)	2	0.317	0
Sulfate (mg/L)	*250*	44.4	0
Nitrate/nitrite (mg-N/L)	10	2.7	0
Common Cations			
Calcium (µg/L)	None	62,300	NA[e]
Magnesium (µg/L)	None	17,200	NA
Potassium (µg/L)	None	5,360	NA
Sodium (µg/L)	None	39,200	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	65.5	0
Arsenic (µg/L)	10	ND	0
Barium (µg/L)	2,000	102	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	22	0
Copper (µg/L)	*1,300/1,000*	0.931	0
Iron (µg/L)	300	162	0
Lead (µg/L)	15[c]	ND	0
Manganese (µg/L)	50	3.22	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	149	NA
Selenium (µg/L)	50	2.42	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	3.85	NA
Zinc (µg/L)	*5,000*	11.7	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	100	0.88	0
Toluene (µg/L)	1,000	10.9	0

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

6.7.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater was not monitored for WAG 5 in 2013. Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-NE-ID 2007).

6.7.6 Summary of Waste Area Group 6 Groundwater Monitoring Results

Independent groundwater monitoring is not performed for WAG 6. Groundwater monitoring in the vicinity of WAG 6 is conducted in accordance with the WAG 10 site-wide monitoring requirements, as discussed in Section 6.7.9.

6.7.6 Summary of Waste Area Group 7 Groundwater Monitoring Results

Aquifer samples collected from monitoring wells in the vicinity of RWMC in November 2013 were analyzed for radionuclides, inorganic constituents, VOCs, and 1,4-dioxane. Of the 387 analyses performed, 13 met reportable criteria established in the Operable Unit 7 13/14 Field Sampling Plan (Forbes and Holdren 2013). Table 6-7 lists contaminants of concern that were detected above regional background concentrations, MCLs, or quantitation limits.

Carbon tetrachloride and TCE were detected at concentrations above the reporting (quantitation) limit of 1 µg/L at several locations. Carbon tetrachloride slightly exceeded its MCL (5 µg/L) at two monitoring locations (i.e., Wells M7S and M16S) (see Figure 6-14). Figure 6-15 shows carbon tetrachloride trends for these two wells. TCE also was detected in several wells at concentrations exceeding the quantitation limit (1 µg/L), but less than its MCL (5 µg/L). Concentrations of VOCs show little change from results reported during the previous year.

None of the radionuclides were detected above reporting thresholds in groundwater samples in 2013. In general, radionuclide concentrations in the aquifer at RWMC are relatively stable or trending slightly downward.

Nitrate was the only inorganic contaminant detected at a reportable concentration during 2013; a nitrate concentration of 2.35 mg/L (as N) was reported for Well M6S. This value slightly exceeds the regional background nitrate-nitrogen concentration of 2 mg/L. Nitrate has not been reported previously above the background concentration at this location.

6.7.7 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the Materials and Fuels Complex (formerly Argonne National Laboratory-West) are sampled twice a year for selected radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters as required under the WAG 9 Record of Decision (Figure 6-16; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-8. Overall, the data show no discernable impacts from activities at the Materials and Fuels Complex.

A detection for ^{137}Cs was noted during the April 2013 sampling of well AN-MON-A-012. This well is an upgradient well, and the ^{137}Cs detection is believed to be a false positive as ^{137}Cs had not been detected in any of the wells historically.

Table 6-7. Summary of WAG 7 Aquifer Sampling and Analyses for Relevant Analytes in Calendar Year 2013.

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[a, b]	Concentration Maximum[a]	Number of Detections Greater Than MCL[a]	MCL[c]
Carbon tetrachloride	14	18	7	5.45 µg/L	2	5 µg/L
Trichloroethylene	14	18	5	2.6 µg/L	0	5 µg/L
Nitrate (as N)	14	16	1	2.35 mg/L	0	10 mg/L

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

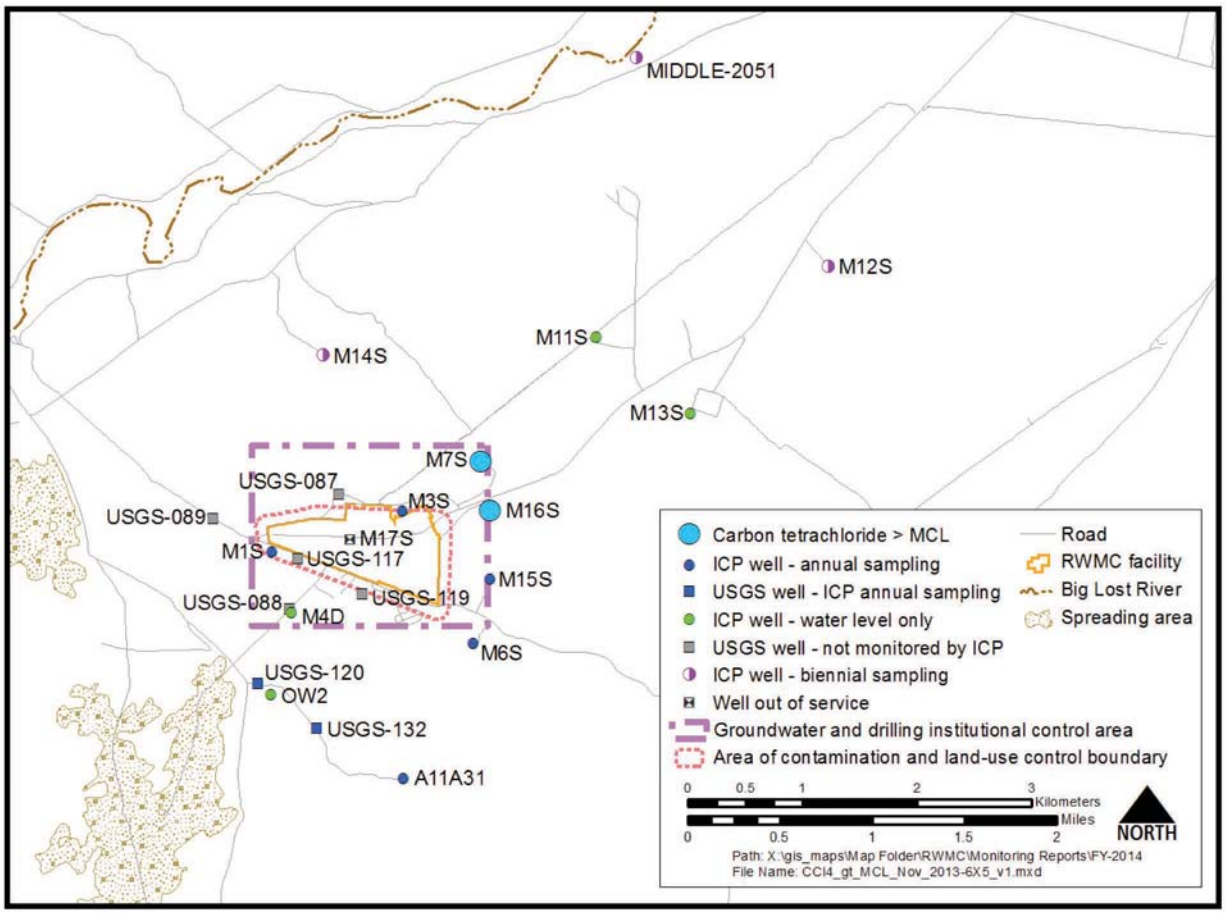

Figure 6-14. Location of Aquifer Monitoring Wells Showing Locations where Carbon Tetrachloride Exceeded the MCL in November 2013.

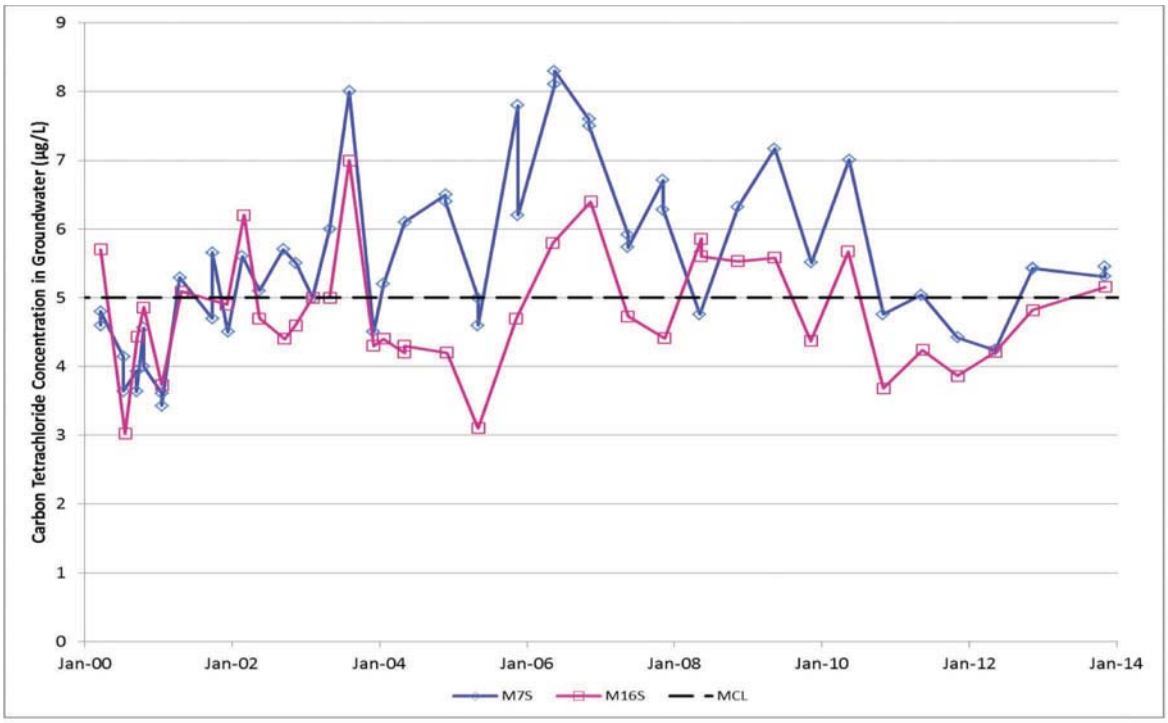

Figure 6-15. Carbon Tetrachloride Concentration Trends for Aquifer Monitoring Wells M7S and M16S.

6.7.8 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the OU10-08 monitoring plan (DOE-ID 2012b), groundwater samples are collected every two years at the locations shown on Figure 6-17. In 2013, eight wells were sampled, and seven intervals from four Westbay wells were sampled (DOE-ID 2014e). Groundwater samples were analyzed for VOCs, metals (filtered), anions, and radionuclides (i.e., ^{129}I, tritium, ^{99}Tc, gross alpha, and ^{90}Sr). No contaminant exceeded EPA MCLs or secondary MCLs (Table 6-9).

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program performed by the ESER contractor, drinking water samples were collected off the INL Site for radiological analyses in 2013. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the state of Idaho Department of Environmental Quality (DEQ) INL Oversight Program (IOP) in May and November. One upgradient location, Mud Lake, was also co-sampled with IOP. ESER also collected samples at Atomic City, Craters of the Moon, Howe, Idaho Falls, and the public rest area at Highway 20/26. A control sample of bottled water was also obtained. The samples were analyzed for gross alpha and beta activities and for tritium. The ESER contractor results are shown in Table 6-10. IOP results are reported quarterly and annually and can be accessed at http://www.deq.idaho.gov/inl-oversight.

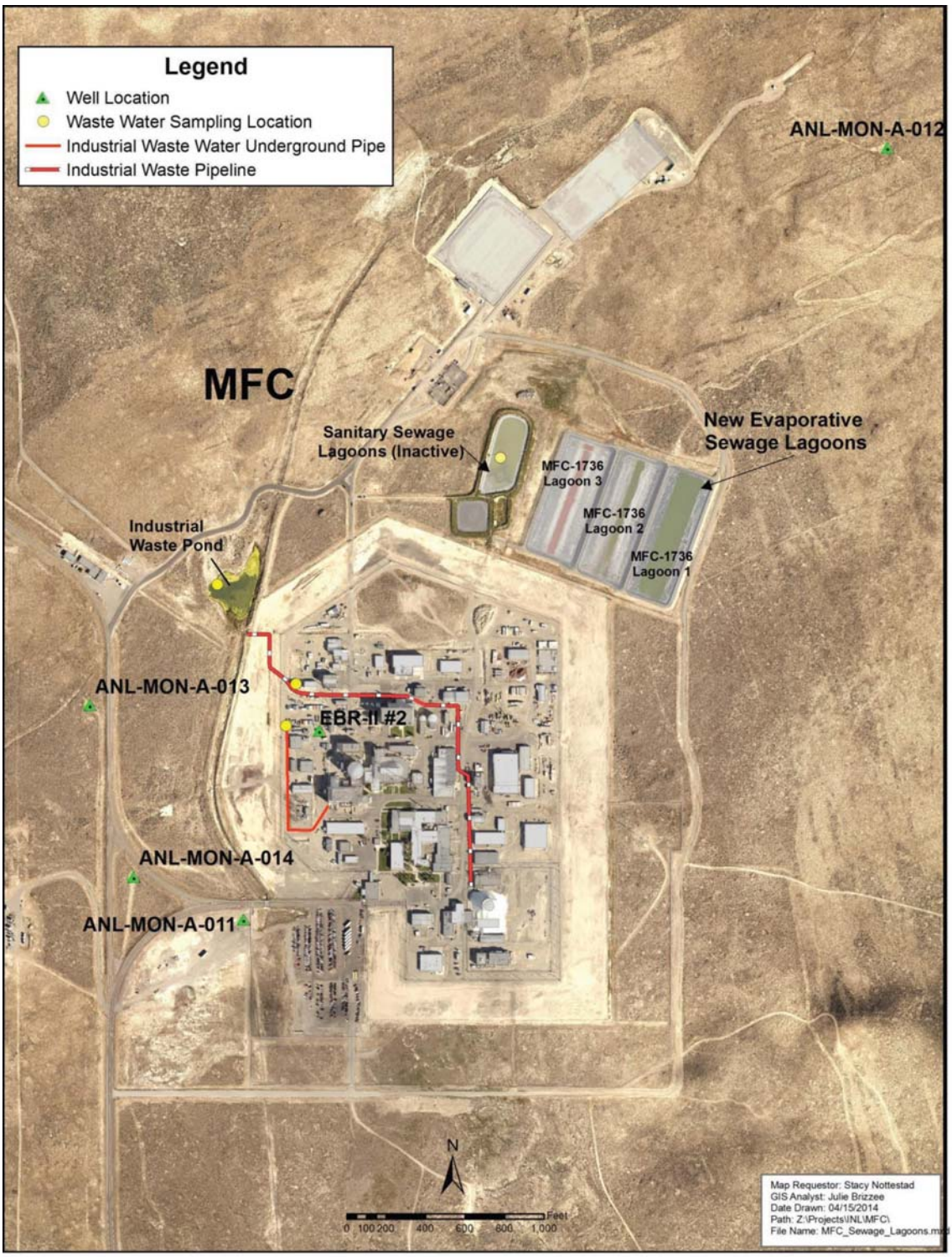

Figure 6-16. Locations of WAG 9 Wells Sampled in 2013.

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2013).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	4/23/2013	9/18/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/25/2013	9/18/2013	
Radionuclides[c]											
Cesium-137 (pCi/L)	ND[d]	ND	2.14 ± 0.688	ND	ND (ND)[e]	ND	ND	ND	ND	ND	200
Gross alpha (pCi/L)	ND	ND	2.88 ± 1.1	ND	ND (1.9 ± 0.798)	ND	ND	ND	ND	ND	15 (pCi/L)
Gross beta (pCi/L)	ND	3.46 ± 0.897	3.06 ± 0.954	3.52 ± 0.84	ND (3.13 ± 0.932)	2.55 ± 0.577	4.92 ± 1.22	ND	3.88 ± 1.13	3.69 ± 0.749	4 mrem/yr
Uranium-233/234 (pCi/L)	1.24 ± 0.186	1.5 ± 0.191	1.16 ± 0.169	1.24 ± 0.163	1.32 ± 0.207 (1.33 ± 0.193)	1.47 ± 0.187	1.46 ± 0.201	1.39 ± 0.182	1.48 ± 0.202	1.46 ± 0.19	186000
Uranium-238 (pCi/L)	0.563 ± 0.116	0.74 ± 0.119	0.661 ± 0.12	0.51 ± 0.0924	0.744 ± 0.146 (0.605 ± 0.12)	0.683 ± 0.111	0.735 ± 0.131	0.617 ± 0.107	0.624 ± 0.118	0.509 ± 0.0956	9.9
Metals											
Aluminum (µg/L)	8.6 [4.4]	7.7 [4]	10.4 [8.6]	14 [5.1]	365 (50.8) [7.1 (6.1)]	20.3 [4.6]	9.5 [8.6]	8.9 [3.2]	5.7 [4.4]	3.6 [3.2]	200
Arsenic (µg/L)	2.3 [2.4]	2.5 [2.5]	2.4 [2.3]	2.6 [2.5]	2.4 (2.3) [2.4 (2.4)]	2.4 [2.4]	2.3 [2.4]	2.5 [2.5]	2.3 [2.3]	2.5 [2.4]	50
Barium (µg/L)	33.8 [33.7]	35.3 [35.3]	37 [36.5]	38.8 [38.6]	43.4 (35.3) [34.3 (33.8)]	36.1 [35.3]	35.4 [34.9]	36.3 [35.8]	34.6 [34.3]	36.3 [36]	2000
Calcium (µg/L)	38,700 [39,000]	36,800 [36,700]	39,600 [39,000]	37,400 [37,300]	46,500 (39,700) [39,100 (38,700)]	37,200 [36,900]	39,000 [39,600]	36,900 [36,800]	39,400 [39,100]	37,300 [36,800]	NE[f]
Chromium (µg/L)	2.8 [2.5 U[g]]	2.5 U 2.5 U	3 [2.5 U]	2.5 U [2.5 U]	9.4 (8.2) [3 (3)]	3.1 [2.5 U]	4.8 [4.4]	3.1 [2.5 U]	2.6 [2.5 U]	2.5 U [2.5 U]	100
Copper (µg/L)	2.5 U [2.5 U]	2.5 U [2.5 U]	6.1 [2.5 U]	2.5 U [2.5 U]	9 (4.5) [2.5 U (2.5 U)]	4.5 [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	5.1 [2.5 U]	13.5 [2.5 U]	1300
Iron (µg/L)	272 [52.6]	143 [50 U]	181 [50 U]	50 U [50 U]	**4,880 (1060)** [80.8 (70.7)][i]	**334** [50 U]	**695** [60.9]	81.1 [50 U]	61.1 [50 U]	50 U [50 U]	300
Lead (µg/L)	0.5 U	0.5 U	0.5 U	0.5 U	0.64 (0.5 U)	[0.5 U]	0.5 U	0.5 U	3	4.1	15

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2013). (cont.)

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	4/23/2013	9/18/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/25/2013	9/18/2013	
	[0.5 U]	[0.5 U]	[0.5 U]	[0.5 U]	[0.5 U (0.5 U)]	[0.5 U]	[0.5 U]	[0.5 U]	[0.5 U]	[0.5 U]	
Magnesium (µg/L)	12,100 [12,100]	11,700 [11,700]	11,900 [11,700]	11,200 [11,200]	12,800 (12,200) [12,500 (12,300)]	11,700 [11,800]	12,200 [12,400]	11,700 [11,600]	12,400 [12,200]	11,700 [11,500]	NE
Manganese (µg/L)	2.5 U [2.5 U]	2.5 U [2.5 U]	4.4 [2.5 U]	2.5 U [2.5 U]	103 (21) [2.5 U (2.5 U)]	15.1 [2.5 U]	8.7 [2.5 U]	3.4 [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	50
Nickel (µg/L)	2.5 U [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	6.3 (3.8) [2.5 U (2.5 U)]	[2.5 U] [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	71.3 [2.5 U]	42.3 [2.5 U]	NE
Potassium (µg/L)	3,380 [3,380]	3,240 [3,200]	3,550 [3,560]	3,460 [3,410]	3,430 (3,360) [3,340 (3,320)]	3,170 [3,190]	3,350 [3,360]	3,180 [3,220]	3,380 [3,350]	3,240 [3,210]	NE
Selenium (µg/L)	0.51 [0.53]	0.59 [0.51]	0.53 [0.59]	0.54 [0.55]	0.7 (0.61) [0.56 (0.51)]	0.59 [0.57]	0.66 [0.6]	0.5 U [0.5 U]	0.58 [0.67]	0.51 [0.5 U]	50
Sodium (µg/L)	18,200 [18,100]	17,300 [17,200]	18,200 [18,100]	17,500 [17,400]	19,600 (19,400) [19,400 (19,400)]	18,000 [18,100]	18,400 [18,500]	17,300 [17,400]	18,800 [18,800]	17,600 [17,400]	NE
Vanadium (µg/L)	5.4 [5]	4.8 [5.3]	4.9 [5]	5.5 [5.5]	9.7 (6) [6.1 (5.8)]	5.3 [5.7]	5.9 [5.3]	4.8 [4.7]	5.4 [5.7]	4.9 [4.8]	NE
Zinc (µg/L)	2.7 [2.5 U]	2.5 U [2.5 U]	8.8 [2.5 U]	2.5 U [2.5 U]	14.4 (4.9) [2.5 U (2.5 U)]	2.5 U [2.5 U]	2.5 U [2.5 U]	2.5 U [2.5 U]	29.7 [9.6]	57.1 [7.1]	5000
Anions											
Chloride (mg/L)	19.1	18.2	17.9	16.9	19.2 (19.5)	18.6	19.5	18.4	19.8	18.4	250
Nitrate as Nitrogen (mg/L)	2.08	2	1.98	1.96	2.04 (2.04)	2.04	2.07	2	2.1	1.98	10
Phosphorus, Total (mg/L)	0.0117	0.0156	0.0114	0.0167	0.016 (0.0153)	0.025	0.0126	0.0173	0.0203	0.0146	NE
Sulfate (mg/L)	17.3	16.8	16.6	16.9	19.1 (19)	17.7	18.8	17.4	18.8	17.3	250

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2013). (cont.)

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	4/23/2013	9/18/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/24/2013	9/17/2013	4/25/2013	9/18/2013	
Water Quality Parameters											
Alkalinity (mg/L)	134	144	137	158	135 (136)	145	134	145	134	143	NE
Bicarbonate as CaCO3 (mg/L)	134	144	137	158	135 (136)	145	134	145	134	143	NE
Organic Carbon, Total (mg/L)	1 U	1 U	1 U	1 U	1.18 (1 U)	1.18	1 U	1 U	1 U	1 U	NE
Solids, Total Dissolved (mg/L)	246	238	244	236	254 (254)	249	251	242	243	240	500

a. EBR-II = Experimental Breeder Reactor II.
b. PCS = primary constituent standard; SCS = secondary constituent standard.
c. Result ± 1s.
d. ND = not detected.
e. Results in parentheses are field duplicate.
f. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
g. U = not detected at the concentration shown.
h. Concentrations shown in **bold** are above the Ground Water Quality Rule SCS. Filtered sample results, shown in brackets, are below the SCS.
i. Results in brackets are filtered (i.e., dissolved) concentrations.

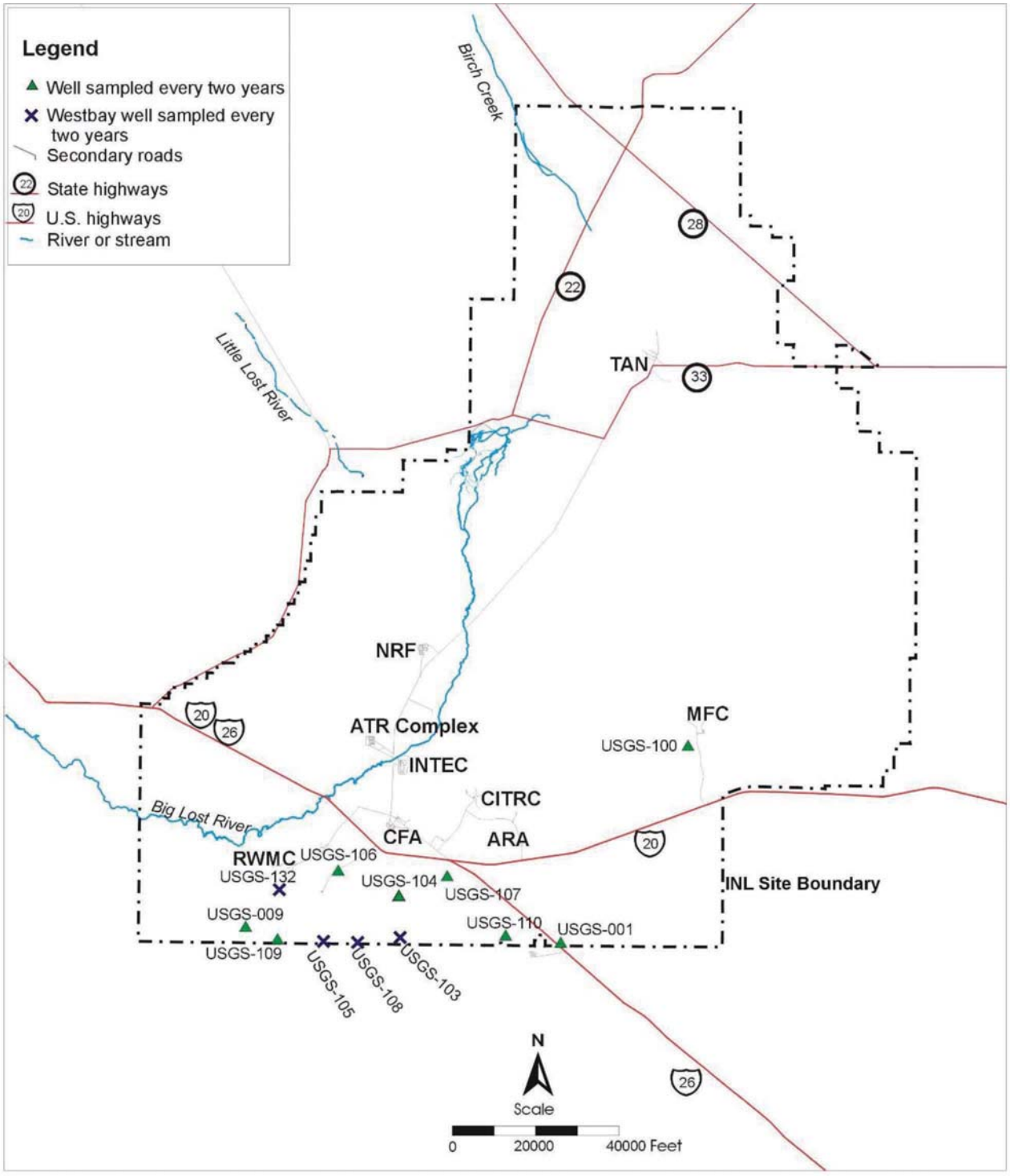

Figure 6-17. Locations and Sampling Frequency for Wells Sampled for Operable Unit 10-08.

Table 6-9. Comparison of Waste Area Group 10 Analytes with Regulatory Levels for 2013.

Analyte	MCL/SMCL[a]	Maximum Concentration[b]	Detections above MCL/SMCL
Radionuclides			
Gross alpha (pCi/L)	15	2.8	0
Iodine-129 (pCi/L)	1	ND	0
Technetium-99 (pCi/L)	900	ND	0
Strontium-90 (pCi/L)	8	ND	0
Tritium (pCi/L)	20,000	767	0
Volatile Organic Compounds[c]			
Carbon tetrachloride (µg/L)	5	0.33	0
Anions			
Chloride (mg/L)	250	18.3	0
Fluoride (mg/L)	2	0.684	0
Nitrate/nitrite as N (mg/L)	10	1.3	0
Sulfate (mg/L)	250	33.2	0
Common Cations			
Calcium (µg/L)	None	47,200	NA
Magnesium (µg/L)	None	19,000	NA
Potassium (µg/L)	None	3,790	NA
Sodium (µg/L)	None	23,300	NA
Metals			
Aluminum (µg/L)	50 to 200	ND	0
Antimony (µg/L)	6	ND	0
Arsenic (µg/L)	10	2.7	0
Barium (µg/L)	2,000	55.3	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	11.3	0
Cobalt (µg/L)	None	ND	NA
Copper (µg/L)	1,300/*1,000*	2.9	0
Iron (µg/L)	300	269	2
Lead (µg/L)	15[d]	ND	0
Manganese (µg/L)	50	26.8	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	2.45	NA
Selenium (µg/L)	50	1.51	0
Silver (µg/L)	None	ND	NA
Thallium (µg/L)	2	0.971	0
Uranium (µg/L)	30	2.98	0
Vanadium (µg/L)	None	8.41	NA
Zinc (µg/L)	5,000	177	0

a. MCL = maximum contaminant level; SMCL = secondary maximum contaminant level. Maximum contaminant levels are in regular text, and secondary maximum contaminant levels are in *italics*.
b. NA = not applicable; ND = not detected
c. Only the detected volatile organic compounds are listed.
d. The action level for lead is 15 µg/L.

Table 6-10. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2013.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring	*Fall*	*EPA MCL[b]*
Atomic City	ND[c]	ND	15 pCi/L
Control (bottled water)	ND	ND	15 pCi/L
Craters of the Moon	ND	1.88 ± 0.49	15 pCi/L
Howe	ND	ND	15 pCi/L
Idaho Falls	ND	ND	15 pCi/L
Minidoka	ND	ND	15 pCi/L
Mud Lake (Well #2)	ND	ND	15 pCi/L
Rest Area (Highway 20/26)	ND	1.30 ± 0.42	15 pCi/L
Shoshone	1.80 ± 0.53	ND	15 pCi/L
Gross Beta			
	Spring	*Fall*	*EPA MCL*
Atomic City	2.91 ± 0.58	4.53 ± 0.58	4 mrem/yr (8 pCi/L ^{90}Sr)[d]
Control (bottled water)	ND	ND	4 mrem/yr (8 pCi/L ^{90}Sr)
Craters of the Moon	3.40 ± 0.53	3.44 ± 0.57	4 mrem/yr (8 pCi/L ^{90}Sr)
Howe	ND	ND	4 mrem/yr (8 pCi/L ^{90}Sr)
Idaho Falls	3.16 ± 0.53	4.88 ± 0.66	4 mrem/yr (8 pCi/L ^{90}Sr)
Minidoka	3.32 ± 0.56	3.12 ± 0.60	4 mrem/yr (8 pCi/L ^{90}Sr)
Mud Lake (Well #2)	4.52 ± 0.53	4.79 ± 0.58	4 mrem/yr (8 pCi/L ^{90}Sr)
Rest Area (Highway 20/26)	ND	3.71 ± 0.51	4 mrem/yr (8 pCi/L ^{90}Sr)
Shoshone	5.33 ± 0.63	4.96 ± 0.64	4 mrem/yr (8 pCi/L ^{90}Sr)
Tritium			
	Spring	*Fall*	*EPA MCL*
Atomic City	ND	91 ± 21	20,000 pCi/L
Control (bottled water)	74 ± 22	106 ± 23	20,000 pCi/L
Craters of the Moon	ND	99 ± 24	20,000 pCi/L
Howe	ND	93 ± 23	20,000 pCi/L
Idaho Falls	ND	ND	20,000 pCi/L
Minidoka	ND	96 ± 23	20,000 pCi/L
Mud Lake (Well #2)	ND	ND	20,000 pCi/L
Rest Area (Highway 20/26)	71 ± 21	193 ± 24	20,000 pCi/L
Shoshone	70 ± 22	ND	20,000 pCi/L

a. Result ± 1s.
b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
c. ND = not detected (results < 3s).
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/y for public drinking water systems is applied a conservative screening level of 8 pCi/L (the MCL for ^{90}Sr) is used.

Gross alpha activity was detected in two samples collected at just above the minimum detectable concentration. Gross beta activity was detected in most drinking water samples collected by ESER, but not in the bottled water. Gross beta activity has been measured at these levels historically in offsite drinking water samples. The results are below the screening MCL of 8 pCi/L for ^{90}Sr. This MCL is extremely conservative because the radionuclides contributing to the gross beta activity are most likely naturally-occurring decay products of thorium and uranium, which are present in the aquifer, and not ^{90}Sr, which is a man-made radionuclide.

Tritium was detected in some of the drinking water samples (including both of the control samples) collected in 2013. The results were within historical measurements and well below the EPA MCL of 20,000 pCi/L

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ IOP in May and November 2013 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman (see Figure 6-18). ESER contractor results are shown in Table 6-11. Gross alpha activity was not detected in any sample. Gross beta activity was detected in all surface water samples. The highest result was measured at Alpheus Springs and the lowest at Hagerman. Alpheus Springs has historically shown higher results, occasionally above 8 pCi/L as in November, and is most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain aquifer.

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

The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called Big Lost River Sinks (see Figure 6-18). The river then mixes with other water in the eastern Snake River Plain Aquifer. Water in the aquifer then emerges about 100 miles (160 km) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The ESER contractor did not collect surface water samples from the Big Lost River on the INL Site in 2013 because the river contained no water at any time during the year.

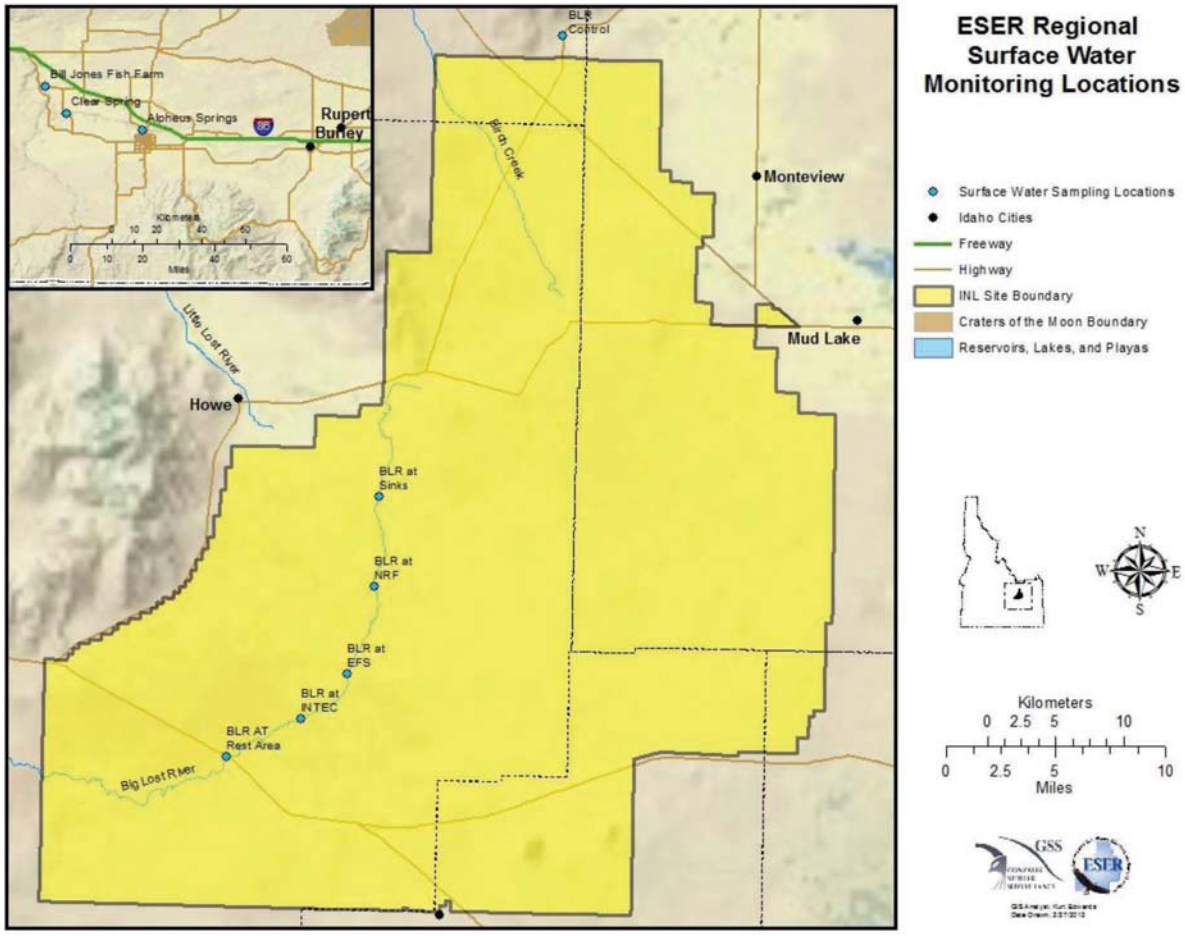

Figure 6-18. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-11. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2013.

Location	Sample Results (pCi/L)[a]		
	Gross Alpha		
	Spring[b]	*Fall*[b]	*EPA MCL*[c]
Alpheus Springs (Twin Falls)	ND[d]	ND	15 pCi/L
Clear Springs (Buhl)	ND	ND	15 pCi/L
Bill Jones Hatchery (Hagerman)	ND	ND	15 pCi/L
	Gross Beta		
	Spring	*Fall*	*EPA MCL*
Alpheus Springs (Twin Falls)	7.63 ± 0.62	10.10 ± 0.65	4 mrem/yr (8 pCi/L ^{90}Sr)[e]
Clear Springs (Buhl)	4.04 ± 0.56	2.79 ± 0.52	4 mrem/yr (8 pCi/L ^{90}Sr)
Bill Jones Hatchery (Hagerman)	3.15 ± 0.58	3.84 ± 0.51	4 mrem/yr (8 pCi/L ^{90}Sr)
	Tritium		
	Spring	*Fall*	*EPA MCL*
Alpheus Springs (Twin Falls)	133 ± 23	94 ± 24	20,000 pCi/L
Clear Springs (Buhl)	114 ± 22	83 ± 23	20,000 pCi/L
Bill Jones Hatchery (Hagerman)	115 ± 22	ND	20,000 pCi/L

a. Result ± 1s.
b. The springs and hatchery were sampled on May 20 and November 19, 2013.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
d. ND = not detected (results < 3s).
e. 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 conservative screening level of 8 pCi/L (the MCL for ^{90}Sr) is used. It is conservative because it is highly unlikely that the gross beta activity is due to ^{90}Sr and more likely due to naturally occurring radionuclides in the sample.

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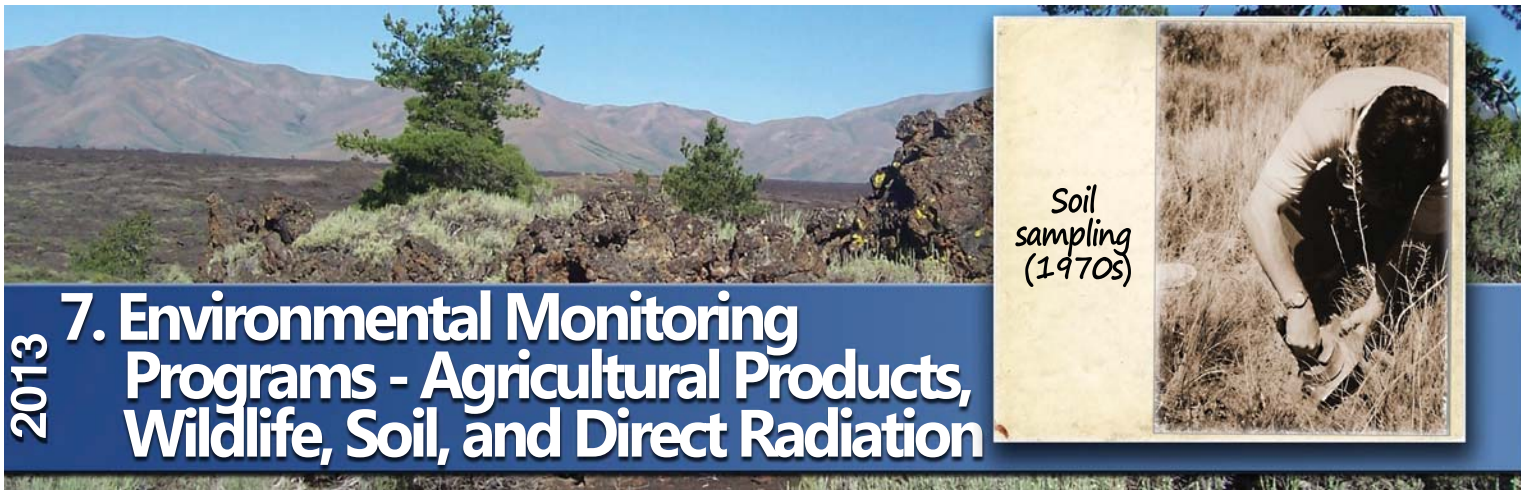
Header Photo Description: The U.S. Geological Survey has studied groundwater at the INL Site since its inception in 1949. The first well, USGS 1, was completed and monitored in December 1949. The U.S. Geological Survey initially was assigned to characterize area water resources. They have since maintained a groundwater quality and water level measurement program to support research and monitor the movement of radioactive and chemical constituents in the eastern Snake River Plain aquifer.



2013 7. Environmental Monitoring Programs - Agricultural Products, Wildlife, Soil, and Direct Radiation

Chapter 7 Highlights

Idaho National Laboratory (INL) Site-released radionuclides may be assimilated by agricultural products and game animals which humans may then consume. These media are thus sampled because of the potential transfer of radionuclides to people through food chains. Radionuclides may also be deposited on soils and can be measured on the surface with detectors or in the laboratory through radioanalysis of samples. Direct radiation measurements detect ionizing radiation in the environment.

Some human-made radionuclides were detected in agricultural products (milk, lettuce, alfalfa, and potatoes) collected in 2013. However, the results could not be directly linked to operations at the INL Site and are well below regulatory limits established for protection of human health.

Cesium-137 was detected in the liver of one of four road-killed mammals sampled in 2013 at a concentration well within historical and background measurements. Several human-made radionuclides (cobalt-60, zinc-65, strontium-90, cesium-137) were detected in some edible tissue samples of waterfowl collected on ponds at the INL Site. Concentrations of several of the manmade radionuclides were higher in waterfowl taken from ponds in the vicinity of the Advanced Test Reactor Complex than in control and other pond samples. The ducks most likely received the contamination while accessing the Advanced Test Reactor Complex ponds area. Results were generally higher than observed the past two years but significantly lower than in previous research studies.

Americium-241, plutonium isotopes, and strontium-90 were detected in crested wheatgrass samples collected at the Radioactive Waste Management Complex (RWMC) at levels consistent with or lower than those observed historically.

Soil samples were not collected off the INL Site and the RWMC in 2013. Cesium-137 was measured in all INL Site surface soils surveyed using an in-situ gamma detector. These measurements are performed annually at and around specific INL Site facilities. Areas of known contamination, from historic activities on the INL Site, had higher scan results than background levels, but consistent with historical measurements at those locations. Other areas showed results consistent with background levels from global fallout.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was

estimated to be 126 mrem at both boundary and distant locations. 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 RWMC were near background levels.

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

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2013. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014). The INL, Idaho Cleanup Project (ICP), and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of INL and ICP contractor monitoring is on the INL Site, particularly on and around facilities (Table 7-1). The ESER contractor's primary responsibility is to monitor the presence of contaminants in media off the INL Site which may originate from INL Site releases (Table 7-1).

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 3-1).

7.1.1 Milk

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows to milk, which is then ingested by humans. During 2013, the ESER contractor collected 140 milk samples at various locations off the INL Site (Figure 7-1) and from commercially-available milk from outside the state of Idaho. The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly in Idaho Falls and monthly at other locations around the INL Site. All samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine is an essential nutrient element and is readily assimilated by cows eating plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear reactors or weapons, is readily detected and, along with cesium-134 (^{134}Cs) and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event such as the Chernobyl

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

Area/Facility[a]	Media							
	Agricultural Products (milk, wheat, and potatoes)	Biota (waterfowl, large game animals)	Biota (vegetation)	CERCLA Ecological (Soil, sediment, water, Vegetation, and animals)	Soil	In-Situ Gamma Spectrometry (^{137}Cs in soil)	Direct Radiation (global positioning radiometric scanner)	Direct Radiation (TLD/OSLDs/Neutron dosimetry)
Environmental Surveillance, Education, and Research Program Contractor								
INL Site/Regional	•	•	•	•	•			•
Idaho National Laboratory Contractor								
CFA (WRP)				•				
INL Site						•		•
Regional								•
Idaho Cleanup Project Contractor								
RWMC			•		•		•	

a. CFA (WRP) = Wastewater Reuse Permit soil sampling at Central Facilities Area. INL Site = Idaho National Laboratory Site facility areas and areas between facilities.
RWMC = Radioactive Waste Management Complex.

accident (Kirchner 1994) or the 2011 accident at Fukushima in Japan. Iodine-131 has a short half-life (8 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. A small amount of ^{131}I (approximately 3.4 mCi in 2013) is still released by the Advanced Test Reactor (ATR) at the INL Site but is not detected in air samples collected at the INL Site boundary (Chapter 4). Iodine-131 was not detected in any milk sample during 2013.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly. It has a half-life of about 30 years and tends to persist in soil, and if in soluble form 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 facilities and resuspension of previously contaminated soil particles. Cesium-137 was not reported in any milk samples collected in 2013.

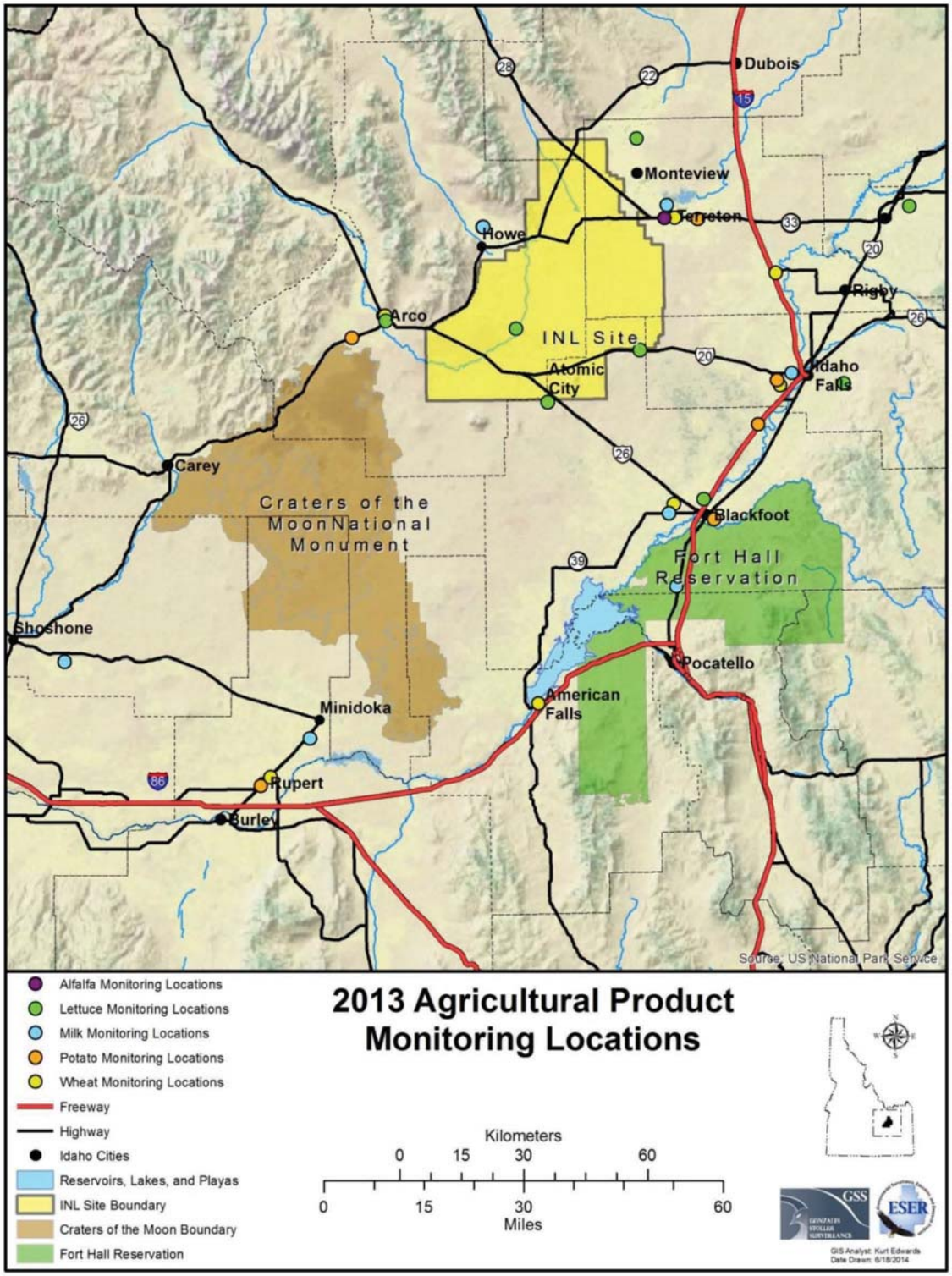


Figure 7-1. Locations of Agricultural Product Samples Collected (2013).

Strontium-90 is an important radionuclide because it behaves like calcium and can deposit in bones. Strontium-90, like ^{137}Cs, is produced in high yields from nuclear reactors or detonations of nuclear weapons. It has a half-life of 28 years and can persist in the environment. Strontium tends to form compounds that are soluble, compared to ^{137}Cs, and therefore comparatively mobile in ecosystems. Strontium-90 was detected in all of the 16 milk samples analyzed, including the two control samples from outside the state. Concentrations ranged from 0.68 pCi/L at Fort Hall to 2.37 pCi/L, also at Fort Hall (Figure 7-2). While the maximum value in 2013 is at the upper end of the range during the past five years shown in Figure 7-2, these levels were consistent with historical levels and with levels reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by cows through ingestion of grass. Results from EPA Region 10 (which includes Idaho) of a limited data set of ten samples collected over a 10-year period (2003-2012) ranged from 0 to 1.0 pCi/L (EPA 2014). Another measure of the consistency of the data is that the milk collected outside Idaho and the milk collected within Idaho both averaged 1.2 pCi/L during the year.

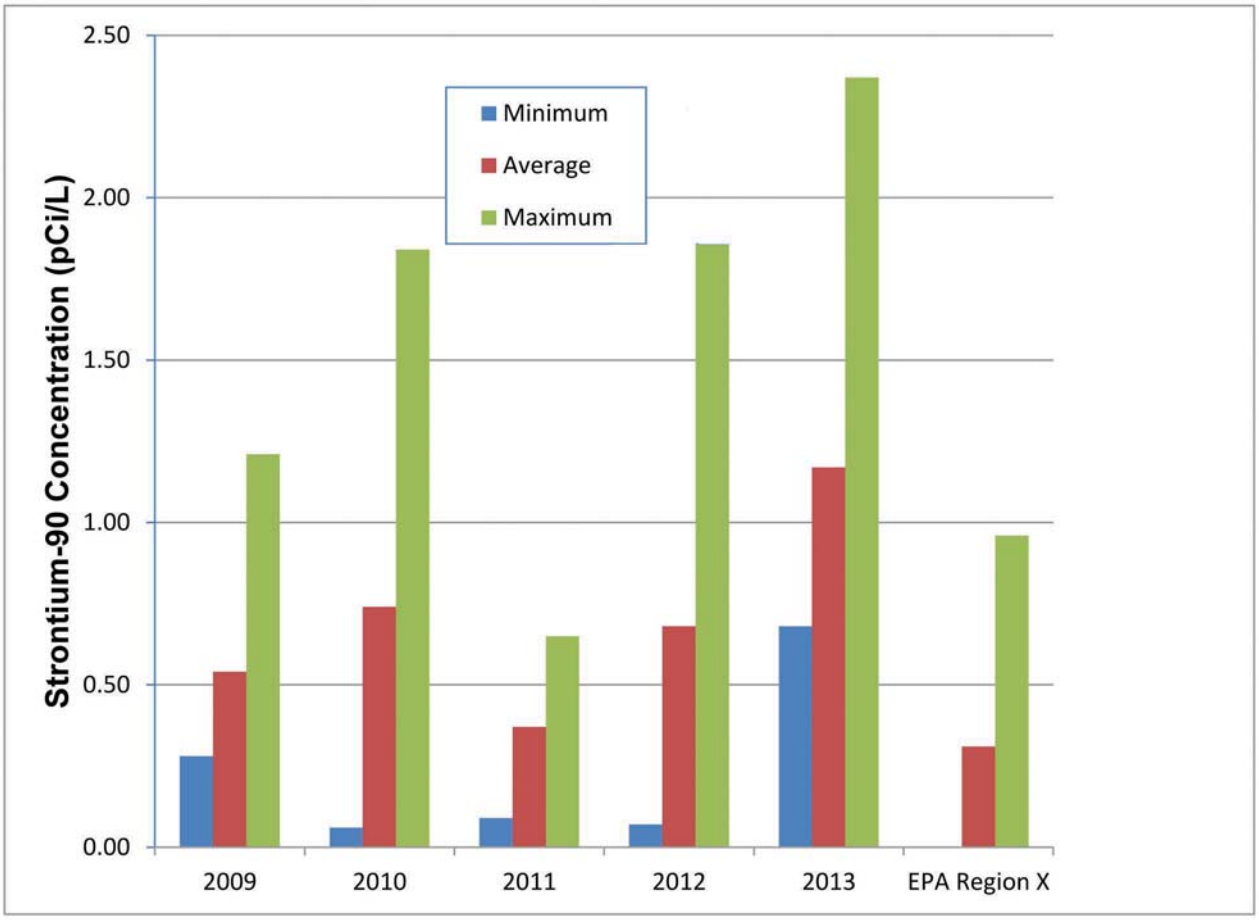


Figure 7-2. Strontium-90 Concentrations in Milk (2009 – 2013).

DOE has established Derived Concentration Standards (DCSs) for radionuclides in air and water. A DCS is the concentration of a radionuclide in air or water that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. There is no established DCS for foodstuffs such as milk. For reference purposes, the DCS for ^{90}Sr in water is 1,100 pCi/L. The maximum observed value in milk samples (2.37 pCi/L) is, therefore, approximately 0.2 percent of this DCS for drinking water.

Tritium, with a half-life of about 12 years, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The environmental behavior of tritiated water is like that of water, and it can be present in surface water, precipitation, and atmospheric moisture. Tritium is formed by natural processes, as well as by reactor operation and nuclear weapons testing. Tritium enters the food chain through surface water that animals drink, as well as from plants that contain water. Tritium was detected in 9 of 16 milk samples analyzed at concentrations ranging from 67 pCi/L in Dietrich to 204 pCi/L in Fort Hall. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in water is 19,000 pCi/L. The maximum observed value in milk samples is about 1.1 percent of the DCS.

7.1.2 Lettuce

Lettuce was sampled in 2013 because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 3-1). Uptake of radionuclides by plants may occur by root uptake from soil or absorption of deposited material on leaves. For most radionuclides, uptake by foliage is the dominant process for contamination of plants (Amaral et al. 1994). For this reason, green leafy vegetables like lettuce have higher concentration ratios of radionuclides to soil than other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site. The number and locations of gardens have changed from year to year depending on whether or not vegetables were available. Some home gardens were replaced with portable lettuce planters (Figure 7-3) because the availability of lettuce from home gardens was unreliable at some key locations. Also, the planters can be placed and lettuce collected at areas previously unavailable to the public, such as on the INL Site and near air samplers. The planters can allow radionuclides deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are placed in the spring, filled with soil, sown with lettuce seed, and self-watered through a reservoir.

Five lettuce samples were collected from portable planters at Arco, Atomic City, the Experimental Field Station, the Federal Aviation Administration Tower, and Monteview. In addition, samples were obtained from home gardens at Blackfoot, Idaho Falls, and Sugar City. A control sample from an out-of-state location was obtained, and a duplicate sample was collected at Sugar City. The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was detected in seven of the ten lettuce samples collected. The maximum ^{90}Sr concentration of 95 pCi/kg, measured in the lettuce sample from Atomic City, was in the middle of the range of concentrations detected in the past 5 years (0-164 pCi/kg). These results were most likely from fallout from past weapons testing and not INL Site operations. Strontium-90 is present in the environment as a residual of fallout from aboveground nuclear weapons testing, which

Figure 7-3. Portable Lettuce Planter.

occurred between 1945 and 1980. Figure 7-4 shows the average and range of all measurements (including those below detection levels) from 2009 through 2013. No other human-made radionuclides were detected in any of the lettuce samples. Although ^{137}Cs from nuclear weapons testing fallout is measureable in soils, the ability of vegetation such as lettuce to incorporate cesium from soil in plant tissue is much lower than for strontium (Fuhrmann et al. 2003; Ng et al. 1982; Schulz 1965). In addition, the availability of ^{137}Cs to plants depends highly on soil properties, such as clay content or alkalinity, which can act to bind the radionuclide (Schulz 1965). Soils in southeast Idaho tend to be moderately to highly alkaline. Strontium, on the other hand, has a tendency to form compounds that are comparatively soluble. These factors could help explain why ^{90}Sr was detected in lettuce and ^{137}Cs was not.

For more detail see http://www.or.nrcs.usda.gov/pnw_soil/id_reports.html.

7.1.3 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. The ESER contractor collected nine grain samples from areas surrounding the INL Site in 2013 and obtained one commercially-available sample from outside the state of Idaho. The locations were

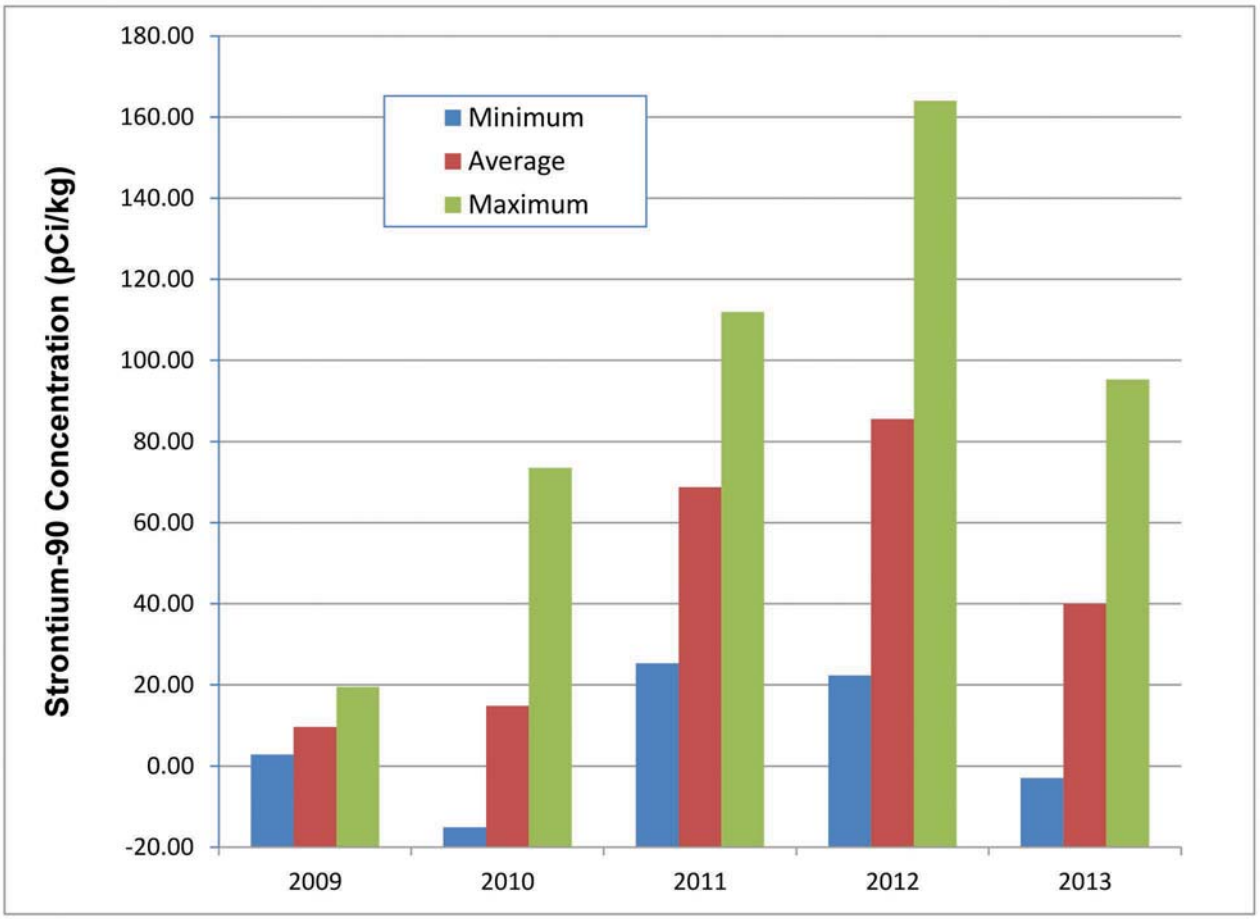


Figure 7-4. Strontium-90 Concentrations in Lettuce (2009 – 2013).

selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made, gamma-emitting radionuclides were found in any samples. None of the ten grain samples collected in 2013 contained detectable concentrations of ^{90}Sr either.

The concentrations of ^{90}Sr sometimes measured in grain are generally less than those measured in lettuce. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990). No other human-made radionuclides were detected in any of the samples. As discussed in Section 7.1.2, strontium in soil from fallout is more bioavailable to plants than cesium.

7.1.4 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because they are not exposed to airborne contaminants,

they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the ESER contractor at seven locations in the vicinity of the INL Site and obtained from one location outside eastern Idaho. None of the nine potato samples collected during 2013 contained a detectable concentration of any human-made, gamma-emitting radionuclides. Strontium-90 was detected in one sample from Shelley at a concentration of 35.7 pCi/kg. This radionuclide is present in the soil as a result of worldwide fallout from nuclear weapons testing, but it is only occasionally detected in potato samples. This is because potatoes, like grain, are generally less efficient at removing radioactive elements from soil than leafy vegetables such as lettuce.

7.1.5 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. This was in response to the DOE Headquarters Independent Oversight Assessment of the Environmental Monitoring program at the INL conducted during that year. The assessment team commented, with reference to the milk sampling program, that the ESER contractor should consider sampling locally grown alfalfa offsite, along with collection of alfalfa usage data. Questionnaires were sent to each milk provider concerning what they feed their cows. All of the dairies feed their cows locally-grown alfalfa. A sample of alfalfa was collected in June from a location in the Mud Lake/Terreton area, the agricultural area where the highest potential offsite air concentration was calculated by the National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (see Figure 8-5). (Note: The highest offsite air concentration used for estimating doses was located south of the INL Site; however, there is no agriculture conducted there.) The sample was divided into three subsamples and analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made gamma-emitting radionuclides were detected in any of the subsamples. Strontium-90 was found in one of the three subsamples at a level just above the detection limit. The measured value of 106 pCi/kg is similar to results from the first two years of sampling and similar to typical concentrations in lettuce.

7.1.6 Large Game Animals

Muscle samples were collected by the ESER contractor from four game animals (two pronghorn, one mule deer, and one elk) accidentally killed on INL Site roads. Liver and thyroid samples were also obtained from three of the animals. The samples were analyzed for ^{137}Cs because it is an analogue of potassium and is readily incorporated into muscle and organ tissues. Thyroids were analyzed for iodine-131 because when assimilated by higher animals, it selectively concentrates in the thyroid gland and is, thus, an excellent bioindicator of atmospheric releases.

No ^{131}I was detected in any of the thyroid samples. No ^{137}Cs or other human-made gamma-emitting radionuclides were found in any of the muscle samples. Cesium-137 was detected in one of the liver samples at a concentration of 7.62 pCi/kg.

In 1998 and 1999, four pronghorn, five elk, and eight mule deer muscle samples were collected as background samples from hunters across the western United States, including three from central Idaho, three from Wyoming, three from Montana, four from Utah, and one each

from New Mexico, Colorado, Nevada, and Oregon (DOE-ID 1999). Each background sample had small, but detectable, ^{137}Cs concentrations in its muscle. These concentrations likely can be attributed to the ingestion of plants containing radionuclides from fallout associated with aboveground nuclear weapons testing. Allowing for radioactive decay since the time of the study, background measurements would be expected to range from about 4 to 11 pCi/kg in 2013. With the exception of an immature deer sampled in 2008 that had elevated ^{137}Cs concentrations, all detected values have been between about 4 and 11 pCi/kg.

7.1.7 Waterfowl

Waterfowl are collected each year by the ESER contractor at ponds on the INL Site and at a location off the INL Site. Eight ducks were collected during 2013: three each from the ATR Complex wastewater ponds and the Materials and Fuels Complex (MFC) wastewater ponds, and two from a control location near American Falls Reservoir. Each sample was divided into the following three subsamples: (1) edible tissue (muscle, gizzard, heart, and liver), (2) external portion (feathers, feet, and head), and (3) all remaining tissue. All samples were analyzed for gamma-emitting radionuclides, ^{90}Sr, plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). These radionuclides were selected because they are often measured in liquid effluents from some INL Site facilities (Chapter 5).

A total of seven human-made radionuclides were detected in the samples from at least one of the ducks collected at the ATR Complex ponds. These included ^{241}Am, ^{137}Cs, cobalt-60 (^{60}Co), ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, and zinc-65 (^{65}Zn). Strontium-90 was also detected in the external and remainder portions of ducks from MFC. No human-made radionuclides were found in either of the control ducks.

Cesium-137, ^{60}Co, ^{90}Sr, and ^{65}Zn were also found in the edible tissue portions of two of the ATR Complex ducks (Figure 7-5). No human-made radionuclides were found in any edible tissues of ducks from MFC or the control samples. Because most of the detected human-made radionuclides were found in ducks from ATR Complex and not at other locations, it is assumed that the evaporation pond associated with this facility is the source of these radionuclides. The ducks were not taken directly from the two-celled hypalon-lined radioactive wastewater evaporation pond, but rather from an adjacent sewage lagoon. However, the ducks probably also spent time at the evaporation pond. It is most likely that the source of the radionuclides is sediment, which acts as a sink for contaminants.

Concentrations were generally higher in 2013 than in 2012 and 2011, but similar to 2010. These vary somewhat based on the length of time the ducks have been present on the ponds at the time of collection. Concentrations were much lower than those reported in ducks during a study conducted during the 1990s (Warren et al. 2001). Potential doses from consuming these ducks are discussed further in Chapter 8.

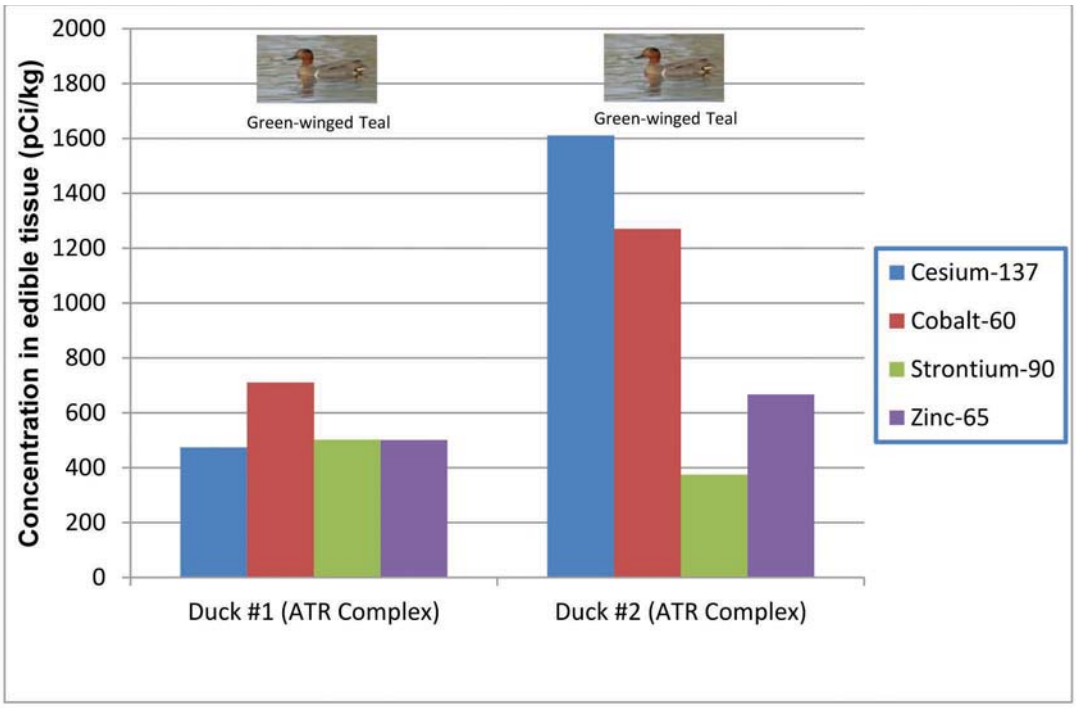


Figure 7-5. Radionuclide Concentrations Detected in Tissues of Waterfowl (2013).

7.2 Soil Sampling and In Situ Gamma Spectrometry

7.2.1 Soil Sampling off the INL Site

Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world via atmospheric deposition. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am are radionuclides that may be detected in soil because of global fallout but could also be present from INL Site operations. These radionuclides are of particular interest because of their abundance resulting from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment due to long half-lives (e.g., $^{239/240}$Pu, with a half-life of 24,110 years). Soil samples are collected by the ESER contractor every two years (in even-numbered years). Soil sampling locations are shown in Figure 7-6. A new location was added in 2010 at Frenchman's Cabin located at the southern boundary of the INL Site. This location has been the site of the maximally exposed individual for EPA dose calculations performed to comply with EPA requirements during recent years (see Chapter 8). Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium radionuclides.

Soil was last sampled by the ESER contractor in 2012 and the results were reported in the calendar year 2012 ASER.

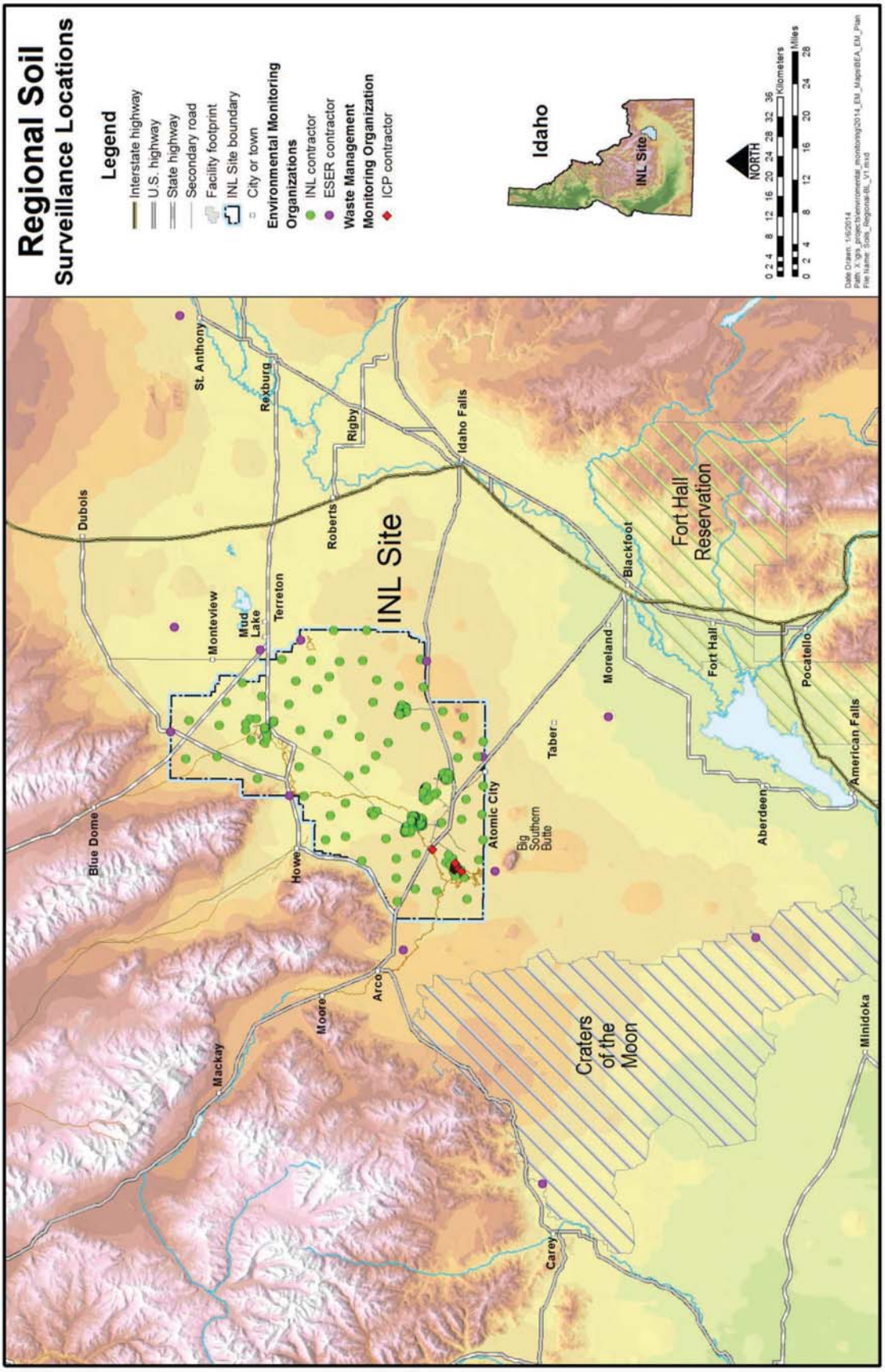


Figure 7-6. Soil Sampling Locations.

7.2.2 Wastewater Reuse Permit Soil Sampling at Central Facilities Area

The Idaho Department of Environmental Quality (DEQ) issued a permit for the CFA Sewage Treatment Plant on March 17, 2010. The permit required soil sampling in the wastewater land application area in 2013. Soil samples were collected in accordance with the Wastewater Reuse Permit (http://www.deq.idaho.gov/media/510634-inl_cfa_idaho_falls_wwreuse_permit_renewal_final_0310.pdf). Data collected in 2013 are presented in Table 7-2 along with the data for 2009 and 2010 for comparison.

DEQ guidance (DEQ 2007) states that "bacteria that decompose organic matter function best at a pH range between 6.5 and 8.5." The 2013 soil pH for all soil depths was within this range (Table 7-2).

Excessive salts can adversely affect soil and plant health. Conversely, low to moderate salinity, measured as electrical conductivity, may actually improve the physical conditions of some soils. Currently, the soil salinity in the application area is below the 6-mmhos/cm level expected to result in a decrease in relative growth of crested wheatgrass (Blaylock 1994) and sagebrush (Swift 1997).

Soils with sodium adsorption ratios below 15 and electrical conductivity levels below 2 mmhos/cm are generally classified as not having sodium or salinity problems (Bohn et al. 1985). The sodium adsorption ratio indicates the exchangeable sodium levels in soil. Soils with high exchangeable sodium levels tend to crust badly or disperse, which greatly decreases soil hydraulic conductivity. All sodium adsorption ratios remained below 4 at all depth intervals. DEQ guidance (DEQ 2007) states, "For most crops grown on land treatment sites, soil sodium adsorption ratios of less than ten are acceptable."

The nitrogen data in Table 7-2 suggest negligible nitrogen accumulation from wastewater application. The low soil-available nitrogen (ammonium and nitrate) concentrations suggest that sagebrush and grass vegetation use all the plant-available nitrogen and that the total nitrogen application is low. Increased nutrients and water from wastewater application may be stimulating plant growth, which in turn rapidly uses plant-available nitrogen. The ammonium and nitrate concentrations are comparable to those of nonfertilized agricultural soils.

DEQ guidance (DEQ 2007) recommends that total phosphorus should be less than 30 ppm (Olsen method used in these analyses) in the 24–36-in. soil depth to ensure there are no groundwater contamination concerns. Table 7-2 shows the phosphorus concentrations are well below the level of concern at all depths.

7.2.3 In-Situ Gamma Spectrometry

In-situ gamma spectrometry using portable high purity germanium detectors is a technique that measures the gamma-ray fluence rate from a gamma-emitting source for the purpose of obtaining the activity or concentration of radioactive materials (Shebell et al. 2003). The most common application of in-situ gamma-ray spectrometry has been the measurement of gamma-emitting radionuclides, such as ^{137}Cs, in surface soils. The technique is a rapid and cost

Table 7-2. Soil Monitoring Results for the CFA Sewage Treatment Facility Wastewater Reuse Permit Area (2009, 2010, and 2013).

Parameter	Depth (in.)	2009	2010	2013
pH	0 – 12	8.26	7.97	8.05
	12 – 24	7.95	7.85	8.07
	24 – 36	8.05	7.85	8.05
Electrical conductivity (mmhos/cm)	0 – 12	0.675	1.091	0.356
	12 – 24	2.49	2.66	1.281
	24 – 36	1.937	2.59	1.516
Organic matter (%)	0 – 12	1.51	1.72	1.43
	12 – 24	0.655	0.828	0.814
	24 – 36	0.424	0.603	0.521
Nitrate as nitrogen (ppm)	0 – 12	1.62	1.41	3.17
	12 – 24	0.998 U[a]	1.02 U	0.980 U
	24 – 36	0.996 U	1.01 U	0.958 U
Ammonium nitrogen (ppm)	0 – 12	0.818	0.512 U	1.08
	12 – 24	0.499 U	0.508 U	0.517 U
	24 – 36	0.498 U	0.507 U	0.516 U
Extractable phosphorus (ppm)	0 – 12	7.77	15.4	8.88
	12 – 24	1.72	3.64	3.17
	24 – 36	1.28	4.34	1.66
Sodium adsorption ratio	0 – 12	3.83	4.32	2.44
	12 – 24	4.19	5.1	3.97
	24 – 36	2.5	4.62	3.07

a. U flag indicates that the result was reported as below the detection limit.

effective way to assay surface soil for gamma-emitting radionuclides, especially as part of site characterization. Results in this report are those that were true positive detects. This means that the reported isotopic concentration was greater than three times the reported uncertainty for that isotope.

The INL contractor performed 50 field-based gamma spectrometry measurements in 2013 using several HPGe detector measurement systems based on the methodology described in the Environmental Measurements Laboratory Procedures Manual (DOE 1997). A summary of 2013 measured results, historical mean background values, and 99 percent upper threshold values based on grab sampling is presented in Table 7-3. Positive detect ^{137}Cs concentrations are reported for most measurement locations except at the collocated air monitoring stations

Table 7-3. In-Situ Gamma Scan Results for INL Site Locations (2013) (all values in pCi/g).

Location/Positive Detection	Number of Observations	Minimum	Maximum	Mean	INL Mean[a]	95 percent/99 percent UTL[a,b] Background Value
ARA Cs-137	7	0.07	1.94	0.92	0.44	1.61
CITRC Cs-137	2	0.15	0.19	0.17	0.44	1.61
INTEC Cs-137	5	1.68	3.72	2.40	0.44	1.61
Air Monitors Cs-137	7	0.07	1.29	0.31	0.44	1.61
MFC Cs-137	3	0.12	0.23	0.16	0.44	1.61
NRF Cs-137	2	0.18	0.33	0.26	0.44	1.61
ATR Complex Cs-137	7	0.20	0.61	0.35	0.44	1.61
RWMC Am-241	3	4.8	15.3	8.6	0.005	0.025
RWMC Cs-137	8	0.19	0.96	0.41	0.44	1.61
TAN-SMC Cs-137	3	0.04	0.38	0.23	0.44	1.61

a. INL Mean background and upper tolerance limit (UTL) values are from INEL-94/0250, Rev 1. August 1996. "Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations at the Idaho National Engineering Laboratory" (Rood, et al. 1996).
b. 95%/99% UTL values give 95% confidence of encompassing the smallest 99% of the background concentrations.

(Blackfoot, Gate 4, TAN, Highway 20 Rest Area and Rexburg). Appendix D shows facility maps with the positive detect values. At Radioactive Waste Management Complex (RWMC), positive detect values of ^{241}Am were noted at three locations along the east and north boundary areas. These values are likely due to the shine from aboveground waste storage and disposal operations sites as noted in previous years. Additional in situ evaluations are being planned using collimators (shielding) to determine whether the positive detects of ^{241}Am are from "shine" or soil contamination. Eight elevated ^{137}Cs values were also noted. At ATR Complex, six locations showed very low concentrations (positive detects) of ^{137}Cs. INTEC results showed six positive detects for ^{137}Cs. At Auxiliary Reactor Area (ARA), seven positive detects for ^{137}Cs were noted. Two positive detects for ^{137}Cs were noted at Critical Infrastructure Test Range Complex (CITRC). For the points located at air monitoring locations, seven positive detects for ^{137}Cs were noted. At MFC three positive detects were noted for ^{137}Cs. At TAN-SMC, there were three ^{137}Cs positive detects, and at NRF there were also three positive detects for ^{137}Cs.

Although some of the measured concentrations of the anthropogenic radionuclides exceed the 95 percent/99 percent Upper Concentration Limit, the values are consistent with levels observed in the past. Additionally, the locations of the positive detections are typically near existing operational facilities, such as INTEC and the ATR Complex, and the activity is attributed to historical releases. Other positive detections occurred near inactive facilities, or facilities that have been removed such as Auxiliary Reactor Area and TAN, and are attributed to residual contamination from historical releases.

The anthropogenic radionuclides detected in INL Site soils in 2013 included ^{137}Cs, ^{134}Cs, ^{60}Co, and ^{241}Am. Cesium-137 has a half-life of 30.2 years and originates as a fallout fission product from nuclear weapons testing or from past effluent or stack releases. Cesium-137 is strongly retained on clay soils, which limits plant uptake and it is not readily soluble in fresh water. Cesium-137 human metabolism resembles that of potassium, so it can be uniformly distributed in the body. The mean background concentration of ^{137}Cs at the INL is documented to be 0.44 pCi/g and the upper threshold limit is 1.61 pCi/g based on results from historical grab sampling of soils. Cesium-134 is an activation product produced in nuclear reactors and has a half-life of 2.1 years. Cobalt-60 is also an activation product produced in reactors and has a half-life of 5.3 years. Americium-241 is a decay product of ^{241}Pu and has a half-life of 432 years. Americium-241 does not occur in nature; however, some americium may be found in the environment as the result of atmospheric testing of nuclear weapons and disposal of wastes.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures in air (in milliRoentgen or mR) to ambient ionizing radiation. TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. TLDs are sensitive to beta energies greater than 200 kilo-electron volts (keV) and to gamma energies greater than 10 keV. The TLD packets contain four lithium fluoride chips and are placed about 1 m (about 3 ft) above the ground at specified locations (Figure 7-7). The four chips provide replicate measurements at each location.

Beginning with the May 2010 distribution of dosimeters, the INL contractor began using optically stimulated luminescence dosimeters (OSLDs) collocated with the traditional TLDs. Similar to TLDs, OSLDs measure the ambient dose equivalent (in mrem).

InLight® OSLDs, manufactured and analyzed by Landauer Inc., were used by the INL contractor in 2013. Each OSLD contains four aluminum oxide detectors that are sensitive to ionizing radiation ranging in energy from 5 keV to 20 MeV, with a minimum ambient dose equivalent reporting of 5 mrem. The primary advantage of the OSLD technology to 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 sampling periods for 2013 were from November 2012 to November 2013 with only OSLDs being deployed.

The 2013 results for OSLDs collected by the INL contractor are provided in Appendix D. Locations of the dosimeters maintained on the INL Site are shown in Figures D-10 through D-19. The results for these locations are displayed in the figures. Historical TLD measurements were reported in units of exposure (mR), while OSLD data are reported in units of ambient dose equivalent (mrem).

Dosimeters on the INL Site are placed at facility perimeters, concentrated in areas likely to show the highest gamma radiation readings. Other dosimeters on the INL Site are located near

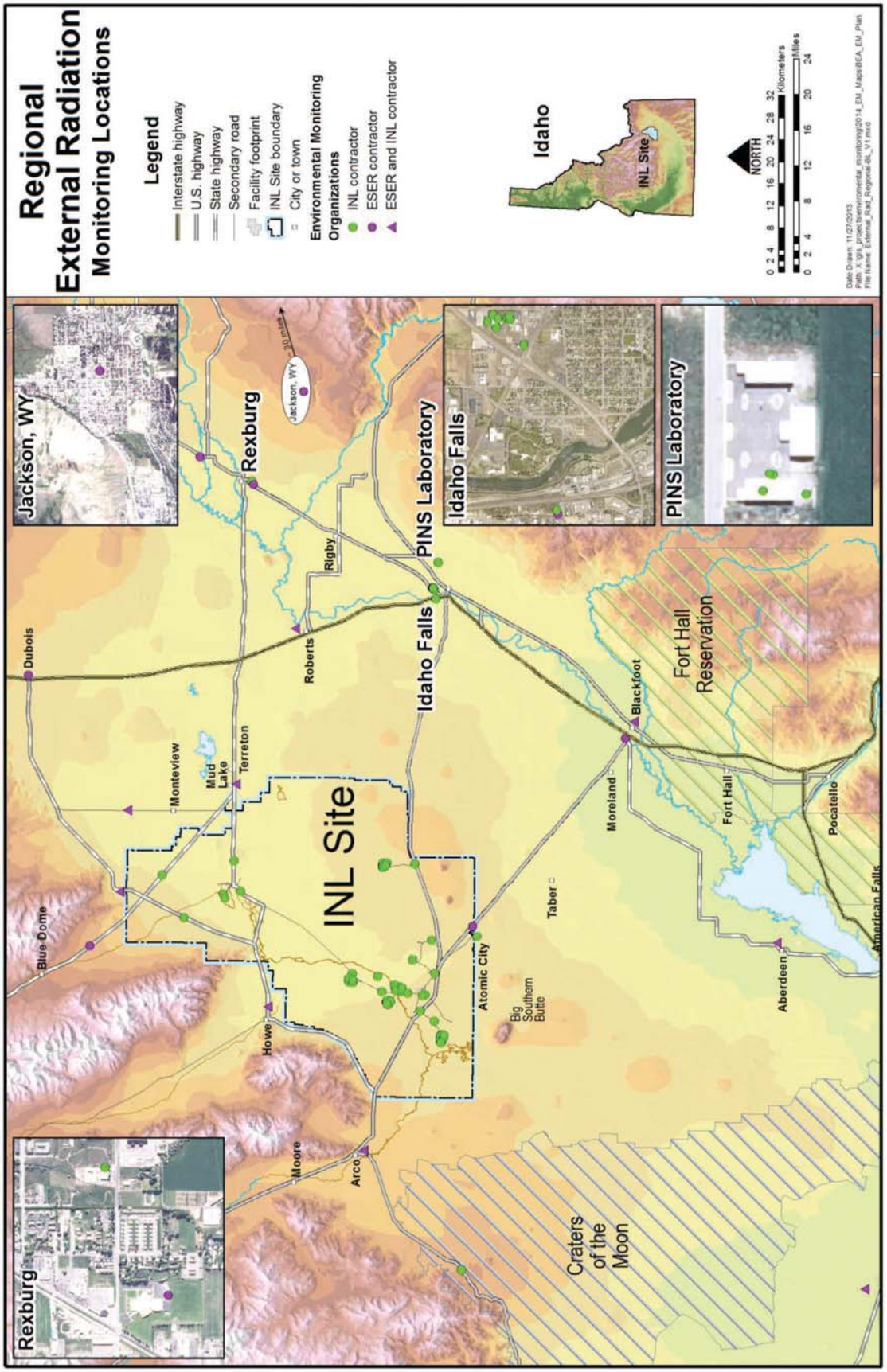


Figure 7-7. Regional Direct Radiation Monitoring Locations.

radioactive materials storage areas and along roads. For decades, the number and locations of INL Site area dosimeters have been relatively constant; however, factors affecting potential exposures have changed. These changes include a reduced number of operating nuclear reactors, personnel, and waste shipments; numerous buildings and facilities have undergone decontamination and demolition; and radionuclide-contaminated ponds and soil areas have been remediated. Because of these changes and because years of TLD exposures at many established locations were equivalent to natural background, the INL contractor reduced the number of INL Site TLD locations while ensuring area exposures are still being measured. Additional monitoring locations have been added near select Research and Education Campus facilities in Idaho Falls. These locations include IF-627, which is the Systems Analysis Facility, IF-603 IRC Laboratory Building, IF-638 the IRC Physics Lab, and IF-6751, which is the Portable Isotopic Neutron Spectroscopy facility. For the purposes of environmental monitoring, the Idaho Falls Facilities are collectively referred to as the "INL REC Group."

The OSLDs placed in November 2012 were collected in November 2013. The OSLD's are received from the manufacturer in Glenwood, Illinois. After the field monitoring period they are returned for analysis. The dose received during transport (transit dose) has been subtracted from the reported dose. The 2013 reported values were primarily below 150 mrem which is the upper range of historical background. There were three on-site measurements above 150 mrem with the maximum on-site measurement of 177.3 mrem at location RWMC-O41, Figure D-17. This location is near controlled radioactive material areas where movement and storage of materials affect the exposure rate. No off-site measurements were above 150 mrem.

Duplicate neutron dosimeters were placed at the PINS laboratory in Idaho Falls and one background location in May 2013 with the plan to collect them at 3-month, 6-month and 12-month increments. The results from the 3-month deployment collected in August (five dosimeters and two controls) indicated damage to four of the dosimeters making them unreadable. The three undamaged neutron dosimeters were reported as "M" (dose equivalents below the minimum measurable quantity of 10 mrem). This high damage rate led us to determine that in November we should collect the planned 6-month and 12-month neutron dosimeters and replace them with a 2-month deployment. The reason for this revision was an attempt to get successful neutron results for 2013. The results from the 16 badges collected in November indicate damage to seven dosimeters making them unreadable. Nine undamaged neutron dosimeters were reported as "M" (dose equivalents below the minimum measurable quantity of 10 mrem). One additional neutron dosimeter was added in proximity to IF-638 (IRC Physics Lab) during the November change out. All neutron dosimeters were collected on January 6, 2014. All seven badges were reported "M" (dose equivalents below the minimum measurable quantity of 10 mrem). The INL contractor is following the recommendations of the dosimetry provider to attempt to prevent environmental damage to the neutron dosimetry by wrapping each with aluminum foil. To keep the foil intact, the badge is inserted into a cloth pouch when deployed. Reassessment of the path forward for measuring neutron dose is continuing.

The ESER contractor deployed OSLDs in November 2011 and ran a side-by-side field comparison with TLDs during 2012 and 2013. Idaho State University also conducted a laboratory

study, as well as analyzed results from the field study for the ESER contractor. The purpose of these studies was to investigate the feasibility of replacing TLDs exclusively with OSLDs.

The measured cumulative environmental radiation exposure in milliroentgens (mR) for locations off the INL Site from November 2012 through October 2013 is shown in Table 7-4 for TLDs maintained by the ESER contractor. For purposes of comparison, annual exposures for both the ESER and INL contractors from 2009 through 2012 also are included for each location. Table 7-5 shows the cumulative radiation doses measured using OSLDs for both the ESER contractor and INL contractor for 2013. Available data for the two previous years are also included for comparison purposes.

The mean annual exposure measured using TLDs from both distant and boundary locations in 2013 was 122 mR. The average annual dose equivalent resulting from external exposure was estimated by converting the exposure measured in free air (mR) to dose equivalent (in mrem) by the factor of 1.03 reported for ^{137}Cs radiation by ANSI (1983). The average annual dose was thus estimated to be 126 mrem.

Using OSLDs, the mean annual ambient dose for distant locations was estimated at 108 mrem for the ESER contractor and 101 mrem for the INL contractor. For boundary locations, the mean annual ambient doses were 104 mrem (ESER contractor) and 97 mrem (INL contractor). Using the data for both contractors and both sample groups the overall average ambient dose measured by OSLDs was 103 mrem in 2013.

Table 7-6 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (cosmic and terrestrial). This table includes the latest recommendations of the National Council on Radiation Protection and Measurements (NCRP) in *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009).

The terrestrial natural background radiation exposure estimate is based on concentrations of naturally occurring radionuclides found in soil samples collected from 1976 through 1993, as summarized by Jessmore et al. (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicated the average concentrations of ^{238}U, thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2013, this resulted in a reduction in the effective dose from soil to a value of 72 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 about 57 mrem. Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Table 7-4. Annual Environmental Radiation Exposures Using TLDs (2009 – 2013).

Location	2009		2010		2011		2012		2013	
	ESER[a]	INL[b] Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor
	(mR)									
Distant Group										
Aberdeen	130	128	130	133	126	128	129	135	129	NA
Blackfoot[c]	110	NA	113	NA	112	NA	120	NA	119	NA
Craters of the Moon	120	125	121	135	119	118	122	136	122	NA
Dubois[c]	103	NA	104	NA	100	NA	107	NA	109	NA
Idaho Falls	120	121	124	121	124	118	127	133	125	NA
Jackson[c]	102	NA	102	NA	101	NA	102	NA	104	NA
Minidoka	111	111	114	119	116	115	115	129	121	NA
Mountain View	122	113	120	114	121	114	113	124	114	NA
Rexburg	138	118	152	128	138	124	150	135	153[d]	NA
Roberts	130	130	--[e]	143	134	133	139	149	138	NA
Mean	119	121	120	126	119	121	122	134	122	NA
Boundary Group										
Arco	121	124	128	129	130	130	126	134	128	NA
Atomic City	122	120	127	122	121	123	132	132	129	NA
Birch Creek Hydro	112	113	--[f]	NA	109	112	113	119	115	NA
Blue Dome[c]	107	NA	105	NA	105	NA	107	NA	109	NA
Howe	116	117	117	119	111	114	122	127	122	NA
Monteview	116	119	119	128	112	116	122	131	118	NA
Mud Lake	130	135	134	138	134	132	138	142	134	NA
Mean	118	121	122	127	116	121	123	131	122	NA

a. ESER = Environmental Surveillance, Education, and Research.
b. INL = Idaho National Laboratory.
c. The INL contractor does not sample at this location.
d. Dosimeter was moved to Sugar City in July 2013.
e. Dosimeter was missing at one of the collection times.
f. Reader malfunctioned during measurement of dosimeter.

Table 7-5. Annual Environmental Radiation Doses Using OSLDs (2011 – 2013).

Location	2011[a]		2012[a]		2013	
	ESER[b]	INL[c] Contractor	ESER	INL Contractor	ESER	INL Contractor
	mrem					
Aberdeen	NA	140	115	134	113	110
Blackfoot[d]	NA	NA	113	NA	107	NA
Craters of the Moon	NA	131	108	143	100	104
Dubois[d]	NA	NA	96	NA	90	NA
Idaho Falls	NA	113	117	136	113	96
Jackson[d]	NA	NA	88	NA	81	NA
Minidoka	NA	131	101	127	99	96
Mountain View	NA	117	102	130	103	90
Rexburg	NA	126	135	139	140[e]	99
Roberts	NA	157	135	147	125	113
Mean	NA	131	111	137	108	101
Arco	NA	137	117	132	112	97
Atomic City	NA	120	119	130	112	101
Birch Creek Hydro	NA	125	105	118	96	91
Blue Dome[d]	NA	NA	96	NA	86	NA
Howe	NA	135	112	--[f]	104	88
Monteview	NA	120	110	132	100	91
Mud Lake	NA	147	122	137	115	116
Mean	NA	131	112	130	104	97

a. INL contractor measurements for 2011 and 2012 do not have transit dose subtracted. See Section 7.3 for further details.
b. ESER = Environmental Surveillance, Education, and Research.
c. INL = Idaho National Laboratory.
d. The INL contractor does not sample at this location.
e. Dosimeter was moved to Sugar City in July 2013.
f. Dosimeter missing at collection time.

Table 7-6. Calculated Effective Dose from Natural Background Sources (2013).

Source of Radiation Dose	Total Average Annual Dose	
	Calculated (mrem)	Measured[a] (mrem)
External irradiation		
Terrestrial	72[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	129	126
Internal irradiation (primarily ingestion)[e]		
Potassium-40	15	
Thorium-232 and uranium-238	13	
Others (carbon-14 and rubidium-87)	1	
Internal irradiation (primarily inhalation)[d]		
Radon-222 (radon) and its short-lived decay products	212	
Radon-220 (thoron) and its short-lived decay products	16	
Total	386	

a. Calculated by converting the average annual external exposure (122 mR) measured by the ESER contractor at distant locations to dose equivalent (mrem) using a conversion factor of 1.03 (ANSI 1983).
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 thermoluminescent devices.
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.

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 2013 was estimated to be 129 mrem/yr. This is only slightly higher than the 126 mrem/yr measured at offsite locations by the ESER contractor using TLD data. Measured values are very close, and within normal variability, of the calculated background doses. Therefore, it is unlikely that INL Site operations contributed to background radiation levels at distant locations in 2013.

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 of the area. The amount of radon also varies among buildings of a given geographic

area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-4 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 U.S. was reported in NCRP Report No. 160 to be 29 mrem/yr (NCRP 2009).

With all of these contributions, the total background dose to an average individual living in southeast Idaho was estimated to be approximately 386 mrem/yr (Table 7-6). This value was used in Table 8-4 to calculate background radiation dose to the population living within 50 miles of INL Site facilities.

7.4 Waste Management Surveillance Sampling

Vegetation and soil are sampled, and direct radiation is measured at RWMC to comply with DOE Order 435.1, “Radioactive Waste Management” (2001).

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, vegetation is collected from four major areas (see Figure 7-8) (due to construction, vegetation was not available in RWMC Area 4) and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Crested wheatgrass and perennials (invasive species) are collected in odd-numbered years if available. Therefore, crested wheatgrass was collected in 2013; however, there were not enough perennials (rabbit brush) to collect.

Table 7-7 shows the radiochemistry results of the crested wheatgrass samples. The ^{241}Am and $^{239/240}$Pu detections are consistent with previous results of past sampling events. The ^{90}Sr results also are consistent with previous results and are at or near the background level of the control location. No human-made gamma-emitting radionuclides were identified in crested wheatgrass samples collected.

7.4.2 Soil Sampling at the Radioactive Waste Management Complex

The ICP contractor samples soil every three years. The triennial soil sample was previously collected in 2012, and the next samples will be collected in 2015.

7.4.3 Direct Radiation at the Radioactive Waste Management Complex

A vehicle-mounted global positioning radiometric scanner was used to conduct soil surface radiation (gross gamma) surveys at the SDA to complement soil sampling. The system utilizes a Trimble Global Positioning System and two plastic scintillation detectors connected to a personal computer on board the vehicle. The global positioning radiometric scanner system data are differentially corrected and transmitted via satellites, and geographic coordinates (latitude and longitude) are recorded at least every two seconds. The vehicle was driven less than or equal to five miles per hour, with the detector height at 36 in. above the ground.

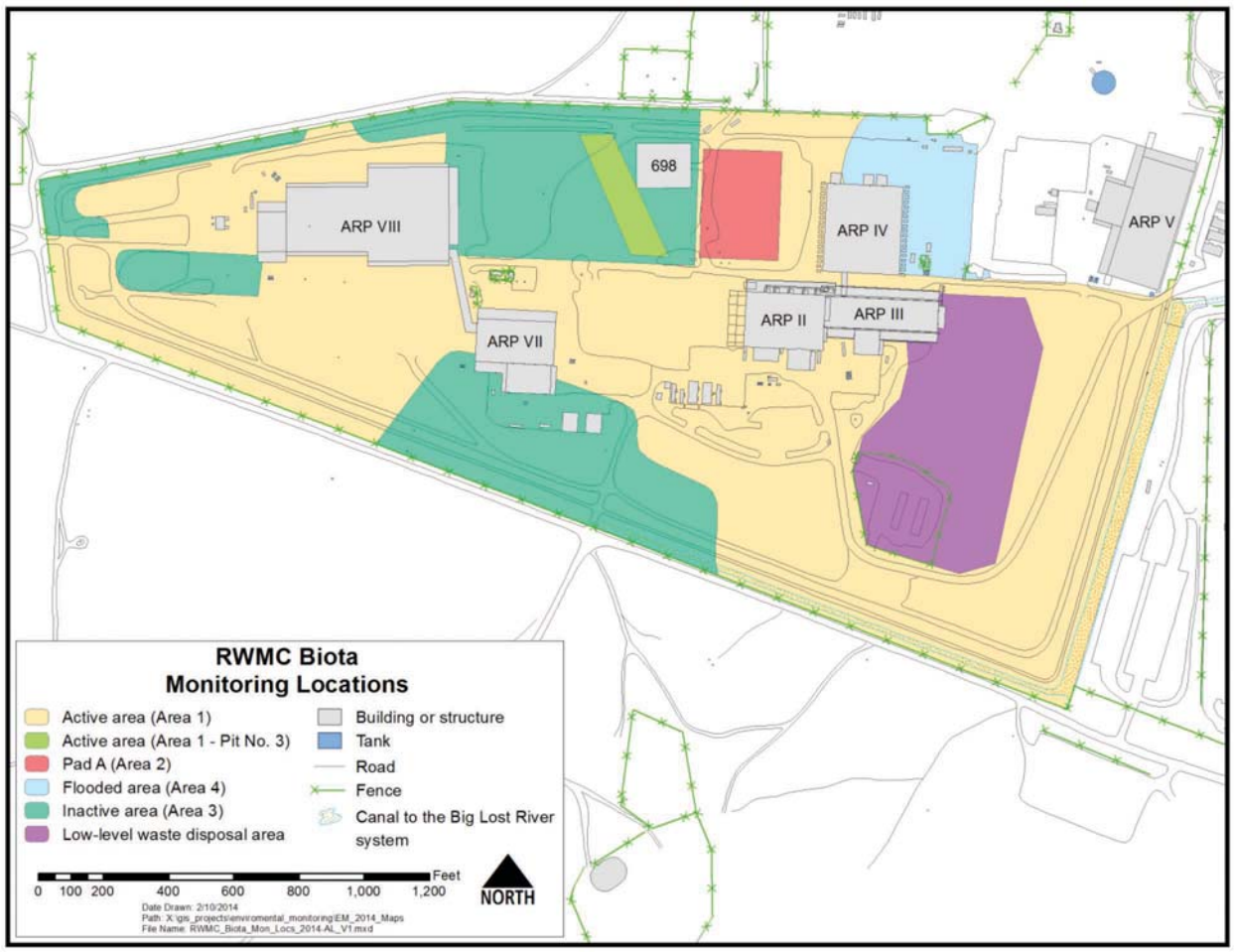


Figure 7-8. Four Vegetation Sampling Areas at the RWMC.

Figure 7-9 shows the radiation readings from the 2013 annual survey. Although readings vary slightly from year to year, the 2013 results for most areas are comparable to previous years' measurements. The active low-level waste pit was covered during 2009, and as a result of the reduced shine, elevated measurements from the buried waste in pits and trenches are more visible. In 2013, the maximum gross gamma radiation measurement on the SDA was 16,337 counts per second, compared to the 2012 measurement of 14,950. The maximum readings generally have been measured at the western end of the SVR-7 soil vault row. In 2013, results were near background levels in the area next to WMF-698, compared to 2012 when they were slightly above background levels. These reduced results are due to the removal of radioactive material.

Table 7-7. Radiochemistry Maximum Results of Vegetation Samples at the RWMC.

	Am-241 (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)	Sr-90 (pCi/g)
Crested Wheatgrass				
RWMC Area 1[a]	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	$(6.25 \pm 1.46) \times 10^{-3}$
RWMC Area 2[a]	$(1.10 \pm 0.10) \times 10^{-2}$	Undetected (sample value <3 sigma)	$(3.83 \pm 0.41) \times 10^{-3}$	$(8.31 \pm 2.17) \times 10^{-3}$
RWMC Area 3[a]	$(4.01 \pm 0.43) \times 10^{-3}$	Undetected (sample value <3 sigma)	$(1.10 \pm 0.02) \times 10^{-3}$	$(2.90 \pm 0.41) \times 10^{-2}$
Frenchman's Cabin (control)[a]	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	$(2.69 \pm 0.88) \times 10^{-4}$	$(6.66 \pm 1.26) \times 10^{-3}$

a. Collected November 12, 2013.

7.5 CERCLA Ecological Monitoring

Ecological monitoring at the INL Site was conducted in accordance with the Record of Decision for Operable Unit 10-04 (DOE-ID 2002) developed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq., 1980). The selected remedy was no action with long-term ecological monitoring to reduce uncertainties in the INL Site-wide ecological risk assessment.

Yearly sampling and surveys occurred from 2003 through 2008 to characterize contaminant levels, evaluate possible effects, and collect population-level data (VanHorn and Haney 2007). In general, samples for contaminant analysis and effects were collocated to minimize sources of variability. Terrestrial samples were collected from surface soil, subsurface soil, *Peromyscus maniculatus* (deer mice), *Artemisia tridentata* (sagebrush), and *Agropyron cristatum* (crested wheatgrass) in areas near INL Site facilities and from background areas. Aquatic samples were collected from sediments, surface water, and plants in facility ponds and an aquatic background area. Effects data for deer mice included kidney-to-body-weight and liver-to-body-weight ratios, and histopathology of kidney and liver. Toxicity testing included deer mice, earthworms, and seedlings. Populations of birds, reptiles, plants, small mammals, and soil fauna were surveyed for presence, absence, abundance, and diversity. Data were compiled in a summary report (VanHorn et al. 2012).

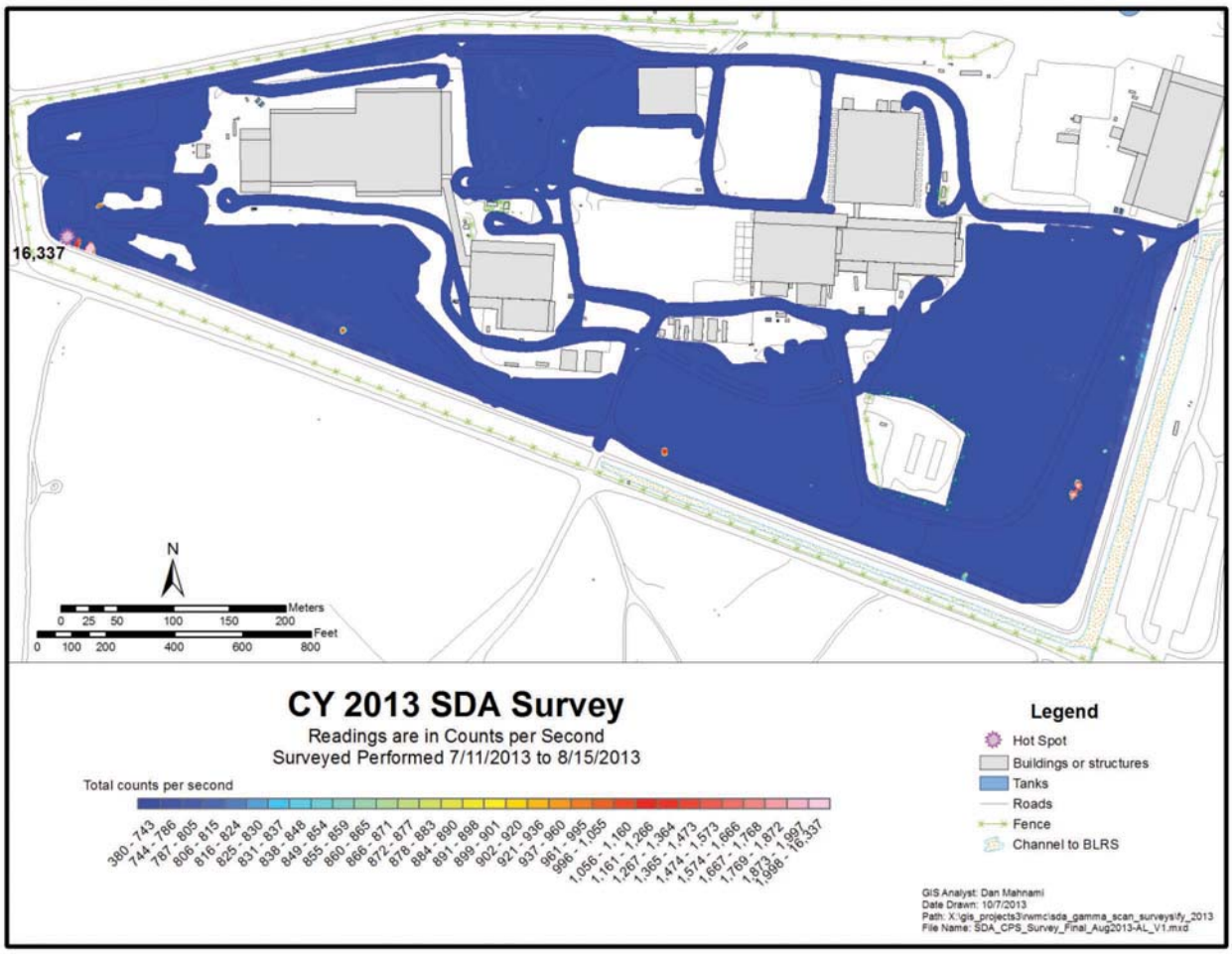


Figure 7-9. RWMC Surface Radiation Survey (2013).

Six years of data and observations detected minimal effects at the population level. Differences between areas near facilities and background areas were slight, and may be attributable wholly or partly to natural variability. Because monitoring substantially reduced uncertainties in the INL Site-wide ecological risk assessment and increased confidence that the no action decision is protective, further ecological monitoring under CERCLA is not required. To validate the conclusion that further ecological monitoring under CERCLA is not required, ecological sampling results and the latest changes in ecological data (e.g., screening and toxicity values) were used to produce waste area group-level ecological risk assessments. Refined ecological risks were presented in a summary report (VanHorn et al. 2012). Several individual release sites within the waste area groups were recommended for further evaluation in the next 5-year review (planned to cover 2010 through 2014) to ensure the remedial action is protective of ecological receptors.

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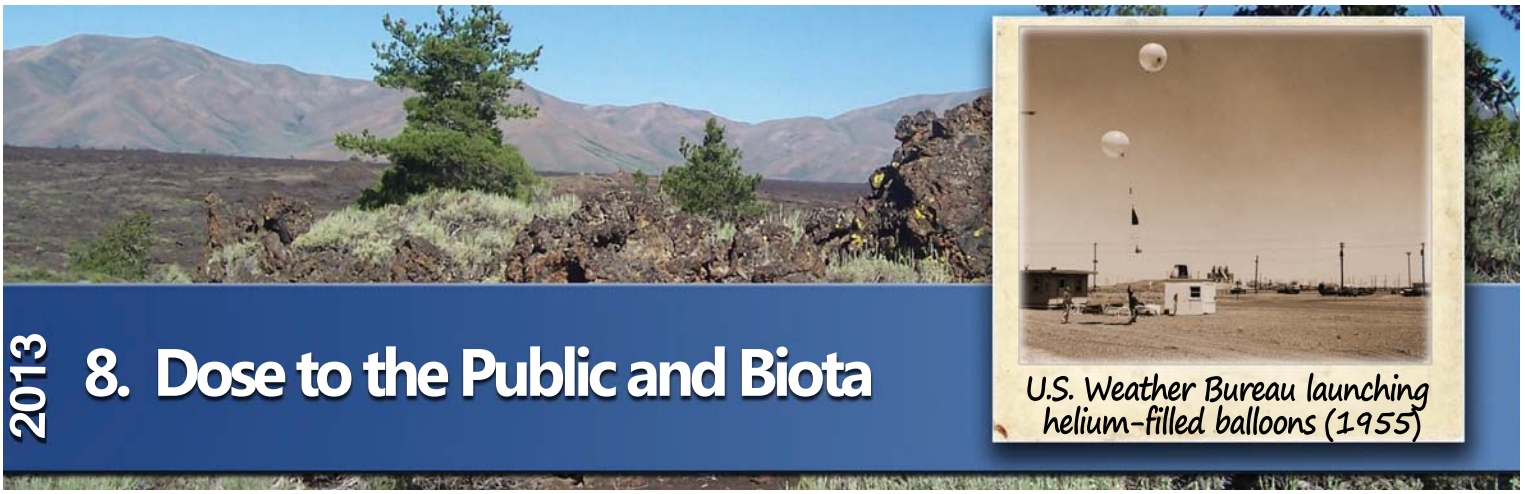
Header Photo Description: Soil sampling has been part of the routine monitoring program since the early 1970s, although some soil was collected around various facilities as far back as 1960.



2013

8. Dose to the Public and Biota

U.S. Weather Bureau launching helium-filled balloons (1955)

Chapter 8 Highlights

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package 88-PC computer program is required by the U.S. Environmental Protection Agency to demonstrate compliance with the Clean Air Act. The dose to the hypothetical, maximally exposed individual in 2013, as determined by this program, was 0.03 mrem (0.3 µSv), well below the applicable standard of 10 mrem (100 mSv) per year. The maximum potential population dose to the approximately 314,069 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 developed by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division, and methodology recommended by the Nuclear Regulatory Commission. For 2013, the estimated potential population dose was 0.499 person-rem (4.99×10^{-3} person-Sv). This dose is about 0.0004 percent of that expected from exposure to natural background radiation of 121,231 person-rem (1,212 person-Sv). Using the maximum radionuclide concentrations in collected waterfowl and large game animals, a maximum potential dose from ingestion was calculated. The maximum potential dose to an individual was calculated to be 0.036 mrem (0.36 mSv) for ingestion of waterfowl. The potential dose to an individual from consuming a liver of a big game animal was estimated to be 0.0002 mrem (0.002 µSv).

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Initially, the potential doses were screened using maximum concentrations of radionuclides detected in soil and effluents at the INL Site. Results of the screening calculations indicate that contaminants released from INL Site activities do not have an adverse impact on plants or animal populations. In addition, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds were used to estimate internal doses to the waterfowl. These calculations indicate that the potential doses to waterfowl do not exceed the Department of Energy limits for biota.

No unplanned releases occurred from the INL Site in 2013, and, therefore, no doses were associated with unplanned releases.

8. DOSE TO THE PUBLIC AND BIOTA

It is the policy of the U.S. Department of Energy (DOE), “To implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements” (DOE Order 436.1). DOE Order 458.1 further states, “It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable...” This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2013 environmental monitoring measurements.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 8-1). Airborne radioactive materials are rapidly carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site, so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from ingestion of meat from wild game animals and waterfowl that access the INL Site. Ingestion doses were calculated from concentrations of radionuclides measured in game animals killed by vehicles on roads at the INL Site and in waterfowl harvested from ponds on the INL Site if animals sampled had detectable levels of human-made radionuclides. External exposure to radiation in the environment (primarily from naturally-occurring radionuclides) was measured directly using thermoluminescent dosimeters and optically stimulated luminescence dosimeters.

Water pathways were not considered major contributors to dose because no surface water flows off the INL Site and no radionuclides associated with INL Site releases have been measured in public drinking water wells.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released by the facilities. During 2013, doses were calculated for the radionuclides and data presented in Table 4-2 and summarized in Table 8-1. Although noble gases were the radionuclides released in the largest quantities, they contributed very little to the cumulative dose (affecting immersion only) largely because of their short half-lives and the fact that they are not

Table 8-1. Summary of Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2013).

	Curies[a] Released										
Facility[b]	Tritium	^{85}Kr	Noble Gases[c] ($T_{1/2}$ < 40 days)	Short-lived Fission and Activation Products[d] ($T_{1/2}$ < 3 hours)	Fission and Activation Products[e] ($T_{1/2}$ > 3 hours)	Total Radioiodine[f]	Total Radiostrontium[g]	Total Uranium[h] Ci/(g)	Plutonium[i]	Other Actinides[j]	Other[k]
ATR Complex	378	0	1290	7.97E-01	4.57E-02	2.57E-02	4.24E-02	1.72E-09/ 5.03E-03	2.67E-05	1.70E-04	3.12E-10
CFA	0.92	1.60E-08	0	2.45E-02	5.89E-07	1.99E-09	4.42E-13	7.56E-08/ 2.63E-04	1.20E-10	1.78E-08	1.03E-11
INTEC	141	1000	0	4.50E-05	1.75E-02	2.50E-02	9.55E-03	3.36E-07/ 8.23E-02	5.05E-03	5.67E-08	10
MFC	0.20	8.27E-03	0	1.38E-07	9.28E-04	5.06E-03	5.38E-06	6.90E-06/ 1.26E-03	3.43E-07	3.40E-07	0
RWMC	81	1.16E-18	0	1.47E-09	0.343	0	1.51E-07	7.99E-06/ 1.81E-01	2.71E-09	1.13E-04	2.94E-11
TAN	0	0	0	0	0	0	1.02E-06	3.34E-08/ 8.35E-02	0	0	0
Total	**601**	**1000**	**1290**	**0.821**	**0.407**	**5.58E-02**	**4.88E-02**	**1.53E-05**	**5.08E-03**	**2.83E-04**	**3.52E-10**

a. One curie (Ci) = 3.7 x 10^{10} becquerels (Bq).
b. CFA = Central Facilities Area; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; ATR Complex = Advanced Test Reactor Complex; RWMC = Radioactive Waste Management Complex (including AMWTP = Advanced Mixed Waste Treatment Project); TAN = Test Area North (including SMC = Specific Manufacturing Capability).
c. Noble gases with half-lives less than 40 days released from the INL Site are: ^{39}Ar, ^{41}Ar, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{127}Xe, ^{129m}Xe, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, and ^{138}Xe. (Ar = argon, Kr = krypton, and Xe = xenon.)
d. Fission products and activation products ($T_{1/2}$<3 hours) = ^{136m}Ba, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{212}Bi, ^{83}Br, ^{60m}Co, ^{138}Cs, ^{67}Cu, ^{179m}Hf, ^{114}In, ^{142}La, ^{56}Mn, ^{93}Mo, ^{99}Mo, ^{97}Nb, ^{212}Po, ^{216}Po, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, ^{103m}Rh, ^{106m}Rh, ^{219}Rn, ^{126m}Sb, ^{129}Te, ^{208}Tl, ^{187}W, ^{90}Y, ^{91m}Y, ^{92}Y, etc. See Table HI-1 for more information.
e. Fission products and activation products ($T_{1/2}$>3 hours) = ^{144}Ce, ^{58}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{55}Fe, ^{175}Hf, ^{181}Hf, ^{203}Hg, ^{22}Na, ^{24}Na, ^{95}Nb, ^{63}Ni, ^{147}Pm, ^{224}Ra, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{124}Sb, ^{125}Sb, ^{127}Sb, ^{46}Sc, ^{151}Sm, ^{182}Ta, ^{99}Tc, ^{99m}Tc, ^{65}Zn, ^{95}Zr, etc. See Table HI-1 for more information.
f. Total radioiodine = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I, and ^{135}I.
g. Total radiostrontium = ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr, and ^{92}Sr.
h. Total uranium = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, and ^{238}U. Grams of uranium released calculated using the specific activity (Ci/g) for each uranium isotope and then summing the results.
i. Total plutonium = ^{236}Pu, ^{237}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu.
j. Other actinides = ^{227}Ac, ^{241}Am, ^{243}Am, ^{249}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{237}Np, ^{239}Np, ^{231}Pa, ^{234}Pa, ^{227}Th, ^{228}Th, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th, and ^{234}Th. See Table HI-1 for more information.
k. Other = radioisotopes of other elements that are not noble gases, activation or fission products or actinides.

incorporated into the food supply. The radionuclides which contributed the most to the overall estimated dose (strontium-90 [^{90}Sr], iodine-129 [^{129}I], cesium-137 [^{137}Cs], americium-241 [^{241}Am], and plutonium [Pu] isotopes) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported.

Two kinds of dose estimates were made using the release data:

- The effective dose to the hypothetical maximally exposed individual (MEI), as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations. The Clean Air Act Assessment Package (CAP) 88-PC computer code (EPA 2007) was used to predict the maximum downwind concentration at the nearest offsite receptor location and estimate the dose to the MEI.
- The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility. For this calculation the mesoscale diffusion model MDIFFH (Sagendorf et al. 2001) was used to model air transport and dispersion. The population dose was estimated using dispersion values from the model projections to comply with DOE Order 458.1.

The dose estimates considered immersion dose from direct exposure to airborne radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from direct exposure to radionuclides deposited on soil (Figure 8-1.) The CAP88-PC computer code uses dose and risk tables developed by the U.S. Environmental Protection Agency (EPA). Population dose calculations were made using the MDIFF air dispersion model in combination with Nuclear Regulatory Commission (NRC) dose calculation methods (NRC 1977), DOE effective dose coefficients for inhaled radionuclides (DOE 2011), EPA dose conversion factors for ingested radionuclides (EPA 2002), and EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (EPA 2002).

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAPs regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (40 Code of Federal Regulations [CFR] 61, Subpart H). This includes releases from stacks and diffuse sources such as resuspension of contaminated soil particles. EPA requires the use of an approved computer code such as CAP88-PC to demonstrate compliance with 40 CFR 61. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses an average annual wind file, based on multiple-year meteorological data collected at the

Who is the maximally exposed individual?

The maximally exposed individual is a hypothetical individual who, because of proximity, activities, or living habits, could potentially receive the maximum possible dose of radiation from a given event or process. This individual lives outside the INL Site at the location where the highest concentration of radionuclides in air have been modeled using reported effluent releases. In 2013, this hypothetical person lived at Frenchman's Cabin, just south of the INL Site boundary (Figure 4-2).

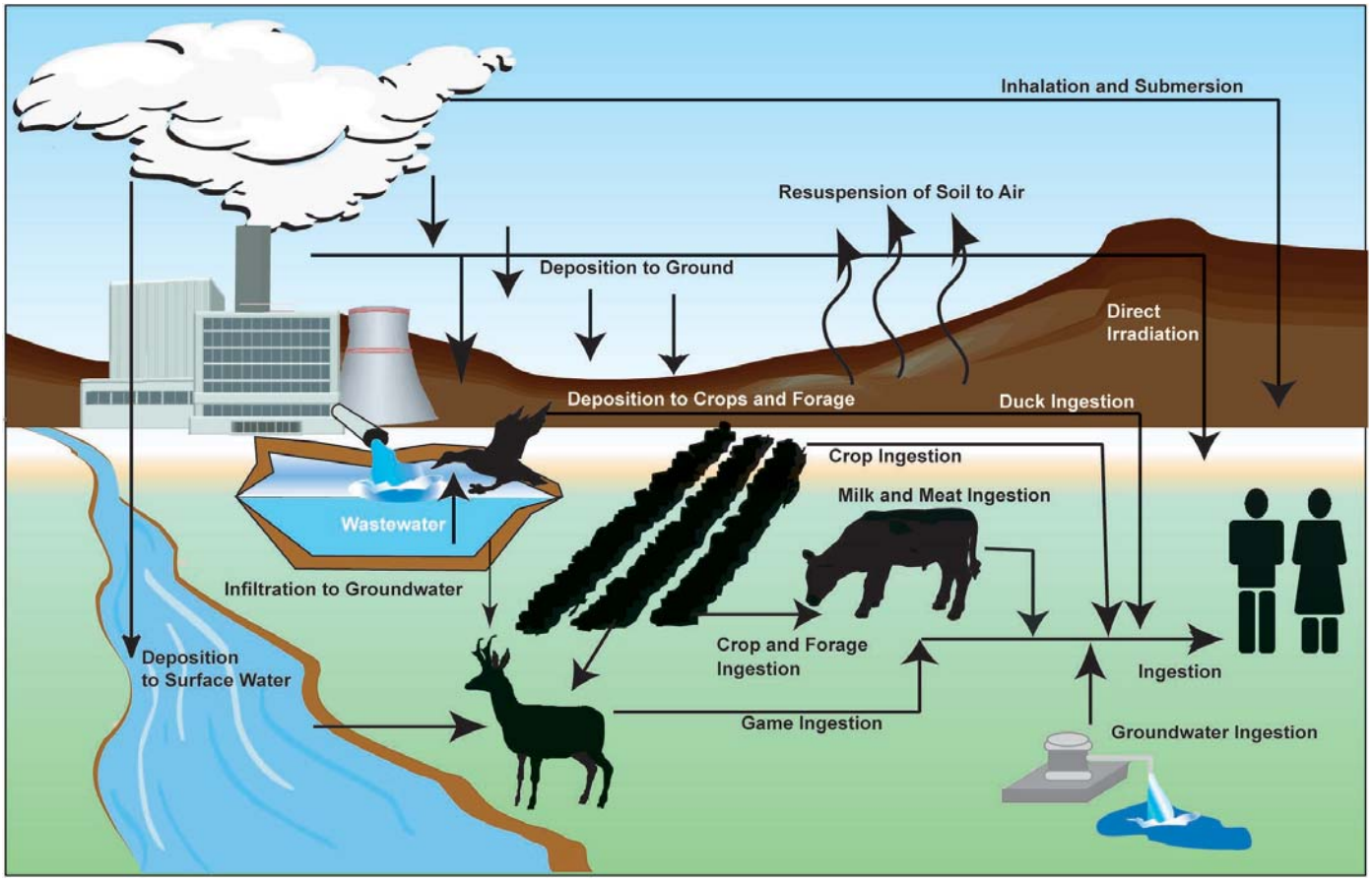


Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

INL Site by NOAA. Assessments are done for a circular grid of distances and directions from each source with a radius of 80 kilometers (50 miles) around the facility. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk and meat consumed by humans are made by coupling the output of the atmospheric transport models with the NRC Regulatory Guide 1.109 terrestrial food chain models.

The dose from INL Site airborne releases of radionuclides was calculated to the MEI to demonstrate compliance with NESHAPs and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2013 INL Report for Radionuclides* (DOE-ID 2014). In order to identify the MEI, the doses at 63 locations were calculated and then screened for the maximum potential dose to an individual who might live at one of these locations. The highest potential dose was screened to be to a hypothetical person living at Frenchman's Cabin, located at the southern boundary of the INL Site (see Figure 4-2). This location is inhabited only during portions of the year, but it must be considered as a potential MEI location according to

NESHAPs. An effective dose of 0.0302 mrem (0.302 μSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2013.

Figure 8-2 compares the maximum individual doses calculated for 2004 through 2013. All of the doses are well below the whole body dose limit of 10 mrem (100 μSv) for airborne releases of radionuclides established by 40 CFR 61. The highest dose was estimated in 2008 and was attributed primarily to plutonium-241 which was reported to be released during the dismantling of facilities at Test Area North.

Although noble gases were the radionuclides released in the largest quantities (~80 percent of the total) in 2013, they represented relatively smaller fractions of the cumulative dose from all pathways (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. For example, 39 percent of the total activity released was argon-41 (^{41}Ar) (Table 4-2), yet ^{41}Ar resulted in only 18 percent of the estimated dose. On the other hand, radionuclides typically associated with airborne particulates (^{241}Am, ^{137}Cs, ^{90}Sr, ^{129}I, ^{239}Pu, and ^{240}Pu) were a tiny fraction (0.004 percent) of the total amount of

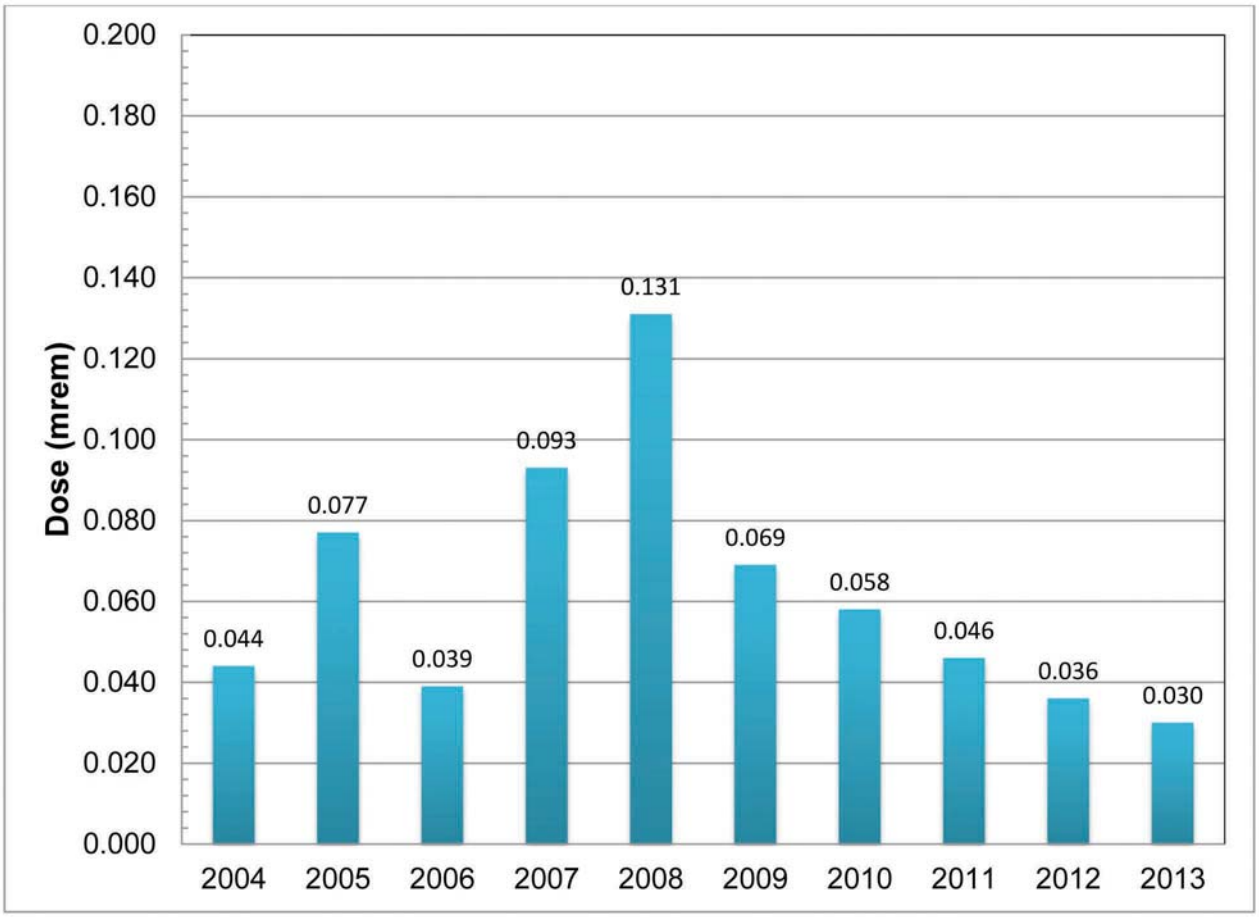


Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2004 – 2013.

radionuclides reported (Table 4-2) yet resulted in 38 percent of the estimated dose (Figure 8-3). Tritium represented about 21 percent of the total activity released and contributed approximately 40 percent of the calculated dose to the MEI in 2013. Tritium interacts with the environment in a unique fashion because it may exchange with hydrogen atoms in water molecules in air. Tritium thus can follow water almost precisely through the environment. The dose calculations in CAP88-PC assume that doses from ingestion of food and water are directly proportional to modelled tritium concentrations in air.

Primary sources of the major radionuclides used to estimate the dose to the MEI (Figure 8-3) were identified during preparation of the annual NESHAP report (DOE-ID 2014) as follows:

- Airborne emission of ^{41}Ar was the result of the operation of the Advanced Test Reactor (ATR) at the ATR Complex.
- Iodine-129, ^{239}Pu, and ^{240}Pu releases were primarily associated with the Three Mile Island-2 Independent Spent Storage Installation at Idaho Nuclear Technology and Engineering Center (INTEC).

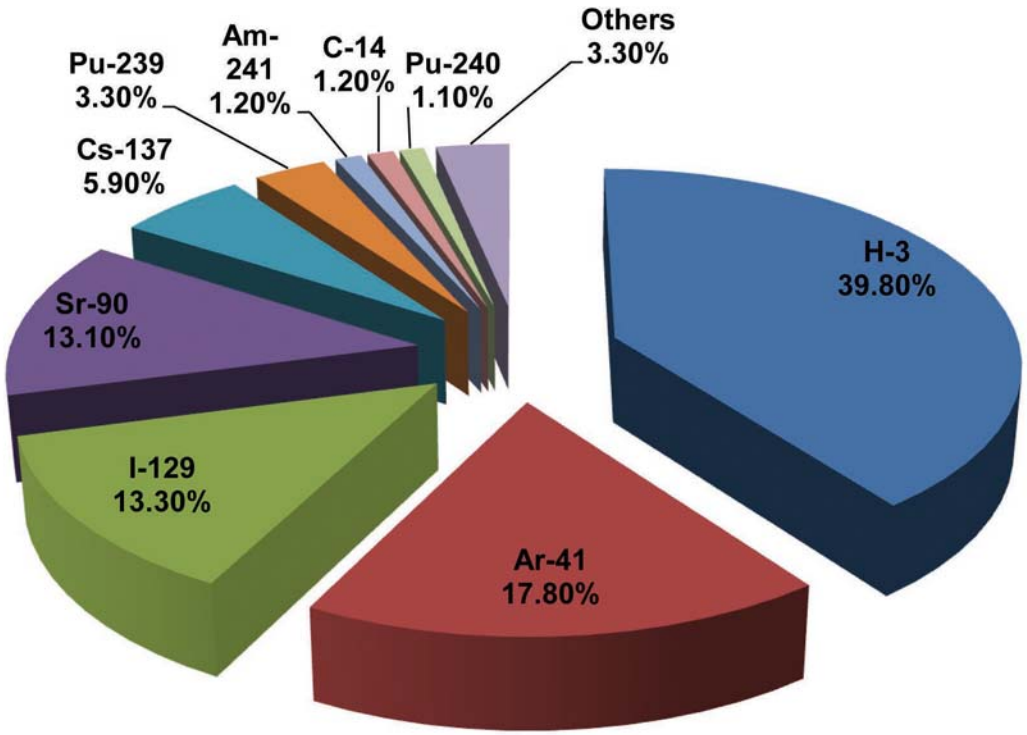


Figure 8-3. Radionuclides Contributing to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2013).

- Tritium doses were estimated to result mainly from releases from the ATR Complex (primarily the Warm Waste Evaporation Pond), the Three Mile Island (TMI)-2 Independent Spent Storage Installation at INTEC, and the beryllium blocks at the RWMC.
- The major source of ^{90}Sr and ^{137}Cs resulting in dose to the MEI was from the Warm Waste Evaporation Pond at the ATR Complex.
- Carbon-14 (^{14}C) doses resulted mainly from emissions associated with several units that extract volatile organic compounds from the subsurface at the RWMC.

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (NOAA ARL-FRD) developed an air transport and dispersion model called MDIFFH, designed specifically for estimating impacts over periods of up to a year or more on and around the INL Site (Sagendorf et al. 2001). It is based on an earlier model called MESODIF and was developed by the NOAA ARL-FRD from field experiments in arid environments (e.g., the INL Site and the Hanford Site in eastern Washington). The model was used in the population dose calculations. A detailed description of the model and its capabilities may be found at http://www.noaa.inel.gov/capabilities/modeling/T&D.htm.

The NOAA ARL-FRD gathered meteorological data continuously at 35 meteorological stations during 2013 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 was projected by the MDIFFH using wind speeds and directions from the 1-hr Mesonet database for 2013. The model predicted average annual air concentrations, resulting from INL Site airborne effluent releases, at each of over 10,000 grid points on and around the INL Site (Figure 8-4).

The results were used to prepare a contour map showing calculated annual air concentrations called time integrated concentrations (Figure 8-5). The higher numbers on the map represent higher annual average concentrations. So, for example, the annual air concentration resulting from INL Site releases were estimated to be nearly ten times higher at Mud Lake than at Dubois. The data used to prepare this map were also used to identify where an individual might be exposed to the highest air concentration during the year, and what the time integrated concentration at that location was. The time integrated

How do the MEI and Reference Resident differ?

The Reference Resident is used to estimate the collective dose to the public living around the INL Site, as required by DOE Order 458.1, while the MEI is used to show compliance with 40 CFR 61. Like the MEI, the Reference Resident is a hypothetical individual who lives a self-sufficient life at the location of the highest air concentration projected by the air dispersion model MDIFFH. The MDIFFH code is a puff trajectory model which uses hourly meteorological data collected from 35 meteorological stations on and around the INL Site. The dose to the MEI is estimated by CAP88-PC, which uses a simple mathematical model, the Gaussian plume model, and average annual wind data measured at one location to estimate the average annual dispersion of radionuclides.

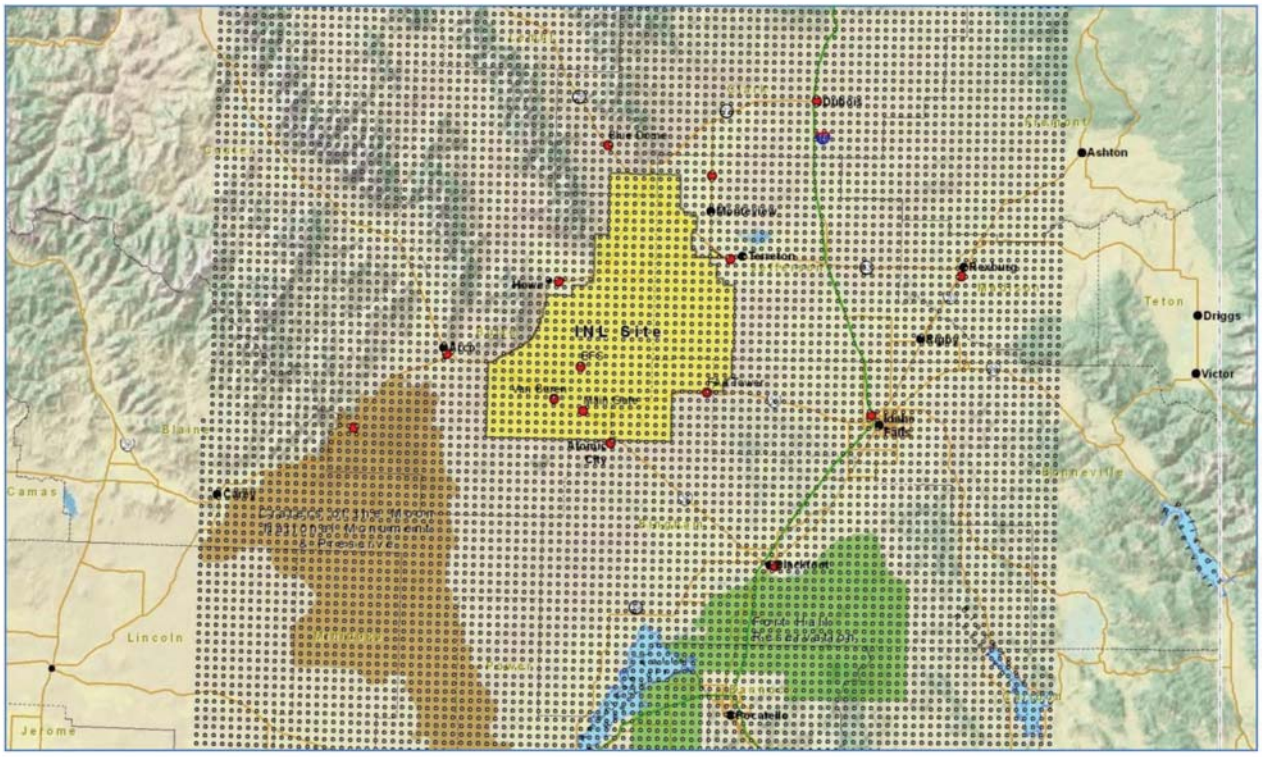


Figure 8-4. INL Site Mesoscale Grid Currently Used in MDIFFH Simulations of INL Site Air Dispersion Annual TICs. Red Circles Represent Current ESER Air Monitoring Locations.

concentration and radionuclide release rates (Table 4-2) were then used to calculate the dose to this individual (the Reference Resident) from each facility release of radionuclides. In 2013 the Reference Resident was projected by MDIFFH to live at Frenchman's Cabin at the southern boundary of the INL Site. Frenchman's Cabin is also the location of the MEI used by CAP88-PC in 2013.

The average time integrated air concentration modeled for each INL Site facility at Frenchman's Cabin was then input into an EXCEL workbook used to estimate doses with mathematical algorithms derived from the original AIRDOS-EPA computer code (Moore et al 1979). AIRDOS-EPA is the basis for CAP88-PC. A detailed discussion of the dose calculation methodology may be found in Appendix B. The dose to the Reference Resident in 2013 was estimated to be 0.0383 mrem (0.383 μSv) per year.

The population of each census division was updated with data from the 2010 census extrapolated to 2013. The doses received by people living in each census division were calculated by multiplying the following four variables together:

- The release rate for each radionuclide (summarized in Table 8-1)

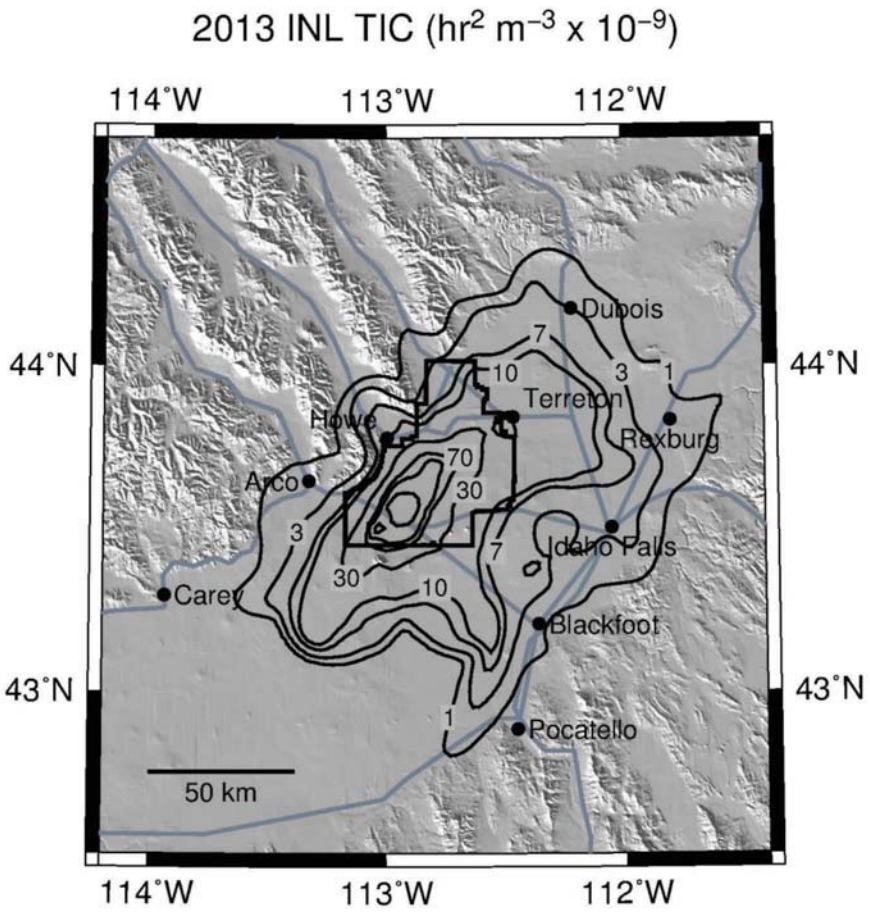


Figure 8-5. INL Site Time Integrated Concentrations (2013).

- The MDIFFH time integrated air concentration calculated for each location (a county census division)
- The population in each census division within that county division
- The dose calculated to be received by the individual exposed to the highest MDIFFH-projected time integrated air concentration (i.e., the Reference Resident).

The estimated dose at each census division was then summed over all census divisions to result in the 50-mi (80-km) population dose (Table 8-2). The estimated potential population dose was 0.499 person-rem (4.99 x 10^{-3} person-Sv) to a population of approximately 314,069. When compared with the approximate population dose of 121,231 person-rem (1,212 person-Sv) estimated to be received from natural background radiation, this represents an increase of about 0.0004 percent. The largest collective dose was in the Idaho Falls census division due to the larger population.

The largest contributors to the population dose were ^{129}I, contributing about 57 percent of the total population dose, and tritium, contributing 10 percent of the total. These were followed by

Table 8-2. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2013).

Census Division[a,b]	Population[c]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,380	1.45×10^{-3}	1.45×10^{-5}
Alridge	577	8.85×10^{-5}	8.85×10^{-7}
American Falls	7,225	1.06×10^{-3}	1.06×10^{-5}
Arbon (part)	29	9.61×10^{-6}	9.61×10^{-8}
Arco	2,580	3.67×10^{-2}	3.67×10^{-4}
Atomic City (division)	2,684	1.94×10^{-2}	1.94×10^{-4}
Blackfoot	15,161	1.42×10^{-2}	1.42×10^{-4}
Carey (part)	1,035	1.31×10^{-3}	1.31×10^{-5}
East Clark	80	5.71×10^{-5}	5.71×10^{-7}
East Madison (part)	268	1.94×10^{-4}	1.94×10^{-6}
Firth	3,268	2.47×10^{-3}	2.47×10^{-5}
Fort Hall (part)	4,394	3.09×10^{-3}	3.09×10^{-5}
Hailey-Bellevue (part)	5	9.13×10^{-11}	9.13×10^{-13}
Hamer	2,347	2.61×10^{-2}	2.61×10^{-4}
Howe	370	1.07×10^{-2}	1.07×10^{-4}
Idaho Falls	101,117	1.53×10^{-1}	1.53×10^{-3}
Idaho Falls, west	1,719	5.56×10^{-3}	5.56×10^{-5}
Inkom (part)	630	9.97×10^{-5}	9.97×10^{-7}
Island Park (part)	93	6.85×10^{-5}	6.85×10^{-7}
Leadore (part)	6	6.13×10^{-8}	6.13×10^{-10}
Lewisville-Menan	4,199	1.87×10^{-2}	1.87×10^{-4}
Mackay (part)	1,232	5.01×10^{-6}	5.01×10^{-8}
Moreland	10,387	4.31×10^{-2}	4.31×10^{-4}
Pocatello	70,640	3.12×10^{-2}	3.12×10^{-4}
Rexburg	27,129	3.46×10^{-2}	3.46×10^{-4}
Rigby	18,126	4.55×10^{-2}	4.55×10^{-4}
Ririe	1,889	1.41×10^{-3}	1.41×10^{-5}
Roberts	1,653	1.01×10^{-2}	1.01×10^{-4}
Shelley	8,529	1.07×10^{-2}	1.07×10^{-4}
South Bannock (part)	320	1.11×10^{-4}	1.11×10^{-6}
St. Anthony (part)	2,549	1.51×10^{-3}	1.51×10^{-5}
Sugar City	6,881	8.01×10^{-3}	8.01×10^{-5}
Swan Valley (part)	6,304	7.14×10^{-4}	7.14×10^{-6}
Ucon	6,381	1.61×10^{-2}	1.61×10^{-4}
West Clark	881	8.45×10^{-4}	8.45×10^{-6}
Total	**314,069**	**0.499**	**4.99×10^{-3}**

a. The U.S. Census Bureau divides the country into four census regions and nine census divisions. The bureau also divides counties (or county equivalents) into census county divisions.
b. (Part) means only a part of the county census division lies within the 80-km (50-mi) radius of a major INL Site facility.
c. Population extrapolated to estimated 2013 values based on 2010 Census Report for Idaho.

^{90}Sr, ^{41}Ar, and ^{239}Pu, contributing about 8, 7, and 6 percent, respectively, and ^{14}C, ^{137}Cs, ^{241}Am, ^{240}Pu, and ^{241}Pu each contributing less than 3 percent of the total population dose (Figure 8-6). The relative contributions of these radionuclides to population dose differ from the relative contributions of the same radionuclides to the MEI dose (Figure 8-3). For example, iodine-129 contributed about 13 percent of the dose to the MEI as compared to 57 percent of the population dose. This difference can be explained by the fact that a much higher air concentration of ^{129}I was projected at Frenchman's Cabin by the MDIFFH model than was calculated using the CAP88-PC code. Argon-41 corresponded to 18 percent of the estimated dose to the MEI but only 7 percent of the population dose. This is because CAP88-PC modeled the immersion dose based on an air concentration at 500 seconds. In contrast, the air concentration of ^{41}Ar at the Reference Resident location was allowed to decay for about 1.5 hours to account for transport from ATR Complex. Tritium was estimated to produce 40 percent of the dose to the MEI, as compared to 10 percent of the population dose. The difference can be attributed mainly to a higher concentration

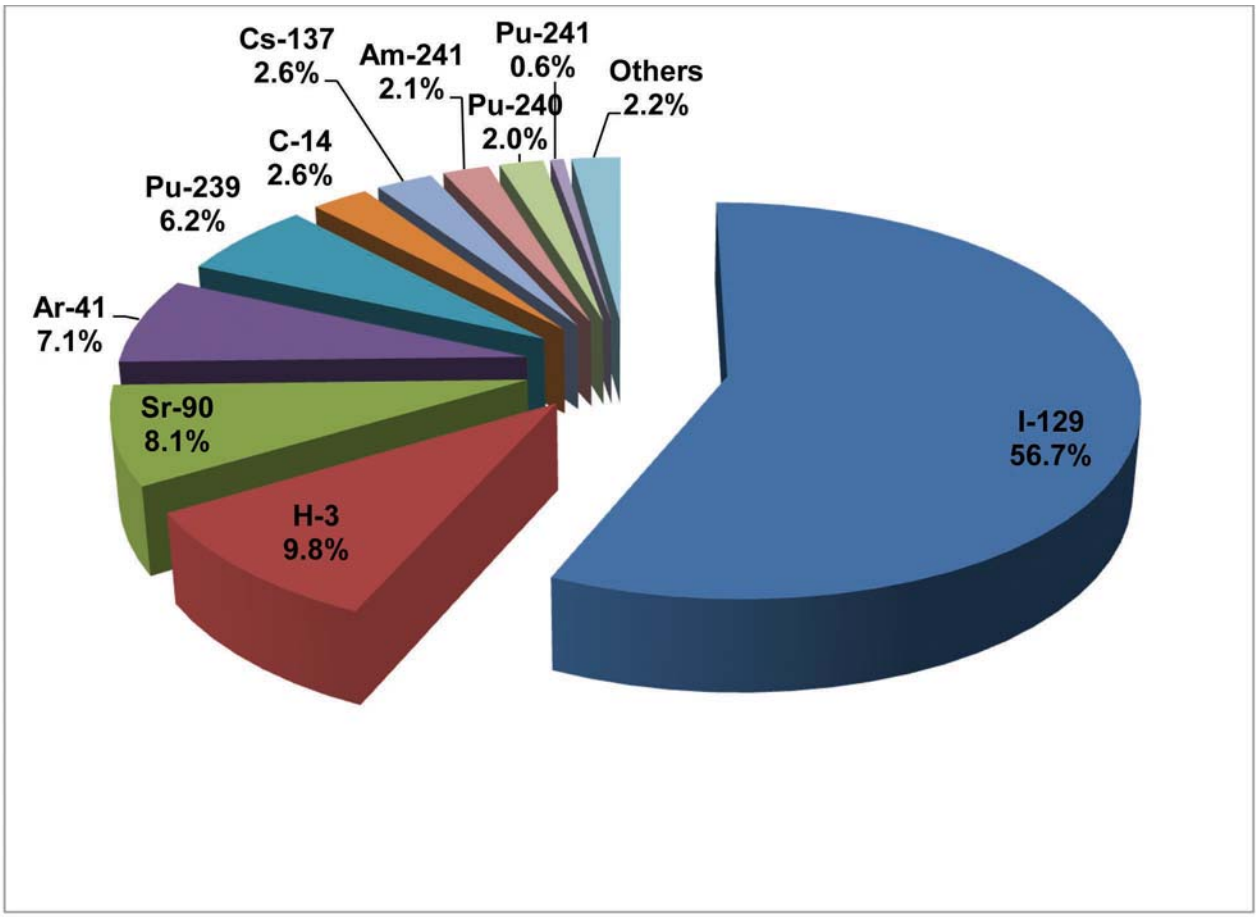


Figure 8-6. Radionuclides Contributing to Dose to the 50-Mile Population from INL Site Airborne Effluents as Calculated Using Excel Workbooks and Results of the MDIFFH Air Dispersion Model (2013).

of tritium projected by CAP88-PC at Frenchman's Cabin, as well as the use of dose conversion factors in the CAP88-PC code which are 1.5 – 2 times higher than the DOE dose conversion factors (DOE-ID 2011) used to estimate the dose to the Reference Resident. The remaining radionuclides (^{14}C, ^{137}Cs, ^{241}Am, ^{240}Pu, and ^{241}Pu) resulted in slightly different doses to the MEI and the Reference Resident due to one or more factors: different air concentrations calculated by the two air dispersion models (CAP88-PC and MDIFFH), different dose conversion values and agricultural transfer factors used by CAP88-PC and DOE, and different algorithms used to estimate deposition.

For 2013, the INTEC contributed nearly 68 percent of the total population dose. The ATR Complex contributed over 19 percent and the RWMC accounted for just over 11 percent. All other facilities contributed a total of just about 2 percent.

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

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

8.3.1 Waterfowl

Eight ducks were collected during 2013: three each from the ATR Complex wastewater ponds and the MFC wastewater ponds, and two from a control location near American Falls Reservoir. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2013 is presented in Table 8-3. Radionuclide concentrations used to determine these doses are reported in Figure 7-5. Doses from consuming waterfowl are conservatively based on the assumption that ducks are eaten immediately after leaving the pond and no radioactive decay occurs.

Table 8-3. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue Using INL Site Wastewater Disposal Ponds in 2013.[a]

Radionuclide	ATR Complex Maximum Dose (mrem/yr)	MFC Maximum Dose (mrem/yr)	Control Sample Maximum Dose (mrem/yr)
Cobalt-60	3.60×10^{-3}	0	0
Zinc-65	3.55×10^{-2}	0	0
Strontium-90	2.19×10^{-3}	0	0
Cesium-137	1.82×10^{-2}	0	0
Total Dose	**3.55×10^{-2}**	**0**	**0**

a. Effective dose from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from Federal Guidance Report No. 13 (EPA 2002).

The maximum potential dose of 0.036 mrem (0.36 µSv) from these waterfowl samples is substantially below the 0.89 mrem (8.9 µSv) dose estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001). These evaporation ponds have been remediated and are no longer available to waterfowl. The ducks were not collected directly from the wastewater disposal ponds at the ATR Complex but from sewage lagoons adjacent to them. However, they probably resided at all the ponds while they were in the area.

8.3.2 Big Game Animals

A study on the INL Site from 1976 to 1986 conservatively estimated the potential whole-body dose that could be received from an individual eating the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity found in these animals was 2.7 mrem (27 µSv) (Markham et al. 1982). Game animals collected at the INL Site during the past few years have generally shown much lower concentrations of radionuclides. In 2013, only one game animal had a detectable concentration of ^{137}Cs in the liver tissue. A dose of 0.0002 mrem was estimated for consumption of this liver.

The contribution of game animal consumption to the population dose has not been calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford et al. 1983). The total population dose contribution from these pathways would, realistically, be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

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

Tritium has previously been detected in two U.S. Geological Survey monitoring wells located along the southern boundary of the INL Site. These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration (<1,150 pCi/L) is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). The maximum contaminant level corresponds to a dose from the drinking water ingestion pathway of 4 mrem per year. An individual drinking water from these wells would hypothetically receive a dose of less than 0.2 mrem (2.0 µSv) in one year. Because no one uses these wells for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to a MEI.

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

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters and optically stimulated luminescence dosimeters (Figure 7-8). In 2013, the external radiation measured along the INL Site boundary was statistically equivalent to that of background radiation and, therefore, does not represent a dose resulting from INL Site operations.

8.6 Dose to the Public from All Pathways

DOE Order 458.1 establishes a radiation dose limit to a member of the general public from all possible pathways as a result of DOE facility operations. This limit is 100 mrem/yr (1 mSv/yr) above the dose from background radiation and includes the air transport, ingestion, and direct exposure pathways. For 2013, 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 on the southern INL Site boundary at Frenchman's Cabin (Figure 4-2), would receive a calculated dose from INL Site airborne releases reported for 2013 (Section 8.2.1). For this analysis, we also assumed that the same hypothetical individual would kill and eat a duck with the maximum radionuclide concentrations detected in 2013 (Figure 7-5). For this scenario, the duck would be killed at the nearby Mud Lake Wildlife Management Area. The duck would be killed soon after it left the INL Site. It was also assumed that the individual would receive a dose from eating a big game animal with the maximum concentration reported for 2013.

The dose estimate for an offsite MEI from the air and game animal pathways is presented in Table 8-4. The total dose was conservatively estimated to be 0.066 mrem (0.66 µSv) for 2013. For comparison, the total dose received by the MEI in 2012 was calculated to be 0.045 mrem (0.45 µSv).

The total dose calculated to be received by the hypothetical MEI for 2013 (0.066 mrem [0.66 µSv]) represents about 0.017 percent of the dose expected to be received from background radiation (386 mrem [3.9 mSv], as shown in Table 7.6) and is well below the 100 mrem/yr (1 mSv/

Table 8-4. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2013).

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (mSv)	Percent of Dose Limit[a]	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	3.02×10^{-2}	3.02×10^{-4}	3.02×10^{-1}	0.499	0.00499	314,069	121,231
Waterfowl ingestion	3.55×10^{-2}	3.55×10^{-4}	NA[c]	NA	NA	NA	NA
Big game animals	1.90×10^{-4}	1.90×10^{-6}	NA	NA	NA	NA	NA
Total pathways	**6.57×10^{-2}**	**6.57×10^{-4}**	**6.57×10^{-2}**	**NA**	**NA**	**NA**	**NA**

a. The EPA regulatory standard for the air pathway is 10 mrem/yr effective dose equivalent. The DOE limit for all pathways is 100 mrem/yr total effective dose equivalent.

b. The individual dose from background was estimated to be 386 mrem (3.9 mSv) in 2013 (Table 7-6).

c. NA = Not applicable.

yr) limit above background established by DOE. As discussed in the Helpful Information section of this report, the 100 mrem limit is far below the exposure levels that cause acute health effects.

The dose received by the entire population within 80 km (50 mi) of INL Site facilities was calculated to be 0.499 person-rem. This is approximately 0.0004 percent of the dose (121,231 person-rem) expected from exposure to natural background radiation in the region.

8.7 Dose to Biota

8.7.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following absorbed doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The graded approach begins the evaluation using conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media termed “Biota Concentration Guides.” Each Biota Concentration Guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organism populations. Instead, it is an indication that more realistic model assumptions may be necessary.

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

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters which 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, which would involve a problem formulation, analysis, and risk characterization protocol similar to that recommended by EPA (1998). RESRAD-Biota cannot perform these calculations.

8.7.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2013 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s (Jessmore et al. 1994). In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with facilities shown in Figure 1-3 and include:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- Idaho Nuclear Technology and Engineering Center (INTEC)
- Large Grid, a 24-mile radius around INTEC
- Materials and Fuels Complex
- Naval Reactors Facility
- RWMC
- Test Area North.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in soil were used (Table 8-5.) The table includes laboratory analyses of soil samples collected in 2005, 2006, and 2012 by the INL and Idaho Cleanup Project contractors. The INL contractor currently uses in situ gamma spectroscopy to determine levels of ^{137}Cs and other gamma-emitting radionuclides in surface soils. The results of these surveys (Table 7-2) are also included in Table 8-5.

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 (see Table 7-2) were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in Appendix C were used to represent surface water concentrations. The combined sum of fractions was less than one for both terrestrial animals (0.225) and plants (0.00331) and passed the general screening test (Table 8-6).

Table 8-5. Concentrations of Radionuclides in INL Site Soils, by Area.

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
ARA	Cesium-137	7.00×10^{-2}	1.94
	Uranium-238	-----[c]	21.4
	Strontium-90	2.10×10^{-1}	3.70×10^{-1}
	Plutonium-238	------	3.90×10^{-3}
	Plutonium-239/240	1.30×10^{-2}	1.80×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
ATR Complex	Cesium-137	2.00×10^{-1}	6.10×10^{-1}
	Strontium-90	------	5.82×10^{-2}
	Plutonium-238	5.90×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	1.70×10^{-2}	2.18×10^{-2}
CITRC	Cesium-137	1.50×10^{-1}	1.90×10^{-1}
MFC	Cesium-137	1.20×10^{-1}	2.30×10^{-1}
	Plutonium-239/240	1.50×10^{-2}	2.90×10^{-2}
	Americium-241	4.30×10^{-3}	1.20×10^{-2}
INTEC	Cesium-137	1.68	3.72
	Strontium-90	4.90×10^{-1}	7.10×10^{-1}
	Plutonium-238	2.50×10^{-2}	4.30×10^{-2}
	Plutonium-239/240	1.10×10^{-2}	2.90×10^{-2}
	Americium-241	6.10×10^{-3}	8.10×10^{-3}
Large Grid	Cesium-137	7.00×10^{-2}	1.29
	Strontium-90	------	1.10×10^{-1}
	Plutonium-238	3.30×10^{-3}	4.00×10^{-3}
	Plutonium-239/240	1.00×10^{-2}	2.50×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
NRF	Cesium-137	1.80×10^{-1}	3.30×10^{-1}
	Plutonium-239/240	5.70×10^{-3}	1.60×10^{-2}
	Americium-241	4.30×10^{-3}	9.70×10^{-3}
RWMC	Cesium-137	1.90×10^{-1}	9.60×10^{-1}
	Sr-90	1.23×10^{-2}	1.78×10^{-1}
	Americium-241[d]	2.02×10^{-2}	4.63×10^{-1}
	Plutonium-238	2.19×10^{-3}	1.51×10^{-2}
	Plutonium-239/240	3.6×10^{-2}	5.25×10^{-1}
TAN/SMC	Cesium-137	4.00×10^{-2}	3.80×10^{-1}
	Plutonium-239/240	1.25×10^{-2}	1.74×10^{-2}
	Americium-241	3.20×10^{-3}	5.70×10^{-3}
ALL	Cesium-137	4.00×10^{-2}	3.72
	Strontium-90	1.23×10^{-2}	7.10×10^{-1}
	Uranium-238	------	21.4
	Plutonium-238	2.19×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	5.70×10^{-3}	5.25×10^{-1}
	Americium-241[d]	4.30×10^{-3}	4.63×10^{-1}

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor Complex; CITRC = Critical Infrastructure Test Range Complex; Large Grid = A 24- mile radius around INTEC; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability.

b. Legend:
- Results measured in 2013 using in situ gamma spectroscopy (see Table 7-2.)
- Results measured by laboratory analyses of soil samples collected in 2005
- Results measured by laboratory analyses of soil samples collected in 2006
- Results measured by laboratory analyses of soil samples collected in 2012.

c. '-----' indicates that only one measurement was taken and is reported as the maximum result.

d. The data shown for Am-241 were the results of laboratory analysis of soil samples collected by the ICP contractor. In situ surveillance of the area also detected Am-241, with results ranging from 4.8 to 15.3 pCi/g. However, these results were probably due to shine from material containing americium-241, which is stored near where the measurements were taken.

Table 8-6. RESRAD Biota 1.5 Biota Dose Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2013).

Terrestrial Animal						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Am-241	0	2.02E+05	0.00E+00	0.463	3.89E+03	1.19E-04
Cs-137	0	5.99E+05	0.00E+00	3.72	2.08E+01	1.79E-01
K-40	93.8	1.93E+06	4.85E-05	0	1.19E+02	0
Pu-238	0	1.89E+05	0.00E+00	0.043	5.27E+03	8.16E-06
Pu-239	0	2.00E+05	0.00E+00	0.525	6.11E+03	8.59E-05
Sr-90	0	5.45E+04	0.00E+00	0.71	2.25E+01	3.16E-02
U-233	1.78	4.01E+05	4.44E-06	0	4.83E+03	0.00E+00
U-234	1.78	4.04E+05	4.40E-06	0	5.13E+03	0.00E+00
U-238	0.809	4.06E+05	1.99E-06	21.4	1.58E+03	1.36E-02
Summed	-	-	**5.93E-05**	-	-	**2.25E-01**
Terrestrial Plant						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Am-241	0	7.04E+08	0.00E+00	0.463	2.15E+04	2.15E-05
Cs-137	0	4.93E+07	0.00E+00	3.72	2.21E+03	1.69E-03
K-40	93.8	5.80E+07	1.62E-06	0	1.38E+04	0
Pu-238	0	3.95E+09	0.00E+00	0.043	1.75E+04	2.46E-06
Pu-239	0	7.04E+09	0.00E+00	0.525	1.27E+04	4.14E-05
Sr-90	0	3.52E+07	0.00E+00	0.71	3.58E+03	1.98E-04
U-233	1.78	1.06E+10	1.14E-10	0	5.23E+04	0.00E+00
U-234	1.78	3.08E+09	3.93E-10	0	5.16E+04	0.00E+00
U-238	0.809	4.28E+07	1.31E-08	21.4	1.57E+04	1.36E-03
Summed	-	-	**1.64-06**	-	-	**3.31E-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.

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

8.7.3 Aquatic Evaluation

For the aquatic evaluation, maximum effluent or pond radionuclide concentrations are typically used. The maximum concentration for each radionuclide reported in any pond or effluent in Appendix C was used. When "uranium-233/234" was reported, it was conservatively assumed that each radionuclide was present in equal concentrations.

The results shown in Table 8-7 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 (9.87E-06) and riparian animals (1.66E-04).

Tissue data from waterfowl collected on the ATR Complex ponds in 2013 were also available (Figure 7-5). Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Figure

Table 8-7. RESRAD Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2013).

Aquatic Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
K-40	93.8	2.90E+03	3.23E-02	0.5159	5.80E+04	8.89E-06
U-233	1.78	2.00E+02	8.91E-03	0.089	1.06E+07	8.40E-09
U-234	1.78	2.02E+02	8.82E-03	0.089	3.08E+06	2.89E-08
U-238	0.809	2.23E+02	3.62E-03	0.04045	4.28E+04	9.44E-07
Summed	-	-	**5.37E-02**	-	-	**9.87E-06**
Riparian Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
K-40	93.8	2.50E+02	3.76E-01	0.5159	4.43E+03	1.16E-04
U-233	1.78	6.76E+02	2.63E-03	0.089	5.28E+03	1.69E-05
U-234	1.78	6.83E+02	2.61E-03	0.089	5.27E+03	1.69E-05
U-238	0.809	7.56E+02	1.07E-04	0.04045	2.49E+03	1.63E-05
Summed	-	-	**3.82E-03**	-	-	**1.66E-04**

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.

7-5. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-8. The estimated dose to waterfowl was calculated by RESRAD- Biota 1.5 to be 0.0303 rad/d (0.303 mGy/d) (DOE 2004). This dose is less than the standard of 1 rad/d (10 mGy/d). Based on these results, there is no evidence that impounded water at the INL Site is harming aquatic biota.

8.8 Doses from Unplanned Releases

No unplanned radioactive releases from the INL site were reported in 2013. As such, there are no doses associated with unplanned releases during 2013.

Table 8-8. RESRAD Biota 1.5 Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2013).

	Waterfowl Dose (rad/d)				
Nuclide	Water[a]	Soil[b]	Sediment	Tissue[c]	Summed
Co-60	0.00E+00	4.97E-06	0.00E+00	1.61E-06	6.58E-06
Cs-137	0.00E+00	1.47E-05	0.00E+00	1.54E-06	3.02E-05
K-40	2.95E-02	0.00E+00	0.00E+00	0.00E+00	2.95E-02
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	0.00E+00	0.00E+00	2.86E-05	2.86E-05
U-233	2.63E-04	0.00E+00	1.68E-06	0.00E+00	2.65E-04
U-234	2.60E-04	0.00E+00	1.66E-06	0.00E+00	2.62E-04
U-238	1.05E-04	0.00E+00	7.00E-07	0.00E+00	1.06E-04
Zn-65	0.00E+00	0.00E+00	0.00E+00	4.83E-06	4.83E-06
Total	**3.02E-02**	**0.00E+00**	**4.03E-06**	**1.08E-04**	**3.03E-02**

a. None of these radionuclides were measured in the ATR Complex Cold Waste Pond. Hence, there were no doses calculated for water and sediment.
b. External doses to waterfowl were calculated using soil concentrations. Maximum concentrations of radionuclides measured in soil at the ATR Complex were used (Table 8-5).
c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Figure 7-5.

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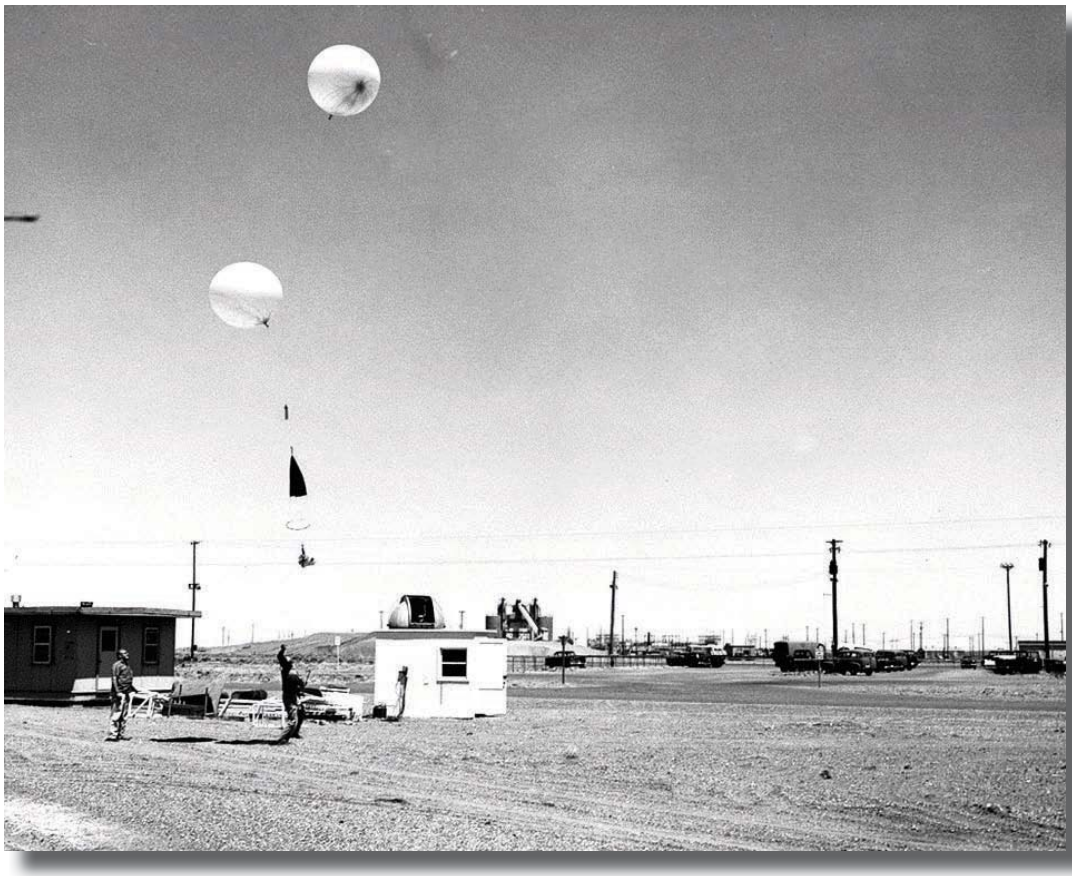
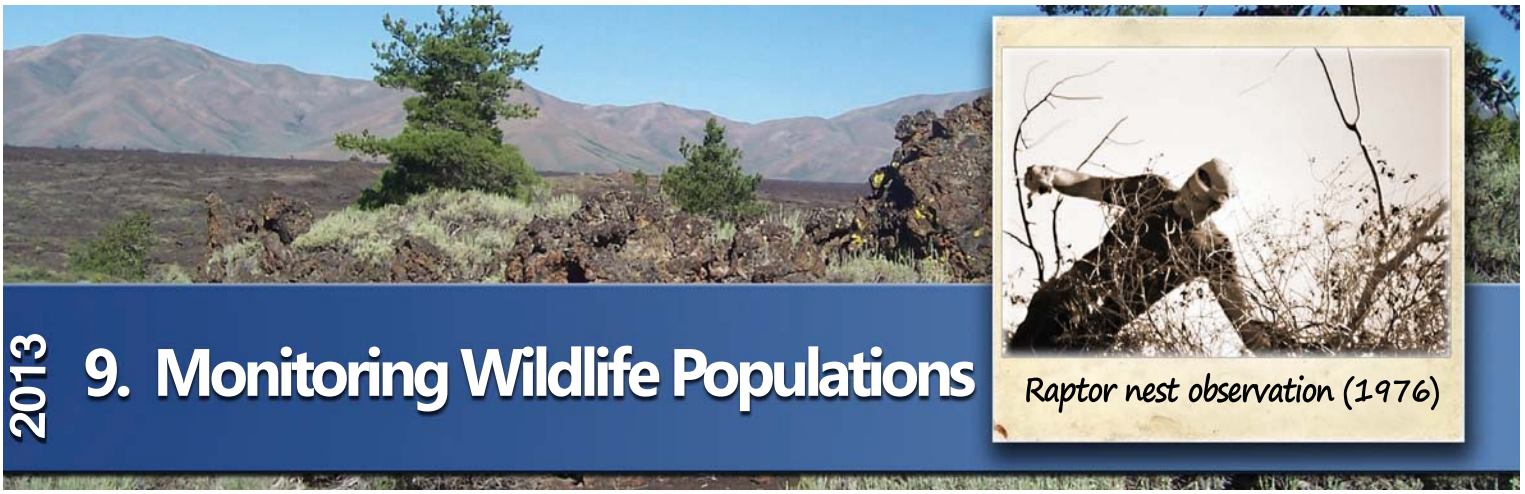


Header Photo Description: A U.S. Weather Bureau Research Station was established at the INL Site in 1948. The station was used to develop a basic understanding of the regional meteorology and climate, with a specific focus on protecting the health and safety of Site workers and nearby residents. The first meteorological monitoring site was installed at the Central Facilities Area in 1949. During the 1950s, a small network of meteorological monitoring sites was deployed. To understand the complex wind flows in the area, the station developed innovative technologies that went beyond basic tower measurements. These included special balloons (called tetroons) that were tracked by radar and the use of tracer chemicals to track the movement of air parcels over time. The Weather Bureau underwent reorganizations over time, and meteorological activities now fall under the National Oceanic and Atmospheric Administration.



2013

9. Monitoring Wildlife Populations

Raptor nest observation (1976)

Chapter 9 Highlights

Field data are routinely collected on several key groups of wildlife at the Idaho National Laboratory (INL) Site for information that can be used to prepare National Environmental Policy Act documents and to enable the U.S. Department of Energy, Idaho Operations Office (DOE-ID) to make informed decisions, based on species use of the INL Site and historical trends, for planning projects and complying with environmental policies and executive orders related to protection of wildlife.

During 2013, midwinter eagle, sage-grouse, breeding bird, and bat surveys were conducted on the INL Site and are highlighted as follows: The midwinter eagle survey has been conducted every January, as part of the national Midwinter Bald Eagle Survey, since 1983. Along with identifying and documenting bald eagles, researchers also identify all raptors, golden eagles, ravens, and other selected bird species. Two bald eagles and five golden eagles were observed in 2013.

Sage-grouse research has been conducted on the INL Site for over 30 years. When sage-grouse were petitioned for listing under the Endangered Species Act, DOE-ID recognized the need to reduce impacts to existing and future mission activities and to develop into a Candidate Conservation Agreement with the U.S. Fish and Wildlife Service to identify threats to the species and its habitat and develop conservation measures and objectives to avoid or minimize threats to sage-grouse. Since 2010, Environmental Surveillance, Education, and Research (ESER) biologists have conducted surveys of sage-grouse leks along routes established by the Idaho Department of Fish and Game (IDFG) in the mid-1990s, as well as at other leks on the INL Site. In 2013, the number of sage-grouse observed on the Tractor Flats Route peaked on March 28 with 53 males. The number of birds observed on the RWMC Route peaked on April 17 with 110 males; whereas the number of sage-grouse observed on the Lower Birch Creek Route peaked at 48 males on April 23. Also, ESER scientists surveyed 29 active leks that were not on the three IDFG lek routes on the INL Site. The number of lekking males at peak attendance on these leks was 331.

The North American Breeding Bird Survey was developed in the 1960s by the U.S. Fish and Wildlife Service along with the Canadian Wildlife Service to document trends in bird populations. The U.S. Geological Survey manages the program in North America, which currently consists of over 4,100 routes with approximately 3,000 of these sampled annually. The INL Site has five permanent official Breeding Bird Survey routes, established in 1985, and eight additional routes which border INL Site facilities. Approximately 3,363 birds from 48 species were documented in 2013 along these routes.

Bats have been monitored on the INL Site periodically for the past several decades. Bat populations are of concern because of their important roles in insect control, plant pollination, and seed dissemination and because of their recent declines due to white-nose syndrome, wind-energy development, climate change, and human destruction of hibernacula. There are 14 known species of bats in Idaho, and 9 of those species have been documented to occupy the INL Site during some part of the year. Currently, bats occupy at least 17 of 23 caves known to exist on the INL Site. During 2012, ESER established permanent bat-monitoring stations at 8 facilities and the 3 largest known hibernacula on the INL Site and continued to monitor bats at these locations in 2013. ESER initiated counts of hibernating bats at 9 caves in 2013 and counted 738 bats, of which 703 were Townsend's big-eared bats and 35 were western small-footed myotis.

9. MONITORING WILDLIFE POPULATIONS

The Environmental Surveillance, Education and Research (ESER) contractor has historically collected data on several key groups of wildlife that occupy the Idaho National Laboratory (INL) Site; including raptors, ungulates, sage-grouse (*Centrocercus urophasianus*), breeding birds, and bats. These surveys provide U.S. Department of Energy, Idaho Operations Office (DOE-ID) with an understanding of how these species use the INL Site, as well as provide context for historical trends of these wildlife. This information is often used in National Environmental Policy Act (NEPA) (NEPA 1970) documents and enables DOE-ID officials to make informed decisions for project planning, as well as maintaining up-to-date information on potentially sensitive species on the INL Site. These surveys also support DOE-ID's compliance with several policies and executive orders including the following:

- Migratory Bird Treaty Act (1918)
- Bald and Golden Eagle Protection Act (1940)
- Endangered Species Act (1973)
- Executive Order 11514 (1970): Protection and Enhancement of Environmental Quality: In furtherance of the purpose and policy of NEPA, directs federal agencies to monitor, evaluate, and control on a continuing basis their activities to protect and enhance the quality of the environment.
- Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service (2013): Regarding implementation of executive order 13186, responsibilities of federal agencies to protect migratory birds.
- Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (2011).

Herein we summarize results from wildlife surveys conducted by the ESER contractor on the INL Site during 2013. The results and population trends reported in this document were based on field observations and do not necessarily represent comprehensive information about population status or occurrence of those species on the INL Site.

9.1 Midwinter Eagle Survey

Each January, hundreds of individuals throughout the United States count eagles along standardized, non-overlapping survey routes as part of the Midwinter Bald Eagle Survey (Steenhof et al. 2008). These surveys were coordinated from 1979 to 1992 by the National Wildlife Federation. After that time, the Bureau of Land Management's (BLM) Raptor Research and Technical Assistance Center assumed responsibility for overseeing these surveys. That responsibility, however, shifted to the National Biological Survey (1993-1996) and later to the U.S. Geological Survey (USGS). In April 2007, the USGS established a partnership with the U.S. Army Corps of Engineers to maintain the long-term, national coordination of Midwinter Bald Eagle Survey data analysis and reporting (Steenhof et al. 2008).

The Midwinter Bald Eagle Surveys were originally established to provide an index of the total number of wintering bald eagles (*Haliaeetus leucocephalus*) in the lower 48 states, as well as to determine bald eagle distribution during a standardized survey period and to identify previously unrecognized areas of important winter habitat (Steenhof et al. 2008). Beginning in 1984, the National Wildlife Federation asked participants in each state to count bald eagles along standard routes. Doing such provided data regarding trends of wintering bald eagles. Survey routes were standardized as clearly described areas where bald eagles had been observed in the past. Observers conduct surveys during the first 2 weeks of January each year, usually on 1 of 2 target days (Steenhof et al. 2008). Each state has a coordinator that is responsible for organizing local counts, enlisting survey participants, and compiling data. Size of survey routes varies from single fixed points to 241 km (150 mi.) in length. Approximately 44 percent of the surveys are conducted from vehicles, 18 percent from fixed-wing aircraft, 8 percent from boats, and 7 percent are conducted by helicopter (Steenhof et al. 2008). The number of states participating in the Midwinter Bald Eagle Survey each year has ranged from 25 to 41, and the number of standard survey routes per state ranges from 1 to 84 (Steenhof et al. 2008).

On the INL Site, Midwinter Bald Eagle Surveys have taken place since 1983. During those years, two teams surveyed two established routes across the north and south of the INL Site in January (Figure 9-1). Along with identifying and documenting bald and golden eagles (*Aquila chrysaetos*), researchers on the INL Site also scan the landscape with binoculars and spotting scopes and identify and document ravens (*Corvus corax*), shrikes (*Lanius* spp.), and black-billed magpies (*Pica hudsonia*) along each route (Figure 9-2). Global positioning system coordinates are collected for each observation, and all data are submitted to the regional coordinator of the USGS Biological Resource Division to be added to the nationwide database.

Two teams surveyed two established routes across the north and south of the INL Site on 15 January 2013 (Figure 9-1). During those surveys, we counted 190 birds, which was higher than the number of individuals observed in 2012 and lower than the average count of 217 birds since

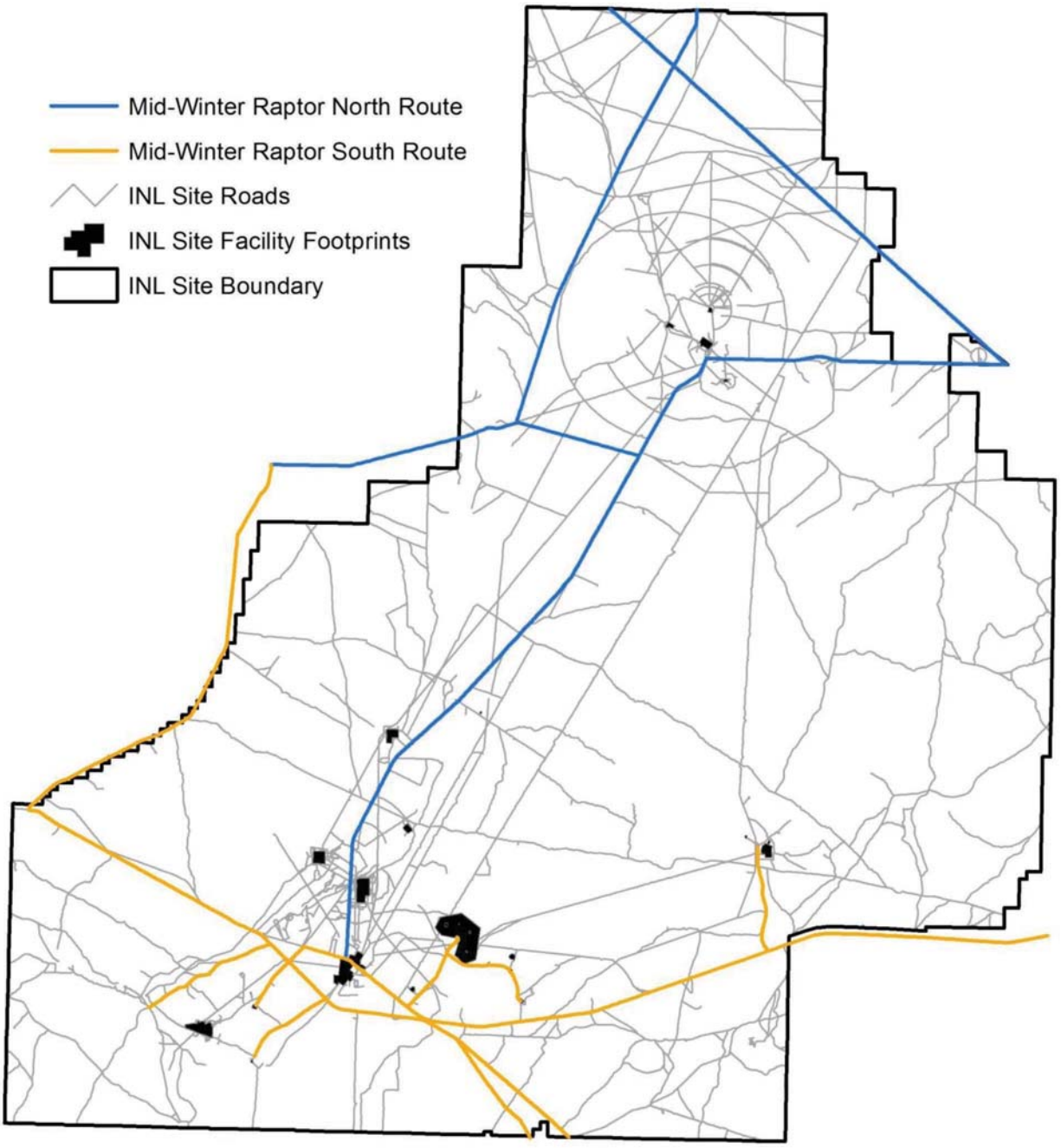


Figure 9-1. Routes for the Midwinter Bald Eagle Surveys on the INL Site.

2002. The raven was the most abundant species we observed (154 sightings), and the rough-legged hawk (*Buteo lagopus*) was the second most abundant species we recorded (17 sightings). We observed 2 bald and 5 golden eagles. No rare or unusual species were documented during those surveys.

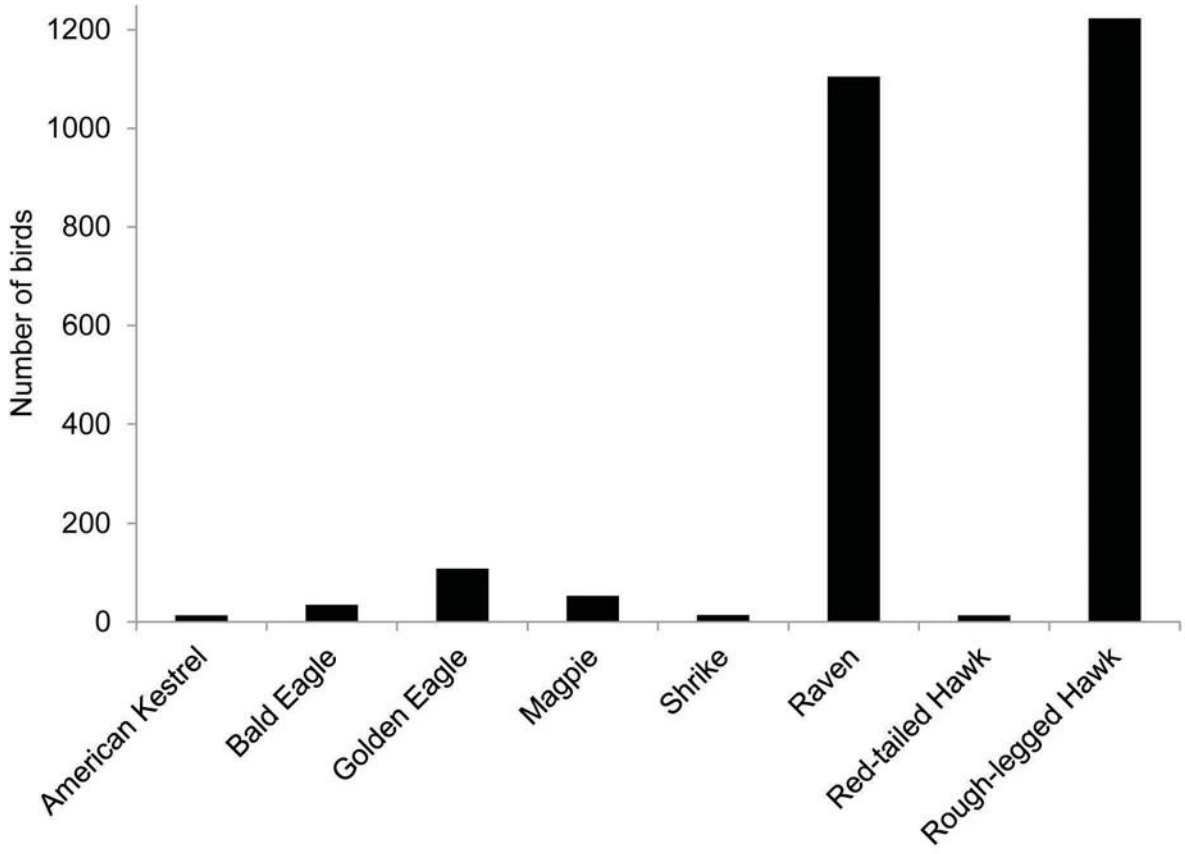


Figure 9-2. Number of Birds Observed during Midwinter Bald Eagle Surveys on the INL Site from 2002 to 2013. Only Birds that were Observed on > 5 Occasions during that Time were Included in this Figure.

9.2 Sage-grouse

Populations of sage-grouse have declined in the last 50 years (Connelly et al. 2004, Garton et al. 2011), and the distribution of this species has been reduced to nearly half of its historic extent across western North America (Schroeder et al. 2004, Connelly et al. 2011a). Although the rate of decline of this species has slowed over the past several decades (Connelly et al. 2004, Garton et al. 2011), concern exists for populations of sage-grouse because of the reliance of this species on sagebrush (*Artemisia* spp.) habitat. Indeed, sagebrush-steppe ecosystems have been greatly altered during the past 150 years; and these areas are currently at risk from multiple threats, such as wildfires, mechanical treatments, agriculture, mining, oil and gas development, livestock grazing, and urbanization (Knick et al. 2003, Connelly et al. 2004). Healthy stands of sagebrush are necessary for sage-grouse to survive. Additionally, sage-grouse require a diverse understory of native forbs and grasses that provide protection from predators, and also provide chicks with high-protein insects necessary for growth (Connelly et al. 2011b).

U.S. Department of Energy, Idaho Operations Office (DOE-ID) has funded some important sage-grouse research on the INL Site (Figure 9-3). Those studies covered diverse topics such as seasonal movements (Connelly and Ball 1982, Connelly et al. 1988), habitat use (Connelly and Ball 1982, Connelly 1982), and food habits of this species (Connelly and Ball 1987). Other research has documented the response of sage-grouse to different land-management practices (Connelly et al. 1981, Connelly 1982), identified leks in areas that were recently disturbed (Connelly and Ball 1979, Connelly et al. 1981), tracked potential movements of radionuclides off-Site by these birds (Connelly and Markham 1983), and documented the location of active leks on the INL Site (Connelly 1982).

When sage-grouse were petitioned for listing under the Endangered Species Act (Connelly et al. 2004), DOE-ID recognized that to reduce impacts to existing and future mission activities on the INL Site they needed develop into a Candidate Conservation Agreement (CCA) with the U.S. Fish and Wildlife Service (FWS). A CCA is a voluntary agreement between the FWS and another federal agency, in which both partners identify threats to a species under consideration for listing and its key habitat, and develop conservation measures and objectives to avoid or minimize those threats. DOE-ID assigned the task of developing the CCA to the ESER contractor, which subcontracted the Wildlife Conservation Society to lead that effort (DOE-ID and FWS 2012). Subsequently, a field study was designed and implemented, and substantial data were collected concerning sage-grouse that occupy the INL Site (DOE-ID and FWS 2012). The draft CCA for sage-grouse is currently under review by the FWS.

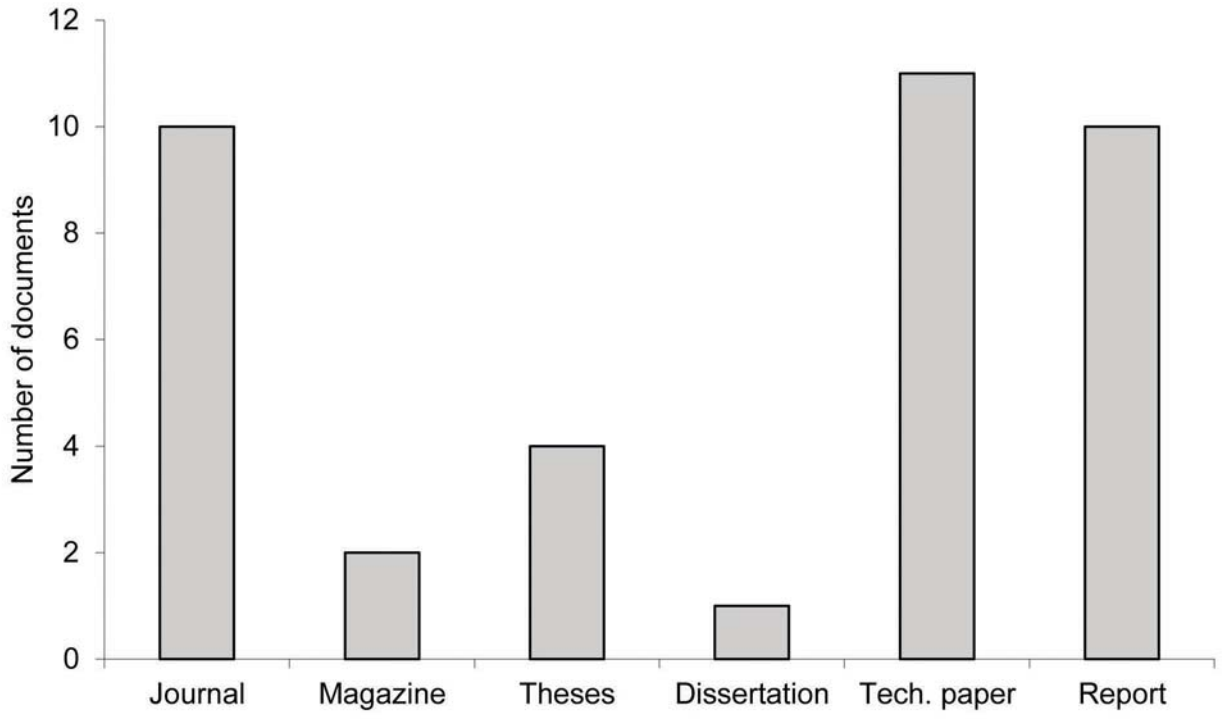


Figure 9-3. Number and Type of Publication Regarding Sage-grouse Research Conducted on the INL Site from 1976 to 2011.

Sage-grouse leks are important displaying and breeding areas that grouse return to each spring (Jenni and Hartzler 1978, Connelly 1981). Some leks may be used by sage-grouse for long periods of time; whereas others may be established after recent, small-scale disturbances occur (Connelly 1981). Leks and their surrounding breeding habitat are important for the survival of sage-grouse populations (Connelly et al. 2000), and counting displaying birds at these areas can be a relatively easy method to document population trends of grouse (Jenni and Hartzler 1978, Connelly et al. 2003, Garton et al. 2011). Therefore, determining the locations of leks, documenting if they are actively attended by grouse, and then tracking the number of grouse across time at these locations can provide important information for sage-grouse management (Jenni and Hartzler 1978, Connelly et al. 2003, Garton et al. 2011).

Three lek routes (Lower Birch Creek, Tractor Flats, and Radioactive Waste Management Complex [RWMC]) were established on the INL Site by the Idaho Department of Fish and Game (IDFG) in the mid-1990s and have been monitored annually since that time using a protocol developed by the IDFG (Figure 9-4). Since 1999, the number of leks monitored across those routes has increased from 12 to 23. Employees of the IDFG surveyed the Lower Birch Creek Route until 2010; thereafter, biologists from the ESER contractor have conducted these surveys.

In 2013, ESER biologists surveyed 29 active leks that were not on the 3 IDFG lek routes, as well as 23 historical leks to document if grouse still used those areas following methods used by the IDFG for surveying sage-grouse leks (ESER Procedure RP-4 and ESER Procedure RP-6). At each lek, we observed birds from a location that provided good visibility of the lek. We then counted the birds on each lek 4 times over a 10-minute period and recorded the highest number of males and females observed at each lek. At historical leks, before approaching the lek, we used binoculars to search the site for sage-grouse. If grouse were observed, we counted the birds as described above. If no grouse were observed, we attempted to hear lekking sage-grouse using a parabolic microphone. If no grouse were detected at the historical lek, we would then walk ~100 m (109 yd) from the center of the lek to four locations in each cardinal direction. We then listened again for sage-grouse calls for two minutes using the parabolic microphone at those four locations in each cardinal direction. If strutting grouse were heard near the location of a cardinal direction, we walked towards the call, and then counted and recorded the number of grouse observed as described above. Additionally, there are large portions of the INL Site where few or no active leks have been identified, even though the habitat in these areas appears adequate for sage-grouse. In 2013, we surveyed some of those regions on the INL Site (e.g., the west side of the INL Site) to identify additional active leks. At each location, we would listen for sage-grouse calls for 2 minutes with a parabolic microphone. If grouse were heard, we would hike to the area and count the birds as described above.

Lek route surveys for sage-grouse began in late March and continued through April 2013; ESER conducted at least 5 surveys on the Tractor Flats, RWMC, and Lower Birch Creek routes (Figure 9-4). The number of sage-grouse observed on the Tractor Flats Route peaked on March 28 with 53 males. The number of birds observed on the RWMC Route peaked on April 17 with 110 males; whereas the number of sage-grouse observed on the Lower Birch Creek Route peaked at 48 males on April 23. Peak attendance by males was lower in 2013 than in 2012 on

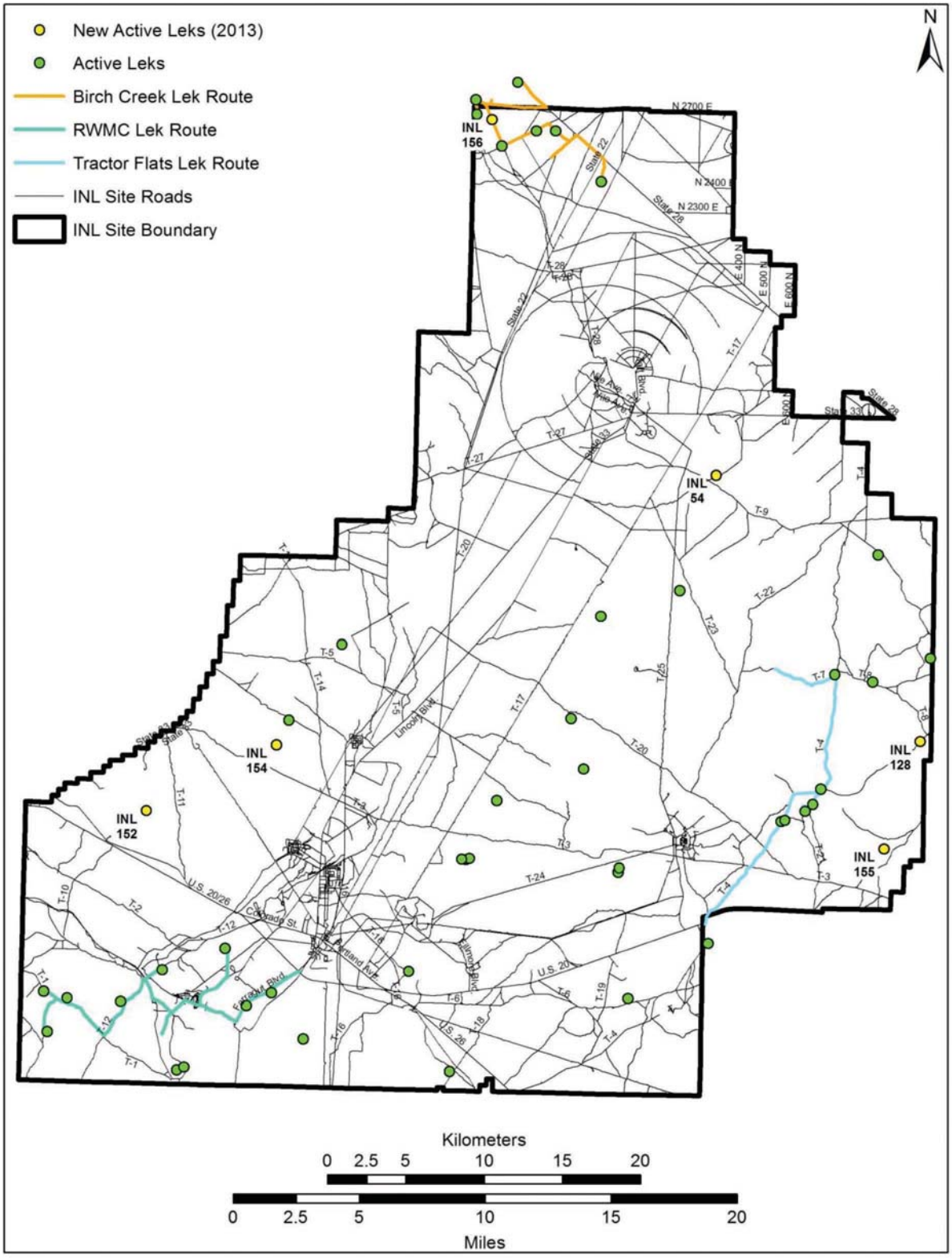


Figure 9-4. Location of Lek Routes and Active Leks of Sage-grouse on the INL Site.

the Tractor Flats Route, when we observed 63 birds. The number of males on the RWMC Route increased slightly compared with 107 birds observed in 2012, and the number of males on the Lower Birch Creek Route decreased slightly compared with 52 birds observed in 2012. We also documented one new lek (INL 156) that was discovered while driving the Lower Birch Creek Lek Route (Figure 9-4). We surveyed that lek each time we conducted the Lower Birch Creek Lek Route, and the maximum number of grouse that we counted at that lek was 3. Combining data from all routes, the average number of male sage-grouse on the INL Site has remained steady the last few years (Figure 9-5). We provided the IDFG with survey data from lek routes on the INL Site. These data were combined with historical data to help members of the local sage-grouse working groups decide on hunting seasons for sage-grouse in eastern Idaho.

In 2013, ESER biologists surveyed the 29 active leks that were on the INL Site and not part of the 3 IDFG lek routes at least 3 times from late March and through April to count sage-grouse using those areas (Figure 9-4). The number of lekking males at peak attendance on those 29 leks was 331. ESER biologists also visited the 23 historical leks on the INL Site during that same time. Of the 23 historical leks that were surveyed, we observed sage-grouse at 2 of those leks (Table 9-1, Figure 9-4). Additionally from late March and through April, ESER biologists visited

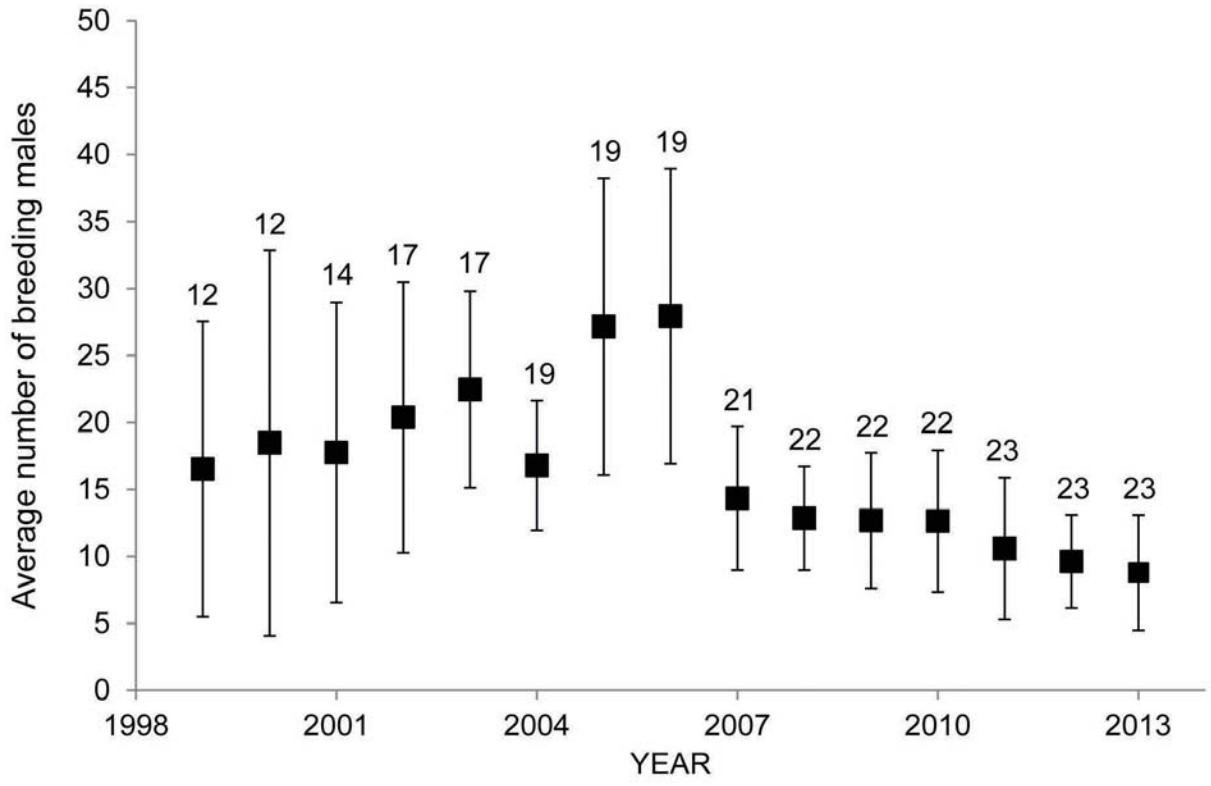


Figure 9-5. Average (± SD) Number of Male Sage-grouse on the Three Lek Routes (Lower Birch Creek, Tractor Flats, and RWMC) on the INL Site. The Number of Leks Sampled in Each Year is Above the Bars.

Table 9-1. Descriptive Statistics for Historical Lek and Lek Discovery Surveys at which We Observed Male Sage-grouse in 2013.

Survey Type and Lek Name	# of Visits	Maximum # of Males Counted	Day of Maximum Count
Historical lek surveys			
INL 54	4	13	April 24
INL 128	3	28	April 17
Lek discovery surveys			
INL 152	3	14	April 26
INL 154	3	18	April 18
INL 155	2	7	April 19

89 road- and remote-survey locations in areas that have not been surveyed intensively for leks to determine if male sage-grouse were lekking in areas near those survey locations. Of those 89 road- and remote-survey locations, we located 3 new leks on the INL Site (Table 9-1, Figure 9-4). Monitoring all active leks will provide DOE-ID greater context regarding the number and trend of lekking sage-grouse on the INL Site.

9.3 Breeding Bird Surveys

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

The INL Site has five permanent, official BBS routes originally established in 1985 (remote routes) and eight additional survey routes near INL Site facilities (facility routes; Figure 9-6). Facility routes were developed to monitor avifauna populations in proximity to anthropogenic activities and disturbances. The annual BBS provides land managers with information regarding the population trends of breeding birds relative to activities conducted on the INL Site.

In 2013, ESER conducted surveys from May 29 to July 3 along the 13 established routes. We documented 3,363 birds from 48 species during those surveys (Figure 9-7). Bird abundance

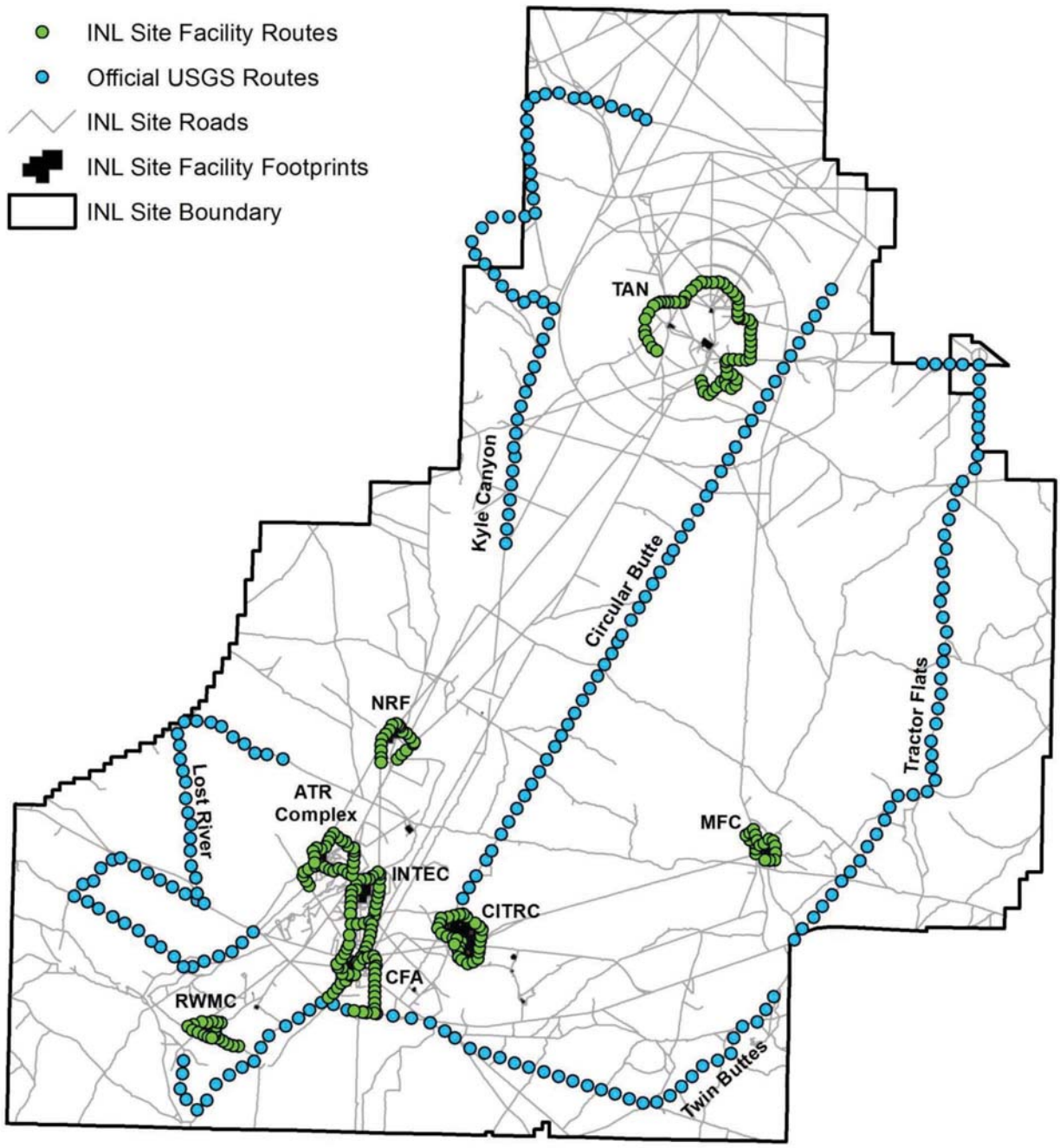


Figure 9-6. Location of Breeding Bird Survey Routes on the INL Site.

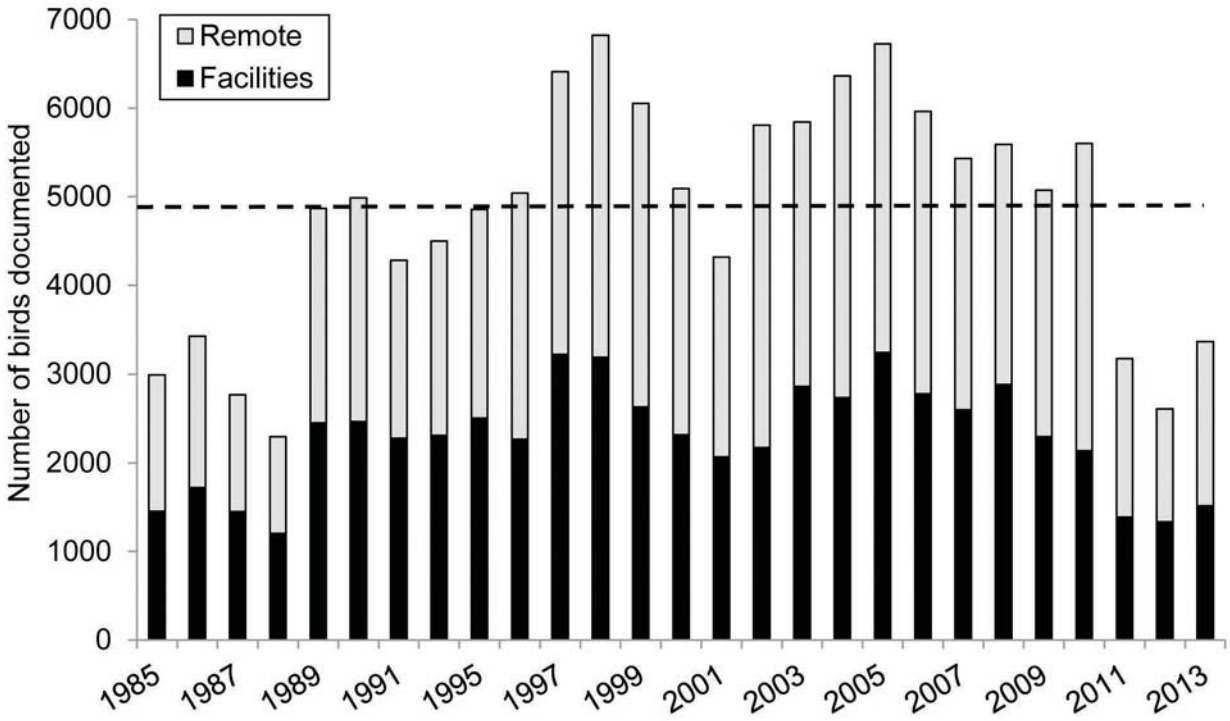


Figure 9-7. Number of Birds Observed during the Breeding Bird Survey on the INL Site. The Dashed Black Line Indicates the Mean Number of Birds Observed from 1985 to 2013. No Breeding Bird Surveys were Conducted on the INL Site in 1992 or 1993.

was less than the 1985-2013 average of 4,880 birds, and the number of species (i.e., species richness) was lower than the 26-year average of 57. Recent fires on the INL Site have reduced the amount of sagebrush habitat. Such reduction in habitat may have affected the total abundance of birds. Furthermore, other factors (i.e., observer or spring weather patterns) could influence bird abundance; therefore, additional years of data will be needed to compare 2013 results with those of previous surveys.

Compared with past surveys, we observed similar patterns of bird abundance among those species that are typically the most numerous. In 2013, the 5 species that were documented in greatest abundance were western meadowlark (*Sturnella neglecta, n* = 827), horned lark (*Eremophila alpestris, n* = 792), sage thrasher (*Oreoscoptes montanus, n* = 564), sage sparrow (*Amphispiza belli, n* = 218), and Brewer's sparrow (*Spizella breweri, n* = 184). During 27 years of breeding bird surveys on the INL Site these species have been the 5 most abundant 20 times, and in the remaining 7 years they were among the 6 most abundant species.

Species observed during the 2013 BBS that are considered imperiled or critically imperiled in Idaho included the Franklin's gull (*Larus pipixcan, n* = 164), long-billed curlew (*Numenius americanus, n* = 5), burrowing owl (*Athene cunicularia, n* = 1), grasshopper sparrow (*Ammodramus savannarum, n* = 1), and greater sage-grouse (*n* = 2). Data from the BBS were submitted to the USGS Patuxent Wildlife Research Center.

9.4 Bats

Many bat species have important roles in ecosystem functions (i.e., insect control, plant pollination, and seed dissemination), and these mammals provide important ecosystem services (Kunz and Reichard 2010, Cryan 2011). For example, insectivorous bats are very effective at suppressing populations of nocturnal insects, and some authors estimate the value of bats to the agricultural industry in the USA at roughly $22.9 billion each year (Boyles et al. 2011). Moreover, insectivorous bats are effective top-down predators of forest insects (Boyles et al. 2011). Potential declines in populations of bats could have far-reaching consequences across ecosystems and biological communities (Miller 2001, Adams 2003, Blehert et al. 2009).

White-nose syndrome (WNS), wind-energy development, climate change, as well as human destruction and modification of hibernacula have impacted populations of bats. WNS has been identified as a recent major threat to many bats that hibernate in caves (Blehert et al. 2009; Foley et al. 2011; Kunz and Reichard 2010), and this disease has killed at least 5.5 to 6.7 million bats in seven species (Blehert et al. 2009; Foley et al. 2011). WNS has been considered as one of the greatest wildlife crises of the past century (Kunz and Reichard 2010), and many species of bats could be at risk of significant declines or extinction due to this disease (Kunz and Reichard 2010). Wind-energy development is expanding rapidly across the western USA, and unprecedented mortality rates of bats have occurred recently at these facilities (Arnett et al. 2008; Cryan 2011; Cryan and Barclay 2009). Additionally, the loss, modification, and disturbance of hibernacula by humans are also concerns for bat populations (Adams 2003).

Research and monitoring of bats have been conducted on the INL Site by contractors of DOE-ID periodically over the past several decades. During that time 4 theses, 3 reports, and 1 publication have been produced by contractors, university researchers, and graduate students. The majority of that research and monitoring, however, occurred in the late 1980s and early 1990s. Of the 14 known species of bats that occur in Idaho, 9 of those species are documented to occupy the INL Site during some part of the year (Table 9-2). Six of those species are likely migratory and use the Site seasonally; whereas, 3 are considered residents (Table 9-2). Many of these species are considered for different levels of protection by the FWS, BLM, Western Bat Working Group, and other conservation organizations.

Currently, at least 17 out of 23 caves that are known to exist on the INL Site are used by several species of bats for winter hibernacula, as well as for summer day and night roosts. Lava caves are also essential habitat during most of the year for 3 resident species. Indeed, much of the information concerning bats on the INL Site comes from research that has centered on counting and trapping individuals at caves (Genter 1984, Wackenhut 1990, Bosworth 1994, Doering 1996). In addition to being used as roost and hibernation areas, caves also provide habitat for concentrated patches of insect prey for these mammals. Additionally, preliminary surveys indicate that caves may be used as stop-over habitat during fall migrations by previously undocumented forest bats, such as the hoary bat (*Lasiurus cinereus*) and possibly the western (*L. blossevillii*) or eastern red bat (*L. borealis*). Very little is known about the use of caves by migrating forest bats (Cryan 2011), and these areas may provide vital resources as bats traverse atypical habitats.

Table 9-2. Bat Species and the Seasons and Areas they Occupy on the INL Site, as well as Threats to these Mammals.

Common and Scientific Name	Distribution, Habitat, and Seasonal Occurrence	Affected by WNS[a]	Affected by Wind Energy
Big Brown Bat (*Eptesicus fuscus*)†	Sitewide; buildings, caves, and lava tubes; year round	Yes	Yes
Hoary Bat (*Lasiurus cinereus*)*	Patchy; riparian and junipers; summer and autumn	No	Yes
Little Brown Myotis (*Myotis lucifugus*)*	Sitewide; roosts in buildings; summer and autumn	Yes	Yes
Pallid Bat (*Antrozous pallidus*)*	Patchy; shrub lands; autumn	No	No
Red Bat (*Lasiurus blossevillii* or *L. borealis*)*	Patchy; caves; autumn	No	Yes
Silver-haired Bat (*Lasionycteris noctivagans*)*	Patchy; riparian and junipers; summer and autumn	No	Yes
Townsend's Big-eared Bat (*Corynorhinus townsendii*)†	Sitewide; caves and lava tubes; year round	Potentially	Potentially
Western Long-eared Myotis (*Myotis evotis*)*	Southeast and northwest INL Site; caves and junipers; summer and autumn	Yes	Potentially
Western Small-footed Myotis (*Myotis ciliolabrum*)†	Sitewide; buildings, caves, and lava tubes; year round	Yes	Potentially

†Resident species, *Migratory species

a. White-nose Syndrome has not be detected in Idaho.

Anthropogenic structures (facilities, bridges, and culverts) are also used as habitat by bats on the INL Site. These areas, and their associated lands, occupy about 0.38 percent of the INL Site. Some of these facilities were constructed in the 1950s, and are surrounded by mature trees and wastewater ponds, which provide bats with vertical-structure habitat, water, and foraging areas. Indeed, during summer all resident and 1 migratory bat species use anthropogenic structures around facilities and near roads for roost sites (Keller et al. 1993, Haymond and Rogers 1997).

In 2013, ESER continued monitoring bat activity using acoustical detectors set at hibernacula and other important habitat features (caves and facility ponds) used by these mammals (Figure 9-8). We are in the process of producing filters to identify calls recorded by the acoustical equipment (Figure 9-9). Cursory examination of the call files, however, indicates that big brown bats (*Eptesicus fuscus*), western small-footed myotis (*Myotis ciliolabrum*), silver-haired bats (*Lasionycteris noctivagans*), western long-legged myotis (*M. evotis*), Townsend's big-eared bats (*Corynorhinus townsendii*), hoary bats, and the little brown myotis (*M. lucifugus*) use areas near caves and the waste-water ponds at facilities.

We also initiated counts of hibernating bats in caves on the INL Site in 2013. We conducted winter hibernacula surveys at 13 caves. Four of those caves were deemed not suitable for hibernating bats; in the remaining 9 caves we counted 738 bats. Of that total, 703 were Townsend's big-eared bats and 35 were western small-footed myotis. The results of our monitoring program will provide critical information regarding bat ecology and conservation on the INL Site.

Figure 9-8. A Passive-acoustical Monitoring Station for Bats with a Microphone Mounted at the Top. These Devices Record the Echolocation Calls of Bats.

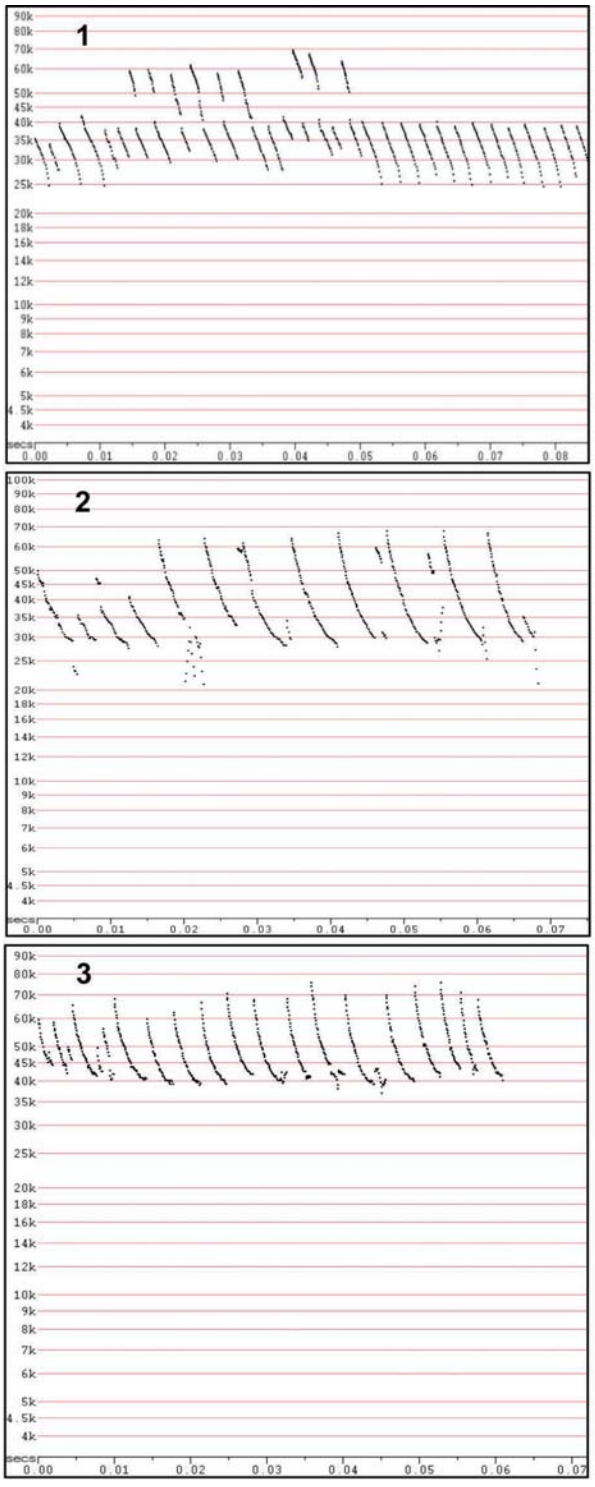


Figure 9-9. Echolocation Calls Recorded by AnaBat Detectors of Three Species of Bats (1 = Townsend's big-eared bat, 2 = big brown bat, 3 = western small-footed myotis) from Caves on the INL Site.

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Header Photo Description: A baseline study of raptor populations at the INL Site was initiated in 1974. The research was used to determine the species, abundance, nest site selection and some specific nesting parameters, such as clutch size. Selected nests were studied by entering the nests once every two days after hatching.

2013

10. Environmental Research at the Idaho National Laboratory Site

Long-Term Vegetation plot (1957)

Chapter 10 Highlights

The Idaho National Laboratory Site was designated as a National Environmental Research Park in 1975. The National Environmental Research Park program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems. The National Environmental Research Park provide rich environments for training researchers and introducing the public to ecological sciences. National Environmental Research Parks have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

During 2013, six ecological research projects were conducted on the Idaho National Environmental Research Park:

- Testing the Efficacy of Seed Zones for Re-Establishment and Adaptation of Bluebunch Wheatgrass (*Pseudoroegneria spicata*)
- Post-wildfire Wind Erosion In and Around the Idaho National Laboratory Site
- Long-term Vegetation Transects – Monitoring Recovery on the T-17 Fire Plots
- Time Interval Photography Monitoring of Cinder Butte Snake Hibernaculum
- The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of Sagebrush Steppe Rangelands on the Idaho National Laboratory Site
- Studies of Ants and Ant Guests at the Idaho National Laboratory Site.

The United States Geological Survey (USGS) has been studying the hydrology and geology of the eastern Snake River Plain and eastern Snake River Plain aquifer since 1949. The USGS INL Project Office collects data from research and monitoring wells to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water that compose the aquifer. Seven reports were published in 2013 by the Idaho National Laboratory Project Office:

- Balancing practicality and hydrologic realism: A parsimonious approach for simulating rapid groundwater recharge via unsaturated-zone preferential flow
- Geochemical evolution of groundwater in the Medicine Lodge Creek drainage basin, eastern Idaho
- Paleomagnetic correlation and ages of basalt flow groups in coreholes at and near the Naval Reactors Facility, Idaho National Laboratory, Idaho
- Optimization of water-level monitoring networks in the eastern Snake River Plain aquifer using a kriging-based genetic algorithm method
- Iodine-129 in the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho 2010-2012
- Ambient changes in tracer concentrations from a multilevel monitoring system in basalt
- An update of hydrologic conditions and distribution of selected constituents in water, eastern Snake River Plain aquifer and perched groundwater zones, Idaho National Laboratory, Idaho emphasis 2009-11.

10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological research performed at the Idaho National Environmental Research Park (Section 10.1) and research conducted on the eastern Snake River Plain (ESRP) and ESRP aquifer by the United States Geological Survey (USGS) (Section 10.2) during 2013.

10.1 Ecological Research at the Idaho National Environmental Research Park

The Idaho National Laboratory (INL) Site was designated as a National Environmental Research Park in 1975. The National Environmental Research Park Program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. This has been one of the few formal efforts to reserve land on a national scale for ecological research and education. In many cases, these protected lands became the last remnants of what were once extensive natural ecosystems.

Five basic objectives guide activities on National Environmental Research Parks:

- Develop methods for assessing and documenting environmental consequences of human actions related to energy development
- Develop methods for predicting environmental consequences of ongoing and proposed energy development

- Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment
- Train people in ecological and environmental sciences
- Educate the public on environmental and ecological issues.

National Environmental Research Parks provide rich environments for training researchers and introducing the public to the ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities and federal and state agencies. Ecological research on National Environmental Research Parks is leading to better land-use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increased contributions to ecological science in general.

Ecological research was conducted at federal laboratories long before National Environmental Research Parks were established. For example, at the INL Site, ecological research began in 1950 with the establishment of the long-term vegetation (LTV) transect study. This is perhaps DOE's oldest ecological data set and one of the most intensive data sets for sagebrush steppe. In addition, in 1989, a long-term reptile monitoring study was initiated, which is the longest continuous study of its kind in the world. Also, in 1993, a protective cap biobarrier experiment was initiated, which evaluated the long-term performance of evapotranspiration caps and biological intrusion barriers. Those long-term plots are now being used to test hypotheses on the potential effects of climate change.

The Idaho National Environmental Research Park provides coordination of ecological research and information exchange at the INL Site. It facilitates ecological research on the INL Site by attracting new researchers to use the area, providing background data for new research projects, and assisting researchers to obtain access to the INL Site. The Idaho National Environmental Research Park provides infrastructure support to ecological researchers through the Experimental Field Station and reference specimen collections. The Idaho National Environmental Research Park tries to foster cooperation and research integration by encouraging researchers to collaborate, developing interdisciplinary teams to address more complex problems, encouraging data sharing, and leveraging funding across projects to provide more efficient use of resources. It also integrates research results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho National Environmental Research Park has developed a centralized ecological data repository to provide an archive for ecological data and to facilitate data retrieval for new research projects and land management decision making. It also provides interpretation of research results to land and facility managers to support compliance with natural resource laws including the National Environmental Policy Act, Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act.

A total of 23 graduate students, post-doctoral students, faculty, and agency and contractor scientists participated in six research projects on the Idaho National Environmental Research Park in 2013. Several undergraduate students and technicians also gained valuable experience through participation in these research activities. The six projects include five graduate student research projects, with students and faculty from Idaho State University (ISU), Boise State University, and The College of Idaho. Other researchers represented the Environmental Surveillance, Education, and Research Program, USGS Forest and Range Ecosystem Science Center, USGS – Southwest Biological Science Center, USDA Forest Service Rocky Mountain Research Station, and USDA Pacific Northwest Research Station.

Three of the six projects received funding from DOE-ID through the Environmental Surveillance, Education, and Research Program (ESER). In addition, all projects received in-kind support (logistics, badging, and training) from DOE-ID through ESER. Other funding sources included the National Science Foundation, USDA Forest Service Rocky Mountain Research Station, USDA Forest Service Pacific Northwest Research Station, USDA Forest Service National Fire Plan, U.S. Department of Interior (USDI) – Bureau of Land Management (BLM)/USDA Forest Service Great Basin Native Plant Program, USDA – National Institute for Food and Agriculture, Rangelands Program, ISU, USGS – Forest and Rangeland Ecosystem Science Center, USGS – Northwest Climate Science Center, and the Orma J. Smith Museum of Natural History at The College of Idaho.

Most of the DOE-ID-funded research and much of the research funded by other agencies addresses land management issues applicable to the INL Site. These issues include preparing for potential Endangered Species Act listings, understanding wildland fire effects, minimizing invasive species impacts, and understanding long-term trends in plant community composition, sagebrush health, and potential effects of climate change. The results of these projects will be used to support the preparation of a Conservation Management Plan.

10.1.1 Testing the Efficacy of Seed Zones for Re-Establishment and Adaptation of Bluebunch Wheatgrass (Pseudoroegneria spicata)

Investigators and Affiliations

- Francis Kilkenny, Ph.D., Research Biologist, USDA Forest Service, Rocky Mountain Research Station, Boise, ID
- Brad St. Clair, Ph.D., Research Geneticist, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR

Funding Sources

- USDA Forest Service Rocky Mountain Research Station
- USDA Forest Service Pacific Northwest Research Station
- USDA Forest Service National Fire Plan
- USDI BLM/USDA Forest Service Great Basin Native Plant Program

Background

Previous genecological research funded by the Great Basin Native Plant Project found that bluebunch wheatgrass populations differed in traits important for adaptation to drought and cold. Based on results of that study, seed zones were delineated for the interior northwest including the Great Basin, Snake River Plain, Columbia Plateau, and Blue Mountains. This study tests the efficacy of seed zones delineated in the previous study for differences in re-establishment and adaptation of bluebunch wheatgrass populations from local seed zones compared to climatically distant seed zones with the hypothesis that local sources will show better establishment as well as better survival, growth and reproduction in the long-term.

This study will test the efficacy of recently delineated seed zones for bluebunch wheatgrass for ensuring successful re-establishment and long-term adaptation, and maintaining genetic diversity, of this ecologically important restoration species with current and future value for use in INL Site seedings. The study will also explore the consequences of changing climates for adaptation by substituting space for time to evaluate different populations in different climates. Long-term productivity and adaptation will be modeled to allow evaluation of trade-offs between different management options for current and future climates. Population movement guidelines and associated seed zones can be adjusted based on results from this study and management objectives.

Objectives

- Evaluate adaptation (establishment, survival, growth and reproduction over time) of bluebunch wheatgrass (*Pseudoroegneria spicata*) populations from local seed zones relative to distant seed zones.
- Model adaptation as a function of the climates of source locations and test sites.
- Characterize traits and climates important for adaptation.
- Model effects of climate change on native populations and the consequences of assisted migration for responding to climate change.

Accomplishments through 2013

To test this hypothesis, seed was collected from five populations in each of eight seed zones in each of two broad regions. Plants from each seed zone will be planted back into a single test site representative of the climate of each of the eight seed zones in a region. We delineated the two broad regions as (1) a transect from the hot, dry climates of the lower Snake River Plain to the cool, somewhat wet climates of the transverse ranges of the Great Basin to the cold, dry climates of the upper Snake River Plain (INL Site) and (2) a transect from the hot, dry climates of the Columbia Plateau to the cool, wet climates of the Blue Mountains to the cold, dry climates east of the Blue Mountains. In addition to populations from each seed zone, two widely used varieties will be included at each test site.

Results

We made seed collections from 138 populations from throughout the two broad regions in summer 2013. From these, 78 populations were chosen for inclusion in the study based on their distribution within each of the seed zones and the amount of available seed (only four populations, not five, were available from the hottest, driest seed zone within each transect). Included were collections from S Transect Seed Zone 2a, which is centered over the INL Site. All seed has been cleaned, tested for germination, and is ready for sowing. The University of Idaho has been contracted to produce the containerized planting stock for the study. Potential collaborators were contacted during the past winter to help with providing test sites on their lands.

Plans for Continuation

Test sites will be finalized in spring 2014, including one on or near the INL Site and any necessary site preparation will be done over the summer. Planting stock will be grown over the summer. Test sites will be planted in fall 2014 beginning with the higher elevation sites in early September and ending with the lower elevation sites in October or November. The experimental design at each of the eight test sites per transect will be a split-plot design with a plot represented by 25 plants from each seed zone and the subplots being five populations per seed zone. Each site will include five replications. Planting spacing will be 0.5 m between plants. Plans are to measure the sites every year for an indefinite length of time, but with early results presented after two growing seasons. The primary variables of interest are cover and biomass of bluebunch wheatgrass on each seed zone plot over time, but survival, plant height, crown diameter, and biomass of individual plants of each population is also of great interest. Cover and biomass of competing vegetation in each plot will also be measured.

Publications, Theses, Reports

Publications:

Kilkenny, F., B. St. Clair, M. Horning. 2013. Climate change and the future of seed zones, 87-89. In: D. Haase, J. Pinto, K. Wilkinson, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2012. RMRS-P-69. USDA Forest Service, Fort Collins, CO.

St.Clair, J. B., F. F. Kilkenny, R. C. Johnson, N. L. Shaw, G. Weaver, George. 2013. Genetic variation in adaptive traits and seed transfer guidelines for *Pseudoroegneria spicata* (bluebunch wheatgrass) in the northwestern United States. Evolutionary Applications 6:933-948.

Report:

Kilkenny, F. F., and J. B. St. Clair. 2013. Testing the efficacy of seed Zones for re-establishment and adaptation of bluebunch wheatgrass (*Pseudoroegneria spicata*). Great Basin Native Plant Project 2013 Annual Report. USDA Forest Service, Rocky Mountain Research Station, Boise, ID.

Presentations:

Kilkenny, F. F. 2013. Characterization of current and future climates within and among seed zones to evaluate options for adapting to climate change. Second National Native Seed Conference, Santa Fe, NM, April 8-11, 2013.

St. Clair, J. B., F. F. Kilkenny, R. C. Johnson. 2013. Adaptation of native grasses to climates of the interior western United States. Second National Native Seed Conference, April 8-11, 2013.

10.1.2 Post-wildfire Wind Erosion In and Around the Idaho National Laboratory Site

Investigators and Affiliations

- Matthew J. Germino, Ph.D., Research Ecologist, United States Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise Idaho

Collaborators

- Nancy F. Glenn, Ph.D., Professor, Geosciences Department, Idaho State University, Boise, Idaho
- Joel Sankey, Ph.D., Research Scientist, United States Geological Survey, Flagstaff, Arizona

Funding Sources

- USDA National Institute for Food and Agriculture, Rangelands Program

Background

Wind erosion following large wildfires on and around the INL Site is a recurrent threat to human health and safety, DOE operations and trafficability, and ecological and hydrological condition of the INL Site and down-wind landscapes. Causes and consequences of wind erosion are mainly known from warm deserts (e.g. Southwest US), dunefields, and croplands, and some but not all findings are transferable to the cold desert environments such as where the INL Site lies.

Objectives

This is a large and multifaceted research program with the overall goal being to determine and describe wildland fire effects on wind erosion in rangelands on and around the INL Site. The specific objectives include the following:

- To quantify the role of wind erosion and dust emissions in post-fire environments as well as the associated potential impacts on site fertility, invasibility by exotic grasses, micro-scale geomorphology, and regional air quality.
- To determine if the aerodynamic parameters friction velocity, roughness length, and displacement height change through time following wildland fire, and to identify how these parameters relate to vegetation recovery after fire.

- To determine the effects of repeat burning on levels of wind erosion, for sites that reburn a few years following prior fires.
- To determine how weather and surface-soil moisture variations relate to (i.e. control) erodibility over the months when vegetation has yet to recover on the site.
- To link monitoring of near-soil saltation activity to dust emission and model regional dust plumes culminating from INL Site fires, using a combination of ground-level, air quality, and remotely sensed approaches.

Accomplishments through 2013

We continued to analyze the robust dataset we have on saltation and sediment flux from the 2010 Jefferson Fire (data through summer 2011) and visited the site to assess vegetation recovery. We have begun preparation of a field guide to post-fire wind erosion for managers.

Results

Our efforts have substantiated patterns reported in our previous report (for 2012) and have newly revealed complex patterns of erosion as a function of rainfall. Whereas rain is typically viewed as stabilizing soils that are otherwise at risk of wind erosion, our preliminary data suggest that this generalization does not hold in the year of erosion we observed after the Jefferson Fire. Furthermore, we made observations of sustained erosion in the very dry summer 2013 on fires burned in 2011 and 2012, which suggests that our previous findings that initial vegetation recovery by the June or July following fire stabilizes the burn site may not apply to all wildfires.

Plans for Continuation

In 2014, we do not plan to collect more field data unless new fire and erosion conditions arise. Our efforts will continue to focus on using existing data for modeling, analysis, and publication.

Publications, Theses, Reports

Presentations:

- Germino, M. J., Sankey J., Glenn N. 2013. Nutrient fluxes and their relationship to ecosystem changes associated with post-fire wind erosion and dust emission. 12th Biennial Conference of Science and Management on the Colorado Plateau. Flagstaff AZ. Sept. 16-19.
- Germino, M. J. 2013. Post-fire wind erosion. EPA Region 10, Air Quality Conference and Workshop on Wildfire Impacts, Ellensburg, WA, March 13 (>100 regulators and stakeholders including EPA admin). (30 min presentation followed by Q/A, at request of EPA).
- Germino, M. J. 2013. Post-fire wind erosion. National Fire Emergency Stabilization and Rehabilitation Program Annual meeting of state leads and BLM Assistant Director, Boise ID, Feb. 26 (30 min presentation followed by Q/A, at request of DOI-ESR program).
- Germino, M. J, Glenn N.F., Hardy R., Miller S. 2013. “Dust, an emerging problem in the Great Basin: insights from 2013. Great Basin Consortium, 2nd annual meeting. Boise ID Jan. 14-16, 2013.

10.1.3 Long-Term Vegetation Transects – Monitoring Recovery on the T-17 Fire Plots

Investigators and Affiliations

- Amy D. Forman, Plant Ecologist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID.
- Jackie R. Hafla, Natural Resource Specialist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID.
- Roger D. Blew, Ecologist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID.

Funding Sources

- U.S. Department of Energy, Idaho Operations Office

Background

During the summer of 2011, LTV data were collected across all active LTV plots and data collection was completed in the first week of August. On August 25, the T-17 Fire burned 11 LTV plots along T-17 (Figure 1), providing a unique opportunity to monitor fire recovery on a number of plots which were recently sampled and had been well-characterized for decades prior to the fire. A few previous fire recovery studies have been conducted on the INL Site over the past twenty years and their results have been useful for understanding general post-fire vegetation dynamics.

Fire ecology studies on the INL Site and from other southeast Idaho locations suggest that a plant community reestablishing after a fire will be a reflection of the community present before the fire, with the exception of big sagebrush (*Artemisia tridentata*; Ratzlaff and Anderson 1995, Buckwalter 2002, Blew and Forman 2010). Typically, native plant communities in good pre-burn ecological condition will return to diverse, native plant communities within a few growing seasons post-burn and can resist invasion and/or dominance by non-native species. Recommendations for management of burned areas on the INL Site were based on the results of these studies and lead to the following guidance (Blew and Forman 2010):

- Vegetation management strategies should focus on enhancing the vigor of native, herbaceous species, regardless of burn status, because areas with vigorous native perennial plant communities are at less risk for post-fire invasions and are less likely to require active restoration to establish a healthy plant community following a fire.
- Managing for vigor of perennial grasses should be the highest vegetation management priority on recently burned areas, because sagebrush and other shrubs that increase habitat value are more likely to establish on good condition sites than on sites with an abundance of non-natives.

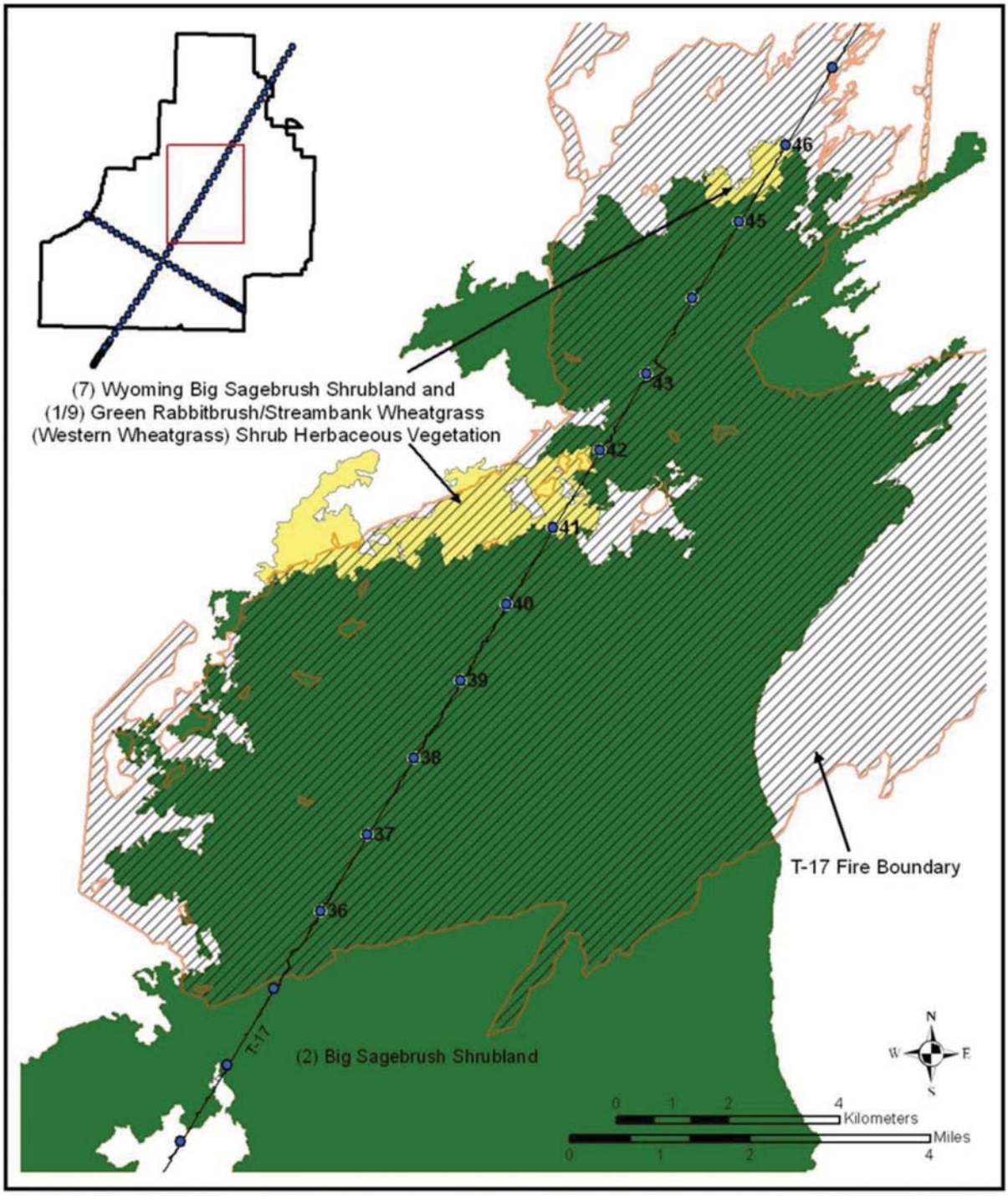

Figure 10-1. Location of 11 Long-term Vegetation Transect Plots which Burned during the 2011 T-17 Fire. Vegetation Classes Represented are Prior to the Fire and are from Shive et al. (2011).

- A healthy pre-fire plant community can increase the resilience of a site, allowing substantial post-fire recovery, even under very adverse conditions like severe drought.

While these guidelines provide a solid overarching philosophy for long-term post-fire vegetation management, they offer little direction for specific scenarios which necessitate enhancing shrub recovery in the short term or identifying specific events or conditions which may shift the recovery trajectory of a plant community to a less desirable state. The studies on which post-fire guidelines are based were conducted entirely post-fire, and pre-burn conditions were extrapolated from general conditions reported for plant communities elsewhere on the INL Site. Monitoring post-fire vegetation composition and comparing it to pre-fire vegetation dynamics will yield information important for characterizing a specific burned site and evaluating its potential to return to a desirable state. This information will in turn be useful for prioritizing restoration efforts by quantifying how the range of variability for recovering communities compares to range of variability in pre-burn communities. This information can be used to address issues like determining the abundance at which cheatgrass shifts from being a minor, somewhat ephemeral component of a plant community to a truly invasive community dominant. Understanding not only the current condition of a site, but its status in terms of its potential historical range of variability can be a powerful tool for determining the need for active restoration.

Objectives

The primary objective of this post-fire monitoring effort is to follow short-term vegetation recovery patterns on the 11 plots burned in the 2011 T-17 Fire and to assess the extent to which post-fire plant communities recover. Specifically, we are interested in how quickly community dynamics reflect pre-burn range of variability and to what extent other factors like weather and non-native species influence vegetation recovery. We also hope to gain information useful for developing more specific guidelines for post-fire assessments of potential recovery to support conservation planning on the INL Site. Specific issues affecting post-fire recovery which can necessitate active restoration and can be monitored using this data set include; risk of post-fire cheatgrass dominance based on pre-fire abundance, effects of precipitation patterns on various native and non-native functional groups pre-and post-burn, and length of time fire induced vegetation compositional changes (other than loss of sagebrush) may persist.

Accomplishments through 2013

All active LTV plots were sampled for the 12th time during the summer of 2011 using the same standard techniques that have been used for estimating cover and density throughout the history of the LTV project. See Forman et al. (2010) for detailed sampling methodology. In 2012 and 2013, we sampled the 11 LTV plots that burned in the T-17 Fire during the same time frame (late-June to mid-July), within about one week of when they were sampled in 2011. Initial results comparing the plant community composition of each plot immediately prior to the fire to the composition of each plot almost one year after the fire are included in the most recent comprehensive LTV report (Forman et al. 2013). Data from 2013, the second post-fire growing season, and beyond, will be analyzed with the next full LTV effort.

Results

Initial results from data collected in 2011 and 2012 confirm that shrub and perennial forb cover are significantly reduced one year post-fire. However, cover from native, perennial graminoids was not significantly different post-fire than it was pre-fire (Table 1). This result indicates established perennial grasses readily resprout post-fire and it is particularly impressive given that total precipitation in spring and early summer of 2012 were far below average. Introduced annual and biennial cover, mostly from cheatgrass, was significantly lower post-fire than it was pre-fire (Table 1). This pattern has been noted in other post-fire data sets from the INL Site (Rew et al. 2012, Forman et al. 2013), but it is unclear whether reductions in abundance are from effects of the fire or are related to precipitation patterns that happen to coincide with post-fire recovery. It is also unknown whether post-fire reductions in cheatgrass are temporary and limited to a few seasons post-fire, or whether they persist and change the trajectory of a plant community long-term. See Forman et al. 2013 for more detailed results from comparison of the 2011 and 2012 data.

Plans for Continuation

Monitoring these 11 plots annually for the 5 years between comprehensive LTV sampling periods (2011 and 2016) will provide important and useful insight on the recovery of native species and on the redistribution and spread of introduced species following fire. Short-term annual data collection will also allow us to characterize the relative importance of precipitation on recovery, especially under more moderate conditions than occurred in 2012. Comparing recovery data over a five year period to historical vegetation dynamics should provide enough information to begin developing a basis for prioritizing restoration activities in burned areas elsewhere on the INL Site using short-term post-fire vegetation data. A comprehensive data analysis from monitoring the 11 LTV plots located in the T-17 burned area for five years post-fire will be included in the next LTV report, following complete LTV sampling in 2016.

Table 10-1. Mean Absolute Cover by Functional Group and One-way Repeated Measures ANOVA Results Comparing Pre- and Post-fire Vegetation on 11 Long-term Vegetation Transect Plots at the Idaho National Laboratory Site.

	2011	2012	Significant
Native Shrubs	18.04	0.48	Yes
Native Perennial Graminoids	7.81	5.98	No
Native Perennial Forbs	1.60	0.74	Yes
Native Succulents	0.16	0.03	Yes
Native Annuals and Biennials	0.23	0.09	No
Introduced Annuals and Biennials	11.96	0.55	Yes

Publications, Theses, Reports, etc.

Results summarizing data collected in 2011 and 2012 can be found in:

Forman, A. D., J. R. Hafla, and R. D. Blew. 2013. The Idaho National Laboratory Site Long-Term Vegetation Transects: Understanding Change in Sagebrush Steppe. Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, LLC, Idaho Falls, ID. GSS-ESER-163.

10.1.4 Time Interval Photography Monitoring of Cinder Butte Snake Hibernaculum

Investigators and Affiliation

- Charles R. Peterson, Ph.D., Department of Biological Sciences, Idaho State University, Pocatello, ID
- Jeremy P. Shive, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, LLC., Idaho Falls, ID
- David Bush, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

- Idaho State University Department of Biological Sciences
- Idaho National Environmental Research Park

Background

The T-17 wildland fire burned approximately 17,807 ha (44,000 acres) in 2011, including the area around Cinder Butte (Figure 2). The basalt outcropping near Cinder Butte supports multiple snake hibernacula, including the primary North den, which has been monitored by the ISU Herpetology Laboratory for over 15 years. Anecdotal field observations following the T-17 fire found there was a lot of soil and sand movement in the areas devoid of vegetation. The wind-blown sand was beginning to fill in the interspaces of the basalt rock and there was some concern whether access to the den would be restricted, and the individuals returning for winter hibernation would be stranded with no alternative refuge.

Objectives

The primary goal of monitoring the Cinder Butte snake hibernaculum is to document the continued use of the den site, and to identify which species of snakes are currently present following the T-17 wildland fire.

Accomplishments through 2013

Photographic monitoring is a relatively inexpensive method to monitor snake den activity. We initially attempted to use the infrared thermal trigger on the camera during fall of 2012, however, snakes are ectothermic and body temperature is closely tied to environmental temperatures.

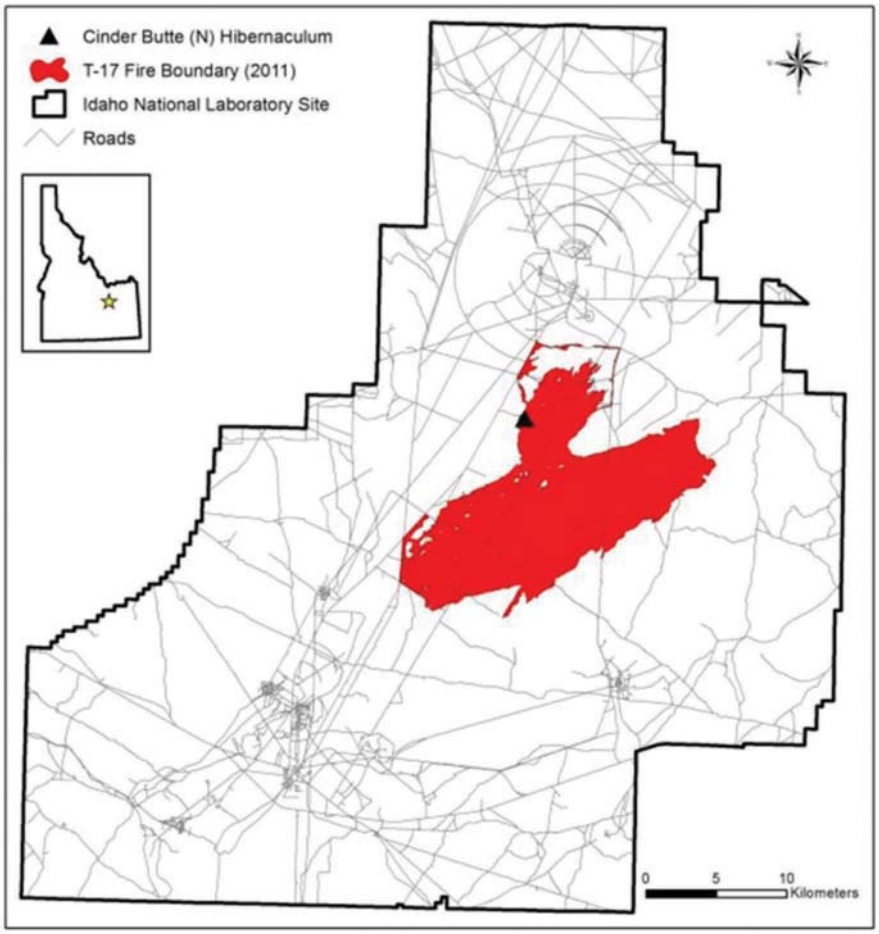

Figure 10-2. The Idaho National Laboratory Site Showing the Extent of the T-17 Wildland Fire and the Location of the Cinder Butte (North) Snake Hibernaculum.

Because snake body temperatures were not substantially different than background temperatures, the thermal trigger did not capture snake movements as the animals were essentially 'invisible' to the thermal sensor.

We modified the camera setting in the spring of 2013 to a fixed time interval of one minute from sunrise to sunset. We collected over 52,000 images during the spring from 4/14 – 6/18, and over 31,000 images in the fall from 9/12 – 10/22. All images were reviewed and each observation event was recorded. An observation event is defined as a single snake observed for one or more consecutive images. If an individual moved out of view or retreated back into the den it concluded the observation event, even if an individual was seen back at the same spot minutes later. Because we cannot be sure it was the same individual, we treated each instance as a new observation event.

The spring dataset was further analyzed at ISU and compared to previous results from radiotelemetry surveys, and to investigate how time and temperature affect snake surface activity

at the den. To test for observer error during the image review process, two independent people reviewed all of the images, and the number of observation events was compared.

Results

Time-interval photography was found to be an effective method for monitoring snake species at the Cinder Butte hibernaculum. All four species (Great Basin Rattlesnake [*Crotalus oreganus lutosus]*, Gopher Snake [*Pituophis catenifer],* Striped Whipsnake [*Masticophis taeniatus]*, and Western Terrestrial Garter Snake [*Thamnophis elegans*]) previously documented at the Cinder Butte hibernaculum by ISU Herpetology Laboratory were successfully detected and present during the spring of 2013.

Observer accuracy was high with an average detection rate of 91 percent. One observer missed four of the observation events and the other observer missed six. Snake surface activity ranged from April 26 to June 12 with a median activity date of May 15. Interestingly, the May 15 median date coincides with the previous median day of surface activity calculated from more intensive radiotelemetry, trapping, and hand capture surveys conducted by the ISU Herpetology Lab from 1990-1992 at Cinder Butte. Snake surface activity ranged from 10:08 to 20:59 with median activity occurring at 13:41. The camera temperature sensor showed a range of -9.4ºC to 39.4ºC with a median temperature of 25.9ºC for snake observation events.

Plans for Continuation

Further analysis including the fall 2013 and spring 2014 datasets is planned. Once a few seasons of data have been collected, a baseline of observation events can be established. Future time interval photographic monitoring could then be conducted and compared to the established baseline to potentially detect changes in population status.

We would like to experiment with different camera settings and systems to optimize the accuracy of snake detections while minimizing overall effort. Solar-powered battery attachments are becoming more common and less expensive. Memory card capacity is also growing rapidly, and it is now feasible to store the entire spring/fall season on a single SD card. Once we are able to power the camera system for the entire season of imaging and store all images on a single memory card without having to make multiple visits, we would like to test the omission error rate of the current time-interval setup. We plan to alter the time interval and capture an image every second (rather than every minute) from sunrise to sunset and essentially record a continuous sampling of the hibernaculum. Then that dataset would be artificially subsampled at different time intervals (e.g. 30-second, 1-minute, 2-minute, etc.), and reviewed for observation events. This analysis will provide insight about how the time interval affects detection rates. If fewer images need to be collected, and detection rates do not vary considerably, we could minimize the required processing time. We have also considered testing a different camera system, such as a GoPro, which has higher image resolution and a larger field of view.

We plan to determine actual snake operative temps using physical snake models attached to a temperature datalogger. By comparing the internal camera system thermometer with the physical models, it will allow us to understand the relationship between camera measurements and the temperatures the snakes are more realistically experiencing at the den.

Publications, reports, theses, etc.

An oral presentation summarizing the spring dataset was given as at the joint meeting of the Idaho Herpetological Society and Idaho Partners in Amphibian and Reptile Conservation at the Northwest Nazarene University in November 2013. The spring data analysis was also presented as a poster at the Idaho Chapter of the Wildlife Society annual meeting held in Boise, ID February 2014.

10.1.5 The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of Sagebrush Steppe Rangelands on the Idaho National Laboratory Site

Investigators and Affiliations

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Collaborators

- Lar Svenson, M.S., US Geological Survey, United States Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise Idaho
- Keith Reinhardt, Ph.D., Postdoctoral Fellow, Idaho State University, Pocatello, Idaho
- Kevin Feris, Ph.D., Assistant Professor, Boise State University, Boise, Idaho
- Kathleen Lohse, Ph.D., Assistant Professor, Idaho State University, Pocatello, Idaho
- Marie-Anne deGraff, Ph.D., Assistant Professor, Boise State University, Boise, Idaho
- David Huber, Ph.D. candidate, Idaho State University, Pocatello, Idaho
- Patrick Sorenson, M.S., Boise State University, Boise, Idaho
- Patricia Xochi Campos, M.S. candidate, Boise State University, Boise Idaho
- Cassandra Gause, B.S./M.S. candidate, Idaho State University, Pocatello, Idaho
- Kate McAbee, M.S. candidate, Idaho State University, Pocatello, Idaho
- Lindsay McCurran, M.S. candidate, Idaho State University, Pocatello, Idaho

Funding Sources

- Idaho Experimental Program to Stimulate Competitive Research (EPSCoR), National Science Foundation
- U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center
- U.S. Geological Survey, Northwest Climate Science Center
- In-kind facilities and infrastructure support from DOE-Idaho, logistics support through Gonzales-Stoller Surveillance, LLC.

Background

The INL Site and other landscapes having sagebrush steppe vegetation are experiencing a simultaneous change in climate and floristics that result from increases in exotic species. 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.

This research uses the 72 experimental plots established and initially maintained for many years as the "Protective Cap Biobarrier Experiment" by Dr. Jay Anderson and the Environmental Surveillance, Education and Research program, and the experiment is also now referred to as the "INL Site Ecohydrology Study." We are evaluating long-term impacts of different plant communities commonly found throughout Idaho subject to different precipitation regimes and to different soil depths. Treatments of amount and timing of precipitation (irrigation), soil depth, and either native/perennial or exotic grass vegetation allow researchers to investigate how vegetation, precipitation and soil interact to influence soil hydrology and ecosystem biogeochemistry. This information will be used to improve a variety of models, as well as provide data for these models.

Objectives

The goal of this study is to assess the interactive and reciprocal effects of hydroclimate shifts and plant community composition on ecohydrological and biogeochemical processes, with the specific objectives to:

- Determine response of vegetation to timing of irrigation and soil depth, and conversely the influence of plant communities and vegetation type on deep soil water infiltration
- Investigate microbial communities and soil microbial enzymatic activity and soil aggregation/porosity, to assess whether fundamental ecosystem changes to treatments are occurring and could feed back on water flow patterns
- Investigate changes in plant and soil nutrient pools and fluxes due to vegetation and precipitation differences.

Accomplishments through 2013

In 2013 we continued to troubleshoot and make functional an additional set of TDR water content sensors installed in an effort to reduce our reliance on manual neutron-probe measurements. Ecosystem responses included measurement of litter deposition, plot biomass (clipping subplots) sagebrush growth and carbon isotopes, biogeochemical shifts, and CO_2 exchange from large chamber measurements.

Results

Our preliminary data suggest differences in sagebrush growth and seedling establishment are occurring as a result of the precipitation treatments, and are accompanied by shifts in litter deposition and biogeochemical patterns. Conclusive findings are expected within the next year as three students prepare their chapters and our synthesis for Northwest Climate Science Center on sagebrush responses is accomplished.

Plans for continuation

We will continue making the same types of measurements as in the past year, generating multiple-years of data to substantiate our findings. New additions will continue to include 1) assessments of soil solution biogeochemistry done through installation of lysimeters via cores from the surface, 2) measurements of net primary productivity, 3) assessment of litter inputs and decomposition processes, along with root growth assessed by root-ingrowth tubes, 4) sagebrush demography.

Publications, theses, reports

Publications

Sorensen, P.O., Germino, M.J., Feris, K., 2013, Microbial community responses to 17 years of altered precipitation are seasonally dependent and coupled to co-varying effects of water content on vegetation and soil carbon. *Soil Biology and Biochemistry*, 64: 155-163

Presentations

Germino, M.J, Brabec, M., Davidson, B., Shinneman D., Halford A., Richardson B. 2013. Post-fire sagebrush establishment across the landscapes: experimental tests to inform restoration success. Great Basin Consortium 3rd annual meeting, Reno, Nevada, Dec. 9.

Germino, M.J. Climate change vulnerability. Lecture to distributed class on Sagebrush and climate. 27 Sept. 2013, delivered at Boise State University

Huber, D.P., Lohse, K., Germino, M.J. 2013. Climate Controls on Soil Hydrological and Nutrient Partitioning in Dryland Ecosystems. Chapman conference on Soil-mediated drivers of coupled biogeochemical and hydrological processes across scales. Tucson AZ. October 21-24

Germino, M.J., Svenson, L., Reinhardt, K. (2013) Sagebrush responses to climate. Intermountain Native Plant Summit (7th annual), Boise, Idaho, March 26-27, 2013 [INVITED]

Germino, M.J., Reinhardt, K. 2013. Experimental evidence for sagebrush responses to climate. Great Basin Consortium, 2nd annual meeting, Boise Idaho, January 14, 2013

10.1.6 Studies of Ants and Ant Guests at the Idaho National Laboratory Site

Investigators and Affiliations

- William H. Clark, Orma J. Smith Museum of Natural History, The College of Idaho, Caldwell, Idaho 83605

Funding Sources

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

Background

Clark and Blom (2007) reported the first comprehensive annotated checklist of ants at the INL Site. This publication gives a starting point for additional research relating to ants, their natural history and ecology, and ant guests at INL Site. Ant guests (*myrmecophiles*) are organisms that live in close association with ants. These are generally mutualistic associations, but may also be commensal or parasitic. Much research remains to be done to better the understanding between ants and their guests.

Objectives

Immediate objectives are to locate living larvae of the ant guest beetle (*Philolithus elata*) (Coleoptera: Tenebrionidae) within nests of the harvester ant (*Pogonomyrmex salinus*) (Hymenoptera: Formicidae). These beetles have been documented from the harvester ant nests here in the past by Clark and Blom (unpublished data), but the larvae have not been previously described. Fresh larvae are needed for scanning electron microscopy (SEM) to provide for a proper description of these organisms. The overall objective will be to document the interaction of this beetle with the ants.

Other observations on additional ant guests will be made as they are encountered. Information relating to the ants of INL Site will be documented as possible.

Accomplishments through 2013

During the fall of 2011, 100 nests of the harvester ant (*Pogonomyrmex salinus*) were selected and marked along Road T-17 near Circular Butte. These nests were then surveyed by INL archaeologists for cultural resources and approval was given for excavation of nests as needed. A total of 10 percent of the nests were excavated during late 2011 and no *Philolithus elata* were found. Additional nests were excavated during the fall of 2012 and again no *Philolithus elata* were found. We surveyed 41 nests during July 2013 and found *Philolithus elata* larvae in six of the nests and pupae in two of the nests.

Results

One ant guest taxa, a desert beetle (Coleoptera: Tenebrionidae: *Philolithus elata*) (Figure 3a and 3b) was collected in *Pogonomyrmex salinus* nests and is the subject of study and description (Clark, et al. *in prep.*). An undescribed species of Jerusalem cricket (Orthoptera: Stenopelmatidae, *Stenopelmatus sp.*) (Figure 4) was found at the INL Site. The *Stenopelmatus* was found in the ant nests during previous field work. A series of live individuals including both males and females were needed for a proper species description. We collected 20 live specimens in July 2013. In addition, one specimen was found in one of the excavated ant nests. They have been shipped to the specialist in the group for rearing and description. Both taxa will require more study during future visits to the INL Site. We have now taken preliminary photographs with light and SEM. The results will be published in Clark et al. (*in prep*).

In addition, we are working on a publication relating to past research at the site involving cicadas and *Pogonomyrmex salinus* nests (Blom and Clark, *in prep.*)

Figure 10-3a. Live *Philolithus Elata* Larvae from Nests of *Pogonomyrmex Salinus* Near Circular Butte, July 2013, W.H. Clark photo. Largest Specimen is Approximately 6 cm in Length.

Figure 10-3b. Live *Philolithus Elata* Pupa from Nest of *Pogonomyrmex Salinus* Near Circular Butte, July 2013, W.H. Clark Photo. Pupa is Approximately 3 cm in Length. The Pupae from this Group are Unknown (i.e. have not yet been described).

Figure 10-4. An Undescribed Species of Jerusalem Cricket (*Stenopelmatus sp.*) Found Near *Pogonomyrmex Salinus* Nests. Near Circular Butte, July 2013, W.H. Clark Photo. Cricket is Approximately 3 cm in Length. These Insects have been Found in the Ant Mounds in the Past at this Site.

Plans for Continuation

- Field research will continue into the foreseeable future.

Publications, theses, reports, etc.

Two draft manuscripts are being prepared, so far, for this project:

Blom, P. E., and W. H. Clark. In Prep. Observations of cicada nymphs, *Okanagana annulata* Davis (Homoptera: Cicadidae) and the harvester ant *Pogonomyrmex salinus* Olsen (Hymenoptera: Formicidae) in southeastern Idaho. Manuscript being prepared for the *Western North American Naturalist*.

Clark, W. H., P. E. Blom, and P. J. Johnson. In Prep. *Philolithus elata* LeConte associated with *Pogonomyrmex salinus* Olsen nest soils in southeastern Idaho (Coleoptera, Tenebrionidae, Asidinae; Hymenoptera, Formicidae, Myrmicinae). Manuscript being prepared for the *Coleopterists Bulletin*.

Acknowledgments

- Mary Clark assisted with the field work. Paul E. Blom has assisted with data analysis and detailed photographs of the immature beetles. Oregon Department of Agriculture assisted with the SEM.

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Clark, W.H., and P.E. Blom. 2007. Ants of the Idaho National Laboratory. *Sociobiology* 49(2):1-117.

Department of Energy, Idaho Operations Office (DOE-ID), and U.S. Fish and Wildlife Service (USFWS). In review. *Candidate conservation agreement for greater sage-grouse (Centrocercus urophasianus) on the Idaho National Laboratory Site*. Idaho Falls, Idaho. GSS-ESER-153.

Forman, A. D., R. D. Blew, and J. R. Hafla. 2010. *The Idaho National Laboratory Site Long-Term Vegetation Transects: A comprehensive review.* STOLLER-ESER-126, Environmental Surveillance, Education, and Research Program, Idaho Falls, ID.

Forman, A. D., J. R. Hafla, and R. D. Blew. 2013. *The Idaho National Laboratory Site Long-Term Vegetation Transects: Understanding Change in Sagebrush Steppe.* Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, LLC, Idaho Falls, ID. GSS-ESER-163.

Ratzlaff, T. D., and J. E. Anderson. 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. *Journal of Range Management* 48:386-391.

Rew, L., B. Maxwell, M. Lavin, T. Brummer, and K. Taylor. 2012. *Survey, monitoring and predicting the occurrence and spread of native and non-native plant species at the Idaho National Laboratory,* Bozeman, MT.

Shive, J. P., A. D. Forman, K. Aho, J. R. Hafla, R. D. Blew, and K. T. Edwards. 2011. *Vegetation community classification and mapping of the Idaho National Laboratory Site.* GSS-ESER-144, Environmental Surveillance, Education, and Research Program, Idaho Falls, ID.

10.2 U.S. Geological Survey 2013 Publication Abstracts

In 1949, the United States Geological Survey (USGS) was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL Site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the ESRP and the ESRP aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells
- Drills new research and monitoring wells, providing information about subsurface water, rock and sediment
- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities is used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse (http://id.water.usgs.gov/projects/INL/pubs.html.)

Seven reports were published by the USGS INL Project Office in 2013. The abstracts of these studies and the publication information associated with each study are presented below.

10.2.1 Balancing Practicality and Hydrologic Realism: A Parsimonious Approach for Simulating Rapid Groundwater Recharge via Unsaturated-zone Preferential Flow (Ben B. Mirus and John R. Nimmo)

The impact of preferential flow on recharge and contaminant transport poses a considerable challenge to water-resources management. Typical hydrologic models require extensive site characterization, but can underestimate fluxes when preferential flow is significant. A recently developed source-responsive model incorporates film-flow theory with conservation of mass to estimate unsaturated-zone preferential fluxes with readily available data. The term source-responsive describes the sensitivity of preferential flow in response to water availability at the source of input. We present the first rigorous tests of a parsimonious formulation for simulating water table fluctuations using two case studies, both in arid regions with thick unsaturated zones of fractured volcanic rock. Diffuse flow theory cannot adequately capture the observed water table responses at both sites; the source-responsive model is a viable alternative. We treat the active area fraction of preferential flow paths as a scaled function of water inputs at the land surface then calibrate the macropore density to fit observed water table rises. Unlike previous applications, we allow the characteristic film-flow velocity to vary, reflecting the lag time between source and deep water table responses. Analysis of model performance and parameter sensitivity for the two case studies underscores the importance of identifying thresholds for initiation of film flow in unsaturated rocks, and suggests that this parsimonious approach is potentially of great practical value.

10.2.2 Geochemical Evolution of Groundwater in the Medicine Lodge Creek Drainage Basin, Eastern Idaho (Michael L. Ginsbach)

This thesis describes and interprets the solute chemistry and hydrogeology of the Medicine Lodge Creek drainage basin in eastern Idaho as part of a comprehensive study by the USGS of the natural geochemistry of the ESRP aquifer at the INL.

Water samples were collected from three springs and seven wells and analyzed for field parameters, major ions, trace elements, nutrients, tritium, and stable isotope ratios of hydrogen and oxygen. Rock and sediment samples were collected from outcrops and streams and analyzed using granulometric, X-ray diffraction, and petrographic methods.

Modeling of water-rock interactions was accomplished using PHREEQC software. Waters are calcium-magnesium-bicarbonate type and show evidence of anthropogenic influences. Host-rock weathering processes, including precipitation of clay, controls the solute chemistry in the northern portion of the drainage basin while southern parts of the drainage basin is impacted by potential mixing with a cryptic geothermal source.

10.2.3 Paleomagnetic Correlation and Ages of Basalt Flow Groups in Coreholes at and near the Naval Reactors Facility, Idaho National Laboratory, Idaho (Duane E. Champion, Linda C. Davis, Mary K. V. Hodges, and Marvin A. Lanphere).

Paleomagnetic inclination and polarity studies were conducted on subcore samples from eight coreholes located at and near the NRF, INL. These studies were used to characterize and to correlate successive stratigraphic basalt flow groups in each corehole to basalt flow groups with similar paleomagnetic inclinations in adjacent coreholes. Results were used to extend the subsurface geologic framework at the INL previously derived from paleomagnetic data for south INL coreholes. Geologic framework studies are used in conceptual and numerical models of groundwater flow and contaminant transport. Sample handling and demagnetization protocols are described, as well as the paleomagnetic data averaging process.

Paleomagnetic inclination comparisons among NRF coreholes show comparable stratigraphic successions of mean inclination values over tens to hundreds of meters of depth. Corehole USGS 133 is more than 5 kilometers from the nearest NRF area corehole, and the mean inclination values of basalt flow groups in that corehole are somewhat less consistent than with NRF area basalt flow groups. Some basalt flow groups in USGS 133 are missing, additional basalt flow groups are present, or the basalt flow groups are at depths different from those of NRF area coreholes.

Age experiments on young, low potassium olivine tholeiite basalts may yield inconclusive results; paleomagnetic and stratigraphic data were used to choose the most reasonable ages. Results of age experiments using conventional potassium argon and argon-40/argon-39 protocols indicate that the youngest and uppermost basalt flow group in the NRF area is 303 ± 30 ka and that the oldest and deepest basalt flow group analyzed is 884 ± 53 ka.

A south to north line of cross-section drawn through the NRF coreholes shows corehole-to-corehole basalt flow group correlations derived from the paleomagnetic inclination data. From stratigraphic top to bottom, key results include the following:

- The West of Advanced Test Reactor (ATR) Complex flow group is the uppermost basalt flow group in the NRF area and correlates among seven continuously cored holes in this study under surficial sediments. The West of ATR Complex flow group is also found in coreholes

near the ATR Complex, the Idaho Nuclear Technology and Engineering Center (INTEC), and in corehole USGS 129.

- The ATR Complex Unknown Vent flow group correlates among seven continuously cored holes in this study underlying the West of ATR Complex flow group and a sedimentary interbed. Additional paleomagnetic inclination and stratigraphic data derived from the NRF coreholes changed the previously reported interpretation of the subsurface distribution of this basalt flow group. The ATR Complex Unknown Vent flow group also is found in coreholes near the ATR Complex and INTEC.
- The Central Facilities Area (CFA) Buried Vent flow group correlates among all eight coreholes in the NRF area. It also is found in coreholes near the CFA and the Radioactive Waste Management Complex (RWMC) to the south. This basalt flow group is thickest near the CFA, which may indicate proximity to the vent. The State Butte flow group is found below the CFA Buried Vent flow group in the four northern NRF coreholes. It correlates to the State Butte surface vent located just northeast of the NRF. It is not found in coreholes south of the NRF.
- The Atomic Energy Commission (AEC) Butte flow group is found in coreholes USGS 133, NRF 6P, and NRF 7P. It probably underlies coreholes NRF B18-1, NRF 89-05, and NRF 89-04, but those coreholes were not drilled deeply enough to penetrate the flow group. The AEC Butte flow group vent is exposed at the surface near the ATR Complex, and its flows are found in many coreholes near the ATR Complex and INTEC. The AEC Butte flow group abruptly pinches out against the Matuyama Chron reversed polarity flows of the East Matuyama Middle flow group between coreholes NRF 7P and NRF 15.
- The East Matuyama Middle flow group correlates between coreholes NRF 15 and NRF 16 and may correlate to coreholes NPR Test/W-02 and ANL-OBS-A-001.
- The North Late Matuyama flow group correlates among coreholes USGS 133, NRF 6P, NRF 7P, NRF 15, and NRF 16. It probably underlies coreholes NRF B18-1, NRF 89-05, and NRF 89-04, but those coreholes were not drilled deeply enough to penetrate the flow group. The vent that produced the North Late Matuyama flow group may be located in the general NRF area because it is thickest near corehole NRF 6P.
- The Matuyama flow group is found in coreholes in the southern INL from south of the RWMC to corehole USGS 133 and may extend north to corehole NRF 15. The Matuyama flow group is thickest near the RWMC and thins to the north.

The Jaramillo (Matuyama) flow group is found in corehole NRF 15, which is the deepest NRF corehole, and shows that the basalt flow group is thick in the subsurface at NRF. This flow group is thickest between the RWMC and INTEC and thins towards the ATR Complex and NRF.

10.2.4 Optimization of Water-level Monitoring Networks in the Eastern Snake River Plain Aquifer using a Kriging-based Genetic Algorithm Method (Jason C. Fisher)

Long-term groundwater monitoring networks can provide essential information for the planning and management of water resources. Budget constraints in water resource management agencies often mean a reduction in the number of observation wells included

in a monitoring network. A network design tool, distributed as an R package, was developed to determine which wells to exclude from a monitoring network because they add little or no beneficial information. A kriging-based genetic algorithm method was used to optimize the monitoring network. The algorithm was used to find the set of wells whose removal leads to the smallest increase in the weighted sum of the (1) mean standard error at all nodes in the kriging grid where the water table is estimated, (2) root-mean-squared-error between the measured and estimated water-level elevation at the removed sites, (3) mean standard deviation of measurements across time at the removed sites, and (4) mean measurement error of wells in the reduced network. The solution to the optimization problem (the best wells to retain in the monitoring network) depends on the total number of wells removed; this number is a management decision. The network design tool was applied to optimize two observation well networks monitoring the water table of the ESRP aquifer, Idaho; these networks include the 2008 Federal-State Cooperative water-level monitoring network (Co-op network) with 166 observation wells, and the 2008 USGS-INL water-level monitoring network (USGS-INL network) with 171 wells. Each water-level monitoring network was optimized five times: by removing (1) 10, (2) 20, (3) 40, (4) 60, and (5) 80 observation wells from the original network. An examination of the trade-offs associated with changes in the number of wells to remove indicates that 20 wells can be removed from the Co-op network with a relatively small degradation of the estimated water table map, and 40 wells can be removed from the USGS-INL network before the water table map degradation accelerates. The optimal network designs indicate the robustness of the network design tool. Observation wells were removed from high well-density areas of the network while retaining the spatial pattern of the existing water-table map.

10.2.5 Iodine-129 in the Eastern Snake River Plain Aquifer at and near the Idaho National Laboratory, Idaho 2010-2012 (Roy C. Bartholomay)

From 1953 to 1988, approximately 0.941 curies of iodine-129 (^{129}I) were contained in wastewater generated at the INL with almost all of this wastewater discharged at or near the INTEC. Most of the wastewater containing ^{129}I was discharged directly into the ESRP aquifer through a deep disposal well until 1984; lesser quantities also were discharged into unlined infiltration ponds or leaked from distribution systems below the INTEC.

During 2010–12, the USGS in cooperation with the DOE collected groundwater samples for ^{129}I from 62 wells in the ESRP aquifer to track concentration trends and changes for the carcinogenic radionuclide that has a 15.7 million-year half-life. Concentrations of ^{129}I in the aquifer ranged from 0.0000013±0.0000005 to 1.02±0.04 picocuries per liter (pCi/L), and generally decreased in wells near the INTEC, relative to previous sampling events. The average concentration of ^{129}I in groundwater from 15 wells sampled during four different sample periods decreased from 1.15 pCi/L in 1990–91 to 0.173 pCi/L in 2011–12. All but two wells within a 3-mile radius of the INTEC showed decreases in concentration, and all but one sample had concentrations less than the U.S. Environmental Protection Agency MCL of 1 pCi/L. These decreases are attributed to the discontinuation of disposal of ^{129}I in wastewater and to dilution and dispersion in the aquifer. The decreases in ^{129}I concentrations, in areas around INTEC where concentrations increased between 2003 and 2007, were attributed to less recharge near INTEC either from less flow in the Big Lost River or from less local snowmelt and anthropogenic sources.

Although wells near INTEC sampled in 2011–12 showed decreases in ^{129}I concentrations compared with previously collected data, some wells south and east of the CFA, near the site boundary, and south of the INL showed small increases. These slight increases are attributed to variable discharge rates of wastewater that eventually moved to these well locations as a pulse of water from a particular disposal period.

Wells sampled for the first time around the NRF had ^{129}I concentrations slightly greater than background concentrations in the ESRP aquifer. These concentrations are attributed to either seepage of unknown wastewater sources discharged at the NRF or seepage from air emission deposits from INTEC, or both.

In 2012, the USGS collected discrete groundwater samples from 25 zones in 11 wells equipped with multilevel monitoring systems to help define the vertical distribution of ^{129}I in the aquifer. Concentrations ranged from 0.000006±0.000004 to 0.082±0.003 pCi/L. Two new wells completed in 2012 showed variability of up to one order of magnitude of concentrations of ^{129}I among various zones. Two other wells showed similar concentrations of ^{129}I in all three zones sampled. Concentrations were well less than the MCL in all zones.

10.2.6 Ambient Changes in Tracer Concentrations from a Multilevel Monitoring System in Basalt (Roy C. Bartholomay, Brian V. Twining, and Peter E. Rose)

Starting in 2008, a 4-year tracer study was conducted to evaluate ambient changes in groundwater concentrations of a 1,3,6-naphthalene trisulfonate tracer that was added to drill water. Samples were collected under open borehole conditions and after installing a multilevel groundwater monitoring system completed with 11 discrete monitoring zones within dense and fractured basalt and sediment layers in the ESRP aquifer. The study was done in cooperation with the DOE to test whether ambient fracture flow conditions were sufficient to remove the effects of injected drill water prior to sample collection. Results from thief samples indicated that the tracer was present in minor concentrations 28 days after coring, but was not present 6 months after coring or 7 days after reaming the borehole. Results from sampling the multilevel monitoring system indicated that small concentrations of the tracer remained in 5 of 10 zones during some period after installation. All concentrations were several orders of magnitude lower than the initial concentrations in the drill water. The ports that had remnant concentrations of the tracer were either located near sediment layers or were located in dense basalt, which suggests limited groundwater flow near these ports. The ports completed in well-fractured and vesicular basalt had no detectable concentrations.

10.2.7 An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Eastern Snake River Plain Aquifer and Perched Groundwater Zones, Idaho National Laboratory, Idaho Emphasis 2009-11 (Linda C. Davis, Roy C. Bartholomay, and Gordon W. Rattray)

Since 1952, wastewater discharged to infiltration ponds (also called percolation ponds) and disposal wells at the INL has affected water quality in the ESRP aquifer and perched groundwater zones underlying the INL. The USGS, in cooperation with the DOE, maintains groundwater monitoring networks at the INL to determine hydrologic trends, and to delineate the movement

of radiochemical and chemical wastes in the aquifer and in perched groundwater zones. This report presents an analysis of water-level and water-quality data collected from aquifer, multilevel monitoring system (MLMS), and perched groundwater wells in the USGS groundwater monitoring networks during 2009–11.

Water in the ESRP aquifer primarily moves through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer primarily is recharged from infiltration of irrigation water, infiltration of streamflow, groundwater inflow from adjoining mountain drainage basins, and infiltration of precipitation.

From March–May 2009 to March–May 2011, water levels in wells generally declined in the northern part of the INL. Water levels generally rose in the central and eastern parts of the INL.

Detectable concentrations of radiochemical constituents in water samples from aquifer wells or MLMS equipped wells in the ESRP aquifer at the INL generally decreased or remained constant during 2009–11. Decreases in concentrations were attributed to radioactive decay, changes in waste-disposal methods, and dilution from recharge and underflow.

In 2011, concentrations of tritium in groundwater from 50 of 127 aquifer wells were greater than or equal to the reporting level and ranged from 200±60 to 7,000±260 picocuries per liter. Tritium concentrations from one or more discrete zones from four wells equipped with MLMS were greater than or equal to reporting levels in water samples collected at various depths. Tritium concentrations in water from wells completed in shallow perched groundwater at the ATR Complex were less than the reporting levels. Tritium concentrations in deep perched groundwater at the ATR Complex equaled or exceeded the reporting level in 12 wells during at least one sampling event during 2009–11 at the ATR Complex.

Concentrations of strontium-90 in water from 20 of 76 aquifer wells sampled during April or October 2011 exceeded the reporting level. Strontium-90 was not detected within the ESRP aquifer beneath the ATR Complex. During at least one sampling event during 2009–11, concentrations of strontium-90 in water from 10 wells completed in deep perched groundwater at the ATR Complex equaled or exceeded the reporting levels.

During 2009–11, concentrations of plutonium-238, and plutonium-239, -240 (undivided), and americium-241 were less than the reporting level in water samples from all aquifer wells and in all wells equipped with MLMS. Concentrations of cesium-137 were equal to or slightly above the reporting level in 8 aquifer wells and from 2 wells equipped with MLMS.

The concentration of chromium in water from one well south of the ATR Complex was 97 micrograms per liter (µg/L) in April 2011, just less than the maximum contaminant level (MCL) of 100 µg/L. Concentrations of chromium in water samples from 69 other wells sampled ranged from 0.8 µg/L to 25 µg/L. During 2009–11, dissolved chromium was detected in water from 15 wells completed in perched groundwater at the ATR Complex.

In 2011, concentrations of sodium in water from most wells in the southern part of the INL were greater than the background concentration of 10 milligrams per liter (mg/L); the highest

concentrations were at or near the INTEC. After the new percolation ponds were put into service in 2002 southwest of the INTEC, concentrations of sodium in water samples from the Rifle Range well rose steadily until 2008, when the concentrations generally began decreasing. The increases and decreases were attributed to disposal variability in the new percolation ponds. Concentrations of sodium in most wells equipped with MLMS generally were consistent with depth. During 2011, dissolved sodium concentrations in water from 17 wells completed in deep perched groundwater at the ATR Complex ranged from 6 to 146 mg/L.

In 2011, concentrations of chloride in most water samples from aquifer wells south of the INTEC and at the CFA exceeded the background concentrations of 15 mg/L, but were less than the secondary MCL of 250 mg/L. Chloride concentrations in water from wells south of the INTEC have generally increased because of increased chloride disposal to the old percolation ponds since 1984 when discharge of wastewater to the INTEC disposal well was discontinued. After the new percolation ponds were put into service in 2002 southwest of the INTEC, concentrations of chloride in water samples from one well rose steadily until 2008 then began decreasing. Chloride concentrations in water from all but one well completed in the ESRP aquifer at or near the ATR Complex were less than background and ranged between 10 and 14 mg/L during 2011, similar to concentrations detected during the 2006–08 reporting period. During 2011, chloride concentrations in water from two aquifer wells at the RWMC were slightly greater than concentrations detected during the 2006–08 reporting period. The vertical distribution of chloride concentrations in wells equipped with MLMS were generally consistent within zones during 2009–11 and ranged from about 8 to 20 mg/L. During April 2011, dissolved chloride concentrations in shallow perched groundwater at the ATR Complex ranged from 7 to 13 mg/L in water from three wells. Dissolved chloride concentrations in deep perched groundwater at the ATR Complex during 2011 ranged from 4 to 54 mg/L.

In 2011, sulfate concentrations in water samples from 11 aquifer wells in the south-central part of the INL equaled or exceeded the background concentration of sulfate and ranged from 40 to 167 mg/L. The greater-than-background concentrations in water from these wells probably resulted from sulfate disposal at the ATR Complex infiltration ponds or the old INTEC percolation ponds. In 2011, sulfate concentrations in water samples from two wells near the RWMC were greater than background levels and could have resulted from well construction techniques and (or) waste disposal at the RWMC. The vertical distribution of sulfate concentrations in three wells near the southern boundary of the INL was generally consistent with depth, and ranged between 19 and 25 mg/L. The maximum dissolved sulfate concentration in shallow perched groundwater near the ATR Complex was 400 mg/L in well CWP 1 in April 2011. During 2009–11, the maximum concentration of dissolved sulfate in deep perched groundwater at the ATR Complex was 1,550 mg/L in a well located west of the chemical-waste pond.

In 2011, concentrations of nitrate in water from most wells at and near the INTEC exceeded the regional background concentrations of 1 mg/L and ranged from 1.6 to 5.95 mg/L. Concentrations of nitrate in wells south of INTEC and farther away from the influence of disposal areas and the Big Lost River show a general decrease in nitrate concentrations through time.

During 2009–11, water samples from 30 wells were collected and analyzed for volatile organic compounds (VOCs). Six VOCs were detected. At least one and up to five VOCs were detected in water samples from 10 wells. The primary VOCs detected include carbon tetrachloride, chloroform, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene. In 2011, concentrations for all VOCs were less than their respective MCL for drinking water, except carbon tetrachloride in water from two wells.

During 2009–11, variability and bias were evaluated from 56 replicate and 16 blank quality-assurance samples. Results from replicate analyses were investigated to evaluate sample variability. Constituents with acceptable reproducibility were stable isotope ratios, major ions, nutrients, and VOCs. All radiochemical constituents and trace metals had acceptable reproducibility except for gross beta-particle radioactivity, aluminum, antimony, and cobalt. Bias from sample contamination was evaluated from equipment, field, container, and source-solution blanks. No detectable constituent concentrations were reported for equipment blanks of the thief samplers and sampling pipes or for the source-solution and field blanks. Equipment blanks of bailers had detectable concentrations of strontium-90, sodium, chloride, and sulfate, and the container blank had a detectable concentration of dichloromethane.

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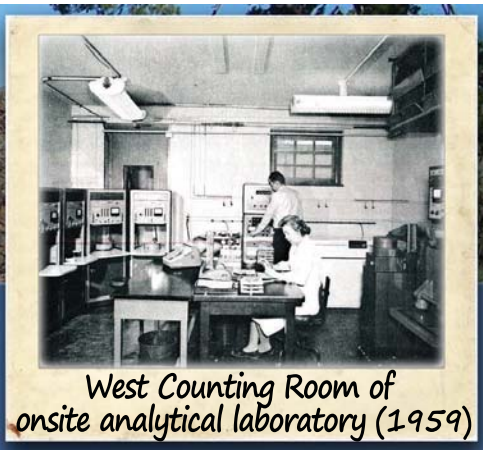
Header Photo Description: The Long-Term Vegetation (LTV) Transects and associated permanent vegetation plots were established on what is now the INL Site in 1950. Vegetation abundance data have been collected periodically once every two to ten years from plots located along two macro-transects which are perpendicular to one another and intersect near the center of the INL Site. LTV data are generally used to monitor vegetation condition and change in sagebrush steppe communities across the INL Site. Specific uses range from support for National Environmental Policy Act documents to conservation management planning.

11. Quality Assurance



West Counting Room of onsite analytical laboratory (1959)

11. QUALITY ASSURANCE

Quality assurance (QA) consists of the planned and systematic activities necessary to provide adequate confidence that the product or service will meet requirements. An effective QA program is essential to collect quality data. QA procedures are designed to ensure sample integrity, precision, and accuracy in the analytical results and to ensure that the environmental data are representative and complete. This chapter presents information on specific measures taken by the effluent monitoring and environmental monitoring programs in 2013 to ensure the quality of data collected and presented in this annual report.

11.1 Quality Assurance Policy and Requirements

The primary policy, requirements, and responsibilities for establishing and maintaining plans and actions that ensure QA in U.S. Department of Energy (DOE) activities are provided in DOE Order 414.1D, "Quality Assurance" (i.e., QA Order), 10 Code of Federal Regulations (CFR) 830, Subpart A, "Quality Assurance Requirements" (i.e., QA Rule) and American Society of Mechanical Engineers (ASME) NQA-1-2012, "Quality Assurance Requirement for Nuclear Facility Applications." The ASME NQA-1-2012 is the preferred standard for activities at nuclear facilities. Additional QA program requirements in 40 CFR 61, Appendix B must be met for all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H.

The ten criteria established in 10 CFR 830, Subpart A and DOE Order 414.1D that are required as part of a quality program are shown in the box on the right. Each Idaho National Laboratory (INL) Site environmental monitoring organization incorporates the requirements into its QA program documentation for environmental monitoring.

Quality Assurance Criteria Established by the U.S. Department of Energy

- Quality assurance program
- Personnel training and qualification
- Quality improvement process
- Documents and records
- Work Processes
- Established standards for design and verification
- Established procurement requirements
- Inspection and acceptance testing
- Management assessment
- Independent assessment

11.2 Environmental Monitoring Program Documentation

Strict adherence to program procedures is an implicit foundation of QA. In 2013, samples were collected and analyzed according to documented program procedures. Samples were collected by personnel trained to conduct sampling and properly process samples. Sample integrity was maintained through a system of sample custody records. Analytical data quality was verified by a continuing program of quality control (QC) detailed in program QA documents. Results were evaluated and input into databases using data management, validation, and reporting procedures. An overview of the Idaho Cleanup Project (ICP) contractor, INL contractor, and Environmental Surveillance, Education, and Research (ESER) contractor environmental monitoring program documentation is presented in Table 11-1, Figure 11-1, and Figure 11-2, respectively.

11.3 Environmental Monitoring Program Quality Assurance Program Documentation

Implementation of QA elements for sample collection and data assessment activities were documented using the approach recommended by the U.S. Environmental Protection Agency (EPA). The EPA policy on QA plans is based on the national consensus standard ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." The EPA approach to data quality centers on the data quality objective process. Data quality objectives are project dependent and are determined on the basis of the data users' needs and the purpose for which data are generated. Quality elements applicable to environmental monitoring and decision-making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001). These elements are categorized as follows:

- Project management
- Data generation and acquisition
- Assessment and oversight
- Data validation and usability.

A Quality Assurance Project Plan documents the planning, implementation, and assessment procedures for a particular project, as well as any specific QA and QC activities. It integrates all the technical and quality aspects of the project in order to provide a "blueprint" for obtaining the type and quality of environmental data and information needed for a specific decision or use.

The following sections summarize how each monitoring organization at the INL Site implements QA requirements.

11.3.1 Idaho National Laboratory Contractor

The INL contractor integrates applicable requirements from *Manual 13A—Quality Assurance Laboratory Requirements Documents* (INL 2014) into the implementing monitoring program plans

Table 11-1. Idaho Cleanup Project Environmental Program Procedures.

Document/Media Type	Document No.[a] and Title
Requirement Documents	PRD-5030, Environmental Requirements for Facilities, Processes, Materials, and Equipment MCP-3480, Environmental Instructions for Facilities, Processes, Materials, and Equipment
Data and Validation Documents	PLN-491, Laboratory Performance Evaluation Program Plan PLN-1401, Transferring Integrated Environmental Data Management System Revised Data to the Environmental Data Warehouse MCP-9236, Analytical Data Verification GDE-201, Inorganic Analyses Data Validation for Sample and Analysis Management GDE-204, Guide to Assessment of Radionuclide Analysis of Performance Evaluation Samples GDE-205, Radioanalytical Data Validation GDE-206, Obtaining Laboratory Services for Sample Analysis GDE-234, Generating Sampling and Analysis Plan Tables for Environmental Sampling Activities GDE-239, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-240, Validation of Gas and Liquid Chromatographic Organic Data GDE-241, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-7003, Levels of Analytical Method Data Validation MCP-1298, Sample and Analytical Data Management Process for the Sample and Analysis Management Program
Sampling Documents	MCP-9439, Environmental Sampling Activities at the INL
Groundwater Documents	PLN, 1305, Wastewater Reuse Permit Groundwater Program Plan SPR-162, Measuring Groundwater Levels and Sampling Groundwater TPR-6539, Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe TRP-7582, Well Inspection/Logging Using Down-Hole Cameras
Liquid Effluent Documents	PLN-729, Idaho Cleanup Project Liquid Effluent Monitoring Program Plan SPR-101, Liquid Effluent Sampling TPR-6539, Calibrating and Using the Hydolab Quanta Water Quality Multiprobe
Drinking Water Documents	PLN-730, Idaho Cleanup Project Drinking Water Program Plan SPR-188, Collecting Water Samples for Radiological Analysis SPR-189, Routine Collection of Samples for Coliform Bacteriological Analysis SPR-190, Sampling of Public Water Systems TPR-6555, Cross Connection Inspections and Backflow Prevention Assembly Testing
Surveillance Documents	PLN-720, Environmental Surveillance Program Plan Biota SPR-106, Biotic Monitoring

Table 11-1. Idaho Cleanup Project Environmental Program Procedures. (cont.)

Document/Media Type	Document No.[a] and Title
	Air
	SPR-107, Waste Management Low-Volume Suspended Particulate Air Monitoring
	SPR-193, Ambient Air Sampling for NESHAP Compliance at Accelerated Retrieval Project
	MCP-1264, Ambient Air Surveillance Instrumentation Calibration
	Soil
	SPR-110, Surface Soil Sampling
	Surface Water
	SPR-213, Surface Water Sampling at Radioactive Waste Management Complex
	Surface Radiation
	TPR-6525, Surface Radiation Surveys Using the Global Positioning Radiometric Scanner
Gamma Documents	TPR-7485, Filling Gamma Detector with Liquid Nitrogen
	TPR-7859, Shipping Screen Gamma Scan
	TPR-7860, Germanium Detector Calibration and Performance Testing Using Gamma Vision-32
Documentation Documents	MCP-9227, Environmental and Regulatory Services Logkeeping Practices
	MCP-9235, Reporting Requirements of the Liquid Effluent Monitoring and Wastewater Land Application Permit Groundwater Monitoring Program
Sample Management Documents	MCP-9228, Managing Nonhazardous Samples
	MCP-1394, Managing Hazardous Samples

a. GDE = Guide
MCP = Management Control Procedure
PLN = Plan
PRD = Program Requirements Documents
SPR = Sampling Procedure
TPR = Technical Procedure

and procedures for non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) monitoring activities. The program plans address the QA elements as stated in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001) to ensure that the required standards of data quality are met.

In addition, the INL contractor uses a documented approach for collecting, assessing, and reporting environmental data. Environmental and effluent monitoring are conducted in accordance with plan (PLN)-8510, “Planning and Management of Environmental Support

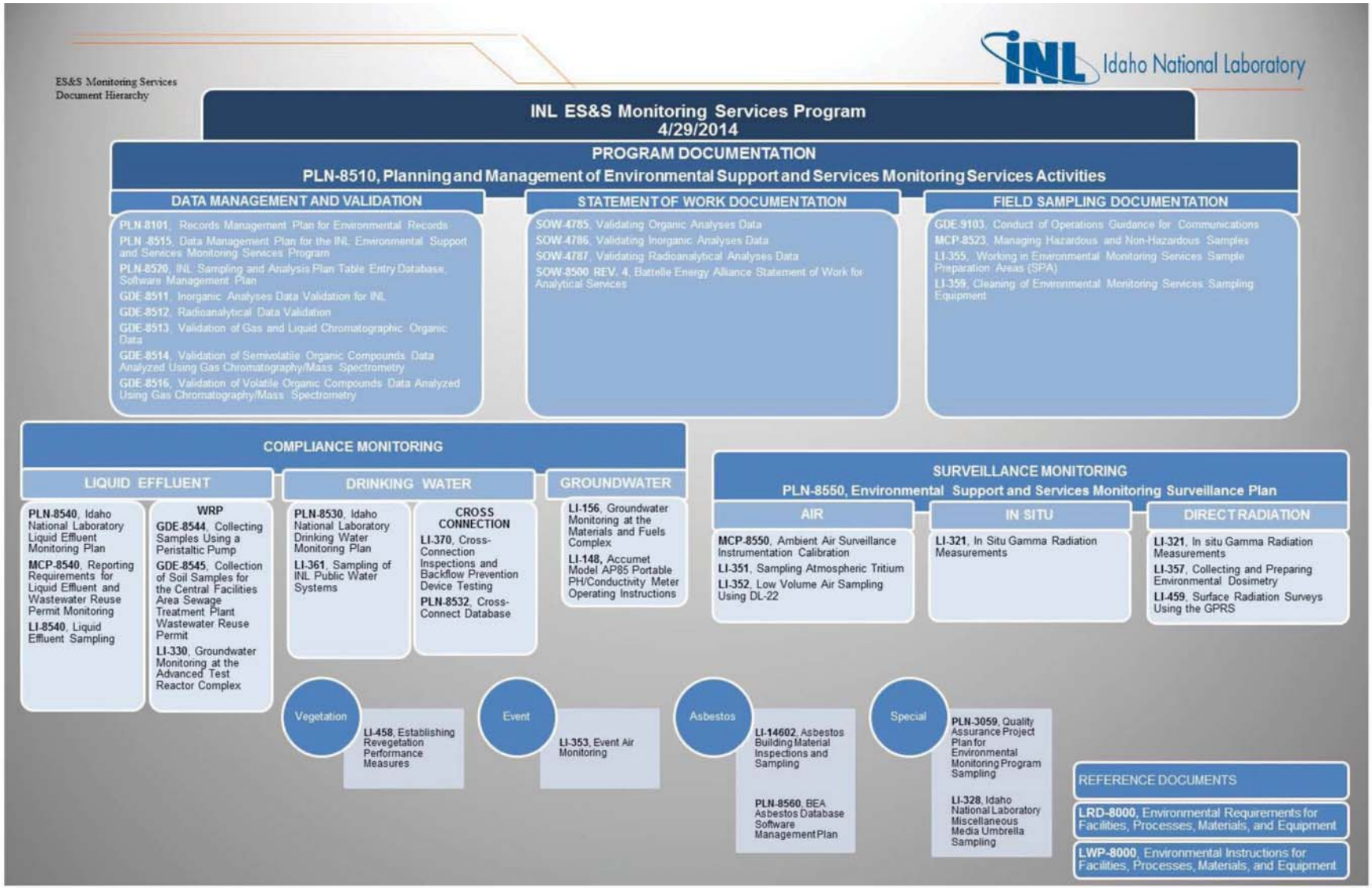


Figure 11-1. Idaho National Laboratory Environmental Support and Services Program Documentation.

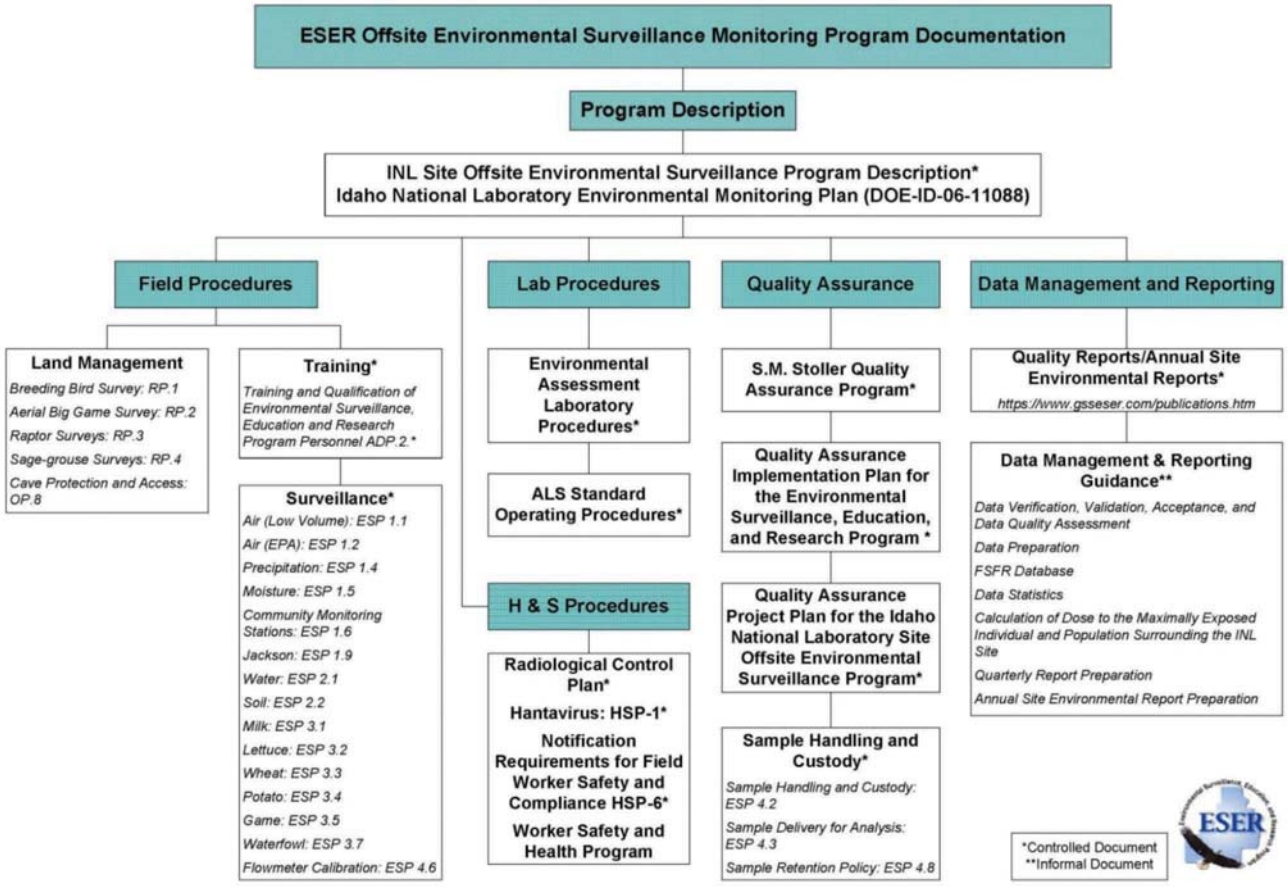


Figure 11-2. Environmental Surveillance, Education and Research Program Offsite Environmental Surveillance Documentation.

and Services Monitoring Services Activities," PLN-8515, "Data Management Plan for the INL Environmental Support and Services Monitoring Services Program," and PLN-8550, "Environmental Support and Services Monitoring Services Surveillance Plan" in order to ensure that analytical work for environmental and effluent monitoring supports data quality objectives.

11.3.2 Idaho Cleanup Project Contractor

All CERCLA monitoring activities at the INL Site are conducted in accordance with the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10 and Removal Actions* (DOE-ID 2009). The Quality Assurance Project Plan was written in accordance with "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988).

In addition, the ICP contractor uses the following program plans for environmental monitoring and surveillance:

- PLN-720, “Environmental Surveillance Program Plan”
- PLN-729, “Idaho Cleanup Project Liquid Effluent Monitoring Program Plan”
- PLN-730, “Idaho Cleanup Project Drinking Water Program Plan”
- PLN-1305, “Wastewater Reuse Permit Groundwater Monitoring Program Plan.”

11.3.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project maintains a QA program in accordance with 40 CFR 61, Appendix B, as required of all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in AMWTP-PD-EC&P-02, *Quality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System*.

11.3.4 Environmental Surveillance, Education, and Research Program

The ESER Program maintains a QA program consistent with the requirements of 10 CFR 830, Subpart A, and DOE Order 414.1D that is implemented through the *ESER Quality Management Plan for the Environmental Surveillance, Education and Research Program*. The ESER Program also has a Quality Assurance Implementation Plan that provides requirements, responsibilities, and authority for implementing the Stoller NQA-1 2008 Quality Assurance Program under a graded and tailored approach to all work activities. Additional QA requirements for monitoring activities are provided in the *ESER Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program*. Analytical laboratories used by the ESER Program maintain their own QA programs consistent with DOE requirements.

11.3.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Quality-of-Water Activities, (Knobel et al. 2008) defines procedures and tasks performed by project-office personnel that ensure the reliability of water quality data. The plan addresses all elements needed to ensure:

- Reliability of the water-quality data
- Compatibility of the data with data collected by other organizations at the INL Site
- That data meet the programmatic needs of DOE and its contractors and the scientific and regulatory communities.

The U.S. Geological Survey (USGS) conducts performance audits on field personnel collecting samples and of the analytical laboratories that analyze their environmental monitoring samples, with the exception of the DOE Radiological and Environmental Sciences Laboratory (RESL). The RESL is assessed by the American Association of Laboratory Accreditation as an ISO 17025 Chemical Testing Laboratory. In addition, the USGS routinely evaluates its QC data and publishes analyses in USGS reports.

11.3.6 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration *Quality Program Plan, NOAA Air Resources Laboratory Field Research Division* (NOAA-ARLFRD 1993) addresses the requirements of DOE Order 414.1D, and is consistent with ASME. Implementing procedures include regular independent system and performance audits, written procedures and checklists, follow-up actions, and continuous automated and visual data checks to ensure representativeness and accuracy. The plan and implementing procedures provide the framework to ensure that the INL Meteorological Monitoring Network meets the elements of "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE/EH-0173T).

All the meteorological sensors in the Air Resources Laboratory Field Research Division tower network are inspected, serviced, and calibrated semiannually as recommended by American Nuclear Society guidelines of ANSI/ANS 3.11 2005. Unscheduled service also is performed promptly whenever a sensor malfunctions.

11.4 Analytical Laboratories

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 11-2.

Radiological analytical laboratories used for routine analyses of radionuclides in environmental media were selected by each environmental monitoring program based on each laboratory's capabilities and past results in performance evaluation programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP) described in Section 11.6.1. Continued acceptable performance in programs such as MAPEP is required to remain as the contracted laboratory.

Each laboratory's adherence to laboratory and QA procedures is checked through audits by representatives of the contracting environmental monitoring program. Subcontract laboratories used by the INL and ICP contractors also are audited by the DOE Consolidated Audit Program (DOECAP). This program uses trained and certified personnel to perform in-depth audits of subcontract laboratories to review:

- Personnel training and qualification
- Detailed analytical procedures
- Calibration of instrumentation
- Participation in an inter-comparison program
- Use of blind controls
- Analysis of calibration standards.

Table 11-2. Analytical Laboratories Used by INL Site Contractors and U.S. Geological Survey Environmental Monitoring Programs.

Contractor and Program	Laboratory	Type of Analysis
ICP Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	UL LLC	Inorganic and organic
ICP Environmental Program	ALS Laboratory Group – Fort Collins	Radiological
ICP Effluent Monitoring Program	ICP Wastewater Laboratory	Microbiological
	GEL Laboratories, LLC	Inorganic and radiological
	Southwest Research Institute	Inorganic
ICP Groundwater Monitoring Program	GEL Laboratories, LLC	Microbiological
	Southwest Research Institute	Inorganic and radiological
INL Drinking Water Program	General Engineering Laboratories	Radiological
	Intermountain Analytical Service – EnviroChem	Inorganic
	Teton Microbiology Laboratory of Idaho Falls	Bacterial
	UL LLC	Organic
INL Liquid Effluent and Groundwater Program	General Engineering Laboratories	Radiological
	Southwest Research Institute	Inorganic and radiological
INL Environmental Surveillance Program	ALS Laboratory Group – Fort Collins	Radiological
	Environmental Services In Situ Gamma Laboratory	^{131}I
	Landauer Inc.	Penetrating radiation (OSL and neutron dosimeters)
Environmental Surveillance, Education and Research Program	Environmental Assessments Laboratory at Idaho State University	Gross radionuclide analyses (e.g., gross alpha and gross beta), OSL dosimetry, liquid scintillation counting (tritium), and gamma spectromy
	ALS Laboratory Group – Fort Collins	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu)
U.S. Geological Survey	DOE's Radiological and Environmental Sciences Laboratory	Radiological
	USGS National Water Quality Laboratory	Nonradiological and low-level tritium and stable isotopes
	Purdue Rare Isotope Measurement Laboratory	Low-level ^{129}I
	TestAmerica Laboratories	Radiological and nonradiological for the USGS Naval Reactors Facility sample program
	Brigham Young University Laboratory of Isotope Geochemistry	Low-level tritium for the USGS Naval Reactors Facility sample program

Audit results are maintained by the DOECAP. Laboratories are required to provide corrective action plans for audit findings.

Laboratory data quality is verified by a continuing program of internal laboratory QC, participation in inter-laboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories. These quality checks are described in the following sections.

11.5 Quality Assurance/Quality Control Results for 2013

Results of the QA measurements for 2013 are summarized in the following sections.

11.5.1 Liquid Effluent Program Quality Assurance/Quality Control

INL Contractor – The INL contractor Liquid Effluent Monitoring and Groundwater Monitoring Programs have specific QA/QC objectives for analytical data. Goals are established for accuracy, precision, and completeness. The program submits field duplicates to provide information on variability caused by sample heterogeneity and collection methods. In 2013, field duplicates were collected at the Advanced Test Reactor Complex Cold Waste Pond, USGS-065, Materials and Fuels Complex Industrial Waste Pipeline and the Industrial Waste Pond, and well ANL-MON-A-013 at the Material and Fuels Complex.

For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the relative percent difference (RPD) using Equation 1:

$$RPD = \frac{|R_1 - R_2|}{(R_1+R_2)/2} x100 \qquad (1)$$

Where

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample.

The precision of the radiological results were considered acceptable if the RPD was less than or equal to 35 percent or if the following condition was met:

$$|R_1 - R_2| \leq 3(s_1^2 + s_2^2)^{1/2} \qquad (2)$$

Where

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample

s_1 = uncertainty (one standard deviation) associated with the laboratory measurement of the first sample

s_2 = uncertainty (one standard deviation) associated with the laboratory measurement of the duplicate sample.

Kinds of Quality Control Samples

Blind Spike: Used to assess the accuracy of the analytical laboratories. Contractors obtain samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to National Institute of Standards and Technology (NIST). These samples are then submitted to the laboratories with regular field samples using the same labeling and sample numbering system. The analytical results are expected to compare to the known value within a set of performance limits. Generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A double blind spike is a sample submitted to evaluate performance with concentration and identity unknown to both the submitter and the analyst.

Performance Evaluation Sample: A type of blind sample. The composition of performance evaluation samples is unknown to the analyst. Performance evaluation samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits. Performance evaluation samples (submitted as double blind spikes) are required to assess analytical data accuracy.

Field Replicates (duplicates or collocated samples): Two samples collected from a single location at the same time. Two separate samples are taken from the same source, stored in separate containers, and analyzed independently. In the case of air sampling, two air samplers are placed side by side and each filter is analyzed separately. Duplicates are useful in documenting the precision of the sampling process. Field duplicates provide information on analytical variability caused by sample heterogeneity, collection **methods and laboratory procedures.**

Split Sample: A sample collected and later divided into two portions that are analyzed separately. The samples are taken from the same container and analyzed independently. Split samples are used to assess analytical variability and comparability.

Trip Blank: A sample of analyte-free media taken from the sample preparation area to the sampling site and returned to the analytical laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples.

Field Blank: A clean analyte-free sample that is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. Collected to assess the potential introduction of contaminants during sampling. This blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport.

The INL contractor Liquid Effluent Monitoring and Groundwater Program requires that the RPD from field duplicates be less than or equal to 35 for 90 percent of the analyses. Over 90 percent of the results for the duplicate samples were comparable to the original samples.

The goal for completeness is to collect 100 percent of all required compliance samples. This goal was met in 2013.

Accuracy was assessed using the results of the laboratory's control samples, initial and continuing calibration samples, and matrix spikes. As an additional check on accuracy, four performance evaluation samples (prepared by RESL as described in Section 11.6.1) were submitted to the laboratory and analyzed for radiological constituents. The results for the spiked constituents were in agreement with the known spiked concentrations.

ICP Contractor – The ICP contractor Liquid Effluent Monitoring Program has specific QA/QC objectives for analytical data

Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. The ICP contractor submits three types of QC samples: performance evaluation samples, field duplicate samples, and equipment rinsate samples.

Performance evaluation samples consist of standards with known concentrations that are submitted to the analytical laboratory as a regular sample. The performance evaluation sample is used to assess laboratory accuracy; results should be within the performance acceptance limits specified on the QC standards certification.

During 2013, performance evaluation samples were submitted to the laboratory with routine monitoring samples on March 13, June 12, August 14, and December 11. Eighty-six percent of the results were within the QC performance acceptance limits, indicating acceptable accuracy. The laboratory was notified of the results outside the performance acceptance limits, and the laboratory implemented corrective action, as necessary.

To quantify measurement uncertainty from field activities, a field duplicate sample is collected annually at each sample location. The RPD determined from nonradiological field duplicate samples should be 35 percent or less for 90 percent of the analyses and is calculated using Equation 3:

$$RPD = \frac{|R_1 - R_2|}{(R_1 + R_2)/2} \times 100 \qquad (3)$$

Where

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample.

Nonradiological field duplicate samples were collected at CPP-769 and CPP-773 on April 10, 2013, and at CPP-797 on April 17, May 22, and June 12, 2013. For 2013, 100 percent of results (with two detectable quantities) were within the program goal of less than or equal to 35 percent.

The mean difference (MD) determined from the radiological field duplicate should be less than or equal to three and is calculated using Equation 4:

$$MD = \frac{|S - D|}{\sqrt{(\sigma_S^2 + \sigma_D^2)}} \qquad (4)$$

Where

MD = mean difference of the duplicate results

S = original sample result

D = duplicate sample result

σ^2_S = associated combined propagated 1σ uncertainty of the original result (as a standard deviation)

σ^2_D = associated combined propagated 1σ uncertainty of the duplicate result (as a standard deviation).

If one of the results is not statistically positive, the MD is calculated by using one-half the required detection level (RDL) value for the nonpositive radionuclide result, as shown in Equation 5:

$$MD = \frac{|Positive\ Result - 1/2\ RDL|}{\sqrt{(\sigma^2_{POS} + 1/2\ RDL^2)}} \qquad (5)$$

Where

MD = mean difference of the duplicate results

Positive Result = positive sample result

½RDL = one-half of the appropriate RDL.

σ^2_{POS} = associated combined propagated 1σ uncertainty of the positive result (as a standard deviation)

$½RDL^2$ = ½RDL value is the assumed uncertainty.

The MD for the radiological field duplicate sample collected at CPP-773 on September 26, 2013, was less than 3. No radiological field duplicate samples were collected at CPP-797 during 2013.

Equipment rinsates are collected annually and are used to evaluate the effectiveness of equipment decontamination. They are collected after completion of decontamination and prior to sampling. Equipment rinsates should be less than the detection limit. For 2013, a rinsate sample was collected at CPP-773 on July 17. The analytical results for the rinsate sample were below the detection/reporting limits, indicating that decontamination procedures were adequate.

The goal for completeness is to collect 100 percent of all required compliance samples. During 2013, this goal was met. In addition, all sample results were usable in 2013 except the March 13 biochemical oxygen demand samples collected at CPP-769, CPP-773, and CPP-797, and the April 10 biochemical oxygen demand sample collected at CPP-773. These sample results were rejected during data validation because of laboratory QC issues.

11.5.2 Idaho Cleanup Project Contractor Wastewater Reuse Permit Groundwater Monitoring Quality Assurance/Quality Control

The ICP contractor Wastewater Reuse Permit Groundwater Monitoring Program has specific QA/QC objectives for analytical data. Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. Groundwater sampling for Wastewater Reuse Permit compliance follows established procedures and analytical methodologies. The ICP contractor submits three types of QC samples: performance evaluation samples, field duplicate samples, and equipment rinsate samples.

Performance evaluation standards consist of a specified parameter type and concentration prepared separately at an independent laboratory. Performance evaluation standards are sent "blind" to the analytical laboratory for analysis and are used to assess laboratory accuracy. The results should be within the QC performance acceptance limits specified on the performance standards certification. In 2013, 90 percent of the results were within the QC performance acceptance limits. For the April groundwater sampling event, the performance evaluation sample results for aluminum, chromium, and silver were outside their QC performance acceptance limits. For the September groundwater sampling event, the sample result for mercury was outside its QC performance acceptance limit. The laboratory was notified so they could evaluate whether corrective action was necessary.

Duplicate samples are collected to assess natural variability and precision of analyses. One duplicate groundwater sample was collected for every 20 samples collected or, at a minimum, 5 percent of the total number of samples collected. Duplicate samples were collected using the same sampling techniques and preservation as regular groundwater samples. In 2013, duplicate samples were collected from perched water Well ICPP-MON-V-200 on April 3, and from perched water Well ICPP-MON-V-212 on September 19. One hundred percent of nonradiological duplicate sample results (with two detectable quantities) were within the program goal for RPD of less than or equal to 35 percent (see Equation 3 for the RPD calculation in Section 11.5.1). The MD determined from the radiological field duplicate (see Equation 4 or Equation 5 for the calculation in Section 11.5.1) should be less than or equal to three. The MDs for the samples collected on April 3 and September 19 were within the goal of less than three.

Field blanks are collected to assess the potential introduction of contaminants during sampling activities. One field blank was collected for every 20 samples collected or, at a minimum, 5 percent of the total number of samples collected. Field blank samples were collected on April 3 and September 19. All analytical results were below the detection/reporting limits. Results from the field blanks indicate that no contaminants were introduced during sample collection, storage, and transport.

Equipment blanks (rinsates) were collected to assess the potential introduction of contaminants from incomplete decontamination activities. They were collected by pouring analyte-free water through the sample port manifold after decontamination and before subsequent use. In 2013, rinsate samples were collected on April 3 and September 19. One hundred percent of the results were below the detection/reporting limits. Results from the equipment rinsates indicate proper decontamination procedures.

The goal for completeness is to collect 100 percent of all required compliance samples. During 2013, this goal was met. In addition, groundwater samples were collected from all of the permitted wells that had sufficient water. Samples were not collected from perched water Well ICPP-MON-V-191 in 2013 because the well was dry. All groundwater sample results were usable.

11.5.3 Drinking Water Program Quality Assurance/Quality Control

INL Contractor – The INL contractor Drinking Water Program has specific QA/QC objectives for analytical data. Drinking Water Program goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses and 100 percent completeness. The Drinking Water Program submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the relative RPD using Equation 1 (see Section 11.5.1).

The precision of the radiological results were considered acceptable if the RPD was less than or equal to 35 percent or if the condition of Equation 2 was met.

RPD was not calculated if either the sample or its duplicate was reported as nondetect. For 2013, the Drinking Water Program had 16 samples of radiological data with detectable quantities. Using the above criteria, 100 percent of the radiological data is comparable, meeting the RPD goal of less than or equal to 35 percent for 90 percent of the analyses.

Blind spike samples are used to determine the accuracy of laboratory analyses for concentrations of parameters in drinking water. Within each calendar year, the program lead determines the percentage of the samples collected (excluding bacteria samples) that are QA/QC samples, which include blind spikes. All blind spike percent recoveries must fall within the standards range.

Representativeness is ensured through use of established sampling locations, schedules, and procedures for field sample collections, preservation, and handling.

The data quality objectives address completeness for laboratory and field operations. The criterion for completeness by laboratories is that at least 90 percent of the surveillance and 100 percent of the compliance samples submitted annually must be successfully analyzed and reported according to specified procedures. Similarly, the criterion for field data collection under the INL Environmental Support and Services Monitoring Services is that at least 90 percent of the surveillance and 100 percent of the compliance samples must be successfully collected on an annual basis and reported according to the specified procedures. If a completeness criterion is not met, the problem will be evaluated, and it will be determined whether the quality of the remaining data is suspect and whether a corrective action is needed either in the field collection or laboratory analysis.

Comparability is ensured through the use of (1) laboratory instructions for sample collection, preparation, and handling, (2) approved analytical methods for laboratory analyses, and (3) consistency in reporting procedures.

ICP Contractor – The ICP contractor Drinking Water Program completeness goal is to collect, analyze, and verify 100 percent of all compliance samples. This goal was met during 2013.

The ICP contractor Drinking Water Program requires that 10 percent of the samples (excluding microbiological) collected be QA/QC samples to include duplicates, trip blanks, performance evaluation (blind spikes), and field blanks. This goal was met in 2013 for all parameters.

The RPD calculation (see Equation 3 in Section 11.5.1) is used for nonradiological field duplicate samples, and an MD calculation (see Equation 4 or Equation 5 in Section 11.5.1) is used for radiological field duplicate samples to assess data precision. The RPD must be within 35 percent or less for 90 percent of the field duplicates that have positive results greater than five times the method detection limit. In 2013, nonradiological field duplicate samples were collected on February 27, June 20, August 6, September 11, and October 30. One hundred percent of the results were within the program goal of less than or equal to 35 percent. The MD for radiological field duplicate samples should be less than or equal to three. The MD of the sample collected on July 30 was less than three.

Trip blank samples were collected on February 27, June 20, September 11, and October 30, 2013. All analytical results were below the detection/reporting limit. Results from the trip blanks indicated that no contamination was associated with the shipping and field handling of the volatile organics samples.

During 2013, performance evaluation samples (blind spikes) were submitted to the laboratory with routine monitoring samples on February 27, June 20, August 6, September 11, and October 30. One hundred percent of the results were within the QC performance acceptance limits, indicating acceptable accuracy.

Field blank samples were collected on February 27, June 20, September 11, and October 30, 2013. All analytical results were below the detection/reporting limit. Results from the field blanks did not indicate field contamination.

11.5.4 Environmental Surveillance, Education, and Research Program Quality Assurance/ Quality Control

Goals are established for completeness, accuracy, and precision, and all analytical results are validated by the laboratories. The ESER Program submitted four types of QC samples to the laboratories in 2013 – blank samples, field duplicate samples, laboratory split samples, and performance evaluation samples (i.e., double blind spike samples).

The ESER contractor met its completeness goals of greater than 98 percent in 2013. Sixteen air samples were considered invalid because insufficient volumes were collected due to power

interruptions. A few milk samples were not collected in 2013, because they were not available for collection. All other samples were collected as planned.

Field blank samples were submitted with each set of samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. Ideally, blank results should be within two standard deviations of zero and preferably within one standard deviation. In 2013, the majority of blanks were within one to two standard deviations of zero.

Field duplicate samples were collected for air, milk, lettuce, potatoes, alfalfa, and grain to help assess data precision and sampling bias. Most duplicate data were associated with the air sampling program. Duplicate air samplers were operated at two locations (Arco and Monteview) adjacent to regular air samples. The objective was to have data close enough to conclude that there was minor sampling bias between the samplers and acceptable laboratory precision. The ESER QA program establishes that sample results should agree within three standard deviations (Equation 2). Any variation outside the predetermined criterion could be due to one of the samplers not operating correctly (e.g., a leak in one sampling system) or not operating within the same operating parameters (e.g., flow rate, sampling time). In addition, any variation outside the predetermined criterion could be attributed to inhomogeneous distribution of a contaminant in the sample medium so that true replication is not possible. The sample and duplicate results agreed with each in over 98 percent of all environmental samples collected during 2013, indicating acceptable precision.

The analytical laboratories split and analyzed a number of agriculture product, precipitation, and atmospheric moisture samples to assess agreement within the 20 percent or the 3σ criterion. The latter criterion was applied in nearly all cases. All but one split sample analyses (tritium in the fourth quarter milk) met acceptance criteria in 2013, indicating acceptable precision.

The Idaho State University, Environmental Assessment Laboratory (ISU-EAL) recounts a number of samples of each media type as another measure of precision. The lab tests each recount using both the 20 percent criterion and the 3σ criterion. All recounts were within acceptable limits.

Accuracy is measured through the successful analysis of samples spiked with a known standard traceable to the NIST. Each analytical laboratory conducted an internal spike sample program using NIST standards to confirm analytical results.

Each laboratory also participated in the MAPEP by analyzing performance evaluation samples provided by that program, as discussed in Section 11.6.1. ISU-EAL analytes of interest to the ESER Surveillance Program are: tritium (^{3}H), gross alpha and gross beta, and multiple gamma spectroscopy radioisotopes. All analytes of interest are “A” (Acceptable), unless noted below. The MAPEP Series 28 (March 2013) and MAPEP Series 29 (August 2013) Flag Results for ISU-EAL are summarized below:

- MAPEP Series 28
  - "NR" (Not Reporting Previously Reported Analyte) for Tritium (^{3}H) Water Sample
  - This is a required analyte of interest for the ESER Surveillance Program and should have been reported
  - "N" for Gross Alpha Water Sample
  - Note: This was the 2nd consecutive MAPEP "N" for Water Gross Alpha analysis reported data to the MAPEP. This automatically generated a MAPEP Letter: Potential Quality Concern (Dated: May 28, 2013).
- MAPEP Series 29
  - "W" (Acceptable with Warning) for Gamma Spec Soil Sample on Potassium-40 (^{40}K)
  - "N" (Not Acceptable) for Gamma Spec Soil Sample on Zinc-65 (^{65}Zn)
  - This was a MAPEP False Positive Test
  - "N" (Not Acceptable) for Tritium (^{3}H) Water Sample
  - This was a MAPEP False Positive Test

While none of the above findings invalidate any of the measurements reported to the ESER in 2013, one matter prompted MAPEP personnel to issue a Letter of Potential Quality Concern (dated May 28, 2013) to the ISU-EAL laboratory. The issue was for two consecutive MAPEP "N" Not Acceptable Flags for Gross Alpha in Water Samples, on the MAPEP Sensitivity Evaluations in MAPEP Series 27 and Series 28 respectively. Although it is the laboratory's responsibility to investigate for corrective action, the ESER Program offers assistance to the laboratory, if it is needed.

ALS-Fort Collins (ALS-FC) analytes of interest to the ESER Surveillance Program are: strontium-90 (^{90}Sr), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}Pu$). The MAPEP Series 28 (March 2013) and MAPEP Series 29 (August 2013) Flag Results for ALS-FC are summarized below:

- MAPEP Series 28
  - "A" (Acceptable) – For All analytes of interest.
- MAPEP Series 29
  - "A" (Acceptable) – For All analytes of interest.

As an additional check on accuracy, the ESER contractor provided blind spiked samples [prepared by personnel at the Radiological and Environmental Sciences Laboratory (RESL) as described in Section 11.6.1 for soil, wheat, air particulate filter, milk, and water samples. Table 11-3 is a summary of the ESER Blind Spike Program for 2013. All the Agreements are for ± 30 percent of the known values for respective sample matrices..

Table 11-3. ESER Blind Spike Program (2013).

Matrix	Analysis	Laboratory	Acceptance Criteria: 3 sigma and +/- 30% Known
Air Filter	Alpha Spectrometry	ALS-FC	Agreement: YES Am-241, Pu-238, Pu-239/240
Air Filter	Alpha Spectrometry	ALS-FC	Agreement: YES Am-241, Pu-238, Pu-239/240
Air Filter	Gamma Spectrometry	ISU-EAL	Agreement: YES Gamma Spec - Blank Sample
Air Filter	Gamma Spectrometry	ISU-EAL	Agreement: YES (Except for Zn-65) Co-57, Co-60,Cs-134, Cs-137, Mn-54 Zn-65 - NO (This isotope is usually not identified in ESER field samples)
Air Filter	Sr-90	ALS-FC	Agreement: NO Sr-90
Air Filter	Sr-90	ALS-FC	Agreement: YES Sr-90
Milk	Gamma Spectrometry and Tritium (H-3)	ISU-EAL	Agreement: YES Co-57, Co-60, Cs-134, Cs-137, Mn-54, Zn-65 H-3
Milk	Gamma Spectrometry and Tritium (H-3)	ISU-EAL	Agreement: YES Co-57, Co-60, Cs-134, Cs-137, Mn-54, Zn-65 H-3
Milk	Sr-90	ALS-FC	Agreement: YES Sr-90
Milk	Sr-90	ALS-FC	Agreement: NO Sr-90
Water	Gross Alpha/Beta	ISU-EAL	Info on spike activities. No recoveries calculated.
Water	Gross Alpha/Beta	ISU-EAL	Info on spike activities. No recoveries calculated. High particulate/salts sample. Smaller aliquot.
Water	Tritium (H-3)	ISU-EAL	Agreement: YES H-3
Water	Tritium (H-3)	ISU-EAL	Agreement: YES H-3
Water	Tritium (H-3)	ISU-EAL	Agreement: YES H-3
Wheat	Gamma Spec	ISU-EAL	Agreement: YES Co-57, Co-60, Cs-134, Cs-137, Mn-54, Zn-65
Wheat	Sr-90	ALS-FC	Agreement: NO Sr-90

Quarterly air filter samples analyzed in 2013 showed higher results for ^{90}Sr (a beta emitter) than those measured historically. In addition the frequency of detection (18 of 26 samples, including 4 replicate samples) was higher than normally seen. Strontium-90 was not detected in blank samples. The ESER QA Manager conducted an audit of the ALS laboratory while they performed ^{90}Sr analyses of air filters collected during the first quarter of 2014. Discussions with the laboratory manager and experienced radiochemists led to the hypothesis that the results may have been due to the presence of a naturally-occurring uranium-238 (^{238}U) decay product. Briefly, ^{90}Sr is determined in the laboratory through a series of steps which involves dissolution of the sample, chemical separation of strontium, ingrowth of the daughter yttrium-90 (^{90}Y) until secular equilibrium is achieved, resin column extraction of the ^{90}Y daughter, also a beta emitter, and final beta counting of the dried product on a planchet. The ALS laboratory manager previously visited with Eichrom about their strontium resin and found out that lead-210 (^{210}Pb), a daughter of ^{238}U, will "stay" in the resin column during column extractions to isolate ^{90}Y. Bismuth-210 (^{210}Bi) is a product of the decay of ^{210}Pb and if it is in the sample will also elute with the ^{90}Y in the final column rinse. Because ^{210}Bi is a beta emitter, if present in the eluent it will be counted in the beta counter along with ^{90}Y and the final count can be interpreted incorrectly as a higher detectable quantity of ^{90}Sr. Analysis of first quarter 2014 air composites with a low-energy gamma detector confirmed the presence of ^{238}U in most samples. The laboratory was instructed to perform the analysis as usual and if beta activity was detected on the planchet to recount 1, 4, and 11 days later to see if the counts decreased due to radioactive decay of ^{210}Bi (half-life of 5 days). Plotting each individual sample and using linear regression, it was shown that the samples contained a beta emitter with a half-life within the range of 3 to 6 days. Based on this information, it was concluded that the results of the first set of 2013 samples may have been artificially high due to the presence of ^{238}U (and thus ^{210}Bi) in the air samples. Because of this, ESER invalidated the results of the first set of samples and sent a second set of 20 air samples collected during 2013 for analysis. The laboratory was asked to wait approximately 2 weeks if beta activity was detected and then to recount in 2 weeks to allow for the decay of ^{210}Bi. Using this protocol, ^{90}Sr was detected in only 4 samples (20 percent of the total number analyzed). The protocol will be used in all future analyses.

11.5.5 INL Environmental Surveillance Program Quality Assurance/Quality Control

The INL contractor analytical laboratories analyzed all Surveillance Monitoring Program samples as specified in the statements of work. These laboratories participate in a variety of intercomparison QA programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA National Center for Environmental Research Quality Assurance Program. The Surveillance Monitoring Program met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. The Environmental Surveillance Program submitted duplicate, blank, and QC samples with routine samples for analyses as required. Results concluded the laboratories met the performance objectives specified by MAPEP and the National Center for Environmental Research.

An employee at the contract laboratory who had just returned to work after an extended vacation inadvertently switched four samples for the week of January 9, 2013. The mistake was

discovered during the compositing process. Because it was unclear if additional samples for that week got mixed, no regular samples were added to the quarterly composite, and while that week's data appear to agree with historical values, because of the mix up, the affected data have been flagged as J or estimated quantities. The laboratory instituted a corrective action plan to prevent recurrence.

As an additional check on accuracy, the INL contractor provided blind spiked samples prepared by personnel at the RESL for air filter samples, which are composited by location quarterly and analyzed by gamma spectroscopy. During 2013 the results ranged from "Acceptable" to "Not Acceptable" for various gamma emitting radionuclides, with all results appearing to have a low bias as compared with the known concentrations. Possible reasons for the bias were identified both in procedure and in sample geometry versus the standard geometry. A double-sided tape being used to secure the filters to the counting planchettes during weekly gross alpha beta counting may have been removing some of the spiked activity from the filters. The standard geometry of dry stacked filters did not well match the liquid geometry used by the laboratory. INL personnel worked with the laboratory to resolve this issue in 2014 by instituting a total dissolution of the composited filters, matching the standard, and including the double-sided tape in the dissolution process.

11.5.6 ICP Waste Management Surveillance Quality Assurance/Quality Control

ALS Laboratory Group of Fort Collins, Colorado, performs a wide range of chemical and radiochemical measurements on a variety of environmental media, including air particulates, fiber media, water, soils, vegetation, tissue, and wastes. ALS Laboratory Group was contracted to analyze samples for the ICP Waste Management Surveillance Program in 2012.

ALS Laboratory Group participated in a variety of intercomparison QA programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA National Center for Environmental Research Quality Assurance Program. The laboratory met the performance objectives specified by MAPEP and the National Center for Environmental Research.

All blind performance evaluation samples submitted to ALS Laboratory Group for analysis in 2013 by the Waste Management Surveillance Program showed satisfactory agreement except the following:

Ambient Air — A false positive was reported for ^{239}Pu in one performance evaluation sample. While this false positive may indicate a potential bias for ^{239}Pu, a second performance evaluation sample was reported well within the acceptable range. Also, a routine blank sample was submitted, and a false positive was not reported. The sample results for the data set are being evaluated as received and interpreted as such.

Vegetation (Crested Wheatgrass) — The results for ^{60}Co and ^{134}Cs were not within ±30 percent of the known value, and the difference between the laboratory result and known value was not within 3-sigma. A false positive was reported for ^{239}Pu. The results for the second performance evaluation sample were within acceptance criteria, with the following exceptions.

The results for ^{137}Cs and ^{90}Sr received a “not acceptable” evaluation. The results were not within ±30 percent of the known value, and the difference between the laboratory result and known value was not within 3-sigma. While there is a potential bias for the radionuclides reported in the vegetation performance evaluation samples, the bias was not repeated in both performance evaluation samples. The sample results are being evaluated as received and compared to previous data.

Water Samples — The water sample results were within acceptance criteria with the following exceptions. The results for ^{238}Pu and ^{239}Pu received a “warning” evaluation on one blind spike sample for ^{238}Pu and ^{239}Pu as they were within ±30 percent of the known value; however, the difference between the laboratory result and the known value was not within 3-sigma. Also, another blind spike sample received a “not acceptable” evaluation for ^{238}Pu and ^{239}Pu. The results were not within ±30 percent of the known value, and the difference between the laboratory result and known value was not within 3-sigma. This results in a possible low bias for ^{238}Pu and ^{239}Pu. This sample was heavily sedimented. In the past, plutonium tended to bind to sediment and followed with it, while uranium and americium tended to stay in the water portion of a sedimented sample. In the future, the laboratory will use more caution when handling samples that are heavily sedimented to try to minimize the amount of sample that can be lost during the preparation procedure.

These results were provided to the DOECAP, and they were addressed during the audit. The most recent DOECAP audit report (DOECAP 2012) showed no major findings, and the corrective action plan was acceptable. ALS Laboratory Group has the instrumentation, procedures, and laboratory systems in place to produce data of documented quality for environmental and waste samples.

The ICP Waste Management Surveillance Program met its completeness and precision goals. The ICP Waste Management Surveillance Program submitted duplicate and blank samples to ALS Laboratory Group with routine samples for analyses per PLN-720. For 2013, the results for the analyzed samples, with the exception of the samples discussed previously, were within the acceptable range.

11.5.7 U.S. Geological Survey Water Sampling Quality Control/Quality Assurance

Water samples are collected in accordance with a QA plan for quality-of-water activities by personnel assigned to the USGS INL project office; the plan was revised in 2008 (Knobel et al. 2008). Additional QA is assessed with QA/QC duplicates, blind replicates, replicates, source solution blanks, equipment blanks, field blanks, splits, trip blanks, and spikes (Knobel et al. 2008). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams et al. (1998); Bartholomay and Twining (2010), and Rattray (2012). During 2013 the USGS collected 17 replicate samples, 6 field blank samples, 1 equipment blank sample, 1 source solution blank, 1 spike sample, and 1 trip blank sample. Evaluation of results will be summarized in a future USGS report.

11.5.8 In Situ Gamma Spectroscopy Quality Control

High purity Germanium detectors used for in situ gamma spectroscopy measurements are calibrated yearly using NIST traceable radioactive sources in a laboratory setting. These calibrations are performed using a fixed geometry, long count time procedure. Collected calibration spectra are stored and then analyzed using a standard peak search peak fit algorithm. Energy calibration is performed to establish a linear relationship between peak positions and spectrum channels. The same calibration spectrum is then used to establish a relationship between the peak widths and peak energies. Finally, the detector efficiency is established, and a mathematical fit of efficiency versus gamma ray energy is established. The peak energy, peak width, and efficiency parameters for each detector are stored and used for all subsequent daily QC checks.

Prior to daily field use, each detector undergoes a QC check. This is performed using the same NIST traceable source as above. The overall activity of the measured source is compared to the certified (NIST) value.

During field measurements, the position of the naturally occurring ^{40}K gamma ray peak is checked to make certain that energy drift has not occurred during field spectrum acquisition. In addition, approximately 10 percent of field measurements are repeated with a different detector so that the two measurements can be compared. Finally, very long time acquisitions are performed at selected field locations in order to assure stability in the measurements. Results from these measurements are also compared to regular count time results at those locations. Software analysis of field spectra is addressed in several publications, including HASL-300 (www.orau.org/ptp/PTP%20library/library/DOE/EML/hasl300/HASL300/TOC.htm) and ICRU Report No. 53 (ICRU 1994).

11.6 Performance Evaluation Programs

11.6.1 Mixed Analyte Performance Evaluation Program

The MAPEP (DOE 2013) is administered by DOE's RESL. DOE has mandated since 1994 that all laboratories performing analyses in support of the Office of Environmental Management shall participate in MAPEP. MAPEP distributes samples of air filter, water, vegetation, and soil for analysis during the first and third quarters. Series 28 was distributed in February 2013, and Series 29 was distributed in August 2013. DOE's RESL maintains accreditation to ISO 17043 (2377.02) as a Performance Testing Provider, ISO 17025 (2377.01) as a Chemical Testing Laboratory, and ISO G34 (2377.03) as a Reference Material Producer by the American Association for Laboratory Accreditation.

Both radiological and nonradiological constituents are included in MAPEP. Results can be found at http://www.id.energy.gov/resl/mapep/mapepreports.html (DOE 2013).

Laboratories that participate in MAPEP sometimes have results with a flag. MAPEP laboratory results may include the following flags:

- A = Result acceptable, bias ≤20 percent

- W = Result acceptable with warning, 20 percent < bias <30 percent
- N = Result not acceptable, bias >30 percent
- L = Uncertainty potentially too low (for information purposes only)
- H = Uncertainty potentially too high (for information purposes only)
- QL = Quantitation limit
- RW = Report warning
- NR = Not reported.

MAPEP issues a letter of concern to a participating laboratory for sequential unresolved failures. This is to help participants identify, investigate, and resolve potential quality issues (http://www.id.energy.gov/resl/mapep/handbookv13.pdf). A letter of concern is issued to any participating laboratory that demonstrates:

- "Not Acceptable" performance for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., plutonium-238 [^{238}Pu] in soil test 13 "+N" [+36 percent bias], ^{238}Pu in soil test 14 "-N" [-43 percent bias])
- "Not Acceptable" performance for a targeted analyte in two or more sample matrices for the current test session (e.g., cesium-137 [^{137}Cs] in water test 14 "+N" [+38 percent], ^{137}Cs in soil test 14 "+N" [+45 percent])
- Consistent bias, either positive or negative, at the "Warning" level (greater than ± 20 percent bias) for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., ^{90}Sr in air filter test 13 "+W" [+26 percent], ^{90}Sr in air filter test 14 "+W" [+28 percent])
- Quality issues (flags other than "Acceptable") that were not identified by the above criteria for a targeted analyte in a given sample matrix over the last three test sessions (e.g., americum-241 [^{241}Am] in soil test 12 "-N" [-47 percent], ^{241}Am in soil test 13 "+W" [+24 percent], ^{241}Am in soil test 14 "-N" [-38 percent])
- Any other performance indicator and/or historical trending that demonstrate an obvious quality concern (e.g., consistent "false positive" results for ^{238}Pu in all tested matrices over the last three test sessions).

A more detailed explanation on MAPEP's quality concerns criteria can be found at http://www.inl.gov/resl/mapep/data/mapep_loc_final_3_.pdf.

11.6.2 National Institute of Standards and Technology

The DOE RESL participates in a Radiological Traceability Program administered through NIST. The RESL prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards in all matrix types for analysis by the RESL to confirm their analytical capabilities. The RESL maintained NIST certifications in both

preparation and analysis in 2013. For further information on the RESL Radiological Traceability Program, go to: http://www.id.energy.gov/resl/rtp/rtp.html.

11.6.3 Dosimetry

The INL contractor Operational Dosimetry Unit QA-tests environmental thermoluminescent dosimeters (TLD) during monthly, quarterly, and semi-annual processing periods. The QA test dosimeters are prepared by a program administrator. The delivered irradiation levels are blind to the processing technician. The results for each of the QA tests have remained within the 30-percent acceptance criteria (Relative Bias) during each testing period.

Landauer InLight dosimeters are designed to meet ANSI N545 Standard and HPS Draft Standard N13.29. The Neutrak CR-39 is Department of Energy Laboratory Accreditation Program accredited.

11.6.4 Other Programs

INL Site contractors participate in additional performance evaluation programs, including those administered by the International Atomic Energy Agency, EPA, and the American Society for Testing and Materials. Contractors are required by law to use laboratories certified by the state of Idaho or certified by another state whose certification is recognized by the state of Idaho for drinking water analyses. The Idaho Department of Environmental Quality (DEQ) oversees the certification program and maintains a list of approved laboratories. Where possible (i.e., the laboratory can perform the requested analysis), the contractors use state-approved laboratories for all environmental monitoring analyses.

11.7 Independent Assessment of INL Site Environmental Monitoring Programs

In 2010, the DOE Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security reviewed QA in conjunction with an independent assessment of the INL Site environmental monitoring programs (see Section 3.1.2). The full assessment report entitled “Independent Oversight Assessment of Environmental Monitoring at the Idaho National Laboratory,” is available at http://www.energy.gov/hss/services/oversight/safety-and-emergency-management-evaluations/review-reports?page=. The report stated that “Quality Assurance laboratory analyses and data reporting is adequate but could be improved further with enhanced laboratory oversight and accountability.” The independent assessment found that all laboratories used by INL Site contractors participate in the MAPEP proficiency testing program. Their conclusions are documented in the following statement:

- However, because proficiency testing is only conducted semiannually for certain analytes within particulate matrices (i.e., soil, water, vegetation, and air filters), it cannot be completely relied upon to ensure the validity and reliability of environmental data. While some contractors are using double blind samples to provide for continuing quality assurance of laboratory data, the approach is inconsistent and is not implemented by all contractors.

To address this, the independent assessment team recommended that minimum standards be established that include double blind sampling by all contractors to complement the MAPEP

process in the overall QA program for environmental monitoring. This will be addressed in the INL Site environmental monitoring technical basis document that is being developed by the INL, ICP, and ESER contractors.

11.8 Duplicate Sampling Between Organizations

The ESER contractor, INL contractor, and the DEQ INL Oversight Program (OP) collected air monitoring data throughout 2013 at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls, and on the INL Site at the Experimental Field Station and Van Buren Boulevard Gate. Results are compared in the INL OP Annual Report for 2013, available at: http://www.deq.idaho.gov/inl-oversight/monitoring/reports.aspx.

DEQ-INL OP also uses a network of passive electret ionization chambers (EICs) on and around the INL to cumulatively measure radiation exposure. These measurements are then used to calculate an average exposure rate for the quarterly monitoring period. Radiation monitoring results obtained by DEQ-INL OP are compared with radiation monitoring results reported by the DOE and its INL contractors for these same locations to determine whether the data are comparable. DEQ-INL OP has placed several EICs at locations monitored by DOE contractors, using TLD. Ambient penetrating radiation measurements during 2013 showed 90 percent of the INL contractor's annual average OSLD and 80% of the ESER contractor's TLD measurements agreed within 20% RPD with results from DEQ-INL OP's collocated EICs, meeting the program's objective.

The DEQ-INL OP also collects surface water and drinking water samples at select downgradient locations in conjunction with the ESER contractor. Samples are collected at the same place and time, using similar methods. Sample-by-sample comparisons are provided in the INL OP Annual Report for 2013.

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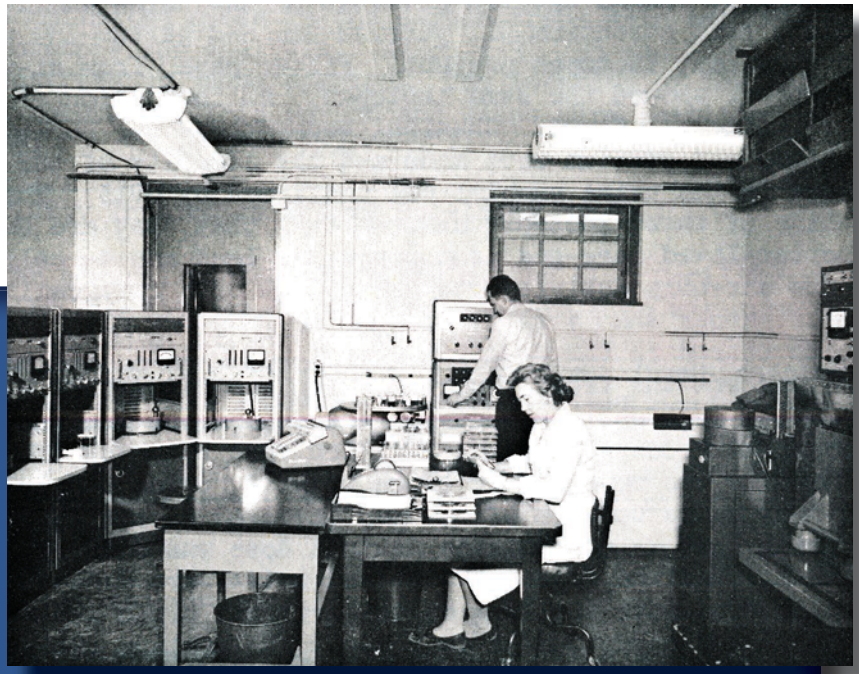

Header Photo Description: In the early days, an analytical laboratory was established at the National Reactor Testing Station (NRTS), which is now known as the INL Site. The laboratory conducted analyses for detection of radioactive materials in urine, air, water, soil, vegetation and other media sampled on or near the NRTS. The West Counting Room was used for gamma analyses and beta counting.

Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations apply, in whole or in part, to the Idaho National Laboratory (INL) or at the INL Site boundary:

- 36 CFR 79, 2013, “Curation of Federally-Owned and Administered Archeological Collections,” U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 50, 2013, “National Primary and Secondary Ambient Air Quality Standards,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, 2013, “National Emission Standards for Hazardous Air Pollutants,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 112, 2013, “Oil Pollution Prevention,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 122, 2013, “EPA Administered Permit Programs: the National Pollutant Discharge Elimination System,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 141, 2013, “National Primary Drinking Water Regulations,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 260, 2013, “Hazardous Waste Management System: General,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 261, 2013, “Identification and Listing of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 262, 2013, “Standards Applicable to Generators of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 263, 2013, “Standards Applicable to Transporters of Hazardous Waste,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 264, 2013, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 265, 2013, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 267, 2013, “Standards for Owners and Operators of Hazardous Waste Facilities Operating under a Standardized Permit,” U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 43 CFR 7, 2013, “Protection of Archeological Resources,” U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 17, 2013, “Endangered and Threatened Wildlife and Plants,” U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 226, 2013, “Designated Critical Habitat,” U.S. Department of Commerce, National Marine Fisheries Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 402, 2013, “Interagency Cooperation – Endangered Species Act of 1973, as Amended,” U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 424, 2013, “Listing Endangered and Threatened Species and Designating Critical Habitat,” U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 450–453, 2013, “Endangered Species Exemption Process,” U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- DOE Order 231.1B, 2011, “Environment, Safety, and Health Reporting,” Change 1, U.S. Department of Energy
- DOE Order 435.1, 2001, “Radioactive Waste Management,” Change 1, U.S. Department of Energy
- DOE Order 436.1, 2011, “Departmental Sustainability,” U.S. Department of Energy
- DOE Order 458.1, 2011, “Radiation Protection of the Public and the Environment,” U.S. Department of Energy
- DOE Standard 1196-2011, 2011, “Derived Concentration Technical standard,” U.S. Department of Energy
- Executive Order 11514, 1970, “Protection and Enhancement of Environmental Quality”
- Executive Order 11988, 1977, “Floodplain Management”
- Executive Order 11990, 1977, “Protection of Wetlands”

- Executive Order 12580, 1987, “Superfund Implementation”
- Executive Order 12856, 1993, “Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements”
- Executive Order 12873, 1993, “Federal Acquisition, Recycling, and Waste Prevention”
- Executive Order 13101, 1998, “Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition”
- Executive Order 13514, 2009, “Federal Leadership in Environmental, Energy, and Economic Performance”
- IDAPA 58.01.01, 2013, “Rules for the Control of Air Pollution in Idaho,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.02, 2013, “Water Quality Standards,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.03, 2013, “Individual/Subsurface Sewage Disposal Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
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- IDAPA 58.01.11, 2013, “Ground Water Quality Rule,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.15, 2013, “Rules Governing the Cleaning of Septic Tanks,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.17, 2013, “Recycled Waste Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

U.S. Department of Energy (DOE) Order 458.1 provides the principal requirements for protection of the public and environment at the INL Site. The DOE public dose limit is shown in Table A-1, along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

Derived Concentration Standards are established to support DOE Order 458.1 in DOE Standard 1196-2011 (DOESTD-1196-2011), “Derived Concentration Technical Standard.” These quantities represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1mSv) effective dose following continuous exposure

for one year for each of the following pathways: ingestion of water, submersion in air, and inhalation. The Derived Concentration Standards used the environmental surveillance programs at the INL Site are shown in Table A-2. The most restrictive Derived Concentration Standard is listed when the soluble and insoluble chemical forms differ. The Derived Concentration Standards consider only inhalation of air, ingestion of water, and submersion in air.

Ambient air quality standards are shown in Table A-3.

Water quality standards are dependent on the type of drinking water system sampled. Tables A-4 through A-7 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 Code of Federal Regulations 141 (2012) and the Idaho groundwater quality values from IDAPA 58.01.11 (2012).

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

Radiation Standard	Effective Dose Equivalent (mrem/yr)	Effective Dose Equivalent (mSv/yr)
DOE standard for routine DOE activities (all pathways)	100[a]	1
EPA standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

Table A-2. Derived Concentration Standards for Radiation Protection.

Derived Concentration Standard[a]			Derived Concentration Standard		
Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)	Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)
Gross Alpha[b]	4×10^{-14}	1.7×10^{-7}	Antimony-125	3.1×10^{-10}	2.7×10^{-5}
Gross Beta[c]	2.4×10^{-13}	2.5×10^{-8}	Iodine-129[f]	3.8×10^{-10}	3.3×10^{-7}
Tritium (tritiated water)	2.1×10^{-7}	1.9×10^{-3}	Iodine-131[f]	2.3×10^{-9}	1.3×10^{-6}
Carbon-14	6.6×10^{-10}	6.2×10^{-5}	Iodine-132[f]	3.0×10^{-8}	9.8×10^{-5}
Sodium-24	4.1×10^{-9}	7.0×10^{-9}	Iodine-133[f]	7.2×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	—	Iodine-135[f]	1.6×10^{-8}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[d]	2.4×10^{-6}	—
Manganese-54	1.1×10^{-9}	4.4×10^{-5}	Xenon-133[d]	6.3×10^{-7}	—
Cobalt-58	1.7×10^{-9}	3.9×10^{-5}	Xenon-133m[d]	6.6×10^{-7}	—
Cobalt-60	1.2×10^{-10}	7.2×10^{-6}	Xenon-135[d]	7.8×10^{-8}	—
Zinc-65	1.6×10^{-9}	8.3×10^{-6}	Xenon-135m[d]	4.5×10^{-8}	—
Krypton-85[d]	3.6×10^{-6}	—	Xenon-138[d]	1.6×10^{-8}	—
Krypton-85m[d,e]	1.3×10^{-7}	—	Cesium-134	1.8×10^{-10}	2.1×10^{-6}
Krypton-87[d]	2.2×10^{-8}	—	Cesium-137	3.9×10^{-10}	3.0×10^{-6}
Krypton-88[d]	8.8×10^{-9}	—	Cesium-138	7.5×10^{-8}	3.1×10^{-4}
Rubidium-88[d]	2.5×10^{-8}	8×10^{-4}	Barium-139	5.8×10^{-8}	2.4×10^{-4}
Rubidium-89[d]	7.9×10^{-9}	2×10^{-3}	Barium-140	6.2×10^{-10}	1.1×10^{-5}
Strontium-89	4.6×10^{-10}	1.1×10^{-5}	Cerium-141	9.9×10^{-10}	4×10^{-5}
Strontium-90	2.5×10^{-11}	1.1×10^{-6}	Cerium-144	7.1×10^{-11}	5.5×10^{-6}
Yttrium-91m	3.1×10^{-7}	2.7×10^{-3}	Plutonium-238	3.7×10^{-14}	1.5×10^{-7}
Zirconium-95	6.3×10^{-10}	3.1×10^{-5}	Plutonium-239	3.4×10^{-14}	1.4×10^{-7}
Technetium-99m	1.7×10^{-7}	1.4×10^{-3}	Plutonium-240	3.4×10^{-14}	1.4×10^{-7}
Ruthenium-103	1.3×10^{-9}	4.2×10^{-5}	Plutonium-241	1.8×10^{-12}	7.6×10^{-6}
Ruthenium-106	5.6×10^{-11}	4.1×10^{-6}	Americium-241	4.1×10^{-14}	1.7×10^{-7}

a. Derived concentration standards are from DOE-STD-1196-2011 (*Derived Concentration Technical Standard)* and support the implementation of DOE Order 458.1. They are based on a committed effective dose equivalent of 100 mrem/yr (1 mSv) for ingestion or inhalation of a radionuclide during one year. Inhalation values shown represent the most restrictive lung retention class.

b. Based on the most restrictive alpha emitter (^{241}Am).

c. Based on the most restrictive beta emitter (^{228}Ra).

d. The DCS for air immersion is used because or there is no inhaled air DCG established for the radionuclide.

e. An "m" after the number refers to a metastable form of the radionuclide.

f. Particulate aerosol form in air.

Table A-3. Environmental Protection Agency Ambient Air Quality Standards.

Pollutant	Type of Standard[a]	Sampling Period	EPA[b] (mg/m^3)
Sulfur dioxide	Secondary	3-hour average	1,300
	Primary	24-hour average	365
	Primary	Annual average	80
Nitrogen dioxide	Primary and secondary	Annual average	100
	Secondary	24-hour average	150
Total particulates[c]	Primary and secondary	Annual average	50

a. National primary ambient air quality standards define levels of air quality to protect the public health. Secondary ambient air quality standards define levels of air quality to protect the public welfare from any known or anticipated adverse effects of a pollutant.

b. The state of Idaho has adopted these ambient air quality standards.

c. The primary and secondary standard to the annual average applies only to "particulates with aerodynamic diameter less than or equal to a nominal 10 micrometers."

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Levels	Groundwater Quality Standards
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4	4
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/yr effective dose equivalent
Radium-226 plus -228 (pCi/L)	5	5
Strontium-90 (pCi/L)	8	8
Tritium (pCi/L)	20,000	20,000
Uranium (µg/L)	30	30
Arsenic (mg/L)	0.01	0.05
Antimony (mg/L)	0.006	0.006
Asbestos (fibers/L)	7 million	7 million
Barium (mg/L)	2	2
Beryllium (mg/L)	0.004	0.004
Cadmium (mg/L)	0.005	0.005
Chromium (mg/L)	0.1	0.1
Copper (mg/L)	1.3	1.3
Cyanide (mg/L)	0.2	0.2
Fluoride (mg/L)	4	4
Lead[a] (mg/L)	0.015	0.015
Mercury (mg/L)	0.002	0.002
Nitrate (as N) (mg/L)	10	10
Nitrite (as N) (mg/L)	1	1
Nitrate and Nitrite (both as N) (mg/L)	--[b]	10
Selenium (mg/L)	0.05	0.05
Thallium (mg/L)	0.002	0.002

a. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.
b. No maximum contaminant level for this constituent.

Table A-5. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

Constituent	Maximum Contaminant Levels (mg/L)	Groundwater Quality Standards (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	—	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	0.005	0.005
1,2-Dichloropropane	0.005	0.005
Ethylbenzene	0.7	0.7
Monochlorobenzene	0.1	0.1
Styrene	0.1	0.1
Tetrachloroethylene	0.005	0.005
Toluene	1.0	1.0
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.005	0.005
Trichloroethylene	0.005	0.005
Vinyl chloride	0.002	0.002
Xylenes (total)	10.0	10.0
Bromate	0.01	—
Bromodichloromethane	—	0.1
Bromoform	—	0.1
Chlorodibromomethane	—	0.1
Chloroform	—	0.002
Chlorite	1.0	—
Haloacetic acids (HAA5)	0.06	—
Total Trihalomethanes (TTHMs)	0.08	0.1

Table A-6. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Synthetic Organic Contaminants.

Constituent	Maximum Contaminant Levels (mg/L)	Groundwater Quality Standards (mg/L)
Alachlor	0.002	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-D	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (silvex)	0.05	0.05
Benzo(a)pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

Table A-7. Environmental Protection Agency National Secondary Drinking Water Regulations and State of Idaho Groundwater Quality Standards for Secondary Contaminants.

Constituent	Secondary Standards[a]	Groundwater Quality Standards
Aluminum (mg/L)	0.05 to 0.2	0.2
Chloride (mg/L)	250	250
Color (color units)	15	15
Foaming agents (mg/L)	0.5	0.5
Iron (mg/L)	0.3	0.3
Manganese (mg/L)	0.05	0.05
Odor (threshold odor number)	3 threshold odor number	3
pH	6.5 to 8.5	6.5 to 8.5
Silver (mg/L)	0.1	0.1
Sulfate (mg/L)	250	250
Total dissolved solids (mg/L)	500	500
Zinc (mg/L)	5	5

a. The Environmental Protection Agency (EPA) has not established National Primary Drinking Water Regulations that set mandatory water quality standards (maximum contaminant levels) for these constituents because these contaminants are not considered a risk to human health. EPA has established National Secondary Drinking Water Regulations that set secondary maximal contaminant levels as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

REFERENCES

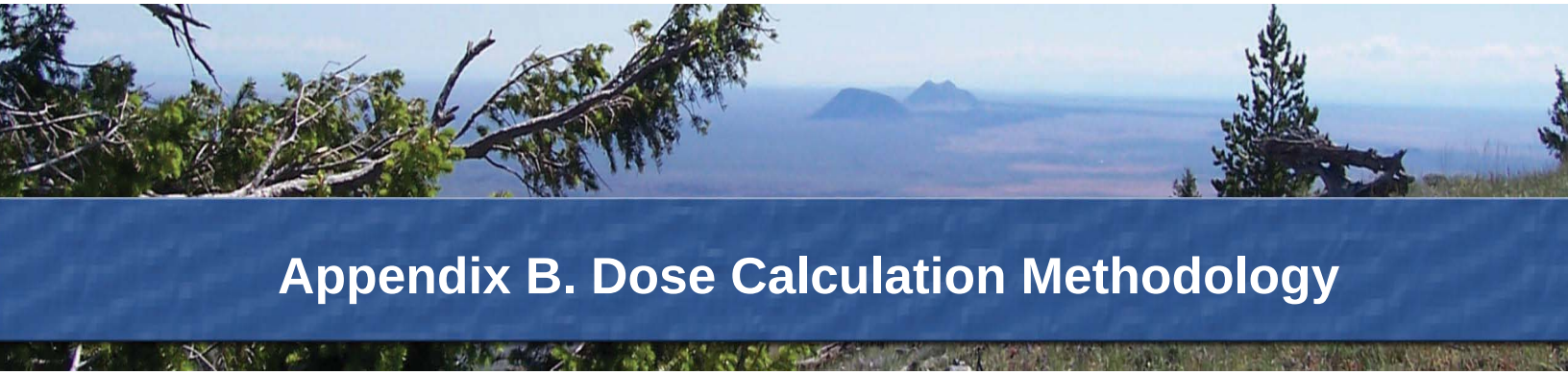
40 CFR 141, 2013, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, Code of Federal Regulations, Office of the Federal Register.

DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," U.S. Department of Energy.

DOE, 1988a, Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, U.S. Department of Energy.

DOE, 1988b, External Dose-Rate Conversion Factors for Calculation of Dose to the Public, DOE/EH-0070, U.S. Department of Energy.

IDAPA 58.01.11, 2013, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.



Appendix B. Dose Calculation Methodology

B1. Introduction

Every year the Environmental Surveillance, Education, and Research (ESER) Program prepares and issues the Department of Energy (DOE) Annual Site Environmental Report (ASER) for the Idaho National Laboratory (INL) Site (DOE-ID 2013a). A key portion of the ASER is reporting the dose to a hypothetical member of the public - the Maximally Exposed Individual (MEI), to the population within a 50-mile (80-km) radius of any site facility, and to biota.

DOE Order 458.1 establishes a radiation dose limit of 100 mrem/yr (1 mSv/yr) to a member of the general public from all possible pathways as a result of DOE facility operations. The most significant pathways to the MEI include the air transport pathway and ingestion of game animals which access the INL Site (Maheras and Thorne 1993).

The dose to the MEI via airborne transport of radionuclides released to air is calculated by the INL contractor (DOE/ID 2013b) to demonstrate that radionuclides released to the air from any DOE facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (National Emission Standards for Hazardous Air Pollutant [NESHAPs] regulation [40 Code of Federal Regulations (CFR) 61, Subpart H]). The NESHAPs dose is estimated using the Clean Air Act Assessment Package (CAP) 88-PC computer code (EPA 2013) and provided to the ESER contractor for inclusion in the ASER.

The ESER Program estimates the potential dose to the MEI via ingestion of game animals which access the INL Site, based on radionuclide concentrations measured in samples collected on the INL Site. ESER collects waterfowl using INL Site ponds and samples big game animals killed by vehicle collisions on roads located within the INL Site for radioanalysis.

In addition to calculating doses to the MEI, DOE Order 458.1 (DOE 2011a) requires reporting of collective doses to the public around DOE sites. This is typically truncated by a distance of 50 miles from DOE facilities. The 50-mile population dose is an integration of estimates of conservative representative doses to the public from INL Site sources. The methodology developed and used by the ESER program involves the use of the air dispersion model, MDIFFH, which has been developed by the U.S. National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (NOAA ARL-FRD) at the INL Site (http://www.noaa.inel.gov/capabilities/modeling/MDIFFTechMemo.pdf). MDIFFH was designed specifically for estimating impacts over periods of up to a year or more and is driven by hourly data derived from the mesonet wind field data collected from 35 meteorological stations on and around the INL Site. It is thus well suited for calculating the transport and dispersion of airborne material on and near the INL Site. The model is based on the MESOscale DIFfusion (MESODIF) computer program, one of the first puff diffusion models developed for use on modern computers. Output from the MDIFFH model is used to identify and quantify

airborne concentrations of radionuclides at gridded points and at resident locations identified within 50 miles of the INL Site. The potential dose received by the individual who lives at the location of the highest projected concentration, hence referred to as the “Reference Resident,” is calculated by the ESER Program, using AIRDOS-U.S. Environmental Protection Agency (EPA) exposure/dose pathway methodology. The dose to the Reference Resident is then used to derive the dose to the 50-mile population, using MDIFFH results and census data.

Finally, DOE Order 458.1 requires the protection of populations of aquatic animals, terrestrial animals, and terrestrial plants in local ecosystems from adverse effects due to radiation and radioactive materials released from DOE operations. The Order provides a graded (tiered) approach to evaluating biota and demonstrating compliance with biota dose rate criteria of 1 rad/day for aquatic organisms and terrestrial vegetation, and 0.1 rad/day for terrestrial animals. The ESER program uses the RESRAD-BIOTA Code (DOE 2004), which was principally sponsored and developed by DOE for this purpose.

B2. Dose to the Maximally Exposed Individual from Airborne Pathways

Calculations of the effective dose equivalent (EDE) to the MEI from atmospheric radionuclide emissions from INL Site sources are performed in accordance with the requirements in CFR, Title 40, “Protection of the Environment,” Part 61, “National Emission Standards for Hazardous Air Pollutants (NESHAPs),” Subpart H, “National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities” (40 CFR 61, Subpart H). Doses are calculated using the computer model CAP88-PC (EPA 2013) for unit emission rates at INL Site facilities and INL in-town facilities and stored in Microsoft Access databases. The unit dose factors (*UDFs*) are then combined with the radionuclide-specific release rates for each facility-specific source to compute doses at predetermined receptor locations, including the MEI location.

The CAP88-PC computer model is a set of programs, databases and associated utility programs for estimation of dose and risk from radionuclide emissions to air. CAP88-PC is a mature model required by the EPA for demonstration of compliance with 40 CFR 61, Subpart H. The EPA website (http://www.epa.gov/rpdweb00/assessment/CAP88/) states any version of CAP-88 may be used for enforcement purposes. Version 3 (released Feb 2013) (EPA 2013) is currently used for the INL Site.

The CAP88-PC modeling is performed using the methodology described in Staley et al. (2004). For INL Site facilities, the modeling entails calculating annual doses for unit emission rates for 167 of the 824 radionuclides that are present in the CAP88-PC Version 3 radionuclide database. For INL in-town facilities in Idaho Falls, annual doses for unit emission rates for 133 radionuclides are calculated. Unit doses are calculated for each INL Site facility at the 62 NESHAP receptor locations that encircle the INL Site boundary. For releases at INL in-town facilities at the Idaho Research Center (IRC) facility and the Radiological and Environmental Sciences Laboratory (located in the IRC complex), radionuclides are assumed to be released from a single ground-level point source and doses calculated 100 m from the source in each of

the 16, 22.5 degree sectors. In other words, the MEI is assumed to be located in the direction of maximum dose, 100 m from the facility. This direction can vary depending on the radionuclide, but is typically in the same direction for nearly all radionuclides.

Meteorological data files provided by the NOAA ARL-FRD are used for the calculations. Table B-1 shows the monitoring locations and wind files used in 2013 for each facility. Stability array (*.str) files for each meteorological station were converted to wind (*.wnd) files using the computer program WINDGET. Stack emissions were modeled for the Idaho Nuclear Technology and Engineering Center (INTEC) Main Stack (INTEC-MS), at ATR and Materials Test Reactor stacks (ATRC-ATR and ATRC-MTR) at the ATR Complex, and the main stack at MFC (MFC-MS) using the nearest wind file from an upper (30 m) measurement height. All other sources were modeled as ground-level releases and use the wind file for the lower (10-15 m) measurement height. Stack parameters are provided in Table B-2. Other NOAA ARL-FRD meteorological data used in modeling are shown in Table B-3.

For dose calculations, the local food production option in CAP88-PC is selected to simulate a rural subsistence-farming scenario for the public receptors, including INL in-town receptors. This scenario uses CAP88-PC Version 3 default parameters (EPA 2013) shown in Table B-4.

B2.1 Unit Dose Factors

Because of the number of radionuclides and sources involved, a *unit dose factor (UDF)* was developed to minimize the number of model runs needed to calculate the dose to the MEI. The *UDF* is the annual dose for a given radionuclide at a given source location for a unit (1 Ci/yr) release, and is given by:

$$UDF_{i,j,k} = D_{i,j,k} / Q_i \quad (1)$$

where:

$UDF_{i,j,k}$ = *UDF* for radionuclide *i* (including progeny), at receptor *j*, from source *k* (mrem/Ci)

$D_{i,j,k}$ = CAP88-PC total pathway parent/progeny annual EDE for radionuclide *i*, at receptor *j*, from source *k* (mrem/yr)

Q_i = unit release rate for radionuclide *i*, (1 Ci/yr)

The CAP88-PC Version 3 computer code is run for each radionuclide-receptor-source combination. Currently, the calculations consider 62 potential residence locations around the INL Site boundary. Because CAP88-PC Version 3 only allows 20 receptors at a time, four separate CAP88-PC runs are made for each radionuclide-receptor-source combination for the thirteen INL Site facilities (see Table B-1). Files are identified by an “A” suffix for receptors 1–20, “B” for receptors 21–39, “C” for receptors 40– 59, and “D” for 60–62. Therefore, the total number of CAP88-PC simulations for INL Site facilities is:

Table B-1. Facilities and Wind Files Used in 2013 CAP88-PC Simulations.

Facility	Facility ID	2013 Wind File Name	Measurement Height (m)
Central Facilities Area	CFA	690L13.WND	10
Critical Infrastructure Test Range Complex	CITRC	PBFL13.WND	10
Idaho Nuclear Technology and Engineering Center, Idaho CERCLA Disposal Facility	INTEC	GRIL13.WND	10
Idaho Nuclear Technology and Engineering Center – Main Stack	INTEC-MS	GRIU13.WND[b]	30
Materials and Fuels Complex	MFC	EBRL13.WND	10
Materials and Fuels Complex Main Stack	MFC-MS	EBRU13.WND	30
Naval Reactor Facility	NRF	NRFL13.WND	10
Advanced Test Reactor Complex[a]	ATRC	TRAL13.WND	10
Advanced Test Reactor Complex[a], Advanced Test Reactor Main Stack	ATRC-ATR	GRIU13.WND[b]	30
Advanced Test Reactor Complex[a], Materials Test Reactor Main Stack	ATRC-MTR	GRIU13.WND[b]	30
Radioactive Waste Management Complex	RWMC	RWMCL13.WND	10
Specific Manufacturing Capability	SMC	LOFL13.WND	10
Test Area North, Technical Support Facility	TAN-TSF	LOFL13.WND	10
INL Research Center	IRC	IDAL13.WND	15
Radiological and Environmental Sciences Laboratory	IRC	IDAL13.WND	15

a. The Advanced Test Reactor Complex (ATRC) was formerly known as the Test Reactor Area (TRA) and Reactor Technology Complex (RTC). The acronyms based on former names may still be used to describe facility buildings, meteorological stations, etc.

b. The nearest tower with an upper (30 m) measurement height (GRID III) was used for stacks at INTEC and the ATR Complex. The GRID III tower is approximately 1.6 km north on INTEC and 1.7 km east of the ATR Complex.

Table B-2. Stack Parameters Used in CAP88-PC Simulations.

Facility ID	Stack Number	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)
INTEC-MS[a]	CPP-708-001	76.2	1.83	10.65
ATRC-ATR	TRA-770-001	76.2	1.524	10.03
ATRC-MTR	TRA-710-001	76.2	1.524	0.977
MFC-MS[a]	MFC-764-001	60	1.524	9.081

a. MS = main stack

Table B-3. Other Meteorological Parameters Used in the CAP88-PC Modeling.

Variable	Value[a]	Units
Lid height	800	meters
Mean temperature	280.2	Kelvin
Precipitation	20.8	cm/yr
Absolute humidity	3.54	g/m^3

a. These values represent a 10-year average at the INL (Clawson et al. 1989).

167 radionuclides × 13 facilities × 4 files/facility = 8,684 radionuclide simulations.

B2.2 Database Implementation for INL Site Facilities

Calculations for INL Site facilities are performed in the Microsoft Access database (*NESHAP-CAP88DoseCalculator2013.mdb*) using three primary data tables (Table B-5). The *UnitDoses* table contains the unit dose factors calculated with CAP88-PC for each radionuclide-receptor-facility combination (see Equation 1). The *Releases* table contains the generator-provided radionuclide release rates from each source. The *MKMEIsBySecName* table contains the distance and direction from each facility to each of the 62 receptor locations. Note that the same data field name is used in multiple tables. This allows relationships between tables to be established.

Doses are calculated for each source-radionuclide-receptor combination in the *CalculatedDoses* query. The *CalculatedDoses* query takes the *UDF*s in the *UnitDoses* table for a facility-radionuclide-receptor combination and multiplies it by the corresponding radionuclide release rate in the *Releases* table. The *MkMEIsBySecName* table provides the receptor number for the dose.

Table B-4. CAP88-PC Version 3 Radionuclide-independent Parameters for the Rural Receptor Scenario.

Parameter Description	Value	Units
Inhalation rate	9.17E+05	cm^3/hr
Effective surface density of soil (15 cm plow depth, dry weight)	215	kg/m^2
Build-up time for radionuclides in soil	100	year
Build-up time radionuclides deposited on ground/water	365	day
Delay time, ingestion of pasture grass by animals	0	hr
Delay time, ingestion of stored feed by animals	2160	hr
Delay time, ingestion of leafy vegetables by man	336	hr
Delay time, ingestion of produce by man	336	hr
Delay time, transport time from animal feed-milk-man	2	day
Delay time, time from animal slaughter to consumption	20	day
Removal rate constant for physical loss by weathering	2.90E-03	1/hr
Crop exposure duration, pasture grass	720	hr
Crop exposure duration, crops, leafy vegetables	1440	hr
Ag Productivity, grass-cow-milk-man pathway	0.28	kg/m^2
Ag Productivity, produce/leafy vegetables for human consumption	0.716	kg/m^2
Fallout interception fraction, vegetables	0.2	---
Fallout interception fraction, pasture	0.57	---
Fraction of year animals graze on pasture	0.4	---
Fraction of daily feed that is pasture grass (when animal on pasture)	0.43	---
Animal consumption rate of contaminated feed/forage (dry weight)	15.6	kg/day
Milk production of cow	11	L/day
Muscle mass of animal at slaughter	200	kg
Fraction of animal herd slaughtered per day	3.81E-03	---
Fraction of radioactivity retained after washing (leafy veg & produce)	0.5	---
Fraction of produce ingested grown in garden	1	---
Fraction of leafy vegetables ingested grown in garden	1	---
Human produce ingestion	176	kg/yr
Human milk ingestion	112	L/yr
Human meat ingestion	85	kg/yr
Human vegetable ingestion	18	kg/yr
Fraction of time spent swimming	0	---
Depth of water for dilution for water immersion doses	1	cm
Fraction vegetables home produced	0.7[a]	---
Fraction milk home produced	0.399[a]	---
Fraction meat home produced	0.442a	---
Fraction vegetables from assessment area	0.3[a]	---
Fraction meat from assessment area	0.601[a]	---
Fraction meat from assessment area	0.558[a]	---
Minimum ingestion fractions from outside area, vegetables	0[a]	---
Minimum ingestion fractions from outside area, meat	0[a]	---
Minimum ingestion fractions from outside area, milk	0[a]	---
Default beef cattle density	7.19E-02[a]	$\#/km^2$
Milk cattle density	8.56E-03[a]	$\#/km^2$
Land fraction cultivated for vegetables	7.15E-02[a]	---

a. CAP88-PC default values for the state of Idaho.

Table B-5. Description of Data Tables in NESHAPs CAP88-PC Database for INL Site Facilities.

Table Name	Field Name	Type	Description
UnitDoses	FacilityID	Text	Facility Identification (see Table B-1)
	Nuclide	Text	Radionuclide name
	Direction	Text	Direction to MEI
	Distance	Double	Distance to MEI
	UDose	Double	Unit dose (mrem/Ci)
Releases	SourceID	Text	Source identification
	FacilityID	Text	Facility Identification (see Table B-1)
	Fugitive	Text	Fugitive or Non-Fugitive release flag
	Radionuclide	Text	Radionuclide name
	Q	Double	Radionuclide Release rate (Ci/yr)
MkMEIsBySecName	FacilityID	Text	Facility Identification (see Table B-1)
	SectorName	Text	Text name of the 16, 22.5-degree sectors
	Distance	Text	Distance from the facility to the receptor
	ReceptorNum[a]	Long	Receptor number index

a. The receptor number is the identification assigned to the 62 receptors surrounding the INL. The distance and direction to each receptor varies by facility.

Subsequent queries use the *CalculatedDoses* query to extract total dose by radionuclide, source, or facility. Of prime importance are the total maximum dose and the location of the total maximum dose. Several queries are used to obtain this value. First, the make-table query *TotalDoseByRecNumber* is run which sums the dose across all radionuclides and sources at each receptor location, sorts the doses in decreasing order, and writes these data to the table *MkTotalDoseByRecNum*. The first record in this table identifies the receptor location. The query *LocationOfMaxTotalDose* extracts this record which is used in subsequent queries to extract dose by radionuclide and dose by source at the receptor. While in most cases the MEI is located at receptor number one (Frenchman's Cabin), this query allows confirmation of the MEI location each time the dose calculations are performed.

B2.3 Database Implementation for INL Facilities at the IRC

Calculations for INL in-town facilities at the IRC are performed in the Microsoft Access database (*CAP88IRCDoseCalculator2013.accdb*) using two primary data tables; *Releases and UnitDoses*. The *UnitDoses* table contains the doses from a unit (1 Ci/yr) release calculated with CAP88-PC for each radionuclide-receptor combination. The receptors are defined for the 16, 22.5-degree sectors, 100 m from the source (16 total potential receptors). The *Releases* table contains the generator-provided radionuclide release rates from each source. The doses are calculated in the query *Doses*.

B2.4 Source Term

Source terms are provided by each facility in spreadsheets or a Microsoft Access Database. These data are checked for formatting and imported into a *Releases* table in databases that

calculate dose. There is one database for the INL Site and one for INL in-town facilities. INL Site facilities report estimated annual emission rates. INL in-town facilities report radionuclide inventories which are multiplied by release factors (1E-06 for solids, 1E-03 for liquids and powders, and 1 for gases) to estimate a potential annual release rate. These calculations are performed before the data are imported into the *Releases* table. Each source is designated as either fugitive or non-fugitive. Point sources such as stacks, vents, ducts, etc. are non-fugitive. Fugitive releases are non-point sources (e.g. volatilization from a pond or wind suspension of surface material) released directly to the atmosphere. Fugitive emissions inside enclosures that are released out stacks, vents or ducts are considered non-fugitive.

For the INL Site, there were 839 radionuclide releases reported in 2013 from 64 different source locations. The total number of unique radionuclides for which a release rate was provided was 168 from all INL Site sources. Only 167 were modeled with CAP88-PC because curium-248 (^{248}Cm) is not included in the CAP88-PC database. Curium-248 was reported from only one source, MFC-1704 (Radiochemistry Laboratory), and the annual release was 5.22E-10 Ci.

For INL in-town sources, inventories were reported in 2013 for 246 radionuclides from five primary sources. Values for 43 radionuclides were dropped from the IRC-AGC source list because the inventories were deemed inconsequential (less than 1E-40 Ci). The total number of unique radionuclides for which an inventory/release rate was provided was 136. Only 133 radionuclides were modeled with CAP88-PC because holmium-163 (^{163}Ho) and niobium-92 (^{92}Nb) are not included in the CAP88-PC database and a viable CAP88-PC input file could not be created for californium-252 (^{252}Cf). Based on the small emission estimates for these radionuclides (^{163}Ho = 7.66E-13 Ci, ^{92}Nb = 1.74E-12 Ci and ^{252}Cf = 9.88E-14 Ci) it is highly unlikely that they would be significant contributors to the total MEI dose.

B3. Dose to the Maximally Exposed Individual from Game Ingestion

Game animals (elk, deer, pronghorn or waterfowl) which access the INL Site could contact contaminated areas, ingest radionuclides, and leave the INL Site. These animals could then be hunted and consumed by members of the public. Each year the ESER collects waterfowl on ponds at INL Site and samples big game killed on roads crossing the INL Site. Samples are analyzed for radionuclides and the results are then used to estimate the maximum dose an individual could potentially receive by consuming the edible portions.

Game animals may become contaminated and subsequently consumed by the MEI, who is assumed to live at the location of the highest concentration of airborne radionuclides, as projected by MDIFFH. Potential doses from consuming waterfowl or big game animals (pronghorn antelope, deer, or elk) are calculated using the following formula:

$$D_{ingG} = M \times C \times DC_{ing} \times 10^{-3} \quad (2)$$

where:

D_{ingG} = effective dose from ingestion of game animal (mrem)

M = mass consumed (g)

C = measured concentration (pCi/g)

DC_{ing} = ingestion dose coefficient (rem/μCi) (EPA 2002)

$10^{-3} = 10^{-6}$ μCi/pCi × 10^{3} mrem/rem

This formula is very conservative in that it does not account for radioactive decay and biological elimination by the animal of concern. That is, it is consumed immediately upon leaving the area where it was contaminated. It is also assumed that one individual (the hunter) consumes the entire animal over a period of time and that no radionuclide decay occurs during that period. The edible mass of each kind of animal is shown in Table B-6.

Table B-6. Weight of Edible Portion of Animal Consumed.

Animal Species	Mass of Edible Portion (g)	Reference
Mallard	227	Maximum weight of mallard breast (ESER)
Pronghorn antelope	20,048	Field et al. (2003a)[a]
Mule deer	21,772	Field et al. (2003b)[b]
Elk (bull)	75,297	Field et al. (2003c)[c]

a. http://www.wyomingextension.org/agpubs/pubs/B565R.pdf
b. http://www.wyomingextension.org/agpubs/pubs/B589R.pdf
c. http://www.wyomingextension.org/agpubs/pubs/B594R.pdf

B4. DOSE TO THE 50-MILE POPULATION

The dose to 50-mile population surrounding the INL Site is calculated assuming that air is the critical pathway from the INL Site to off-Site receptors (DOE-ID 2014). The analysis involves four major steps: 1) MDIFFH simulation of INL Site annual average time-integrated concentrations (TICs) using wind-field measurements conducted continuously at and near the INL Site by NOAA ARL-FRD; 2) calculation of the potential effective dose to an individual subsisting at the location of the highest annual TIC projected by MDIFFH for offsite residences (i.e., the Reference Resident location); 3) determination of the average TIC in each census division within 50 miles of any INL site facility using the most recent geospatially distributed census data; and 4) estimation of the 50-mile population dose using results of the previous calculations and census data.

The Reference Resident used to represent a member of the 50-mile population living outside the INL Site is different from the MEI used for NESHAP compliance calculations. The NESHAP compliance code CAP88-PC uses a modified straight-line Gaussian plume model to estimate the average dispersion of radionuclides from up to six emitting sources, which are characterized by data such as type of release (stack or area), height of release, exit velocity, and temperature. Site-specific wind field data from the INL Site that consist of annualized frequencies of wind direction and speed for the meteorological tower used (e.g., the Grid III tower, which is central to the INL Site) are entered into the code. The user provides distances of potential receptor locations, such as Frenchman's Cabin. Dose assessments are then performed by the code for a circular grid of distances and 16 compass directions within a radius of 80 kilometers (50 miles) around the facility. The MEI is selected based on the most conservative dose calculated among these receptor locations. The calculated dose to the MEI is used to demonstrate compliance with the NESHAP regulatory requirement.

The Reference Resident used for the 50-mile population dose assessment is selected based on the location of the highest time-integrated air concentration projected by the MDIFFH air dispersion code among those modeled for 98 potential residence locations around the INL Site boundary. The MDIFFH model uses the 1-hour mesonet database representing each of over 10,000 grid points on and around the INL Site, as discussed in more detail in Section B4 below. The MDIFFH algorithm is conceptually very simple: 1) every release of material is represented as a series of puffs; 2) each puff is allowed to move and grow independently; 3) concentrations are calculated as the sum of the concentrations due to all of the puffs (Sagendorf et al. 2001). This technique is preferred over a straight line Gaussian calculation used in CAP88-PC because "puff" trajectory is based on frequently measured wind field data which better represents the movement of airborne effluents from INL Site facilities to the receptor location. The dose estimated to the Reference Resident from the modeled air concentration is then scaled to members of the population within the 50-mile area, based on the concentrations modeled for each grid point. In this fashion, the Reference Resident is used to project a representative dose to the population residing within 50 miles of the INL Site.

B4.1 MDIFFH Modeling of Annual TICs (Step One)

One of the key pieces of information in this calculation is the MDIFFH air dispersion model to determine annual TICs (hr^2/m^3) in the region on and surrounding the INL Site. The MDIFFH model uses wind data collected continuously from a regional network of 35 atmospheric stations (Figures B-1 and B-2). A unit release from the INL Site is assumed (i.e., 1 Ci/yr), with percent contributions from each major facility (Advanced Test Reactor [ATR], Central Facilities Area [CFA], INTEC, Materials and Fuels Complex [MFC], Naval Reactors Facility [NRF], Radioactive Waste Management Complex [RWMC], and Test Area North [TAN]) incorporated in the modeling. The percent contributions are based on emissions data used to estimate the MEI dose for the annual NESHAPs report) and are reported in Table 4-2 of the ASER. So, for example, in 2013 the following were the facility contributions to the entire INL Site release:

- ATR – 57.6 percent
- INTEC – 39.5 percent
- RWMC – 2.8 percent
- CFA – 0.03 percent

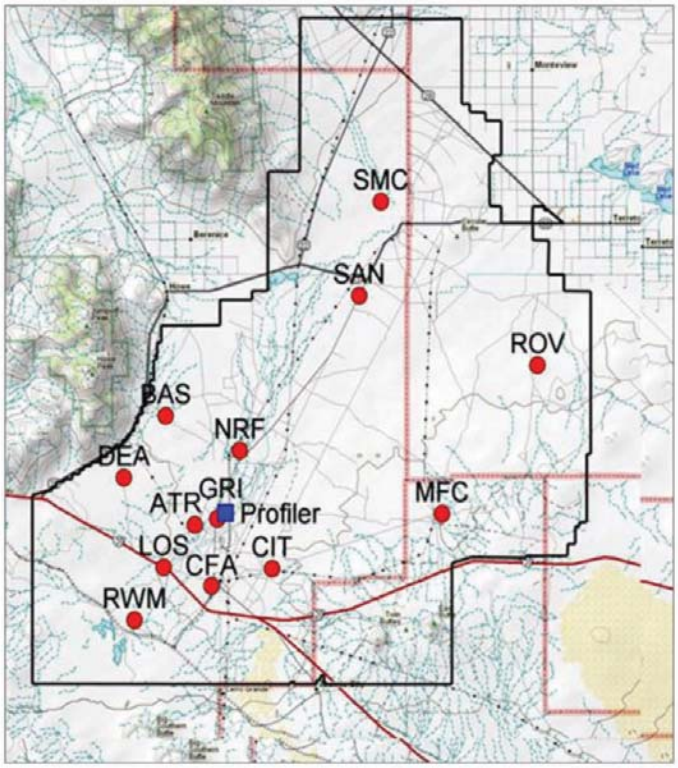


Figure B-1. NOAA/INL Mesonet Stations on the INL Site as of December 31, 2012.

- MFC – 0.01 percent
- TAN – 0.001 percent

(Note: The actual release rates of each radionuclide from each facility are accounted for in Step Two of the analysis, as described in Section B4.2 below.)

The TICs for the year are calculated for 11,236 points on and around the INL Site, using the grid shown in Figure B-3. The results are provided to ESER by NOAA ARL-FRD in files for ATR, CFA, INTEC, MFC, NRF, RWMC, and TAN. The ESER Program combines the files into one file named "Total_*YEAR*_Grid.xlxs," where YEAR is the current year.

In addition to the grid results, NOAA ARL-FRD also provides the TICs for the exact locations of residences within approximately 5 miles of the INL Site boundary. Prior to 2013, NOAA ARL-FRD calculated the TICS at each of 62 resident locations for each major facility releasing radionuclides. These locations were identified in 2001 through observations from helicopter and then identified on the ground using global positioning system equipment (Figure B-4). The 62 locations were reevaluated by ESER GIS analysts in late 2013 using the 2011 Idaho National Agricultural Imaging Program (NAIP) 1 m resolution imagery. As a result of this analysis, four locations were removed because there was no evidence of human activity or habitation and 40 new residence locations were added. Ninety-eight resident locations (Figure B-5) were thus used for 2013 population dose calculations and will be included in future ASERs.

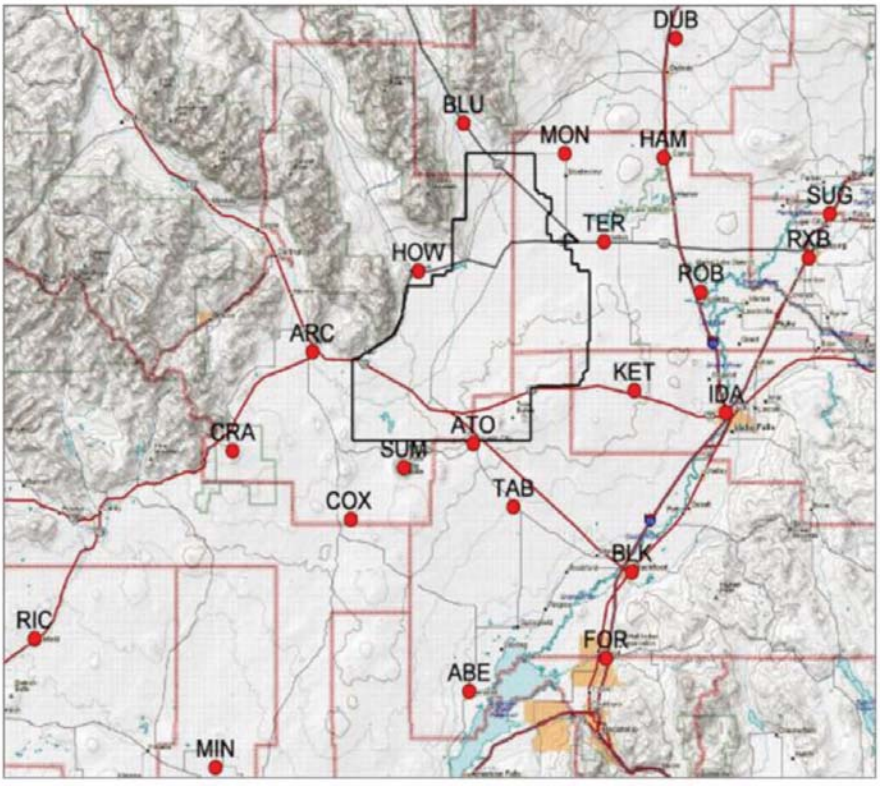


Figure B-2. NOAA/INL Mesonet Stations off the INL Site as of December 31, 2012.

The highest total TIC (the MDIFFH modeled result for each facility summed at each resident location) is used to determine the geographic position of the Reference Resident. The ESER file with these data is named "*YEAR*_Total_Residence.xlsx." The dose to this Reference Resident is calculated (Step 2) and then scaled according to the average TIC calculated for each census division included in the 50-mile population surrounding the INL Site (Step 3). This scaled result is multiplied by the population within each census division and summed over all divisions to yield the total population dose (Step 4).

B4.2 Calculation of Reference Residence Dose (Step Two)

Excel workbooks which calculate the dose to the Reference Resident have been developed for each major facility contributing to the population dose (ATR, CFA, INTEC, MFC, NRF, RWMC, and TAN). The workbooks are identified by the filename "*YEAR*_MDIFF_*Facility*_Calcs.xlxs," where "YEAR" is the year being analyzed and "Facility" is the facility name. These are hereafter simply referred to as MDIFFH workbooks. There are seven MDIFFH workbooks.

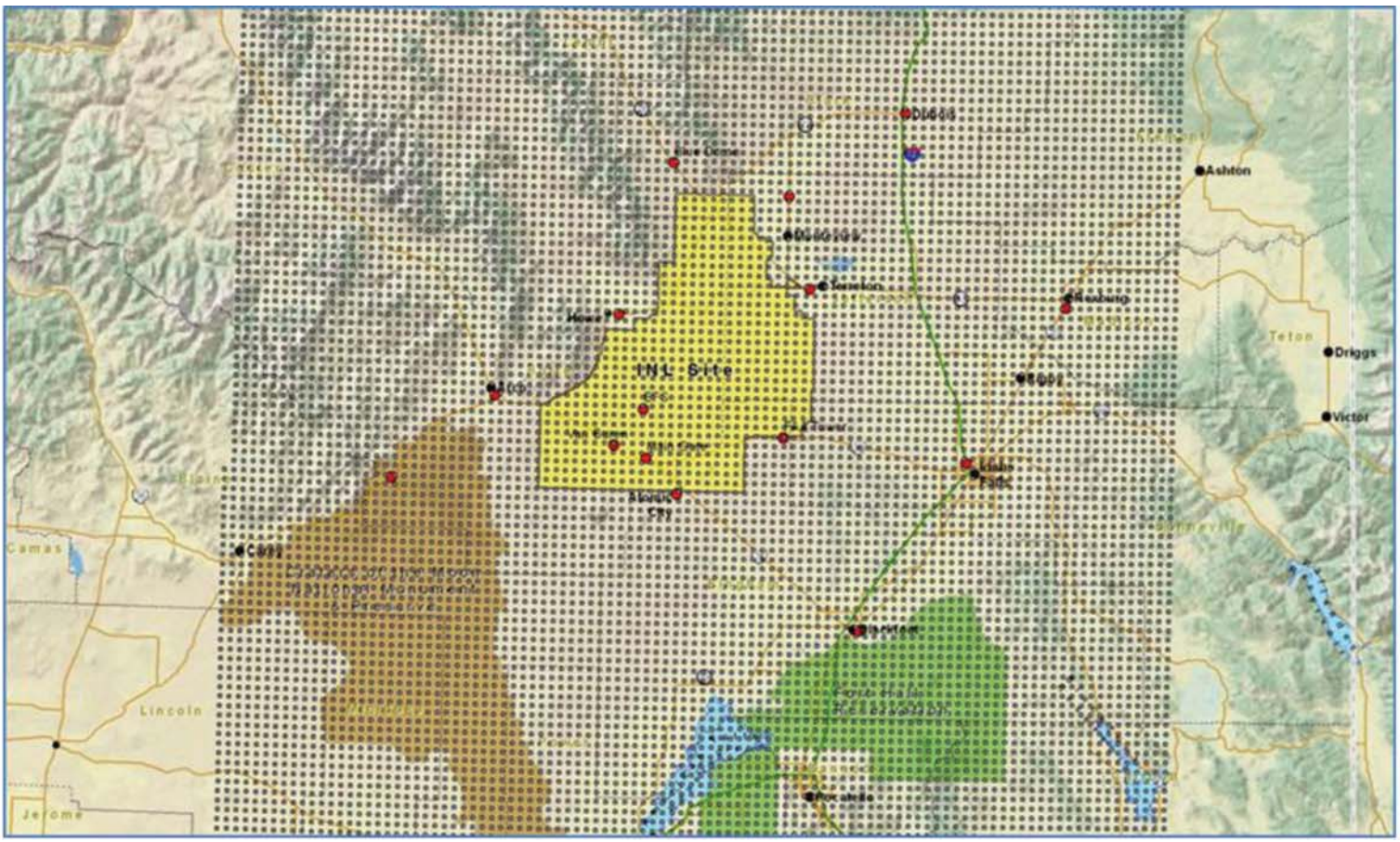


Figure B-3. INL Site Mesoscale Grid Used in MDIFFH Simulations of INL Site Air Dispersion Annual TICs.

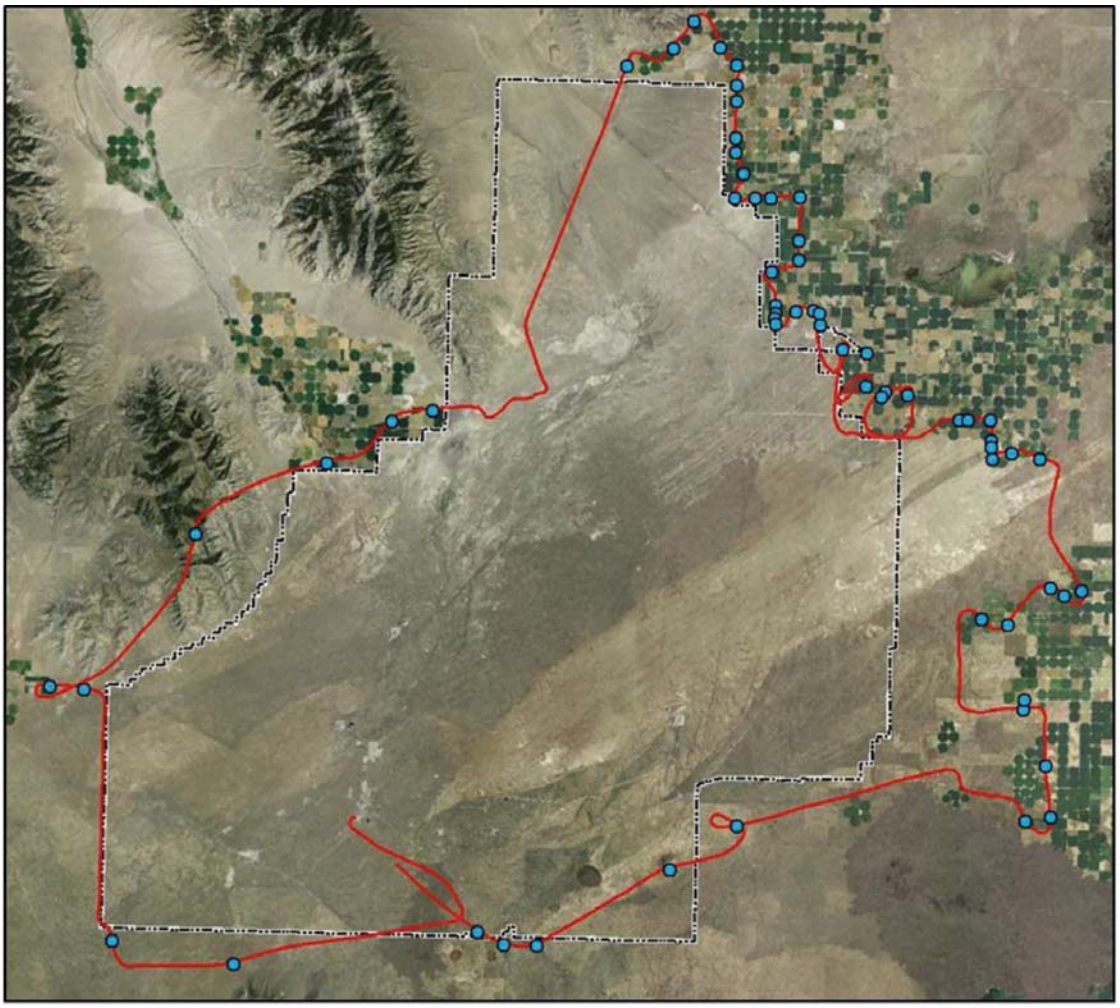


Figure B-4. Aerial Mapping of Residences Around the INL Site in 2001. The Red Line Represents the Route Flown by the Helicopter During the Initial Aerial Mapping. The Blue Points Indicate the Original 62 Locations of Residences and/or Buildings.

Each MDIFFH workbook requires inputs unique for that facility and year of concern, as shown in Table B-7. These data are input into the worksheet named "*Data Inputs*" within each MDIFFH workbook.

The dose calculations are dependent on currently available dose conversion factors used by DOE, which are documented in the worksheet entitled "*Radionuclide-specific Constants.*" The dose conversion factors for inhalation of and submersion in air contaminated with radionuclides are the "effective dose coefficients" (EDCs) presented in the DOE Derived Concentration Technical Standard (DOE 2011b) which supports the implementation of DOE Order 458.1. EDCs are not available for ingestion and exposure to radionuclides deposited on the ground, so the "ingestion dose coefficients" and "ground plane dose coefficients" reported in FGR 13_DB, Version 2.1.13 (EPA 2002) were used.

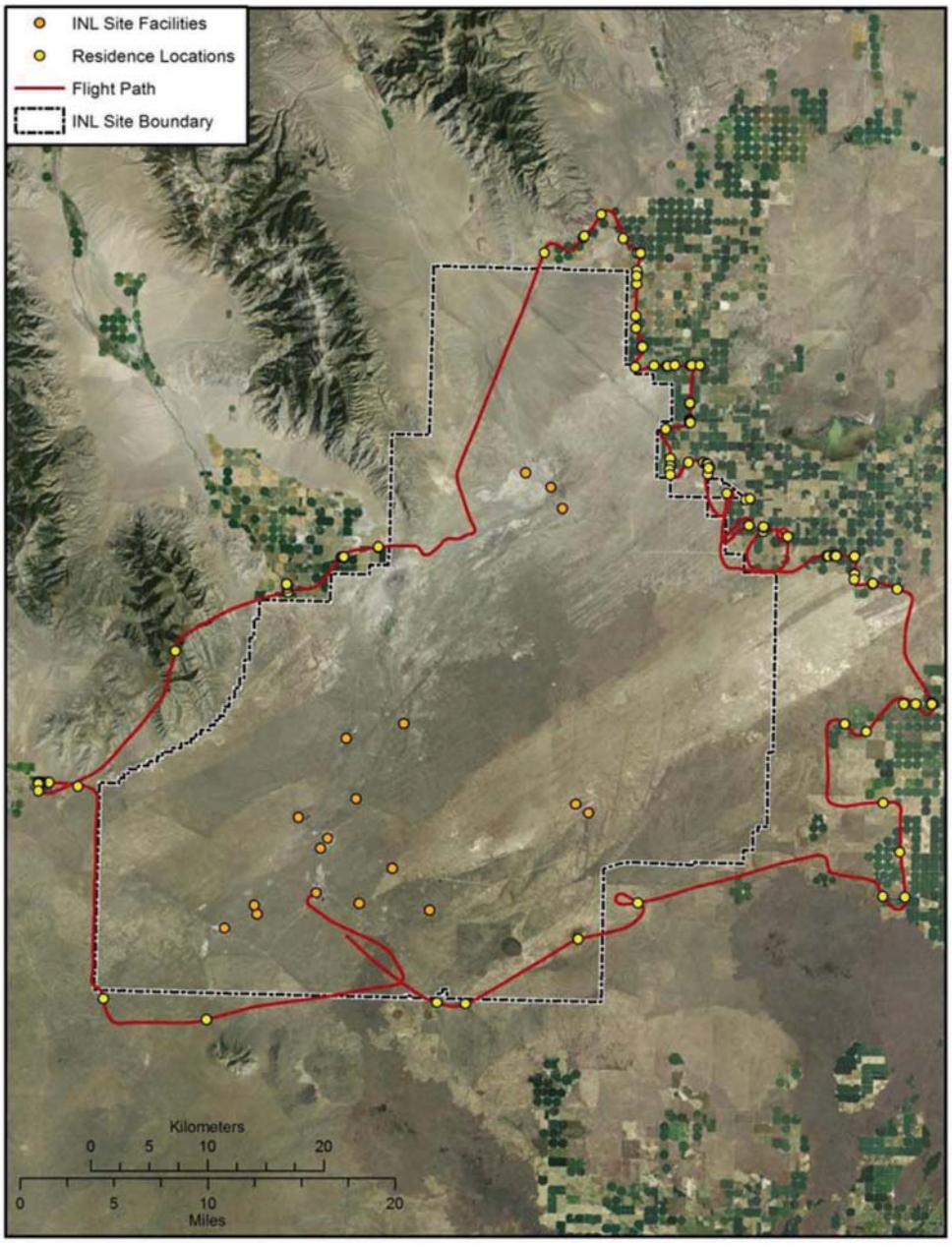


Figure B-5. The Corrected Distribution of Residences Around the INL Site Following ESER Review and Editing.

Radionuclide-specific agricultural transfer factors are those used in the code RESRAD 6.0 (Yu et al. 2001). The factors were selected among the most current published values as the most appropriate for modeling agricultural pathways (Wang et al. 1993).

Radionuclide-independent constants used in the dose calculations are generally those documented in the CAP88-PC Version 3.0 User's Guide (EPA 2013). The values are documented in the worksheet entitled "Nuclide-independent Parameters."

Table B-7. MDIFF Spreadsheet Inputs.

Variable	Description	Units	File name	Source
RR	Amount of radionuclide released during the year (facility specific airborne emission)	Ci	YEAR_ASER_Table 4-2.xlsx	INL contractor
TIC	Time integrated concentration at location of the Reference Resident	hr^2/m^3	YEAR_Total_Residence.xlsx	NOAA ARL-FRD
$\bar{\mu}$	Average annual wind speed for each facility	km/hr	Wind speed.xlxs	NOAA ARL-FRD
Location of highest resident TIC	Location of the highest TIC projected by MDIFFH for offsite residences	N/A	YEAR_Total_Residence.xlsx	NOAA ARL-FRD

The dose to the Reference Resident is calculated using algorithms in the original AIRDOS-EPA computer code (Moore et al. 1979), which is also the basis for the CAP 88-PC program. The exposure pathways modeled are: immersion in air; inhalation; ingestion of vegetation; and exposure to soil contaminated through deposition. Each pathway is evaluated with a worksheet in the MDIFFH workbook. The dose worksheets are appropriately named "*Air Immersion Dose,*" "*Inhalation Dose,*" "*Vegetable Ingestion Dose,*" "*Milk Ingestion Dose,*" "*Meat Ingestion Dose,*" and "*Deposition Dose.*" Each MDIFFH dose calculation worksheet first calculates the individual contribution of each radionuclide to the total dose. These values are then summed to provide the total dose for each pathway. The total doses for each pathway are then summed for the total dose received by the Reference Resident in the worksheet named "*Reference Resident Dose.*" The formulae used in the MDIFFH workbooks to estimate dose to the Reference Resident are described in the following sections.

B4.2.1 Air Concentrations of Radionuclides at the Reference Resident Location

In order to estimate the hypothetical dose to the Reference Resident for any of the exposure routes considered, it is first necessary to calculate the average annual airborne radionuclide concentration at the location of the resident. Based on this concentration, doses due to inhalation of airborne radionuclides, external exposure to airborne and deposited radionuclides, and ingestion of contaminated foods produced at the residence can be calculated.

The equation for the average airborne concentration of a radionuclide emitted from a specific INL site facility and transported by wind to the Reference Resident location, without undergoing radioactive decay, is:

$$AAC_{(undecayed)} = \frac{TIC}{7.67E07} RR \quad (3)$$

where:

$AAC_{(undecayed)}$ = the average undecayed concentration of the radionuclide (Ci/m^3)

TIC = time integrated concentration (hr^2/m^3)

RR = Ci of radionuclide released via airborne effluent from the facility during the year

7.67E07 = (number of hours/year)^2

The TIC is input into the MDIFFH workbook developed for each facility.

In addition, for radioiodine, equation (2) is multiplied by a plume depletion factor to account for deposition of iodine during transport from the release point to the location of the Reference Resident. The equation is modified because the MDIFFH model does not account for plume depletion and therefore results in a conservative estimate of radioiodine concentration at the receptor location. This is not as important for particulate radionuclides because deposition velocity for these radionuclides is about 20 times less than that for radioiodine (i.e. dry deposition rate is 0.035 m/s for iodine versus 0.0018 m/s for particulates). Using CAP88-PC, a plume depletion fraction of 0.446 was estimated. Details of this calculation are described in the worksheet entitled "*Plume Depletion*" in the MDIFFH workbook.

The radioactive decay of the radionuclides during airborne transit is accounted for in the next equation:

$$AAC_{(decayed)} = AAC_{(undecayed)} \; e^{-t\lambda_r} \quad (4)$$

where:

$AAC_{(decayed)}$ = the average airborne concentration of the radionuclide (Ci/m^3) at ground level, accounting for radioactive decay during transit to the location of the Reference Resident

λ_r = radioactive decay constant of the radionuclide (hr^{-1}), which is documented in the "*Radionuclide-specific Constants*" worksheet and is derived from the half-lives ($T_{½}$) documented in DOE (2011b) and the known relationship:

$$\lambda_r = \frac{0.693}{T_{½}} \quad (5)$$

t = transit time of the plume (hr), calculated using the following equation in the "Data inputs" worksheet:

$$t = \frac{D}{\mu} \quad (6)$$

where:

D = distance between the facility release point and the location of Reference Resident (km)

$\bar{\mu}$ = average wind speed for the year (km/yr).

The distance from each release point to each resident location may be found in the file named "Resident_to_Facility_Distances.xlsx." These distances were determined by ESER GIS analysts. For example, in 2013 the highest TIC modeled for the resident locations near the INL Site boundary was determined to be at Frenchman's Cabin. The distances from the major facilities to that point are shown in Table B-8. Frenchman's Cabin is typically the location of the MEI for NESHAPs (DOE/ID 2013) as well as for the Reference Resident.

A number of radionuclides released from the INL Site decay into radioactive daughter products, which then decay according to their own radiological half-lives. The calculation of the daughter radionuclide concentration in air depends on the amount of parent and daughter radionuclides initially released and the relationship between their half-lives.

If the half-life of the parent is much greater than the half-life of the daughter ($T_{½(p)} >> T_{½(d)}$), it is assumed that the parent and daughter have attained a condition of secular equilibrium. This results when the average decayed average air concentration of the daughter product is assumed to be equal to the decayed average air concentration of the parent multiplied by the percentage yield of the daughter. The radionuclides in secular equilibrium which are addressed in the MDIFFH workbook are shown in Table B-9.

In the case of the antimony-125 (^{125}Sb)/tellurium-125m (^{125m}Te), the daughter reaches a condition of secular equilibrium with the parent (half-life of 2.76 years) after about 250-300 days and has a yield of only 2.31 percent. Thus, the ingrowth of ^{125m}Te (half-life of 58 days) is minimal during the period of transit and is not included in the calculations.

Table B-8. Distances from Major INL Site Facilities to Frenchman's Cabin.

Facility Name	Distance (km)
ATR	19.26
CFA	14.5
INTEC	18.86
MFC	37.36
NRF	27.15
RWMC	8.2
TAN (TSF)	54.63

Table B-9. Radionuclides in Secular Equilibrium with Parent Radionuclides.

Parent Radionuclide	Daughter Radionuclide	Percentage Yield
^{137}Cs	^{137m}Ba	94.6%
^{106}Ru	^{106}Rh	100%
^{90}Sr	^{90}Y	100%

A second parent-daughter relationship occurs when the parent and daughter have roughly equivalent half-lives. This is known as transient equilibrium. An example of this is the decay of krypton-88 (^{88}Kr) to rubidium-88 (^{88}Rb). The state of transient equilibrium is reached ~1-2 hours, which is the time period similar to the typical transit time from an INL Site facility to the Reference Resident. The equation used to estimate the ingrowth of ^{88}Rb is:

$$AAC_{^{88}Rb\ (decayed)} = AAC_{^{88}Kr\ (decayed)} \times \frac{T_{1/2(^{88}Kr)}}{(T_{1/2(^{88}Rb)} - T_{1/2(^{88}Kr)})} \times Y(1) = AAC_{^{88}Kr\ (decayed)} \times 1.12 \quad (7)$$

where:

$T_{½\ (^{88}Kr)}$ = half-life of ^{88}Kr (2.84 hr)

$T_{½\ (^{88}Rb)}$ = half-life of ^{88}Rb (17.7 min)

Y = yield of ^{88}Rb from decay of ^{88}Kr = 1.

Finally, in the case where the half-life of the daughter is much longer than that of the parent ($T_{½(p)} << T_{½\ (d)}$) there is no equilibrium. In typical INL Site releases, the daughter ingrowth following the release and transport of the shorter-lived parent is considered negligible and is ignored. Examples of this situation include: the $^{87}Kr/^{87}Rb$ decay sequence, where the half-lives of the parent and daughter are 76.3 minutes and 4.7E10 years, respectively; the ^{89}Rb/stronium-89 (^{89}Sr) decay series, where the half-lives of parent and daughter are 14.4 minutes and 50.52 days, respectively; and the plutonium-241 (^{241}Pu)/americium-241 (^{241}Am) decay sequence, where the half-lives of the parent and daughter are 14 years and 432 years, respectively. In some cases the daughter activity may reach a maximum during the transit time from an INL Site facility to the Reference Resident location. An example is the decay of xenon-138 (^{138}Xe) (half-life of 14.17 minutes) to cesium-138 (^{138}Cs) (half-life of 33.41 m). In this case, the concentration of ^{138}Cs reaches a maximum at ~30 minutes. However, by the time the plume reaches the Reference Resident area (~2 hours), less than five percent of the parent is left and the daughter has also decayed to less than 25 percent of its peak concentration and therefore represents a trivial contribution to dose.

Other parent-daughter decay sequences considered involve more complex decay sequences and algorithms and have been evaluated for current INL Site releases to result in daughter concentrations that are relatively inconsequential in terms of dose to the Reference Resident.

They are therefore not included in the current MDIFFH calculations. These include the following parent daughter sequences: iodine-135 (^{135}I)/^{135m}Xe/^{135}Xe; ^{135}I/^{135m}Xe/^{135}Xe; and ^{133}I/^{133m}Xe/^{133}Xe.

The average air concentrations of radionuclides at the location of the Reference Resident are modeled in the worksheet entitled "*Average Airborne Concentration*" of the MDIFFH workbook.

B4.2.2 Air Immersion Dose

The equation used for estimating external doses from immersion in air containing gamma-emitting radionuclides is:

$$Dose_{imm} = AAC_{decayed} \times EDC_{sub} \quad (8)$$

where:

$Dose_{imm}$ = radionuclide-specific effective dose (rem/yr) from continuous, nonshielded exposure via submersion in a semi-infinate cloud containing the radionuclide

EDC_{sub} = radionuclide-specific effective dose coefficient ($\frac{rem/yr}{Ci/m^3}$) for submersion in contaminated air (DOE 2011b).

The dose estimated for each radionuclide is summed to yield total immersion dose from all radionuclides. The immersion dose calculations may be found in the worksheet named "*Air Immersion Dose*" in the MDIFFH workbook.

B4.2.3 Inhalation Dose

The following equation is used to estimate inhalation dose at the Reference Resident location:

$$Dose_{inh} = AAC_{decayed} \times BR \times EDC_{inh} \times 10^6 \quad (9)$$

where:

$Dose_{inh}$ = radionuclide-specific effective dose (rem/yr) from inhalation of air containing the radionuclide

BR = breathing rate (m^3/yr)

EDC_{inh} = radionuclide-specific effective dose coefficient (rem/µCi) for inhalation (DOE 2011b)

10^6 = µCi/Ci.

The dose estimated for each radionuclide is summed to yield total inhalation dose from all radionuclides. The inhalation doses are estimated in the worksheet called "*Inhalation Dose*" in the MDIFFH workbook.

B4.2.4 Ingestion Dose

Doses from the ingestion of radionuclides other than tritium and carbon-14 (^{14}C) are calculated from radionuclide concentrations in food and annual consumption rates for an individual. The algorithms used in AIRDOS-EPA are based on models presented in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (1977) and are described below.

Concentrations in vegetation. Radioactive material concentrates in vegetation (produce, leafy vegetables, pasture grass or stored feed) as a result of deposition onto the plant foliage and from uptake of activity initially deposited on the ground. The following equation is used to estimate the concentration of each radionuclide in vegetation at the Reference Resident location:

$$C_{veg} = R_t \times \{deposition\ buildup\ factor + uptake\ buildup\ factor\} \times decay\ factor$$

$$= R_t \left\{ \frac{R[1-e^{(-\lambda_E t_e)}]}{(Y_V \lambda_E)} + \frac{B_{iv}[1-e^{(-\lambda_R t_b)}]}{(P \lambda_R)} \right\} e^{(-\lambda_R t_h)} \quad (10)$$

where:

C_{veg} = concentration of radionuclide in vegetation (pCi/kg)

R_t = rate of deposition of radionuclide onto ground at Reference Resident location (pCi/m^2-hr)
= dry deposition rate (R_d) + wet deposition rate (R_s), as calculated in Equations 29-30

R = fraction of deposited activity retained on edible portions of crops

λ_R = radioactive decay constant of radionuclide (hr^{-1})

λ_E = the effective removal rate constant for radionuclide from crops (hr-1), where $\lambda_E = \lambda_R + \lambda_W$, and λ_W is the removal rate constant for weathering, in m/hr)

t_e = the time period that crops are exposed to contamination during the growing season, in hr

Y_v = the agricultural productivity (yield), of the edible portion of vegetation in kg/m^2

B_{iv} = the concentration factor for uptake of radionuclide from soil by edible parts of crops, in pCi/kg per pCi/kg dry soil

t_b = the period of long-term buildup for activity in soil, in hr

P = the effective density of the top 15 cm of soil, in kg (dry soil)/m^2

t_h = a holdup time that represents the time interval between harvest and consumption of the vegetation, in hr.

Radionuclide-independent constants used in this algorithm (as well as in other MDIFFH calculations) may be found in Table B-10 (as documented in "*Nuclide-independent Parameters*" of the MDIFFH workbook). The radionuclide-dependent parameters λ_R and B_{iv} are documented in "*Radionuclide-specific constants*" in the MDIFFH workbook. The B_{iv} data are also presented, along with other agricultural transfer factors, in Table B-11. The values of the parameters R, t_e, t_h, Y_v, and B_{iv} differ for the types of vegetation addressed (i.e., vegetables eaten by humans, pasture grazed by animals, or stored feed consumed by animals).

Concentrations in vegetables (non-leafy produce and leafy vegetables). The concentrations of radionuclides in garden produce and leafy vegetables are estimated using equation (10) with R_2 = 0.2, t_{e2} = 1440 hr, $t_{h3} = t_{h4}$ = 336 hr, and Y_{V2} = 0.716 kg/m^2. The radionuclide-specific parameter B_{iv2} is used in equation (10) for vegetables. The concentration calculated for produce ($C_{produce}$) is thus equal to that for leafy vegetables (C_{leafy}). In addition, a washing factor DD1 (=0.5) is multiplied by the first term of Equation (10) to account for removal of surface-adhered radionuclides during processing of food to be consumed.

Table B-10. Radionuclide-independent Parameters Used in Dose Calculations.[a]

Variable	Value	Units	Description
V_d	6.48	m/hr	Dry deposition velocity for **particulates** (0.0018 m/s) and unit conversion (3600 sec/hr)
	126	m/hr	Dry deposition velocity for **molecular iodine** (0.035 m/s) and unit conversion (3600 sec/hr)
BR	8.033E+03	m^3/yr	Breathing rate
DD1	0.5		Fraction of radioactivity retained on leafy vegetables and produce after washing.
f_g	1		Fraction of produce grown in garden of interest
f_l	1		Fraction of leafy vegetables grown in garden of interest
f_p	0.40		Fraction of year animals graze on pasture
f_s	0.43		Fraction of daily feed that is pasture grass when animal grazes on pasture
λ_W	0.0029	hr^{-1}	Removal rate constant for physical loss by weathering
P	215	kg/m^2	Effective surface density of soil
Q_f	15.6	kg/da	Consumption rate of contaminated feed or forage by an animal (dry wt)
R_1	0.57		Fallout interception fraction (pasture)
R_2	0.2		Fallout interception fraction (vegetables)
t_{h1}	0	hr	Time delay-ingestion of pasture grass by animals
t_{h2}	2,160	hr	Time delay-ingestion of stored feed by animals
t_{h3}	336	hr	Time delay-ingestion of leafy vegetables by man
t_{h4}	336	hr	Time delay-ingestion of produce (hr)
t_b	876,000	hr	Buildup time in soil (hr) (100 yrs)
t_{e1}	720	hr	Period of exposure (grassy pasture)
t_{e2}	1,440	hr	Period of exposure (crops/leafy vegetables)
t_f	2	day	Transport time: animal feed-millk-man
t_s	20	day	Average time from slaughter of meat animal to consumption
U_F	85	kg/yr	Ingestion rate of meat by man
U_L	18	kg/yr	Ingestion of leafy vegetables by man
U_M	112	liter/yr	Ingestion rate of milk by man
U_V	176	kg/yr	Ingestion rate of produce by man
Y_m	11	liter/day	Milk production of cow
Y_{V1}	0.28	kg/m^2	Productivity: agriculture (grass-cow-milk-man pathway)
Y_{V2}	0.716	kg/m^2	Productivity: produce and vegetables (wet)

a. Rosnick, R., 2007, CAP88-PC Version 3.0 User Guide, Washington, DC: Office of Radiation and Indoor Air, U.S. Environmental Protection Agency. Available at: http://www.epa.gov/radiation/docs/cap88/userguide_120907.pdf

Table B-11. Agricultural Transfer Factors.

Element	B_{iv2}[a] (Vegetable/Soil) $\frac{pCi/kg(fresh\ weight)}{pCi/kg(dry\ weight)}$	B_{iv1}[a] (Forage/Soil) $\frac{pCi/kg(fresh\ weight)}{pCi/kg(dry\ weight)}$	F_f[b] (Meat) $\frac{pCi/kg}{pCi/da}$	F_m[c] (Milk) $\frac{pC/L}{pCi/da}$
Ag	1.50E-01	1.50E-01	3.00E-03	2.50E-02
Am	1.00E-03	1.00E-03	5.00E-05	2.00E-06
Am	1.00E-03	1.00E-03	5.00E-05	2.00E-06
Ar	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba	5.00E-03	5.00E-03	2.00E-04	5.00E-04
Bi	1.00E-01	1.00E-01	2.00E-03	5.00E-04
Br	7.60E-01	7.60E-01	2.00E-02	2.00E-02
C	5.50E+00	5.50E+00	1.20E-02	3.10E-02
Ce	2.00E-03	2.00E-03	2.00E-05	3.00E-05
Cm	1.00E-03	1.00E-03	2.00E-05	2.00E-06
Co	8.00E-02	8.00E-02	2.00E-02	2.00E-03
Cr	2.50E-04	2.50E-04	9.00E-03	2.00E-03
Cs	4.00E-02	4.00E-02	3.00E-02	8.00E-03
Eu	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Fe	1.00E-03	1.00E-03	2.00E-02	3.00E-04
Ga	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H[d]	4.80E+00	4.80E+00	1.00E-02	1.20E-02
Hf	3.00E-03	3.00E-03	4.00E-04	2.00E-05
Hg	3.80E-01	3.80E-01	1.00E-01	5.00E-04
I	2.00E-02	2.00E-02	7.00E-03	1.00E-02
Ir	3.00E-02	3.00E-02	2.00E-03	2.00E-06
K	3.00E-01	3.00E-01	2.00E-02	7.00E-03
Kr	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Mn	3.00E-01	3.00E-01	5.00E-04	3.00E-04
Mo	1.30E-01	1.30E-01	1.00E-03	1.70E-03
Na	5.00E-02	5.00E-02	8.00E-02	4.00E-02
Nb	1.00E-02	1.00E-02	3.00E-07	2.00E-06
Ni	5.00E-02	5.00E-02	5.00E-03	2.00E-02
Np	2.00E-02	2.00E-02	1.00E-03	5.00E-06
Pb	1.00E-02	1.00E-02	8.00E-04	3.00E-04
Pm	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Pr	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Pu	1.00E-03	1.00E-03	1.00E-04	1.00E-06
Ra	4.00E-02	4.00E-02	1.00E-03	1.00E-03
Rb	1.30E-01	1.30E-01	1.50E-02	1.00E-02
Rh	1.30E-01	1.30E-01	1.00E-03	5.00E-03
Ru	3.00E-02	3.00E-02	2.00E-03	3.30E-06
Sb	1.00E-02	1.00E-02	1.00E-03	1.00E-04
Sc	2.00E-03	2.00E-03	1.50E-02	5.00E-06
Sm	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Sr	3.00E-01	3.00E-01	8.00E-03	2.00E-03
Tc	5.00E+00	5.00E+00	1.00E-04	1.00E-03

Table B-11. Agricultural Transfer Factors. (cont.)

Element	B_{iv2}[a] (Vegetable/Soil) $\frac{pCi/kg(fresh\ weight)}{pCi/kg(dry\ weight)}$	B_{iv1}[a] (Forage/Soil) $\frac{pCi/kg(fresh\ weight)}{pCi/kg(dry\ weight)}$	F_f[b] (Meat) $\frac{pCi/kg}{pCi/da}$	F_m[c] (Milk) $\frac{pC/L}{pCi/da}$
Te	6.00E-01	6.00E-01	7.00E-03	5.00E-04
Th	1.00E-03	1.00E-03	7.00E-03	5.00E-04
Tl	2.00E-01	2.00E-01	7.00E-03	5.00E-04
U	2.50E-03	2.50E-03	7.00E-03	5.00E-04
W	1.80E-02	1.80E-02	4.00E-02	3.00E-04
Xe	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y	2.50E-03	2.50E-03	2.00E-03	2.00E-05
Zn	4.00E-01	4.00E-01	1.00E-01	1.00E-02
Zr	1.00E-03	1.00E-03	1.00E-06	6.00E-07

a. Radionuclide concentration in edible ground portion of plant at maturity per radionuclide concentration in soil. From Table 9 of: Wang, Y-Y, B M Biwer, and C Yu, 1993. *A Compilation of Radionuclide Transfer Factors for the Plant, Meat, Milk, and Aquatic Food Pathways and the Suggested Default Values for the RESRAD Code* ANL/EAS/TM-103, DOE, August 1993. Available at: http://web.ead.anl.gov/resrad/documents/Radionuclide_Transfer_factors.pdf
b. Radionuclide transfer factors for meat. From Table 11 of: Wang el al., 1993
c. Radionuclide transfer factors for milk. From Table 12 of: Wang et al, 1993
d. Although agricultural transfer factors for hydrogen and carbon are provided in this table, they are not used in the ingestion dose calculations because special equations are used for tritium and carbon-14 (see Sections 3.2.4.6 and 3.2.4.7).

Concentrations in milk. The concentration of each radionuclide in milk depends on the amount and contamination level of the feed consumed by the animal. The concentration of a radionuclide in the animal's feed is calculated by use of the equation:

$$C_{feed} = f_p f_s \quad C_{pasture} + (1 - f_p f_s) \quad C_{stored\ feed} \qquad (11)$$

where:

C_{feed} = concentration of radionuclide in the animal's feed in pCi/kg

$C_{pasture}$ = concentration of radionuclide on pasture grass (calculated using Equation [10] and B_{iv1}, with R_1 = 0.57, t_{e1} = 720 hr, t_{h1} = 0 hr, and Y_{V1} = 0.28 kg/m^2), in pCi/kg

$C_{stored\ feed}$ = concentration of radionuclide in stored feeds (calculated using Equation [10] and B_{iv1} with R_1 = 0.57, t_{e1} = 720 hr, t_{h2} = 2,160 hr, and Y_{V1} = 0.28 kg/m^2), in pCi/kg

f_p = the fraction of the year that animals graze on the pasture

f_s = the fraction of daily feed that is pasture grass when the animals graze on pasture.

Using the value of C_{feed}, calculated using Equation (11), the concentration of the radionuclide in milk is estimated as:

$$C_{milk} = F_m C_{feed} Q_F e^{(-\lambda_R t_f)} \quad (12)$$

where:

C_{milk} = the concentration in milk of a radionuclide, in pCi/L

F_m = the average fraction of the animal's daily intake of the radionuclide which appears in each liter of milk, days/L

Q_F = the amount of feed consumed by the animal per day, in kg/day

λ_R = radiological decay constant of radionuclide, in days^{-1}

t_f = the average transport time of the activity from the feed into the milk and to the receptor.

The values of the radionuclide-independent parameters used in Equations (11) and (12) may be found in Table B-10. The values of F_m may be found in Table B-11.

Concentrations in meat. The radionuclide concentration in meat depends upon the amount and contamination level of the feed consumed by the animal, as in the milk pathway. Using the value of C_{feed}, as calculated in Equation (11), the radionuclide concentration in meat is estimated as:

$$C_{flesh} = F_f C_{feed} Q_F e^{(-\lambda_R t_s)} \quad (13)$$

where:

C_{flesh} = the concentration in meat of a radionuclide, in pCi/kg

F_f = the fraction of the animal's daily intake of radionuclide which appears in each kilogram of flesh, in days/kg

Q_F = the amount feed consumed by the animal per day, in kg/day

λ_R = radiological decay constant of radionuclide, in days^{-1}

t_s = the average time (days) from slaughter to consumption.

The values of the radionuclide-independent parameters used in Equation (12) may be found in Table B-10. The values of F_f may be found in Table B-11. For concentration in beef, it is assumed that beef cattle are on open pasture for the same grazing periods as given for milk cattle.

Calculation of annual ingestion doses. The following equation is used to calculate the annual effective dose to the whole body from ingestion of each radionuclide other than tritium and ^{14}C in produce, milk, meat, and leafy vegetables:

$$Dose_{ing} = DC_{ing} \left(U_g f_g C_{produce} + U_l f_l C_{leafy} + U_m C_{milk} + U_f C_{flesh}\right) \times 10^{-6} \quad (14)$$

where:

$Dose_{ing}$ = the annual effective dose an individual from dietary intake of an atmospherically release radionuclide

DC_{ing} = dose coefficient for ingestion of a radionuclide in food (rem/µCi)

U_g, U_l, U_m, U_f = ingestion rates of produce (nonleafy vegetables, fruit, and grains), leafy vegetables (kg/yr), milk (l/yr), and meat (kg/yr), respectively, for individuals

f_g = the fraction of produce ingested grown in garden of interest

f_l = the fraction of leafy vegetables from in garden of interest

10^{-6} = µCi/pCi.

The non-radionuclide specific constants are presented in Table B-10. The values for ingestion dose coefficients are from FRG 13_DB, Version 2.1.13 (EPA 2002) and are documented in the "*Radionuclide-specific Constants*" worksheet in the MDIFFH workbook. The dose for each radionuclide is summed to yield the total dose due to ingestion of food.

The concentration of radionuclides in produce is equivalent to that in leafy vegetables. In addition, it is assumed that the Reference Resident obtains all produce and leafy vegetables from the garden of interest (i.e., $f_g = f_l = 1$). For this reason, the dose from ingestion of each radionuclide from foodstuffs grown in the garden can be reduced to the following equation

$$Dose_{veg} = DC_{ing}\,(U_g + U_l)\;C_{veg} \quad (15)$$

where:

$C_{veg} = C_{produce} = C_{leafy}$.

The ingestion doses are modeled in the worksheets labelled "*Veg Ingestion Dose,*" "*Milk Ingestion Dose,*" and "*Meat Ingestion Dose*" in the MDIFFH workbook.

Calculation of annual ingestion doses for tritium. Tritium and ^{14}C interact with environmental components in unique fashion because the stable form of these elements constitute significant fractions of the elemental composition of the human body and an individual's food and drink.

In AIRDOS-EPA (Moore et al. 1979), it is stated that tritium (T) released to air as HT or T2, atoms of T may exchange with hydrogen atoms in water molecules in air and the plume can be conservatively treated as though it contained HTO initially. The tritium may be assumed to follow water almost precisely through the environment. Rather than attempting to relate the doses to ground deposition rate, it is assumed that doses from ingestion of food and drinking water at an environmental location are proportional to tritium concentration in the air (1 percent of drinking water is tritiated in the CAP88-PC code.) Because southeast Idaho is a high desert environment with little precipitation (~20 cm/yr) and public drinking water is typically obtained from deep aquifer wells which are not impacted by INL Site releases (DOE 2013b), ingestion of drinking water is not included in the ingestion dose calculations in the MDIFFH workbook. Rather, the ingestion dose estimates focus on tritium in food.

The total ingestion dose from tritium, if the source of all of the Reference Resident's food is assumed to grow at the individual's environmental location, is equal to

$$D_T = C_{fT}\ \chi\ \times\ 10^6 \quad (16)$$

where:

D_T = dose from ingestion of tritium (rem/yr)

C_{fT} = air pathway dose conversion factor for tritium in food (rem/yr per pCi/cm^3)

χ = ground-level concentration of tritium in air at an environmental location (Ci/m^3)

$10^6 = 10^{12}$ pCi/Ci × 10^{-6} m^3/cm^3.

The total-body dose conversion factor (DCF) of 8.3E-05 rem/µCi for ingestion was used to derive C_{fT} for the AIRDOS-EPA code, based on the specific activity of tritium in atmospheric moisture with an average specific humidity of 8 grams of water per cubic meter of air (Moore et al. 1979). The C_{fT} value was estimated to be 6.18 rem/cm^3 per pCi/yr, assuming that tritium in food is in equilibrium with atmospheric tritium and that the individual consumes 1638 grams of water daily in food. A dose conversion factor of 8.3E-05 rem/µCi was used to estimate this value for AIRDOS-EPA (Moore et al. 1979). The ingestion dose factor of 7.09 E-05 rem/µCi is used for the MDIFFH workbook calculations [from the Federal Regulatory Guide (FRG) 13 Database, Version 2.1.13 (EPA 2002)]. The ratio of the FRG 13 dose factor to the AIRDOS-EPA dose conversion factor is 0.854 (7.09/8.3). The C_{fT} of 6.18 rem/cm^3 per pCi/yr was multiplied by this fraction to yield a value of 5.279 rem/cm^3 per pCi/yr for use in the MDIFFH dose calculations.

In the AIRDOS-EPA code (Moore et al. 1979) the tritium ingestion dose from food was further broken down into ingestion doses from vegetables (D_v), meat (D_b), milk (D_c). The total food ingestion dose from tritium is thus equal to the sum of D_v, D_b, and D_c. The AIRDOS-EPA allows for ingestion of food grown at the individual's environmental location and from a larger assessment area as well. It was assumed for the MDIFFH workbook equations that the Reference Resident is self-sufficient and 100 percent of the food is produced at the individual's environmental location where the maximum air concentration is projected. The equations used in the AIRDOS-EPA code (Moore et al. 1979) were thus modified accordingly for use in the MDIFFH workbook and are:

$$D_v = 0.505\ C_{fT}\ \chi \quad (17)$$

$$D_b = 0.185\ C_{fT}\ \chi \quad (18)$$

$$D_c = 0.310\ C_{fT}\ \chi \quad (19)$$

where:

0.505 = the fraction of C_{fT} for vegetable ingestion

0.185 = the fraction of C_{fT} for meat ingestion

0.310 = the fraction of C_{fT} for milk ingestion.

Calculation of annual ingestion doses for ^{14}C. If ^{14}C is released in the form CO_2, it will mix with atmospheric CO_2 and become available for plant photosynthesis. The radionuclide can then become incorporated into an individual's diet via the vegetable, meat, and milk pathways. Nearly all of the ^{14}C doses come from ingestion and is modeled with the following equation

$$D_C = C_{fC} \chi \times 10^6 \quad (20)$$

where:

D_C = dose from ingestion of ^{14}C (rem/yr)

C_{fC} = air pathway dose conversion factor for ^{14}C in food (rem/yr per pCi/cm^3)

χ = ground-level concentration of ^{14}C in air at an environmental location (Ci/m^3)

$10^6 = 10^{12}$ pCi/Ci × 10^{-6} m^3/cm^3

The total-body dose conversion factor of 1.9E-03 rem/µCi for ingestion was used to derive C_{fC} for the AIRDOS-EPA code, based on the specific activity calculations for ^{14}C in body tissues in equilibrium with atmospheric ^{14}C (Moore et al. 1979; Killough and Rohwer 1978). The C_{fC} value was estimated for the whole body to be 1.16E+03 rem/cm^3 per pCi/yr. A dose factor of 2.15E-03 rem/µCi is used for the MDIFFH calculations (from the Federal Regulatory Guide [FRG] 13 Database, Version 2.1.13 [Eckerman et al. 2002]). The ratio of the FRG 13 DCF to the AIRDOS-EPA DCF is 1.132 (2.15/1.9). The C_{fC} of 1.16E+03 rem/cm^3 per pCi/yr was multiplied by this fraction to yield a value of 1.31E+03 rem/cm^3 per pCi/yr for use in the MDIFFH dose calculations.

In the AIRDOS-EPA code (Moore et al. 1979) the dose from ingestion of ^{14}C in food was further broken down into ingestion doses from vegetables (D_v), meat (D_b), milk (D_c). The total food ingestion dose from ^{14}C is thus equal to the sum of D_v, D_b, and D_c. As discussed previously, AIRDOS-EPA allows for ingestion of food grown at the individual's environmental location and from a larger assessment area as well. It was conservatively assumed for the MDIFFH workbook equations that the Reference Resident produces all food at the individual's environmental location. The equations used in the AIRDOS-EPA code were thus simplified for use in the MDIFFH workbook and are

$$D_v = F_v C_{fC} \chi \quad (21)$$

$$D_b = F_b C_{fC} \chi \quad (22)$$

$$D_c = F_c C_{fC} \chi \quad (23)$$

where:

F_v = the weight fraction of ^{14}C from vegetables

F_b = the weight fraction of ^{14}C from meat

F_c = the weight fraction of ^{14}C from milk.

The weight of the total carbon intake per year is approximated in AIRDOS-EPA by the relations

$$W_v = 79.96\ V \quad (24)$$

$$W_b = 238.16\ T_b \quad (25)$$

$$W_c = 68.9\ T_c \quad (26)$$

$$W_t = W_v + W_b + W_c \quad (27)$$

where:

W_v = weight of annual carbon intake via vegetables

W_b = weight of annual carbon intake via meat

W_c = weight of annual carbon intake via milk

W_t = total carbon intake from vegetables, meat, and milk

V = daily vegetable consumption (kg) (note: = UL + UV from Table B-10, divided by 365 days/yr)

T_b = daily meat consumption (kg) (note: = UF from Table B-10, divided by 365 days/yr)

T_c = daily milk consumption (l) (note: = UL from Table B-10, divided by 365 days/yr).

Based on these equations and the data in Table B-10, the weight of total carbon intake is 69.03 kg and W_v = 42.5 kg, W_b = 5.39 kg and W_c = 21.14 kg. The weight fractions are therefore F_v = 0.62, F_b = 0.08, and F_c = 0.31.

B4.2.5 Calculation of Doses from Exposure to Radionuclides Deposited on Ground Surfaces

The dose due to gamma emissions from radionuclides deposited on ground surfaces is estimated by the following algorithm (adapted from Moore et al. 1979):

$$D_{ground} = C_s \times DC_{ground} = R_t \frac{1-e^{(-\lambda_T T)}}{\lambda_T} DC_{ground} \quad (28)$$

where:

D_{ground} = dose from exposure to radionuclides on ground surface (rem/yr)

C_s = surface concentration after 100 years of buildup (C/m^2)

R_t = surface deposition rate (Ci/m^2-yr)

λ_T = radioactive decay constant (λ_R) + weathering rate constant (λ_w), in days^{-1}

T = time allotted for surface buildup (100 yrs)

DC_{ground} = dose coefficient for surface exposure to an infinite plane at a point 1 m above ground (rem/yr per Ci/m^2).

According to Moore et al. (1979), there is very little available information on environmental removal rates from ground surfaces, so a value of zero is usually used for λ_w in AIRDOS-EPA calculations. However, the CAP88-PC code uses λ_w = 2.9 E-03 hr^{-1}. This value is also used in the MDIFFH workbook.

The expression $Rt = \frac{1-e^{(-\lambda_T T)}}{\lambda_T}$ represents the surface concentration after a buildup of 100 years. According to the CAP88-PC User Guide (EPA 2013), deposition consists of two components which are summed to yield total deposition rate: dry deposition rate and precipitation scavenging (i.e., wet deposition rate).

Dry deposition is modeled as:

$$R_d = V_d \chi \quad (29)$$

where:

R_d = surface deposition rate (Ci/m^2-hr)

V_d = deposition velocity (m/hr) (6.48 m/hr for particulates and 126 m/hr for molecular iodine)

χ = ground-level concentration of radionuclide in air (Ci/m^3).

The deposition rate from precipitation scavenging, which occurs when rain or snow removes particles from the plume, is modeled as:

$$R_s = \phi \chi_{ave} L \quad (30)$$

where:

R_s = surface deposition rate (Ci/m^2-hr)

Φ = scavenging coefficient (hr^{-1})

χ_{ave} = average concentration in plume up to lid height (pCi/cm^3)

L = lid height (tropospheric mixing layer (m).

The scavenging coefficient, Φ (in sec-1), is calculated in CAP88-PC by multiplying the rainfall rate (cm/yr) by 1E-7 yr/cm-sec. For the INL Site, which has an annual rainfall of 20 cm/yr, the scavenging coefficient is estimated to be 2.0E-06 s^{-1}.

The average concentration in plume up to lid height (χ_{ave}) is approximated in the CAP88-PC code for short distances (until the downwind distance x becomes equal to 2xL, where xL is the value of x for which the vertical dispersion coefficient (σ_z) is 0.47 times the height of the lid) by the expression (EPA 2013):

$$\chi_{ave} = Q / (0.397825\ L\ \mu) \quad (31)$$

where:

Q = release rate from source (Ci/yr)

L = lid height (m)

μ = wind velocity (m/s).

For long distances, such as those modeled at the INL Site, it is assumed the average concentration within a 22.5° sector is simply a uniform distribution in a rectangle of dimensions L and 2x tan (11.25°). However, the MDIFFH workbook does not model plume dispersion in the same fashion, as it uses the results of the NOAA MDIFFH dispersion calculations. For our purposes χ_{ave} is conservatively assumed to be $AAC_{decayed}$, as estimated in Equation (4).

For the MDIFFH dose calculations, the average annual wind velocity provided by NOAA for the year of concern is used for μ. A lid height of 800 m, used by the INL contractor in CAP88-PC calculations for NESHAP compliance, is assumed.

B4.3 Determination of the Average TIC in Each Census Division (Step 3)

This step involves the use of the Geographic Information System (GIS). The GIS population dose project contains all of the data layers needed to produce the calculations, and the last three years of calculations are included in the project for reference grouped by year. The only dataset that needs to be imported each year is the gridded Time Integrated Concentration (TIC) values provided by NOAA. The TIC grid data are provided in an Excel file with coordinates in Latitude/ Longitude (Decimal Degrees) format.

The imported NOAA TIC grids cover a larger area than required to produce the population dose calculations, and the point grid needs to be subset to the 50-mile assessment area (Figure B-6). The GIS is used to “clip” the 130 x 130 TIC grid to the 50-mile buffered area (Figure B-7).

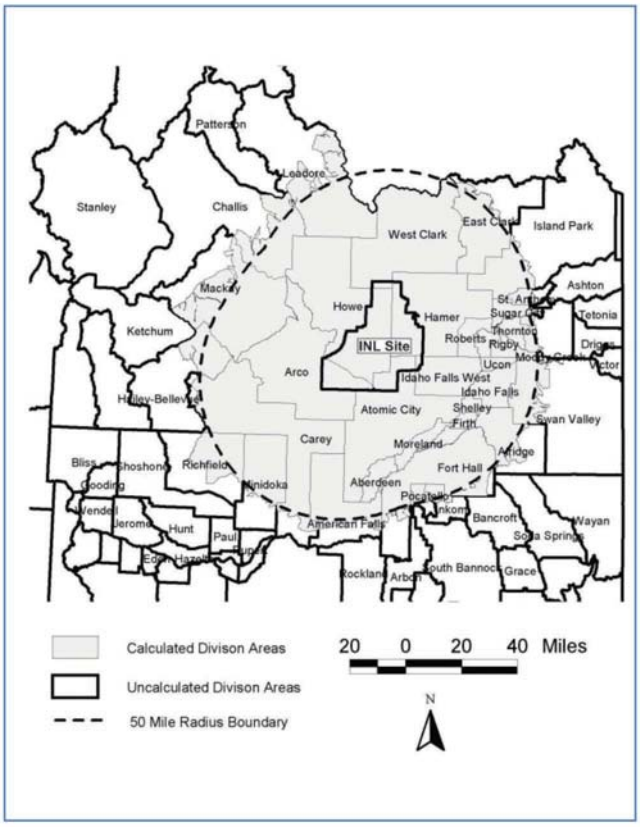


Figure B-6. Region within 50 miles of INL Site Facilities. Census Divisions Used in the 50-mile Population Dose Calculation are Shown.

The Census County Division boundaries include all of southeast Idaho, but we are only concerned with those that lie within the 50 mile distance of the INL Site boundary. The next step uses GIS to "clip" the 130 x 130 grid by each of the census division polygons to match the 50-mile buffered area (Figure B-8).

The next step is the actual calculation where all TIC points within each county division (within the 50-mile buffered area) are averaged and appended to the ‘Census Divisions Clip’ attribute table.

B4.4 Population Dose Calculation (Step 4)

Using the most recent geospatially distributed census data, the population in each census division is determined. Each census division population value is then multiplied by an average TIC for that division, determined in Step 3, divided by the TIC for the Reference Resident. The result is then multiplied by the dose to the Reference Resident (determined in Steps 1 and 2 above) to arrive at the population dose for each census division (as reported in Table 8-2 of the ASER.) The division doses are then summed for the total population dose:

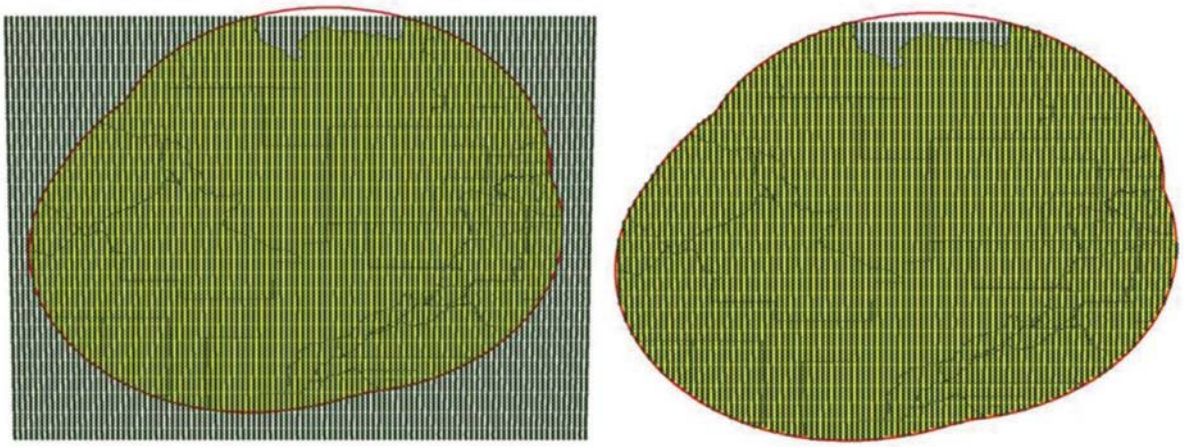


Figure B-7. NOAA TIC Point Grid "Clipped" to Become a Subset to the 50 Mile Population Dose Assessment Area.

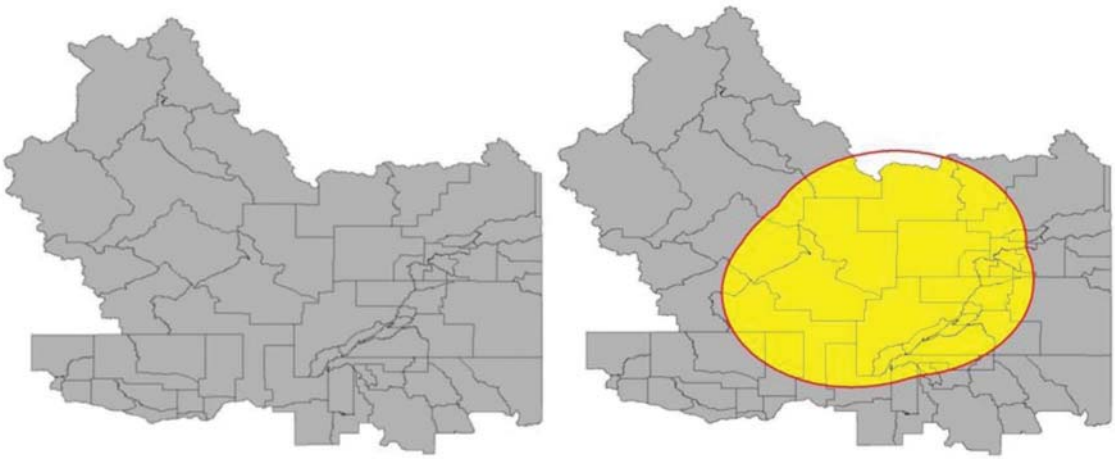


Figure B-8. Census Divisions "Clipped" to 50-mile Buffered Area.

$$Dose_{pop} = \sum(Pop_{census\ division}) \times \frac{\overline{TIC}_{census\ division}}{TIC_{reference\ resident}} \times Dose_{reference\ resident}) \quad (32)$$

where:

$Dose_{pop}$ = annual effective dose to the population within 50 miles of the INL Site (person-rem)

$Pop_{census\ division}$ = population within a census division (within the 50-mile buffered area)

TIC = average time integrated concentration for the census division (hr^2/m^3)

$TIC_{reference\ resident}$ = time integrated concentration at the location of the Reference Resident (hr^2/m^3)

$\overline{Dose}_{reference\ resident}$ = effective dose calculated for the Reference Resident (rem).

B5. Biota Dose

B5.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following absorbed doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The graded approach begins the evaluation using conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media termed “Biota Concentration Guides.” Each Biota Concentration Guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organism populations. Instead, it is an indication that more realistic model assumptions may be necessary.

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

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters which 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, which would involve a problem formulation, analysis, and risk characterization protocol similar to that recommended by EPA (1998). RESRAD-Biota cannot perform these calculations.

B5.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2013 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s. In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with facilities and include:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- Large Grid, a 24-mile radius around INTEC
- MFC
- NRF
- RWMC
- TAN.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in soil are used (Table 8-5 in the ASER) and input into the model (Figure B-9). Using the maximum radionuclide concentrations for all locations in the year of analysis, a screening level analysis is made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations are not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in Appendix C of the ASER used to represent surface water concentrations. The combined sum of fractions must be less than one for both terrestrial animals and plants in order to pass the general screening test. An example of a results table is shown in Table B-12. If the combined sum of fractions is greater than one, than a level 2 analysis must be performed.

B5.3 Aquatic Evaluation

For the aquatic evaluation, maximum effluent or pond radionuclide concentrations are typically used. The maximum concentration for each radionuclide reported in any pond or effluent in Appendix C of the ASER is used. When “uranium-233/234” is reported, it is conservatively assumed that each radionuclide was present in equal concentrations. As in the case of the terrestrial biota analysis, the combined sum of fractions must be less than one for both aquatic animals and riparian animals in order to pass the general screening test. If the sum exceeds one, then a Level 2 analysis must be performed.

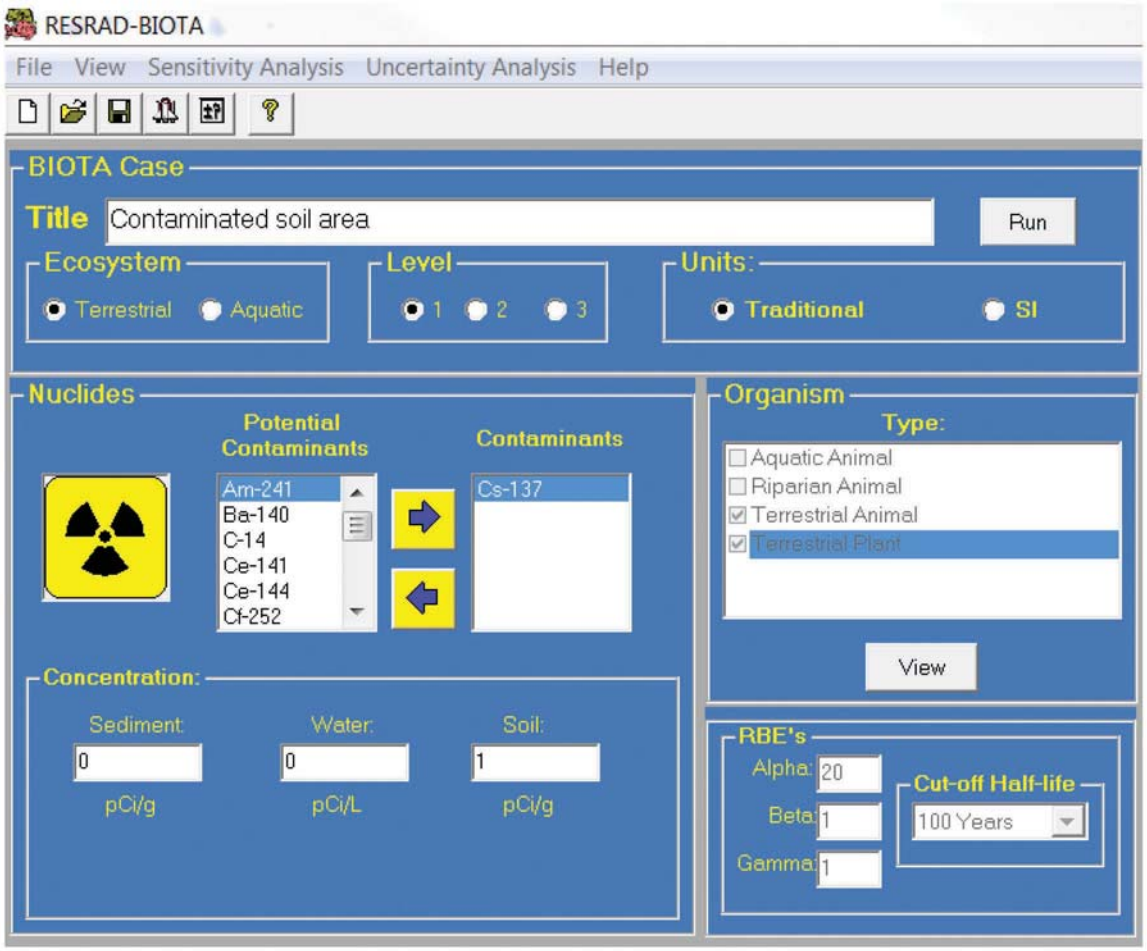


Figure B-9. Input Screen for Level 1 Resrad-Biota Calculations.

Tissue data from waterfowl collected on INL Site ponds are also available. 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 using INL Site ponds are not harmful, a Level 3 analysis is performed using the maximum tissue concentrations reported. The waterfowl are assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. Concentrations of radionuclides detected in the pond are input as water concentrations. It is also assumed that the water is in equilibrium with the sediment. This is done by clicking the box next to water and leaving the box next to sediment unchecked. External dose is calculated using the maximum radionuclide concentrations measured in soils around the pond of concern. The main input screen is shown in Figure B-10. A “duck” was created by first selecting “New” organism and then constructing the animal with a geometry of “5” and a weight of 1.1 kg (mass of a mallard, according to Sibley [2000]). The input source selection screen (Figure B-11) allows the user to select whether the input source is a measurement in tissue or an internal model calculation

Table B-12. Example of RESRAD-BIOTA Results for Terrestrial Animal and Plant.

Terrestrial Animal								
	Water				Soil			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
^{241}Am	0	2.02E+05	0.00E+00	Yes	0.463	3.89E+03	1.19E-04	Yes
^{60}Co	0	1.19E+06	0.00E+00	Yes	0.2	6.92E+02	2.89E-04	Yes
^{134}Cs	0	3.26E+05	0.00E+00	Yes	0.08	1.13E+01	7.08E-03	Yes
^{137}Cs	0	5.99E+05	0.00E+00	Yes	2.72	2.08E+01	1.31E-01	Yes
^{152}Eu	0	2.55E+06	0.00E+00	Yes	0.78	1.52E+03	5.12E-04	Yes
^{3}H	0	2.31E+08	0.00E+00	Yes	0	1.74E+05	0.00E+00	Yes
^{129}I	0	5.70E+06	0.00E+00	Yes	0	5.67E+03	0.00E+00	Yes
^{238}Pu	0	1.89E+05	0.00E+00	Yes	0.043	5.27E+03	8.16E-06	Yes
^{239}Pu	0	2.00E+05	0.00E+00	Yes	0.525	6.11E+03	8.59E-05	Yes
^{90}Sr	0	5.45E+04	0.00E+00	Yes	0.71	2.25E+01	3.16E-02	Yes
^{233}U	1.21	4.01E+05	3.02E-06	Yes	0	4.83E+03	0.00E+00	Yes
^{234}U	1.21	4.04E+05	2.99E-06	Yes	0	5.13E+03	0.00E+00	Yes
^{238}U	0.562	4.06E+05	1.38E-06	Yes	5.56	1.58E+03	3.52E-03	Yes
Summed	-	-	**7.40E-06**	-	-	-	**1.74E-01**	-

Terrestrial Plant								
	Water				Soil			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
^{241}Am	0	7.04E+08	0.00E+00	No	0.463	2.15E+04	2.15E-05	No
^{60}Co	0	1.49E+07	0.00E+00	No	0.2	6.13E+03	3.26E-05	No
^{134}Cs	0	2.28E+07	0.00E+00	No	0.08	1.09E+03	7.36E-05	No
^{137}Cs	0	4.93E+07	0.00E+00	No	2.72	2.21E+03	1.23E-03	No
^{152}Eu	0	3.06E+07	0.00E+00	No	0.78	1.47E+04	5.30E-05	No
^{3}H	0	7.04E+09	0.00E+00	No	0	1.68E+06	0.00E+00	No
^{129}I	0	4.93E+08	0.00E+00	No	0	1.69E+05	0.00E+00	No
^{238}Pu	0	3.95E+09	0.00E+00	No	0.043	1.75E+04	2.46E-06	No
^{239}Pu	0	7.04E+09	0.00E+00	No	0.525	1.27E+04	4.14E-05	No
^{90}Sr	0	3.52E+07	0.00E+00	No	0.71	3.58E+03	1.98E-04	No
^{233}U	1.21	1.06E+10	1.14E-10	No	0	5.23E+04	0.00E+00	No
^{234}U	1.21	3.08E+09	3.93E-10	No	0	5.16E+04	0.00E+00	No
^{238}U	0.562	4.28E+07	1.31E-08	No	5.56	1.57E+04	3.54E-04	No
Summed	-	-	**1.36E-08**	-	-	-	**2.01E-03**	-

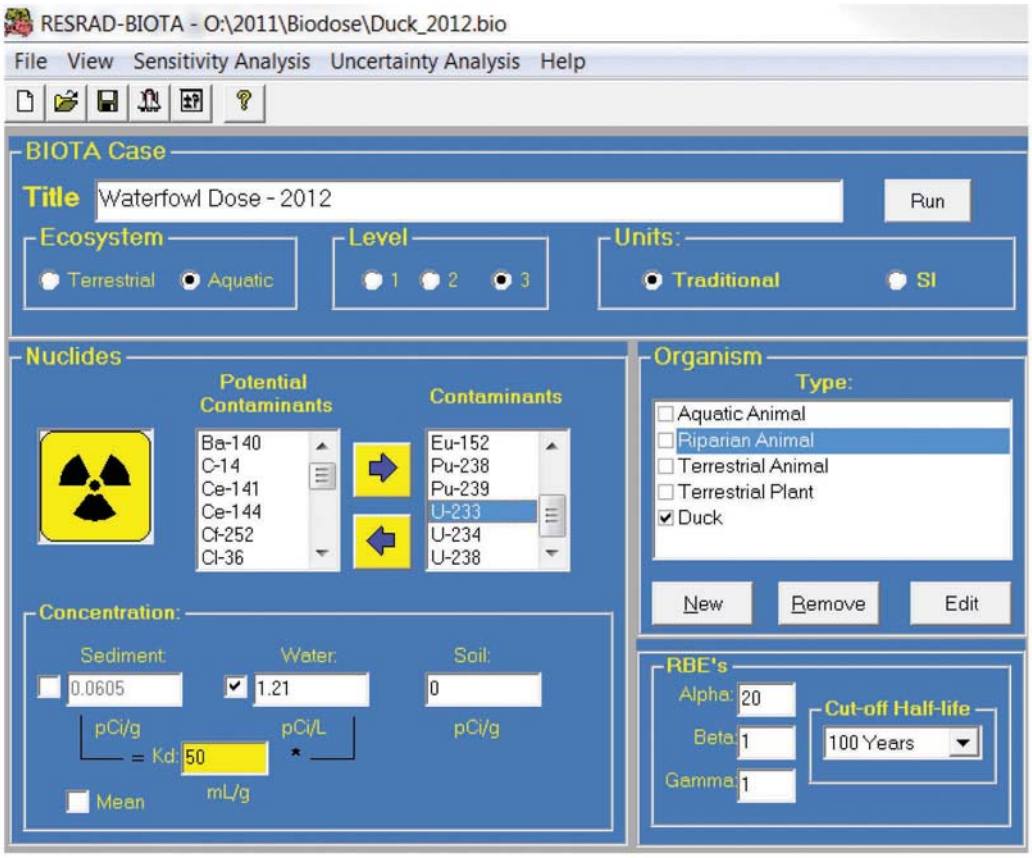


Figure B-10. Main Input Screen for Level 3 RESRAD-BIOTA Calculations.

using a bioaccumulation factor (B_{iv}). The maximum concentrations measured in waterfowl for the year of interest are then entered in the tissue concentration screen (Figure B-12). Results of the dose evaluation to waterfowl are compared to the standard of 1 rad/d (10 mGy/d). An example of the output screens for a Level 3 analysis is shown in Figure B-13.

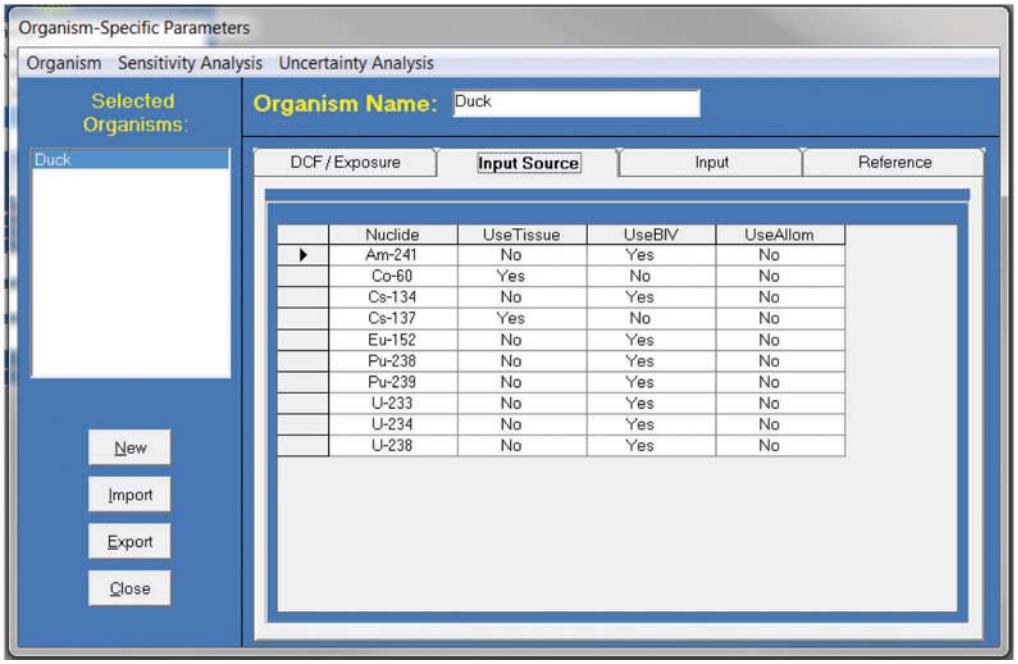


Figure B-11. Input Source Selection Screen for Level 3 RESRAD-BIOTA Calculations.

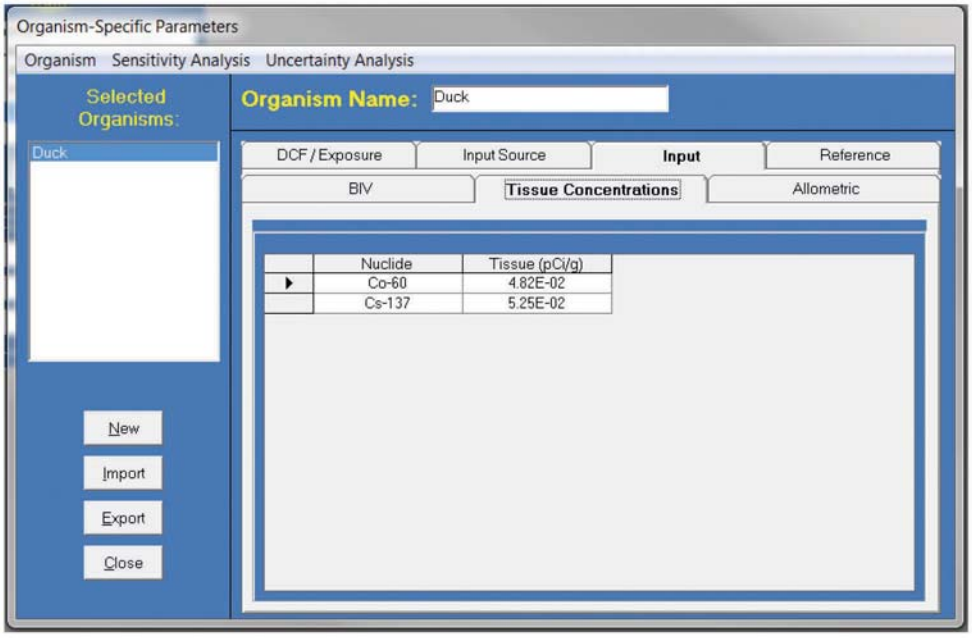


Figure B-12. Input Tissue Concentration Screen for Level 3 RESRAD-BIOTA Calculations.

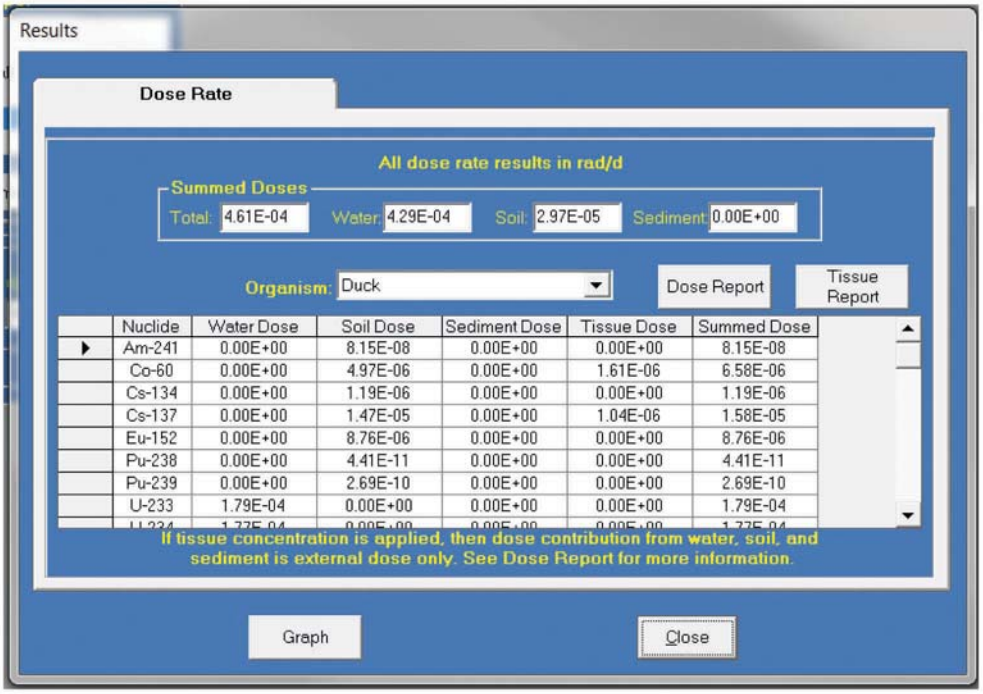


Figure B-13. Example of an Output Screen for a RESRAD-BIOTA Level 3 Analysis of Waterfowl

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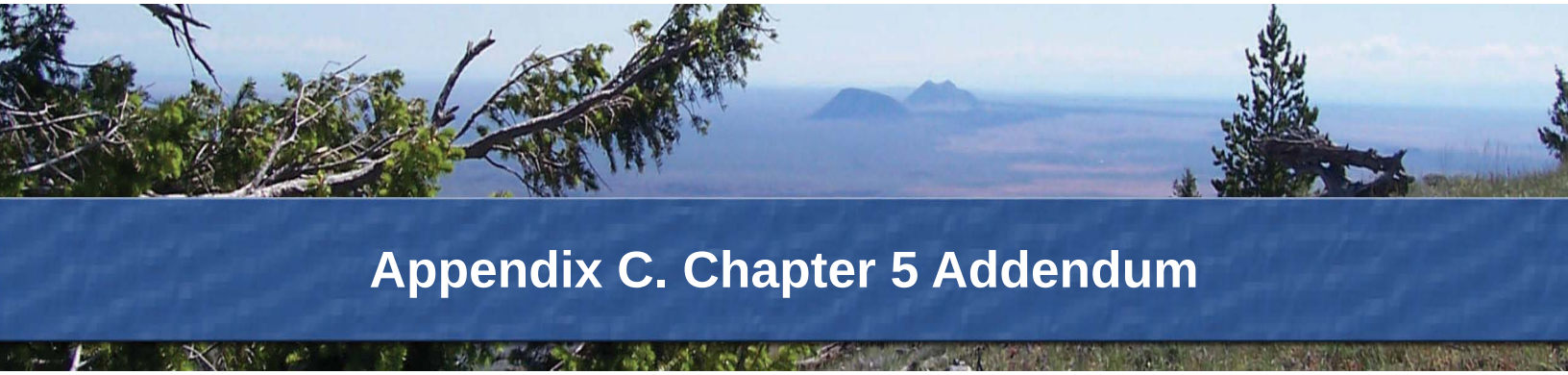

Appendix C. Chapter 5 Addendum

Table C-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Monitoring Results (2013).[a]

Parameter	Minimum	Maximum	Median
Aluminum (mg/L)	0.025 U[b]	0.025 U	0.025 U
Antimony (mg/L)	0.00025 U	0.0014	0.00063
Arsenic (mg/L)	0.005 U	0.0067	0.005 U
Barium (mg/L)	0.0432	0.147	0.0918
Beryllium (mg/L)	0.0008 U	0.0008 U	0.0008 U
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	10.3	39.1	21.85
Chromium (mg/L)	0.0029	0.0116	0.00635
Cobalt (mg/L)	0.0025 U	0.0025 U	0.0025 U
Copper (mg/L)	0.001 U	0.007	0.0036
Fluoride (mg/L)	0.179	0.498	0.302
Iron (mg/L)	0.025 U	0.175	0.06515
Lead (mg/L)	0.00025 U	0.00025 U	0.00025 U
Manganese (mg/L)	0.0025 U	0.0044	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nickel (mg/L)	0.0025 U	0.0025 U	0.0025 U
Nitrate + Nitrite as Nitrogen (mg/L)	0.796	3.06	1.6205
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.1 U	0.519	0.2065
Selenium (mg/L)	0.0012	0.0044	0.00255
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sodium (mg/L)	9.06	30	17.45
Solids, Total Dissolved (mg/L)	246	1060	589.5
Solids, Total Suspended (mg/L)	4 U	4 U	4 U
Sulfate (mg/L)	24	509	228.3
Thallium (mg/L	0.00025 U	0.00025 U	0.00025 U
Zinc (mg/L)	0.0025 U	0.0038	0.0025 U

a. Duplicate samples were collected in February and the results for the duplicate samples are included in the summary.

b. U flag indicates the result was below the detection limit.

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2013).

Well Name	USGS-065 (GW-016102)		TRA-07 (GW-016103)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
Sample Date	04/17/13	10/08/13	04/18/13	10/08/13	04/17/13	10/07/13	04/18/13	10/07/13	04/17/13	10/07/13	
Water Table Depth (ft below ground surface)	474.14	475.78	483.05	484.31	482.52	483.82	488.46	489.71	492.26	493.61	NA[b]
Water Table Elevation (above mean sea level in ft)[c]	4454.38	4452.74	4452.09	4450.83	4450.69	4449.39	4450.61	4449.35	4450.61	4449.26	NA
Borehole correction Factor (ft)[d]	NA	NA	0.06	0.06	NA	NA	0.63	0.63	NA	NA	NA
pH	7.81	7.18 7.94[e]	7.79	7.4 7.91[e]	7.86	7.93	7.82	7.73	7.86	7.86	6.5 to 8.5 (SCS)
Total Kjeldahl nitrogen (mg/L)	0.1U[f]	0.1 U [0.05 U][g]	0.142	0.1 U	0.127	0.1 U	0.145	0.1 U	0.144	0.1 U	NA
Nitrite nitrogen (mg/L)	0.05 U	0.05 U [0.05 U]	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	1 (PCS)
Nitrate nitrogen (mg/L)	1.43	1.41 [1.4]	1.04	0.985	1.02	0.983	0.982	0.942	0.937	0.929	10 (PCS)
Total nitrogen[h] (mg/L)	<1.58	<1.56 <1.56	<1.232	<1.135	<1.197	<1.133	<1.177	<1.092	<1.131	<1.079	NA
Total dissolved solids (mg/L)	431	451 [440]	413	445	256	273	266	279	262	257	500 (SCS)
Aluminum (mg/L)	0.095 (0.0049)[i]	0.004 [0.0095] [0.0076] [0.007]	**0.993**[j] (0.016)	**3.320** (0.0069)	0.021 (0.0045)	0.010 (0.0066)	**1.190** (0.0152)	**2.000** (0.0285)	0.189 (0.0032)	0.0787 (0.0018)	0.200 (SCS)

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2013). (cont.)

Well Name	USGS-065 (GW-016102)		TRA-07 (GW-016103)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
Sample Date	04/17/13	10/08/13	04/18/13	10/08/13	04/17/13	10/07/13	04/18/13	10/07/13	04/17/13	10/07/13	
Antimony (mg/L)	0.0004 U	0.0004 U [0.0004 U]	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.006 (PCS)
Arsenic (mg/L)	0.0013	0.0015 [0.0015]	0.0015	0.002	0.0019	0.0018	0.0019	0.0021	0.0019	0.002	0.05 (PCS)
Barium (mg/L)	0.0455	0.443 [0.044]	0.0728	0.111	0.0773	0.0713	0.0663	0.0969	0.066	0.0621	2 (PCS)
Cadmium (mg/L)	0.00025 U	0.00025 U [0.00025 U]	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.005 (PSC)
Chloride (mg/L)	19	20.2 [20.2]	21.6	22.1	14	13.8	12.8	12.3	12.1	11.7	250 (SCS)
Cobalt (mg/L)	0.0025 U	0.0025 U [0.0025 U]	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	NA
Copper (mg/L)	0.0025 U	0.0025 U [0.0025 U]	0.0072	0.0194	0.0954	0.0025 U	0.0781	0.0062	0.0025 U	0.0025 U	1.3 (PCS)
Fluoride (mg/L)	0.236	0.221 [0.225]	0.222	0.225	0.186	0.185	0.211	0.203	0.191	0.181	4 (PCS)
Iron (mg/L)	0.215 (0.0982)	0.050 U [0.05 U] (0.05 U) [(0.05)]	0.744 (0.0754)	3.490 (0.050 U)	1.530 (0.0852)	0.050 U (0.050 U)	0.775 (0.0759)	0.878 (0.050 U)	0.147 (0.0668)	0.050 U (0.050 U)	0.3 (SCS)
Manganese (mg/L)	0.0025 U (0.0025 U)	0.0025 U [0.0025 U] (0.0025 U) [(0.0025)]	0.0106 (0.0025 U)	0.0595 (0.0025 U)	0.0122 (0.0025 U)	0.0025 U (0.0025 U)	0.0117 (0.0025 U)	0.0199 (0.0025 U)	0.0049 (0.0025 U)	0.0031 (0.0025 U)	0.05 (SCS)

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2013). (cont.)

Well Name	USGS-065 (GW-016102)		TRA-07 (GW-016103)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
Sample Date	04/17/13	10/08/13	04/18/13	10/08/13	04/17/13	10/07/13	04/18/13	10/07/13	04/17/13	10/07/13	
Mercury (mg/L)	0.0002 U	0.0002 U [0.002 U]	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U (PCS)
Selenium (mg/L)	0.0022 U	0.0024 [0.0022]	0.0018	0.0022	0.0014	0.0015	0.0017	0.0017	0.0012	0.0013	0.05 (PCS)
Silver (mg/L)	0.005 U	0.005 [0.005 U]	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.1 (SCS)
Sulfate (mg/L)	164	160 [161]	155	154	33.3	33.9	50.4	48.7	34.7	35.9	250 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

b. NA - Not applicable.

c. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

d. The United States Geological Survey performed gyroscopic surveys on wells TRA-07 and TRA-08 circa 2002 to 2005. The surveys revealed these two wells were not perfectly straight or vertical which can cause the water level measurements to be greater than the true distance from the measuring point on the well to the water table. The water level measurements for these two wells have been adjusted using the borehole correction factors that were determined from the gyroscopic surveys.

e. This pH results was taken by a different contractor using a different pH meter on October 8, 2013. This data is being presented due to a concern that the pH meter being used by MS personnel was providing low readings at the time of sampling.

f. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

g. Results shown in brackets are the results from field duplicate samples.

h. Total nitrogen is calculated as the sum of the TKN, nitrite nitrogen, and nitrate nitrogen. For results reported below the instrument detection limit, the detection limit for that parameter is used in the calculation. The resulting total nitrogen is then reported as a less than (<) number.

i. Filtered sample results for aluminum, iron, and manganese, shown in parentheses, are used for permit compliance determinations.

j. Concentrations shown in bold are above the Ground Water Quality Rule SCS.

Table C-3. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2013).[a]

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	73.2	1755	290
Nitrate + nitrite, as nitrogen (mg/L)	0.015 U[a]	1.21	0.19
Total Kjeldahl nitrogen (mg/L)	27.5	349	84
Total phosphorus (mg/L)	2.78	98.3	13
Total suspended solids (mg/L)	42.6	294	105

a. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

Table C-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2013).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	3.54	37.5	18.4
Nitrate + nitrite, as nitrogen (mg/L)	1.00	6.64	3.16
pH (standard units) (grab)	7.44	8.80	8.17
Total coliform (colonies/100 mL)	75	7300	1204
Total Kjeldahl nitrogen (mg/L)	6.72	24.3	14.2
Total phosphorus (mg/L)	2.02	4.27	3.40
Total suspended solids (mg/L)	3.1	67	26

Table C-5. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2013).[a]

Parameter	Minimum	Maximum	Mean
Aluminum (mg/L)	0.025 U[a]	0.068 U	0.036 U
Arsenic (mg/L)	0.0025 U	0.005 U	0.0033 U
Biochemical oxygen demand (5-day) (mg/L)	0.819 U	3.74	2.26
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	13.9	70	24.06
Chromium	0.0044	0.0066	0.0056
Conductivity (µS/cm) (composite)	385	596	413
Copper (mg/L)	0.0023	0.0120	0.0052
Fluoride (mg/L)	0.197	0.302	0.248
Iron (mg/L)	0.025 U	0.150	0.067
Manganese (mg/L)	0.002 U	0.0034	0.0025 U
Mercury (mg/L)	0.00007 U	0.00020 U	0.00017 U
Nitrate + nitrite, as nitrogen (mg/L)	0.84	2.06	1.29
pH (grab)	7.48	8.17	7.81
Selenium (mg/L)	0.0013	0.0019	0.0015
Silver (mg/L)	0.001 U	0.005 U	0.004 U
Sodium (mg/L)	10.7	31.8	16.22
Total coliform (colonies/100 mL)	1	120	23
Total dissolved solids (mg/L)	216	316	250
Total Kjeldahl nitrogen (mg/L)	0.29	1.22	0.70
Total phosphorus (mg/L)	0.212	0.998	0.712
Total suspended solids (mg/L)	0.1	6.1	3.4

a. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2013).

	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		PCS/SCS[a]
Sample Date	4/2/2013	9/17/2013	4/2/2013	9/17/2013	4/3/2013	9/17/2013	
Depth to water (ft below brass cap)	502.78	504.08	509.94	510.68	501.89	503.05	NA[b]
Water table elevation (at brass cap in ft)[c]	4,450.13	4,448.83	4,449.60	4,448.86	4,450.28	4,449.12	NA
Aluminum (mg/L)[d]	0.025 U[e]	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.2
Arsenic (mg/L)	0.0016	0.0017	0.002	0.002	0.0016	0.0017	0.05
Biochemical oxygen demand (mg/L)	2.0 U	2.0 U	2.0 U	2.0 U	1.38	2.91	NA
Cadmium (mg/L)	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.005
Chloride (mg/L)	43	42.3	9.04	9.27	9.29	10.4	250
Chromium (mg/L)	0.0126	0.0215	0.005	0.006	0.008	0.0105	0.1
Coliform, fecal (colonies/100 mL)	0 UJ[f]	0	0 UJ	0	0 UJ	0	NA
Coliform, total (colonies/100 mL)	0	0	0 UJ	0	0 UJ	0	1 col/100 mL
Copper (mg/L)	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	1.3
Fluoride (mg/L)	0.227	0.223	0.29	0.285	0.217	0.206	4
Iron (mg/L)[d]	0.059	0.05 U	0.11	0.05 U	0.0677	0.05 U	0.3
Manganese (mg/L)[d]	0.0025 U	0.0025 U	0.02	0.0142	0.0025 U	0.0025 U	0.05
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Nitrate, as nitrogen (mg/L)	1.01	1.0	0.24	0.292	0.709	0.674	10
Nitrite, as nitrogen (mg/L)	0.0973	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	1
pH	7.78	8.1	7.59	8.17	7.75	8.21	6.5–8.5
Selenium (mg/L)	0.0013	0.0012	0.00086	0.0008	0.0011	0.0013	0.05
Silver (mg/L)[d]	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.1
Sodium (mg/L)	15.3	16	8.78	9.14	8.22	9.65	NA

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2013). (cont.)

	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		PCS/SCS[a]
Sample Date	4/2/2013	9/17/2013	4/2/2013	9/17/2013	4/3/2013	9/17/2013	
Total dissolved solids (mg/L)	334	335	211	196	260	252	500
Total Kjeldahl nitrogen (mg/L)	0.13	0.151	0.137	0.1 U	0.119	0.118	NA
Total phosphorus (mg/L)	0.0188	0.022	0.0273	0.0242	0.0275	0.029	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.

b. NA—Not applicable.

c. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

d. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.

e. U flag indicates the result was reported as below the detection/reporting limit.

f. UJ flag indicates the result was non-detect. The 30-hour collection to analysis holding time was exceeded but was less than 2 times the required holding time.

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2013).

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		PCS/SCS[a]
Sample Date	**4/3/2013**	**9/19/2013**	**4/3/2013[b]**	**9/19/2013**	**4/3/2013**	**9/19/2013[b]**	
Depth to Water (ft below brass cap)	Dry[c]	Dry[c]	113.06	114.55	236.15	236.46	NA[d]
Water elevation at brass cap (ft)[e]			4,839.91	4,838.42	4,722.19	4,721.88	NA
Aluminum (mg/L)[f]			0.025 U[g] (0.025 U)	0.025 U	0.025 U	0.025 U (0.025 U)	0.2
Arsenic (mg/L)			0.0069 (0.0071)	0.0079	0.0022	0.0025 (0.0025)	0.05
Biochemical oxygen demand (mg/L)			2.0 U (2.0 U)	2.0 U	2.0 U	2.0 U (2.0 U)	NA
Cadmium (mg/L)			0.0025 U (0.0025 U)	0.0025 U	0.0025 U	0.0025 U (0.0025 U)	0.005
Chloride (mg/L)			51.8 (51.5)	27.2	49.6	48.0 (48.2)	250
Chromium (mg/L)			0.0034 (0.0032)	0.006	0.0042	0.0067 (0.0073)	0.1
Coliform, fecal (colonies/100 mL)			0 UJ[h] (0 UJ)	0	0 UJ	0 (0)	NA
Coliform, total (colonies/100 mL)			0 UJ (0 UJ)	0	0 UJ	0 (0)	1 col/100 mL
Copper (mg/L)			0.005 U (0.005 U)	0.005 U	0.005 U	0.005 U (0.005 U)	1.3
Fluoride (mg/L)			0.233 (0.236)	0.236	0.302	0.287 (0.292)	4
Iron (mg/L)[f]			0.0507 (0.053)	0.05 U	0.05 U	0.05 U (0.05 U)	0.3
Manganese (mg/L)[f]			0.0025 U (0.0025 U)	0.0025 U	0.0025 U	0.0025 U (0.0025 U)	0.05
Mercury (mg/L)			0.0002 U (0.0002 U)	0.0002 U	0.0002 U	0.0002 U (0.0002 U)	0.002

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2013). (cont.)

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		PCS/SCS[a]
Sample Date	**4/3/2013**	**9/19/2013**	**4/3/2013[b]**	**9/19/2013**	**4/3/2013**	**9/19/2013[b]**	
Nitrate, as nitrogen(mg/L)			1.95 (1.95)	1.91	1.92	1.66 (1.63)	10
Nitrite, as nitrogen (mg/L)			0.0941 (0.117)	0.05 U	0.106	0.05 U (0.05 U)	1
pH			7.43 (7.43)	7.62	7.60	7.73 (7.73)	6.5–8.5
Selenium (mg/L)			0.0013 (0.0013)	0.0012	0.0014	0.0013 (0.0013)	0.05
Silver (mg/L)[f]			0.005 U (0.005 U)	0.005 U	0.005 U	0.005 U (0.005 U)	0.1
Sodium (mg/L)			26.3 (24.2)	27.2	45.8	47.3 (47.5)	NA
Total dissolved solids (mg/L)			336 (340)	276	329	320 (316)	500
Total Kjeldahl nitrogen (mg/L)			0.165 (0.172)	0.182	0.193	0.27 (0.226)	NA
Total phosphorus (mg/L)			0.129 (0.136)	0.148	0.0314	0.101 (0.0982)	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. Results in parentheses are duplicate sample results.
c. ICPP-MON-V-191was dry in April and September 2013.
d. NA—Not applicable.
e. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
f. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.
g. U flag indicates the result was reported as below the detection/reporting limit.
h. UJ flag indicates the result was non-detect. The 30-hour collection-to-analysis holding time was exceeded but was less than 2 times the required holding time.

Table C-8. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2013).[a]

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0025 U[b]	0.005	0.005 U
Barium (mg/L)	0.0292	0.0417	0.0345
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	18.4	53.1	24.4
Chromium (mg/L)	0.0025 U	0.0084	0.0025 U
Fluoride (mg/L)	0.529	0.673	0.5935
Iron (mg/L)	0.025 U	1.71	0.09575
Lead (mg/L)	0.00025 U	0.0809	0.00068
Manganese (mg/L)	0.0025 U	0.0227	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.002 U
Nitrate + Nitrite as Nitrogen (mg-N/L)	1.77	2.36	2.085
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.1 U	1.54	0.264
pH (standard units)	7.27	8.48	8.24
Phosphorus, Total (mg/L)	0.0000963	0.000526	0.0001305
Selenium (mg/L)	0.00054	0.0066	0.00085
Silver (mg/L)	0.005 U	0.0064	0.005 U
Sodium (mg/L)	17.4	39.1	22.9
Sulfate (mg/L)	16	21.8	17.6
Solids, Total Dissolved (mg/L)	202	323	268
Solids, Total Suspended (mg/L)	4 U	13.4	4 U
Zinc (mg/L)	0.0073	0.0511	0.01045

a. Duplicate samples were collected in February and the results for the duplicate samples are included in the data summary.

b. U flag indicates the result was below the detection limit.

Table C-9. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2013).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0033	0.0055	0.0052
Barium (mg/L)	0.0741	0.0844	0.07795
Cadmium (mg/L)	0.001 U[a]	0.001 U	0.001 U
Chloride (mg/L)	41.8	61	47.55
Chromium (mg/L)	0.0033	0.004	0.0039
Fluoride (mg/L)	1.29	1.65	1.46
Iron (mg/L)	0.025 U	0.133	0.0635
Lead (mg/L)	0.00025 U	0.00049	0.000265
Manganese (mg/L)	0.0025 U	0.0025 U	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrate + Nitrite as Nitrogen (mg/L)	4.31	6.29	4.915
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.277	0.722	0.4455
pH (standard units)	7.2	8.49	7.65
Phosphorus, total	0.275	1.15	0.7135
Selenium (mg/L)	0.0011	0.0015	0.0013
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sodium (mg/L)	42	55.4	46.6
Sulfate (mg/L)	34.9	49.5	40.95
Solids, Total Dissolved (mg/L)	482	636	556.5
Solids, Total Suspended (mg/L)	4 U	4 U	4 U
Zinc (mg/L)	0.0069	0.0132	0.117

a. U flag indicates the result was below the detection limit.

Table C-10. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond.

Well Name	ANL-MON-A-012 (GW-016001)		ANL-MON-A-013 (GW-016002)		ANL-MON-A-014 (GW-016003)		PCS/SCS[a]
Sample Date:	04/24/2013	09/17/2013	04/24/2013	09/17/2013	04/24/2013	09/17/2013	
Water Table Depth (ft bgs)	656.99	659.99	645.52	648.36	644.52	647.29	NA[b]
Water Table Elevation (ft above mean sea level)[c]	4475.71	4472.87	4474.85	4472.01	4473.56	4470.79	NA
pH	8.08	8.26	8.03	7.88	8.01	7.83	6.5 to 8.5 (SCS)
Temperature (°C)	12.7	13.2	12.5	13.6	13.2	13.7	None
Conductivity (µS/cm)	376	368	387	364	381	368	None
Nitrate nitrogen (mg/L)	1.98	1.96	2.02 [2.04][d]	2.04	2.07	2	10 (PCS)
Phosphorus (mg/L)	0.0114	0.0167	0.0116 [0.0153]	0.025	0.0126	0.0173	None
Total dissolved solids (mg/L)	244	236	254 [254]	249	251	242	500 (SCS)
Sulfate (mg/L)	16.6	16.9	19.1 [19.0]	17.7	18.7	17.4	250 (SCS)
Arsenic (µg/L)	2.4	2.6	2.4 [2.3]	2.4	2.3	2.5	50 (PCS)
Barium (µg/L)	37	38.8	43.4 [35.3]	36.1	35.4	36.3	2,000 (PCS)
Cadmium (µg/L)	0.25 U[e]	0.25 U	0.25 U [25 U]	0.25 U	0.25 U	0.25 U	5 (PCS)
Chloride (mg/L)	17.9	16.9	19.2 [19.5]	18.6	19.5	18.4	250 (SCS)
Chromium (µg/L)	3	2.5 U	9.4 [8.2]	3.1	4.8	3.1	100 (PCS)
Iron (µg/L)	181	50 U	**4,880** (80.8)[f] **[1,060]** [(70.7)]	**334** (50 U)	**695** 60.9	81.1	300 (SCS)
Lead (µg/L)	0.5 U	0.5 U	0.64 (0.5 U]	0.5 U	0.5 U	0.5 U	15 (PCS)
Manganese (µg/L)	4.4	2.5 U	**103** (2.5 U) [21.0] [(2.5 U)]	15.1	8.7	3.4	50 (SCS)

Table C-10. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond. (cont.)

Well Name	ANL-MON-A-012 (GW-016001)		ANL-MON-A-013 (GW-016002)		ANL-MON-A-014 (GW-016003)		PCS/SCS[a]
Sample Date:	04/24/2013	09/17/2013	04/24/2013	09/17/2013	04/24/2013	09/17/2013	
Mercury (µg/L)	0.2 U	0.2 U	0.2 U [0.2 U]	0.2 U	0.2 U	0.2 U	2 (PCS)
Selenium (µg/L)	0.53	0.54	0.7 [0.61]	0.59	0.66	0.5 U	50 (PCS)
Silver (µg/L)	5.0 U	5.0 U	5.0 U [5.0 U]	5.0 U	5.0 U [5.0 U]	5.0 U	100 (SCS)
Sodium (µg/L)	18,200	17,500	19,600 [19,400]	18,000	18,400	17,300	None
Zinc (µg/L)	8.8	2.5 U	14.4 [4.9]	2.5 U	2.5 U	2.5 U	5,000 (SCS)

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) from IDAPA 58.01.11 (Ground Water Quality Rule).
b. NA - Not applicable.
c. Elevations are given in the National Geodetic Vertical Datum of 1928.
d. Concentrations shown in brackets are the results from field duplicate samples.
e. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.
f. Concentrations shown in parentheses are from filtered samples.

Table C-11. Advanced Test Reactor Complex Cold Waste Pond Results (2013).[a]

Parameter	Minimum	Maximum	Median
Antimony (mg/L)	0.00025 U[b]	0.0014	0.00063
Arsenic (mg/L)	0.005 U	0.0067	0.005 U
Barium (mg/L)	0.0432	0.147	0.0918
Chloride (mg/L)	10.3	39.1	21.85
Chromium (mg/L)	0.0029	0.0116	0.00635
Copper (mg/L)	0.001 U	0.007	0.0036
Fluoride (mg/L)	0.179	0.498	0.302
Iron (mg/L)	0.025 U	0.175	0.06515
Manganese (mg/L)	0.0025 U	0.0044	0.0025 U
Nitrogen+Nitrite as Nitrogen (mg/L)	0.796	3.06	1.6205
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.1 U	0.519	0.2065
Selenium (mg/L)	0.0012	0.0044	0.00255
Sodium (mg/L)	9.06	30	17.45
Solids, Total Dissolved (mg/L)	246	1060	589.5
Sulfate (mg/L)	24	509	228.3
Zinc (mg/L)	0.0025 U	0.0038	0.0025 U
Gross alpha (pCi/L ± 1s)	0.012 ± 0.609 U	2.8 ± 0.637	1.395 ± 0.716 U
Gross beta (pCi/L ± 1s)	-0.761 ± 0.783 U	14.2 ± 1.58	4.82 ± 0.982
pH	7.22	8.23	7.91
Potassium-40 (pCi ± 1s)	-28.3 ± 15.4 U	29.1 ± 8.36	4.55 ± 11.7 U

a. Only parameters with at least one detected result are shown.
b. U flag indicates the result was below the detection limit.

Table C-12. Radioactivity Detected in Groundwater Samples Collected at the Advanced Test Reactor Complex (2013).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-065	04/14/2013	Gross Alpha	1.12 (± 0.399)[a]
		Gross Beta	4.43 (± 0.713)
		Tritium	2,930 (± 349)
	10/08/2013	Gross Alpha	2.84 (± 0.749) ND[b,c]
		Gross Beta	5.32 (± 1.04) 3.39[b] (± 0.799)
		Tritium	2,890 (± 343) 3,130[b] (± 368)
TRA-07	04/18/2013	Gross Alpha	4.11 (± 1.2)
		Gross Beta	5.9 (± 1.36)
		Tritium	7,390 (± 787)
	10/08/2013	Gross Alpha	6.29 (± 1.18)
		Gross Beta	9.96 (± 0.993)
		Tritium	7,200 (± 768)
TRA-08	04/18/2013	Gross Alpha	ND
		Gross Beta	3.5 (± 0.731)
		Tritium	1,250 (± 182)
	10/07/2013	Gross Alpha	ND
		Gross Beta	9.75 (± 1.06)
		Tritium	1,360 (± 193)
USGS-076	04/17/2013	Gross Alpha	ND
		Gross Beta	ND
		Tritium	397 (± 102)
	10/07/2013	Gross Alpha	ND
		Gross Beta	ND
		Tritium	561 (± 113)
Middle-1823	04/17/2013	Gross Alpha	ND
		Gross Beta	2.86 (± 153)
		Tritium	960 (± 153)
	10/07/2013	Gross Alpha	ND
		Gross Beta	2.42 (± 0.715)
		Tritium	725 (± 129)

a. One sigma uncertainty shown in parentheses.
b. Analytical result from field duplicate sample collected on October 8, 2013.
c. ND – Not detected.

Table C-13. Liquid Influent and Effluent and Groundwater Surveillance Monitoring Results for Idaho Nuclear Technology and Engineering Center (2013).

Parameter	Minimum	Maximum	Mean
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	245	2,940	1,007
pH (standard units) (grab)	7.11	8.54	8.10
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	656	981	808
pH (standard units) (composite)	7.88	9.33	8.40
Gross alpha (pCi/L ± 1s uncertainty)	0.19 ± 0.78 U[a]	0.79 ± 0.76 U	Not Calculated
Gross beta (pCi/L ± 1s uncertainty)	8.91 ± 1.57	14.6 ± 1.32	Not Calculated
Effluent to INTEC New Percolation Ponds (CPP-797)			
Conductivity (µS/cm) (composite)	385	596	413
pH (standard units) (composite)	7.52	8.02	7.82
Gross alpha (pCi/L ± 1s uncertainty)	0.35 ± 0.69 U	4.34 ± 1.19	Not Calculated
Gross beta (pCi/L ± 1s uncertainty)	3.13 ± 1.08 U	12.6 ± 1.61	Not Calculated
Groundwater at INTEC New Percolation Ponds			
Gross alpha (pCi/L ± 1s uncertainty)	0.25 ± 0.33 U	2.79 ± 0.73	Not Calculated
Gross beta (pCi/L ± 1s uncertainty)	0.74 ± 0.27 U	7.83 ± 0.89	Not Calculated

a. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

Table C-14. Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2013).[a]

Parameter	Minimum	Maximum	Median
Gross beta (pCi/L ± 1s)	13.8 ± 1.69	96.6 ± 7.24	33.6 ± 2.45
Potassium-40 (pCi/L ± 1s)	2.99 ± 12.6 U[b]	93.8 ± 13.7	29.3 ± 11.3
Uranium-233/234 (pCi/L ± 1s)[c]	1.78 ± 0.219	1.78 ± 0.219	Not calculated
Uranium-235 (pCi/L ± 1s)	0.121 ± 0.0502	5.38 ± 4.89 U	2.6 ± 4.76 U
Uranium-238 (pCi/L ± 1s)[c]	0.809 ± 0.128	0.809 ± 0.128	Not calculated

a. Only parameters with at least one detected result are shown.
b. U flag indicates the result was below the detection limit.
c. Parameter was analyzed in July only; therefore, the minimum and maximum are the same.

Table C-15. Surveillance Monitoring Results for Materials and Fuels Complex Secondary Sanitary Lagoon (2013).[a]

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)[b]	0.0103	0.0103	Not calculated
Barium (mg/L)[b]	0.0815	0.0815	Not calculated
Chemical Oxygen Demand (mg/L)[b]	1.55	1.55	Not calculated
Chloride (mg/L)[b]	293	293	Not calculated
Chromium (mg/L)[b]	0.0026	0.0026	Not calculated
Fluoride (mg/L)[b]	1.88	1.88	Not calculated
Gross beta (pCi/L ± 1s)	13.8 ± 1.69	96.6 ± 7.24	33.6 ± 2.45
Iron (mg/L)[b]	1.27	1.27	Not calculated
Lead (mg/L)[b]	0.0017	0.0017	Not calculated
Manganese (mg/L)[b]	0.07	0.07	Not calculated
Nitrogen, Total Kjeldahl Nitrogen (TKN)(mg/L)[b]	81.2	81.2	Not calculated
Phosphorus, Total (mg/L)[b]	12.1	12.1	Not calculated
Potassium-40 (pCi/L ± 1s)	2.99 ± 12.6 U[c]	93.8 ± 13.7	29.3 ± 11.3
Selenium (mg/L)[b]	0.0038	0.0038	Not calculated
Sodium (mg/L)[b]	220	220	Not calculated
Solids, Total Dissolved (mg/L)[b]	1730	1730	Not calculated
Solids, Total Suspended (mg/L)[b]	670	670	Not calculated
Sulfate (mg/L)[b]	109	109	Not calculated
Uranium-233/234b (pCi/L ± 1s)[b]	1.78 ± 0.219	1.78 ± 0.219	Not calculated
Uranium-235 (pCi/L ± 1s)[b]	0.121 ± 0.0502	5.38 ± 4.89	2.6 ± 4.76 U
Uranium-238 (pCi/L ± 1s)[b]	0.809 ± 0.128	0.809 ± 0.128	Not calculated
Zinc (mg/L)[b]	0.0758	0.0758	Not calculated

a. Only parameters with at least one detected result are shown.
b. Parameter was only analyzed in the samples collected in July; therefore the minimum and maximum are the same.
c. U flag indicates the result was below the detection limit.

Appendix D. In Situ Soil and Onsite Dosimeter Measurements and Locations

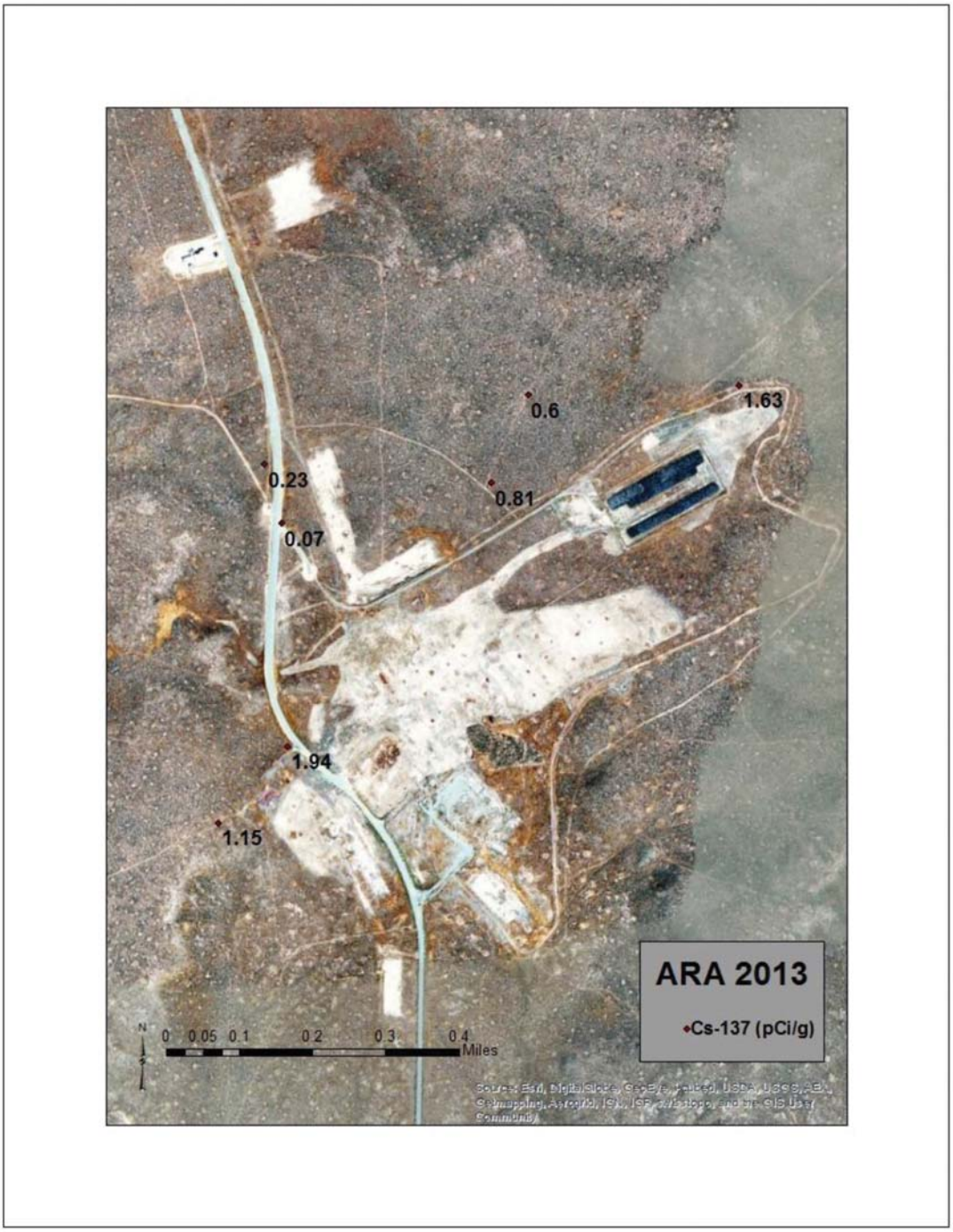

Figure D-1. In Situ Soil Measurements at Auxiliary Reactor Area (2013).

Figure D-2. In Situ Soil Measurements at Advanced Test Reactor Complex (2013).

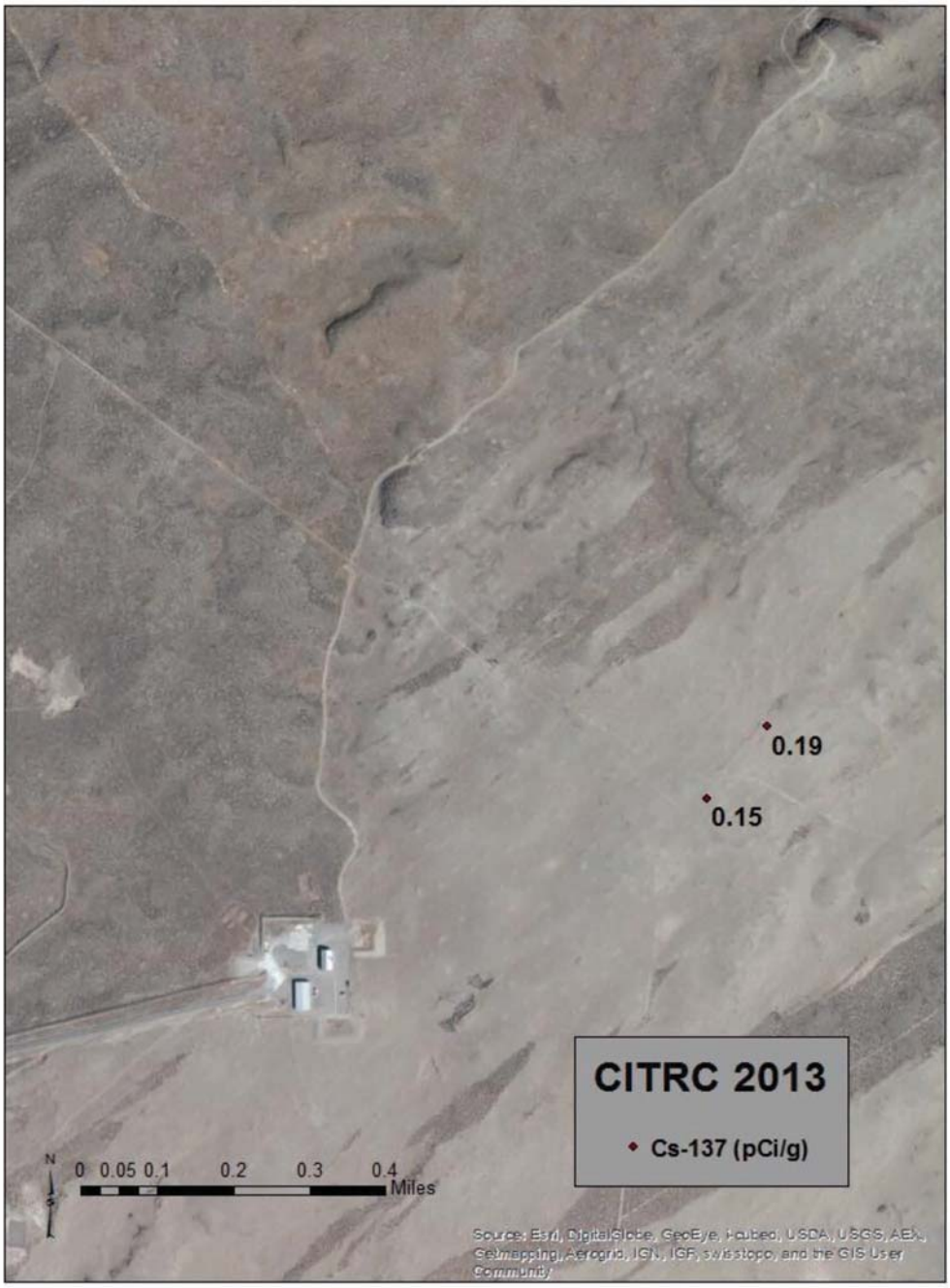

Figure D-3. In Situ Soil Measurements at Critical Infrastructure Test Range Complex (2013).

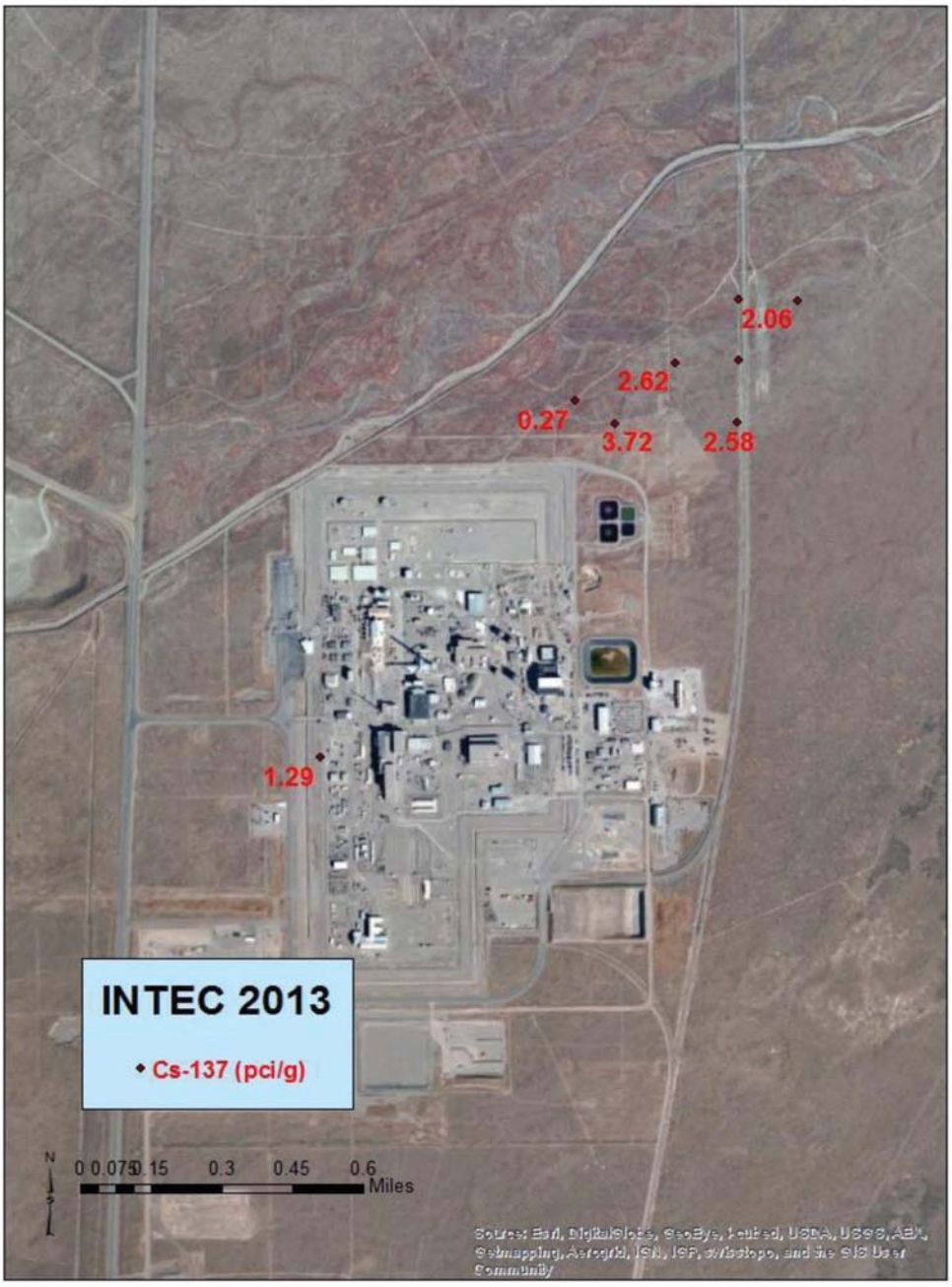

Figure D-4. In Situ Soil Measurements at Idaho Nuclear Technology and Engineering Center (2013).

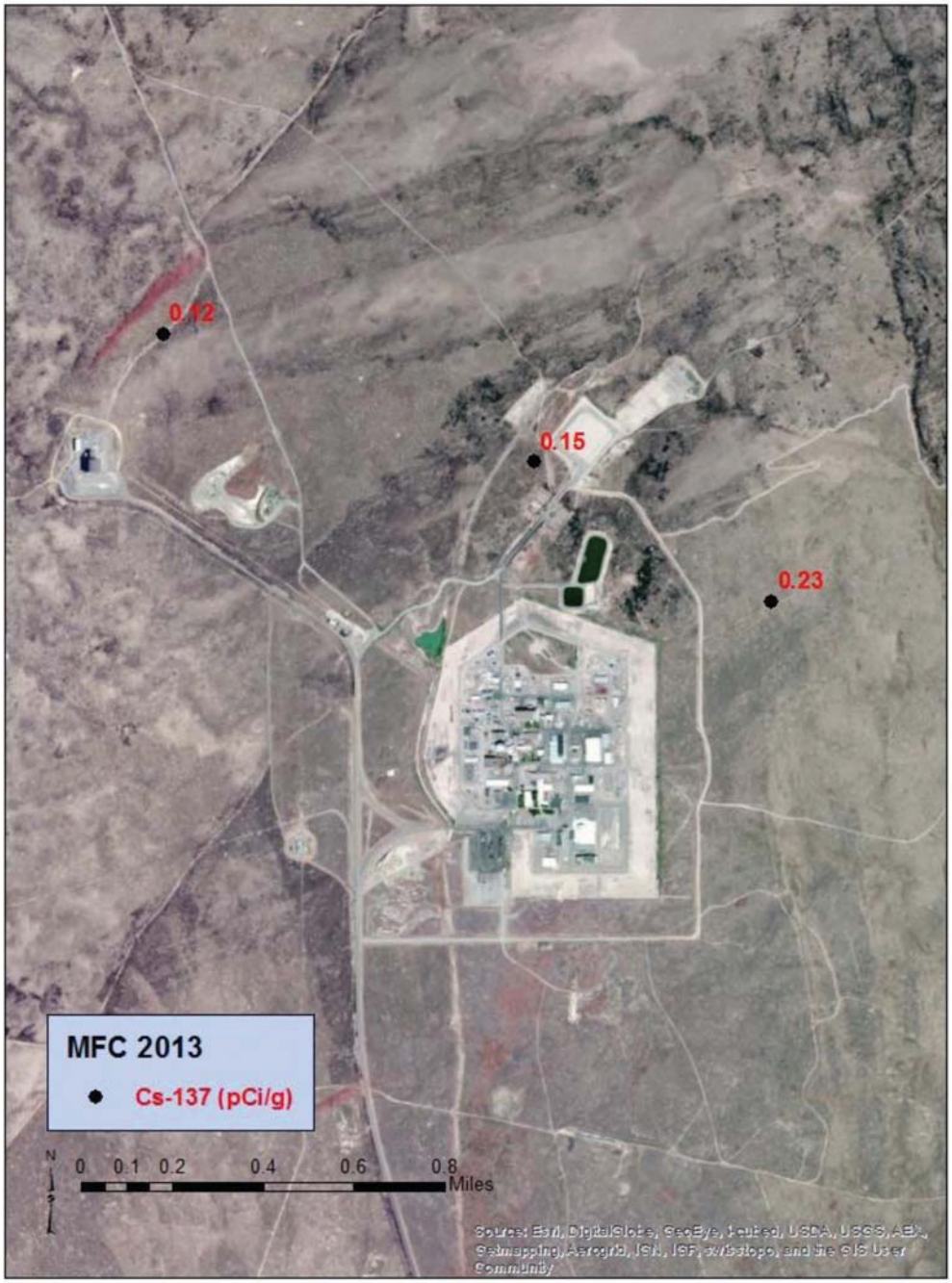

Figure D-5. In Situ Soil Measurements at Materials and Fuels Complex (2013).

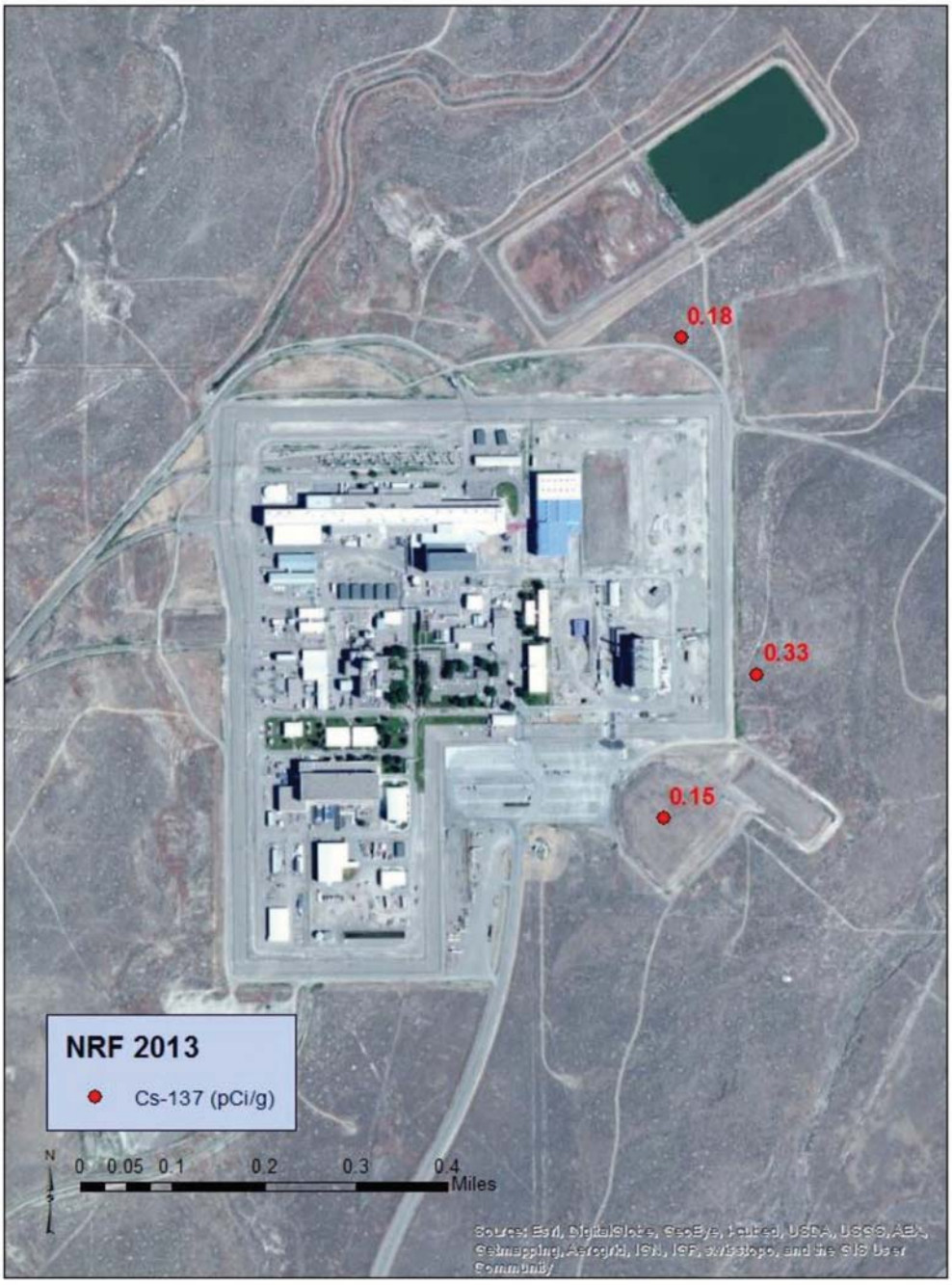

Figure D-6. In Situ Soil Measurements at Naval Reactors Facility (2013).

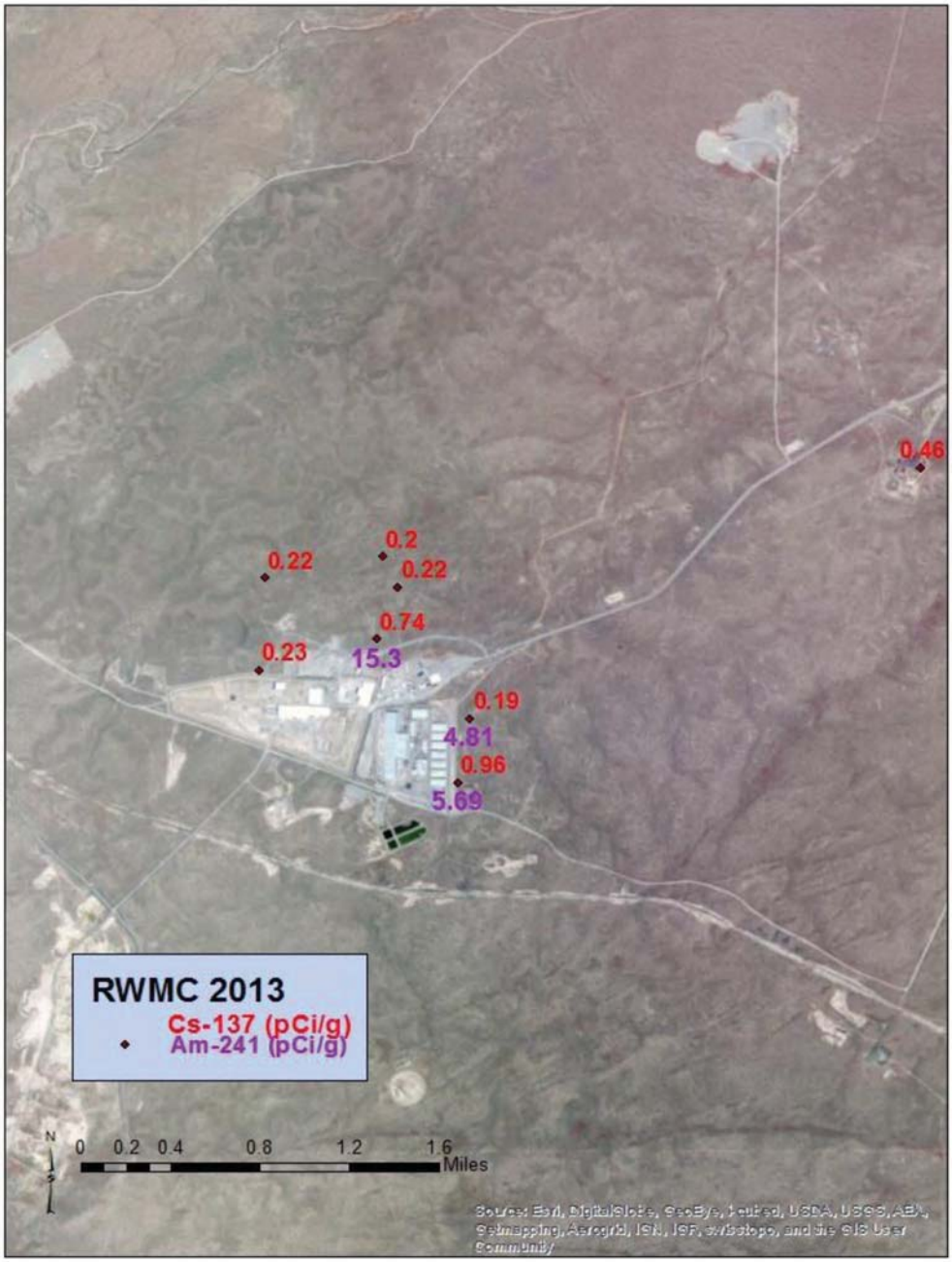

Figure D-7. In Situ Soil Measurements at Radioactive Waste Management Complex (2013).

Figure D-8. In Situ Soil Measurements at Test Area North (2013).

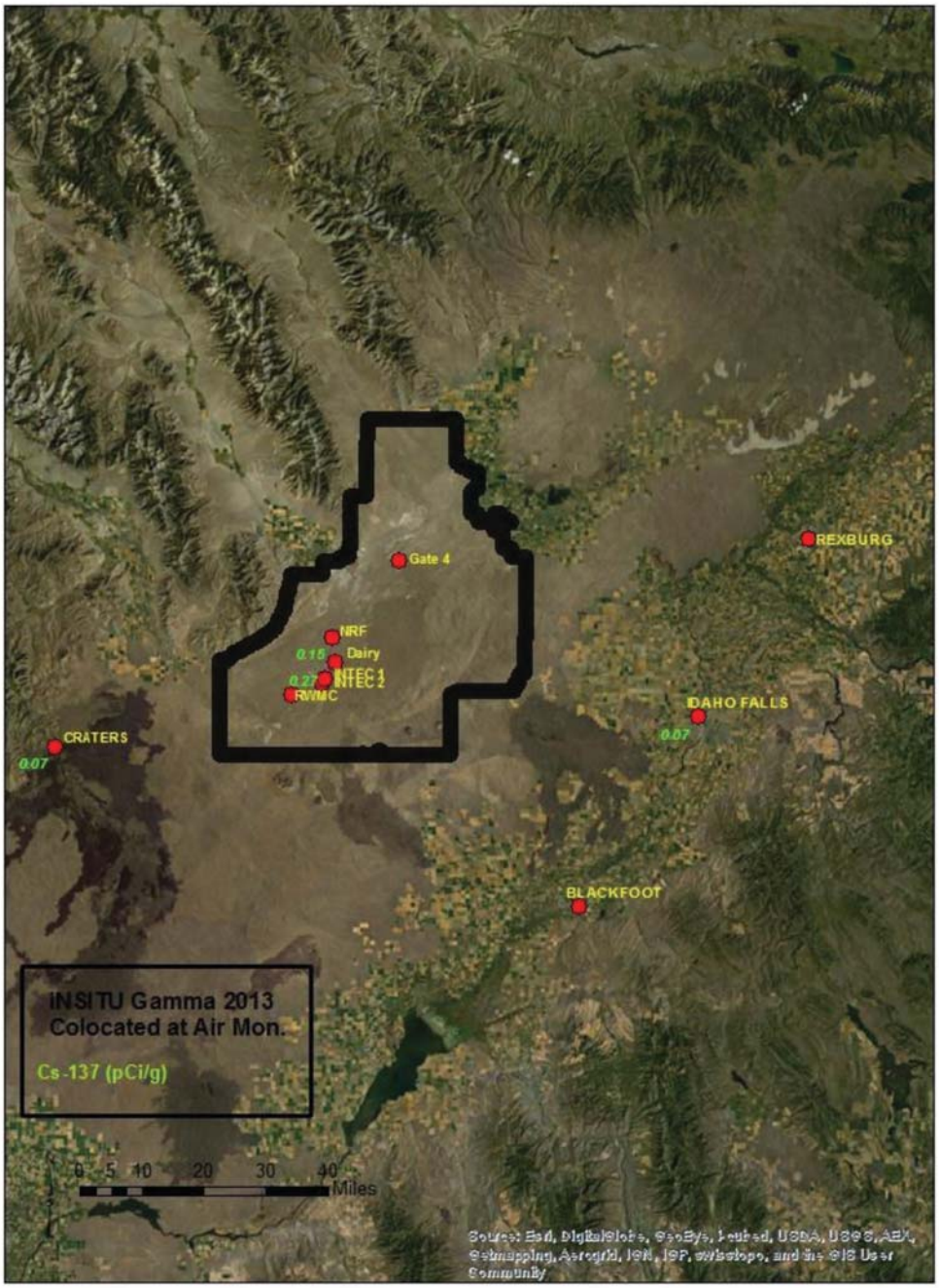

Figure D-9. In Situ Soil Measurements at Air Monitoring Locations (2013)

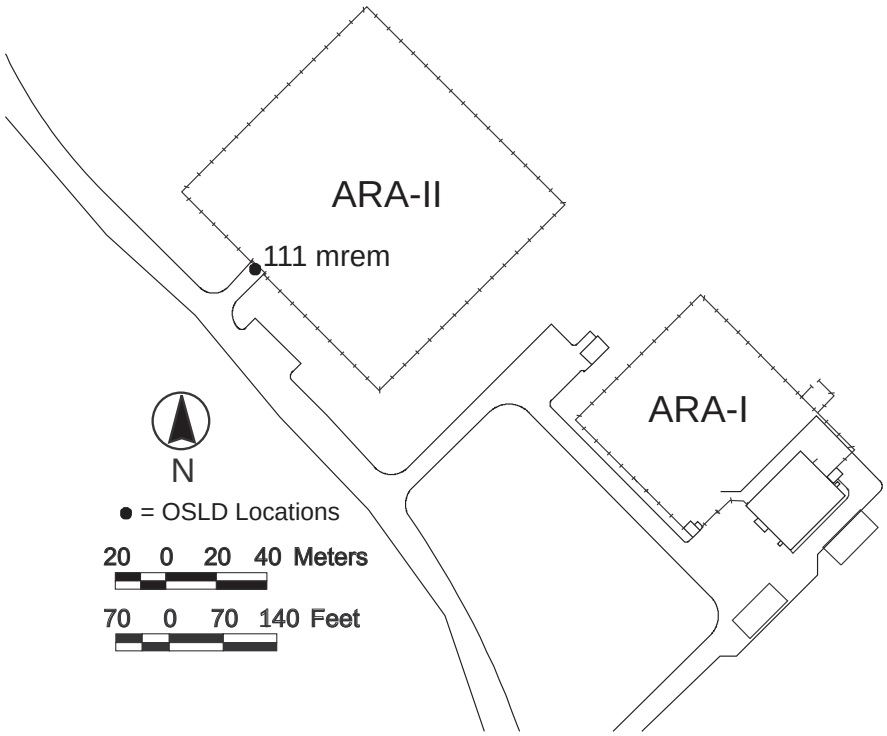

Figure D-10. Environmental Radiation Measurements OSLD Result (mrem) at Auxiliary Reactor Area (2013).

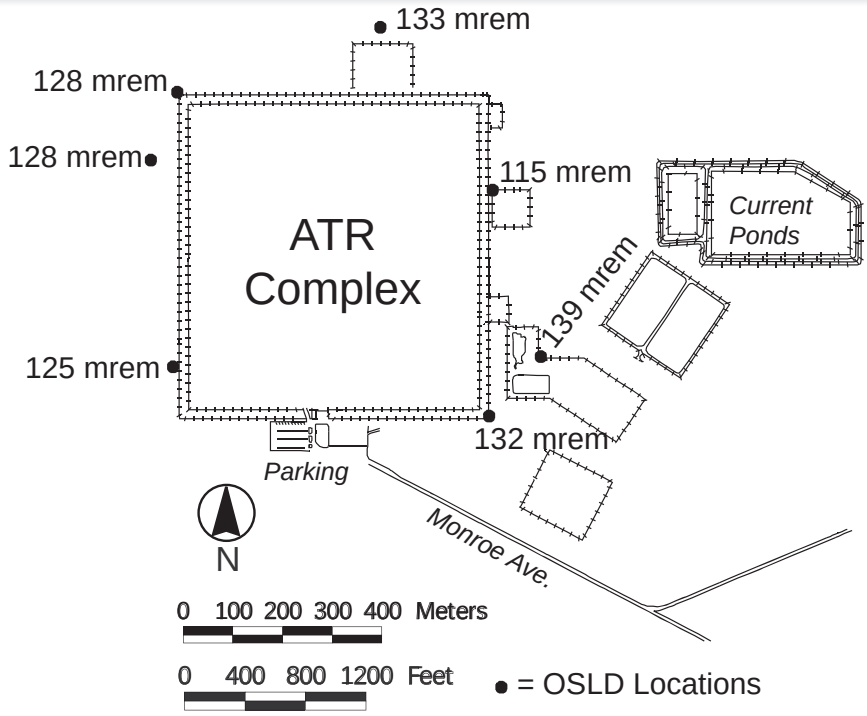

Figure D-11. Environmental Radiation Measurements OSLD Result (mrem) at Advanced Test Reactor Complex (2013).

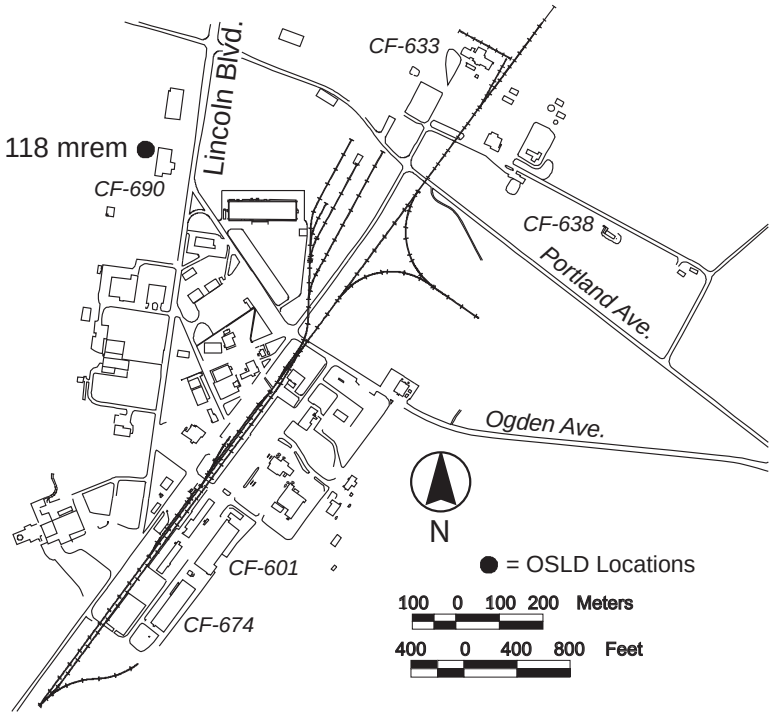

Figure D-12. Environmental Radiation Measurements OSLD Result (mrem) at Central Facilities Area (2013).

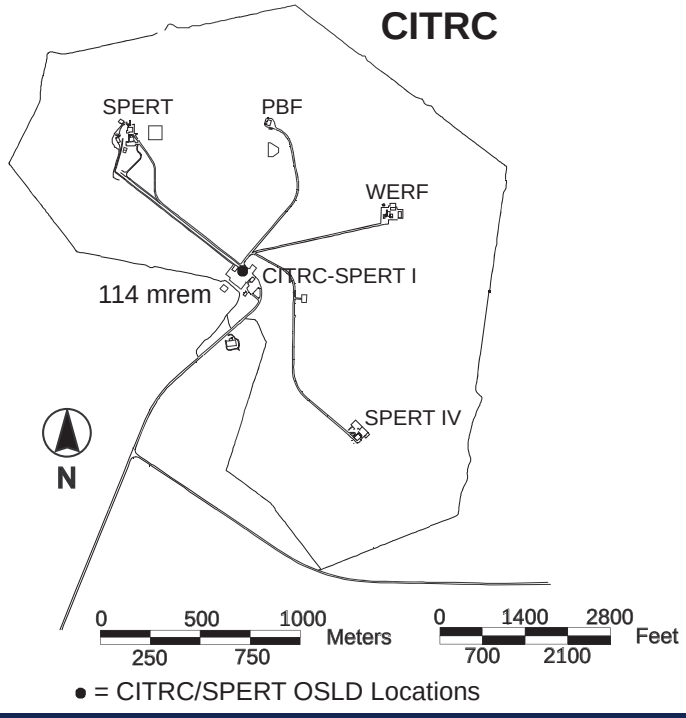

Figure D-13. Environmental Radiation Measurements OSLD Result (mrem) at Critical Infrastructure Test Range Complex (2013).

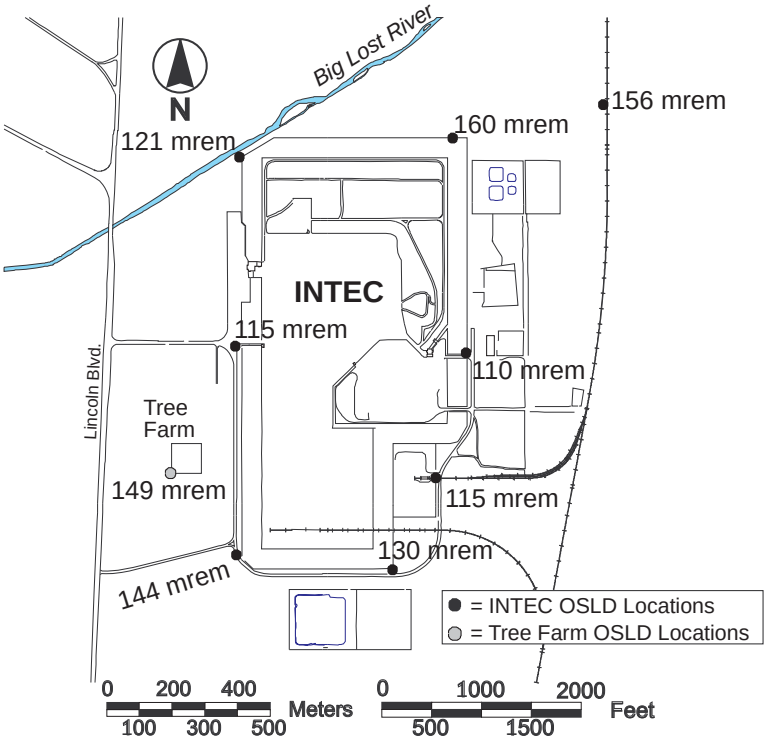

Figure D-14. Environmental Radiation Measurements OSLD Result (mrem) at Idaho Nuclear Technology and Engineering Center (2013).

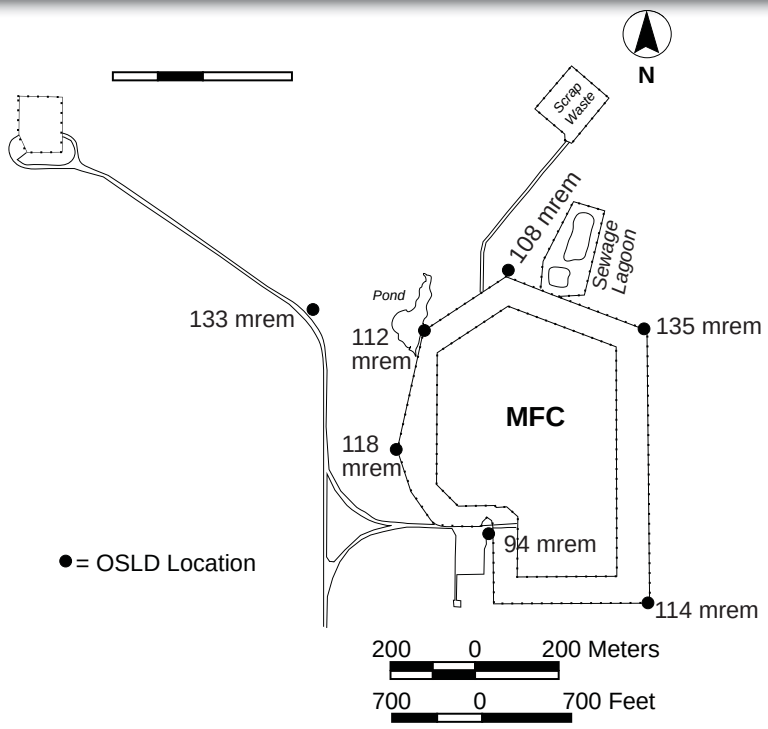

Figure D-15. Environmental Radiation Measurements OSLD Result (mrem) at Materials and Fuels Complex (2013).

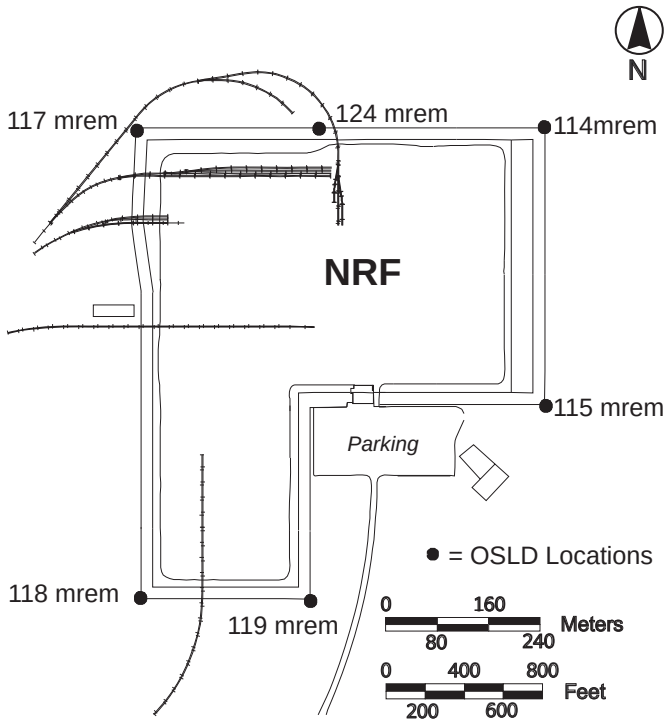

Figure D-16. Environmental Radiation Measurements OSLD Result (mrem) at Naval Reactors Facility (2013).

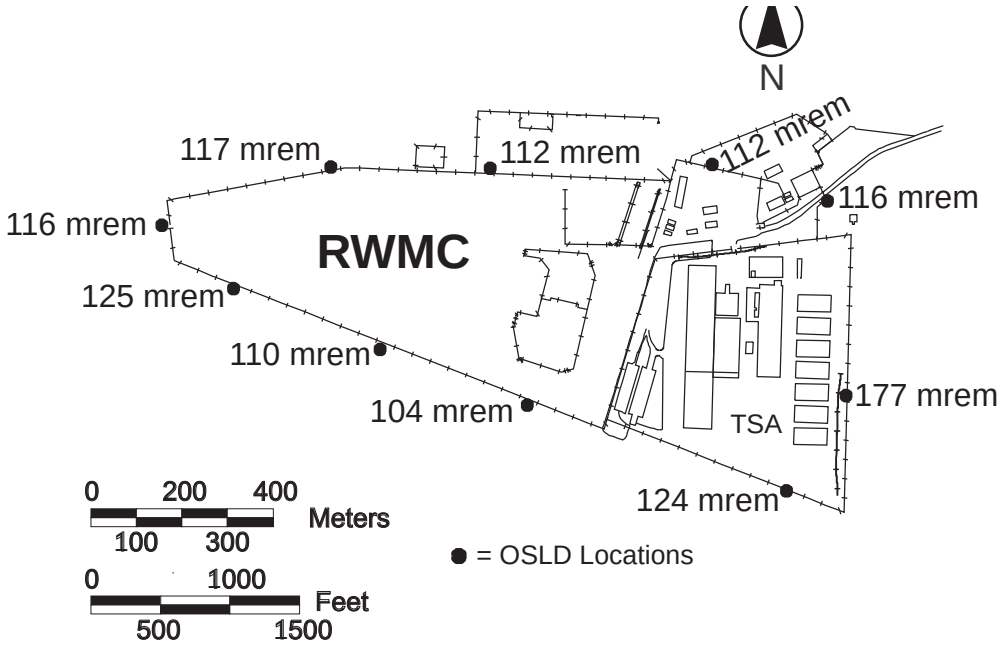

Figure D-17. Environmental Radiation Measurements OSLD Result (mrem) at Radioactive Waste Management Complex (2013).

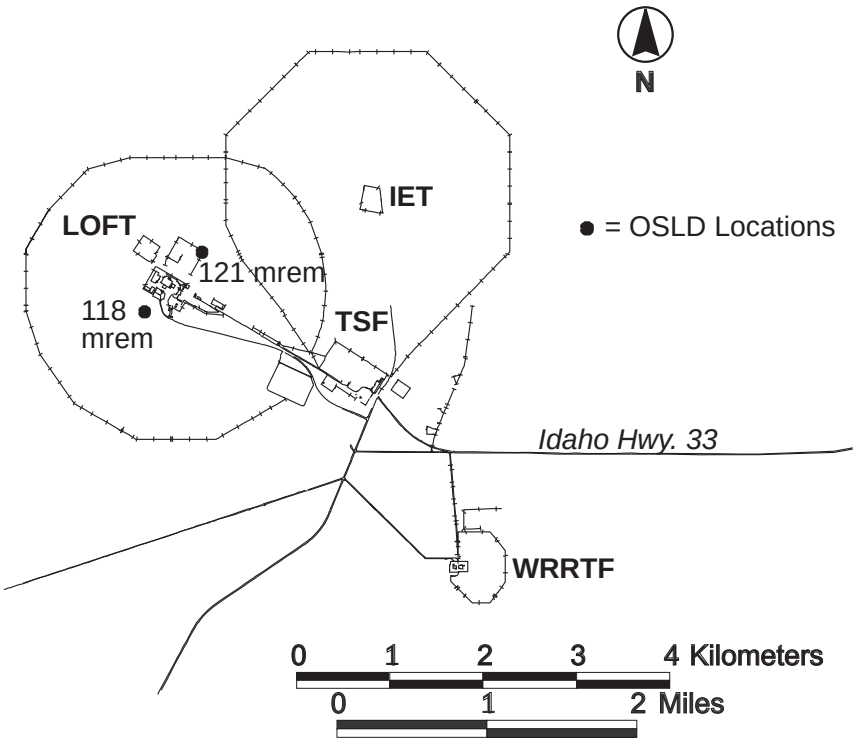

Figure D-18. Environmental Radiation Measurements OSLD Result (mrem) at Test Area North (2013).

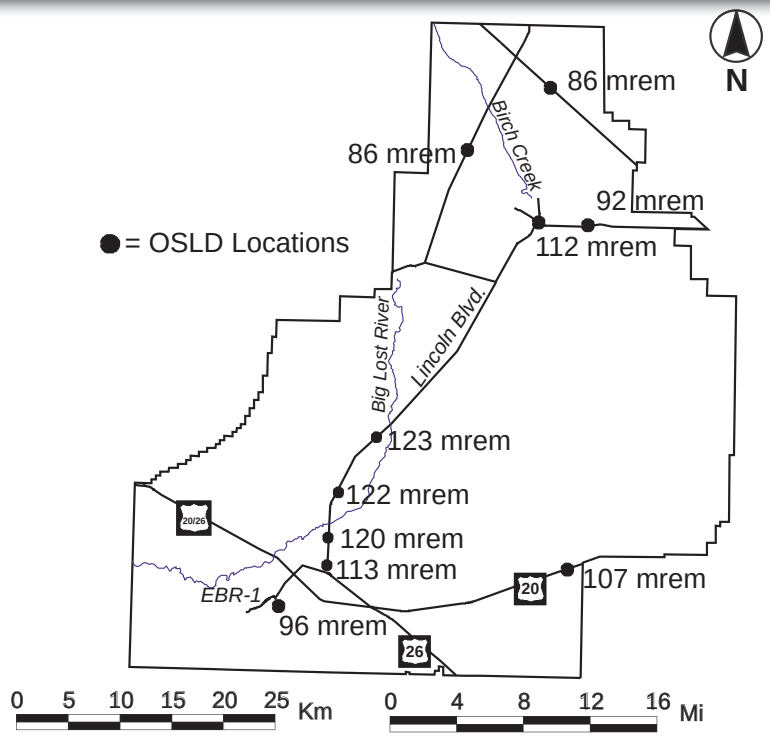

Figure D-19. Environmental Radiation Measurements OSLD Result (mrem) at Sitewide Locations (2013).

Appendix E. Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the “true” value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium on. Includes the naturally occurring radionuclides thorium and uranium, as well as 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 (ICRU) to approximate the effective dose received by a human from external exposure to ambient ionizing radiation.

anthropogenic radionuclide: Radionuclides produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission. The typically quoted average individual exposure from background radiation is 360 millirems per year.

basalt: The most common type of solidified lava; a dense, dark grey, fine-grained, igneous rock that is composed chiefly of plagioclase, pyroxene, and olivine; often displaying a columnar structure.

becquerel (Bq): A quantitative measure of radioactivity. This is an alternate measure of activity used internationally. One becquerel of activity is equal to one nuclear decay per second. There are 3.7×10^{10} Bq in 1 Curie (Ci).

beta radiation: Radiation comprised of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly more penetrating than alpha, and it may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements, such as potassium-40, emit beta radiation.

bias: The tendency for an estimate to deviate from an actual or real event. Bias may be the tendency for a model to over- or under-predict.

bioremediation: The process of using various natural or introduced microbes or both to degrade, destroy or otherwise permanently bond contaminants contained in soil or water or both.

biota concentration guide: The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded.

blank: Used to demonstrate that cross contamination has not occurred. See **field blank**, **laboratory blank**, **equipment blank**, and **reagent blank**.

blind sample: Contains a known quantity of some of the analytes of interest added to a sample media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in a person's custody if the item is (1) in the physical possession of that person, (2) within direct view of that person, or (3) placed in a secured area or container by that person.

comparability: A measure of the confidence with which one data set or method can be compared to another.

composite sample: A sample of environmental media that contains a certain number of sample portions collected over a time period. The samples may be collected from the same location or different locations. They may or may not be collected at equal intervals over a predefined period (e.g., quarterly).

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected under optimum conditions.

confidence interval: A statistical range with a specified probability that a given parameter lies within the range.

contaminant: Any physical, chemical, biological, radiological substance, matter, or concentration that is in an unwanted location.

contaminant of concern: Contaminant in a given media (usually soil or water) above a risk level that may result in harm to the public or the environment. At the INL Site, a contaminant that is above a 10^{-6} (1 in 1 million) risk value.

control sample: A sample collected from an uncontaminated area that is used to compare INL Site analytical results to those in areas that could not have been impacted by INL Site operations.

cosmic radiation: Penetrating ionizing radiation, both particulate and electromagnetic, that originates in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 300 millirem of natural background radiation that an average member of the US 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 equal to that quantity of radioactive material in which the number of atoms decaying per second and is equal to 37 billion (3.7×10^{10}). It was based on the rate of decay of atoms within one gram of radium. It is named for Marie and Pierre Curie who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. (see also **becquerel**)

D

data gap: An area between all available data and the conclusions that are drawn from the data where the existing data are sparse or nonexistent. An example would be inferring the interactions in the environment of one radionuclide that has not been studied from a chemically similar radionuclide that has been studied.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay products: Decay products are also called “daughter products”. They are radionuclides that are formed by the radioactive decay of parent radionuclides. In the case of radium-226, for example, nine successive different radioactive decay products are formed in what is called a “decay chain.” The chain ends with the formation of lead-206, which is a stable nuclide.

derived concentration standard (DCS): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose of 100 mrem (1 mSv). U.S. Department of Energy Order 458.1 “Radiation Protection of the Public and the Environment” establishes this limit and DOE Standard DOE-STD-1196-2011, “Derived Concentration Technical Standard” provides the numerical values of DCSs.

deterministic effect: Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Deterministic effects generally result from the receipt of a relatively high dose over a short time period. Skin erythema (reddening) and radiation-induced cataract formation is an example of a deterministic effect (formerly called a nonstochastic effect).

diffuse source: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

direct radiation: External radiation from radioactive plumes or from radionuclides deposited on the ground or other surfaces.

dispersion: The process of molecular movement by physical processes.

dispersion coefficient: An empirical concentration, normalized to a unit release rate, used to estimate the concentration of radionuclides in a plume at some distance downwind of the source. The National Oceanic and Atmospheric Administration, using data gathered continuously at meteorological stations on and around the INL Site and the MDIFF air dispersion model, prepared the dispersion coefficients for this report.

dose: A general term used to refer to the effect on a material that is exposed to radiation. It is used to refer either to the amount of energy absorbed by a material exposed to radiation (see **dose, absorbed**) or to the potential biological effect in tissue exposed to radiation (see **dose, equivalent** and **dose, effective**). See also: **dose, population**.

dose, absorbed: The amount of energy deposited in any substance by ionizing radiation per unit mass of the substance. It is expressed in units of rad or gray (Gy) (1 rad = 0.01 gray).

dose, effective (*E*): The summation of the products of the equivalent dose received by specified tissues and organs of the body, and tissue weighting factors for the specified tissues and organs, and is given by the expression:

$$E = \sum_T w_T \sum_R w_R \; D_{T,R} \; or \; E = \sum_T w_T H_T$$

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 d**ose, absorbed** and **quality factor**).

dose, population or collective: The sum of the individual effective doses received in a given time period by a specified population from exposure to a specified source of radiation. Population dose is expressed in the SI unit person-sievert (person-Sv) or conventional unit person-rem. (1 person-Sv = 100 person-rem). (See **dose, effective**).

dosimeter: Portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry: The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

drinking water: Water for the primary purpose of consumption by humans.

duplicate sample: A sample collected from the same sampling location using the same equipment and sampling technique and placed into an identically prepared and preserved container. Duplicate samples are analyzed independently as an indication of gross errors in sampling techniques.

E

eastern Snake River Plain aquifer: One of the largest groundwater “sole source” resources in the United States. It lies beneath a rolling topography extending some 308 km (191 mi) from Ashton to King Hill, Idaho, and ranges in width from 64 to 130 km (40 to 80 mi). The plain and aquifer were formed by repeated volcanic eruptions that were the result of a geologic hot spot beneath the earth’s crust.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effluent: Any liquid discharged to the environment, including storm water runoff at a site or facility.

effluent waste: Treated wastewater leaving a treatment facility.

electrometallurgical treatment: The process of treating spent nuclear fuel using metallurgical techniques.

environment: Includes water, air, and land and the interrelationship that exists among and between water, air, and land and all living things.

environmental indicators: Animal and plant species that are particularly susceptible to decline related to changes, either physical or chemical, in their environment.

environmental media: Includes air, groundwater, surface water, soil, flora, and fauna.

environmental monitoring: Sampling for contaminants in air, water, sediments, soils, agricultural products, plants, and animals, either by direct measurement or by collection and analysis of samples. It is a combination of two distinct activities (effluent monitoring and environmental surveillance) that together provide information on the health of an environment.

equipment blank: Sample prepared by collecting uncontaminated water passed over or through the sampling equipment. This type of blank sample is normally collected after the sampling equipment has been used and subsequently cleaned. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning.

exposure: The interaction of an organism with a physical or chemical agent of interest. Examples of such agents are radiation (physical) and carbon tetrachloride (chemical).

exposure pathway: The mechanism through which an organism may be exposed to a contaminant. An example is the surface water pathway, whereby an organism may be exposed to a contaminant through the consumption of surface water containing that contaminant.

external dose or exposure: That portion of the dose received from radiation sources outside the body (i.e., external sources).

extremely hazardous chemical: A substance listed in the appendices to 40 CFR 355, “Emergency Planning and Notification.”

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing that has been deposited on the earth’s surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage, and transport. A known uncontaminated sample, usually

deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning. Namely, any material that is fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission: The splitting of the nucleus of an atom (generally of a heavy element) into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the subsequent decay products of the radioactive fission fragments.

fissionable material: Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

flood plain: Lowlands bordering a river that are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See alpha radiation.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See beta radiation.

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

hazardous air pollutant: See hazardous substance.

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200 (“Hazard Communication”) and 40 CFR 370.2 (“Definitions”).

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b)(2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture with respect 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 does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 (“Identification and Listing Hazardous Waste”) or that exhibits one or more of four characteristics (corrosiveness, reactivity, flammability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: (1) In environmental surveillance, a localized area of contamination or higher contamination in an otherwise uncontaminated area. (2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth’s surface. The hot spot does not move, but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process of water soaking into soil or rock.

influent waste: Raw or untreated wastewater entering a treatment facility.

inorganic: Relating to or belonging to the class of compounds not having a carbon basis; hydrochloric and sulfuric acids are called inorganic substances.

ionizing radiation: Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons and light. High

doses of ionizing radiation may produce severe skin or tissue damage.

isopleth: A line on a map connecting points having the same numerical value of some variable.

isotope: Two or more forms of an element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties. Examples of isotopes are plutonium-238, plutomium-239, and plutonium-241; each acts chemically like plutonium but have 144, 145, and 146 neutrons, respectively.

L

laboratory blank: A sample, usually deionized water, that is intended to contain none of the analytes of interest and is subjected to the same analytical or measurement process as other samples to establish a zero baseline or laboratory background value. Laboratory blanks are run before and after regular samples are analyzed to measure contamination that may have been introduced during sample handling, preparation, or analysis. A laboratory blank is sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

management and operating (M&O) contract: An agreement under which the government contracts for the operation, maintenance, or support, on its behalf, of a government-owned or -controlled research, development, special production, or testing establishment wholly or principally devoted to one or more major programs of the contracting federal agency.

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) or composition (soil, filter, groundwater, or air) of a sample.

maximally exposed individual (MEI): A hypothetical member of the public whose location and living habits tend to maximize his or her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

millirem (mrem): A unit of radiation dose that is equivalent to one one-thousandth of a rem.

millisievert (mSv): The International System of Units (SI) for radiation dose and effective dose equivalent. The SI equivalent of the millirem (1 millisievert = 100 millirem).

minimum detection concentration (MDC): The lowest concentration to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDC are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. Natural background radiation is comprised of several sources, the most important of which are:

- Cosmic radiation: Radiation from outer space (primarily the sun)
- Terrestrial radiation: Radiation from radioactive materials in the crust of the earth
- Inhaled radionuclides: Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Indian tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

optically stimulated luminescence dosimeter (OSLD): Used to measure direct penetrating gamma radiation through the absorption of energy from ionizing radiation by trapping electrons that are excited to a higher energy band. The trapped electrons in the OSLD are released by exposure to green light from a laser.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a U.S. Environmental Protection Agency reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: 1) Pollutant or contaminant as defined by Section 101(33) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States. 2) Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance: Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control: Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor: The factor by which the absorbed dose (rad or gray) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, quality factor, has now been replaced by "radiation weighting factor" in the latest system of recommendations for radiation protection.

R

rad: short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of

ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \; x \; 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302 ("Designation, Reportable Quantities, and Notification"), the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory's ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk: In many health fields, risk means the probability of incurring injury, disease, or death. Risk can be expressed as a value that ranges from zero (no injury or harm will occur) to one (harm or injury will definitely occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public, and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals; usually are denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapid 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.

stochastic effects: Effects that occur 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 water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Parameters monitored to observe trends but not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total effective dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above listed quantities. See also hazardous chemical.

traceability: The ability to trace history, application, or location of a sample standard and like items or activities by means of recorded identification.

transient noncommmunity water system: A water system that is not a community water system, and serves 25 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

transuranic (TRU): Elements on the periodic table with an atomic number greater than uranium (>92). Common isotopes of transuranic elements are neptunium-239 and plutonium-238.

transuranic waste: Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (radionuclide isotopes with atomic numbers greater than uranium [92]) per gram of waste with half-lives greater than 20 years.

tritium: A radioactive isotope of hydrogen, having three times the mass of ordinary hydrogen.

V

vadose zone: That part of the subsurface between the ground surface and the water table.

W

water quality parameter: Parameter commonly measured to determine the quality of a water body or sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

weighting factor (w_T): A multiplier that is used for converting the equivalent dose to a specific organ or tissue (T) into what is called the effective dose. The goal of this process was to develop a method for expressing the dose to a portion of the body in terms of an equivalent dose to the whole body that would carry with it an equivalent risk in terms of the associated fatal cancer probability. The equivalent dose to tissue (H_T) is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. (See **dose, equivalent** and **dose, effective**).

wetland: An area inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

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