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Site Environmental Report

Calendar Year 2006

Environmental Surveillance, Education and Research Program

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U.S. Department of Energy Idaho Operations Office

September 2007

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Elk in Grass

Preface

Every person in the world is exposed to ionizing radiation, which may have sufficient energy to remove electrons from atoms, damage chromosomes, and cause cancer. There are three general sources of ionizing radiation: those of natural origin unaffected by human activities, those of natural origin but enhanced by human activities, and those produced by human activities (anthropogenic).

The first general source includes terrestrial radiation from natural radiation sources in the ground, cosmic radiation from outer space, and radiation from radionuclides naturally present in the body. Exposures to natural sources may vary depending on the geographical location and altitude at which the person resides. When such exposures are substantially higher than the average, they are considered to be elevated.

The second general source includes a variety of natural sources from which the radiation has been increased by human actions. For example, radon is a radioactive gas which is heavier than air. It comes from the natural decay of uranium and is found in nearly all soils. Concentrations of radon inside buildings may be elevated because of the type of soil and rock upon which they are built (high in uranium or radon) and may be enhanced by cracks and other holes in the foundation (providing access routes for the gas). Another example is the increased exposure to cosmic radiation that airline passengers receive when traveling at normal cruising altitudes.

The third source includes a variety of exposures from human-made materials and devices such as medical x-rays, radiopharmaceuticals used to diagnose and treat disease, and consumer products containing minute quantities of radioactive materials (UNSCEAR 2000).

To verify that exposures resulting from operations at U.S. Department of Energy (DOE) nuclear facilities remain very small, each site where nuclear activities are conducted operates an environmental surveillance program to monitor the air, water, and other pathways whereby radionuclides from operations might conceivably reach workers and members of the public. Environmental surveillance and monitoring results are reported annually to DOE Headquarters.

This report presents a compilation of data collected in 2006 for the environmental monitoring and surveillance programs conducted on and around the Idaho National Laboratory (INL) Site. It also presents a summary of sitewide environmental programs and discusses potential impacts from INL Site operations to the environment and the public. These programs are managed by various private companies and other Federal agencies through contracts and interagency agreements with the DOE - Idaho Operations Office (DOE-ID).

Beginning in 2005, the research and development activities at the site became the INL, which is managed and operated by Battelle Energy Alliance (BEA). BEA conducted effluent and facility monitoring, as well as sitewide environmental surveillance on the INL Site. The cleanup operations, called the Idaho Cleanup Project (ICP), were managed separately by CH2M-WG Idaho (CWI). CWI performed environmental monitoring at and around waste management facilities involved in the ICP. The Environmental Surveillance, Education, and Research Program, managed by S. M. Stoller Corporation, performed environmental surveillance of offsite locations.

The U.S. Geological Survey (USGS) performed groundwater monitoring both on and off site. The ICP contractor also conducted onsite groundwater monitoring related to waste management, clean-up/restoration, and environmental surveillance. The National Oceanic and Atmospheric Administration (NOAA) collected meteorological data.

The Advanced Mixed Waste Treatment Project (AMWTP), located on the INL Site at the Radioactive Waste Management Complex (RWMC), is operated by Bechtel BWXT Idaho, LLC. AMWTP performs regulatory compliance monitoring and other limited monitoring as a best management practice. These monitoring activities are reported to DOE-ID and regulators as required and are not presented in this report.

The Naval Reactors Facility (NRF), operated by Bechtel Bettis, Inc (BBI), is excluded from this report. As established in Executive Order 12344 (FR 1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 450.1 (DOE 2003), 5400.5 (DOE 1993), and 414.1c (DOE 2005). The director, Naval Nuclear Propulsion Program, established reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. NRF's program is documented in the NFT Environmental Monitoring Report (BBI 2006).

This report also contains information on nonradiological monitoring performed during the year. Results of this monitoring, both chemical (liquid effluent constituent concentrations) and physical (particulates) are presented. Nonradiological parameters monitored are those required under permit conditions or are related to material released from INL Site operations.

This report, prepared in accordance with the requirements in DOE Orders 450.1 and 231.1A, is not intended to cover the numerous special environmental research programs conducted at the INL Site (DOE 2003, 2004).

REFERENCES

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000, "Sources and Effects of Ionizing Radiation," Vol. 1, UNSCEAR 2000 Report to the General Assembly with Scientific Annexes.

U.S. Department of Energy (DOE), 2003, "Environmental Protection Program," DOE Order 450.1, January.

U.S. Department of Energy (DOE), 2004, "Environment, Safety, and Health Reporting," DOE Order 231.1A, June.

Executive Summary

Approximately 8,500 people work at the Idaho National Laboratory (INL) Site, making it the largest employer in eastern Idaho and the third largest employers in the State. The INL Site has a tremendous economic impact on eastern Idaho. Boise State University's College of Business and Economics studied the effects of INL operations on the Idaho economy and found that the INL Site accounts for more than 2.5 percent of personal income and 3 percent of all tax revenues in Idaho. Moreover, the impacts of employees' charitable contributions, educational outreach and volunteer activities are significant to the region and state.

The prime contractors at the INL Site are: Battelle Energy Alliance (BEA), the management and operations (M&O) contractor for the INL and CH2M-WG Idaho, LLC (CWI) which manages ongoing cleanup operations under the Idaho Cleanup Project or ICP. Other contractors include Bechtel BWXT Idaho, LLC, which operates the Advanced Mixed Waste Treatment Project (AMWTP), and Bechtel Bettis, Inc., which manages the Naval Reactors Facility.

This Annual Site Environmental Report (ASER) summarizes environmental data, information, and regulations, and highlights major environmental programs and efforts during calendar year 2006 at the INL Site. The report is published annually for the U.S. Department of Energy - Idaho Operations Office (DOE-ID) in compliance with DOE Order 231.1A, Environment, Safety and Health Reporting (DOE 2004).

ENVIRONMENTAL PROGRAM INFORMATION

Many environmental programs help implement the environmental compliance policy for the INL Site, as discussed in Chapter 3. Most of the regulatory compliance activity is performed through environmental monitoring programs, the Environmental Restoration Program, the Waste Management Program, and other risk reduction activities.

The major objectives of the environmental monitoring programs conducted at the INL Site are to identify the key contaminants released to the environment, to evaluate different pathways through which contaminants move in the environment, and to determine the potential effects of these contaminants on the public and the environment. This is accomplished through sampling and analysis of air; surface, subsurface, and drinking water; soil; wildlife; and vegetation, as well as measurement of direct radiation. During 2006, BEA and CWI had primary responsibility for environmental monitoring at the INL Site. The Environmental Surveillance, Education and Research Program (ESER) contractor, which was a team led by the S. M. Stoller Corporation, was responsible for offsite environmental monitoring.

Ambient air, drinking water, surface water, groundwater, soils, vegetation, agricultural products, wildlife, and direct radiation were sampled by the monitoring programs. Samples were analyzed for a variety of contaminants including, but not limited to, pH, inorganics, volatile organics, gases, gross and beta activity, and specific radionuclides, such as tritium, strontium-90 (^{90}Sr), and plutonium isotopes.

The ICP continued progress during 2006 toward final cleanup of contaminated sites at the INL Sites. Examples of significant accomplishments during 2006 are:

- Reinitiated exhumation and processing of targeted waste from the Accelerated Retrieval Project;
- Completed removal of sludge and water from the CPP-603 spent nuclear fuel basins and grouted basins;

- High-level waste tank closure activities began at the Idaho Nuclear Technology and Engineering Center (INTEC);
- Over 4,135 m^2 (44,507 ft^2) of buildings and structures were demolished;
- A total of 6,655 m^3 (234,842 ft^3) of transuranic waste was shipped to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

ENVIRONMENTAL MONITORING PROGRAMS

The INL Site environmental surveillance programs, conducted by the INL and ICP contractors and the ESER contractor, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to receptors. The INL Site contractor monitors airborne effluents at individual INL facilities and ambient air outside the facilities to comply with appropriate regulations and DOE orders. The ICP contractor focuses on environmental surveillance of waste management facilities. The ESER contractor samples ambient air at locations within, around, and distant from the INL Site. Chapter 4 presents results of airborne monitoring.

An estimated total of 6,340 Ci of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents in 2006. Samples of airborne particulates, atmospheric moisture, and precipitation were analyzed for gross alpha and gross beta activity, as well as for specific radionuclides, primarily tritium, ^{90}Sr, iodine-131 (^{131}I), cesium-137 (^{137}Cs), plutonium-239/240 ($^{239/240}Pu$), and americium-241 (^{241}Am). All concentrations were well below regulatory standards and were within historical measurements.

Nonradiological pollutants, including particulates, were monitored at select locations around the INL Site. All results were well below regulatory standards.

One potential pathway for exposure (primarily to workers) to the contaminants released from the INL Site is through surface, drinking, and groundwater. INL Site contractors monitored liquid effluents, drinking water, groundwater, and storm water runoff at the INL Site to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., Wastewater Land Application Permit [WLAP] requirements). The ESER contractor monitored drinking water and surface water at offsite locations. Chapter 5 presents results of monitoring drinking water, effluent and WLAP site performance.

During 2006, liquid effluent and groundwater monitoring were conducted in support of WLAP requirements for INL Site facilities that generate liquid waste streams covered under WLAP rules. The WLAPs generally require compliance with the Idaho groundwater quality primary and secondary constituent standards in specified groundwater monitoring wells. The permits specify annual discharge volume and application rates and effluent quality limits. As required, an annual report was prepared and submitted to the Idaho Department of Environmental Quality (DEQ). Additional parameters were also monitored in the effluent in support of surveillance activities.

Most wastewater and groundwater regulatory and surveillance results were below applicable limits in 2006. However, several elevated concentrations of metals and other constituents were detected in some samples taken from wells at INTEC and at the Test Area North (TAN). An investigation of these exceedances will be conducted during 2007.

A maximum effective dose equivalent of 0.3 mrem/year (3 µSv/year), less than the 4 mrem/year (40 µSv/year) U.S. Environmental Protection Agency (EPA) standard for public drinking water systems, was calculated for workers at the Central Facilities Area on the INL Site in 2006.

The DOE no longer conducts compliance activities associated with storm water as it was determined by EPA that no project has a reasonable potential to discharge to U.S. waters.

Chapter 6 presents the results of environmental monitoring of the Eastern Snake River Plain Aquifer and surface water. Results from a number of special studies conducted by the USGS of the properties of the aquifer were published during 2006. Two monitoring wells downgradient of Reactor Technology Complex (RTC) and INTEC show the highest tritium concentrations in the aquifer and are thus representative of maximum tritium concentration trends in the rest of the aquifer. Tritium concentrations in these two wells demonstrate a decreasing trend over time. Several purgeable organic compounds continue to be found in monitoring wells, including drinking water wells at the INL Site. Concentrations of organic compounds were below the state of Idaho groundwater primary and secondary constituent standards as well as EPA maximum contaminant levels (MCLs) for these compounds.

Groundwater surveillance monitoring continued for the WAG on the INL Site in 2006. At TAN, results of groundwater monitoring indicated that in situ bioremediation of the plume of Trichloroethene has been effective. Chromium was above the MCL in one well at the the RTC. However this concentration has been decreasing over time. Monitoring at Central Facilities Area landfills detected nitrate and thallium levels above their respective MCLs. At the INTEC, four constituents exceeded their MCLs, but concentrations of most radionuclides are decreasing over time. Concentrations of carbon tetrachloride and trichloroethylene consistently exceeded the MCLs in two wells located north of the Subsurface Disposal Area (SDA). While concentrations of these two constituents are increasing at locations north of the SDA, they are decreasing in wells south of the SDA.

Thirty semiannual drinking water samples were collected from 14 locations off the INL Site and around the Snake River Plain in 2006. Two samples had measurable tritium, three samples had measurable gross alpha activity, and 26 samples had measurable gross beta activity. None of the sample results exceeded the EPA MCL for these constituents and were considered to be within background levels.

Thirteen offsite surface water samples were collected from six offsite locations, including the Big Lost River. Two samples had measurable gross alpha activity. All samples had measurable gross beta activity, while only two samples had measurable tritium. None of these constituents were above regulatory limits and are consistent with background levels.

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, wheat, potatoes, and sheep), wildlife, and soil were sampled and analyzed for radionuclides (see Chapter 7). In addition, direct radiation was measured on and off the INL Site in 2006. Some human-made radionuclides were detected in agricultural product, wildlife, and soil samples. Direct radiation measurements made at offsite, boundary, and onsite locations (except RWMC) were consistent with background levels.

DOSE TO THE PUBLIC AND BIOTA

Chapter 8 provides an analysis of the potential radiation dose to members of the public and to biota. Potential radiological doses to the public from INL Site operations were evaluated to determine compliance with pertinent regulations and limits. Two different computer programs were used to estimate doses: the Clean Air Act Assessment Package, 1988 (CAP-88) computer code and the mesoscale diffusion (MDIFF) air dispersion model. CAP-88 is required by the EPA to demonstrate compliance with the Clean Air Act. The NOAA Air Resources Laboratory-Field Research Division developed MDIFF to evaluate dispersion of pollutants in arid environments such as those found at the INL Site.

The maximum calculated dose to an individual by either of the methods was well below the applicable radiation protection standard of 10 mrem/year. The dose to the maximally exposed individual, as determined by the CAP-88 program, was 0.04 mrem (0.4 μSv). The dose calculated using the MDIFF dispersion guide was 0.05 mrem (0.5 μSv). The dose from natural background radiation was estimated to be 357 mrem (3.6 mSv). The maximum potential population dose to the approximately 290,819 people residing within an 80-km (50-mi) radius of any INL facility was calculated as 0.61 person-rem (6.1×10^{-3} person-Sv), well below that expected from exposure to background radiation (103,822 person-rem or 1,038 person-Sv).

The maximum potential individual doses from consuming waterfowl and big game animals at the INL, based on the highest concentrations of radionuclides measured in samples of these animals, were estimated to be 0.01 mrem (.13 μSv), and 0.007 mrem (0.07 μSv), respectively. These estimates are conservatively high.

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

ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

Chapter 9 describes the ecological research activities that took place on the INL Site. The INL Site was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in the 1970s 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 NERPs provide rich environments to train researchers and introduce the public to ecological science. They have been used to educate grade school and high school students and the general public about ecosystem interactions at DOE sites; to 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 at the INL Site began in 1950 with the establishment of the long-term vegetation transect. This is perhaps DOE's oldest ecological data set and one of the oldest vegetation data sets in the West. Ecological research on the NERPs is leading to planning for better land use, identifying sensitive

areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increasing contributions to ecological science in general.

The following ecological research projects took place at the Idaho NERP during 2006:

- Monitoring amphibian and reptile populations on the INL Site as indicators of environmental health and change;
- Annotated checklist of the ants on the INL Site;
- Ecology and conservation of rattlesnakes in sagebrush steppe ecosystems;
- Seasonal and landscape variation of snake mortality on the Upper Snake River Plain;
- The Protective Cap/Biobarrier Experiment;
- Developing a conservation management plan for the INL Site;
- Cesium in soils and plants in the sagebrush steppe ecosystems;
- Monitoring risk of Cheatgrass invasion and dominance at the INL Site;
- Sagebrush demography on the INL Site; and
- Long-term vegetation trends on the INL Site.

QUALITY ASSURANCE

Chapter 10 describes programs used at the INL Site to ensure environmental data quality. Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to ensure precise, accurate, representative, and reliable results and maximize data completeness. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, these laboratories participate in a number of laboratory quality check programs.

Quality issues that arose with laboratories used by the INL, ICP and ESER contractors were addressed with the laboratories and resolved.

Big Lost River Wash

Helpful Information

SCIENTIFIC NOTATION

Scientific notation is used to express numbers that are very small or very large. A very small number is expressed with a negative exponent, for example, 1.3×10^{-6}. To convert this number to the decimal form, the decimal point must be moved left by the number of places equal to the exponent (six, in this case). The number, thus, becomes 0.0000013.

For large numbers, those with a positive exponent, the decimal point is moved to the right by the number of places equal to the exponent. The number 1,000,000 can be written as 1.0×10^{6}.

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 1000 of a given unit. One kilometer is, therefore, equal to 1000 meters. Table HI-1 shows fractions and multiples of units while, Table HI-2 provides useful conversions.

Table HI-1. Fractions and Multiples of Units.

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

UNITS OF RADIOACTIVITY, RADIATION EXPOSURE, AND DOSE

The basic unit of radioactivity used in this report is the curie (abbreviated Ci). The curie is historically based on the number of disintegrations that occur in 1 gram of the radionuclide radium-226, which is 37 billion nuclear disintegrations per second. For any other radionuclide, 1 Ci is the amount of the radionuclide that decays at this same rate.

Table HI-2. Most Commonly Used Radionuclides and Symbols Used in this Report.

Radionuclide	Symbol
Actinium-227	^{227}Ac
Americium-241	^{241}Am
Americium-242	^{242}Am
Americium-242m[a]	^{242m}Am
Americium-243	^{243}Am
Antimony-124	^{124}Sb
Antimony-125	^{125}Sb
Antimony-126	^{126}Sb
Antimony-126m[a]	^{126m}Sb
Antimony-127	^{127}Sb
Argon-41	^{41}Ar
Barium-133	^{133}Ba
Barium-137	^{137}Ba
Barium-139	^{139}Ba
Barium-140	^{140}Ba
Barium-141	^{141}Ba
Beryllium-7	^{7}Be
Bismuth-210	^{210}Bi
Bismuth-211	^{211}Bi
Bismuth-212	^{212}Bi
Bismuth-214	^{214}Bi
Cadmium-115m[a]	^{115m}Cd
Californium-252	^{252}Cf
Carbon-14	^{14}C
Cerium-141	^{141}Ce
Cerium-143	^{143}Ce
Cerium-144	^{144}Ce
Cesium-134	^{134}Cs
Cesium-135	^{135}Cs
Cesium-137	^{137}Cs
Cesium-138	^{138}Cs
Chlorine-36	^{36}Cl
Chromium-51	^{51}Cr
Cobalt-57	^{57}Co
Cobalt-58	^{58}Co
Cobalt-60	^{60}Co
Curium-242	^{242}Cm
Curium-243	^{243}Cm
Curium-245	^{245}Cm
Curium-246	^{246}Cm
Curium-247	^{247}Cm
Curium-248	^{248}Cm
Curium-244	^{244}Cm
Europium-152	^{152}Eu
Europium-154	^{154}Eu
Europium-155	^{155}Eu

Radionuclide	Symbol
Francium-221	^{221}Fr
Francium-223	^{223}Fr
Hafnium-181	^{181}Hf
Holmium-166	^{166}Hf
Holmium-166m[a]	^{166m}Ho
Iodine-125	^{125}I
Iodine-129	^{129}I
Iodine-131	^{131}I
Iodine-132	^{132}I
Iodine-133	^{133}I
Iodine-134	^{134}I
Iodine-135	^{135}I
Indium-115	^{115}In
Iridium-192	^{192}Ir
Iron-55	^{55}Fe
Iron-59	^{59}Fe
Krypton-85	^{85}Kr
Krypton-85m[a]	^{85m}Kr
Krypton-87	^{87}Kr
Krypton-88	^{88}Kr
Lanthanum-140	^{140}La
Lead-209	^{209}Pb
Lead-210	^{210}Pb
Lead-211	^{211}Pb
Lead-212	^{212}Pb
Lead-214	^{214}Pb
Manganese-54	^{54}Mn
Mercury-203	^{203}Hg
Molybdenum-99	^{99}Mo
Neodymium-147	^{147}Nd
Neptunium-237	^{237}Np
Neptunium-238	^{238}Np
Neptunium-239	^{239}Np
Neptunium-240	^{240}Np
Neptunium-240m[a]	^{240m}Np
Nickel-59	^{59}Ni
Nickel-63	^{63}Ni
Niobium-93m[a]	^{93m}Nb
Niobium-94	^{94}Nb
Niobium-95	^{95}Nb
Niobium-95m[a]	^{95m}Nb
Palladium-107	^{107}Pd
Potassium-40	^{40}K
Plutonium-236	^{236}Pu

Table HI-2. Most Commonly Used Radionuclides and Symbols Used in this Report. (continued)

Radionuclide	Symbol
Plutonium-238	^{238}Pu
Plutonium-239	^{239}Pu
Plutonium-239/240	$^{239/240}$Pu
Plutonium-240	^{240}Pu
Plutonium-241	^{241}Pu
Plutonium-242	^{242}Pu
Plutonium-243	^{243}Pu
Plutonium-244	^{244}Pu
Polonium-210	^{210}Po
Polonium-218	^{218}Po
Praseodymium-144	^{144}Pr
Praseodymium-144m[a]	^{144m}Pr
Promethium-147	^{147}Pm
Promethium-148	^{148}Pm
Promethium-148m[a]	^{148m}Pm
Protactinium-231	^{231}Pa
Protactinium-233	^{233}Pa
Radium-223	223Ra
Radium-225	225Ra
Radium-226	226Ra
Radium-228	228Ra
Rhodium-103m[a]	^{103m}Rh
Rhodium-105	^{105}Rh
Rubidium-87	^{87}Rb
Rubidium-88	^{88}Rb
Rubidium-88d	^{88d}Rb
Rubidium-89	^{89}Rb
Ruthenium-103	^{103}Ru
Ruthenium-106	^{106}Ru
Samarium-147	^{147}Sm
Samarium-151	^{151}Sm
Scandium-46	^{46}Sc
Silver-109m[a]	^{109m}Ag
Silver-110	^{110}Ag
Silver-110m[a]	^{110m}Ag
Sodium-22	^{22}Na
Sodium-24	^{24}Na
Strontium-89	^{89}Sr
Strontium-90	^{90}Sr
Strontium-91	^{91}Sr
Strontium-92	^{92}Sr
Technetium-99	^{99}Tc
Technetium-99m[a]	^{99m}Tc
Tellurium-127	^{127}Te
Tellurium-127m[a]	^{127m}Te
Tellurium-129	^{129}Te
Tellurium-129m[a]	^{129m}Te
Terbium-160	^{160}Tb
Tin-113	^{113}Sn
Tin-123	^{123}Sn
Tin-126	^{126}Sn
Thallium-207	^{207}Tl
Thallium-208	^{208}Tl
Thalllium-209	^{209}Tl
Thorium-227	^{227}Th
Thorium-230	^{230}Th
Thorium-231	^{231}Th
Thorium-232	^{232}Th
Tritium	^{3}H
Tungsten-187	^{187}W
Uranium-232	^{232}U
Uranium-233	^{233}U
Uranium-233/234	$^{233/234}$U
Uranium-234	^{234}U
Uranium-235	^{235}U
Uranium-236	^{236}U
Uranium-237	^{237}U
Uranium-238	^{238}U
Uranium-240	^{240}U
Xenon-127	^{127}Xe
Xenon-131m[a]	^{131m}Xe
Xenon-133	^{133}Xe
Xenon-133m[a]	^{133m}Xe
Xenon-135	^{135}Xe
Xenon-135m[a]	^{135m}Xe
Xenon-137	^{137}Xe
Xenon-138	^{138}Xe
Yttrium-90	^{90}Y
Yttrium-90m[a]	^{90m}Y
Yttrium-91	^{91}Y
Zinc-65	^{65}Zn
Zirconium-93	^{93}Zr
Zirconium-95	^{95}Zr

a. The letter 'm' after a number denotes a metastable (transitional isotope normally with very short half lives) isotope.

Radiation exposure is expressed in terms of the roentgen (R), the amount of ionization produced by gamma radiation in air. Dose is given in units of roentgen equivalent man (or rem), which takes into account the effect of radiation on tissues. For the types of environmental radiation generally encountered, the unit of roentgen is approximately numerically equal to the unit of rem. A person-rem is the sum of the doses received by all individuals in a population.

The concentration of radioactivity in air samples is expressed in units of microcuries per milliliter (µCi/mL) of air. For liquid samples, such as water and milk, the units are in picocuries per liter (pCi/L). Radioactivity in agricultural products is expressed in picocuries per gram (pCi/g) dry weight. Annual human radiation exposure, measured by environmental dosimeters, is expressed in units of milliroentgens (mR). This is sometimes expressed in terms of dose as millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor.

The Système International is also used to express units of radioactivity and radiation dose. The basic 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. Radiation dose may also be expressed using the Système International unit sievert (Sv), where 1 Sv equals 100 rem.

UNCERTAINTY OF MEASUREMENTS

There is always an uncertainty associated with the measurement of environmental contaminants. For radioactivity, a major source of uncertainty is the inherent statistical nature of radioactive decay events, particularly at the low activity levels encountered in environmental samples. The uncertainty of a measurement is denoted by following each result with plus or minus (±) uncertainty term. Individual analytical results are presented in tables in this report with plus or minus one analytical deviation (± 1s). Generally the result is considered "detected" if the measurement is greater than three times its estimated analytical uncertainty (3s) unless noted otherwise, for consistency with other INL Site environmental monitoring reports.

NEGATIVE NUMBERS AS RESULTS

Negative values occur in radiation measurements when the measured result is less than a pre-established average background level for the particular counting system and procedure used. These values are reported as negative, rather than as "not detected" or "zero," to better enable statistical analyses and observe trends or bias in the data.

RADIONUCLIDE NOMENCLATURE

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different isotopes, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the atom). Most commonly used radionuclide symbols used in this report are shown in Table HI-2.

Acronyms

AMWTP	Advanced Mixed Waste Treatment Project
ANL-W	Argonne National Laboratory-West
ANOVA	Analysis of Variance
ARA	Auxiliary Reactor Area
ARP	Accelerated Retrieval Project
ASER	Annual Site Environmental Report
ATR	Advanced Test Reactor
BBI	Bechtel Bettis, Inc.
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
BEA	Battelle Energy Alliance
BLM	U.S. Bureau of Land Management
BNFL	British Nuclear Fuels Limited
BOD	Biochemical Oxygen Demand
BLR	Big Lost River
BSU	Boise State University
CAES	Center for Advanced Energy Studies
CAP-88	Clean Air Act Assessment Package, 1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFD	Cumulative Frequency Distribution
CFR	Code of Federal Regulations
CINB	Cinder Butte
CITRC/PBF	Critical Infrastructure Test Range Complex/Power Burst Facility
CMS	Community Monitoring Station
COC	Contaminant of Concern
COD	Chemical Oxygen Demand
CRAB	Crater Butte
CRMP	Cultural Resource Management Plan
CTF	Contained Test Facility
CWA	Clean Water Act

CWI	CH2M-WG Idaho
DCG	Derived Concentration Guide
DD&D	Decontamination, Decommissioning, and Demolition
DEQ	Department of Environmental Quality (state of Idaho)
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy - Headquarters
DOE-ID	U.S. Department of Energy - Idaho Operations Office
DOI	U.S. Department of the Interior
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor - No. 1
ECF	Expended Core Facility
ECG	Environmental Concentration Guide
EFS	Experimental Field Station
EIS	Environmental Impact Statement
EM	DOE Office of Environmental Management
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESER	Environmental Surveillance, Education, and Research
ESRPA	Eastern Snake River Plain Aquifer
ESRP	Eastern Snake River Plain
ET	Evapotranspiration
ETR	Engineering Test Reactor
FAA	Federal Aviation Administration
FAST	Fluorinel Dissolution Process and Fuel Storage Facility
FEIS	Final Environmental Impact Statement
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Regulations
FY	Fiscal Year
GEL	General Engineering Laboratories

GEM	Glovebox Excavator Method
GIS	Geographic Information System
GPRS	Global Positioning Radiometric Scanner
GPS	Global Positioning System
HAER	Historic American Engineering Record
HDR	Hydrogeological Data Repository
HLW	High-level Waste
HLW & FD EIS	High-Level Waste and Facilities Disposition Environmental Impact Statement
HpGe	High-Purity Germanium Detector
ICDF	INL CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IFSF	Irradiated Fuel Storage Facility
IFSFI	Irradiated Fuel Storage Facility Installation
IMPROVE	Interagency Monitoring of Protected Visual Environments
INEEL	Idaho National Engineering and Environmental Laboratory
INEL	Idaho National Engineering Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
ISU	Idaho State University
keV	Kilo-electron Volts
LDRD	Laboratory Directed Research and Development
LOFT	Loss-of-Fluid Test
LTS	Long-Term Stewardship
LTV	Long-Tern Vegetation
M&O	Management and Operating
Ma	Million Years

MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MFC	Materials and Fuels Complex
MNA	Monitored Natural Attenuation
NCER	National Center for Environmental Research
ND	Non Detected
NE	Nuclear Energy, Science and Technology
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory - Field Research Division
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NS	No Sample
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment

PCS	Primary Constituent Standard
PE	Performance Evaluation
POC	Purgeable Organic Compounds
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
QA	Quality Assurance
QC	Quality Control
RCAV	Rattlesnake Cave
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
RH	Remote Handled
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
ROD	Record of Decision
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SA	Supplement Analysis
SAM	Sample and Analysis Management
SAR	Sodium Absorption Ratio
SBW	Sodium Bearing Waste
SCS	Secondary Constituent Standard
SD	Sample was Destroyed
SDA	Subsurface Disposal Area
SEM	Structural Equation Model
SHPO	State Historic Preservation Office
SI	International System of Units
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level

SNF	Spent Nuclear Fuel
SP	Suspended Particle
SRP	Snake River Plain
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TIC	Total Integrated Concentration
TLD	Thermoluminescent Dosimeter
TMI	Three-Mile Island
TRA	Test Reactor Area
TRIGA	Training, Research, Isotopes, General Atomics
TRU	Transuranic (waste)
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
WAG	Waste Area Group
WIPP	Waste Isolation Pilot Plant
WLAP	Wastewater Land Application Permit
WRRTF	Water Reactor Research Test Facility
YSRP	Yellowstone-Snake River Plain

Units

Bq	becquerel
cfm	cubic feet per minute
C	Celsius
Ci	curie
cm	centimeter
cps	counts per second
F	Fahrenheit
ft	feet
g	gram
gal	gallon
gpd	gallons per day
ha	hectare
in.	inch
KeV	kilo-electron-volts
kg	kilogram
km	kilometer
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6} curies)
µg	microgram
µm	micrometer
µS	microsiemens
µSv	microsieverts
Ma	million years
mg	milligram
MG	million gallons
mGy	milligrey
mi	mile
min	minutes
mL	milliliter
mm	millimeters
mmhos/cm	millimhos per centimeter
mR	milliroentgen
mrem	millirem
mSv	millisievert
ng	nanogram
oz	ounce
pCi	picocurie (10^{-12} curies)
ppm	parts per million
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard

Paintbrush

Chapter 1 - Introduction

Long-tailed Weasel

M. Case - S. M. Stoller Corporation
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1. INTRODUCTION

This report provides an introduction to the Idaho National Laboratory (INL) Site, discusses site missions, and highlights the Site's various environmental-related programs. Included are sections discussing site compliance with local, state, and federal environmental laws and regulations; site operations including environmental restoration, waste management, and footprint reduction activities; effluent and emissions from Site facilities; onsite and offsite environmental monitoring activities; radiological doses to public and biota; and ecological research activities at the Site. The report describes the INL Site's impact to the public and the environment, particularly with regard to radioactive contaminants. It is prepared annually in compliance with U.S. Department of Energy (DOE) Orders 231.1A, 450.1, and 5400.5.

1.1 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 project activities stemming from past operations. 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, Science and Technology (NE) and the Office of Environmental Management (EM). NE is the Lead Program Secretarial Officer for all DOE-ID managed operations on the INL Site, while EM provides direction and guidance to DOE-ID for environmental cleanup operations on the INL Site and functions in the capacity of Cognizant Secretarial Officer. Naval Reactors operations on the INL Site report to the Pittsburgh Naval Reactors Office and so fall outside the purview of DOE-ID.

Idaho National Laboratory

The INL mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems and unique national and homeland security capabilities. Its vision is to be the preeminent nuclear energy laboratory, with synergistic, world-class, multiprogram 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 a Generation IV prototype reactor, creation of national user facilities based on the Advanced Test Reactor (ATR) and the Critical Infrastructure Test Range Complex, piloting of an Advanced Fuel Cycle Facility, demonstration of thermochemical/high-temperature hydrogen production, and expansion of the Center for Advanced Energy Studies. Applying critical mission enablers will propel the INL transformation. These enablers will include developing public trust and confidence in

INL and nuclear energy; demonstrating world-leading safety, environmental, and operational performance; creating three modern laboratory campuses; developing, recruiting, and retaining a world-class work force; adopting best-in-class laboratory management systems and information technology; and establishing and leveraging new research centers. The management and operation responsibility for the INL belongs to Battelle Energy Alliance (BEA).

Idaho Cleanup Project

The Idaho Cleanup Project (ICP) involves the safe, environmental cleanup of the INL Site, which has been contaminated with waste generated from World War II-era conventional weapons testing, government-owned research and defense reactors, laboratory research, and defense missions at other DOE sites. The 7-year, $2.9 billion cleanup project, led by CH2M-WG Idaho (CWI) and funded through the DOE's EM, focuses equally on reducing risks to workers, the public, and the environment and on protecting the Snake River Plain Aquifer, the sole drinking water source for more than 300,000 residents of eastern Idaho.

CWI will treat a million gallons of sodium-bearing waste, remove targeted transuranic waste from the Subsurface Disposal Area, and demolish more than 200 structures including reactors, spent nuclear fuel storage basins, and labs used for radioactive experiments.

Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) Facility is the DOE's most advanced waste treatment facility and is a cornerstone of DOE's commitment to prepare and ship waste out of Idaho. AMWTP is managed and operated by Bechtel BWXT Idaho.

Operations at AMWTP require the retrieval, characterization, treatment and packaging of transuranic waste currently stored at the INL Site. The project's schedule is aligned with court-mandated milestones in a 1995 Settlement Agreement between the state of Idaho, the U.S. Navy, and DOE to remove the waste from Idaho. The vast majority of the waste AMWTP processes resulted from the manufacture of nuclear components at Colorado's Rocky Flats Plant. Shipped to Idaho in the 1970s and early 1980s for storage, the waste 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 non-radioactive hazardous chemicals such as oil and solvents. Since 1999, more than 14,000 m^3 (494,405 ft^3) of waste have been shipped offsite.

Primary INL Site Facilities

The INL Site is a 2305 km^2 (890 mi^2) area located in southeastern Idaho. The INL Site consists of several facility areas situated on an expanse of otherwise undeveloped, cool desert terrain (Figure 1-1). Most buildings and structures at the INL Site occur within those developed site areas, which are typically less than a few square miles in size and separated from each other by miles of primarily undeveloped land. DOE controls all land within the INL Site. 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 border.

Central Facilities Area (CFA) - CFA is the main service and support center for INL's desert facilities. Activities here support transportation, maintenance, construction, environmental and radiological monitoring, security, fire protection, warehouses and calibration activities. CFA is operated by BEA.

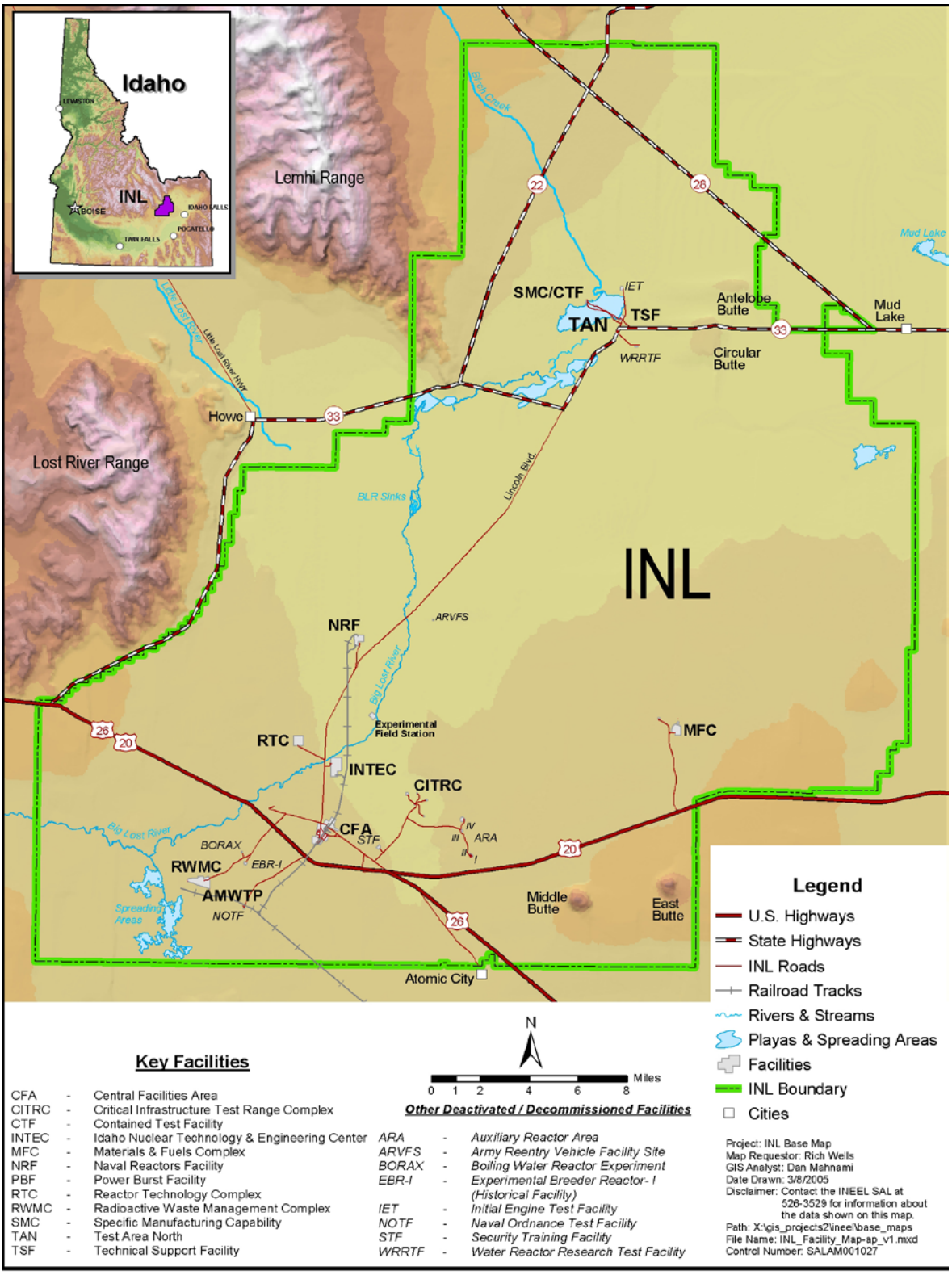

Figure 1-1. Location of the INL Site, showing Facilities.

Critical Infrastructure Test Range Complex (CITRC) - 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. The Test Range provides open landscape, technical employees, and specialized facilities for performing work in three main areas: Physical Security, Contraband Detection, and Infrastructure Testing. CITRC is operated by BEA.

Idaho Nuclear Technology and Engineering Center (INTEC) - The Idaho Chemical Processing Plant was established in the 1950s to recover usable uranium in spent fuel from government reactors. Over the years, the facility recovered more than $1 billion worth of highly enriched uranium, which 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. Calcination reduced the volume of liquid radioactive waste generated during reprocessing and placed it in a more-stable granular solid form. The facility underwent an ambitious modernization during the 1980s, when safer, cleaner, and more efficient structures were built to replace most major facilities. In 1992, the DOE announced that the changing world political situation and the lack of demand for highly enriched uranium made reprocessing no longer necessary. In 1998, the plant was renamed the Idaho Nuclear Technology and Engineering Center. Current operations at INTEC include management of sodium-bearing waste, nuclear material disposition, environmental remediation, and demolition of excess facilities. INTEC is operated by CWI.

Materials and Fuels Complex (MFC) - The Materials and Fuels Complex (formerly Argonne National Laboratory-West) 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. Depending on the feasibility of a key project, buildings will be constructed at this location to support manufacturing and assembling components for use in space applications. MFC is operated by BEA.

Naval Reactors Facility (NRF) - The Naval Reactors Facility is operated for Naval Reactors by Bechtel Bettis, Inc. Developmental nuclear fuel material samples, naval spent fuel and irradiated reactor plant components/materials are examined at the Expended Core Facility (ECF). The knowledge gained from these examinations is used to improve current reactor designs and to monitor the performance of existing reactors. The naval spent fuel examined at ECF is critical to the design of longer-lived cores, which minimizes the creation of spent fuel requiring long-term disposition. NRF is also preparing the current inventory of naval fuel for dry storage and eventual transportation to a repository.

NRF is excluded from this report. As established in Executive Order 12344 (FR 1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 450.1, 5400.5, and 414.1c. The director, Naval Nuclear Propulsion Program, establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. NRF's program is documented in the NRF Environmental Monitoring Report (BBI 2006).

Radioactive Waste Management Complex (RWMC) - Since the 1950s, the DOE has used the RWMC to manage, store, and dispose of waste contaminated with radioactive elements generated in national defense and research programs. The RWMC manages solid transuranic and low-level radioactive waste. The facility supports research projects dealing with waste retrieval and processing technology and provides temporary storage and treatment of transuranic waste destined for the Waste Isolation Pilot Plant (WIPP).

The Subsurface Disposal Area (SDA), a 39-ha (97-acre) radioactive waste landfill that is the major focus for remedial decisions at the RWMC. The landfill has been used for more than 50 years. Approximately 14 of the 39-ha contain waste from historical operations, including weapons production and reactor research. This waste includes radioactive elements, organic solvents, acids, nitrates, and metals. Organic solvents are now found in the aquifer beneath the SDA. Most of the waste that would be considered transuranic by today's standards was received from the Rocky Flats Plant in Colorado prior to 1970 and buried at the SDA. Although transuranics do not threaten the aquifer, they could one day pose a threat through exposure at the surface if no action is taken. The RWMC is operated by CWI.

Reactor Technology Complex (RTC) - RTC 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 RTC is operation of the Advanced Test Reactor, the world's premier test reactor, which is used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The complex also features the Advanced Test Reactor – Critical Facility; Hot Cell Facility; Radiation Measurements Laboratory; Radiochemistry Laboratory; and the Safety and Tritium Applied Research Facility – a national fusion safety user facility. RTC will be the focal point for designing, testing and proving the new technologies of the nuclear renaissance. RTC is operated by BEA.

Science and Technology Campus - The Science and Technology Campus, operated by BEA, is the collective name for INL's administrative, technical support, and computer facilities in Idaho Falls, as well as the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. The name of this cadre of facilities indicates both basic science research and the engineering that translates new knowledge into products and processes that improve our 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. New laboratory facilities and a new building for the Center for Advanced Energy Studies (CAES) are envisioned within this campus environment. The CAES facility is designed to promote education and world-class research and development. Other facilities proposed over the next 10 years include a national security building, a visitor's center, visitor housing and a parking structure–all in close proximity to current campus buildings. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory.

Test Area North (TAN) – TAN was established in the 1950s to support the government's Aircraft Nuclear Propulsion program. The goal was 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. LOFT, constructed between 1965 and 1975, was a scaled-down version of a commercial pressurized water reactor. Its design allowed engineers, scientists and operators to create or recreate loss-of-fluid accidents (reactor fuel meltdowns) under very controlled conditions. The LOFT dome provided containment for a relatively small, mobile test reactor that was moved in and out of the facility on a railroad car. The Nuclear Regulatory Commission received the results from these accident tests and incorporated the data into commercial reactor operating codes. The facility conducted 38 experiments, including several small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island in Pennsylvania, before the LOFT facility was closed.

TAN also housed the Three Mile Island (TMI) Unit 2 Core Offsite Examination Program that ended in 1990. Shipment of TMI-2 core samples to the INL Site began in 1985 to study and obtain technical data necessary to understand the sequential events tied to the TMI-2 reactor accident. INL scientists also used the core samples to develop a database that predicts how nuclear fuel will behave when a reactor core degrades. Currently, the TAN facilities support two projects. The Specific Manufacturing Capability Project, operated for the U.S. Department of Defense by BEA, manufactures protective armor for the U.S. Army M1-A1 and M1-A2 Abrams tanks. TAN personnel also manage cleanup of environmental contamination from previous operations. The TAN facility has gone through major changes in the last few years as cleanup projects are completed and buildings no longer needed for the INL mission are demolished. The cleanup mission at TAN is performed by CWI.

1.2 Physical Setting of the INL Site

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe habitat. Approximately 94 percent of the land on the INL Site is open and undeveloped. The INL Site has an average elevation of 1500 m (4900 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 rangeland, foothills, or agricultural fields. Agricultural activity is concentrated in areas northeast of the INL Site. Approximately sixty percent of the INL Site is open to livestock grazing.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (less than 22.8 cm/year [9 in/year]), warm summers (average daily temperature of 15.7°C [60.3°F]), and cold winters (average daily temperature of -5.2°C [22.6°F]) (DOE-ID 1989). The altitude, intermountain setting, and latitude of the INL Site combine to produce a semiarid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain. Air masses, which gather moisture over the Pacific Ocean, traverse several hundred miles of mountainous terrain before reaching southeastern Idaho. Frequently, the result is dry air and little cloud cover. Solar heating can be intense with extreme day-to-night temperature fluctuations.

Basalt flows, which produce a rolling topography, cover most of the plain. Vegetation is visually dominated by big sagebrush (*Artemisia tridentata*). Beneath these shrubs are grasses and flowering plants, most adapted to the harsh climate. A recent inventory counted 409 plant species 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 counts 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 toward the northeast, ending in a playa area, called the Big Lost River Sinks, on the northwest portion of the Site. Here it evaporates or infiltrates into the subsurface. Surface water does not move offsite. The fractured volcanic rocks under the INL Site, however, form a portion of the Eastern Snake River Plain Aquifer (ESRPA), which stretches 267 km (165 mi) from St. Anthony to Bliss, Idaho, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 80 to 120 million ha-ft (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from waters of the Henry's Fork and the South Fork of the Snake River, as well as the Big Lost River, the Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally to the southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The ESRPA emerges in springs along the Snake River between Milner and Bliss, Idaho. The primary use of both surface water and groundwater on the Snake River Plain is crop irrigation.

1.3 History of the INL

The geologic events that have shaped the modern Snake River Plain (SRP) 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 (YSRP) volcanic field is based on the time-progressive volcanic origin of this region that is characterized by several large calderas in the eastern SRP 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 and are followed by a sequence of silicic centers at about 6 Ma, southwest of Yellowstone. A third group, near ~10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the SRP are ~16 Ma, and are distributed across a 150 km-wide (93 mi-wide) zone in southwestern Idaho and northern Nevada, the suspected origin of the YSRP (from Smith and Siegal, 2000).

Humans first appeared on the upper SRP approximately 11,000 years ago. Tools recovered from this period indicate these earliest human inhabitants were almost certainly hunters of large game. The ancestors of the present-day Shoshone and Bannock people came north from the Great Basin around 4500 years ago (ESRF 1996).

The earliest exploratory visits by European descendants came between 1810 and 1840. Trappers and fur traders were some of the first to make their way across the plain seeking new supplies of beavers for 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 Station 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. The DOE's predecessor, the U.S. Atomic Energy Commission (AEC), needed an isolated location with an ample groundwater supply on which to build and test nuclear power reactors. The relatively isolated SRP was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station (NRTS) in 1949.

By the end of 1951, EBR-I became the first reactor to produce useful electricity. In 1955, the BORAX-III reactor provided electricity to Arco, Idaho – the first time a nuclear reactor powered an entire community

in the U.S. The laboratory 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 NRTS was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory (INEEL) in 1997 to reflect the Site's leadership role in environmental management. The AEC 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 the DOE announced in 2003 that Argonne National Laboratory-West (ANL-W) and the INEEL would be the lead laboratories for development of the next generation of power reactors. On February 1, 2005, the INEEL and ANL-W became the INL. The INL is committed to providing international nuclear leadership for the 21st Century, developing and demonstrating compelling national security technologies, and delivering excellence in science and technology as one of the DOE's multiprogram national laboratories.

1.4 Regional Impact

In 2006, Boise State University's (BSU) College of Business and Economics evaluated the effects on the Idaho economy of all cleanup, research and administrative operations at the INL Site (Black et al. 2006). The Impacts 2006 report details the results of this latest comprehensive research and demonstrates to stakeholders the significant and positive effects INL Site operations have on the region immediately surrounding its facilities, as well as on the entire state.

The report provides an analysis of three dimensions of the lab's contributions to the state and region. The first is INL's impact on employment, personal income and total output for the state. Second, the report assesses the impacts of the lab and its employees on state and local tax revenues. Third, the study examines the effects of INL Site employees' charitable contributions, educational outreach and volunteer activities on the surrounding communities and the state. The report measures direct, secondary and tertiary impacts of INL's operations.

Major findings of Impacts 2006 include:

- The INL Site, when considered as a whole, is the third-largest employer in Idaho, with 8452 employees, ranking behind only Micron and state government. When secondary and tertiary impacts on employment are analyzed, INL operations annually account for 19,860 jobs in Idaho.
- Wages and salaries to INL Site employees account for more than 2.5 percent of personal income in Idaho with direct and secondary effects on personal income amounting to $1.108 billion annually.
- Fiscal impacts of Idaho state tax revenues by the INL Site and its employees approach $85 million or nearly 3 percent of all tax revenues received by the state.
- These direct tax payments to the state of Idaho by INL employers and their workers exceed the cost of state-provided services by a broad margin.
- Annual property tax payments by INL employees approach $23 million.
- The INL Site provides $3.4 million to Idaho colleges and universities for continuing education of its employees.

The research for Impacts 2006 was performed by three highly respected BSU economists - Dr. Geoffrey Black, chair of the Economics Department; Dr. Don Holley, former corporate economic forecaster

and analyst and now a visiting professor; and John Church, former corporate economist and now special lecturer in the Economics Department and a member of the Western Blue Chip Forecast Panel (Black et al 2006).

In their summary comments, the researchers conclude, "Whether improving quality of life through the development and commercialization of cutting-edge technologies, reducing risks through accelerated environmental cleanup, providing much-needed tax revenues, or stabilizing and strengthening Idaho's economy by its mere presence, INL's overall impacts on Idaho are unquestionably significant."

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Evening Primrose

Chapter 2 - Environmental Compliance Summary

Least Chipmunk

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2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (INL) Site with environmental protection requirements. Section 2.1 discusses the compliance status of the INL Site with respect to major environmental acts, agreements, and orders. Section 2.2 discusses environmental occurrences, which are nonpermitted releases that require notification of a regulatory agency outside of the U.S. Department of Energy (DOE). Section 2.3 presents a summary of environmental permits for the INL Site. The programs in place to attain compliance with major acts, agreements, and orders are discussed in Chapter 3.

2.1 Compliance Status

Operations at the INL Site are subject to numerous federal and state environmental statutes, executive orders, and DOE orders. These are listed in Appendix A. This section presents a brief summary of the INL's compliance status with those regulations. Table 2-1 shows how the discussion is organized.

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 and/or radioactive substances. Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. The INL Site was placed on the National Priorities List under CERCLA on November 29, 1989. The U. S. Department of Energy-Idaho Operations Office (DOE-ID), the state of Idaho, and the U.S. Environmental Protection Agency (EPA) Region 10 signed the Federal Facility Agreement and Consent Order (FFA/CO) in December 1991. The cleanup contractor, CH2M-WG Idaho in accordance with the FFA/CO, is conducting environmental restoration activities at the INL Site.

The INL Site is divided into ten Waste Area Groups (WAGs) as a result of the FFA/CO. Field investigations are used to evaluate potential release sites within each WAG 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 Further Action" listing is possible or if it is appropriate to proceed with an interim cleanup action or further investigation using a remedial investigation/feasibility study (RI/FS). Results from the RI/FS form the basis for assessment of risks and alternative cleanup actions. This information, along with the agencies proposed cleanup plan is presented to the public in a document called a Proposed Plan. After reviewing public comments, DOE-ID, EPA, and the State reach a final cleanup

Table 2-1. Environmental Compliance Status.

Activity	Governing Statute or Order
Radiation Protection	DOE Order 5400.5, "Radiation Protection of the Public and the Environment"
Environmental Remediation and Protection	Comprehensive Environmental Response, Compensation, and Liability Act DOE Order 450.1, "Environmental Protection Program" Emergency Planning and Community Right-to-Know Act National Environmental Policy Act Endangered Species Act Executive Order 11988 – Floodplain Management Executive Order 11990 – Protection of Wetlands
Waste Management	Resource Conservation and Recovery Act Federal Facility Compliance Act Toxic Substances Control Act DOE Order 435.1, "Radioactive Waste Management" State of Idaho Wastewater Land Application Permits Idaho Settlement Agreement
Air Quality and Protection	Clean Air Act
Water Quality and Protection	Clean Water Act Safe Drinking Water Act
Cultural Resources	National Historic Preservation Act Native American Graves Protection and Repatriation Act

decision, which is documented in a Record of Decision (ROD). Cleanup activities then can be designed, implemented, and completed. Specific environmental restoration activities are discussed in Chapter 3.

Natural Resource Trusteeship and Natural Resources Damage Assessment – Executive Order 12580, Section 2(d), appoints the Secretary of Energy as the primary Federal Natural Resource Trustee for natural resources located on, over, and under land administered by DOE. Natural resource trustees act on behalf of the public when natural resources may be injured, destroyed, lost, or threatened as a result of the release of hazardous substances. In the case of the INL Site, other natural resource trustees with jurisdiction over trust resources are the state of Idaho and U.S. Department of Interior (Bureau of Land Management and the U.S. Fish and Wildlife Service).

Past releases of hazardous substances resulted in the INL Site's placement on the National Priorities List. These same releases created the potential for injury to natural resources. DOE is liable under CERCLA for damages to natural resources resulting from releases of hazardous substances to the environment.

Although the ecological risk assessment is a separate effort from the Natural Resources Damage Assessment, it is anticipated that the ecological assessment performed for CERCLA remedial actions can be used to help resolve natural resource issues. Ecological risk assessments at the INL Site have

been conducted using the established guidance manual for conducting screening level ecological risk assessments (Van Horn et al. 1995).

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) ensure that sites, such as the INL Site, provide the public with information about hazardous chemicals stored and used, and establishes emergency planning and notification procedures to protect the public from chemical releases. EPCRA also contains requirements for periodic reporting on hazardous chemicals stored and/or used at a facility. Executive Order 13148, "Greening the Government through Leadership in Environmental Management," requires all federal facilities to comply with the provisions of EPCRA.

311 Report – EPCRA Section 311 reports were submitted quarterly for those chemicals that met the threshold planning quantity. These reports were sent to local emergency planning committees, the State Emergency Response Commission, and to local fire departments for each quarter in calendar year 2006. These quarterly reports satisfied the 90-day notice requirement for new chemicals brought onsite.

312 Report – Local and State planning and response agencies received the Emergency and Hazardous Chemical Inventory (Tier II) Report for calendar year 2005 by March 1, 2006. This report identified the types, quantities, and locations of hazardous and extremely hazardous chemicals stored at INL Site facilities that exceeded:

- 4536 kg (10,000 lbs) (for Occupational Safety and Health Act hazardous chemical),
- 230 kg (500 lbs) (for Extremely Hazardous Substances as defined in Title 40 Code of Federal Regulations, Part 355 [40 Code of Federal Regulations (CFR 355)]), or
- the Threshold Planning Quantity, whichever is less.

313 Report – The Toxic Chemical Release Inventory Report was transmitted to the EPA and the state of Idaho July 1, 2006. The report identifies quantities of 313-listed toxic chemicals that were used/released above activity thresholds. Once these activity thresholds (for manufacturing, processing, or otherwise used) are exceeded, an EPA 313 Toxic Release Inventory Form R report must be completed for each specific chemical. Releases under EPCRA reporting include transfers to offsite waste storage and treatment, air emissions, recycling, and other activities. The INL Site submitted ten reports for calendar year 2005 for toluene, ethylbenzene, lead and lead compounds, nitric acid, naphthalene, propylene, xylene, 1,2,4-trimethylbenzene, nickel, and polycyclic aromatic compounds.

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 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. The DOE-ID NEPA Compliance Officer and NEPA Planning Board implement the process.

The DOE-ID issued the Annual NEPA Planning Summary in January 2006. The summary is a requirement of DOE Order 451.1B, and it is prepared to inform the public and other DOE elements of:

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

Ongoing NEPA reviews of INL Site projects are described below.

Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (Idaho HLW & FD EIS) – This EIS describes the potential environmental impacts of various alternatives for treating and managing high-level radioactive waste and related radioactive wastes and facilities at the Idaho Nuclear Technology and Engineering Center (INTEC). DOE received and considered agency and public comments on a draft EIS. In response to those comments and updated information, DOE incorporated changes into the final EIS. The final EIS was issued in the fall of 2002.

DOE planned for a phased decision-making process. In December 2005, DOE issued a ROD for the Idaho HLW & FD EIS. DOE decided to treat sodium–bearing liquid waste using the steam reforming technology; conduct performance-based closure on all existing facilities directly related to the High-Level Waste (HLW) Program at INTEC, except for the INTEC Tank Farm Facility and bin sets, once their missions are complete; design and construct new waste processing facilities needed to implement the decisions in the ROD consistent with clean closure methods and planned to be clean closed when their missions are complete; and develop HLW calcine retrieval demonstration process and conduct risk-based analysis, including disposal options, focused on the calcine stored at INTEC.

An amended ROD addressing closure of the INTEC Tank Farm Facility was issued in November 2006 in coordination with the Secretary of Energy's determination, in consultation with the Nuclear Regulatory Commission, under Section 3116 of the Fiscal Year 2005 Ronald W. Reagan National Defense Authorization Act. An additional ROD for HLW calcine disposition and bin set closure is scheduled for issuance in 2009.

Environmental Assessment for the Idaho National Laboratory Remote-Handled Waste Disposition (Formerly known as the Remote Treatment Project) - The proposed action is to provide heavily shielded handling services for the sodium contaminated remote-handled (RH) waste stored at the Materials and Fuels Complex (MFC) and the Hanford Reservation and other INL Site legacy remote-handled waste. The project would include a shielded hot cell with equipment for sorting, characterizing, treating and repackaging highly radioactive transuranic, mixed, and other radioactive waste. The facility mission is to make RH radioactive wastes ready for shipment to disposal locations. Much of the proposed action was analyzed in the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final EIS (DOE-ID 1995) as the Remote Mixed Waste Treatment Facility project. DOE notified the state of Idaho and Shoshone-Bannock Tribal contacts in January of 2001. The draft EA is scheduled for public comment in 2007.

Environmental Assessment for the National Security Test Range - The proposed action is to consolidate all INL National Security research and development testing activities at one centralized location

that can accommodate increased explosive weights and eliminate scheduling conflicts. The proposed test range would be specifically designed and constructed to accommodate testing activities in support of analyzing the effects of explosives and explosive devises, munitions, and similar items on security systems, facilities, vehicles, structures, and other materials. The draft environmental assessment was released on December 6, 2006, for public review and comment. Comments received on the draft environmental assessment will be considered by DOE when developing the final environmental assessment.

Endangered Species Act

The Endangered Species Act provides a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, provides a program for the conservation of such endangered species and threatened species, and takes such steps as may be appropriate to achieve the purposes of the international treaties and conventions on threatened and endangered species. It requires that all federal departments and agencies shall seek to conserve endangered species and threatened species and shall use their authorities in furtherance of the purposes of this act.

The Environmental Surveillance, Education and Research Program conducts 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 and Idaho Fish and Game Department.

Two federally protected species may occasionally spend time on the INL Site: the threatened bald eagle (*Haliaeetus leucocephalus*) and the gray wolf (*Canis lupus*). Gray wolves found in the geographical region that includes the INL Site are identified as an experimental/nonessential population and treated as a threatened species. Bald eagles occasionally winter on part of the INL Site and there have been unsubstantiated sightings of gray wolves.

Executive Order 11988 – Floodplain Management

Executive Order 11988 – Floodplain Management 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 reflect consideration of flood hazards and floodplain management. It is the intent of this Executive Order that federal agencies implement floodplain requirements through existing procedures such as those established to implement NEPA. The Code of Federal Regulations (10 CFR 1022) contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an EIS under NEPA, alternative floodplain evaluation requirements are established through the INL Site environmental checklist process.

For the Big Lost River, DOE-ID has accepted the Big Lost River Flood Hazard Study, Idaho National Laboratory (INL), Idaho, U.S. Bureau of Reclamation, 2005. This flood hazard report based on the geomorphological models and has undergone peer review. On January 12, 2006, DOE-ID directed the Idaho Cleanup Project contractor to use this floodplain determination for any activities that require the characterization of flows and hazards associated with the Big Lost River. All activities on the INL site requiring characterization of flows and hazards are expected to utilize this report.

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

Executive Order 11990 – Protection of Wetlands

Executive Order 11990 – Protection of Wetlands 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 environmental checklist process. Activities in wetlands considered waters of the United States or adjacent to waters of the United States may also be subject to the jurisdiction of Section 404 and 402 of the Clean Water Act.

The only area of the INL Site identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The U.S. Fish and Wildlife Service National Wetlands Inventory map is used to identify potential jurisdictional wetlands and nonregulated sites with ecological, environmental, and future development significance. In 2006, no actions took place or had an impact on potentially jurisdictional wetlands on the Site, no future actions are planned that would impact wetlands. However, private parties do conduct cattle grazing in the Big Lost River Sinks area under Bureau of Land Management permits.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE Orders, regulates radioactive wastes and the radioactive part of mixed wastes. Idaho DEQ has issued two RCRA Part A permits for the INL Site and seven Part B permits. One additional Part B permit is pending.

Notices of Violation/Non-compliance – On February 21 - 24, 2006, Idaho DEQ conducted an inspection of the INL. The Idaho DEQ issued a Notice of Violation (NOV) to DOE-ID and BEA on May 15, 2006, for eighteen alleged violations. DOE-ID, BEA and Idaho DEQ conducted a compliance conference on June 23, 2006, to discuss the NOV. The NOV was resolved by execution of a Consent Order signed by all parties on August 10, 2006. The Consent Order required deliverables which were submitted to Idaho DEQ on August 17, 2006. The deliverables included documentation required by the NOV and payment of $32,790 penalty. The Consent Order is closed with all deliverables having been completed.

RCRA Closure Plans – The state of Idaho approved closure plans for the following facilities in 2006:

- Reactor Technology Complex (RTC) Catch Tank modified closure plan (TRA-630)
- INTEC Basin Water Treatment System (CPP-603)
- Radioactive Solids and Liquid Waste Storage Vessel INTEC VES SFE-106 modified closure plan

- Tank System INTEC VES-SFE-126 (CPP-603)
- TAN V-Tanks 1, 2, and 3 Intermediate-Level Radioactive Waste Feed System Phase II modified closure plan
- Radioactive Liquid Waste Transfer and Storage Facility (TAN-666).

RCRA Reports – As required by the state of Idaho, the INL Site submitted the Idaho Hazardous Waste Generator Annual Report for 2006. The report contains information on waste generation, treatment, recycling, and disposal activities at INL Site facilities.

DOE-ID submitted the INL Site 2006 Affirmative Procurement Report to the EPA, as required by Section 6002 of RCRA and Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition." This report provides information on the INL's Site procurement of products with recycled content.

The INL Site RCRA permit for the Hazardous Waste Storage Facility at the Central Facilities Area (CFA) and some areas at the Materials and Fuels Complex (MFC) requires submittal of an annual certification to Idaho DEQ that the INL Site has a waste minimization program in place to reduce the volume and toxicity of hazardous waste. The certification was submitted by July 1, 2006.

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 INL Site Proposed Site Treatment Plan formed the basis for negotiations between the state of Idaho and DOE-ID on the consent order for mixed waste treatment at the INL Site. The Federal Facility Compliance Act Consent Order and Site Treatment Plan were finalized and signed by the state of Idaho on November 1, 1995.

A status of Site Treatment Plan milestones for 2006 is provided in Chapter 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 Clean Air Act, the Clean Water Act, and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with TSCA at the INL Site is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls (PCBs). Removal of PCB-containing light ballasts continues at buildings undergoing demolition. The ballasts are disposed of off-site in a TSCA-approved disposal facility. One PCB spill occurred at MFC and the area was cleaned per regulatory requirements.

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.

This Order, effective July 1, 1999, replaces DOE Order 5820.2A, "Radioactive Waste Management," and includes the requirements that DOE facilities and operations must meet in managing radioactive waste. INL Site activities related to this Order are discussed in Chapters 3 and 6.

State of Idaho Wastewater Land Application Permits

Applications for state of Idaho Wastewater Land Application Permits have been submitted for all existing land application facilities. The CFA Sewage Treatment Plant, the TAN/Technical Support Facility Sewage Treatment Plant, and the combined INTEC Sewage Treatment Plant effluent and service wastewater for disposal at the new INTEC percolation ponds have current permits. Idaho DEQ is reviewing permit applications for the Reactor Technology Complex Cold Waste Ponds, the Naval Reactors Facility Industrial Waste Ditch, and the Materials and Fuels Complex industrial waste pond.

Idaho 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 makes Idaho the only state with a federal court-ordered agreement limiting shipments of DOE and Naval spent nuclear fuel into the State and setting milestones for shipments of spent nuclear fuel and radioactive waste out of the State.

The only milestone schedule for 2006, related to shipment of transuranic waste out of Idaho, was achieved on February 21, 2006. One shipment of spent fuel was transported to the INL in 2006. Progress was made toward meeting future milestones, including waste and spent nuclear fuel shipments.

Clean Air Act

The Clean Air Act is the law that forms the basis for the national air pollution control effort. Basic elements of the act include national ambient air quality standards for major air pollutants, hazardous air pollutant standards, state attainment plans, motor vehicle emissions standards, stationary source emissions standards and permits, acid rain control measures, stratospheric ozone protection, and enforcement provisions.

The EPA is the federal regulatory agency of authority, but states may administer and enforce provisions of the act by obtaining EPA approval of a state implementation plan. Idaho has been delegated such authority.

The Idaho air quality program is primarily administered through the permitting process. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is specifically exempt from permitting requirements and if the source's emissions are significant or insignificant. If emissions are determined to be significant, several actions may occur:

- Permitting determinations to demonstrate that the project/process either is below emission thresholds or listed as exempted source categories in state of Idaho regulations allowing self-exemption.
- Submittal of an application for a Permit to Construct (PTC). If emissions are deemed major under Prevention of Significant Deterioration (PSD) regulations, then a PSD analysis, as described in the regulations, must be completed. If not deemed significant per PSD regulations, an application for

only a PTC without the additional modeling and analyses is needed. All PTCs are applied for using the state of Idaho air regulations and guidelines.

Permitted sources of air pollutants at the INL Site are listed in Table 2-2.

Table 2-2. Permit Summary for the INL Site (2006).

Media/Permit Type	Issuing Agency	Active	Pending
Air			
Permit to Construct	State of Idaho	16	1
NESHAPs (Subpart H)[a]	EPA Region 10	8	0
Operating Permit	State of Idaho	2	0
Groundwater			
Injection Well	State of Idaho	22	0
Well Construction	State of Idaho	1	0
Surface Water			
Wastewater Land Application Permit	State of Idaho	3	3
Industrial Waste Acceptance	City of Idaho Falls	15	0
RCRA			
Part A	State of Idaho	2	0
Part B[b]	State of Idaho	7[b]	1[b]

a. NESHAPs = National Emissions Standards for Hazardous Air Pollutants (40 CFR 61, Subpart H, National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities).

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

Title V Operating Permit – Title V of the 1990 Clean Air Act Amendments required the EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state and/or local air pollution agencies. The EPA promulgated regulations in July 1992 that defined the requirements for state programs. Idaho has promulgated regulations and EPA has given interim approval of the Idaho Title V (Tier I) Operating Permit program. The INL Site was issued two Tier I operating permits with effective dates of June 28, 2005, and November 15, 2006.

National Emission Standards for Hazardous Air Pollutants – DOE-ID submitted the 2005 INL National Emission Standards for Hazardous Air Pollutants-Radionuclides report to EPA, DOE Headquarters, and state of Idaho officials in June 2006. CFR Title 40, part 61, subpart H requires the use of 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."

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, set by the EPA, for specific industry categories 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 two CWA permits through the implementation of procedures, policies, and best management practices. The permits are:

- Discharges from Idaho Falls facilities to the City of Idaho Falls publicly owned treatment works.
- NPDES General Permit for Storm Water Discharges from Construction Activities provides protective requirements for construction activities located within the INL Site storm water corridor (63 FR 31).

National Pollutant Discharge Elimination System Permits – 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. Industrial Wastewater Acceptance Forms are obtained for facilities that discharge process wastewater through the City of Idaho Falls sewer system. Twelve Idaho Falls facilities have associated Industrial Wastewater Acceptance Forms for discharges to the city sewer system.

The Industrial Wastewater Acceptance Forms for these facilities contain 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 2006 were within compliance levels established on the acceptance forms.

Storm Water Discharge Permits for Construction Activity – DOE-ID obtained coverage for the INL Site under the General Permit for Storm Water Discharges from Construction Sites issued in June 1993. The coverage under the general permit has been renewed twice. INL Site contractors obtain coverage under the general permit for individual construction projects. Storm Water Pollution Plans are completed for individual construction projects. Inspections of construction sites are performed in accordance with permit requirements.

Only construction projects that are determined to have a reasonable potential to discharge pollutants to a regulated surface water are required to have a Storm Water Pollution Prevention Plan and Permit.

Safe Drinking Water Act

The Safe Drinking Water Act was reauthorized on August 6, 1996. It establishes primary standards for water delivered by systems supplying drinking water to 15 or more connections or 25 individuals for at least 60 days per year. The INL Site drinking water supplies meet these criteria for public water systems and are classified as either nontransient noncommunity or transient noncommunity systems. The INL Site has 12 active public water systems, one of which serves the Naval Reactors Facility. All facilities at the INL Site perform sampling of drinking water as required by the State and EPA. Chapter 5 contains details on drinking water monitoring results.

National Historic Preservation Act

Preservation of historic properties on lands managed by DOE is mandated under Section 106 of the National Historic Preservation Act (NHPA) of 1966. The Section 106 process is the legal mechanism used to determine if adverse effects to historic properties will occur and if so, the nature and extent of these adverse effects. Consultation with the Idaho State Historic Preservation Office (SHPO) and interested parties are then conducted to mitigate these effects.

The INL Site Cultural Resources Management Plan (CRMP) was written specifically for site resources, providing a tailored approach to comply with Section 106 of the NHPA. The CRMP is reviewed and updated annually. Additionally, a Programmatic Agreement between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho SHPO, dated July 2004, *Concerning Management of Cultural Resources on the Idaho National Laboratory Site*, formally implements the CRMP.

Signature Properties as defined in the CRMP, is a term coined by DOE-Headquarters that denotes its most historically important properties across the site. In 2006 DOE-ID submitted the Historic American Engineering Record (HAER) report for the Fuel Reprocessing Complex to the National Park Service (NPS). The HAER report describes the various scientific programs and buildings covering nearly four decades of uranium recycling from spent reactor fuel that powered the United States Navy's nuclear fleet and National Reactor Testing Station leading to scientific advances in fuel processing and waste management. Additionally, the HAER report for the Test Reactor Area was completed and submitted to the NPS. The report details the programs and reactors built to support the area now known as the Reactor Technology Complex. The HAER reports contain extensive written and photographic documentation of these historic programs and buildings. INL HAER reports are archived among other significant scientific documents and manuscripts in the collections of the U.S. Library of Congress. They are also distributed to a wide variety of professional historians, colleagues in the DOE complex, universities with nuclear programs, politicians, and tribes.

In 2006, 21 properties were reviewed of which six were completely removed through deactivation, decontamination and demolition. Historic Architectural Reviews continued to focus on removal or demolition of historic properties that have historically contributed to the overall landscape of INL's World War II and pioneering nuclear history as the INL facilities consolidate into three main campus areas. However, consultation with the Idaho SHPO and National Park Service led to the retention of the several buildings and structures at the CFA and the 1954 Lead Shielded Locomotive from Test Area North.

Native American Graves Protection and Repatriation Act

The INL Site is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-Bannock Tribes are major stakeholders in INL Site activities. They are particularly concerned with how the remains of their ancestors and culture are treated by DOE-ID and its contractors. The Native American Graves Protection and Repatriation Act provides for the protection of Native American remains and the repatriation of human remains and associated burial objects. Repatriation refers to the formal return of human remains and cultural objects to the Tribes with whom they are culturally affiliated.

2.2 Environmental Occurrences

In 2006, five releases were deemed reportable to external regulatory agencies:

- On January 24, 2006, a release of an initially unknown quantity of diesel fuel #2 was discovered in soil near a fuel tank at INTEC 701A. Further investigation of the release site indicated approximately 940 gallons of fuel had been released from the 250,000-gallon fuel tank. The tank was drained of fuel and removed from service. Because the spill could not be cleaned up within 24 hours of discovery, notifications were made to the appropriate authorities within the state of Idaho according to regulatory requirements.

- On April 19, 2006, while an outlet pipe from Tank V-9 at TAN was being cut using a processor head on a backhoe, approximately 1.2 pounds of sludge was spilled to the soil in the area surrounding the pipe. The waste spilled carried the RCRA F001 hazardous waste number and is subject to a RCRA Closure Plan. Federal regulations (40 CFR 264.196(d)) require that a leak or spill of hazardous waste from a Subpart J Tank System undergoing RCRA closure must be reported if it is equal to or more than a quantity of one pound and it is not immediately contained and cleaned up. The sludge released to the soil was immediately cleaned up but was greater than one pound and therefore this release was reported to the appropriate state of Idaho authorities.
- On July 12, 2006, electrician subcontractors encountered an oily substance while removing electrical cables from a conduit at the Experimental Breader Reactor-II Power Plant as part of an electrical upgrade project. The subcontractor workers did not anticipate encountering PCB contaminated material during the project and continued to remove the cables from the conduit. On July 18, 2006, sample results concluded they contained PCB. The maximum amount of PCB material that could have been released, including material that may remain in the electrical conduit, was as much as six pounds. This calculated amount exceeded the EPA Reportable Quantity limit of one pound and the required notifications were made. A subsequent estimate, which used better information not available at the time of the original estimate, placed the amount released at less than 1 lb. All cleanup actions were completed on October 25, and confirmed by sample results.
- On October 6, 2006, approximately 32 gallons of diesel fuel was spilled to soil when the 786-M-1 day-tank at the RTC was overfilled. The flow of diesel was stopped upon discovery by the operator and the spilled material was contained to a drainage ditch located east of the day tank inside the RTC perimeter fence. The spill occurred during a severe rain storm; therefore, the immediate cleanup of the diesel fuel was not possible. Since the spill was to soil and exceeded the 25 gallon reportable quantity, notification was made to appropriate authorities within the state of Idaho according to regulatory requirements.
- On November 19, 2006, approximately 50 gallons of fuel oil #2 was spilled to asphalt from a portable tank associated with a boiler near CFA-688. The majority of the fuel oil was cleaned up within 24 hours of discovery. However, a small portion (less than three gallons) of the fuel oil reached the soil through several small cracks in the asphalt and was not cleaned up within 24 hours as required by Idaho regulations. Therefore, the spill was reported to appropriate authorities within the state of Idaho according to regulatory requirements.

None of these releases posed significant threats to the environment or human health. All releases were appropriately remediated.

2.3 Permits

Table 2-2 summarizes permits applied for, and granted to, the INL Site through year-end 2006.

REFERENCES

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Executive Order 12580, "Superfund Implementation," January 1987.

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U.S. Department of Energy Order 451.1B, Change 1, 2001, "National Environmental Policy Act Compliance Program," U.S. Department of Energy, September 28.

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VanHorn, R.L., Hampton, N.L., and Morris, R.C., 1995, Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL, INEL-95/0190, June.

Beaver

Chapter 3 - Environmental Program Information

Yellow-bellied Marmot

M. Case - S.M. Stoller Corporation
B. Holmes - U.S. Department of Energy - Idaho Operations Office
M. Verdoorn - Battelle Energy Alliance
R. Wilhelmsen - CH2M-WG Idaho

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), Risk Reduction (Section 3.2), Environmental Restoration (Section 3.3), and Waste Management (Section 3.4). Sections 3.5 and 3.6 summarize other significant INL Site environmental programs and activities.

3.1 Environmental Monitoring Programs

Environmental monitoring consists of two separate activities: effluent monitoring and environmental surveillance. Effluent monitoring is the measurement of constituents within a waste stream before its release to the environment, such as the monitoring of stacks or discharge pipes. Environmental surveillance is the measurement of contaminants in the environment. Surveillance involves determining whether or not contaminants are present or measurable in environmental media and, if present, in what concentrations are they found.

Effluent monitoring is conducted by various INL Site organizations. Airborne effluent measurements and estimates, required under the Idaho State Implementation Plan, are the responsibility of the regulated facilities. At the INL Site, these facilities include Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Naval Reactors Facility (NRF), Critical Infrastructure Test Range Complex/Power Burst Facility (CITRC/PBF), Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North/Specific Manufacturing Capability (TAN/SMC). The Liquid Effluent Monitoring Program, conducted by the Idaho Cleanup Project (ICP) contractor, is designed to demonstrate compliance with the Clean Water Act, Wastewater Land Application Permits (WLAPs), and other associated permits.

Environmental surveillance is the major environmental monitoring activity conducted at the INL Site. As such, much of this report concentrates on this task. The remainder of this section summarizes environmental monitoring program objectives; the history of environmental monitoring at the INL Site; and information on monitoring of specific environmental media (air, water, agricultural products, animal tissue, and soil), direct radiation, and meteorology.

Results of the environmental monitoring programs for 2006 and additional information on major programs can be found in Chapter 4 (air), Chapters 5 and 6 (water), and Chapter 7 (agricultural, wildlife, soil, and direct radiation). Chapter 8 discusses radiological doses to humans and biota, and Chapter 9 presents 2006 results on current ecological research programs at the INL Site. Quality assurance activities of the various organizations conducting environmental monitoring are described in Chapter 10.

Objectives of Environmental Monitoring

Operations of INL Site facilities have the potential to release materials, which may include both radioactive and nonradioactive contaminants, into the environment. These materials can enter the environment through two primary routes: into the atmosphere as airborne effluents and into surface water and groundwater as liquid effluents or storm water runoff. Through a variety of exposure pathways (Figure 3-1), contaminants can be transported away from INL Site facilities, where they could potentially impact the surrounding environment and the population living in these areas.

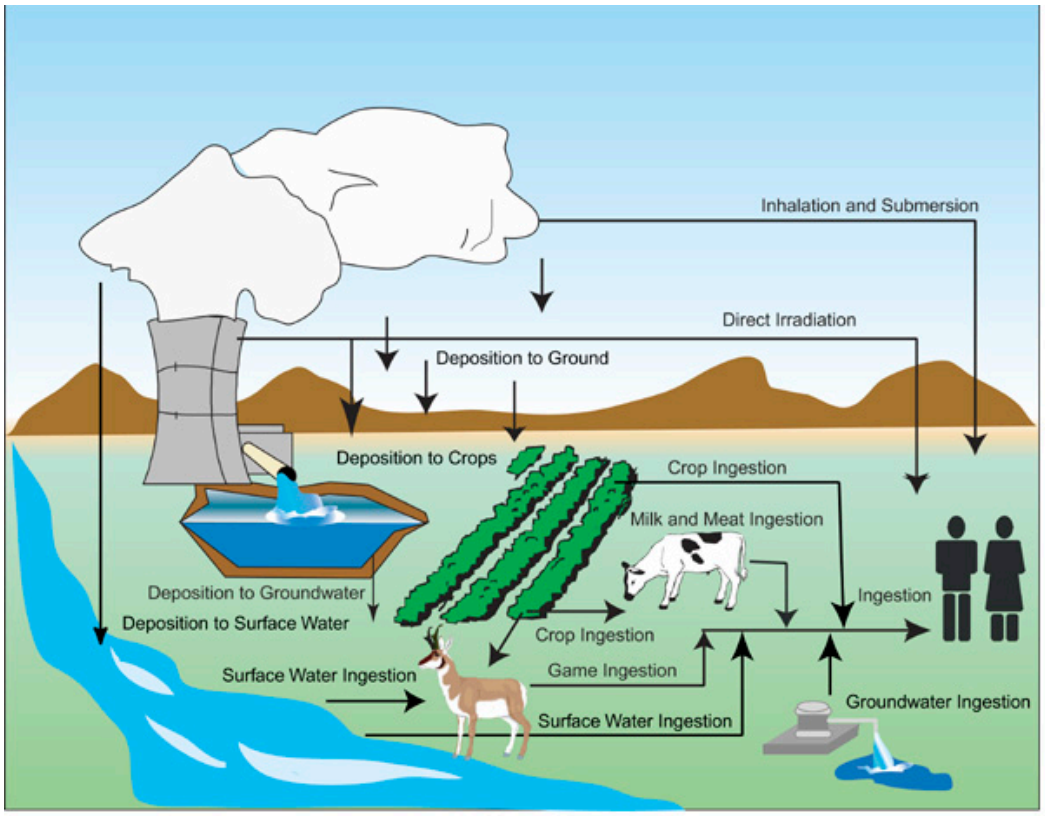

Figure 3-1. Potential Exposure Pathways to Humans from the INL Site.

The major objectives of the various environmental monitoring programs conducted at the INL Site are to identify the key pollutants released to the environment, to evaluate different pathways through which pollutants move in the environment, and to determine the potential effects of these pollutants on the public and on the environment.

As discussed previously, monitoring also provides the information to verify compliance with a variety of applicable environmental protection laws, regulations, and permits, described in Chapter 2. The establishment and conduct of an environmental monitoring program at the INL Site is required by the U.S. Department of Energy (DOE) Order 450.1 (DOE 2003). The various environmental monitoring programs are also used to detect, characterize, and report unplanned releases; evaluate the effectiveness of effluent treatment, control, and pollution abatement programs; and determine compliance with commitments made in environmental impact statements (EIS), environmental assessments, safety analysis reports, and other official DOE documents.

History of Environmental Monitoring

Environmental monitoring has been performed at the INL Site by DOE and its predecessors, the Atomic Energy Commission (AEC) and Energy Research and Development Administration, as well as by other federal agencies, various contractors, and State agencies since its inception in 1949.

The organization of environmental monitoring programs has remained fairly constant throughout much of the history of the INL Site. The AEC's Health Services Laboratory, later named the DOE's Radiological and Environmental Sciences Laboratory (RESL), was responsible for conducting most environmental surveillance tasks from the early 1950s to 1993 both on and off the INL Site. Contractors operating the various facilities were responsible for monitoring activities performed within the facility boundaries and for effluent monitoring.

Early monitoring activities focused on evaluating the potential of exposing the general public to a release of radioactive materials from INL Site facilities. Radionuclides were the major contaminants of concern because the INL Site was heavily involved in testing nuclear facilities. DOE and its predecessor agencies sampled and analyzed environmental media that could be affected by atmospheric releases. During those early years, the various INL Site contractors conducted sampling of liquid and airborne effluents from facilities to develop waste inventory information.

Throughout the history of the INL Site, the U.S. Geological Survey (USGS) has monitored groundwater quantity and quality in the Eastern Snake River Plain Aquifer (ESRPA), with emphasis on the portion of the aquifer beneath the INL Site. The National Oceanic and Atmospheric Administration (NOAA) has also monitored weather conditions at the INL Site since the Site's inception.

In 1993, the DOE environmental monitoring program was divided into separate onsite and offsite programs. Responsibility for the onsite program was transferred to the INL Site contractor. During 2006, Battelle Energy Alliance (BEA) was the prime INL contractor. CH2M-WG Idaho (CWI) assumed responsibility for the ICP on May 1, 2005. The monitoring activities performed by BEA and CWI comprise of the onsite monitoring program. The offsite monitoring program is performed by the Environmental Surveillance, Education and Research (ESER) Program contractor. During 2006, ESER offsite monitoring activities were performed by a team led by the S. M. Stoller Corporation.

Air Monitoring

Historical Background – Low-volume air samplers have been operating on and in the vicinity of the INL Site since 1952. Table 3-1 lists the areas where samplers have been located and the dates of operation for these samplers (derived from DOE-ID 1991). Before 1960, radiation detection devices, such as a Geiger-Műller tube, were used to record the amount of radioactivity on the filters. Gross beta

Table 3-1. Historic Low-Volume Radiological Air Sampling Locations and Dates of Operation.

Sampling Location	Dates of Operation
Distant Locations	
Aberdeen	1952–1957, 1960–1970
American Falls	1970
Blackfoot	1968–2001
Blackfoot Community Monitoring Station	1983–present
Carey	1961–1970
Craters of the Moon[a]	1973–present
Dubois	2001–present
Dietrich	1961–1970
Idaho Falls	1953–1955, 1956–present
Jackson	2001–present
Minidoka	1961–1970
Pocatello	1969–1980
Rexburg Community Monitoring Station	1983–present
Spencer	1953–1956
Boundary Locations	
Arco	1968–present
Atomic City	1953–1957, 1960–1970, 1973–present
Butte City	1953–1957, 1960–1973
Blue Dome	2001–present
Federal Aviation Administration Tower	1981–present
Howe	1958–present
Monteview	1958–present
Mud Lake	1958–present
Reno Ranch/Birch Creek	1958–2001
Roberts	1960–1970
Terreton	1953–1956, 1964–1965
INL Site Locations	
Aircraft Nuclear Propulsion Program	1953–1955, 1961–1963
Auxiliary Reactor Area	1966–present
Central Facilities Area	1953–present
Critical Infrastructure Test Range Complex/Power Burst Facility	1958–present
East Butte	1953–1955
Experimental Breeder Reactor No. 1	1952–1956, 1958–present
Experimental Field Station	1972–present
Fire Station #2	1958–1963
Gas-Cooled Reactor Experiment	1961–1963
Gate 4	2004-present
Idaho Nuclear Technology and Engineering Center	1953–1956, 1958–1970, 1981–present
Main Gate	1976–present
Materials and Fuels Complex (formerly ANL-W)[b]	1961–present
Mobile Low Power Reactor No. 1	1961–1963
Naval Reactors Facility	1956, 1958–present
Organic Moderated Reactor Experiment	1957–1963
Radioactive Waste Management Complex	1973–present
Reactor Technology Complex (formerly TRA)[c]	1953–1956, 1958–present
Rest Area, Highway 20	2000–present
Specific Manufacturing Capability Facility	2004-present
Stationary Low-Power Reactor No. 1	1961–1963
Test Area North	1953–1955, 1956–present
Van Buren Gate	1976–present

a. Designated as a boundary location 1973–1981
b. ANL-W = Argonne National Laboratory West
c. TRA = Test Reactor Area

measurements were made starting in 1960, and by 1967 the present series of analytical measurements were being performed.

High-volume air samplers were operated at the Experimental Field Station (EFS) and CFA from 1973 until October 1996. In 1996, a program evaluation determined that the cost of operating the high-volume samplers was not commensurate with the data being collected, and operations were suspended. Also in 1973, a high-volume sampler began operation in Idaho Falls as part of the U.S. Environmental Protection Agency's (EPA's) nationwide Environmental Radiation Ambient Monitoring System, now known as RadNet.

Tritium in atmospheric moisture has been measured at a minimum of two locations since at least 1973. Some limited monitoring may have been performed before this time.

One monitoring location at CFA collected samples of noble gases, with specific interest in krypton-85 (^{85}Kr) from approximately 1984 until 1992. This station was used to monitor releases of ^{85}Kr from the INTEC during periods when fuel reprocessing was taking place.

Nitrogen dioxide and sulfur dioxide were first monitored for a nine-week period at five onsite locations in 1972. A nitrogen dioxide sampling station operated from 1983 to 1985 to monitor waste calcining operations at INTEC. A sulfur dioxide sampler was also used from 1984 to 1985. The two sampling locations were reactivated in 1988 for nitrogen dioxide and operated through 2003, and one station operated from 1989 through 2001 for sulfur dioxide.

The National Park Service, in cooperation with other federal land management agencies, began the Interagency Monitoring of Protected Visual Environments (IMPROVE) program in 1985. This program was an extension of an earlier EPA program to measure fine particles of less than 2.5 µm in diameter ($PM_{2.5}$). These particles are the largest cause of degraded visibility. In May 1992, one IMPROVE sampler was established at CFA on the INL Site and a second was located at Craters of the Moon National Monument as part of the nationwide network. Each of the two samplers collected two 24-hr $PM_{2.5}$ samples a week. Analyses were performed for particulate mass, optical absorption, hydrogen, carbon, nitrogen, oxygen and the common elements from sodium through lead on the periodic table. Operation of the CFA sampler ceased in May 2000 when the EPA removed it from the nationwide network.

Current Programs – Both the ESER and INL contractors maintain a network of low-volume air samplers to monitor for airborne radioactivity (Figure 3-2). ESER operates 13 samplers at offsite locations and three onsite samplers. Two of the onsite samplers are located at INL Site entrances that are in close proximity to public access via State Highway 20/26. The third onsite sampler is located at the Experimental Field Station (EFS), which is typically within the highest air concentration isopleths estimated by air dispersion models (see Figure 8-1.) ESER added the thirteenth offsite sampler in June 2001 at Jackson, Wyoming. Two samplers were also moved to new locations in July 2001 when the landlords terminated the leases at the previous stations. The sampler at Blackfoot was moved to Dubois and the sampler at Reno Ranch/Birch Creek was moved to Blue Dome. The INL contractor maintains 17 onsite and four offsite sampling locations. Additional samplers were added at SMC, Gate 4, the RTC and INTEC due to increased decontamination and dismantlement activity.

Each low-volume air sampler maintains an average airflow of 57 L/minute (2.0 ft^3/minute) through a set of filters consisting of a 1.2 µm pore membrane filter followed by a charcoal cartridge. The membrane

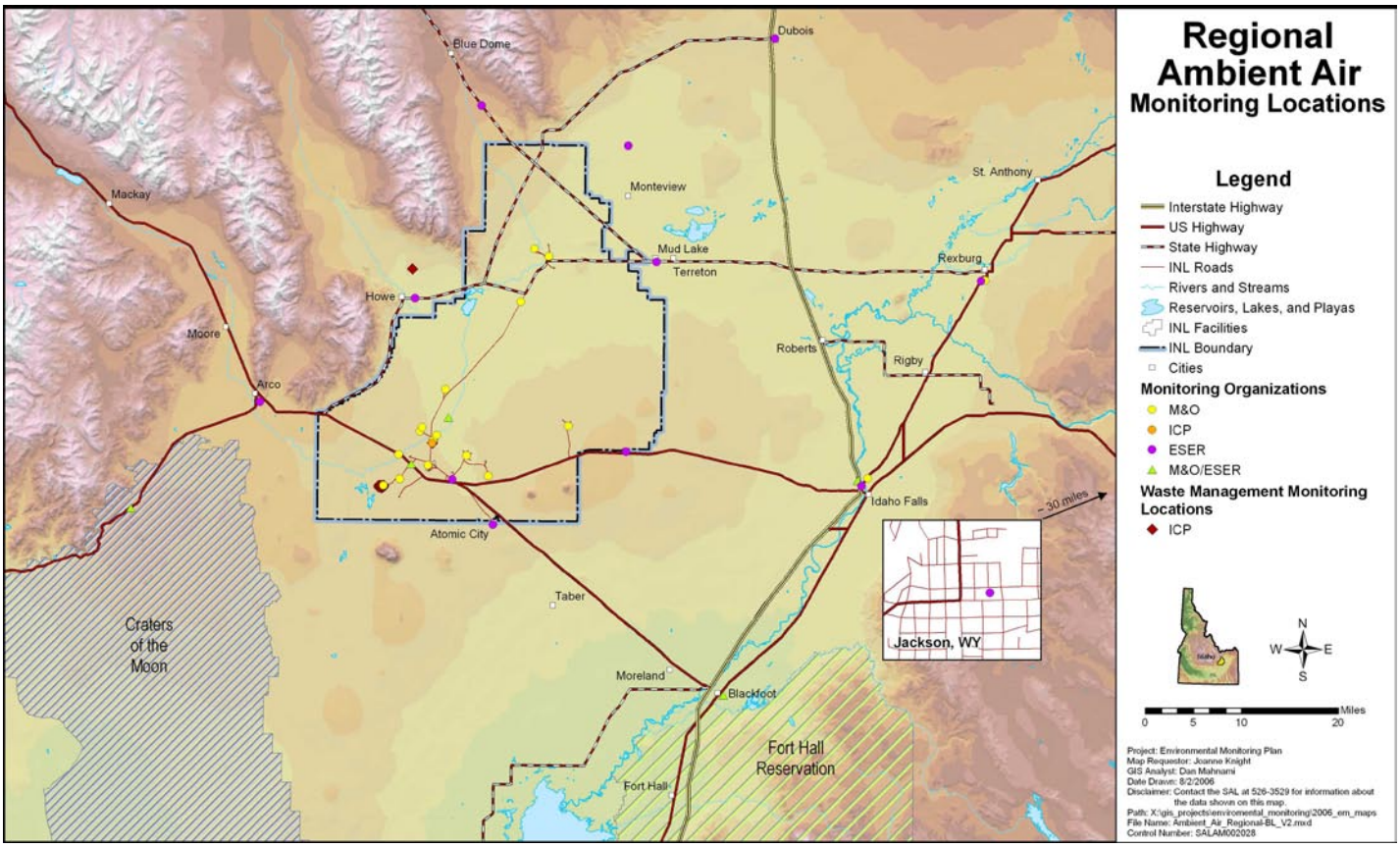

Figure 3-2. ESER and INL Site Contractors Low-Volume Radiological Air Sampling Locations.

filters are 99 percent efficient for airborne particulates with an aerodynamic diameter of 0.32 µm, and higher for larger diameter particulates.

Filters from the low-volume air samplers are collected and analyzed weekly. Charcoal cartridges are analyzed for iodine-131 (^{131}I) either individually or in batches of up to ten cartridges. During batch counting, if any activity is noted in a batch, each cartridge in that batch is recounted individually.

Particulate filters are analyzed weekly using a proportional counting system. Filters are analyzed after waiting a minimum of four days to allow naturally occurring radon progeny to decay. Gross alpha and beta analyses are used as a screening technique to provide timely information on levels of radioactivity in the environment.

Specific radionuclide analyses are more sensitive than gross alpha and gross beta analyses for detecting concentrations of anthropogenic (human-made) radionuclides in air. The particulate filters of the low-volume samplers are composited by location at the end of each quarter, and all composites are analyzed for specific radionuclides by gamma spectrometry. Composites are then submitted for analyses for specific transuranic radionuclides (americium-241 [^{241}Am], plutonium-238 [^{238}Pu], plutonium-239/240 [$^{239/240}$Pu]), and strontium-90 (^{90}Sr).

Measurements of suspended particulates are also performed on the 1.2 µm pore membrane filters from the low-volume air samplers. Both ESER and the INL contractor weigh their filters weekly before and after

sampling to determine the amount of material collected. In both cases, the amount of material collected is determined by subtracting the presampling (clean filter) weight from the postsampling (used filter) weight. The concentration of suspended particulates is calculated by dividing the amount of material collected on the filters by the total volume of air that passed through the filters.

Samplers for tritium in atmospheric moisture are located at two onsite and four offsite locations. In these samplers, air is pulled through a column of desiccant material (i.e., silica gel or molecular sieve) at 0.3–0.5 L/hour (0.01-0.02 ft^3/hour). The material in the column absorbs water vapor. Columns are changed when sufficient moisture to obtain a sample is absorbed (typically from one to three times per quarter). The absorbed water is removed from the desiccant through heat distillation. Tritium concentrations in air are then determined from the absorbed water (distillate) by liquid scintillation counting. Atmospheric concentrations are determined from the tritium concentration in the distillate, quantity of moisture collected, and the volume of air sampled.

Tritium is also monitored using precipitation samples collected on the INL Site monthly at CFA and weekly at EFS. A monthly sample is also obtained offsite in Idaho Falls. Each precipitation sample is submitted for tritium analysis by liquid scintillation counting.

Water Monitoring

Historical Background – The USGS has conducted groundwater studies at the INL Site since its inception in 1949. The USGS was initially assigned the task to characterize water resources of the area. 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 ESRPA. The first well, USGS 1, was completed and monitored in December 1949. USGS personnel have maintained an INL Project Office since 1958 (USGS 1998). During 2005, the USGS released a report documenting their monitoring programs for the period 1949-2001 (Knobel et al. 2005).

In 1993, the DOE Idaho Operations Office (DOE-ID) initiated a program to integrate all of the various groundwater monitoring programs at the Idaho National Engineering Laboratory (INEL) Site. This resulted in the development of the *INEL Groundwater Monitoring Plan* (DOE-ID 1993a) and the *INEL Groundwater Protection Management Plan* (DOE-ID 1993b). The monitoring plan described historical conditions and monitoring programs, and it included an implementation plan for each facility. The protection management plan established policy and identified programmatic requirements.

Sampling and analyses of drinking water both onsite and offsite began in 1958. Analysis for tritium began in 1961. Up to 28 locations were sampled before increased knowledge of the movement of groundwater beneath the INL Site led to a decrease in the number of sampling locations. In 1988, a centralized drinking water program was established. Each contractor participates in the INL Site Drinking Water Program. The Drinking Water Program was established to monitor drinking water and production wells, which are multiple use wells for industrial use, fire safety, and drinking water. Drinking water is monitored to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. The Idaho Regulations for Public Drinking Water Systems and the federal Safe Drinking Water Act establish requirements for the Drinking Water Program. A program to monitor lead and copper in drinking water in accordance with EPA regulations has been in place since 1992. Three successive years of monitoring lead and copper levels in drinking water were concluded in 1995. Since regulatory values were not exceeded, this monitoring has been reduced to once every three years beginning in 1998.

As one of the requirements of the National Pollutant Discharge Elimination System General Permit effective October 1, 1992, the INL Site was obligated to develop a storm water monitoring program. Sampling of snowmelt and rain runoff began in 1993, and it included 16 sites at eight INL Site facilities. Samples were collected from storms of at least 0.25 cm (0.1 in.) of precipitation preceded by a minimum of 72 hours without precipitation.

In September 1998, the EPA issued the "Final Modification of the National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities" (63 FR 189). The permit requires sample collection and laboratory analyses for two of the years during every five-year cycle at potential discharge locations. This usually occurs during years two and four; the INL Site last collected and analyzed storm water samples in 2003. The permit also required continued annual monitoring from coal piles at INTEC whenever there was a discharge to the Big Lost River System. In addition, quarterly visual monitoring was required at all other designated locations.

Current Programs – USGS personnel collect samples from 171 observation or production wells, auger holes, surface water sites, and multi-depth sampling wells (21 samples are collected from four multi-depth sites) and have them analyzed for selected organic, inorganic, and radioactive constituents. Sampling is performed on schedules ranging from monthly to annually. These samples are submitted to the RESL at CFA for analysis of radioactive constituents and to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analyses of organic and inorganic constituents. The USGS also records water levels at 214 selected wells on schedules ranging from monthly to annually.

The USGS also conducts special studies of the groundwater resources of the ESRPA. The abstract of each study published in 2006 is provided in Appendix C. These special studies provide more specific geological, chemical, and hydrological information on the characteristics of the aquifer and the movement of chemical and radiochemical contaminants in the groundwater.

The INEL Groundwater Monitoring Plan was updated in 2003 to include the monitoring wells, constituent lists, and sampling frequencies of current programs. The updated plan does not replace the 1993 plan but uses it as the basis for the information previously presented regarding operational history, contaminant sources, and monitoring networks for each INL Site facility. The updated plan modifies groundwater monitoring recommendations in accordance with more recent information (i.e., requirements in records of decision), relying on existing multiple groundwater programs rather than a single comprehensive program.

Agricultural Products and Vegetation Monitoring

Historical Background – Milk was the first agricultural product to be monitored, beginning in at least 1957. The number of samples collected per year has been relatively constant since about 1962. Because of improvements in counting technology, the detection limit for ^{131}I has decreased from about 15,000 pCi/L in early sampling to the current detection level of about 2 pCi/L.

Wheat was first sampled as part of the radioecology research program in about 1962. The current monitoring program dates back to 1963. Potatoes were first collected in 1976 as part of an ecological research project. Regular potato sampling was resumed in 1994 in response to public interest. Lettuce has been collected since 1977.

Current Programs – Milk samples are collected from both commercial and single-family dairies. A 2 L (0.5 gal) sample is obtained from Idaho Falls weekly. Other locations are sampled monthly. Each milk sample is analyzed for ^{131}I and other gamma-emitting radionuclides. One sample at each location is analyzed for ^{90}Sr and tritium during the year.

Wheat samples are collected from farms or grain elevators in the region surrounding the INL Site. All wheat samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

Potato samples are collected from farms or storage warehouses in the vicinity of the INL Site, with three to five samples from distant locations. The potatoes, with skins included, are cleaned and weighed before processing. All potato samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

Lettuce samples are obtained from private gardens in communities in the vicinity of the INL Site. In addition, self-contained growing boxes are distributed throughout the region, usually at existing air monitoring locations. Lettuce is grown from seed at each location and collected when mature. The use of self-contained growing boxes allowed the collection of samples at areas on the INL Site (e.g., EFS) and at boundary locations where lettuce could not previously be obtained (e.g., Atomic City). Samples are washed to remove any soil as in normal food preparation, dried, reduced to a powdered form, and weighed. All lettuce samples are analyzed for ^{90}Sr and gamma-emitting radionuclides.

The ICP contractor annually collects perennial and grass samples from around the major waste management facilities. These samples are analyzed for gamma-emitting radionuclides.

Animal Tissue Monitoring

Historical Background – Monitoring of game animals has focused on research concerning the movement of radionuclides through the food chain. Rabbit thyroids and bones were first sampled in 1956. In 1973, routine sampling of game animal tissues was instituted. The first studies on waterfowl that were using wastewater disposal ponds containing various amounts of radionuclides occurred the following year. Waterfowl studies have covered the periods 1974–1978, 1984–1986, and 1994–present. In 1998, the collection of waterfowl became part of the regular surveillance program.

Mourning doves were collected in 1974 and 1975 as part of a radioecology research project. Periodic dove sampling as part of the environmental surveillance program was initiated in 1996. In 1998, periodic sampling of yellow-bellied marmots was added to the sampling program.

Sheep that have grazed onsite have been part of the routine monitoring program since a special study was conducted in 1975. Beef cattle grazing in the vicinity of RWMC were also monitored biennially during the period 1978 to 1986. Grazing near RWMC was discontinued due to drought conditions.

Current Programs – All INL Site animal tissue monitoring is performed by the ESER Program. Selected tissues (muscle, liver, and thyroid) are collected from big game animals accidentally killed on INL Site roads. Thyroid samples are placed in vials and analyzed within 24-hours by gamma spectrometry specifically for ^{131}I. Muscle and liver samples are processed, placed in a plastic container, and weighed before gamma spectrometry analysis.

Waterfowl samples are collected from waste disposal ponds at up to four facilities on the INL Site. Control samples are also taken in areas distant from the INL Site. Waterfowl samples are separated into

an external portion (consisting of the skin and feathers); edible portion (muscle, liver, and gizzard tissue); and the remaining portion. All samples are analyzed by gamma spectrometry. Selected samples are also analyzed for ^{90}Sr and transuranic radionuclides.

Mourning doves are collected in some years from the vicinity of INTEC and RTC wastewater ponds and from a control area distant to the INL Site. Because of the small size of a typical dove, muscle tissues from several doves collected at the same location are composited into one sample. Samples are analyzed for gamma-emitting radionuclides.

Soil Monitoring

Historical Background – Soil sampling has been included as part of routine monitoring programs since the early 1970s, although some limited soil collection was performed around various facilities as far back as 1960. Offsite soil sampling at distant and boundary locations was conducted annually from 1970 to 1975. The collection interval was extended to every two-years starting in 1978. Soil samples in 1970, 1971, and 1973 represented a composite of five cores of soil 5 cm (2 in.) in depth from an approximately 0.9 m^2 (10 ft^2) area. In all other years, the five cores were collected from two depths: 0–5 cm (0–2 in.) and 5–10 cm (2–4 in.) within a 100 m^2 (~1076 ft^2) area.

A soil sampling program began in 1973 around onsite facilities. Soils at each facility were sampled every seven years. In 2001, all locations were sampled as the frequency was increased to every two years.

Current Programs – Twelve offsite soil locations are sampled by the ESER Program in even numbered years by the ESER contractor. Following collection, soil samples are dried for at least three hours at 120°C (250°F) and sieved. Only soil particles less than 500 µm in diameter (35-mesh) are analyzed. All offsite samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and transuranic radionuclides.

The INL contractor now performs soil sampling on a two-year rotation. One hundred seventy-five sites were sampled in 2006. All sites are analyzed in situ for gamma emitting radionuclides and ^{90}Sr. Approximately 10-percent of the sites have a physical sample collected for laboratory analysis of gamma-emitting and transuranic radionuclides. Samples are collected from 0–5 cm (0–2 in.) and sieved at the sample site with the 35-mesh fraction being collected. The INL contractor also performs annual sampling of the CFA sewage treatment plant irrigation spray field to show compliance with the WLAP soil loading limits.

Direct Radiation Monitoring

Historical Background – Measurements of radiation in the environment have been made on the INL Site since 1958. The technology used for radiation measurements at fixed locations has evolved from film badges to thermoluminescent dosimeters (TLDs). In addition to these locations, surveys using hand-held and vehicle-mounted radiation instruments have been conducted since at least 1959. Aerial radiological surveys were also performed in 1959, 1966, 1974, 1982, and 1990.

Current Programs – Environmental TLDs are used to measure ambient ionizing radiation exposures. The TLDs measure ionizing radiation exposures from all external sources. External sources include natural radioactivity in the air and soil, cosmic radiation from space, residual fallout from nuclear weapons tests, radioactivity from fossil fuel burning, and radioactive effluents from INL Site operations and other industrial processes.

At each location, a TLD holder containing four individual chips is placed one meter (3.3 ft) above ground level. The INL contractor maintains dosimeters at 13-offsite locations and approximately 135 locations onsite. The ESER contractor has dosimeters at 17-offsite locations. The dosimeter card at each location is changed semiannually, and cumulative gamma radiation is measured by the INL contractor Dosimetry Unit.

In addition to TLDs, a radiometric scanner arrangement is used to conduct gamma radiation surveys onsite. Two plastic scintillation detectors and global positioning system equipment are mounted on a four-wheel drive vehicle. The vehicle is driven slowly across the area to be surveyed while radiometric and location data are continuously recorded.

Meteorological Monitoring

Historical Background – The NOAA Air Resources Laboratory-Field Research Division (NOAA ARL-FRD) began work at the INL Site in 1948 as a Weather Bureau Research Station. The first meteorological observation station established to support the onsite activities began operation in 1949 at CFA. The network of stations expanded in the 1950s to provide more closely spaced data. The current mesonet was designed and constructed in the 1990s.

Current Programs – NOAA ARL-FRD currently maintains a network of 36 meteorological stations in the vicinity of the INL Site. These stations provide continuous measurements of a variety of parameters, including air temperature at two or three elevations, wind direction and speed, relative humidity, barometric pressure, solar radiation, and precipitation. In addition, continuous measurements of wind speed/direction and air temperature at various heights above the ground are taken using a radar wind profiling system and a radio acoustic sounding system. Data are transmitted via radio and telephone to the NOAA ARL-FRD Idaho Falls facility, where they are stored in a computerized archive.

Sitewide Monitoring Committees

A Monitoring and Surveillance Committee was formed in March 1997 and holds bimonthly meetings to coordinate activities between groups involved in INL Site-related onsite and offsite environmental monitoring. This standing committee brings together representatives of DOE-ID; INL Site contractors; ESER contractor; Shoshone-Bannock Tribes; state of Idaho INL Oversight Program; NOAA; and USGS. The Monitoring and Surveillance Committee has served as a valuable forum to review monitoring, analytical, and quality assurance methodologies; to coordinate efforts; and to avoid unnecessary duplication.

The Drinking 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. The committee includes DOE-ID and INL Site contractors.

The Water Resources Committee serves as a forum for coordinating and exchanging technical information on water-related activities. The committee was established in 1991 and includes DOE-ID, INL Site contractors, USGS, NOAA, and other agencies that have an interest in INL Site water issues but are not necessarily part of the governing agencies.

Monitoring Summary

Tables 3-2 through 3-4 present a summary of the environmental surveillance programs conducted by the ESER contractor, the INL Site contractors, and the USGS, respectively, in 2006. In addition to the monitoring constituents listed in Table 3-4, the USGS collects an expanded list of constituents from four multi-depth sampling wells. This expanded constituent list will change from year to year in response to USGS program Remedial Investigation/Feasibility Study (RI/FS) requirements. The additional constituents collected during 2006 were major anions and cations, uranium isotopes, selected dissolved gases, and selected stable isotopes. These data are available from the USGS by request.

3.2 Risk Reduction

The mission of the Office of Environmental Management (EM) is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. DOE-ID's EM objectives include completing efforts to safely achieve risk reduction, to safely achieve footprint reduction, and continued protection of the Snake River Plain Aquifer.

The risk reduction objectives are now embodied in DOE's new performance-based cleanup contract with CWI that will achieve accelerated cleanup priorities through 2012. The INL Site made significant progress in 2006, most notably:

- Demolished over 4135 m^2 (44,507 ft^2) of buildings and structures.
- Reinitiated exhumation and processing of targeted waste from the Accelerated Retrieval Project.
- Finalized Operable Unit (OU) 7-13/14 Remedial Investigation and Baseline Risk Assessment.
- Completed the OU 3-14 (INTEC Tank Farm Soils and Ground Water) RI/FS documents, public comment period on the Proposed Plan, and submitted a draft Record of Decision (ROD) for EPA and state review.
- Completed removal of sludge and water from the CPP-603 spent nuclear fuel (SNF) basins and grouted basins.
- Completed demolition of Loss-of-Fluid Test facility to its final end state.
- Made significant progress on preparatory stages for demolition of Engineering Test Reactor (ETR) complex by demolishing several support facilities.
- Completed cleanup of three contaminated soil sites at INTEC.
- Completed excavation and treatment of contents of three of four V-tanks at TAN.

Accelerated cleanup activities are further discussed throughout this Chapter in specific program emphasis areas.

3.3 Environmental Restoration

Since the Federal Facility Agreement and Consent Order (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

Table 3-2. ESER Environmental Surveillance Program Summary (2006).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	1 x 10^{-15} µCi/mL
	Gross beta	4 weekly	14 weekly	2 x 10^{-12} µCi/mL
	Specific gamma	4 quarterly	14 quarterly	3 x 10^{-16} µCi/mL
	^{238}Pu	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	$^{239/240}$Pu	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	^{241}Am	2 quarterly	7 quarterly	2 x 10^{-18} µCi/mL
	^{90}Sr	2 quarterly	7 quarterly	6 x 10^{-17} µCi/mL
	^{131}I	4 weekly	14 weekly	2 x 10^{-15} µCi/mL
	Total particulates	4 quarterly	14 quarterly	10 µg/m^3
Air (high volume)[b]	Gross beta	None	1, twice per week	1 x 10^{-15} µCi/mL
	Gamma scan	None	If gross ζ > 1 pCi/m^3	1 x 10^{-14} µCi/mL
	Isotopic U and Pu	None	1 annually	2 x 10^{-18} µCi/mL
Air (PM_{10})	Weighing filter	None	3 weekly	± 0.0001 g
Air (atmospheric moisture)	Tritium	None	4 locations, 2 to 4 per quarter	2 x 10^{-13} µCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[c]	1 monthly	100 pCi/L
Drinking Water	Gross alpha	None	14 semiannually	3 pCi/L
	Gross beta	None	14 semiannually	2 pCi/L
	Tritium	None	14 semiannually	300 pCi/L
Surface Water	Gross alpha	None	5 semiannually	3 pCi/L
	Gross beta	None	5 semiannually	2 pCi/L
	Tritium	None	5 semiannually	300 pCi/L
Animal Tissue (sheep)	Specific gamma	4 annually[d]	2 annually	5 pCi/g
	^{131}I	4 annually	2 annually	3 pCi/g
Animal Tissue (game)	Specific gamma	Varies annually[e]	Varies annually	5 pCi/g
	^{131}I	Varies annually	Varies annually	3 pCi/g
Agricultural Products (milk)	^{137}Cs	None	1 weekly	1 pCi/L
	^{131}I	None	1 weekly/9 monthly	3 pCi/L
	^{90}Sr	None	9 annually	5 pCi/L
	Tritium	None	9 annually	300 pCi/L
Agricultural Products (potatoes)	Specific gamma	None	8-10 annually	0.1 pCi/g
	^{90}Sr	None	8-10 annually	0.2 pCi/g
Agricultural Products (wheat)	Specific gamma	None	11 annually	0.1 pCi/g
	^{90}Sr	None	11 annually	0.2 pCi/g
Agricultural Products (lettuce)	Specific gamma	None	7-9 annually	0.1 pCi/g
	^{90}Sr	None	7-9 annually	0.2 pCi/g
Soil	Specific gamma	None	12 biennially	0.001 pCi/g
	^{238}Pu	None	12 biennially	0.005 pCi/g
	$^{239/240}$Pu	None	12 biennially	0.1 pCi/g
	^{241}Am	None	12 biennially	0.005 pCi/g
	^{90}Sr	None	12 biennially	0.05 pCi/g
Direct Radiation Exposure (TLDs)	Ionizing radiation	None	17 semiannually	5 mR

a. Onsite include three locations and a blank, offsite includes 13 locations and a blank.

b. Filter are collected by ESER personnel and sent to EPA for analysis. Data are reported by EPA's RadNet at http://www.epa.gov/narel/radnet/.

c. A portion of the monthly sample collected at Idaho Falls is sent to EPA for analysis and are reported by Environmental Radiation Ambient Monitoring System.

d. Onsite animals grazed on the INL for at least two weeks before being sampled. Offsite animals have never grazed on the INL Site and served as controls.

e. Only animals that are victims of road-kills or natural causes are sampled onsite. No controls are generally collected except for specific ecological studies (i.e., ducks).

Table 3-3. INL Site Contractors Environmental Surveillance Program Summary (2006).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite[b]	Offsite	
Air (low volume)	Gross alpha	17 weekly	4 weekly	1×10^{-15} µCi/mL
	Gross beta	17 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	17 quarterly	4 quarterly	—[c]
	^{238}Pu	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	$^{239/240}$Pu	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{241}Am	17 quarterly	4 quarterly	2×10^{-18} µCi/mL
	^{90}Sr	17 quarterly	4 quarterly	2×10^{-14} µCi/mL
	Particulate matter	17 quarterly	4 quarterly	10 µg/m^3
Air (atmospheric moisture)	Tritium	2 to 4 per quarter	2 to 4 per quarter	1×10^{-11} µCi/mL (water)
Soil	Specific gamma	Varies annually[d]	—	0.1 pCi/g
	Pu isotopes	Varies annually	—	0.003 pCi/g
	^{241}Am	Varies annually	—	0.003 pCi/g
	^{90}Sr	Varies annually	—	0.06 pCi/g
Vegetation	Specific gamma	Varies annually[d]	—	1×10^{-7} µCi/g
	^{238}Pu	Varies annually	—	1.2×10^{-8} µCi/g
	$^{239/240}$Pu	Varies annually	—	6×10^{-10} µCi/g
	^{241}Am	Varies annually	—	1.2×10^{-8} µCi/g
	^{90}Sr	Varies annually	—	1.2×10^{-8} µCi/g
Drinking Water	Gross alpha	12 quarterly	—	1 pCi/L
	Gross beta	12 quarterly	—	4 pCi/L
	Tritium	12 quarterly	—	1,000 pCi/L
	^{90}Sr	4 quarterly	—	2 pCi/L
	Other radionuclides	12 quarterly	—	[c]
	Volatile organics	10 annually/ 4 quarterly	—	Varies by analyte
	Semivolatile organics	12 triennially	—	Varies by analyte
	Inorganics	12 triennially	—	Varies by analyte
Direct Radiation Exposure (TLDs)	Ionizing radiation	135 semiannually	13 semiannually	5 mR
Direct Radiation Exposure (mobile radiation surveys)	Gamma radiation	Facilities and INL Site roads[e]	—	NA

a. INL Site Contractors refers to both the INL contractor (BEA) and the ICP contractor (CWI).

b. 17th sampler was added to the northeast corner of the RTC in October 2005.

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

d. Onsite soil sampling is performed each year at different onsite facilities on a rotating two-year schedule.

e. Surveys are performed each year at different onsite facilities on a rotating three-year schedule. All INL Site roadways over which waste is transported are surveyed annually.

Table 3-4. U.S. Geological Survey Monitoring Program Summary (2006).

Constituent	Groundwater		Surface water		Minimum Detectable Concentration
	Number of Sites	Number of Samples	Number of Sites	Number of Samples	
Gross Alpha	57	69	4	4	3 pCi/mL
Gross Beta	57	69	4	4	3 pCi/mL
Tritium	164	166	7	7	400 pCi/mL
Specific Gamma	105	109	4	4	—[a]
Strontium-90	114	118	NS[b]	NS	5 pCi/mL
Americium-241	28	42	NS	NS	5 pCi/mL
Plutonium Isotopes	28	42	NS	NS	4 pCi/mL
Specific Conductance	164	166	7	7	Not applicable
Sodium Ion	153	157	NS	NS	0.1 mg/L
Chloride Ion	164	166	7	7	0.1 mg/L
Nitrates (as nitrogen)	116	123	NS	NS	0.05 mg/L
Sulfate	110	115	NS	NS	0.1 mg/L
Chromium (dissolved)	96	106	NS	NS	0.005 mg/L
Purgeable Organic Compounds[c]	29	37	NS	NS	0.0002 mg/L
Total Organic Carbon	55	67	NS	NS	0.1 mg/L
Trace Elements	16	32	NS	NS	varies

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

b. NS – No Sample.

c. Each purgeable organic compound water sample is analyzed for 60 volatile organic compounds.

materials. Cleanup of this contamination is being conducted under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). By the end of 2006:

- Twenty-two RODs have been signed and are being implemented.
- One RI/FS was completed, another neared completion, and a third is under development.
- Closeout activities at Waste Area Groups (WAG) 2, 4, 5, and 8 have been completed.

By progressing on these cleanup projects, workers were able to significantly reduce risks posed by past contamination at INL Site facilities. Also, by reducing the number of unneeded buildings, money that would otherwise have been applied to upkeep can now be applied to cleanup projects.

Comprehensive RI/FSs have been completed for WAGs 1, 2, 3, 4, 5, 8, 9, and 10 (6 is combined with 10). The comprehensive RI/FSs, which take an average of 40 months to complete, accomplish the following:

- Determine risks by assessing the combined impact release sites being assessed.
- Review assumptions used in previous investigations.
- Identify data gaps and recommend actions, such as field sampling or historical document research, to resolve questions.
- Perform feasibility studies to evaluate cleanup alternatives.

The information in the RI/FS is summarized in a Proposed Plan, which is provided for public comment. Proposed Plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments DOE, EPA and the state of Idaho develop a ROD selecting a cleanup approach from the alternatives evaluated.

The general procedure for all comprehensive investigations begins with developing a work plan outlining potential data gaps and release sites that may require more field sampling. When the investigation is complete, DOE, EPA and the state of Idaho hold public comment meetings on the proposed cleanup alternative. Responses to comments and the final cleanup decision are documented in the ROD. Three RODs remain to be completed:

- Buried waste at the RWMC (WAG 7) – public comment expected during 2007
- Soil contamination at the INTEC Tank Farm (WAG 3, OU 3-14) – public comment completed during 2006
- Eastern Snake River Plain Aquifer contamination (WAG 10, OU 10-8) – public comment expected during 2008

A complete catalog of documentation associated with the FFA/CO is contained in the CERCLA Administrative Record at http://ar.inel.gov/. The location of each WAG is shown on Figure 3-3.

Waste Area Group 1 – Test Area North

During 2006, the remediation of V-tanks 1, 2, and 3 was completed and was initiated on V-9. The V-tanks site consists of four out-of-service underground storage tanks, related structures, and the surrounding contaminated soil. There were three 37,854 L (10,000 gal) and one 1514 L (400 gal) underground storage tanks. The contents were contaminated with radionuclides, heavy metals, and organic

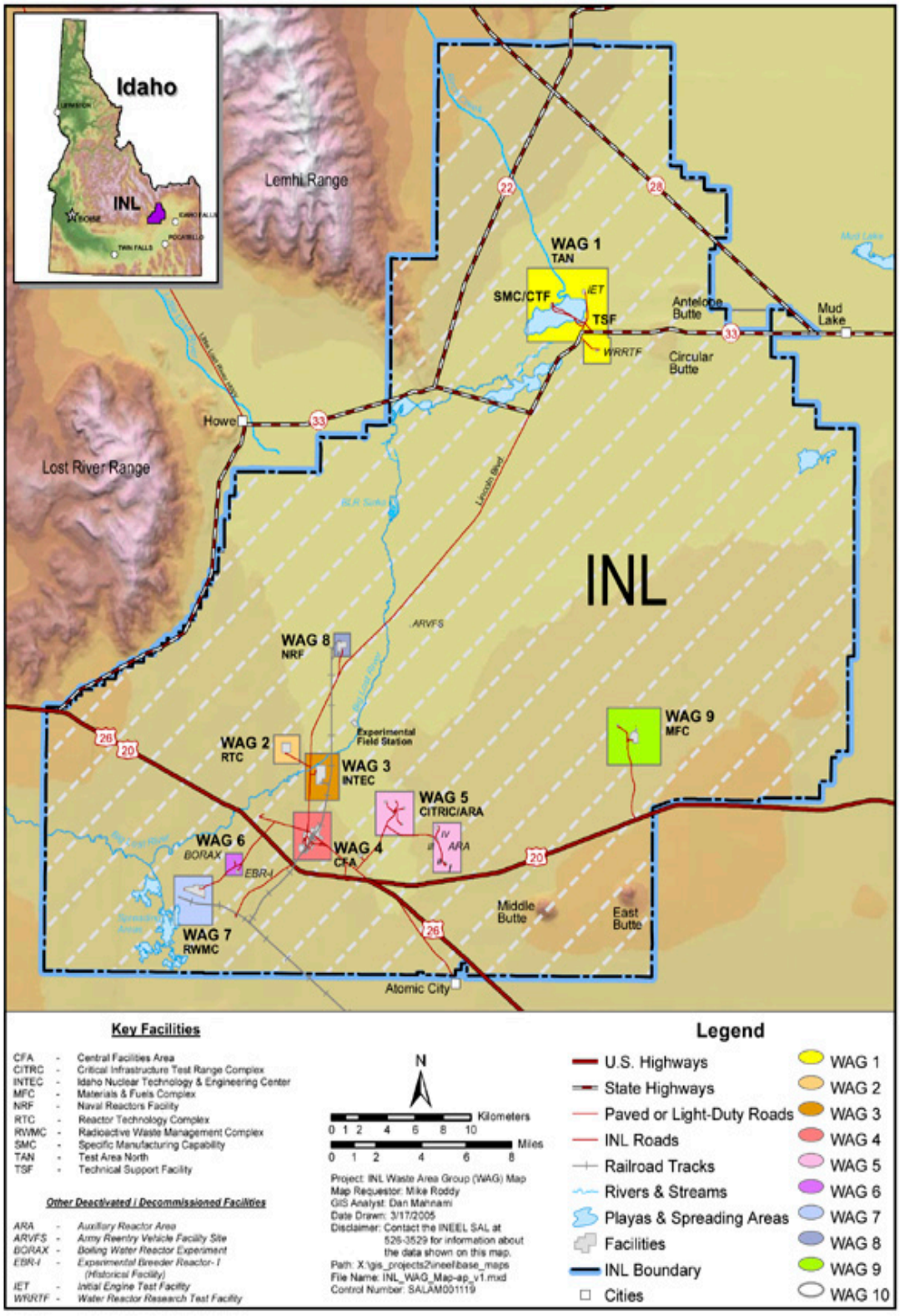

Figure 3-3. Map of the INL Site Showing Locations of the Facilities and Corresponding WAGs.

compounds. The remedy consisted of soil and tank removal, treatment of tank contents using air sparging followed by stabilization, and disposal.

Remediation of the two PM-2A tanks (V-13 and V-14) began in 2004 and was completed during 2006. The two 190,000 L (50,000 gal) tanks were first removed from the ground. Tank V-13 did not require treatment and was then disposed directly in the INL CERCLA Disposal Facility (ICDF). Tank V-14 was moved to the ICDF and its contents treated via air sparging to remove tetrachloroethene prior to disposal in the ICDF landfill.

In addition to the V-tank work, the OU 1-07B groundwater cleanup continued throughout 2006. The in situ bioremediation nutrient injection system continued to reduce contaminant concentrations in the aquifer. The New Pump and Treat Facility remained on standby to test rebound of aquifer contamination levels. Significant rebound did not occur through the end of 2006. The rebound test is scheduled to be completed in early 2007.

Waste Area Group 2 – Reactor Technology Complex

All active remediation in WAG 2 is complete. Some elements of the remedy, including monitoring of 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. In 2006, all of these Institutional Controls were maintained.

Waste Area Group 3 – Idaho Nuclear Technology and Engineering Center

Operations continued at the ICDF during 2006, disposing of contaminated soil and debris in the landfill cell as well as liquid waste to the evaporation pond. This site consolidates low-level contaminated soils and debris from CERCLA cleanup operations and segregates those wastes from potential migration to the aquifer, reducing risk to the public and environment. During 2006, treatment of 403 metric tons (1216 tons) of mercury-contaminated soil was completed followed by disposal in the landfill cell. The soil came from a cleanup project at the CFA. Other major accomplishments at WAG 3 include:

- Finalized the RI/FS Reports for the tank farms soils and ground water, issued a proposed plan for pubic comment, and submitted a draft ROD for comment by EPA and the state of Idaho. Issuance of the ROD is expected during 2007.
- Maintained interim actions at the Tank Farm Facility to reduce water infiltration that might transport contaminants from tank farm soils toward the aquifer.

Waste Area Group 4 – Central Facilities Area

Remediation of WAG 4 was completed in 2004. As with WAG 2, Institutional Controls are in place to maintain and monitor the completed remediation.

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

Cleanup activities at WAG 5 are complete. This area supported two reactor facilities–the Power Burst Facility (PBF) and the Auxiliary Reactor Area. The Remedial Action Report was completed during 2005.

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

Ecological and groundwater monitoring continued during 2006. Work on the INL Site-wide groundwater model also continued. These activities are to prepare for the upcoming OU 10-08 RI/FS. The OU 10-04 ROD is being implemented in four phases. The Phase I Remedial Action Report, documenting implementation of institutional controls and ecological monitoring, was completed during 2005. The Phase II remedial design/remedial action (RD/RA) Work Plan to address remediation of TNT contaminated soils sites was completed during 2004. The Phase III RD/RA Work Plan was completed during 2005. The Phase IV RD/RA Work Plan to address unexploded ordnance was completed during 2006.

Waste Area Group 7 – Radioactive Waste Management Complex

Waste Area Group 7 includes the Subsurface Disposal Area (SDA), a 39 hectare (ha) (97 acre) disposal area containing buried hazardous and radioactive waste. Organic solvents contained in this waste are a source of groundwater contamination and are being removed by an ongoing cleanup action. The state, EPA, and DOE-ID agreed on a revised technical approach, the Glovebox Excavator Method project (GEM), to demonstrate retrieval from a small area of Pit 9. Workers remotely excavated wastes and examined them in a shielded confinement structure or glovebox. The waste is to be treated for shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Waste retrieved during this successful excavation has been used to validate the characterization data generated by several noninvasive techniques and by ground probes. The ongoing Accelerated Retrieval Project (ARP), and ARP-II project to be initiated during 2007, are larger-scale excavations (one-half acre) in Pits 4 and 6 using many of the safe operating concepts developed during the GEM project. These projects are being performed as CERCLA Removal Actions. Additional excavations are anticipated in future years as the retrieval approach is proven effective.

The following accomplishments were achieved at WAG 7 in 2006:

- Finalized OU 7-13/14 Remedial Investigation and Baseline Risk Assessment report and submitted the feasibility study report to EPA and the state of Idaho for review and comment.
- Continued the Organic Contamination in the Vadose Zone Project, a vacuum extraction system that removes solvent vapors that have escaped from buried waste. The vapors are brought to the surface and destroyed using thermal and catalytic processes.
- ARP excavations of buried waste were reinitiated during 2006, after a drum fire occurred and retrieval excavations were discontinued while conducting an extensive evaluation to ensure continued excavations would be safe. Retrieval excavations are anticipated to be initiated for ARP-II during 2007.

Waste Area Group 8 - Naval Reactors Facility

NRF results are not included in this report.

Waste Area Group 9 – Materials and Fuels Complex

All WAG 9 remediation activities have been completed. Three sites will remain under institutional controls until 2097 to allow for natural decay of Cesium-137 to background levels.

3.4 Waste Management and Disposition

The INL Site's waste management activities provide safe, compliant, and cost-effective management services for facility waste streams. Waste management and disposition covers a variety of operations and functions including: (1) storage of waste pending disposition, (2) characterization of waste in order to allow it to be placed in storage or offered for transportation/treatment/disposal, (3) transportation of waste to onsite and/or offsite locations for treatment and/or disposal, (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 and the INL Site Treatment Plan.

Federal Facility Compliance Act

The Federal Facility Compliance Act requires the preparation of a site treatment plan for the treatment of mixed wastes (those containing both radioactive and nonradioactive hazardous materials) at the INL Site.

In accordance with the Site Treatment Plan, the INL Site began receiving offsite mixed waste for treatment in January 1996. The INL Site received mixed waste from other sites within the DOE complex including Hanford, Los Alamos, Paducah, Pantex, Sandia, and six locations managed by the Office of Naval Reactors. The INL Site is storing the backlog of mixed waste in permitted storage at the Waste Reduction Operations Complex and INTEC. The Site Treatment Plan covers the treatment and disposal of legacy waste by means of a backlog schedule. Below is a list of backlog waste and amounts that were dispositioned in 2006 in accordance with the milestone schedules.

- High-Efficiency Particulate Air Filter Leach –26 m^3 (918.2 ft^3)
- Commercial treatment/disposal of a backlog –35 m^3 (1236.0 ft^3)
- Sodium Components Maintenance Shop treatment backlog –2.0 m^3 (70.66 ft^3)
- Advanced Mixed Waste Treatment Project – 4500 m^3 (158,985 ft^3)

The Site Treatment Plan covers the development of a treatment facility for sodium-bearing waste (SBW) and the research process to identify treatment options for calcine waste.

Advanced Mixed Waste Treatment Project

The overall goal of the Advanced Mixed Waste Treatment Project (AMWTP) is the treatment of alpha-containing low level mixed and transuranic (TRU) mixed wastes for final disposal by a process that minimizes overall costs while ensuring safety. This will be accomplished through a treatment facility with the capability to treat specified INL Site waste streams and the flexibility to treat other INL Site and DOE regional and national waste streams. The facility will treat waste to meet the most current requirements, reduce waste volume and life-cycle cost to DOE, and perform tasks in a safe, environmentally compliant manner.

A contract for treatment services was awarded to British Nuclear Fuels Limited (BNFL), Inc. in December 1996. BNFL completed construction of the facility in December 2002, fulfilling a Settlement Agreement milestone. AMWTP retrieval operations commenced in March 2003 and treatment facility operations commenced in August 2004. The BNFL contract was terminated effective April 30, 2005, and Bechtel BWXT Idaho (BBWI) assumed operations of AMWTP on May 1, 2005. Certification of the treatment facility was obtained in May 2005 allowing for certification and shipment of treated TRU waste to WIPP. The first

shipment of treated TRU waste from AMWTP was sent to WIPP on May 31, 2005. During 2006, a total of 6655 m^3 (234,842 ft^3) of transuranic waste was shipped from AMWTP to WIPP. Since 1999, 14,365 m^3 (506,912 ft^3) of waste have been shipped offsite.

High-Level Waste (HLW) and Facilities Disposition

In 1953, reprocessing of SNF began at the INTEC, resulting in the generation of liquid HLW and SBW. 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, known as 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 non-sodium-bearing liquid HLW was completed on February 20, 1998, four months ahead of the June 30, 1998, Idaho Settlement Agreement milestone. Calcining of remaining SBW began immediately following completion of non-sodium liquid HLW treatment, more than three years ahead of the Idaho Settlement Agreement milestone. Per that Agreement, all such waste was required to be calcined by the end of the year 2012.

In October 2002, DOE issued the Final Idaho HLW and Facilities Disposition Environmental Impact Statement (FEIS) that included alternatives other than calcination for treatment of the SBW. DOE issued a ROD for this FEIS on December 13, 2005. This ROD chose steam reforming to treat the remaining SBW in the tank farm. DOE plans to complete SBW treatment using this technology by December 31, 2012. The state of Idaho, in a letter dated November 17, 2005, to James A. Rispoli, DOE Assistant Secretary for Environmental Management, stated: "Solidification via steam reforming is, therefore, an acceptable substitute technology for meeting DOE's commitment under the 1995 court settlement in Public Service Company of Colorado v. Kempthorne, CV-91-0035-S-EJL to 'complete calcination of sodium-bearing liquid HLWs by December 31, 2012…" "The State notes that steam reformed waste shall be subject to other 1995 court settlement requirements for treatment and removal of calcined waste from the state of Idaho." This technology will treat the remaining approximately 3.4 million L (900,000 gal) of liquid SBW that has been consolidated into three 1.14 million L (300,000 gal) below grade tanks at the INTEC Tank Farm for interim storage. Seven other 1.14 million L (300,000 gal) 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 EIS ROD in November 2006. Tank closure activities began in November 2006.

The FEIS also included analysis of alternatives for treatment of the calcined waste. DOE continues to investigate technologies for efficient retrieval of the existing HLW calcine from the consolidated calcine storage facilities (bin sets) and to evaluate treatment technologies to comply with repository disposal requirements. A National Environmental Policy Act ROD will be issued by December 31, 2009, and will support maintaining a dual path—disposal of untreated calcine and selection of a preferred treatment technology.

Low-Level and Mixed Radioactive Waste

In 2006, the INL Site treated and disposed offsite more than 578 m^3 (20,412 ft^3) of mixed low-level waste and 468 m^3 (16,537 ft^3) of low-level waste. Approximately 8680 m^3 (306,531 ft^3) of legacy and newly generated low-level waste were disposed at the SDA in 2006.

Waste Minimization/Pollution Prevention

The mission of the Pollution Prevention Program is to reduce, reuse and recycle wastes generated and pollutants by implementing cost-effective pollution prevention techniques, practices, and policies. Pollution prevention is required by various federal statutes including, but not limited to, the Pollution Prevention Act and the Resource Conservation and Recovery Act; Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management.

It is the policy of the INL Site to incorporate pollution prevention into every activity onsite and in the Idaho Falls facilities. Pollution prevention is one of the key underpinnings of the INL Site Environmental Management System (see Section 3.5). It functions as an important preventive mechanism because generating less waste reduces waste management costs, compliance vulnerabilities, and the potential for releases to the environment. The INL Site is promoting the inclusion of pollution prevention into all planning activities as well as the concept that pollution prevention is integral to mission accomplishment.

3.5 Environmental Management System

The INL contractor continued to make progress on the effort initiated in 1997 to develop and implement a sitewide Environmental Management System (EMS). The EMS meets the requirements of International Organization for Standardization (ISO) 14001, an international voluntary standard for environmental management systems. This standard is being vigorously embraced worldwide as well as within the DOE complex. An EMS provides an underlying structure to make the management of environmental activities more systematic and predictable. The 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.

An audit and onsite readiness review conducted in 2001 by an independent ISO 14001 auditor concluded that the INL Site was ready for a formal registration audit. A registration audit was conducted May 6–10, 2002, by a third-party registrar. There were no nonconformances identified during the audit and the lead auditor recommended ISO 14001 registration for INL Site facilities, which was received in June 2002. In February and May of 2005, DOE brought two new contractors on board to run the future development of the INL (BEA) and the cleanup of legacy facilities and waste under the Idaho Cleanup Project (CWI), along with changing the operating contractor at the AMWTP from BNFL to BBWI. Because these contract changes occurred during the ISO 14001 registration audit period, the new contractors allowed the former system to lapse while focusing on a new system under the new contracts (for BEA and CWI; BBWI remained exempt under terms of the contract). In November 2005, both BEA and CWI successfully applied and passed the registration audit to regain ISO 14001 registration. In early December 2005, the DOE-ID Manager was able to certify to DOE Headquarters that a successful Environmental Management System was being implemented at the INL Site.

Throughout 2006, both CWI and BEA have maintained their ISO 14001 registration. BBWI has developed a self-certifying EMS in accordance with DOE Order 450.1. All three EMS programs have been successfully integrated into each contractor's Integrated Safety Management System. DOE performed annual evaluations of the contractor's EMS and found the programs satisfactory and compliant with the standards outlined in the DOE Order 450.1.

3.6 Other Major Environmental Issues and Activities

Deactivation, Decontamination, and Decommissioning (DD&D) Activities

The INL Site continued with an aggressive approach to reducing the EM "footprint" through accelerated DD&D activities of EM-owned buildings and structures. This effort achieved significant cost and risk reductions by eliminating aging facilities no longer necessary for the INL mission. In 2006 efforts were placed on the decontamination of high-risk facilities in preparation for final decommissioning slated for 2007. In total, 4,135 m^2 (44,507 ft^2) of buildings and structures were demolished in 2006. Specific projects at various facilities are described below.

Test Area North (TAN) – Minor structures and buildings that no longer have a mission were demolished at TAN along with the Control and Equipment Building (TAN-630) which was part of the Loss of Fluid Test Reactor Complex. In 2006 a total of 3,040 m^2 (32,719 ft^2) of footprint reduction was achieved at TAN.

Reactor Technology Complex (RTC) – Emphasis was placed on the decontamination of the Engineering Test Reactor (ETR) complex which is slated for final decommissioning in FY 2008. Minor buildings and structures were demolished at RTC in order to acquire open access to the ETR Complex. A total of 1,095 m^2 (11,788 ft^2) of buildings and structures was demolished in 2006. Decontamination work continued in the ETR Complex.

Idaho Nuclear Technology and Engineering Center – There was no footprint reduction at INTEC in FY 2006. However, characterization and deactivation work was initiated on INTEC's Fuel Reprocessing Complex (CPP-601/640).

Spent Nuclear Fuel

Spent nuclear fuel (SNF) is defined as fuel that has been irradiated in a nuclear reactor, has produced power, has been removed from the reactor and has not been reprocessed to separate any constituent elements. 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 ICP at INTEC, by the Naval Nuclear Propulsion Program at NRF, and by Nuclear Energy at RTC and MFC. Over 220 different types of SNF ranging in size from 0.9 kg (2 lbs), to 0.45 metric ton (0.5 ton) are managed at the INL Site.

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 a spent nuclear fuel and HLW repository. The Idaho Settlement Agreement requires all INL Site fuel be removed from the state of Idaho by 2035. The INL Site's goal is to begin shipping SNF to the repository as soon as the facility is licensed and operating.

In 2006, INL Site SNF was stored in both wet and dry condition. Dry storage is preferred because it reduces concerns about corrosion and is less expensive to monitor. An effort is underway to put all INL Site SNF in dry storage. The capacity to place SNF in standard canisters for transport to the repository will be

built after 2012. SNF storage facilities are described below. All ICP-managed SNF was consolidated at INTEC in 2003.

Fluorinel Dissolution Process and Fuel Storage Facility (FAST) (CPP-666) – This INTEC facility, also called FAST, is divided into two parts:

1. A SNF storage basin area
2. The Fluorinel Dissolution Facility, which operated from 1983 to 1992.

The storage area consists of six storage basins currently storing SNF under about 11 million L (3 million gal) of water, which provides protective shielding and cooling. ICP-managed SNF is being removed from the basins and stored in the INTEC dry storage facilities described below. All ICP-managed SNF will be in dry storage by the end of 2009. Eventually, all SNF will be removed from this underwater storage pool and placed in dry storage in preparation for shipment to a repository. In 2006, the Advanced Test Reactor (ATR) sent shipments of SNF to FAST for storage.

Irradiated Fuel Storage Facility (IFSF) (CPP-603) – This INTEC facility, also called the IFSF, is the dry side of the Wet and Dry Fuel Storage Facility. It has 636 storage positions and has provided dry storage for SNF since 1973. In 2006, the DD&D of the old fuel storage basin continued. The IFSF was approximately 70 percent full at the end of 2006 and will continue to receive SNF from the CPP-666 basin, and foreign and domestic research reactors SNF in 2007.

TMI-2 Independent Spent Fuel Storage Installation (ISFSI) (CPP-1774) – This INTEC facility, also called the ISFSI, is an U.S. Nuclear Regulatory Commission-licensed dry storage area for SNF and debris from the Three Mile Island reactor accident. Fuel and debris were transferred to TAN 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, which is kept in metal casks inside the concrete vaults.

Peach Bottom Fuel Storage Facility (CPP-749) – This INTEC facility consists of below-ground vaults for the dry storage of SNF. Located on approximately 2 ha (5 acres), this facility houses 193 underground vaults of various sizes for the dry storage of nuclear fuel rods. The vaults are generally constructed of carbon steel tubes with some of them containing concrete plugs. All of the tubes are completely below grade and are accessed from the top using specially designed equipment. This facility currently stores SNF as well as unirradiated fuels from Peach Bottom Atomic Power Station located in York County, Pennsylvania. It will be used to store additional types of SNF to achieve the 2009 goal for all ICP SNF to be in dry storage.

Fort Saint Vrain Independent Spent Fuel Storage Installation – The DOE-ID manages this offsite NRC-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 IFSF, described above.

Advanced Test Reactor (TRA-670) – The ATR is located at the RTC. 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 FAST, as described above. The

ATR canal is designated as a working facility rather than a storage facility. The ultimate disposition of ATR spent fuel may be either recycle or disposition in the repository.

Environmental Oversight and Monitoring Agreement

The 2005 Environmental Oversight and Monitoring Agreement 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 DOE activities in Idaho
- Assure citizens of Idaho that all DOE activities in Idaho are protective of the health and safety of Idahoans and the environment
- Communicate findings to the citizens of Idaho in a manner that provides them the opportunity to evaluate these potential impacts.

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

Citizens Advisory Board

The INL Site Environmental Management Citizens Advisory Board, one of the EM Site Specific Advisory Boards, was formed in March 1994. Its charter is to provide input and recommendations on DOE EM site-specific topics. These topics include cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of non-stockpile 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 produced over 125 recommendations during its tenure. Currently, the Board is working on the following issues, in addition to numerous others:

- Cleanup and closure of RWMC, including the SDA
- Cleanup and Closure of INTEC
- Disposition of Calcined HLW
- Decommissioning the old test Reactors (ETR, Materials Test Reactor [MTR], & PBF)
- Decontamination and Decommissioning (D&D) activities at the Test Area North
- Engineering Evaluation/Cost Analysis for all ICP activities at the INL Site
- INL Site Budget for D&D and Cleanup progress

More information about the Board's recommendations, membership, and meeting dates and topics can be found at http://www.inlemcab.org/.

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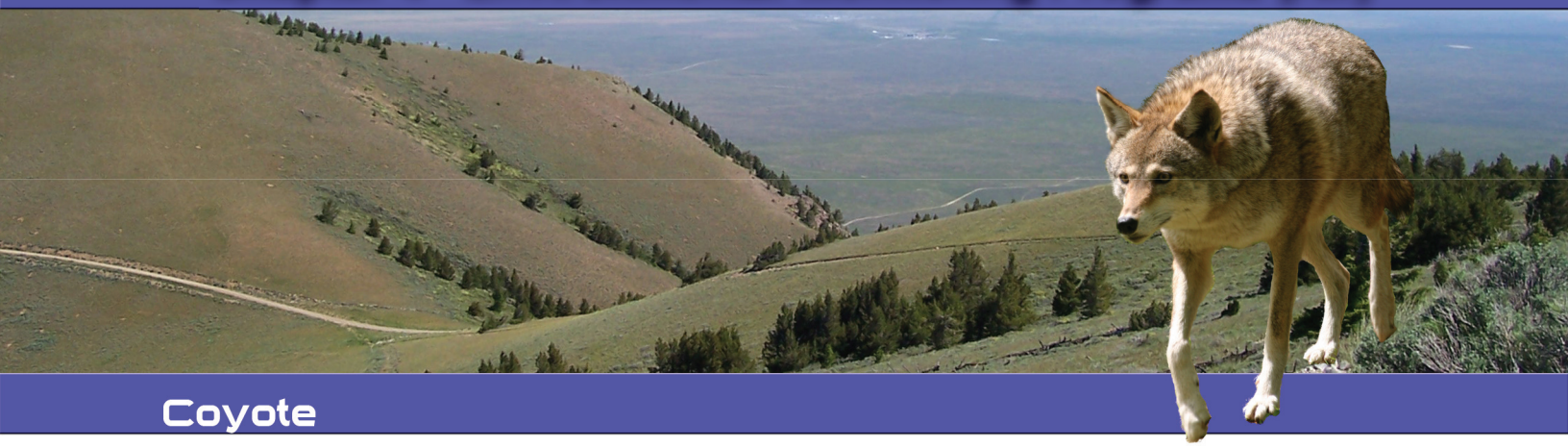
Chapter 4 - Environmental Monitoring Programs (Air)



Coyote

M. Case - S. M. Stoller Corporation
M. Verdoorn - Battelle Energy Alliance
R. Wilhelmsen - CH2M-WG Idaho

4. ENVIRONMENTAL MONITORING PROGRAMS (AIR)

This chapter presents the results of radiological and nonradiological analyses performed on airborne effluents and ambient air samples taken at locations both on the Idaho National Laboratory (INL) Site and offsite. Results from sampling conducted by the INL contractor, the Idaho Cleanup Project (ICP) contractor, and the Environmental Surveillance, Education and Research Program (ESER) contractor are presented. Results are compared to the U.S. Environmental Protection Agency (EPA) health-based levels established in environmental statutes and/or the U.S. Department of Energy Derived Concentration Guides (DCGs) for inhalation of air (Appendix A).

4.1 Purpose and Organization of Air Monitoring Programs

The facilities operating on the INL Site release both radioactive and nonradioactive constituents into the air. Various pathway vectors (such as air, soil, plants, animals, and groundwater) may transport radioactive and nonradioactive materials from the INL Site to nearby populations. These transport pathways have been ranked in terms of relative importance (EG&G 1993). The results of the ranking analysis indicate that air is the most important transport pathway. The INL Site environmental surveillance programs emphasize measurement of airborne radionuclides because air has the potential to transport a large amount of activity to a receptor in a relatively short period and can result in direct exposure to offsite receptors. Table 4-1 summarizes the air monitoring activities conducted at the INL Site.

The INL contractor monitors airborne effluents at individual INL Site facilities and ambient air outside the facilities to comply with applicable statutory requirements and DOE orders. The INL contractor collected approximately 2400 air samples (primarily on the INL Site) for analyses in 2006.

The ESER contractor collects samples from approximately 23,309 km^2 (9000 mi^2) area of southeastern Idaho and Jackson, Wyoming, at locations on, around, and distant to the INL Site. The ESER Program collected approximately 2300 air samples, primarily off the INL Site, for analyses in 2006. Section 4.2 summarizes results of air monitoring by the INL and ESER contractors. Section 4.3 discusses air sampling performed by the ICP contractor in support of waste management activities.

The INL Oversight Program operates a series of air monitoring stations, often collected at locations used by the INL and ESER contractors. These results are presented in annual reports prepared by the Oversight Program and are not reported in Chapter 4.

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	Suspended Particulates	Filtered Particulates (PM_{10})[d]	IMPROVE samplers
INL & ICP Contractors: Battelle Energy Alliance (BEA) & CH2M-WG Idaho, LLC (CWI)										
INTEC	•									
MFC	•									
RWMC	•	•	•	•	•	•		•	•	
INL/Regional		•	•	•	•	•		•	•	
Environmental Surveillance, Education and Research Program (S. M. Stoller Corporation)										
INL/Regional		•	•	•	•	•	•	•	•	•[e]
National Oceanic and Atmospheric Administration										
INL/Regional						•	•	•	•	

a. INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, RWMC = Radioactive Waste Management Complex, IMPROVE = Interagency Monitoring of Protected Environments.

b. Facilities with stacks that required continuous monitoring during 2006 for compliance with Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H, National Emissions Standards for Hazardous Air Pollutants (NESHAP) Regulation.

c. Gamma-emitting radionuclides and strontium-90, plutonium-238, plutonium-239/240, and americium-241.

d. PM_{10} = particles with an aerodynamic diameter less than or equal to 10 microns.

e. The IMPROVE samplers are operated by the National Park Service for the Environmental Protection Agency.

Unless specified otherwise, the radiological results discussed in the following sections are those greater than three times the associated analytical uncertainty (see Appendix B for information on statistical methods). Each individual result is reported in tables as the measurement plus or minus one sigma analytical (± 1s) uncertainty for that radiological analysis.

4.2 Air Sampling

Airborne effluents are measured at or estimated for regulated facilities as required under the Idaho State Implementation Plan. Monitoring or estimating effluent data is the responsibility of programs associated with the operation of each INL Site facility and not the environmental surveillance programs.

Environmental surveillance of air pathways is the responsibility of the INL, ICP, and ESER contractors. Figure 4-1 shows the surveillance air monitoring locations for the INL Site environmental surveillance programs.

For onsite and offsite air surveillance monitoring, filters are collected from a network of low-volume air monitors weekly. Air flows (at an average of about 57 L/minute [2 ft^3/minute]) through a set of filters consisting of a 5 cm (2 in.), 1.2 µm pore membrane filter followed by a charcoal cartridge. The membrane filters are analyzed weekly for gross alpha and gross beta activity. Filters are then composited quarterly by location for analysis of gamma-emitting radionuclides using gamma spectrometry and for specific alpha- and beta-emitting radionuclides using radiochemical techniques. In addition to the membrane filter samples, charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) using gamma spectrometry.

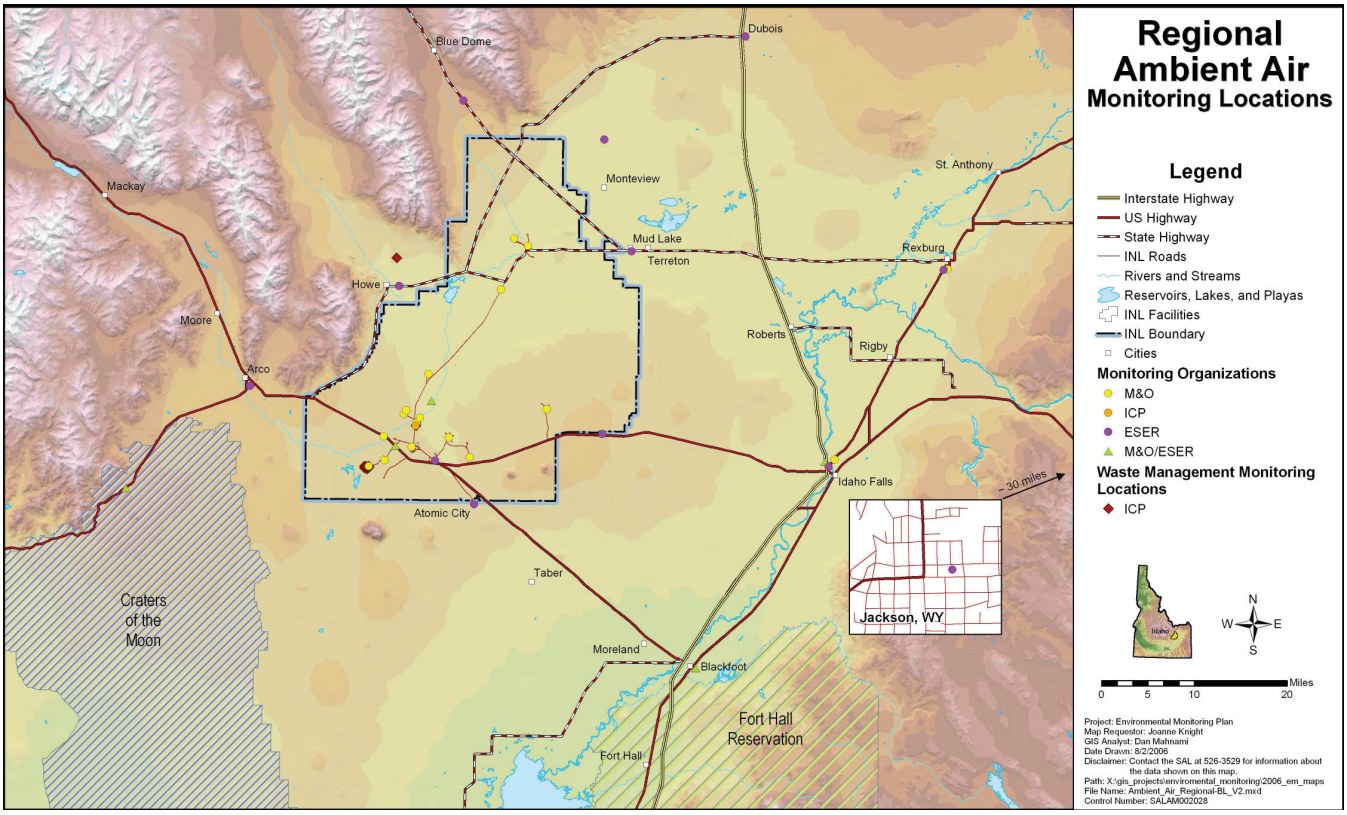


Figure 4-1. INL Site Environmental Surveillance Air Sampling Locations.

There is no requirement to monitor the dust burden at the INL Site, but the INL and ESER contractors monitor this to provide comparison information for other monitoring programs. The suspended particulate dust burden is monitored with the same low-volume filters used to collect the radioactive particulate samples by weighing the filters before and after their use in the field.

The ESER contractor also monitors particles with an aerodynamic diameter less than or equal to 10 microns (PM_{10}) to compare to EPA air quality standards.

Tritium in water vapor in the atmosphere is monitored by the INL and ESER contractors using samplers located at two onsite locations (Experimental Field Station [EFS] and Van Buren Boulevard) and five offsite locations (Atomic City, Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg). Air passes through a column of adsorbent material (molecular sieve) that adsorbs water vapor in the air. Columns are changed when the material absorbs sufficient moisture to obtain a sample. Water is extracted from the material by distillation and collected. Tritium concentrations are then determined by liquid scintillation counting of the water extracted from the columns.

Airborne Effluents

During 2006, an estimated 6,340 Ci of radioactivity were released to the atmosphere from all INL Site sources. The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Calendar Year 2006 INL Report for Radionuclides (DOE-ID 2007) describes three categories of airborne emissions. The first category includes sources that require continuous monitoring under the NESHAP regulation. The second category consists of releases from other point sources. The final category is nonpoint, or diffuse, sources. These include radioactive waste ponds and contaminated soil areas. All three categories are represented in Table 4-2 of this report. Only radionuclides that are potentially significant contributors to the INL Site dose (i.e., >1E-05 mrem) are listed in the NESHAPs report.

The largest facility contributions to the total emissions came from the Idaho Nuclear Technology and Engineering Center (INTEC) at 57 percent, Reactor Technology Complex (RTC) at approximately 22 percent, the Materials and Fuels Complex (MFC) at 19 percent, and the Radioactive Waste Management Complex (RWMC) at 1 percent (Table 4-2). Approximately 88 percent of the radioactive effluent was in the form of noble gases (argon, krypton, and xenon) and most of the remaining effluent was tritium.

Low-Volume Charcoal Cartridges

Both the ESER and INL Site contractors collected charcoal cartridges weekly and analyzed them for gamma-emitting radionuclides. Charcoal cartridges are primarily used to collect gaseous radioiodines. If traces of any human-made radionuclide were detected, the filters were individually analyzed. During 2006, the ESER contractor analyzed 936 cartridges, looking specifically for ^{131}I. No ^{131}I was detected in any of the individual ESER samples.

The INL Site contractor collected and analyzed 1,201 cartridges. Iodine was detected in excess of the 3 sigma value in one sample collected at RTC at a level of 5.06×10^{-15} µCi/mL.

Low-Volume Gross Alpha

Particulates filtered from the air were sampled weekly as part of the INL Site environmental surveillance programs (see Figure 4-1). All were analyzed for gross alpha activity and gross beta activity. Gross alpha concentrations found in INL contractor samples, both on and offsite, tended to be higher than

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2006).[a]

Nuclide	Half-life	Airborne Effluent (Ci)[b]						
		CFA[c]	INTEC[c,d]	MFC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Ac-227	21.7 y	--[e]	1.27E-13	--	4.86E-12	--	--	4.99E-12
Ag-109M	39.6 s	--	3.06E-20	--	--	--	--	3.06E-20
Ag-110	24.6 s	--	3.22E-19	--	--	--	--	3.22E-19
Ag-110M	249.9 d	--	8.52E-05	--	1.67E-06	--	2.66E-03	2.75E-03
Am-241	432.2 y	5.26E-10	4.88E-05	--	1.04E-04	5.41E-05	2.41E-06	2.10E-04
Am-242	16 h	--	1.24E-12	--	--	--	--	1.24E-12
Am-242M	152 y	--	2.81E-13	--	--	--	--	2.81E-13
Am-243	7380 y	4.00E-13	7.47E-11	--	1.01E-07	--	--	1.01E-07
Ar-41	1.827 h	--	--	1.52E+00	5.40E+02	--	--	5.42E+02
Ba-133	10.5 y	--	--	--	1.67E-08	--	--	1.67E-08
Ba-139	82.7 m	--	--	--	2.11E-03	--	--	2.11E-03
Ba-140	12.74 d	--	--	--	5.66E-06	--	--	5.66E-06
Ba-141	18.3 m	--	--	--	5.76E-09	--	--	5.76E-09
Be-7	53.3 d	--	--	--	--	4.42E-08	--	4.42E-08
Bi-210	5 d	--	6.80E-15	--	--	--	--	6.80E-15
Bi-211	2.1 m	--	1.14E-13	--	--	--	--	1.14E-13
Bi-212	60.6 m	--	3.44E-12	--	--	1.98E-09	--	1.98E-09
Bi-214	19.9 m	--	3.50E-14	--	--	--	--	3.50E-14
C-14	5730 y	--	1.45E-09	--	6.96E-04	9.40E-01	--	9.41E-01
Cd-115M	44.6 y	--	2.65E-62	--	--	--	--	2.65E-62
Ce-141	32.5 d	--	1.12E-79	--	4.41E-05	--	--	4.41E-05
Ce-143	33 h	--	--	--	2.21E-08	--	--	2.21E-08
Ce-144	284.3 d	--	1.54E-07	--	5.95E-05	--	1.35E-05	7.31E-05
Cf-252	2.638 y	--	1.40E-28	--	3.52E-05	--	--	3.52E-05
Cl-36	3.01E5 y	--	--	--	--	--	--	0.00E+00
Cm-242	162.8 d	--	1.23E-11	--	8.21E-11	--	1.16E-11	1.06E-10
Cm-243	28.5 y	--	8.84E-07	--	--	--	1.49E-06	2.37E-06
Cm-244	18.11 y	--	8.84E-07	--	1.94E-09	4.00E-08	1.49E-06	2.41E-06
Cm-245	8500 y	--	4.99E-16	--	--	--	--	4.99E-16
Cm-246	4730 y	--	1.11E-17	--	--	--	--	1.11E-17
Cm-247	1.6E7 y	--	3.98E-24	--	--	--	--	3.98E-24
Cm-248	3.4E5 y	--	1.22E-24	--	6.72E-10	--	--	6.72E-10
Co-57	270.9 d	1.43E-09	--	--	7.26E-08	--	--	7.40E-08
Co-58	70.8 d	--	--	--	2.75E-06	--	--	2.75E-06
Co-60	5.271 y	2.59E-08	9.01E-03	--	1.23E-02	8.39E-09	1.96E-04	2.15E-02

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2006).[a] (continued)

Nuclide	Half-life	Airborne Effluent (Ci)[b]						
		CFA[c]	INTEC[c,d]	MFC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Cr-51	27.704 d	--	--	--	7.23E-02	--	--	7.23E-02
Cs-134	2.062 y	4.19E-09	7.15E-05	--	2.35E-03	8.24E-09	5.71E-07	2.42E-03
Cs-135	2.3E6 y	--	2.51E-10	--	--	--	--	2.51E-10
Cs-137	30.0 y	2.30E-08	4.55E-02	--	5.43E-03	1.68E-07	2.02E-01	2.53E-01
Cs-138	32.2 m	--	--	--	3.88E-01	--	--	3.88E-01
Eu-152	13.33 y	--	5.72E-02	--	6.93E-05	--	2.30E-05	5.73E-02
Eu-154	8.8 y	--	3.27E-02	--	6.33E-05	--	8.73E-06	3.28E-02
Eu-155	4.96 y	--	3.20E-03	--	1.73E-05	--	1.81E-06	3.22E-03
Fe-55	2.7 y	3.98E-10	4.11E-13	--	2.37E-02	8.39E-11	--	2.37E-02
Fe-59	44.529 d	--	--	--	1.20E-07	--	--	1.20E-07
Fr-221	4.8 m	--	3.19E-16	--	--	--	--	3.19E-16
Fr-223	21.8 m	--	1.76E-15	--	--	--	--	1.76E-15
H-3	12.35 y	2.06E+00	4.31E+02	8.51E+00	4.84E+02	7.47E+01	1.17E-03	1.00E+03
Hf-181	42.39 d	--	--	--	9.11E-06	--	--	9.11E-06
Hg-203	46.6 d	--	--	--	4.07E-05	--	--	4.07E-05
Ho-166	26.8 h	--	--	--	2.40E-11	--	--	2.40E-11
Ho-166M	1.2E3 y	--	1.68E-14	--	8.55E-13	--	--	8.71E-13
I-125	60.1 d	--	--	--	1.10E-03	--	--	1.10E-03
I-129	1.57E7 y	--	5.04E-02	--	2.35E-05	--	--	5.04E-02
I-131	8.04 d	--	--	--	1.78E-01	--	--	1.78E-01
I-132	2.30 h	--	--	--	7.81E-03	--	--	7.81E-03
I-133	20.8 h	--	--	--	3.31E-03	--	--	3.31E-03
I-134	52.6 m	--	--	--	1.94E-03	--	--	1.94E-03
I-135	6.61 h	--	--	--	2.70E-03	--	--	2.70E-03
In-115	5.2E15 y	--	3.60E-20	--	--	--	--	3.60E-20
Ir-192	74.02 d	--	--	--	1.26E-09	--	--	1.26E-09
K-40	1.277E8 y	--	4.43E-06	--	3.13E-15	5.90E-08	1.50E-04	1.54E-04
Kr-85	10.72 y	--	3.20E+03	1.22E+03	2.50E-01	1.70E-07	--	4.42E+03
Kr-85M	4.48 h	--	--	--	1.54E+01	--	--	1.54E+01
Kr-87	76.3 m	--	--	--	3.75E+00	--	--	3.75E+00
Kr-88	2.84 m	--	--	--	1.70E+01	--	--	1.70E+01
Mn-54	312.5 d	1.78E-09	1.27E-08	--	3.27E-04	--	4.07E-07	3.27E-04
Mo-93	3.5E3 y	--	--	--	--	--	--	0.00E+00
Mo-99	66.0 h	--	--	--	4.37E-05	--	--	4.37E-05
Na-22	2.6 y	--	--	--	3.01E-08	--	--	3.01E-08

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2006).[a] (continued)

Nuclide	Half-life	Airborne Effluent (Ci)[b]						
		CFA[c]	INTEC[c,d]	MFC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Na-24	15.0 h	--	--	--	1.58E-04	--	--	1.58E-04
Nb-93M	13.6 y	--	8.41E-11	--	4.80E-11	--	--	1.32E-10
Nb-94	2.03E4 y	--	1.03E-04	--	1.32E-06	--	2.16E-05	1.26E-04
Nb-95	35.15 d	--	1.27E-06	--	7.16E-05	--	5.74E-07	7.34E-05
Nb-95M	86.6 h	--	1.15E-43	--	--	--	--	1.15E-43
Nd-147	10.98 d	--	--	--	2.98E-06	--	--	2.98E-06
Ni-59	7.5E4 y	--	2.66E-09	--	1.72E-05	--	2.90E-11	1.72E-05
Ni-63	96 y	1.44E-09	6.23E-04	--	2.32E-03	2.65E-10	1.22E-03	4.16E-03
Np-237	2.14E6 y	1.50E-13	5.73E-07	--	7.67E-06	--	--	8.25E-06
Np-238	2.1 d	--	1.36E-15	--	--	--	--	1.36E-15
Np-239	2.355 d	--	2.08E-12	--	8.58E-05	--	--	8.58E-05
Np-240	65 m	--	1.74E-22	--	--	--	--	1.74E-22
Np-240M	7.4 m	--	1.58E-19	--	--	--	--	1.58E-19
Pa-231	3.3E4 y	--	4.34E-13	--	--	--	--	4.34E-13
Pa-233	27 d	--	2.71E-10	--	4.50E-11	--	--	3.16E-10
Pb-209	3.3 h	--	3.02E-16	--	--	--	--	3.02E-16
Pb-210	22.3 y	--	3.18E-14	--	3.25E-11	1.33E-08	--	1.33E-08
Pb-211	36.1 m	--	1.14E-13	--	--	--	--	1.14E-13
Pb-212	10.6 h	--	3.44E-12	--	--	1.98E-09	--	1.98E-09
Pb-214	26.8 m	--	3.50E-14	--	--	--	--	3.50E-14
Pd-107	6.5E6 y	--	3.87E-11	--	--	--	--	3.87E-11
Pm-147	2.6234 y	--	1.42E-04	--	8.15E-04	2.03E-09	--	9.57E-04
Pm-148	5.4 d	--	2.47E-67	--	--	--	--	2.47E-67
Pm-148M	41.3 d	--	5.12E-66	--	--	--	--	5.12E-66
Po-210	138.4 d	--	6.32E-15	--	--	--	--	6.32E-15
Po-218	3.05 m	--	3.50E-14	--	--	--	--	3.50E-14
Pr-144	17.3 m	--	1.35E-11	--	--	2.02E-09	--	2.03E-09
Pr-144M	7.2 m	--	1.58E-13	--	--	--	--	1.58E-13
Pu-236	2.9 y	2.50E-13	1.43E-13	--	3.16E-13	--	--	7.10E-13
Pu-238	87.74 y	6.67E-11	1.84E-04	--	6.83E-07	8.61E-06	7.66E-06	2.01E-04
Pu-239	24065 y	1.40E-10	7.70E-04	--	2.34E-05	1.47E-04	1.49E-04	1.09E-03
Pu-240	6537 y	--	2.76E-04	--	8.56E-07	3.30E-05	1.49E-04	4.58E-04
Pu-241	14.4 y	--	1.30E-02	--	2.80E-05	1.20E-05	6.20E-09	1.30E-02
Pu-242	3.8E5 y	1.50E-13	1.50E-12	--	3.64E-10	7.72E-11	--	4.43E-10
Pu-243	5 h	--	7.26E-11	--	--	--	--	7.26E-11
Pu-244	8.3E7 y	--	1.58E-19	--	1.06E-14	--	--	1.06E-14
Ra-223	11.4 d	--	1.26E-13	--	--	--	--	1.26E-13

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2006).[a] (continued)

Nuclide	Half-life	Airborne Effluent (Ci)[b]						
		CFA[c]	INTEC[c,d]	MFC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Ra-225	14.8 d	--	3.19E-16	--	2.28E-10	--	--	2.28E-10
Ra-226	1600 y	--	4.35E-05	--	1.09E-11	--	1.23E-05	5.58E-05
Rb-87	4.7E10 y	--	6.94E-14	--	--	--	--	6.94E-14
Rb-88	17.8 m	--	--	--	6.36E+00	--	--	6.36E+00
Rb-89	15.2 m	--	--	--	3.08E-02	--	--	3.08E-02
Rh-103M	56.1 m	--	1.76E-66	--	--	--	--	1.76E-66
Rh-105	35.36 h	--	--	--	--	--	--	0.00E+00
Ru-103	39.28 d	--	1.76E-66	--	3.44E-05	--	--	3.44E-05
Ru-106	368.2 d	--	3.39E-07	--	2.65E-05	--	1.09E-05	3.77E-05
Sb-124	60.2 d	--	1.29E-48	--	4.43E-06	--	--	4.43E-06
Sb-125	2.77 y	--	1.47E-05	--	2.66E-06	1.23E-10	4.46E-09	1.74E-05
Sb-126	12.4 d	--	1.28E-10	--	--	--	--	1.28E-10
Sb-126M	19 m	--	9.17E-10	--	--	--	--	9.17E-10
Sb-127	3.9 d	--	--	--	--	--	--	0.00E+00
Sc-46	83.83 d	--	--	--	5.56E-07	--	--	5.56E-07
Sm-147	1.1E11 y	--	2.55E-14	--	--	--	--	2.55E-14
Sm-151	90 y	--	4.03E-03	--	2.57E-06	--	--	4.03E-03
Sm-153	46.7 h	--	--	--	3.15E-09	--	--	3.15E-09
Sn-113	115.09 d	4.43E-10	--	--	9.82E-12	--	--	4.53E-10
Sn-123	129.2 d	--	5.24E-25	--	--	--	--	5.24E-25
Sn-126	1E5 y	--	9.32E-10	--	5.40E-11	--	--	9.86E-10
Sr-89	50.5 d	--	3.73E-52	--	1.43E-03	--	--	1.43E-03
Sr-90	29.12 y	4.21E-10	4.42E-02	6.09E-06	7.36E-04	3.81E-07	9.59E-03	5.46E-02
Sr-91	9.5 h	--	--	--	2.11E-09	--	--	2.11E-09
Sr-92	2.7 h	--	--	--	2.11E-09	--	--	2.11E-09
Tb-160	72.3 d	--	1.97E-42	--	--	--	--	1.97E-42
Tc-99	2.13E5 y	--	5.15E-08	--	8.50E-08	--	--	1.37E-07
Tc-99M	6.02 h	--	--	--	1.90E-04	--	--	1.90E-04
Te-127	9.4 h	--	5.83E-28	--	--	--	--	5.83E-28
Te-127M	109 d	--	5.91E-28	--	--	--	--	5.91E-28
Te-129	69.6 m	--	4.20E-79	--	--	--	--	4.20E-79
Te-129M	33.6 d	--	6.67E-79	--	--	--	--	6.67E-79
Th-227	18.7 d	--	1.13E-13	--	--	--	--	1.13E-13
Th-230	7.7E4 y	--	6.24E-09	--	2.73E-07	--	--	2.79E-07
Th-231	25.5 h	--	1.00E-09	--	--	--	--	1.00E-09
Th-232	1.405E10 y	1.81E-13	1.59E-06	--	4.88E-09	5.43E-10	--	1.59E-06

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2006).[a] (continued)

Nuclide	Half-life	Airborne Effluent (Ci)[b]						
		CFA[c]	INTEC[c,d]	MFC[c]	RTC[c]	RWMC[c]	TAN[c]	TOTAL
Tl-207	4.8 m	--	1.14E-13	--	--	--	--	1.14E-13
Tl-208	3.1 m	--	1.23E-12	--	--	7.08E-10	--	7.09E-10
Tl-209	2.2 m	--	6.54E-18	--	--	--	--	6.54E-18
U-232	72 y	2.50E-13	3.33E-12	--	9.08E-08	1.93E-09	--	9.27E-08
U-233	1.585E5 y	--	2.24E-06	--	1.01E-07	7.57E-08	6.16E-05	6.41E-05
U-234	2.457E5 y	1.30E-10	1.86E-04	--	1.38E-06	4.29E-10	6.16E-05	2.49E-04
U-235	7.038E8 y	1.51E-14	1.58E-05	--	3.24E-08	--	1.87E-05	3.46E-05
U-236	4.468E9 y	--	8.36E-09	--	2.44E-09	--	--	1.08E-08
U-237	6.8 d	--	--	--	9.73E-10	--	--	9.73E-10
U-238	4.5 E9 y	1.68E-07	2.44E-04	--	3.50E-06	--	1.70E-05	2.65E-04
U-240	14.1 h	--	1.58E-19	--	--	--	--	1.58E-19
W-187	23.9 h	--	--	--	1.26E-05	--	--	1.26E-05
Xe-127	9.4 h	--	9.84E-81	--	--	--	--	9.84E-81
Xe-131M	11.8 d	--	1.68E-120	--	--	--	--	1.68E-120
Xe-133	5.245 d	--	--	--	2.00E+02	--	--	2.00E+02
Xe-133M	5.2 d	--	--	--	1.00E+00	--	--	1.00E+00
Xe-135	9.09 h	--	--	--	1.32E+02	--	--	1.32E+02
Xe-135M	15.29 m	--	--	--	1.47E+00	--	--	1.47E+00
Xe-138	14.17 m	--	--	--	1.13E+00	--	--	1.13E+00
Y-90M		--	--	--	--	1.50E-07	--	1.50E-07
Y-91	58.5 d	--	2.58E-45	--	--	--	--	2.58E-45
Y-91M	49.71 m	--	--	--	4.53E-04	--	--	4.53E-04
Zn-65	243.9 d	3.29E-09	4.58E-08	--	4.69E-05	--	1.46E-06	4.84E-05
Zr-93	1.5E6 y	--	5.42E-09	--	6.00E-12	--	--	5.42E-09
Zr-95	63.98 d	--	5.60E-06	--	7.08E-05	--	6.25E-07	7.70E-05
Total		2.06E+00	3.64E+03	1.20E+03	1.40E+03	7.57+01	2.18E-01	6.34E+03

a. Radioactive release information provided by CH2M WG Idaho, LLC (CWI).
b. Includes only those radionuclides with a total Site release that potentially contribute >1E-05 mrem dose.
c. CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center , MFC = Materials and Fuels Complex, CITRC = Critical Infrastructure Test Range Complex, RTC = Reactor Technology Complex, RWMC = Radioactive Waste Management Area, TAN = Test Area North
d. Most of the INTEC emissions are from the Three Mile Island Dry Fuel Storage Facility and are based on conservative calculations.
e. A double dash signifies the radionuclide was not released to air from that facility during the calendar year.

those found in ESER contractor samples at common locations. Reasons for differences in concentrations measured at the same locations are likely caused by differences in laboratory analytical techniques and instrumentation, as different analytical laboratories were used. Both sets of data indicated gross alpha concentrations at onsite locations were generally equal to or lower than concentrations at boundary locations.

Weekly gross alpha concentrations detected in ESER contractor samples (i.e., measurements which exceeded their associated 3 sigma uncertainties) ranged from a minimum of 0.4 x 10^{-15} µCi/mL at Craters of the Moon during the week ending December 12, 2006, to a maximum of 8.0 x 10^{-15} µCi/mL during the week ending September 13, 2006, at the Mud Lake replicate sampler. Concentrations measured by the INL contractor that exceeded their 3 sigma uncertainty ranged from a low of 0.4 x 10^{-15} µCi/mL collected at Craters of the Moon on January 4, 2006, to a high of 49.0 x 10^{-15} µCi/mL collected at Naval Reactors Facility NRF) on September 6, 2006.

Figure 4-2 displays the median weekly gross alpha concentrations for the ESER and INL contractors at INL Site, boundary, and distant station groups. It also shows historical medians and ranges measured by the ESER contractor from 1999 - 2005. Each weekly median was computed using all measurements, including those less than their associated 3 sigma uncertainties. These data are typical of the annual natural fluctuation pattern for gross alpha concentrations in air. According to Figure 4-2, the highest median weekly concentration of gross alpha was measured by the ESER contractor for the INL group in the third quarter of 2006. The maximum median weekly gross alpha concentration was 5.3 x 10^{-15} µCi/mL and is below the DCG for the most restrictive alpha-emitting radionuclide in air (americium-241 [^{241}Am]) of 20 x 10^{-15} µCi/mL.

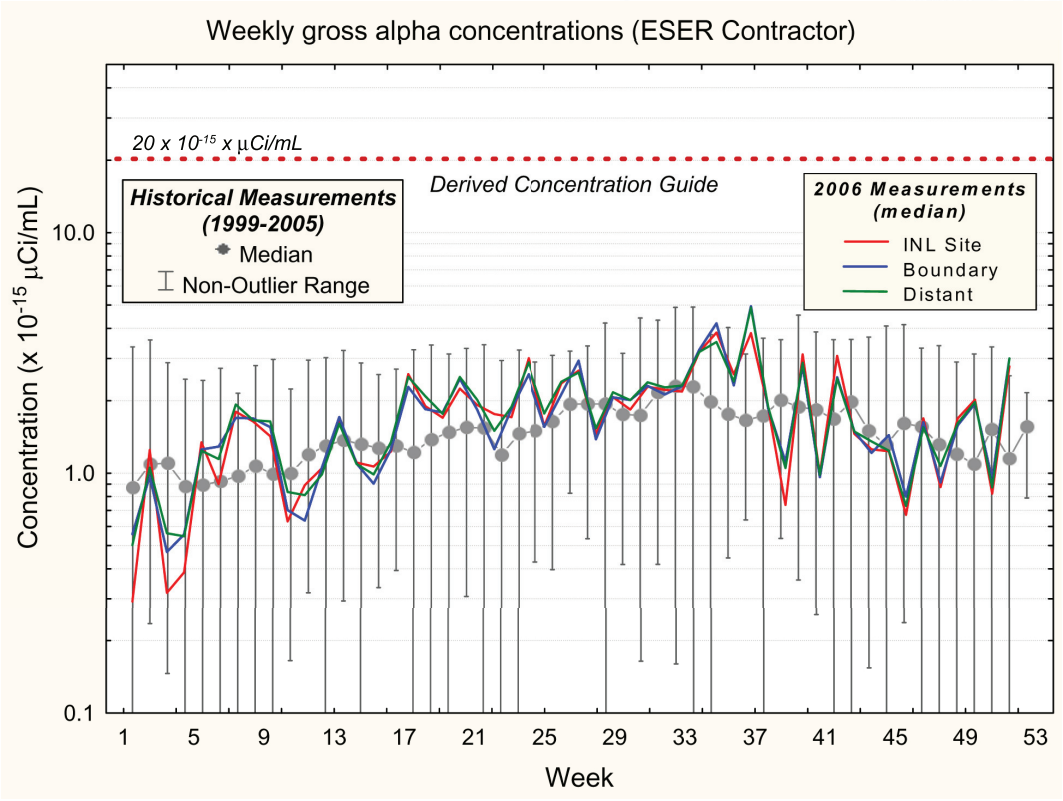
Annual median gross alpha concentrations calculated by the ESER contractor ranged from 1.3 x 10^{-15} µCi/mL at the FAA tower to 2.1 x 10^{-15} µCi/mL at Idaho Falls (Table 4-3). Confidence intervals are not calculated for annual medians. Annual median gross alpha concentrations calculated by the INL contractor ranged from 8.8 x 10^{-16} µCi/mL at the Craters of the Moon to 1.6 x 10^{-15} µCi/mL at Rexburg. In general, gross alpha concentrations were typical of those detected previously and well within the range of measurements observed historically for the eight-year period from 1999 through 2006 (Figure 4-3).

Low-Volume Gross Beta

Gross beta concentrations in ESER contractor samples were fairly consistent with those found in INL contractor samples.

Weekly gross beta concentrations detected in ESER contractor samples ranged from a low of 0.3 x 10^{-14} µCi/mL on January 4, 2006, at Jackson to a high of 5.8 x 10^{-14} µCi/mL at Jackson on December 13, 2006. Concentrations measured above 3 sigma by the INL contractor ranged from a low of 0.4 x 10^{-14} µCi/mL at Gate 4 on July 5, 2006, to a high of 8.1 x 10^{-14} µCi/mL at Location A on October 4, 2006.

Figure 4-4 displays the median weekly gross beta concentrations for the ESER and INL contractors at INL Site, boundary, and distant station groups. as well as historical median and range data measured by the ESER contractor from 1999-2005. These data are typical of the annual natural fluctuation pattern for gross beta concentrations in air, with higher values generally occurring at the beginning and end of the calendar year during winter inversion conditions. The highest median weekly concentration of gross beta activity was detected in the fourth quarter of 2006 by the INL contractor on the INL Site. Each median value was



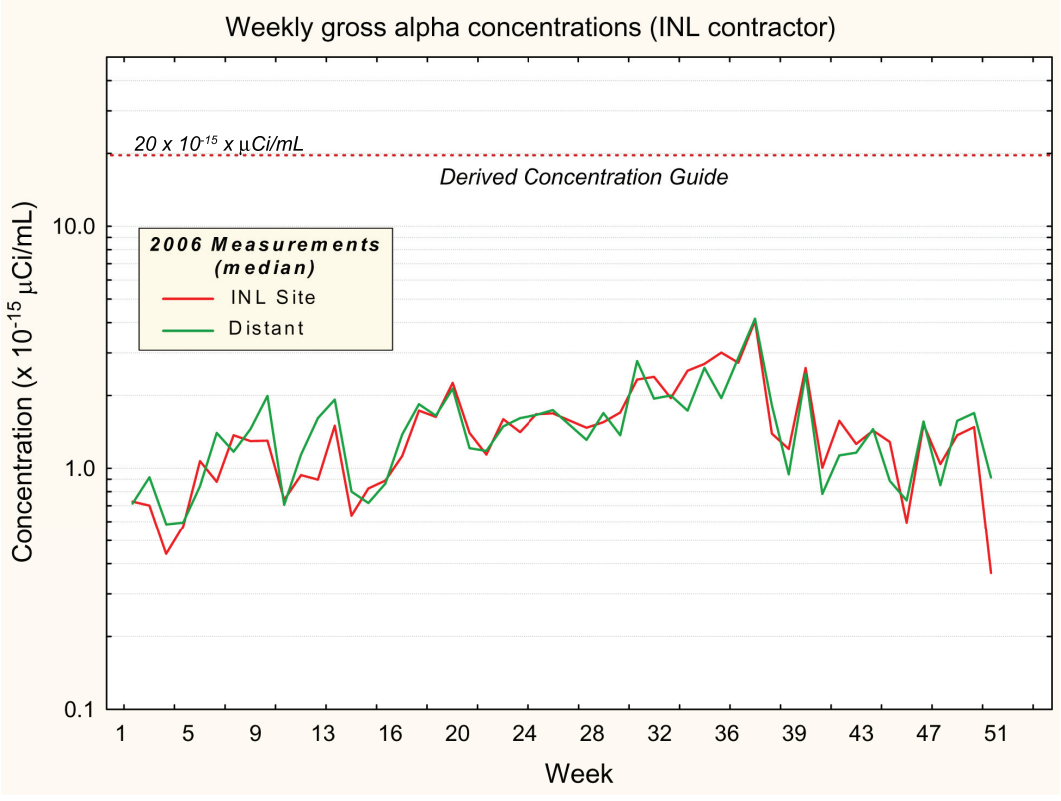


Figure 4-2. Median Weekly Gross Alpha Concentrations in Air (2006).

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2006).[a]

ESER Contractor Data			Concentration[a,b]	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS[c]	52	0.23 – 4.63	1.40
	Craters of the Moon	51	0.20 – 3.78	1.51
	Dubois	50	-0.26 – 4.83	1.67
	Idaho Falls	51	0.36 – 4.53	2.13
	Jackson	51	-0.05 – 1.89	1.74
	Rexburg CMS	52	0.55 – 5.25	1.92
			Distant Median:	1.82
Boundary	Arco	52	-0.02 – 5.14	1.79
	Atomic City	52	0.20 – 4.99	1.52
	Blue Dome	52	0.06 – 4.89	1.84
	Federal Aviation Administration Tower	51	0.30 – 2.75	1.32
	Howe	52	0.26 – 5.17	1.74
	Monteview	52	0.55 – 4.19	1.69
	Mud Lake	103[d]	0.41 – 4.94	1.88
			Boundary Median:	1.63
INL Site	EFS	103[d]	0.21 – 4.98	1.69
	Main Gate	52	0.07 – 3.50	1.68
	Van Buren	52	0.25 – 4.10	1.70
			INL Site Median:	1.69
M&O Contractor Data			**Concentration[a,b]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	51	-1.49 – 3.38	1.10
	Craters of the Moon	51	-1.76 – 3.46	0.88
	Idaho Falls	51	-0.79 – 4.68	1.19
	Rexburg	52	-0.18 – 4.23	1.63
			Distant Median	1.40
INL Site	MFC (formerly ANL-W)	51	0.50 – 4.34	1.45
	ARA	47	0.12 – 4.03	1.19
	CFA	51	0.19 – 3.51	1.40
	CPP	50	0.15 – 3.73	1.47
	EBR-I[c]	50	0.16 – 3.76	1.25
	EFS	50	0.06 – 3.31	1.37
	Gate 4	51	0.24 – 8.44	1.34
	INTEC	51	0.32 – 11.20	1.50
	NRF	49	0.41 – 48.50	1.52
	CITRC (formerly PBF)	51	0.47 – 4.50	1.26
	Rest Area	51	0.16 – 4.91	1.46
	RTC (formerly TRA)	50	0.17 – 4.62	1.54
	RTC (NE corner)	50	0.24 – 3.59	1.45
	RWMC	46	0.23– 4.46	1.39
	SMC	51	0.01 – 11.4	1.39
	TAN	51	0.30 – 4.33	1.44
	Van Buren	51	0.31 – 3.93	1.37
			INL Site Median	1.40

a. All values are × 10^{-15} mCi/mL.
b. All measurements, including those less than three times their analytical uncertainty, are included in this table and in computation of annual median values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. CMS = Community Monitoring Station; EBR-I = Experimental Breeder Reactor No. 1.
d. Includes duplicate measurements made at this station.

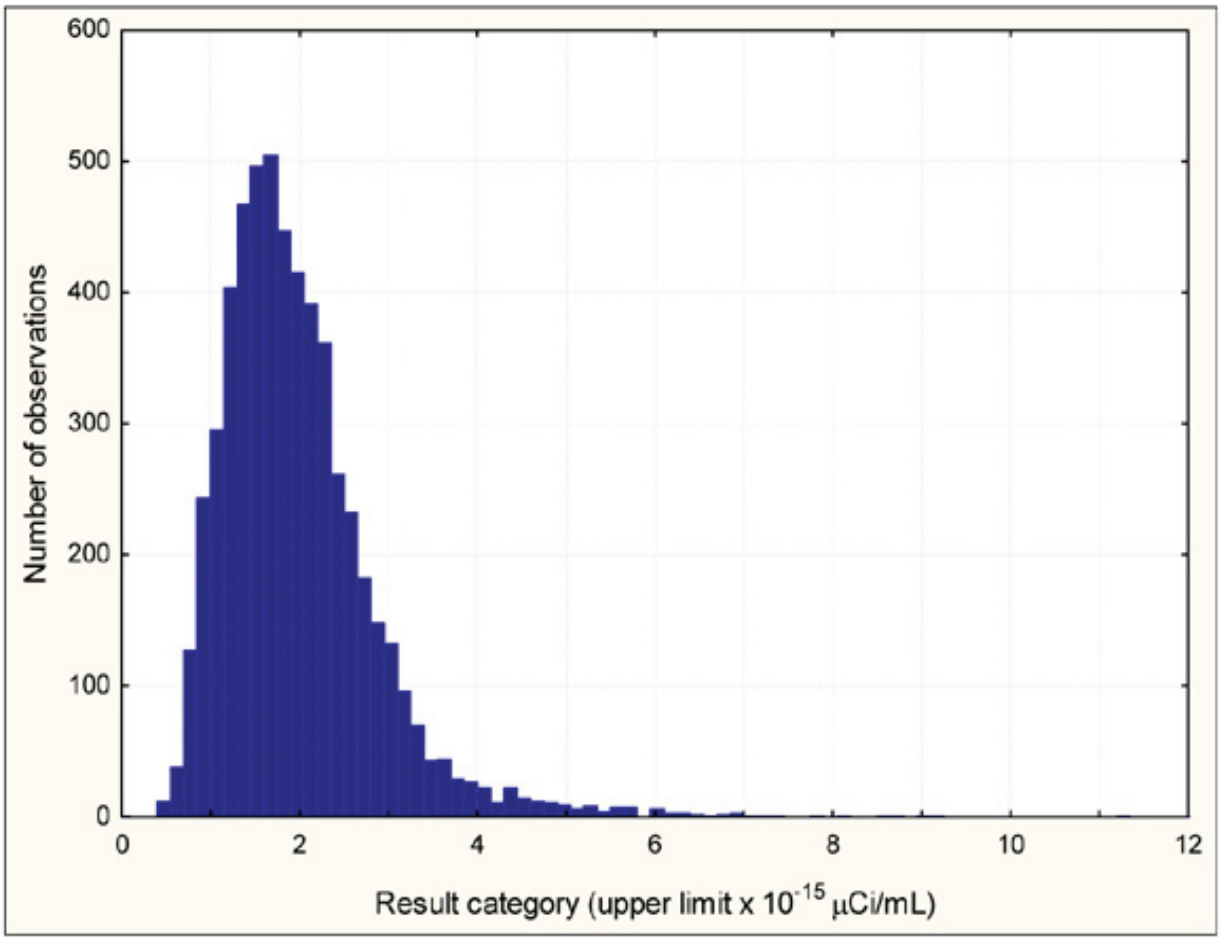
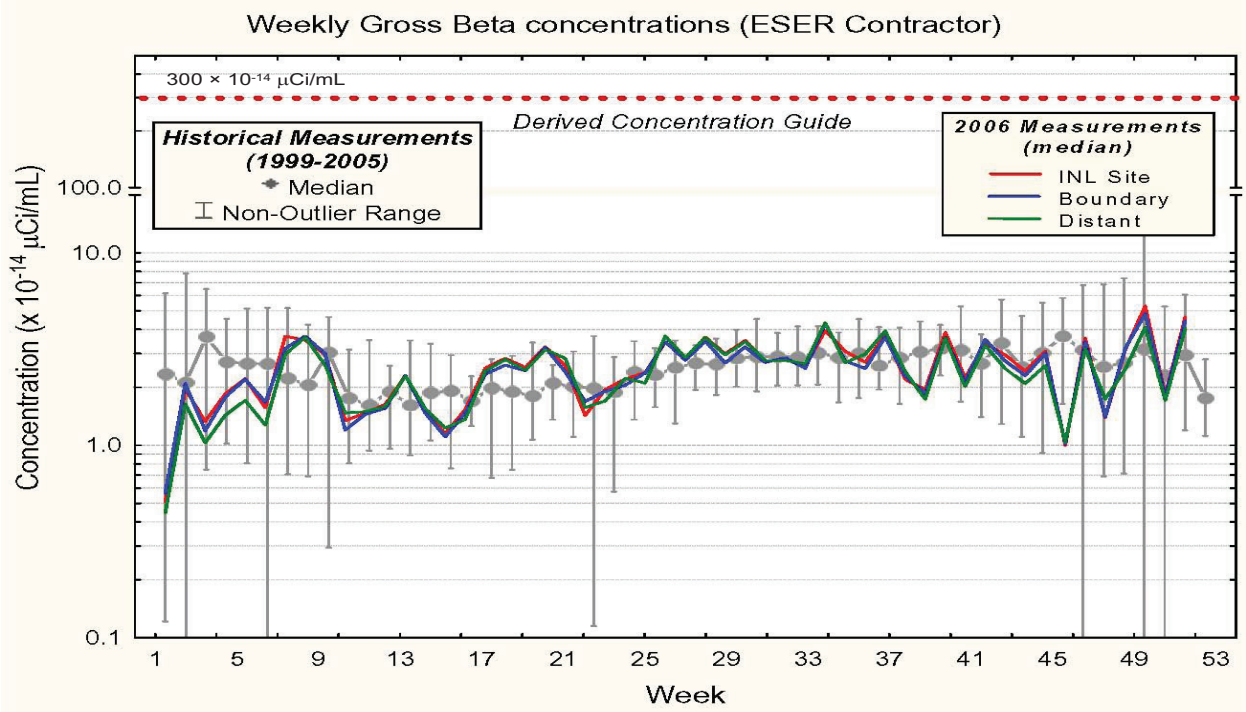


Figure 4-3. Frequency Distribution of Gross Alpha Activity Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1996 though 2006.

calculated using all measurements, including those less than their associated 3 sigma uncertainties. The maximum weekly median gross beta concentration was 6.3 x 10^{-14} µCi/mL and is significantly below the DCG of 300 x 10^{-14} µCi/mL for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

Annual median gross beta concentrations are shown in Table 4-4. ESER contractor annual median gross beta concentrations ranged from 2.1 x 10^{-14} µCi/mL at Craters of the Moon to 2.6 x 10^{-14} µCi/mL at the EFS. INL contractor data ranged from an annual median of 1.2 x 10^{-14} µCi/mL at Idaho Falls to 2.8 x 10^{-14} µCi/mL at Gate 4. In general, the levels of airborne radioactivity for the three groups (INL Site, boundary, and distant locations) tracked each other closely throughout the year. In addition, all results greater than 3 sigma reported by the ESER contractor are well within valid measurements taken within the last ten years (Figure 4-5). This indicates that the pattern of fluctuations occurred over the entire sampling network is representative of natural conditions and is not caused by a localized source such as a facility or activity at the INL Site.



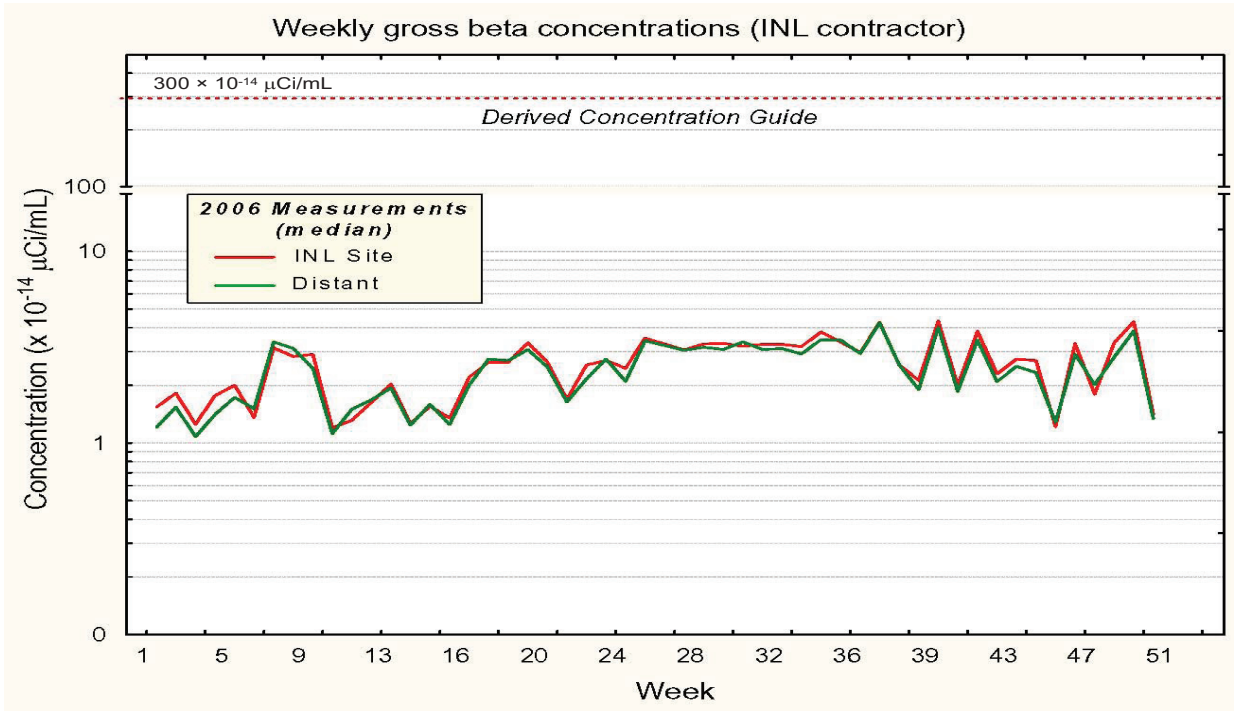


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2006).

Table 4-4. Median Annual Gross Beta Concentrations in Air (2006).[a]

ESER Contractor Data			Concentration[a,b]	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot CMS[c]	52	0.59 – 4.90	2.39
	Craters of the Moon	51	0.45 – 4.10	2.13
	Dubois	50	0.44 – 3.95	2.25
	Idaho Falls	51	0.53 – 4.51	2.49
	Jackson	51	0.29 – 5.76	2.39
	Rexburg CMS	52	0.41 – 4.47	2.48
			Distant Median:	2.42
Boundary	Arco	52	0.62 – 4.94	2.51
	Atomic City	52	0.48 – 4.82	2.37
	Blue Dome	52	0.61 – 4.00	2.26
	Federal Aviation Administration Tower	51	0.46 – 4.27	2.35
	Howe	52	0.54 – 4.94	2.51
	Monteview	52	0.57 – 4.98	2.45
	Mud Lake	103[d]	0.51 – 4.78	2.71
			Boundary Median:	2.37
INL Site	EFS	103[d]	0.18 – 3.85	2.61
	Main Gate	52	0.40 – 3.40	2.59
	Van Buren	52	0.22 – 3.93	2.58
			INL Site Median:	2.59
M&O Contractor Data			**Concentration[a,b]**	
Group	**Location**	**No. of Samples**	**Range of Samples**	**Annual Median**
Distant	Blackfoot	51	0.84 – 4.24	2.47
	Craters of the Moon	51	0.81 – 7.92	2.22
	Idaho Falls	51	1.05 – 3.96	1.19
	Rexburg	52	0.00 – 4.72	2.61
			Distant Median	2.30
INL Site	MFC (formerly ANL-W)	51	1.12 – 5.03	2.46
	ARA	47	0.69 – 5.03	2.50
	CFA	51	1.16 – 4.24	2.32
	CPP	50	1.11 – 4.40	2.65
	EBR-I[c]	50	1.22 – 4.82	2.63
	EFS	50	1.09 – 4.41	2.64
	Gate 4	51	4.51 – 5.82	2.76
	INTEC	51	1.07 – 7.44	2.55
	NRF	49	1.14 – 4.56	2.78
	CITRC (formerly PBF)	51	1.08 – 5.33	2.58
	Rest Area	51	1.07 – 4.76	2.72
	RTC (NE corner)	50	1.06 – 4.49	2.58
	RWMC	46	0.94 – 4.53	2.56
	SMC	51	-0.01 – 6.32	2.53
	TAN	51	1.05 – 4.45	2.55
	RTC (formerly TRA)	50	1.06 – 4.90	2.58
	Van Buren	51	1.13 – 4.40	2.70
			INL Site Median	2.59

a. All values are × 10^{-14} μCi/mL.
b. All measurements, including those less than three times their analytical uncertainty, are included in this table and in computation of annual median values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. CMS = Community Monitoring Station; EBR-I = Experimental Breeder Reactor No. 1.
d. Includes duplicate measurements made at this station.

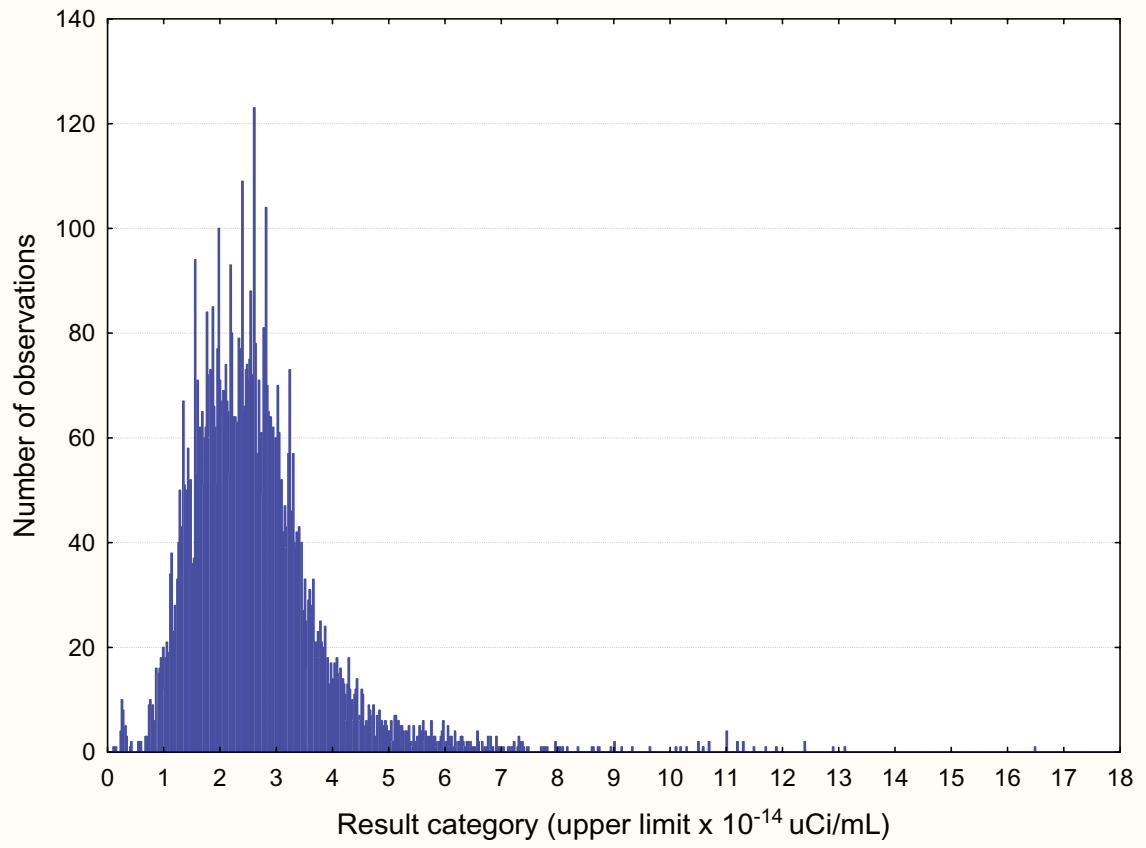


Figure 4-5. Frequency Distribution of Gross Beta Activity Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1996 through 2006.

Statistical Comparisons

Gross beta concentrations, unlike gross alpha concentrations, are typically detected above the 3s uncertainty levels. They can vary widely from location to location as a result of a variety of factors, such as local soil type and meteorological conditions. When statistical differences are found in gross beta activity, these and other factors are examined to assist with identifying the cause for the differences, including a possible INL Site release.

Statistical comparisons were made using the gross beta radioactivity data collected from the onsite, boundary, and distant locations (see Appendix B for a description of statistical methods). Figure 4-6 is a graphical comparison of all gross beta concentrations measured during 2006 by the ESER contractor. The results are grouped by location (that is, INL Site, boundary, and distant stations). Looking at the graph, there appeared to be no difference between locations. The figure also shows that the largest measurement was well below the DCG for the most restrictive beta-emitting radionuclide (^{228}Ra) in air of 300 x 10^{-14} µCi/mL. If the INL Site were a significant source of offsite contamination, concentrations of contaminants would be statistically greater at boundary locations than at distant locations. There were no statistical differences between annual concentrations collected from INL Site, boundary, and distant locations in 2006.

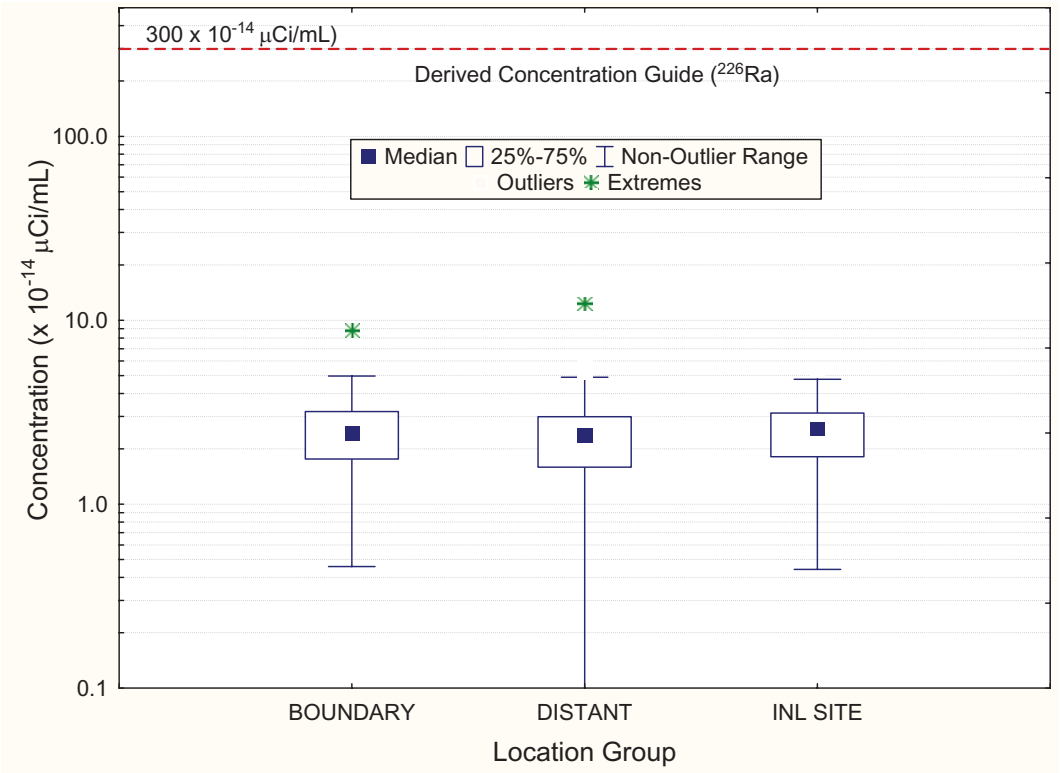


Figure 4-6. Comparisons of Gross Beta Concentrations Measured in Air at Distant, Boundary, and INL Site Locations by the ESER Contractor (2006).

There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2006. The differences observed can be attributed to expected statistical variation in the data.

INL contractor onsite and distant data sets were compared and there were no statistical differences between data obtained from INL Site and distant locations.

Specific Radionuclides in Air

Human-made radionuclides were observed above 3 sigma values in some ESER contractor and INL contractor quarterly composite samples (Tables 4-5 and 4-6).

Since mid-1995, the ESER contractor has detected ^{241}Am in some air samples, although there has been no discernable pattern with respect to time or location. Americium-241 was again detected in three quarterly composited samples collected onsite at EFS and at boundary locations Howe and Mud Lake. A frequency plot of ^{241}Am concentrations detected in ESER contractor samples over the past ten years is shown in Figure 4-7. The results detected in 2006 are within the range measured historically all well below the ^{241}Am DCG of 20,000 x 10^{-18} µCi/mL.

Plutonium isotopes were detected in some onsite and boundary ESER samples in 2006. Valid $^{239/240}$Pu concentrations measured historically in ESER samples are consistent with worldwide levels related to atmospheric nuclear weapons testing and are well within past measurements (Figure 4-8).

Table 4-5. Human-made Radionuclides on ESER Contractor Quarterly Composite Air Samples (2006).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}$Pu	^{90}Sr
First Quarter 2006					
Blackfoot	ND[b]	ND	5.74	14.7	ND
Howe	ND	ND	ND	ND	41.60
Jackson	ND	ND	37.5	9.29	ND
Main Gate	ND	ND	84.1	ND	ND
Monteview	ND	ND	ND	ND	41.5
Mud Lake (Replicate Sampler)	ND	16.1	ND	ND	ND
Second Quarter 2006					
Atomic City	ND	ND	ND	ND	89.6
Blue Dome	ND	ND	ND	ND	49.3
Craters of the Moon	ND	ND	70.50	ND	ND
Experimental Field Station (EFS)	ND	3.97	9.6	3.56	ND
FAA Tower	ND	ND	3.08	ND	ND
Howe	ND	15.5	ND	7.65	ND
Jackson	ND	ND	ND	ND	64.2
EFS (Replicate Sampler)	ND	ND	13.5	ND	ND
Rexburg	ND	ND	21.2	ND	ND
Van Buren	ND	ND	ND	15.3	ND
Third Quarter 2006					
Craters of the Moon	435.1	ND	ND	ND	ND
Idaho Falls	659.3	ND	ND	ND	ND
Van Buren	527.1	ND	ND	ND	ND
Fourth Quarter 2006					
Arco	512.0	ND	ND	ND	ND

a. Concentrations shown are greater than 3s analytical uncertainty (result x 10^{-18} µCi/mL).
b. ND = Not detected (results < 3s analytical uncertainty or result not valid).

Strontium-90 (^{90}Sr) was detected in two onsite and three boundary ESER samples within the range of historical measurements (Figure 4-9). The values measured are much below the DCG of 9,000,000 x 10^{-18} µCi/mL.

Cesium-137 (^{137}Cs) was detected in four ESER samples at onsite, boundary and distant locations. All were well with historical measurements and below the DCG.

The INL contractor reported the detection of ^{241}Am in seven samples. The detections showed no temporal or spatial pattern and, with the exception of the Central Facilities Area (CFA) sample taken in the first quarter, were within the range of historical results. In addition to ^{241}Am, ^{238}Pu and $^{239/240}$Pu were detected in the CFA sample. The ^{238}Pu was within the historical range. The analytical results for ^{241}Am and $^{239/240}$Pu in the field samples are similar to those of a spiked sample. After discussions with the analytical laboratory, it was concluded that the analytical instrument could have become contaminated between analyses and that the results are thus considered to be invalid. A review of site operations for this period showed no abnormal release events and supports this decision. Stontium-90 was not detected in any sample collected by the INL contractor during 2006.

Cesium-137 was detected in six INL contractor samples within the 1997-2005 range of values.

Table 4-6. Human-made Radionuclides in INL Site Contractor Quarterly Composited Air Samples (2006).[a]

Location	^{137}Cs	^{241}Am	^{238}Pu	$^{239/240}$Pu	^{90}Sr
First Quarter 2006					
CFA	ND[b]	123.0 ± 13.8[c]	57.3 ± 7.8[c]	221.0 ± 17.0	ND
Second Quarter 2006					
ARA	8540.0 ± 2580.0	ND	ND	ND	ND
NRF	ND	24.8 ± 8.2	ND	ND	ND
TAN	ND	24.0 ± 7.7	ND	ND	ND
TRA	ND	29.3 ± 8.9	ND	ND	ND
Third Quarter 2006					
CFA	ND	12.1 ± 4.0	ND	ND	ND
RTC	ND	14.8 ± 4.3	ND	ND	ND
Rexburg	2120.0 ± 596.0	ND	ND	ND	ND
TAN	2420.0 ± 582.0	ND	ND	ND	ND
Fourth Quarter 2006					
Blackfoot	2390.0 ± 563.0	ND	ND	ND	ND
Location A	2240.0 ± 677.0	13.6 ± 4.2	ND	ND	ND
TAN	2540.0 ± 806.0	ND	ND	ND	ND

a. All values are x 10^{-18} µCi/mL ± 1s and represent results greater than their associated 3s uncertainties.
b. ND = Not detected (result < 3s analytical uncertainty or result not valid.)
c. Results considered to be included. See text for discussion.

Isotopes of uranium (^{234}U, ^{235}U, or ^{238}U) were detected in numerous INL contractor quarterly composites at levels which indicate their origin as naturally occurring. They are therefore not reported.

Atmospheric Moisture

During 2006 the ESER contractor collected 71 atmospheric moisture samples from four locations (Atomic City, Blackfoot, Idaho Falls, and Rexburg) using molecular sieve material. Table 4-7 presents the range of values for each station by quarter.

Tritium was detected in 21 of the samples. Samples that exceeded the respective 3 sigma values ranged from a low at Atomic City of 2.6 x 10^{-13} µCi/mL to a high of 14.2 x 10^{-13} µCi/mL at Rexburg.

These detected radioactive concentrations were similar at distant and boundary locations. This similarity suggests that the detections probably represent tritium from natural production in the atmosphere by cosmic ray bombardment, residual weapons testing fallout, and possible analytical variations, rather than tritium from INL Site operations. The highest observed tritium concentration is far below the DCG for tritium in air (as hydrogen tritium oxygen) of 1 x 10^{-7} µCi/mL.

The INL contractor collected atmospheric moisture samples at the EFS and at Van Buren Boulevard on the INL Site and at Idaho Falls and Craters of the Moon off the INL Site (Table 4-8). During 2006, 50 samples were collected. Tritium detected above the three sigma level ranged from a low of 4.8 x 10^{-13} µCi/mL at Craters of the Moon to a high of 225 x 10^{-13} µCi/mL at Van Buren Avenue. All values are less than the DCG for tritium in air.

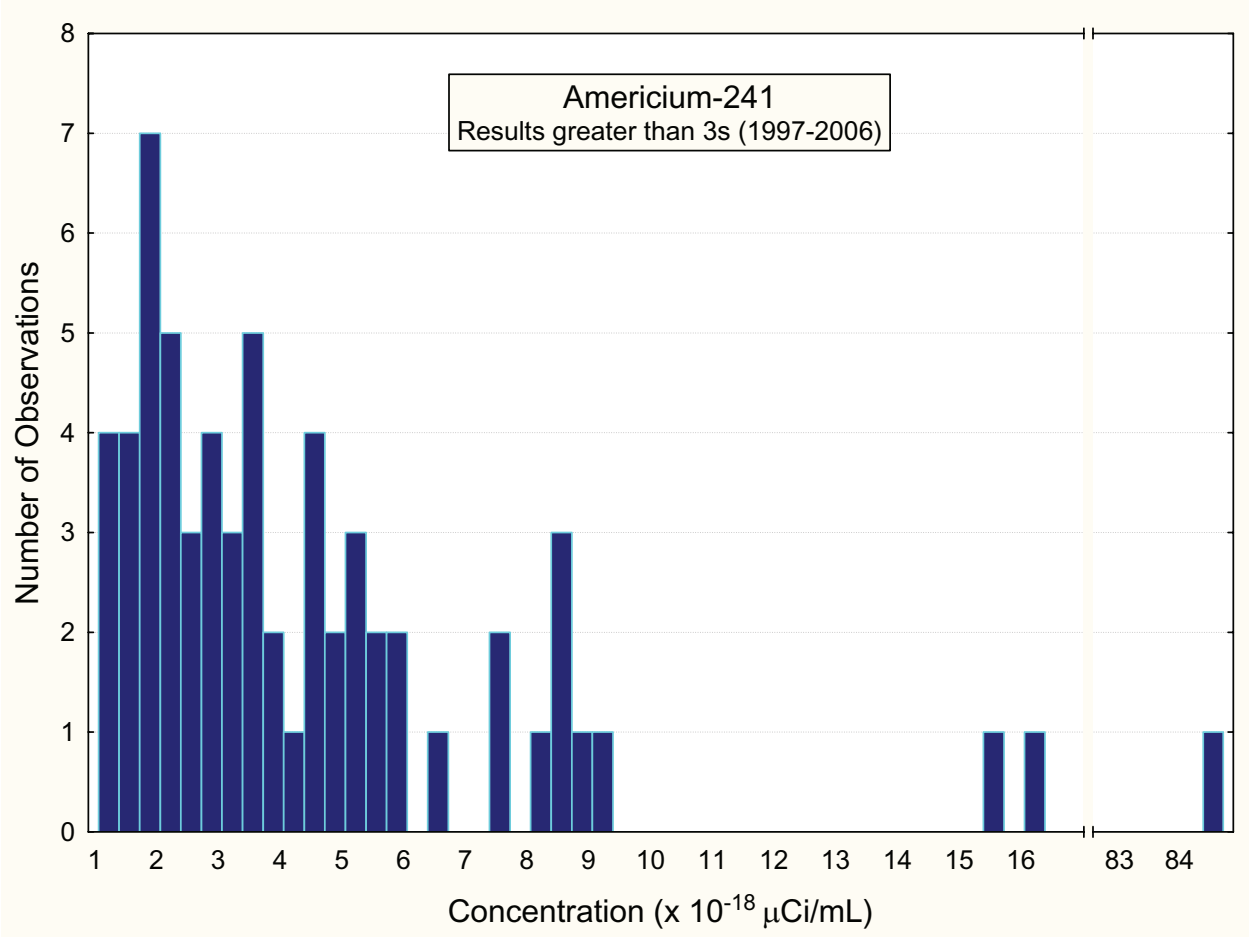


Figure 4-7. Frequency Distribution of ^{241}Am Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2006.

Precipitation

The ESER contractor collects precipitation samples weekly at the EFS and monthly at the CFA and offsite in Idaho Falls. A total of 44 precipitation samples were collected during 2006 from the three sites. Tritium concentrations were measured above the 3 sigma uncertainty level in seven samples and results ranged from 199 to 274 pCi/L. Table 4-9 shows the maximum concentration by quarter for each location. The highest radioactivity was from a sample collected at CFA during the second quarter and is far below the DCG level for tritium in water of 2 x 10^6 pCi/L. The concentrations are well within the normal range observed historically at the INL Site. The maximum concentration measured since 1998 was 553 pCi/L, measured at the EFS in 2000. The results are also 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/).

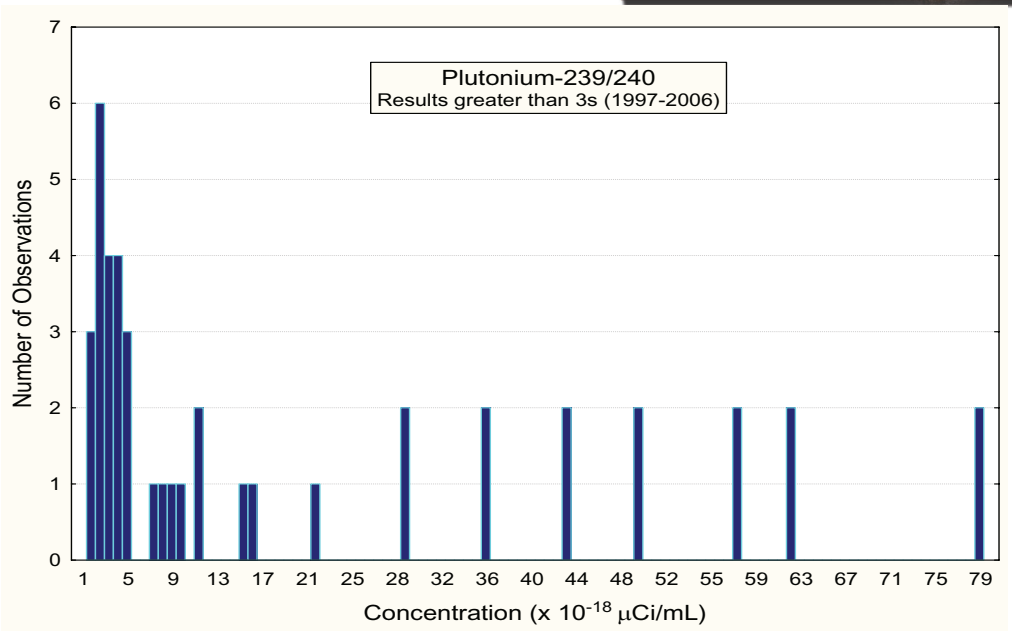


Figure 4-8. Frequency Distribution of $^{239/240}$Pu Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2006.

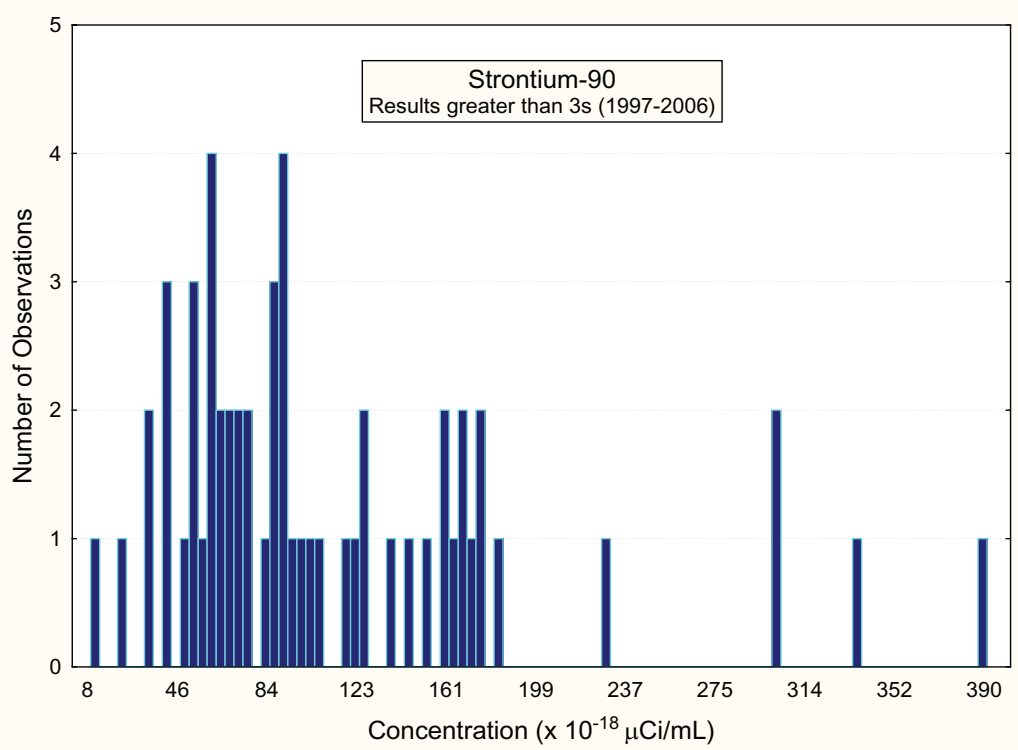


Figure 4-9. Frequency Distribution of ^{90}Sr Detected Above the 3s Level in Air Filters Collected by the ESER Contractor from 1997 through 2006.

Table 4-7. Tritium Concentrations in ESER Contractor Atmospheric Moisture Samples (2006).

	Range[a]			
Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Atomic City	2.6 ± 0.8 - 5.5 ± 1.0	4.5 ±1.5 - 5.6 ± 2.8	6.6 ± 1.7 - 8.5 ± 2.4	4.8 ± 1.3 - 6.2 ± 1.5
Blackfoot	4.1 ± 1.0 - 8.6 ± 1.8	11 ± 2.5[b]	8.8 ± 2.2 - 11.8 ± 2.5	3.9 ±1.2 - 9.0 ± 1.4
Idaho Falls	5.7 ± 1.3	8.3 ± 2.6 - 9.3 ± 2.4	9.3 ± 2.1 - 10.6 ± 2.2	6.3 ± 1.2
Rexburg	4.4 ± 1.3 - 8.0 ± 1.4	9 ± 2.6	9.4 ± 2.6	6.0 ± 1.8 - 14.2 ± 1.3

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s unertainties.
b. When a single value is reported, tritium was detected in only one sample.

Table 4-8. Tritium Concentrations in INL Contractor Atmospheric Moisture Samples (2006).

	Range[a]		
Location	First Quarter	Second Quarter	Third Quarter
Craters of the Moon	4.8 ± 1.0[b]	ND[c]	ND
EFS	ND	7.5 ± 2.4	29.5 ± 1.8
Van Buren	ND	25.1 ± 3.8 – 225.0 ± 5.5	29.8 ± 5.1
Idaho Falls	ND	ND	11.3 ± 3.6

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s uncertainties.
b. When a single value is reported, tritium was detected in only one sample.
c. ND = Not detected. Results <3s.

Suspended Particulates

In 2006, both the ESER and INL contractors 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. Unlike the fine particulate samplers discussed in the next section, these samplers do not selectively filter out particles of a certain size range, so they collect the total particulate load greater than 0.3 µm in diameter.

Particulate concentrations from ESER contractor samples ranged from 0.0 µg/m^3 at Craters of the Moon to 19.7 µg/m^3 at Blackfoot. In general, particulate concentrations were higher at distant locations than at the INL Site stations. This is mostly influenced by agricultural activities in offsite areas.

The total suspended particulate concentrations measured by the INL contractor ranged from 0.0 µg/m^3 at numerous locations and dates to 518 µg/m^3 at Craters of the Moon. Sample particulate concentrations were generally higher at distant locations than at the INL Site stations. The high level

Table 4-9. Tritium Concentrations in ESER Contractor Precipitation Samples (2006).

	Range[a]			
Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
CFA	217.0 ± 28.2[b]	274.0 ± 33.9	190.0 ± 30.8	112.0 ± 30.3 - 124.0 ± 30.3
EFS	ND[c]	ND	102.0 ± 30.1 - 219.0 ± 31.4	ND

a. All values are x 10^{-13} µCi/mL of air ± 1s and represent results greater than their associated 3s unertainties.
b. When a single value is reported, tritium was detected in only one sample.
c. ND = Not detected. Result < 3s analytical uncertainty.

at Craters of the Moon is due to road construction on U.S. Highway 26 and reached its maximum value during the August 16, 2006, sample period.

Filtered Particulates

The EPA's air quality standard is based on concentrations of "particles with an aerodynamic diameter less than or equal to 10 microns" (PM_{10}) (40 CFR Part 50.6). Particles of this size can reach the lungs and are considered to be responsible for most of the adverse health effects associated with airborne particulate pollution. The air quality standards for PM_{10} are an annual average of 50 µg/m^3, with a maximum 24-hour concentration of 150 µg/m^3.

The ESER contractor collected 55 valid 24-hour samples at Rexburg from January through December 2006. A valid sample is one that has run for the proper length of time (24 hours continuously) and that has a beginning weight less than the ending weight (does not yield a negative weight). Concentrations of PM_{10} particulates collected at Rexburg ranged from 0.0 to 44.8 µg/m^3. At the Blackfoot Community Monitoring Station, 60 valid samples were collected from January through December. Concentrations ranged from 0.3 to 50.1 µg/m^3. At Atomic City, 58 valid samples were collected from January through December. Concentrations ranged from 0.0 to 66.1µg/m^3. All measurements were less than the EPA standard for mean annual concentration.

IMPROVE Samplers

Interagency Monitoring of Protected Visual Environments (IMPROVE) samplers began continuous operation at Craters of the Moon and CFA during the spring of 1992. The EPA removed the CFA sampler from the national network in May 2000, when the location was determined to be no longer necessary. The most recent data available for the station at Craters of the Moon are through November 2003.

The IMPROVE samplers measure several elements, including aluminum, silicon, calcium, titanium, and iron. These elements are derived primarily from soils and show a seasonal variation, with lower values during the winter when the ground is often covered by snow.

Other elements are considered tracers of various industrial and urban activities. Lead and bromine, for example, result from automobile emissions. Annual concentrations of lead at IMPROVE sites in the mid-

Atlantic states are commonly in the range of 2 to 6 ng/m^3, or up to ten times higher than at Craters of the Moon. Selenium, in the 0.1 ng/m^3 range at Craters of the Moon, is a tracer of emissions from coal-fired plants.

Fine particles with a diameter less than 2.5 microns ($PM_{2.5}$) are the size fraction most commonly associated with visibility impairment. At Craters of the Moon, $PM_{2.5}$ has ranged over the period of sampler operation from 409 to 25,103 ng/m^3, with a mean of 3443 ng/m^3.

More IMPROVE data and information can be accessed at http://vista.cira.colostate.edu/improve/.

4.3 Waste Management Surveillance Monitoring

Gross Alpha and Gross Beta Air Monitoring Results

Samples of airborne particulate material were collected from waste management areas by the ICP contractor in 2006. Samples were obtained using suspended particle (SP) monitors. Gross alpha and gross beta activity were determined on all SP samples. Table 4-10 shows the SP monitoring results.

Specific Radionuclides

No human-made gamma-emitting radionuclides were detected in 2006 that exceeded the three-sigma error.

Table 4-11 shows radiochemical detections of alpha- and beta-emitting radionuclides greater than the three-sigma error for 2006. These detections are consistent with levels measured in resuspended soils at the RWMC in previous years. No trends in airborne radioactivity were indicated by the monitoring results from calendar year 2006.

Table 4-10. Suspended Particle Monitoring Results (2006).

Radionuclide	High	Low	Annual Mean (µCi/mL)
Gross Alpha	(9.37 ± 2.56) x 10^{-15} µCi/mL 2nd half of July at Subsurface Disposal Area (SDA) 4.2	(0.1 ± 1.7) x 10^{-16} µCi/mL 2nd half of January at SDA 4.3	2.75 x 10^{-15}
Gross Beta	(4.48 ± 0.68) x 10^{-14} 2nd half of December at SDA 1.3	(1.21 ± 0.10) x 10^{-15} µCi/mL 1st half of March at SDA 2.3	2.19 x 10^{-14}

Table 4-11. Radionuclide Detections Greater than the Three-sigma Error in 2006.

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Pu-239/240	$(1.99 \pm 0.42) \times 10^{-17}$	SDA 4.3	2nd
Sr-90	$(9.89 \pm 2.4) \times 10^{-17}$	SDA 1.3	3rd
Am-241	$(1.52 \pm 0.14) \times 10^{-17}$	SDA 4.2	3rd

REFERENCES

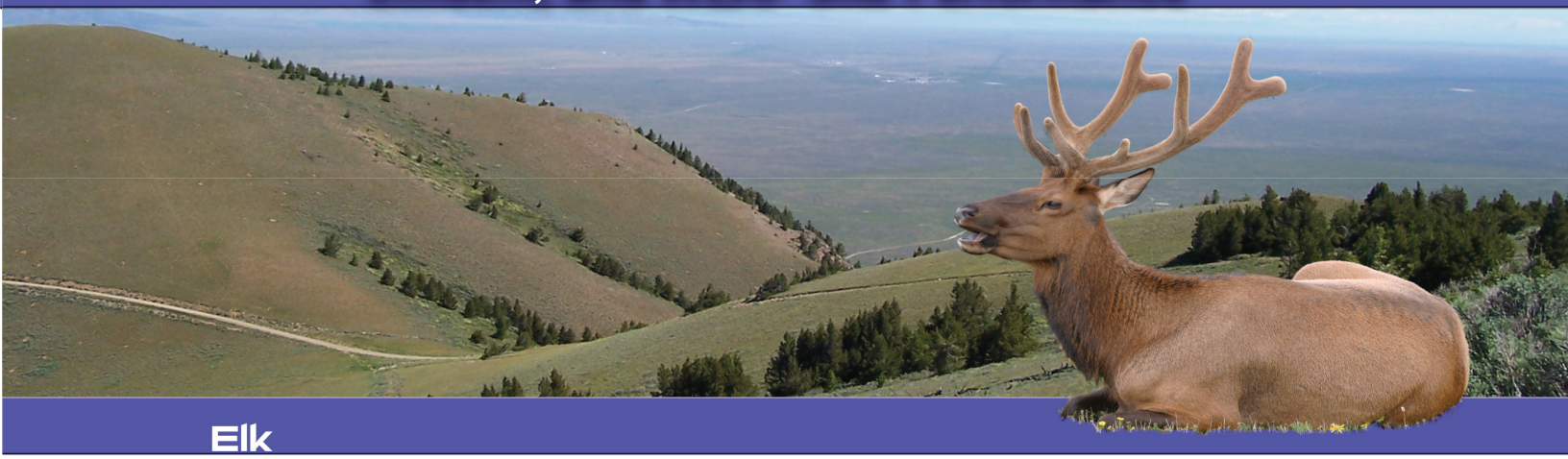
40 Code of Federal Regulations, Part 50.6, "National Primary and Secondary Ambient Air Quality Standards for Particulate Matter," Code of Federal Regulations, Office of the Federal Register.

EG&G of Idaho, Inc., 1993, New Production Reactor Exposure pathways at the INEL, EGG-NPR-8957.

U.S. Department of Energy-Idaho Operations Office (DOE-ID), 2007, National Emissions Standards for Hazardous Air Pollutants (NESHAPs) – Calendar year 2006 INEL Report for Radionuclides, DOE/NE-ID-10890(05).

False Dandelion

Chapter 5 - Compliance Monitoring for Drinking Water, Liquid Effluent, and WLAP Site Performance



Elk

D. Frederick, B. Anderson, and M. Verdoorn - Battelle Energy Alliance
R. Wilhelmsen - CH2M-WG Idaho

5. COMPLIANCE MONITORING FOR DRINKING WATER, LIQUID EFFLUENT, AND WLAP SITE PERFORMANCE

Operations at facilities located on the Idaho National Laboratory (INL) Site release radioactive and nonradioactive constituents into the environment. These releases are in compliance with regulations and monitoring of these releases ensures protection of the public and environment. This chapter presents results from radiological and nonradiological analyses of various water samples collected at both onsite and offsite locations. Results from sampling conducted by the INL and Idaho Cleanup Project (ICP) contractors are presented here. Results are compared to the appropriate regulatory limit (e.g., liquid effluent discharge permit limits, U.S. Environmental Protection Agency [EPA] health-based maximum contaminant levels [MCL] for drinking water, and/or the U.S. Department of Energy [DOE] Derived Concentration Guide [DCG] for ingestion of water).

A general overview of the organizations responsible for monitoring the various types of water at the INL Site is presented in Section 5.1. Sections 5.2 and 5.3 describe liquid effluent and groundwater monitoring as required by the City of Idaho Falls and Idaho Wastewater Land Application Permits (WLAPs), and effluent monitoring that is done for surveillance activities only. The INL Site drinking water programs are discussed in Section 5.4. Section 5.5 describes surface runoff monitoring conducted at the onsite waste management facility.

5.1 Summary of Monitoring Programs

The INL contractor and the ICP contractor monitor liquid effluent, groundwater, drinking water, and surface runoff at the INL Site to comply with applicable laws and regulations, DOE orders, and other requirements (e.g., WLAP requirements).

The INL Oversight Program collects split samples with INL Site contractors of liquid effluents, groundwater, drinking water, and storm water. Results of the Oversight Program's monitoring are presented in annual reports prepared by that organization and are not reported here.

Table 5-1 presents the various water-related monitoring activities performed on and around the INL Site.

Table 5-1. Water-related Monitoring at the INL Site and Surrounding Area.

	Media				
Area/Facility[a]	**Liquid Effluent (Permitted)**	**Liquid Effluent (Surveillance)**	**Liquid Effluent (Groundwater)**	**Drinking Water**	**Surface Runoff**
Idaho Cleanup Project: CH2M-WG Idaho, LLC. (CWI)					
INTEC	•	•	•	•	
TAN/TSF, CTF	•	•	•	•	
RWMC				•	•
INL Contractor: Battelle Energy Alliance (BEA)					
CFA[b]	•	•		•	
IRC	•				
MFC		•		•	
PBF				•	
RTC	•[c]	•		•	

a. INTEC = Idaho Nuclear Technology and Engineering Center, TAN/TSF = Test Area North/Technical Support Facility, CTF = Contained Test Facility, RWMC = Radioactive Waste Management Complex, CFA = Central Facilities Area, IRC = INL Research Center, MFC = Materials and Fuels Complex, PBF = Power Burst Facility, and RTC = Reactor Technology Complex.

b. Includes Gun Range, EBR-I (Experimental Breeder Reactor-I), and Main Gate.

c. The Idaho DEQ has not issued a Wastewater Land Application Permit (WLAP) for RTC. However, RTC follows WLAP regulations for total suspended solids and nitrogen.

5.2 Liquid Effluent and Related Groundwater Compliance Monitoring

The INL contractor and the ICP contractor monitor nonradioactive and radioactive parameters in liquid waste effluent and groundwater. Wastewater is typically discharged to the ground surface and evaporation ponds. Discharges to the ground surface are through infiltration ponds, trenches, and a sprinkler irrigation system at the following areas:

- Infiltration ponds at the Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds, Test Area North (TAN)/Technical Support Facility (TSF) Sewage Treatment Facility Disposal Pond, and Reactor Technology Complex (RTC) Cold Waste Pond
- A sprinkler irrigation system at the Central Facilities Area (CFA) that is used during the summer months to apply industrial and treated sanitary wastewater.

Discharge of wastewater to the land surface is regulated under WLAP rules (Idaho Administrative Procedures Act [IDAPA] 58.01.17). A WLAP normally requires monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater, as applicable. The liquid effluent and groundwater monitoring programs support WLAP requirements for INL Site facilities that generate liquid waste streams covered under WLAP rules. Table 5-2 lists the current WLAP status of each facility.

Table 5-2. Status of Wastewater Land Application Permits.

Facility	Permit Status at End of 2006	Explanation
CFA Sewage Treatment Facility	WLAP issued	Idaho Department of Environmental Quality (DEQ) issued a permit in January 2005. The permit was modified on 10/19/05.
INTEC New Percolation Ponds	WLAP issued	WLAP LA-000130-04 was issued on November 19, 2004 (Johnston 2004), revised on October 25, 2005 (Johnston 2005a), and expires on November 18, 2009. The permit covers the combined effluent from the Sanitary and Service Waste Systems to the INTEC New Percolation Ponds.
MFC Industrial Waste Pond	WLAP application submitted to Idaho DEQ	A WLAP application is being developed for Idaho DEQ.
TAN/TSF Sewage Treatment Facility	WLAP issued	Idaho DEQ issued a permit in January 2005 (Johnston 2005b), and issued a minor modification in October 2005 (Johnston 2005a).
RTC Cold Waste Pond	WLAP application submitted to Idaho DEQ	Idaho DEQ has not issued a WLAP. Idaho DEQ authorized INL to operate the wastewater land application facility under the conditions and terms of State of Idaho WLAP rules and Idaho DEQ's Handbook for Land Application of Municipal and Industrial Wastewater until a permit is issued (Johnston 2001).

The permits generally require compliance with the Idaho groundwater quality primary constituent standards (PCSs) and secondary constituent standards (SCSs) in groundwater monitoring wells specified in the permit (IDAPA 58.01.11). The permits specify annual discharge volumes, application rates, and effluent quality limits. As required, annual reports (ICP 2007a, 2007b; INL 2007) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2006, the contractors conducted monitoring as required by the permits for the following facilities (see Table 5-2):

- CFA Sewage Treatment Plant
- INTEC New Percolation Ponds
- TAN/TSF Sewage Treatment Facility.

The RTC Cold Waste Pond has not been issued a permit; however, quarterly samples for total nitrogen and total suspended solids (TSS) are collected to show compliance with the regulatory effluent limits for rapid infiltration systems. The following subsections present results of wastewater and groundwater monitoring for individual facilities conducted for permit compliance purposes.

Additional parameters are also monitored in the effluent to comply with DOE Orders 5400.5 and 450.1 (DOE 1993, DOE 2003) environmental protection objectives. Section 5.3 discusses the results of liquid effluent surveillance monitoring.

Idaho Falls Facilities

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 and U.S. Department of Energy-Idaho Operations Office (DOE-ID) 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.

Industrial Wastewater Acceptance Permits were issued for facilities that discharge process wastewater through the City of Idaho Falls sewer system. Twelve INL contractor facilities in Idaho Falls have associated Industrial Wastewater Acceptance Permits for discharges to the city sewer system. The Industrial Wastewater Acceptance Permits for these facilities contain special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters; however, only the INL Research Center has specific effluent monitoring requirements.

Wastewater Monitoring Results – Table 5-3 summarizes the semiannual monitoring results conducted at the INL Research Center in April and October of 2006.

Table 5-3. Semiannual Effluent Monitoring Results for INL Research Center (2006).[a]

Parameter	INL Research Center		Discharge Limit[c]
	April 2006	October 2006[b]	
Cyanide	0.005 U	0.005 U (0.005 U)	1.04
Silver	0.0025 U	0.0025 U (0.0025 U)	0.43
Arsenic	0.005 U	0.0025 U (0.0025 U)	0.04
Cadmium	0.001 U	0.001 U (0.001 U)	0.26
Chromium	0.0025 U	0.0025 U (0.0025 U)	2.77
Copper	0.0252	0.0281 (0.0276)	1.93
Mercury	0.0002 U	0.0002 U (0.0002 U)	0.002
Nickel	0.0025 U	0.0025 U (0.0025 U)	2.38
Zinc	0.0148	0.0263 (0.0261)	0.90
Lead	0.0008 U	0.0004 U (0.0004 U)	0.29
Conductivity (µS/cm[e])	653.1/559.9[f]	1078/613[f]	NA
pH (standard units)	7.99/7.92[f]	8.05/7.74[f]	5.5-9.0

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. Regular and (duplicate) samples were collected in October.
c. Limit as set in the applicable Industrial Wastewater Acceptance Forms.
d. U flag indicates that the result was below the detection limit.
e. µS/cm = microSiemans per centimeter
f. Values are the maximum and average of the grab samples collected during the semiannual monitoring.

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 (2200 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 desert rangeland through a computerized center pivot irrigation system. The permit limits wastewater application to 23 acre-inches/acre/year from April 1 through October 31.

WLAP Wastewater Monitoring Results – The permit requires influent and effluent monitoring, as well as soil sampling in the application area (see Chapter 7 for results pertaining to soils). Influent samples were collected monthly from the lift station at CFA (prior to Lagoon No. 1) during 2006. Effluent samples were collected from the pump pit (prior to the pivot irrigation system) starting in June 2006 and continuing through September 2006 (the period of irrigation operation for 2006). All samples collected were 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables 5-4 and 5-5 summarize the results. Additional samples for total Kjeldahl Nitrogen (TKN) and total phosphorus were collected in August to confirm the analytical results reported during June/July sampling events (Table 5-6).

Wastewater was intermittently applied via the center pivot irrigation system from June 21, 2006, to September 26, 2006. On the days it was operational, discharge to the pivot irrigation system averaged 606,370 liters per day (160,186 gallons per day).

A total of 6.43 million gallons (MG) of wastewater was applied to the land application area in 2006, which is equivalent to a loading rate of 3.22 acre-inch/acre/year. This is significantly less than the permit

Table 5-4. Summary of CFA Sewage Treatment Facility Influent Monitoring Results (2006).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Biochemical oxygen demand (5-day)	15.3	522	97
pH (grab)	7.09	8.01	7.66
Chemical oxygen demand	47.4	603	143
Nitrogen, nitrate+nitrite (mg-N/L)	0.742	2.15	1.38
Nitrogen, total Kjeldahl	2.08	31.3	21.2
Total suspended solids	11.1	116	71.4

a. With the exception of pH, which is unitless, all values are in milligrams per liter (mg/L) unless otherwise noted.
b. Duplicate samples were collected in August for all parameters (excluding pH) and the duplicate results are included in the summaries.
c. There are no permit limits set for these parameters.
d. Annual average is determined from the average of the monthly values.

Table 5-5. Summary of CFA Sewage Treatment Plant Effluent Monitoring Results (2006).[a]

Sample Date	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as Nitrogen (mg/L)	Biological Oxygen Demand (mg/L)	Chemical Oxygen Demand (mg/L)	Total Dissolved Solids[a] (mg/L)	Total Suspended Solids (mg/L)	pH	Total Phosphorus (mg/L)	Fecal Coliform[b] (/100 mL)	Total Coliform[b] (/100 mL)
6/27/2006	2.90	0.158	3.04	48.4	1,010	5.9	8.02	2.120	<1	6
7/12/2006	2.66	0.108	2.00 U[c]	42.3	1,080	4.0 U	7.91	2.650	11	17
8/29/2006	2.35	0.050 U	2.00 U	45.8	1,100	4.0 U	9.47	0.336	<1	<1
9/26/2006	1.99[d]	0.014[d]	2.00[d]U	45.9[d]	1,095[d]	4.0[d] U	9.84	0.156[d]	<1	4
Average[e]	2.48	0.076	1.51	45.6	1,071	3.0	8.81	1.316	3	7

a. There are no permit limits set for these parameters.

b. Coliform samples were collected independently of the composite samples on 7/10/2006, 8/30/2006, and 9/25/2006.

c. U flag indicates that the result was reported as below the detection limit.

d. The result shown is the average of the original and duplicate samples taken for the month. For those results shown as below detection limits, the detection limit is the value given.

e. The annual average is determined from the average of the monthly values. Half the reported detection limit was used in the yearly average calculation for those results reported as below the detection limit.

Table 5-6. Confirmation Samples Collected at the CFA Sewage Treatment Plant in Response to Elevated Concentrations of TKN and Total Phosphorous in the 2006 CFA STF Effluent Sample.

Sample Date	TKN (mg/L)	Total Phosphorus (mg/L)
8/7/2006	2.54	1.110
8/23/2006	2.92	0.416
8/28/2006	2.26	0.335
Average:	2.57	0.620

limit of 46 MG (23.0 acre-inch/acre/year). Hydraulic loading was highest in July and lowest in September. The nitrogen loading rate (1.89 lb/acre/yr) was significantly lower than the projected maximum loading rate of 32 lb/acre/yr. As a general rule, nitrogen loading should not exceed the amount necessary for crop utilization plus 50 percent. However, wastewater is applied to rangeland without nitrogen removal via crop harvest. To estimate nitrogen buildup in the soil under this condition, a nitrogen balance was prepared by Cascade Earth Science, Ltd., which estimated it would take 20 to 30 years to reach normal nitrogen agricultural levels in the soil (based on a loading rate of 32 lb/acre/year) (CES 1993). The low 2006 nitrogen loading rate had a negligible effect on nitrogen accumulation.

The 2006 annual total chemical oxygen demand (COD) loading rate at the CFA Sewage Treatment Facility (32.72 lb/acre/year) was less than state guidelines of 50 lb/acre/day (which is equivalent to 18,250 lb/acre/year).

The annual total phosphorus loading rate (1.09 lb/acre/year) was below the projected maximum loading rate of 4.5 lb/acre/year. The amount of phosphorus applied was probably removed by sorption reactions in the soil and utilized by vegetation, rather than lost to groundwater.

The INL Site contractor tracks operating parameters for the CFA lagoon for information only. For example, removal efficiencies (REs) were calculated to gauge treatment. The REs for biological oxygen demand (BOD) and TSS were above the design criterion of 80 percent, while COD was below the projected

efficiency of 70 percent. The RE for total nitrogen was 71 percent. Since these estimates for information only, no action is required.

WLAP Groundwater Monitoring Results – The WLAP does not require groundwater monitoring at the CFA Sewage Treatment Plant.

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

Description – The INTEC New Percolation Ponds are a rapid infiltration system and comprised of two ponds excavated into the surficial alluvium and surrounded by bermed alluvial material. Each pond is approximately 305 ft × 305 ft at the top of the berm and is about 10 ft deep. Each pond is designed to accommodate a continuous wastewater discharge rate of approximately 3 MG per day.

The INTEC Sewage Treatment Plant (STP) is east of INTEC, outside the INTEC security fence. It treats and disposes of sanitary and other related waste at INTEC.

The STP depends on natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) to treat the wastewater in four lagoons. After treatment in the lagoons, the effluent is gravity fed to lift station CPP-2714 where it is pumped to the service waste system. For the STP, automatic flow-proportional composite samplers are located at control stations CPP-769 (influent) and CPP-773 (wastewater effluent from the STP to the service waste system).

WLAP Wastewater Monitoring Results – Monthly samples were collected from:

- CPP-797—combined effluent prior to discharge to the INTEC New Percolation Ponds
- CPP-769—influent to STP
- CPP-773—effluent from STP prior to combining with service waste.

All samples are collected as 24-hour flow proportional composites, except pH and total coliform, which are taken as grab samples as required by the permit.

The permit-required data are summarized in Tables 5-7 through 5-9. The permit for the INTEC New Percolation Ponds sets monthly concentration limits for the combined effluent (CPP-797) for TSS (100 mg/L) and total nitrogen (20 mg/L). During 2006, neither TSS nor total nitrogen exceeded the permit limit in the combined effluent, but the June 2006 result for TSS (99.9 mg/L) approached the permit limit (100 mg/L). The permit does not set limits for total nitrogen or TSS at CPP-769 and CPP 773. The 2006 Wastewater Land Application Report for the INTEC New Percolation Ponds (ICP 2007a) provides detailed wastewater monitoring results.

The permit specifies a hydraulic loading rate for the INTEC New Percolation Ponds of up to 3 MG per day or 1095 MG per year. During 2006, the maximum daily flow was 1.761 MG, and the total yearly flow to the INTEC New Percolation Ponds was 507.504 MG, both of which were below the permit limits.

WLAP Groundwater Monitoring Results –To measure potential impacts to groundwater from the INTEC New Percolation Ponds, the permit requires that groundwater samples be collected from six monitoring wells (Figure 5-1):

- One background aquifer well (ICPP-MON-A-167) upgradient of the INTEC New Percolation Ponds.

Table 5-7. Summary of INTEC New Percolation Ponds Effluent Monitoring Results at CPP-797 (2006).[a,b]

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Aluminum	0.0125[d]	0.0125[d]	0.0125[e]	NA[f]
Arsenic	0.00125[d]	0.0026	0.00135	NA
Biological oxygen demand (5-day)	1.0[d]	7.58	1.70	NA
Cadmium	0.0005[d]	0.0005[d]	0.0005[e]	NA
Chloride	22.5	181	115.6	NA
Chromium	0.0049	0.0061	0.0055	NA
Conductivity (grab)(µS/cm)	116	8,570	1,323.8	NA
Copper	0.0018	0.0084	0.0039	NA
Fluoride	0.1[d]	0.247	0.191	NA
Iron	0.0125[d]	0.167	0.0715	NA
Manganese	0.00125[d]	0.00125[d]	0.00125[e]	NA
Mercury	0.0001[d]	0.0001[d]	0.0001[e]	NA
Nitrate+nitrite, as nitrogen	0.76	1.6	1.092	NA
pH (grab)	6.96	8.0	7.66	NA
Selenium	0.001[d]	0.001[d]	0.001[e]	NA
Silver	0.00125[d]	0.00125[d]	0.00125[e]	NA
Sodium	41.3	101	72.4	NA
Total coliform (colonies/100 mL)	0.5[d]	200	27.3[g]	NA
Total dissolved solids	280	563	442	NA
Total Kjeldahl nitrogen	0.163	0.721	0.436	NA
Total nitrogen[h]	1.05	2.091	1.528	20
Total phosphorus	0.0269	0.167	0.0988	NA
Total suspended solids	2.0[c]	99.9	8.5	100

a. With the exception of pH, which is unitless, all values are in milligrams per liter (mg/L) unless otherwise noted.

b. Duplicate samples were collected in November for aluminum, arsenic, biochemical oxygen demand (5-day), cadmium, chloride, chromium, copper, fluoride, iron, manganese, mercury, selenium, silver, sodium, total dissolved solids, and total suspended solids parameters (excluding total coliform). Due to limited sample volume available in November, duplicate samples were collected December 20, 2006, for nitrate+nitrite, as nitrogen, total Kjeldahl nitrogen, total dissolved solids, total phosphorus, and total suspended solids (excluding total coliform). Duplicate results are included in the summaries. The December monthly sample was collected on December 6, but due to limited volume, an additional sample was collected December 20, 2006.

c. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in the yearly average calculation for those data reported as below the detection limit.

d. Sample result was less than the detection limit; value shown is half the detection limit.

e. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.

f. NA—Not applicable; no permit limit is set for this parameter.

g. The average was calculated using the censored value of 200 colonies/100 mL. The July sample colonies were too numerous to count.

h. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.

Table 5-8. Summary of INTEC Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2006).[a,b]

Parameter	Minimum	Maximum	Average[c]
Biological oxygen demand (5-day)	131.0	285.0	176.8
Nitrate+nitrite, as nitrogen	0.0101	0.3420	0.0836
Total Kjeldahl nitrogen	29.90	64.40	47.22
Total phosphorus	4.20	11.70	6.05
Total suspended solids	41.1	792.0	192.2

a. All values are in milligrams per liter (mg/L).

b. There are no permit limits set for these parameters.

c. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in the yearly average calculation for those data reported as below the detection limit.

Table 5-9. Summary of INTEC Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2006).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Biological oxygen demand (5-day)	1.00[e]	39.9	11.7
Chloride	95.0	130.	109.
Conductivity (µS/cm) (composite)	583.	897.	820.
Nitrate+nitrite, as nitrogen	0.0283	3.43	1.68
pH (standard units) (grab)	7.69	9.73	8.52
Sodium	59.2	88.2	71.0
Total coliform (colonies/100 mL)	20	3,000	534
Total dissolved solids	388	528	464
Total Kjeldahl nitrogen	5.09	23.4	14.6
Total nitrogen[f]	6.33	24.5	16.3
Total phosphorus	1.06	4.46	3.18
Total suspended solids	2.00[e]	65.0	15.3

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. There are no permit limits set for these parameters.

c. Duplicate samples were collected in November and December for all parameters (excluding conductivity, pH, and total coliform), and the duplicate results are included in the summaries. The December monthly sample was collected on December 6, but due to limited volume, an additional sample was collected December 20, 2006.

d. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in any calculation for those data reported as below the detection limit.

e. Sample result was less than the detection limit; value shown is half the detection limit.

f. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.

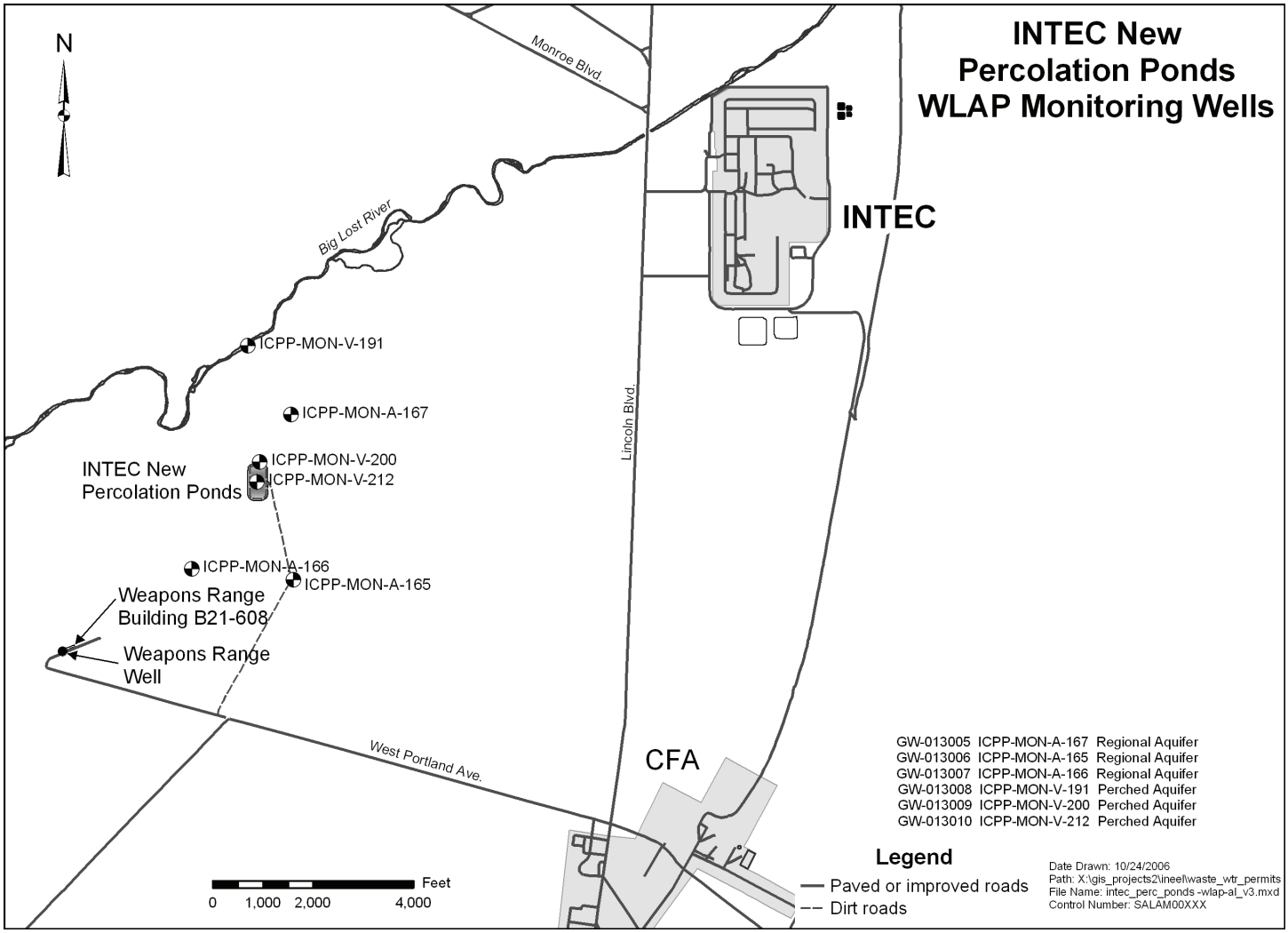


Figure 5-1. Wastewater Land Application Permit Monitoring Locations at INTEC.

- One background perched water well (ICPP-MON-V-191) north of the INTEC New Percolation Ponds and just south of the Big Lost River.
- Two aquifer wells (ICPP-MON-A-165 and ICPP-MON-A-166) downgradient of the INTEC New Percolation Ponds.
- Two perched water wells (ICPP-MON-V-200 and ICPP-MON-V-212) adjacent to the INTEC New Percolation Ponds. Well ICPP-MON-V-200 is north of the INTEC New Percolation Ponds, and well ICPP-MON-V-212 is between the two ponds.

The permit requires that groundwater samples be collected semiannually during April and October and lists which parameters must be analyzed. Aquifer wells ICPP-MON-A-165 and ICPP-MON-A-166 and perched water wells ICPP-MON-V-200 and ICPP-MON-V-212 are the permit compliance points. Aquifer well ICPP-MON-A-167 and perched water well ICPP-MON-V-191 are listed in the permit as upgradient, noncompliance points. Contaminant concentrations in the compliance wells are limited by PCS and SCS

specified in IDAPA 58.01.11, "Ground Water Quality Rule." All permit-required samples are collected as unfiltered samples.

Table 5-10 shows the April and October 2006 depth to water table and water table elevations, determined before purging and sampling. The analytical results are reported as filtered and unfiltered for all parameters specified by the permit. Table 5-11 presents similar information for the perched water wells.

Aquifer well ICPP-MON-A-167 was dry during the April and October 2006 sampling events, and, therefore, could not be sampled. This well was dry for the first time in October 2005. Between October 2002, when WLAP sampling began, and October 2005, the depth of water in this well has ranged from approximately 150.9 m (495 ft) to just less than 152.4 m (500 ft). The pump is currently positioned near the bottom of this well and cannot be lowered further. Unless the water level rises above the pump intake, future WLAP compliance samples cannot be collected from this well. Similarly, water levels in wells ICPP-MON-A-165 and ICPP-MON-A-166 have also been decreasing (see Figure 5-2). In October 2006, an approximate 5.5-ft increase in water level in well ICPP-MON-A-166 was recorded.

During 2006, the Big Lost River flowed in the vicinity of the INTEC New Percolation Ponds from April 16 to July 4, 2006. Before 2006, the Big Lost River had been dry since May 2000, except for a 10-day period starting on May 31, 2005. Perched water well ICPP-MON-V-191 was sampled in April 2006; however, the well was dry during the October 2006 sampling event. Similarly, this well also was dry during the April and October 2005 sampling events. Water is in this well only when the Big Lost River is flowing; therefore, samples can be collected from this well only when the Big Lost River is flowing.

The majority of the permit-required monitoring parameters remained below their respective PCS or SCS during 2006 for all wells associated with the INTEC New Percolation Ponds. Exceedances were reported for three metals (aluminum, iron, and manganese) in unfiltered samples from three perched water wells and increased (but not exceeded) total dissolved solids (TDS) concentration in one aquifer well (see discussion below and in the 2006 Wastewater Land Application Report for the INTEC New Percolation Ponds [ICP 2007a]).

Aluminum, Iron, and Manganese Concentrations - Aluminum, iron, and manganese concentrations in unfiltered samples from permitted aquifer and perched water monitoring wells for the INTEC New Percolation Ponds have exceeded the associated groundwater quality standards in the past. Elevated concentrations were detected in preoperational unfiltered groundwater samples taken downgradient (aquifer well ICPP-MON-A-166) and upgradient (aquifer well ICPP-MON-A-167) of the INTEC New Percolation Ponds. For aquifer wells, the preoperational concentrations (see Table 5-12) in the upgradient aquifer well (ICPP-MON-A-167) are considered the natural background level (IDAPA 58.01.11.200.03) and are used for determining compliance with the permit and the "Ground Water Quality Rule." If concentrations of aluminum, iron, or manganese in aquifer wells exceed an SCS, yet are below the preoperational upgradient concentrations, they are considered in compliance with the permit and the "Ground Water Quality Rule." Preoperational samples could not be collected from the perched water wells because of insufficient water volumes. Therefore, the PCSs and SCSs from the "Ground Water Quality Rule" (IDAPA 58.01.11.200.01.a and b) are used for determining compliance for the perched water wells.

During 2006, the following parameters exceeded the associated groundwater quality standards:

- Aluminum in perched water wells ICPP-MON-V-191, ICPP-MON-V-200, and ICPP-MON-V-212 (see Table 5-11)

Table 5-10. INTEC New Percolation Ponds WLAP Groundwater Quality Data from Aquifer Wells for April and October 2006.[a,b]

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)			ICPP-MON-A-166 (GW-013007)			
Sample Date	April 2006	October 2006	4/24/2006	4/24/2006[a]	10/03/2006	4/13/2006	10/04/2006	10/04/2006[a]	PCS/SCS[b]
Depth to water table (ft)	Dry[c]	Dry[c]	503.09	503.09	502.81	506.16	500.51[d]	500.51[d]	NA[e]
Water table elevation (ft)	—	—	4,449.08	4,449.08	4,450.10	4,453.34	4,458.99	4,458.99	NA
Aluminum (mg/L)	—	—	0.136 R[f]	0.152 R[f]	0.0250 U[g]	0.237[h] U	0.170	0.177	0.2
Aluminum-filtered (mg/L)	—	—	0.120 R[f]	0.155 R[f]	0.0250 U	0.261[h] U	0.0250 U	0.0250 U	0.2
Arsenic (mg/L)	—	—	0.0013	0.0015	0.0050 U	0.0020	0.0050 U	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	—	0.0013	0.0010	0.0050 U	0.0019	0.0050 U	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	—	—	1.36	1.38	2 U	3.0 R[i]	2 U	2 U	NA
Cadmium (mg/L)	—	—	0.0007 U	0.0007 U	0.0025 U	0.0010 U	0.0025 U	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	0.0007 U	0.0008 U	0.0025 U	0.0010 U	0.0025 U	0.0025 U	0.005
Chloride (mg/L)	—	—	63.5	61.3	75.7	8.0	8.18	8.20	250
Chromium (mg/L)	—	—	0.034	0.037	0.0352	0.007	0.0071	0.0068	0.1
Chromium-filtered (mg/L)	—	—	0.008	0.008	0.0069	0.007	0.0069	0.0068	0.1
Copper (mg/L)	—	—	0.016	0.016	0.0025 U	0.010	0.0025 U	0.0025 U	1.3
Copper-filtered (mg/L)	—	—	0.016	0.015	0.0025 U	0.010	0.0025 U	0.0025 U	1.3
Fecal coliform (colonies/100 mL)	—	—	Absent	Absent	Absent	Absent	Absent[j]	Absent[j]	NA
Fluoride (mg/L)	—	—	0.16	0.16	0.213	0.22	0.264	0.273	4
Iron (mg/L)	—	—	0.341 R[f,h]	0.406 R[f,h]	0.369[h]	0.162	0.246	0.251	0.3
Iron-filtered (mg/L)	—	—	0.108 R[f,k]	0.118 R[f,k]	0.122	0.162	0.0863	0.0989	0.3
Manganese (mg/L)	—	—	0.008	0.009	0.0036	0.037 R[f]	0.0311	0.0314	0.05
Manganese-filtered (mg/L)	—	—	0.008	0.007	0.0025 U	0.037 R[f]	0.0281	0.0278	0.05
Mercury (mg/L)	—	—	0.000200 U	0.000200 U	0.00020 U	0.000200 U	0.00020 U	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	0.000200 U	0.000200U	0.00020 U	0.000200 U	0.00020 U	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	—	—	0.772 R[i]	0.754 R[i]	0.838	0.27 R[i]	0.240	0.232	10
Nitrite, as nitrogen (mg/L)	—	—	0.0200 R[i]	0.0200 R[i]	0.1 U	0.020 R[i]	0.1 U	0.1 U	1
pH	—	—	7.92	7.92	7.94	7.97	7.91	7.91	6.5–8.5
Selenium (mg/L)	—	—	0.0029 U	0.0027 U	0.0013	0.0012 U	0.00072	0.00072	0.05
Selenium-filtered (mg/L)	—	—	0.0028 U	0.0020 U	0.0013	0.0014 U	0.00081	0.00058	0.05
Silver (mg/L)	—	—	0.010 U	0.010 U	0.0025 U	0.010 U	0.0025 U	0.0025 U	0.1

Table 5-10. INTEC New Percolation Ponds WLAP Groundwater Quality Data from Aquifer Wells for April and October 2006.[a,b] (continued)

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)			ICPP-MON-A-166 (GW-013007)			
Sample Date	April 2006	October 2006	4/24/2006	4/24/2006[a]	10/03/2006	4/13/2006	10/04/2006	10/04/2006[a]	PCS/SCS[b]
Silver-filtered (mg/L)	—	—	0.010 U	0.010 U	0.0025 U	0.010 U	0.0025 U	0.0025 U	0.1
Sodium (mg/L)	—	—	19.8	19.4	22.9	9.93	10.8	9.61	NA
Sodium-filtered (mg/L)	—	—	19.4	19.9	19.7	9.98	9.44	9.29	NA
Total coliform (colonies/100 mL)	—	—	Absent	Absent	Absent	Absent	Absent[j]	Absent[j]	1 colony/ 100 mL
Total dissolved solids (mg/L)	—	—	266	231	354	171	204	203	500
Total Kjeldahl Nitrogen (mg/L)	—	—	0.10 R[k]	0.10 R[k]	0.110	0.10 U	0.100 U	0.153	NA
Total phosphorus (mg/L)	—	—	0.0480	0.0602	0.0174	0.0543	0.0223	0.0163	NA

a. Duplicate sample.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.

c. ICPP-MON-A-167 was dry in April and October 2006 when permit-required sampling was performed, and the pump is located at the bottom of the well and cannot be lowered farther. Therefore, the well could not be sampled.

d. Because a similar water level increase was not observed in the other two aquifer wells, an additional water level measurement was taken at Well ICPP-MON-A-166 on February 5, 2007. The water level measurement was 509.08 ft, which is comparable to the April and October 2005 measurements taken at this well.

e. NA—Not applicable.

f. The reported result was rejected during validation due to poor laboratory serial dilution sample precision.

g. U flag indicates the result was below the detection limit.

h. The preoperational concentrations (see Section 3.2.1) in the upgradient well (ICPP-MON-A-167) are considered the natural background level and are used for determining compliance.

i. The reported result was rejected during validation due to missed holding time by the analytical laboratory.

j. Due to analytical laboratory missed holding time, sample was recollected on October 26, 2006.

k. The reported result was rejected during validation due to poor laboratory duplicate sample precision.

Table 5-11. INTEC New Percolation Ponds, Groundwater Quality Data from Perched Water Wells for April and October (2006).

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
Sample Date	4/25/2006	10/05/06	4/25/2006	10/05/2006	4/25/2006	10/04/2006	PCS/SCS[a]
Depth to water table (ft)	112.25	Dry[b]	108.54	105.16	193.67	233.15	NA[c]
Water table elevation (ft)	4,835.71	—	4,844.43	4,847.81	4,764.67	4,725.19	NA
Aluminum (mg/L)	**0.312 R**[d,e]	—	**0.206 R**[d,e]	**0.431**[e]	**3.68 R**[d,e]	**0.944**[e]	0.2
Aluminum-filtered (mg/L)	—	—	0.178 R[d]	0.0250 U[f]	0.136 R[d]	0.0250 U	0.2
Arsenic (mg/L)	0.0011	—	0.0037	0.0050 U	0.0014 U	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	—	0.0035	0.0050 U	0.0009	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	2.0 U	—	2.0 U	2 U	2.0 U	2 U	NA
Cadmium (mg/L)	0.0006 U	—	0.0008 U	0.0025 U	0.0012 U	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	0.0009 U	0.0025 U	0.0008 U	0.0025 U	0.005
Chloride (mg/L)	7.3	—	138	109	124	122	250
Chromium (mg/L)	0.010	—	0.010	0.0075	0.093	0.102	0.1
Chromium-filtered (mg/L)	—	—	0.006	0.0058	0.003	0.0058	0.1
Copper (mg/L)	0.012	—	0.016	0.0025 U	0.019	0.0025 U	1.3
Copper-filtered (mg/L)	—	—	0.016	0.0025 U	0.016	0.0025 U	1.3
Fecal coliform (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent[g]	NA
Fluoride (mg/L)	0.23	—	0.26	0.264	0.19	0.223	4
Iron (mg/L)	0.283 U	—	**0.309**[e] **U**	**0.968**[e]	**4.04**[e]	**1.670**[e]	0.3
Iron-filtered (mg/L)	—	—	0.081 U	0.105	0.111 U	0.144	0.3
Manganese (mg/L)	0.007	—	0.007	0.0160	**0.064**[e]	0.0198	0.05
Manganese-filtered (mg/L)	—	—	0.004	0.0025 U	0.013	0.0025 U	0.05
Mercury (mg/L)	0.000200 U	—	0.000200 U	0.00020 U	0.000200 U	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	0.000200 U	0.00020 U	0.000200 U	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	1.2	—	1.3	0.941	1.3	1.01	10
Nitrite, as nitrogen (mg/L)	0.020 U	—	0.020 U	0.1 U	0.020 U	0.1 U	1
pH	8.09	—	7.82	8.76	7.75	7.80	6.5–8.5

Table 5-11. INTEC New Percolation Ponds, Groundwater Quality Data from Perched Water Wells for April and October (2006). (continued)

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
Sample Date	4/25/2006	10/05/06	4/25/2006	10/05/2006	4/25/2006	10/04/2006	PCS/SCS[a]
Selenium (mg/L)	0.0024 R[h]	—	0.0038 R[h]	0.00050 U	0.0010 R[h]	0.0013	0.05
Selenium-filtered (mg/L)	—	—	0.0025 R[h]	0.0017	0.0031 R[h]	0.0017	0.05
Silver (mg/L)	0.010 U	—	0.010 U	0.0025 U	0.010 U	0.0025 U	0.1
Silver-filtered (mg/L)	—	—	0.010 U	0.0025 U	0.010 U	0.0025 U	0.1
Sodium (mg/L)	7.32	—	91.3	80.4	54.3	62.3	NA
Sodium-filtered (mg/L)	—	—	91.1	69.7	53.8	53.5	NA
Total coliform (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent[g]	1 colony forming unit/100 mL
Total dissolved solids (mg/L)	266	—	472	428	430	471	500
Total Kjeldahl nitrogen (mg/L)	1.0 R[i]	—	0.10 R[i]	0.192	0.10 R[i]	0.128	NA
Total phosphorus (mg/L)	0.587	—	0.0500	0.0706	0.208	0.0680	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.

b. ICPP-MON-V-191 is a perched well and was dry in October 2006.

c. NA—Not applicable.

d. The reported result was rejected during validation due to poor laboratory serial dilution sample precision.

e. **Bold** text indicates exceedances.

f. U flag indicates that the result was below the detection limit.

g. Due to analytical laboratory missed holding time, sample was recollected on October 30, 2006.

h. The reported result was rejected during validation due to poor laboratory duplicate sample precision.

1. i. The reported result was rejected during validation due to poor laboratory matrix spike percent recovery.

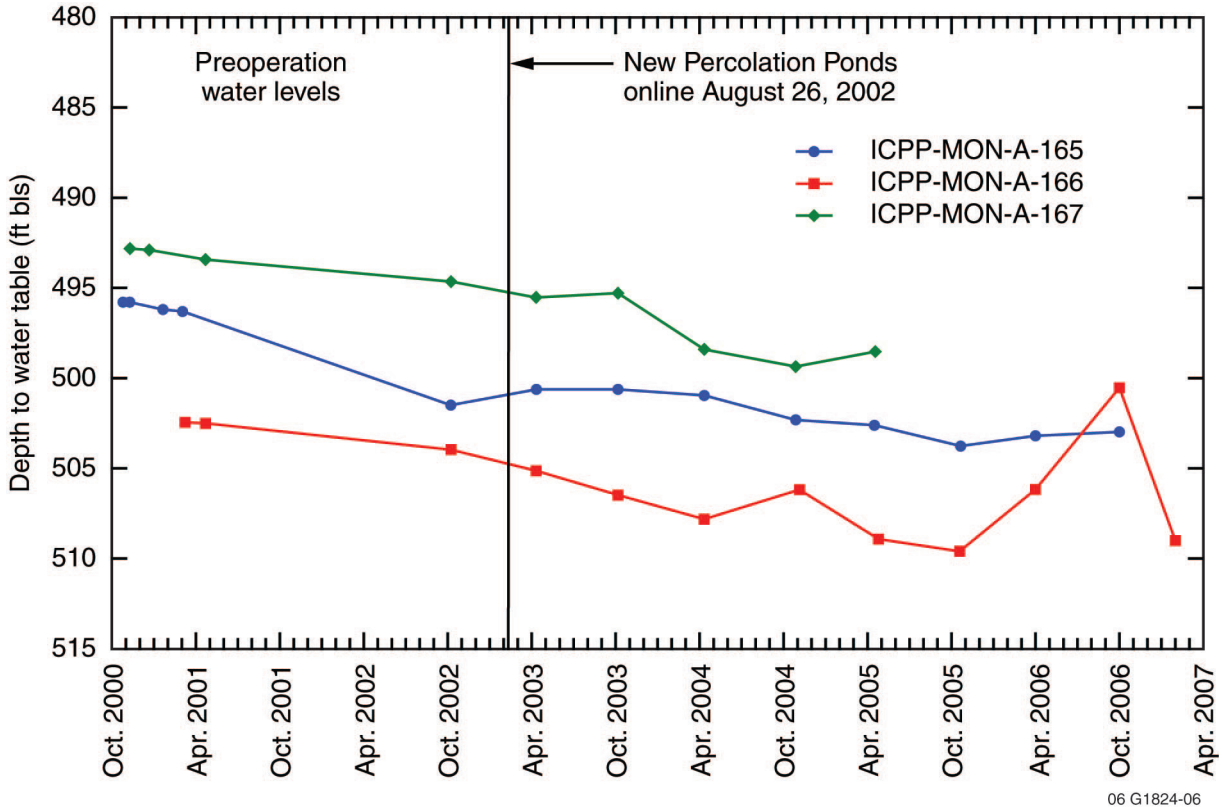


Figure 5-2. Depth of Water Table in the New Percolation Ponds Aquifer Monitoring Wells.

- Iron in perched water wells ICPP-MON-V-200 and ICPP-MON-V-212 (see Table 5-11)
- Manganese in perched water well ICPP-MON-V-212 (see Table 5-11).

As required by the permit, DEQ was notified of these exceedances (McNeel 2006).

Concentrations of aluminum in aquifer well ICPP-MON-A-166 and iron in aquifer well ICPP-MON-A-165 exceeded the associated SCS (see Table 5-10); however, they were below the preoperational concentrations in upgradient aquifer well ICPP-MON-A-167 (see Table 5-12), and are considered in compliance with the permit and the "Ground Water Quality Rule."

The April 2006 aluminum concentration in well ICPP-MON-V-191 exceeded the SCS (see Table 5-11). However, the result was rejected due to poor laboratory serial dilution sample precision. The accuracy of this April 2006 data is questionable, and it is recommended that the data not be used.

Concentrations of aluminum and iron in the unfiltered samples from well ICPP-MON-V-200 were first measured above SCSs in April 2003. During 2006, concentrations of aluminum in the unfiltered samples from ICPP-MON-V-200 remained above the SCSs (see Table 5-11). However, the April aluminum result was rejected due to poor laboratory serial dilution sample precision; therefore, the accuracy is questionable. The April iron result also exceeded the SCS, but was below the detection limit.

The concentration of iron in unfiltered samples from well ICPP-MON-V-212 was first measured above the SCS in October 2004, and remained above the SCS during 2006. Also in 2006, the April and October aluminum and April manganese concentrations exceeded the SCS in well ICPP-MON-V-212. This was the first

Table 5-12. Preoperational Concentrations and Secondary Constituent Standards.[a]

ICPP-MON-A-167	Nov. 2001	Jan. 2001	Feb. 2001	March 2001	May 2001	SCS
Aluminum (mg/L)	32.8	27.2	17.7	23.7	14.9	0.2
Iron (mg/L)	19.2	16.6	10.2	14.2	10.4	0.3
Manganese (mg/L)	0.355	0.3	0.218	0.205	0.165	0.05

a. Preoperational concentrations from INEEL (2004); secondary constituent standards (SCS) from Idaho Administrative Procedures Act 58.01.11.200.01.b.

exceedance of aluminum and manganese SCSs in well ICPP-MON-V-212. However, the April aluminum result was rejected due to poor laboratory serial dilution sample precision.

Until 2006, concentrations of aluminum and iron in all filtered samples from perched water wells ICPP-MON-V-191, ICPP-MON-V-200, ICPP-MON-V-212 were below the associated groundwater quality standards. This indicates that the elevated metals measured in unfiltered samples were not in solution in the perched water, but were associated with the sediment that dissolved during the analytical process (e.g., acidification).

Several studies have been performed and actions taken to address the high concentrations of aluminum, iron, and manganese in the permitted wells. The 2005 annual report (DOE 2006) summarizes the studies and actions. An investigation of exceedances of these and other constituents at the INL Site will be conducted during 2007. The results of the investigation will be reported in the 2007 annual report. Also, semiannual monitoring of the permitted wells will continue, and additional actions will be implemented as needed.

TDS Concentrations in Groundwater - During 2006, concentrations of TDS were below the SCS in the two downgradient aquifer wells and in all three perched water wells. As shown in Table 5-10, the concentration of TDS in aquifer well ICPP-MON-A-165 increased considerably from April 2006 (266 mg/L) to October 2006 (354 mg/L). Since October 2002, TDS concentrations in this well have averaged 244 mg/L. In addition, the chloride concentrations in this well have steadily increased from a concentration of 8.9 mg/L in October 2002 to a concentration of 75.7 mg/L in October 2006, indicating that mobile contaminants in wastewater effluent from the CPP-606 Treated Water System is now impacting the aquifer in this area. In contrast, the concentrations of TDS in aquifer well ICPP-MON-A-166 have remained constant since 2002, with an average concentration of 187 mg/L.

The concentration of TDS in upgradient perched water well ICPP-MON-V-191 was 266 mg/L and below the SCS of 500 mg/L. The April 2006 and October 2006 TDS results for the two downgradient perched water wells, ICPP-MON-V-200 and ICPP-MON-V-212, were also below the SCS. However, the concentration of TDS in these two wells remained high, with a concentration of 472 mg/L in April and 426 mg/L in October for perched water well ICPP-MON-V-200, and a concentration of 430 mg/L in April and 471 mg/L in October for perched water well ICPP-MON-V-212. The wastewater effluent from the CPP-606 Treated Water System continues to impact the perched water in the vicinity of the New Percolation Ponds.

The concentrations of TDS, chloride, and sodium in the aquifer near aquifer well ICPP-MON-A-165 and in the perched water near the New Percolation Ponds are influenced by the wastewater discharges from the

CPP-606 Treated Water System. To reduce concentrations of TDS, chloride, and sodium in the groundwater, a new water treatment system is being installed at INTEC and is expected to be operational by the end of 2007.

Actions To Address Groundwater Quality Standard Exceedances - Because of persistently high concentrations of aluminum, iron, and manganese in unfiltered samples taken from both aquifer and perched water wells, several investigative and corrective actions have been taken (ICP 2006a). These include analyzing sediment samples from permitted wells, well completion material (bentonite), and nearby interbeds; evaluating data from the Service Waste System effluent and previous well sampling events; evaluating metals data from additional INTEC area wells that are known to be outside the influence of the INTEC New Percolation Ponds; and performing additional well development. Several studies have indicated that the most likely source for the sediment in the permitted wells is washed-in interbed material and that the elevated concentrations of these metals in unfiltered samples taken from these wells can be attributed to the undissolved sediments in the samples. During analysis of unfiltered samples, metals concentrations in the liquid portion of the sample increase after the acidification process as aluminum and iron minerals are dissolved. This is supported by the fact that, before 2006, concentrations of these metals in all filtered samples taken from these wells have been below the associated groundwater quality standards, indicating that aluminum and iron are not in solution in the groundwater, at least in great quantities, but are associated with the undissolved sediment in the unfiltered samples.

The following will be implemented to address aluminum, iron, and manganese exceedances:

- An investigation of exceedances of aluminum, iron, manganese, and other constituents at the INL Site will be conducted during 2007. The results of the investigation will be reported in the 2007 annual report.
- Semiannual monitoring of permitted wells will continue.

TAN/TSF Sewage Treatment Facility

Description – The TAN/TSF Sewage Treatment Facility (TAN-623) was constructed and designed to treat raw wastewater by biologically digesting the majority of the organic waste and other major contaminants, then applying it to the land surface for infiltration and evaporation. The Sewage Treatment Facility consists of:

- Wastewater-collection manhole
- Imhoff tank
- Sludge drying beds
- Trickle filter and settling tank
- Contact basin (chlorination not performed)
- Infiltration disposal pond.

The TAN/TSF Disposal Pond was constructed in 1971 and consists of a primary disposal area and an overflow section, both of which are located within an unlined, fenced 14-ha (35-acre) area (see Figure 5-3). The Overflow Pond is rarely used; it is used only when the water is diverted to it for brief periods of cleanup and maintenance. The TAN/TSF Disposal Pond and Overflow Pond areas are approximately 0.4 ha (0.9 acres) and 0.13 ha (0.330 acres), respectively, for a combined area of approximately 0.5 ha (1.23 acres).

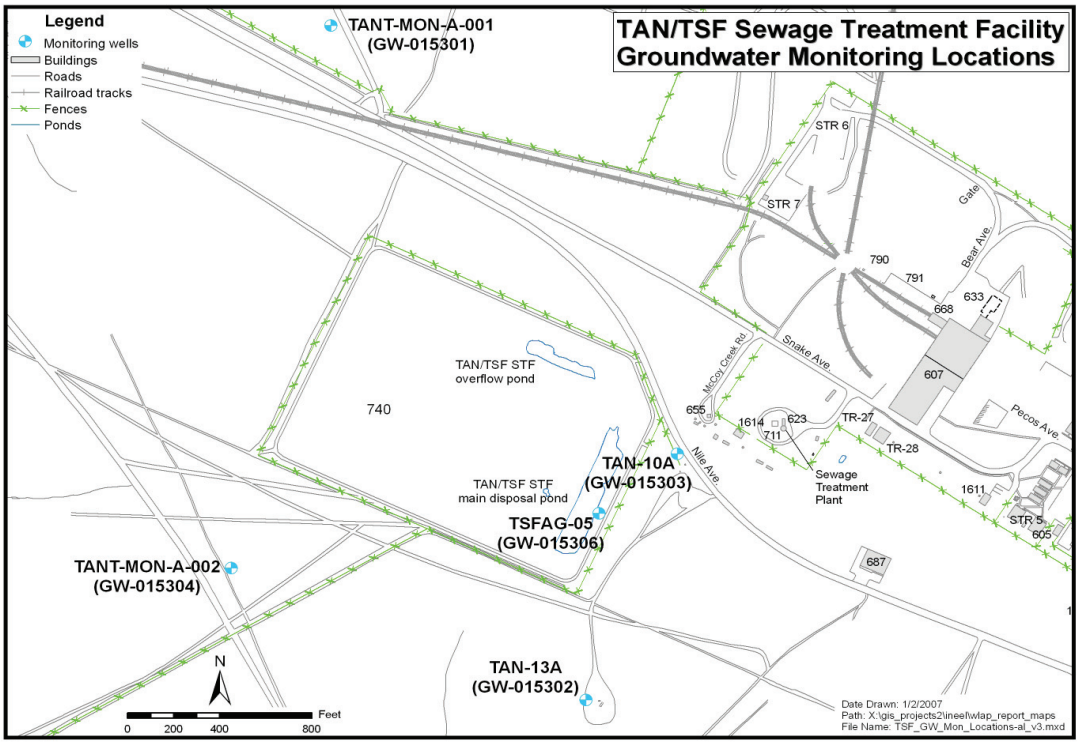


Figure 5-3. Wastewater Land Application Permit Monitoring Locations at TAN/TSF.

In addition to receiving treated sewage wastewater, the TAN/TSF Disposal Pond also receives process wastewater, which enters the facility at the TAN-655 lift station.

The TSF sewage primarily consists of spent water containing waste from restrooms, sinks, and showers. The sanitary wastewater goes to the TAN-623 Sewage Treatment Facility, and then to the TAN-655 lift station, which pumps to the TAN/TSF Disposal Pond.

The process drain system collects wastewater from process drains and building sources originating from various TAN facilities. The process wastewater consists of liquid effluent, such as steam condensate; water softener and demineralizer discharges; fire water discharges; and cooling, heating, and air conditioning water. The process wastewater is transported directly to the TAN-655 lift station, where it is mixed with sanitary wastewater before being pumped to the TAN/TSF Disposal Pond.

WLAP Wastewater Monitoring Results – Total effluent to the TAN/TSF Disposal Pond for calendar year 2006 was approximately 41.03 million L (10.84 MG), which was under the permit limit of 15 MG per year. During 2006, an average of 29,690 gal per day was discharged to the TAN/TSF Disposal Pond.

The permit for the TAN/TSF Sewage Treatment Facility sets concentration limits for TSS and total nitrogen (measured at the effluent to the TAN/TSF Disposal Pond) and requires that the effluent be sampled and analyzed monthly for specific parameters. During 2006, 24-hour composite samples (except pH, fecal coliform, and total coliform, which were grab samples) were collected from the TAN-655 lift station effluent monthly.

Table 5-13 shows the effluent monitoring results for 2006. All monthly total nitrogen (total Kjeldahl nitrogen plus nitrate + nitrite, as nitrogen) concentrations were below the permit limit of 20 mg/L. All

Figure 5-2. Depth of Water Table in the New Percolation Ponds Aquifer Monitoring Wells.

Parameter	Minimum	Maximum	Average[c]	Permit Limit
Aluminum	0.0125[d]	1.12	0.166	NA[e]
Arsenic	0.00125[d]	0.00440	0.00227	NA
Barium	0.0921	0.114	0.100	NA
Beryllium	0.00025[d]	0.00025[d]	0.00025[f]	NA
Biological oxygen demand (5-day)	2.82	18.6	7.83	NA
Cadmium	0.0005[d]	0.0005[d]	0.0005[f]	NA
Chloride	17.5	395.	158.	NA
Chromium	0.00125[d]	0.00480	0.00267	NA
Fecal coliform (colonies/100 mL)	0.5[d]	57,273	9,355	NA
Fluoride	0.212	0.301	0.245	NA
Iron	0.0544	1.23	0.307	NA
Lead	0.00020[d]	0.0015	0.00060	NA
Manganese	0.0029	0.031	0.0092	NA
Mercury	0.00005[d]	0.0001[d]	0.00009[f]	NA
Nitrogen, as ammonia	0.639	4.16	1.71	NA
Nitrate+nitrite, as nitrogen	3.45	8.05	4.91	NA
pH (standard units) (grab)	7.62	9.43	8.00	NA
Total Kjeldahl nitrogen	1.35	4.90	2.59	NA
Selenium	0.0010[d]	0.0026	0.0012	NA
Sodium	9.65	246.	91.9	NA
Sulfate	29.9	45.7	36.5	NA
Total coliform (colonies/100 mL)	0.5[d]	94,545	19,566	NA
Total phosphorus	0.320	1.09	0.747	NA
Total dissolved solids	283	967	525	NA
Total nitrogen[g]	5.66	12.0	7.50	20
Total suspended solids	2.00[d]	18.4	9.40	100
Zinc	0.0132	0.0391	0.0248	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. Duplicate samples were collected in January for all parameters (excluding total coliform and fecal coliform), and the duplicate results are included in the summaries.

c. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in any calculation for those data reported as below the detection limit.

d. Sample result was less than the detection limit; value shown is half the detection limit.

e. NA—Not applicable; no permit limit is set for this parameter.

f. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.

g. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.

monthly TSS concentrations were below the permit limit of 100 mg/L. No permit limits are established for other parameters. The 2006 Wastewater Land Application Report for the TAN/TSF Sewage Treatment Facility (ICP 2007b) provides detailed wastewater monitoring results.

In addition to the permit-required effluent monitoring, samples were collected at the Sewage Treatment Facility (TAN-623) (see Table 5-14). This additional monitoring was performed in anticipation of the reduced process wastewater flows to the TAN-655 lift station and to determine if there would be any nutrient loading and other impacts to the Disposal Pond. The results from TAN-623 are similar to the results from TAN-655 and were below permit limits.

WLAP Groundwater Monitoring Results – To measure potential TAN/TSF Disposal Pond impacts to groundwater, the permit requires that groundwater samples be collected from five monitoring wells (see Figure 5-3):

- One background aquifer well (TANT-MON-A-001) upgradient of the TAN/TSF Disposal Pond
- Three aquifer wells (TAN-10A, TAN-13A, and TANT-MON-A-002) that serve as points of compliance
- One perched water well (TSFAG-05) located inside the Disposal Pond fence.

Sampling must be conducted semiannually and must include permit-specified parameters for analysis. As specified in Section F of WLAP-LA-000153-02, parameter concentrations in wells TAN-10A (except for iron), TAN-13A, and TANT-MON-A-002 are limited to the PCSs and SCSs in IDAPA 58.01.11, "Ground Water Quality Rule." All permit required samples are collected as unfiltered samples.

During 2006, groundwater samples were collected in April and October. Table 5-15 shows water table elevations and depth to water table, determined before purging and sampling, and analytical results for all parameters specified by the permit. Well TSFAG-05 was dry during both April and October 2006. Therefore, no analytical results are presented for this well.

As Table 5-15 shows, groundwater parameters were below their respective PCSs and SCSs, except for the following exceedances:

- Iron (unfiltered) concentrations in well TANT-MON-A-002 in October 2006
- Manganese concentrations in well TAN-10A in April and October 2006
- TDS concentrations in well TAN-10A in October 2006
- Aluminum concentrations in well TANT-MON-A-002 in October 2006 and in well TAN-10A in April 2006.

Iron and filtered iron concentrations in well TAN-10A were above the SCS of 0.3 mg/L in April 2006 and October 2006 (see Table 5-15). However, Section F of WLAP LA-000153-02 exempts the iron concentrations in well TAN-10A from the limits set forth in IDAPA 58.01.11.200.01.b; therefore, these exceedances do not represent permit noncompliances.

The cadmium concentration in April for well TAN-10A was reported as undetected at the reporting limit of 0.010 mg/L. Although this result is above the PCS of 0.005 mg/L, a review of the raw data and supporting documentation indicate that cadmium was not present above the method detection limit of 0.004 mg/L. In addition, cadmium was not detected in the October 2006, October 2005, and April 2005 samples from this well, indicating groundwater concentrations were below the PCS. Cadmium was not a required groundwater parameter before the new permit was issued in January 2005.

Table 5-14. Summary of TAN-623 Effluent from Sewage Treatment Plant Results (2006).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Aluminum	0.0281	0.131	0.0637	NA[c]
Antimony	0.0003[d]	0.0003[d]	0.0003[e]	NA
Arsenic	0.0025	0.0036	0.0029	NA
Barium	0.0932	0.0980	0.0953	NA
Beryllium	0.00025[d]	0.00025[d]	0.00025[e]	NA
Biological oxygen demand (5-day)	4.21	7.50	6.01	NA
Cadmium	0.0005[d]	0.0005[d]	0.0005[e]	NA
Chloride	17.5	19.5	18.3	NA
Chromium	0.00125[d]	0.00360	0.00281	NA
Conductivity (µS/cm) (grab)	421.	469.	446.	NA
Copper	0.0022	0.0037	0.0031	NA
Fluoride	0.235	0.302	0.258	NA
Gross alpha[f]	2.51 ± 0.730	3.50 ± 2.58	2.58 ± 0.700	NA
Gross beta[f]	3.95 ± 1.67	5.65 ± 1.10	4.96 ± 0.850	NA
Iron	0.167	0.235	0.199	NA
Lead	0.0002[d]	0.00043	0.00026	NA
Manganese	0.0025	0.0104	0.0064	NA
Mercury	0.0001[d]	0.0001[d]	0.0001[e]	NA
Nickel	0.00125[d]	0.00125[d]	0.00125[e]	NA
Nitrogen, as ammonia	1.54	4.25	2.50	NA
Nitrate+nitrite, as nitrogen	3.47	6.67	4.77	NA
pH (standard units) (grab)	8.04	8.38	8.20	NA
Potassium-40[f]	3.42 ± 31.4	105 ± 62.4	22.9 ± 22.4	NA
Total Kjeldahl nitrogen	2.01	4.38	3.10	NA
Selenium	0.001[d]	0.001[d]	0.001[e]	NA
Silver	0.00125[d]	0.00125[d]	0.00125[e]	NA
Sodium	9.53	10.8	10.0	NA
Sulfate	29.0	37.4	32.8	NA
Thallium	0.0002[d]	0.0002[d]	0.0002[e]	NA
Total phosphorus	0.704	0.949	0.828	NA
Total dissolved solids	286	320	297	NA
Total nitrogen[g]	6.48	10.4	7.86	20
Total suspended solids	4.80	10.6	7.80	100
Zinc	0.0194	0.0296	0.0261	NA

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

b. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.

c. NA—Not applicable; no permit limit is set for this parameter.

d. Sample result was less than the detection limit; value shown is half the detection limit.

e. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.

f. Radionuclide values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).

g. g. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate+nitrite, as nitrogen.

Table 5-15. TAN/TSF Sewage Treatment Facility Groundwater Data for April and October (2006).

	TANT-MON-A-001 (GW-015301)			TANT-MON-A-002 (GW-015304)			TAN-10A (GW-015303)		TAN-13A (GW-015302)		TSFAG-05 (GW-015306)		
Sample Date	**4/24/2006**	**4/24/2006[a]**	**10/09/2006**	**4/19/2006**	**10/09/2006**	**10/09/2006[a]**	**4/11/06**	**10/10/2006**	**4/19/2006**	**10/10/2006**	**04/06**	**10/06**	**PCS/SCS[b]**
Depth to water table (ft)	211.73	211.73	215.67	216.62	219.01	219.01	213.38	217.11	215.4	217.45	Dry[c]	Dry[c]	NA[d]
Water table elevation at brass cap (ft)	4,571.02	4,571.02	4,567.08	4,568.24	4,565.85	4,565.85	4,570.79	4,567.06	4,568.57	4,566.52	—	—	NA
Aluminum (mg/L)	0.113 R[e]	0.113 R[e]	0.0250 U[f]	0.146 U	**0.337**[g]	**0.394**[g]	**0.751**[g]	0.0250 U	0.104 U	0.0407	—	—	0.2
Ammonia, as nitrogen (mg/L)	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	—	—	NA
Arsenic (mg/L)	0.0026	0.0026	0.0050 U	0.0022	0.0050 U	0.0050 U	0.0012	0.0050 U	0.0020	0.0050 U	—	—	0.05
Barium (mg/L)	0.0814	0.0809	0.0782	0.075	0.0787	0.0804	0.296	0.318	0.071	0.0736	—	—	2
Beryllium (mg/L)	0.00030 U	0.00030 U	0.0025 U	0.00030 U	0.0025 U	0.0025 U	0.0003 U	0.0025 U	0.00014 U	0.0025 U	—	—	0.004
Biochemical oxygen demand (mg/L)	2.0 U	2.0 U	2 U	2.0 U	2 U	2 U	3.7	5.52	2.0 U	2 U	—	—	NA
Cadmium (mg/L)	0.00078 U	0.00093 U	0.0025 U	0.001 U	0.0025 U	0.0025 U	0.010 U	0.0025 U	0.001 U	0.0025 U	—	—	0.005
Chloride (mg/L)	12.1	11.8	12.2	3.7	3.70	3.78	105	130	3.6	3.41	—	—	250
Chromium (mg/L)	0.00471	0.00435	0.0042	0.007	0.0089	0.0089	0.005	0.0025 U	0.004	0.0046	—	—	0.1
Fecal coliform (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	—	—	NA
Fluoride (mg/L)	0.24	0.25	0.269	0.19	0.235	0.267	0.31	0.155	0.18	0.237	—	—	4
Iron (filtered) (mg/L)	—	—	—	—	—	—	1.26[h]	1.420[h]	—	—	—	—	0.3
Iron (mg/L)	0.0855 U	0.0730 U	0.113	0.280	**0.390**[g]	**0.509**[g]	1.23[h]	1.720[h]	0.046 U	0.152	—	—	0.3
Lead (mg/L)	0.0010 U	0.0010 U	0.00025 U	0.0005 U	0.00045	0.00073	0.0010 U	0.00025 U	0.0002 U	0.00025 U	—	—	0.015
Manganese (mg/L)	0.00386	0.00382	0.0025 U	0.006 R[e]	0.0133	0.0232	**0.699**[g]	**0.796**[g]	0.012 R[e]	0.0054	—	—	0.05
Mercury (mg/L)	0.000200 U	0.000200 U	0.00020 U	0.000200 U	0.00020 U	0.00020 U	0.000200 U	0.00020 U	0.000200 U	0.00020 U	—	—	0.002
Nitrate, as nitrogen (mg/L)	0.95	0.94	0.858	0.56	0.526	0.530	0.020 U	0.1 U	0.41	0.374	—	—	10
Nitrite, as nitrogen (mg/L)	0.020 U	0.020 U	0.1 U	0.020 U	0.1 U	0.1 U	0.020 U	0.1 U	0.020 U	0.1 U	—	—	1
pH	8.01	8.01	8.01	7.89	7.89	7.89	7.49	7.61	7.91	7.69	—	—	6.5–8.5
Selenium (mg/L)	0.0028 R[i]	0.0029 R[i]	0.0017	0.0014 U	0.0015	0.0012	0.0038	0.00050 U	0.0013 U	0.0013	—	—	0.05
Sodium (mg/L)	7.66	7.70	7.24	12.2	5.91	5.97	58.4	57.7	5.80	5.56	—	—	NA
Sulfate (mg/L)	29.2	28.8	31.8	13.9	14.8	14.9	33.6	36.8	14.9	14.9	—	—	250
Total coliform (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	—	—	1 colony/ 100 mL

Table 5-15. TAN/TSF Sewage Treatment Facility Groundwater Data for April and October (2006). (continued)

Sample Date	TANT-MON-A-001 (GW-015301)			TANT-MON-A-002 (GW-015304)			TAN-10A (GW-015303)		TAN-13A (GW-015302)		TSFAG-05 (GW-015306)		PCS/SCS[b]
	4/24/2006	4/24/2006[a]	10/09/2006	4/19/2006	10/09/2006	10/09/2006[a]	4/11/06	10/10/2006	4/19/2006	10/10/2006	04/06	10/06	
Total dissolved solids (mg/L)	153	368	248	186	211	207	439	**620**[g]	198	193	—	—	500
Total Kjeldahl nitrogen (mg/L)	0.10 U	0.10 U	0.161	0.10 U	0.189	0.318	0.10 U	0.374	0.010 U	0.100 U	—	—	NA
Total phosphorus (mg/L)	0.0578	0.0500 U	0.0277	0.0934	0.0533	0.0546	0.106	0.0659	0.0419	0.0162	—	—	NA
Zinc (mg/L)	0.0314	0.0325	0.0304	0.198 R[i]	0.111	0.132	0.013	0.0440	0.102 R[i]	0.100	—	—	5

a. Duplicate sample.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.

c. Well TSFAG-05 was dry in April and October 2006.

d. NA—Not applicable.

e. The reported result was rejected during validation due to poor laboratory serial dilution sample precision.

f. U flag indicates the result was below the detection limit.

g. **Bold** text indicates exceedance of the Wastewater Land Application Permit limit.

h. Iron concentrations in Well TAN-10A are exempt from the limit, and, therefore, these exceedances do not represent permit noncompliances.

i. The reported result was rejected during validation due to poor laboratory duplicate sample precision.

The following subsections discuss exceedances of iron, manganese, TDS, and aluminum. The 2006 Wastewater Land Application Report for the TAN/TSF Sewage Treatment Facility (ICP 2007b) also discusses exceedances.

Iron Concentrations in Wells TAN-10A and TANT-MON-A-002- Unfiltered iron concentrations exceeded the SCS of 0.3 mg/L in well TANT-MON-A-002 in October 2006 (see Table 5-15). The concentration was 0.390 mg/L, which slightly exceeded the standard. A duplicate sample was collected at the same time, and that concentration was 0.509 mg/L.

Elevated iron concentrations historically have been measured in the TAN permitted monitoring wells; therefore, a corrosion evaluation (CORRPRO 2000) was performed. This evaluation confirmed that the riser pipes at several TAN wells were significantly corroded. The riser pipes were replaced with stainless steel riser pipes in all four TAN permitted monitoring wells during August 2001. After the riser pipes were replaced, iron concentrations decreased in wells TAN-13A, TANT-MON-A-001, and TANT-MON-A-002. Conversely, at well TAN-10A, both unfiltered and filtered iron concentrations increased immediately after the riser pipes were replaced. Unfiltered iron concentrations have since dropped, and filtered iron concentrations have continued to increase, and concentrations of both have consistently remained above the SCS (ICP 2006b).

Manganese and TDS Concentrations in Well TAN-10A - Concentrations of manganese and TDS in well TAN-10A exceeded their SCSs during 2006 (see Table 5-15):

- Manganese concentrations were 0.699 mg/L in April 2006 and 0.796 mg/L in October 2006. The SCS is 0.05 mg/L.
- The April 2006 TDS concentration of 439 mg/L was below the SCS of 500 mg/L for the first time since October 2004. However, the October 2006 TDS concentration of 620 mg/L exceeded the SCS.

As required by the permit, DEQ was notified of the exceedances.

For well TAN-10A, concentrations of both manganese and TDS have periodically been above their SCSs. The peak TDS concentration occurred shortly after riser pipe replacement, and the corroded well casing may still be contributing to the TDS concentrations in well TAN-10A. The 2004 annual report (ICP 2005a) stated that the TDS in the effluent could be impacting the concentrations in well TAN-10A. Figure 5-4 shows the historical TDS concentrations in the effluent and in well TAN-10A. While increases in well TAN-10A in early 2000 seem to follow earlier increases in the effluent, no pattern is evident from 2000 forward, with increases in well TAN-10A occurring prior to increases in the effluent. Similarly, no pattern is evident for the concentrations of manganese in the effluent when compared to concentrations in well TAN-10A.

To further evaluate manganese and TDS concentrations measured in the five permitted wells, 17 additional wells were sampled during 2006. The additional wells are within the trichloroethene plume, and five of the 17 wells are in the TSF-05 injection well hot spot. Exceedances of TDS and manganese were reported in all of the additional wells. The highest TDS concentration was 12,900 mg/L at well TAN-26 in April 2006. This concentration is approximately 20 times the highest concentration at well TAN-10A (620 mg/L). The highest manganese concentration was 6.94 mg/L at well TSF-05B in April 2006. This concentration is about 10 times greater than was measured in well TAN-10A in April (0.699 mg/L) and October (0.796 mg/L).

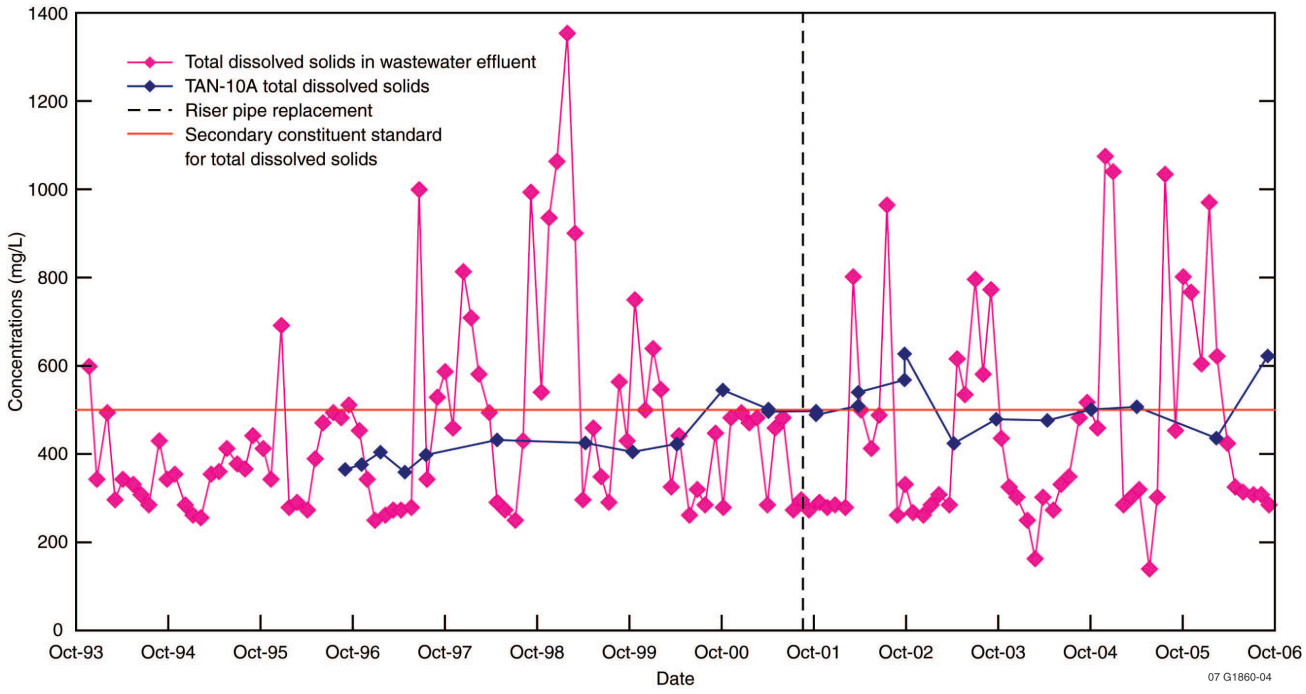


Figure 5-4. Total Dissolved Solids Concentrations in TAN-655 Effluent and Well TAN-10A.

Aluminum Concentrations in Wells TANT-MON-A-002 and TAN-10A - The aluminum concentrations in two monitoring wells exceeded the SCS of 0.2 mg/L during 2006. The aluminum concentration in the sample collected from well TAN-10A on April 11, 2006, was 0.751 mg/L; the aluminum concentration in the sample collected from well TANT-MON-A-002 on October 9 2006, was 0.337 mg/L (duplicate was 0.394 mg/L) (see Table 5-15).

The historical data for wells TAN-10A and TANT-MON-A-002 show that aluminum was not detected in samples collected in April 2005, October 2005, or April 2006. Aluminum was not a required groundwater parameter for the permitted wells before the new permit was issued in January 2005. The historical data for other TAN area groundwater monitoring wells were also reviewed. From 1995 through 2006, there were only three other aluminum exceedances, which occurred in 2000 at wells TANT-MON-A-024 and TANT-MON-A-011.

Actions To Address Groundwater Quality Standard Exceedances - An investigation of exceedances of iron, manganese, TDS, and aluminum at the INL Site will be conducted during 2007. The results of the investigation will be reported in the 2007 annual report. Aluminum concentrations in wells TAN-10A and TANT-MON-A-002 will continue to be monitored.

Surveillance Sampling of Pit 9 Production Well

The ICP contractor collected a surveillance sample from the Pit 9 production well on October 18, 2006, to evaluate the extent of carbon tetrachloride contamination at the RWMC. Of the 158 analyses, only 27 constituents were detected. The detected results, along with the applicable MCLs or secondary maximum contaminant levels (SMCLs), are shown in Table 5-16. Iron, manganese, and turbidity were the only three results that exceeded the MCLs or SMCLs.

5.3 Liquid Effluent Surveillance Monitoring

As stated in Section 5.2, additional radiological and nonradiological parameters specified in the Idaho groundwater quality standards also are monitored. The following sections discuss results of this additional monitoring by individual facility. This additional monitoring is performed to comply with DOE Orders 450.1 and 5400.5 environmental protection objectives.

Central Facilities Area

Both the influent and effluent to the CFA Sewage Treatment Facility (STF) are monitored according to the WLAP issued for the plant. Table 5-17 summarizes the additional monitoring conducted during 2006 at the CFA STF and shows those parameters with at least one detected result during the year. During 2006, most additional parameters were within historical concentration levels.

Idaho Nuclear Technology and Engineering Center

A WLAP is in effect for the INTEC New Percolation Ponds. Table 5-18 summarizes the additional monitoring conducted during 2006 at INTEC and shows the analytical results for parameters that were detected in at least one sample during the year. The 2006 INTEC New Percolation Ponds Radiological Monitoring Report (ICP 2007c) provides additional information.

During 2006, most additional parameters were within historical concentration levels.

Materials and Fuels Complex

During 2006, the Industrial Waste Pond, Industrial Waste Ditch, and Secondary Sanitary Lagoon were sampled monthly for iron, sodium, chloride, fluoride, sulfate, pH, conductivity, TSS, turbidity, biological oxygen demand, gross alpha, gross beta, gamma spectrometry, and tritium. Additionally, a sample for selected metals is collected once a year. The Industrial Waste Pond was dry for part of the year and was only sampled in June, July, October, and November. Tables 5-19 to 5-21 summarize the analytical results for parameters which were detected in at least one sample.

Cesium-134 was reported at an activity of 9.13 pCi/L in the sample collected from the Materials and Fuels Complex (MFC) Industrial Waste Ditch on August 16, 2006. Iron-55 and ^{95}Zn were not detected in the first sample collected from the Industrial Waste Ditch on July 19, 2006; however, activities of 15.3 pCi/L and 7.83 pCi/L, respectively, were reported for the field duplicate. Iron-55 was also detected in the laboratory blank.

Two samples for low levels of uranium were collected from the Industrial Waste Ditch on July 19, 2006: a regular sample and a field duplicate. The activities of $^{233/234}$U in the sample and duplicate were 1.69 pCi/L and 1.85 pCi/L, respectively. The reported activities of ^{238}U in the sample and duplicate were 0.705 pCi/L and 0.959 pCi/L, respectively.

A sample for low levels of uranium was collected from the Industrial Waste Pond on July 19, 2006. The $^{233/234}$U activity was 3.69 pCi/L, ^{235}U was reported at 0.147 pCi/L, and ^{238}U was 1.82 pCi/L.

Tritium was detected in the samples collected from the Sanitary Sewage Lagoon in November and December.

Table 5-16. Pit 9 Production Well Detected Surveillance Results (2006).[a]

Constituent	Result[a]	Duplicate Result[a]	MCL or SMCL[b]
Alkalinity (mg/L)	143	142	None
Aluminum (mg/L)	0.057	0.063	0.05 to 0.2
Barium (mg/L)	0.056	0.09	2.0
Calcium (mg/L)	41	39	None
Carbon tetrachloride (mg/L)	0.0012	0.0012	0.005
Chloride (mg/L)	13	12	250
Chromium (mg/L)	0.02	0.02	0.1
Copper (mg/L)	0.043	0.05	1.0
Di(2-ethylhexyl)phthalate (mg/L)	0.0016	0.0028	0.006
Fluoride (mg/L)	0.2	0.2	2.0
Gross beta (pCi/L plus or minus the uncertainty [1 standard deviation])	—	2.55 ± 0.81	4 mrem/year
Iron (mg/L)	**5.6**	**4.4**	0.3
Magnesium (mg/L)	14	13	None
Manganese (mg/L)	**0.072**	**0.061**	0.05
Nickel (mg/L)	0.0067	0.0065	None
Nitrogen, as nitrate (mg/L)	0.73	0.72	10
Ortho Phosphate (mg P/L)	0.06	0.09	None
Silica (mg/L)	25	24	None
Sodium (mg/L)	7.7	8.4	None
Sulfate (mg/L)	22	22	250
Radium-226 (pCi/L plus or minus the uncertainty [1 standard deviation])	0.13 ± 0.10	0.06 ± 0.12	5
Total dissolved solids (mg/L)	220	220	500
Total uranium (ug/L)	1.65 ± 0.02	1.62 ± 0.02	30
Tritium (pCi/L plus or minus the uncertainty [1 standard deviation])	1170 ± 111	1110 ± 110	20,000
Turbidity (NTU)	**49**	**41**	5
Zinc (mg/L)	0.0067	0.041	5

a. **Bold** results indicate exceedance of MCL or SMCL.

b. MCL = maximum contaminant level; SMCL = secondary maximum contaminant level.

Table 5-17. Summary of CFA Liquid Effluent Surveillance Monitoring Results (2006).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Influent to CFA Sewage Treatment Plant Pond			
Conductivity (µS/cm) (grab)	800	3538	1589
Total Phosphorus	1.32	5.27	3.12
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System			
Conductivity (µS/cm) (grab)	1390	1630	1565
Chloride[e]	417	417	417
Fluoride[e]	0.599	0.599	0.599
Sulfate[e]	55.4	55.4	55.4
Aluminum[e]	0.0738	0.0738	0.0738
Arsenic[e]	0.0067	0.0067	0.0067
Barium[e]	0.0824	0.0824	0.0824
Copper[e]	0.0066	0.0066	0.0066
Iron[e]	0.0393	0.0393	0.0393
Manganese[e]	0.0097	0.0097	0.0097
Sodium[e]	186	186	186
Gross beta[e,f]	6.55 ± 1.8	6.55 ± 1.8	6.55 ± 1.8
Tritium[e,f]	4510 ± 160	4510 ± 160	4510 ± 160
Iodine-129[e,f]	0.307 ± 0.0358	0.307 ± 0.0358	0.307 ± 0.0358

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. No permit limits are set for these parameters.
d. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
e. The minimum, maximum, and average are the same for parameters analyzed for only in August.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).

Table 5-18. Summary of INTEC Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2006)[a,b]

Parameter	Minimum	Maximum	Average[c]
Effluent to INTEC New Percolation Ponds			
Cesium-137[d]	-1.45 ± 7.24[e]	4.18 ± 0.98	3.43 ± 0.45
Gross alpha[d]	-0.42 ± 3.52[e]	18.4 ± 5.78	3.53 ± 0.81
Gross beta[d]	8.51 ± 4.00	44.4 ± 6.40	23.3 ± 1.39
Total strontium[d]	0.15 ± 1.19[e]	2.05 ± 0.98	1.01 ± 0.54
Influent to INTEC Sewage Treatment Plant			
Conductivity (µS/cm) (grab)	673.4	1369	891.8
pH (standard units) (grab)	8.14	8.99	8.63
Effluent from INTEC Sewage Treatment Plant			
Conductivity (µS/cm) (grab)	568	888	796.6
Gross alpha[d]	1.60 ± 1.85[e]	2.16 ± 1.21	1.99 ± 1.02
Gross beta[d]	9.34 ± 3.28	10.1 ± 1.59	9.96 ± 1.43
pH (standard units) (composite)	7.45	9.75	8.55

a. Only parameters with at least one detected result are shown.
b. No permit limits are set for these parameters.
c. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
d. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
e. Result was a statistical nondetect.

Table 5-19. Summary of Analytical Results for Samples Collected from MFC Industrial Waste Pond (2006).[a,b]

Parameter	Minimum	Maximum	Average[c]
Arsenic[d]	0.0106	0.0106	0.0106
Barium[d]	0.191	0.191	0.191
Biological oxygen demand (5-Day)	1[e]	2.88	1.91
Chloride	16.5	37.5	23.9
Chromium[d]	0.0649	0.0649	0.0649
Conductivity (µS/cm)	274.2	539.7	377
Fluoride	0.25	0.494	0.328
Iron	3.28	14.65[g]	8.235
Lead[d]	0.0055	0.0055	0.0055
Nitrogen, nitrate + nitrite (mg-N/L)	0.0381	2.9	1.79
Nitrogen, total Kjeldahl	0.763	1.95	1.23
pH (standard units)	7.88	8.31	8.06
Sodium	17	34.6	22.99
Sulfate	39.6	94.9	60.4
Total dissolved solids	296	585	460
Total phosphorus	0.301	1.0[g]	0.608
Total suspended solids	17	75.7[g]	38.4
Zinc[d]	0.0695	0.0695	0.0695
Gross alpha[f]	3.99 ± 0.594	15 ± 1.23[g]	7.83 ±0.66
Gross beta[f]	9.1 ± 0.474	38.85 ± 1.66[g]	22.7 ± 0.71

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. For duplicate samples, the average monthly concentration was calculated and used to calculate the average annual concentration.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).
g. Average of concentrations/activities in the original and duplicate sample.

Table 5-20. Summary of Analytical Results for Samples Collected from the MFC Industrial Waste Ditch (2006).[a,b]

Parameter	Minimum	Maximum	Average[c]
Arsenic[d]	0.00265[h]	0.00265[h]	0.00265[h]
Barium[d]	0.04205[h]	0.04205[h]	0.04205[h]
Biological oxygen demand (5-Day)	1[e]	1[e]	1[e]
Chloride	0.5[e]	141	59.9
Conductivity (µS/cm)	6.1	740	502
Fluoride	0.1[e]	0.904	0.645
Iron	0.025	24.7	2.597
Nitrogen, nitrate + nitrite (mg-N/L)	0.0164	2.235	1.62
Nitrogen, total Kjeldahl	0.112	0.62	0.326
pH (standard units)	6.62	8.26	7.57
Sodium	0.772	194	55.487
Sulfate	1	23.5	17
Total dissolved solids	18	525[h]	321.5
Total phosphorus	0.0677	0.589	0.339
Total suspended solids	2[e]	121	13
Zinc[d]	0.01[h]	0.01[h]	0.01[h]
Gross alpha[f]	0.125 ± 1.08[g]	3.29 ± 1.15[g]	1.84 ± 0.24
Gross beta[f]	1.17 ± 0.841[g]	20.6 ± 2.14	5.53 ± 0.3

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).
g. Result was a statistical nondetect.
h. Average of concentrations/activities in the original and duplicate sample.

Table 5-21. Summary of Analytical Results for Samples Collected from the MFC Secondary Sanitary Lagoon (2006).[a,b]

Parameter	Minimum	Maximum	Average[c]
Arsenic[d]	0.0032	0.0032	0.0032
Barium[d]	0.0189	0.0189	0.0189
Biochemical oxygen demand[i] (5-day)	7.13	152	46.7
Chloride	50.5	275	176.9
Conductivity (µS/cm)	450.8	1667	1263
Fluoride	0.1	0.503	0.2
Iron	0.0312	0.713	0.230
Nitrogen, nitrate + nitrite (mg-N/L)	0.005[e]	2.26	0.295
Nitrogen, total Kjeldahl	9.47	88.5	26.8
pH (standard units)	5.55	9.73	8.23
Sodium	33.6	216	139.8
Sulfate	14.6	78.7	53.5
Total dissolved solids	248	1140	799
Total phosphorus	2.93	15.1	6.7
Total suspended solids	4.8	218	52
Zinc[d]	0.0046	0.0046	0.0046
Gross beta[f]	15.1 ± 0.886	63.4 ± 1.55	46.1 ± 0.75
Potassium-40[f,h]	26.7 ± 20.3[g]	130 ± 37.9	55.8 ± 6.6
Radium-226[f]	0.128 ± 2.22[g]	14 ± 5.18[g]	6.66 ± 1.06
Tritium	-192 ± 110[g]	1320 ± 94.5[g]	235 ±42

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection.
d. Parameter was analyzed in July only. Therefore, the minimum, maximum, and average are the same.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).
g. Result was a statistical nondetect.
h. Not analyzed in December 2006.

Test Area North/Technical Support Facility

The effluent to the TAN/TSF Disposal Pond receives a combination of process water and treated sewage waste. Additional monitoring for surveillance purposes is conducted monthly for metal parameters and quarterly for radiological parameters (with the exception of ^{89}Sr, ^{129}I, and tritium, which are monitored annually, and ^{90}Sr, which was monitored monthly starting in March 2005). Table 5-22 summarizes the results of this additional monitoring for those parameters detected in at least one sample during the year. The 2006 TAN/TSF Radiological Monitoring Report (ICP 2007d) provides additional information.

Table 5-22. Summary of TAN/TSF Liquid Effluent Surveillance Monitoring Results (2006).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Effluent to TAN/TSF Disposal Pond			
Conductivity (µS/cm) (grab)	434	2,050	709.7
Copper	0.0022	0.0229	0.0097
Gross alpha[e]	0.10 ± 1.54[f]	3.93 ± 2.70	2.11 ± 0.67
Gross beta[e]	4.58 ± 2.02	5.62 ± 2.22	4.84 ± 0.97
Nickel	0.00125[g]	0.0026	0.00135

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. No permit limits are set for these parameters.
d. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
e. Radionuclide values are in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations).
f. Result was a statistical nondetect.
g. Sample result was less than the detection limit; value shown is half the detection limit.

During 2006, the concentrations of most additional parameters were within historical concentration levels.

Reactor Technology Complex

The effluent to the Cold Waste Pond receives a combination of process water from various RTC facilities. Additional monitoring for surveillance purposes is conducted quarterly for metals and for radiological parameters. Table 5-23 summarizes the results of this additional monitoring for those parameters with at least one detected result.

During 2006, concentrations of sulfate and TDS were elevated in samples collected during reactor operation. These differences are caused by the normal raw water hardness, as well as corrosion inhibitors and sulfuric acid added to control the cooling water pH. Concentrations of sulfate and TDS exceeded the risk-based release levels for the RTC Cold Waste Pond of 280 mg/L and 560 mg/L, respectively, in March, May, and November.

Table 5-23. Summary of RTC Effluent Surveillance Monitoring Results (2006).[a,b,c]

Parameter	Minimum	Maximum	Average[d]
Effluent from RTC Cold Waste Pond			
Conductivity (µS/cm) (grab)	343.2	1328	1024
pH (standard units) (grab)	7.7	8.01	7.86
Chloride	9.5	37.5[h]	27.4
Fluoride	0.1[e]	0.512	0.386
Nitrogen, nitrate + nitrite (mg-N/L)	0.966	3.12	2.49
Sulfate	21.6	550[h]	386
Total dissolved solids	243	1080[h]	820
Total Kjeldahl nitrogen	0.05[e]	0.304	0.21
Antimony	0.0003[e]	0.00195[h]	0.00104
Arsenic	0.0038	0.0052	0.0046
Barium	0.0497	0.145	0.115
Chromium	0.0038	0.0109[h]	0.0083
Copper	0.0024	0.00375[h]	0.003
Iron	0.0125[e]	0.214	0.074
Lead	0.0002[e]	0.00085	0.00036
Manganese	0.00125[e]	0.0047	0.002
Selenium	0.001[e]	0.00245	0.0015
Sodium	8.02	32.2[h]	23.3
Zinc	0.00125[e]	0.004	0.002
Gross alpha[f]	1.2 ± 0.92[g]	4.17 ± 0.856	2.88 ± 0.50
Gross beta[f]	1.3 ± 0.619[g]	15.35 ± 0.89[h]	10.3 ± 0.62

a. Only parameters with at least one detected result are shown.
b. All values are in milligrams per liter (mg/L) unless otherwise noted.
c. No permit limits set for these parameters.
d. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
e. Sample result was less than the detection limit; value shown is half the detection limit.
f. Radiological values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation).
g. Result was a statistical nondetect.
h. Average of concentrations/activities in the original and duplicate sample.

The Radium-226 activity in the sample from the effluent to the RTC Cold Waste Pond collected on November 8, 2006, was 13.00 pCi/L. Radium-226 was not detected in the other samples.

5.4 Drinking Water Monitoring

In 1988, a centralized INL Site drinking water programs was established. Today, INL and ICP participates in the INL Site drinking water programs. During 2006, each contractor administered its own drinking water program. In 2006, RTC separated their multiple-use wells from the potable water by completing a new well dedicated to potable water usage only.

The INL Site Drinking Water Program was established to monitor drinking water and production wells, which are multiple use wells for industrial use, fire safety, and drinking water. 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 transient, noncommunity water systems are at the Experimental Breeder Reactor No. 1 (EBR-I), Gun Range, Critical Infrastructure Test Range Complex (CITRC), and the Main Gate. The remaining water systems are classified as nontransient, noncommunity water systems, which have more stringent requirements than transient, noncommunity water systems.

The INL Site Drinking Water Program monitors drinking water to ensure it is safe for consumption and to demonstrate that it meets Federal and state regulations (i.e. that MCLs are not exceeded). The Federal Safe Drinking Water Act also establishes requirements for the INL Site drinking water programs.

Because groundwater supplies the drinking water at the INL Site, information on groundwater quality was used to help develop the INL Site drinking water programs. The U.S. Geological Survey (USGS) and the various contractors monitor and characterize groundwater quality at the INL Site. Three groundwater contaminants have impacted INL drinking water systems: tritium at CFA, carbon tetrachloride at the Radioactive Waste Management Complex (RWMC), and trichloroethylene at TAN/TSF.

As required by the state of Idaho, the INL Site Drinking Water Program uses EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and Title 40 Code of Federal Regulations (CFR) Parts 141–143. State regulations also require the use of laboratories that either are certified by the state or by another state whose certification is recognized by Idaho. The Idaho DEQ oversees the certification program and maintains a listing of approved laboratories.

Currently, the INL Site Drinking Water Program monitors eleven onsite water systems. 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 during every three-year compliance period. Parameters with secondary MCLs are monitored every three years based on a recommendation by the EPA. The three year compliance periods for the INL Site Drinking Water Program are 2005 to 2007, 2008 to 2010, and so on. Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline.

Because of known contaminants, the INL Site Drinking Water Program monitors certain parameters more frequently than required. For example, the Program monitors for bacteriological analyses more frequently because of historical problems with bacteriological contamination. These past detections were probably caused by biofilm of older water lines and stagnant water. In routine compliance sampling for 2006, total coliform bacteria were not detected in any water systems.

INL Site Drinking Water Monitoring Results

During 2006, 533 routine samples and 76 quality control samples were collected and analyzed from CFA, CITRC, EBR-I, Gun Range (Live Fire Test Range), INTEC, Main Gate, MFC, RWMC, RTC, TAN/Contained Test Facility (CTF), and TAN/TSF. In addition to the routine sampling, the nonroutine samples

are also collected. A nonroutine sample is one collected after a water main is repaired to determine if the water is acceptable for use before the main is put back into service. Thirty-one requests for nonroutine sampling were received during 2006.

Analytical results of interest (carbon tetrachloride, trichloroethylene, and tritium) and nitrate (required to be monitored annually) results for 2006 are presented in Tables 5-24 and 5-25, respectively, and are discussed in the following subsections. EBR-I, CITRC, Gun Range, INTEC, Main Gate, MFC, RTC, and TAN/CTF were well below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report.

In 2006, the carbon tetrachloride concentration in the RWMC public water system remained below the EPA established MCL of 5 µg/L. The MCL applies only at the compliance point, which is the distribution system. The annual average for the compliance point of the distribution system was 4.13 µg/L. The annual average for the production well was 6.0 µg/L. Trichloroethylene concentrations in samples from the TAN drinking water Well #2 remained below the MCL during 2006.

Central Facilities Area

The CFA water system serves approximately 700 people daily. Since the early 1950s, wastewater containing tritium was disposed to the Snake River Plain Aquifer (SRPA) at INTEC and at RTC through

Table 5-24. Monitored Drinking Water Parameters of Interest in 2006.

Parameter[a]	Location	Results[b]	MCL[b]
Carbon Tetrachloride	RWMC Distribution	4.13	5
	RWMC Well[c]	6.00	NA[d]
Trichloroethylene	RWMC Distribution	2.15	5
	RWMC Well[c]	2.88	NA
	TAN/TSF Distribution	1.73	5
	TAN/TSF #2 Well[c]	2.48	NA
Tritium	CFA Distribution	6,980	20,000
	CFA #1 Well[c]	6,860	NA
	CFA #2 Well[c]	5,990	NA

a. The parameters shown are known contaminants that the Drinking Water Program is tracking.

b. Results and maximum contaminant levels are in micrograms per liter (µg/L). Tritium is in picocuries per liter (pCi/L), plus or minus the uncertainty (two standard deviations). Results are an average of four quarters.

c. Sampled for surveillance purposes (not required by regulations to be sampled). The RWMC Well and TAN/TSF #2 Well were sampled four times while other locations sampled once. The compliance point is the distribution system.

d. NA = Maximum contaminant level is not applicable to the well concentration.

Table 5-25. Nitrate Results for INL Water Systems in 2006. (Nitrate as Nitrogen.)

Water System	PWS Number	Concentration	MCL (mg/L)
MFC	6060036	1.80	10
CFA	6120008	2.90	10
INTEC	6120012	0.77	10
EBR-1	6120009	0.30	10
Gun Range	6120025	0.90	10
Main Gate	6120015	0.60	10
CITRC	6120019	1.00	10
RWMC	6120018	0.90	10
TAN/CTF	6120013	0.90	10
TAN/TSF	6120021	0.80	10
RTC	6120020	0.90	10

injection wells and infiltration ponds. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. This practice of disposing of wastewater through injection wells was discontinued in the mid-1980s.

In 2006, water samples were collected once from CFA #1 Well (at CFA-651), once from CFA #2 Well (at CFA-642), and quarterly from CFA-1603 (manifold) for compliance purposes. Since December 1991, the mean tritium concentration has been below the MCL at all three locations. In general, tritium concentrations in groundwater have been decreasing (see Figure 5-5) because of changes in disposal techniques, recharge conditions, and radioactive decay.

CFA Worker Dose – Because of the potential impacts to downgradient workers at CFA from radionuclides in the Snake River Plain Aquifer, the potential effective dose equivalent from radioactivity in water was calculated. CFA was selected because tritium concentrations found in these wells were the highest of any drinking water wells. The 2006 calculation was based on the mean tritium concentration for the CFA distribution system in 2006 (Table 5-24).

For the 2006 dose calculation, it was assumed that each worker's total water intake came from the CFA drinking water distribution system. This assumption overestimates the 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 2006 was 0.32 mrem (3.2 μSv), below the EPA standard of 4 mrem/yr for public drinking water systems.

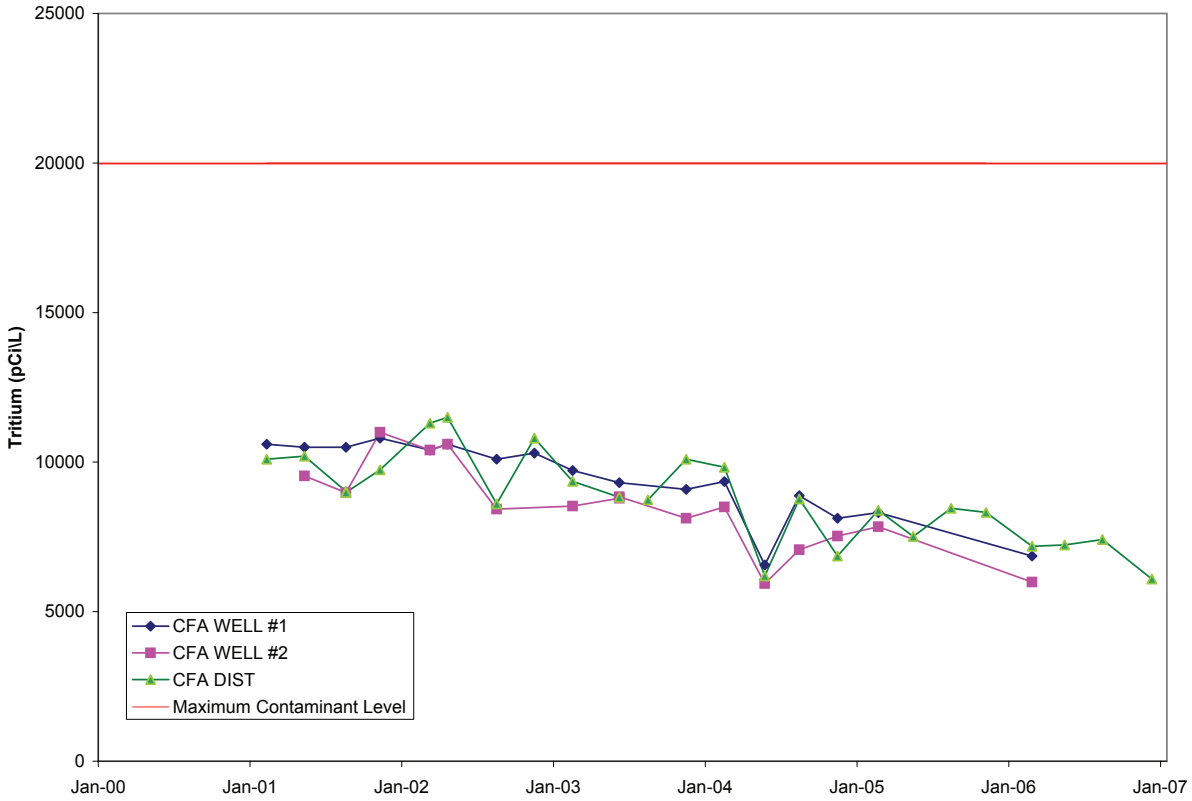


Figure 5-5. Tritum Concentrations in Two CFA Wells and CFA Distribution Systems (2000-2006).

Radioactive Waste Management Complex (RWMC)

The RWMC production well is located in WMF-603 and supplies all of the drinking water for more than 500 people. The well was put into service in 1974. Water samples were collected at the wellhead and from the point of entry to the distribution system, which is the point of compliance, at WMF-604.

Since monitoring began at RWMC in 1988, there had been an upward trend in carbon tetrachloride concentrations until 1999. Since 1999, carbon tetrachloride concentrations have remained fairly constant. Table 5-26 summarizes the carbon tetrachloride concentrations at the RWMC drinking water well and distribution system for 2006. The mean concentration at the well for 2006 was 6.0 µg/L, and the maximum concentration was 6.5 µg/L. The mean concentration at the distribution system was 4.13 µg/L, and the maximum concentration was 4.5 µg/L.

A potential source of the carbon tetrachloride is the estimated 334,630 L (88,400 gal) of organic chemical waste (including carbon tetrachloride, trichloroethylene, tetrachloroethylene, toluene, benzene, 1,1,1-trichloroethane, and lubricating oil) that were disposed of at the RWMC before 1970. High vapor-phase concentrations (up to 2700 PPM vapor phase) of volatile organic compounds were measured in the zone above the water table. Groundwater models predict that volatile organic compound concentrations will continue to increase in the groundwater at the RWMC. To ensure the drinking water at RWMC remains safe and in compliance with the appropriate drinking water standards, the RWMC Potable Water VOC Reduction Project was initiated in 2006 to install a packed column air stripping system to remove carbon tetrachloride and other VOCs from the groundwater source.

Table 5-26. Carbon Tetrachloride Concentrations in the RWMC Drinking Water Well and Distribution System (2006).

Location	Number of Samples	Carbon Tetrachloride Concentration (µg/L)			
		Minimum	Maximum	Mean	MCL
RWMC WMF-603 Well	4	5.6	6.5	6.0	NA[a]
RWMC WMF-604 Distribution	4	3.6	4.5	4.13	5.0

a. NA= Not applicable. MCL applies to the distribution system only.

Permanent chlorination was installed in 2003 because of a history of total coliform bacteria detection. Since permanent chlorination was installed, no coliform bacteria have been detected.

Test Area North/Technical Support Facility

In 1987, trichloroethylene was detected at both TSF #1 and #2 Wells, which supply drinking water to approximately 200 employees at TSF. The inactive TSF injection well (TSF-05) is believed to be the principal source of trichloroethylene contamination at the TSF. Bottled water was provided until 1988 when a sparger system (air stripping process) was installed in the water storage tank to volatilize the trichloroethylene to levels below the MCL.

During the third quarter of 1997, TSF #1 Well was taken offline, and TSF #2 Well was put online as the main supply well because the trichloroethylene concentration of TSF #2 had fallen below the MCL of 5.0 µg/L. Therefore, by using TSF #2 Well, no treatment (sparger air stripping system) is implemented other than the chlorination system. TSF #1 Well is used as a backup to TSF #2 Well. If TSF #1 Well must be used, the sparger system must be reactivated to treat the water.

Figure 5-6 illustrates the concentrations of trichloroethylene in both TSF wells and the distribution system from 2000 through 2006. Past distribution system sample exceedances are attributed to preventive maintenance activities that interrupted the operation of the sparger system.

Table 5-27 summarizes the trichloroethylene concentrations at TSF #2 Well and the distribution system. TSF #2 Well is sampled for surveillance purposes only (not required by regulations), and the distribution system is the point of compliance (required by regulations). The mean concentration at TSF #2 Well and distribution system for 2006 are 2.48 µg/L and 1.73 µg/L, respectively, which are below the MCL.

5.5 Waste Management Surveillance Water Sampling

In compliance with DOE Order 435.1, the ICP contractor collects surface water, as surface runoff, at the RWMC Subsurface Disposal Area from the location shown in Figure 5-7. The control location for the RMWC Subsurface Disposal Area is 1.5 km (0.93 mi) west from the Van Buren Boulevard intersection on U.S. Highway 20/26 and 10 m (33 ft) north on the T-12 Road.

Figure 5-6. Trichloroethylene Concentrations in TSF Drinking Water Wells and Distribution System from (2000-2006).

Table 5-27. Trichloroethylene Concentrations at TSF #2 Well and Distribution System (2006).

Location	Number of Samples	Trichloroethylene (micrograms per liter [µg/L])			
		Minimum	Maximum	Mean	MCL
TAN/TSF #2 Well (612)[a]	4	1.9	3.4	2.48	NA[b]
TAN/TSF Distribution (610)	4	1.0	2.7	1.73	5.0

a. Regulations do not require sampling at this well.
b. NA=not applicable. MCL applies to the distribution system only.

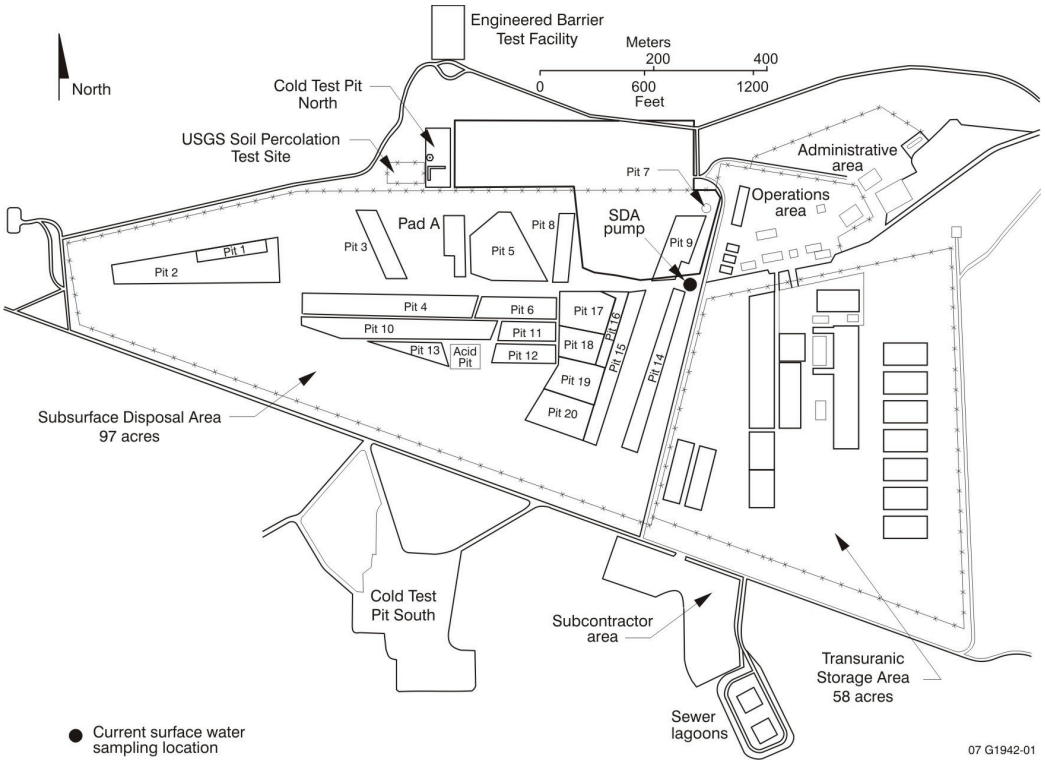


Figure 5-7. RWMC Surface Water Sampling Locations.

Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data.

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

Surface water runoff samples were collected at the RWMC SDA during the first and second quarters of 2006. Table 5-28 summarizes the results of human-made radionuclides. All sample results were comparable to historical concentrations.

Table 5-28. Surface Water Runoff Results (2006).[a]

Location	Parameter	Maximum Concentration[a]	% DCG	Comment
SDA	Americium-241	0.0947 ± 0.0187	0.32	Comparable to historical concentrations
SDA	Plutonium-239/240	0.0482 ± 0.0119	0.16	Comparable to historical concentrations

a. All values are in picocuries per liter (pCi/L), plus or minus the uncertainty (one sigma).

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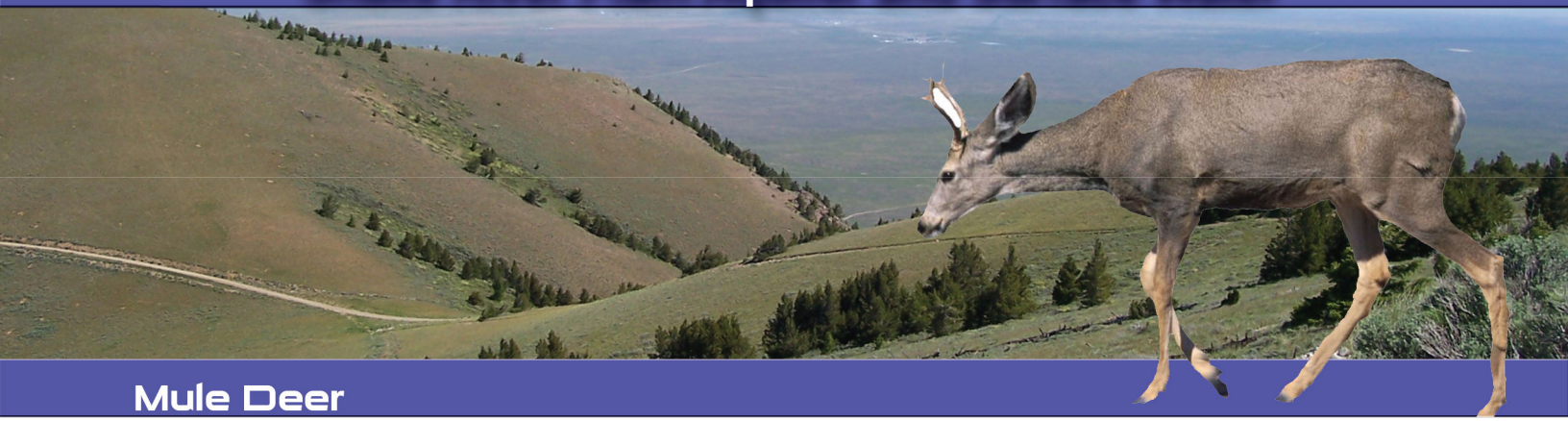
Chapter 6 - Environmental Monitoring Program - Eastern Snake River Plain Aquifer and Surface Water



Mule Deer

R. Wells - CH2M-WG Idaho
M. Roddy, L. Nelson - CH2M-WG Idaho
L. Knobel, L. Davis - U.S. Geological Survey
M. Case - S. M. Stoller Corporation

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

This chapter presents results from both radiological and nonradiological surveillance sampling and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sampling of groundwater and surface water samples taken at both onsite and offsite locations. Reported results from sampling conducted by the Idaho Cleanup Project (ICP) contractor; the U.S. Geological Survey (USGS); and the Environmental Surveillance, Education and Research (ESER) contractor are presented here. Results are compared to the state of Idaho groundwater primary and secondary constituent standards (PCS) of Idaho Administrative Procedures Act (IDAPA) 58.01.11 and the U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCL) for drinking water and/or the U.S. Department of Energy (DOE) Derived Concentration Guide for ingestion of water.

Section 6.1 summarizes the monitoring programs. Sections 6.2 and 6.3 present discussions of the hydrogeology of the INL Site and hydrogeologic data management, respectively. Section 6.4 describes aquifer studies related to the INL Site and ESRPA. Radiological and nonradiological monitoring of groundwater at the INL Site are discussed in Sections 6.5 and 6.6, respectively. Section 6.7 outlines the CERCLA groundwater activities performed in 2006. Section 6.8 describes offsite drinking and surface water monitoring.

6.1 Summary of Monitoring Programs

The USGS INL Project Office performs groundwater monitoring, analyses, and studies of the ESRPA under and adjacent to the INL Site. This is done through 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 (ESRP). Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2006, USGS personnel collected and analyzed over 1200 samples for radionuclides and inorganic constituents including trace elements and approximately 35 samples for purgeable organic compounds.

As detailed in Chapter 3, CERCLA activities at the INL Site are divided into ten Waste Area Groups (WAGs) (Figure 3-3). Each WAG addresses groundwater for its particular contaminant(s). WAG 10 has

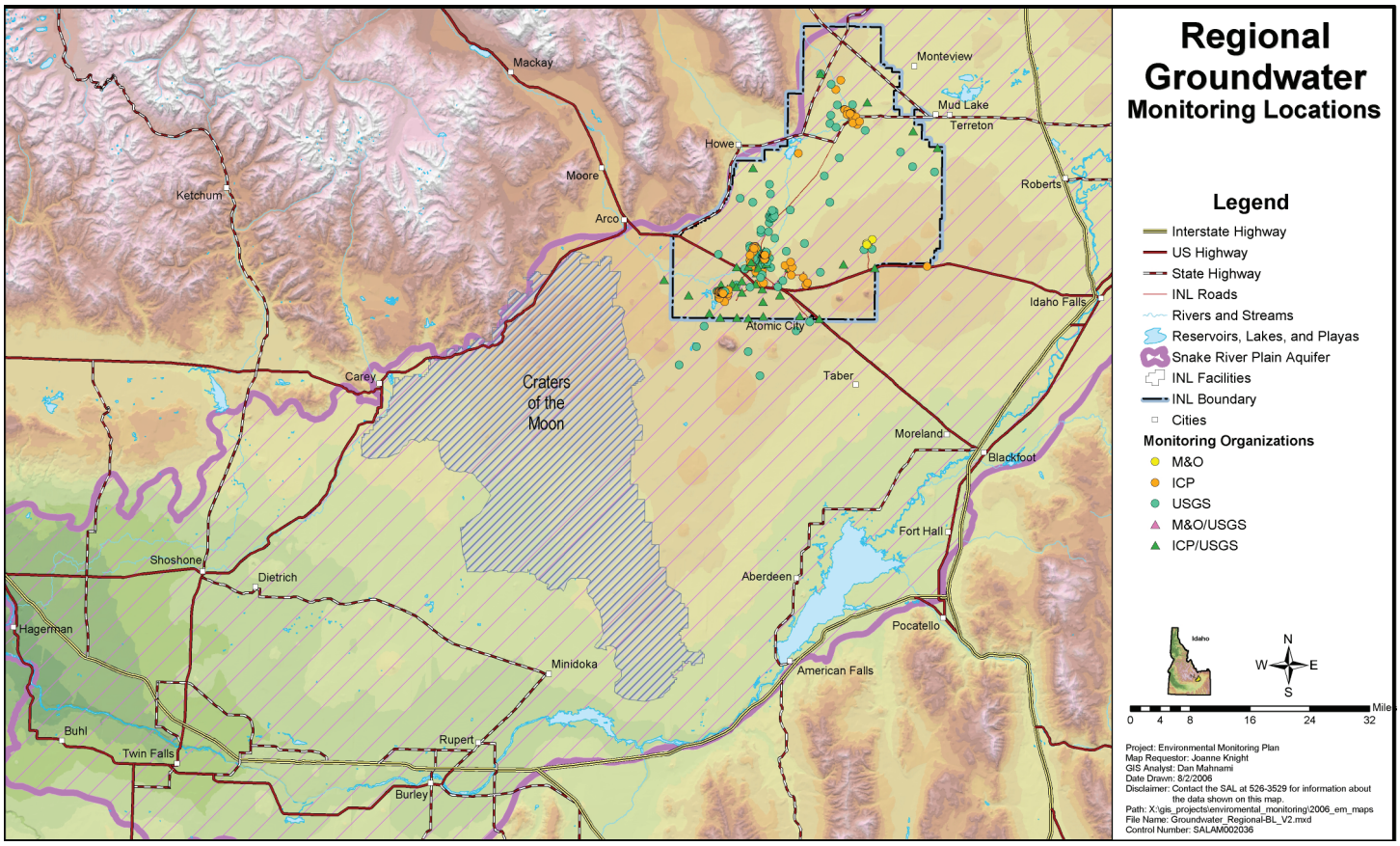


Figure 6-1. Regional Groundwater Monitoring Locations.

been designated as the site wide WAG and addresses the combined impact of the individual contaminant plumes. As individual Records of Decision (RODs) are approved for each WAG, many of the groundwater monitoring activities are turned over to the Long-Term Stewardship program as an effort to consolidate monitoring activities.

The ESER contractor monitors offsite drinking and surface water. There were 30 drinking water and 12 surface water samples analyzed in 2006.

Table 6-1 presents the various groundwater and surface water monitoring activities performed on and around the INL Site.

6.2 Hydrogeology

The INL Site occupies 2,300 km^2 (890 mi^2) at the northwest edge of the ESRP, with the site boundaries coinciding with the Mud Lake sub-basin and the Big Lost Trough. The ESRPA owes its existence and abundance to a unique sequence of tectonic, volcanic, and sedimentologic processes associated with the migration of the North American tectonic plate southwestward across the Yellowstone hotspot, or mantle plume (Geslin et al. 1999). 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

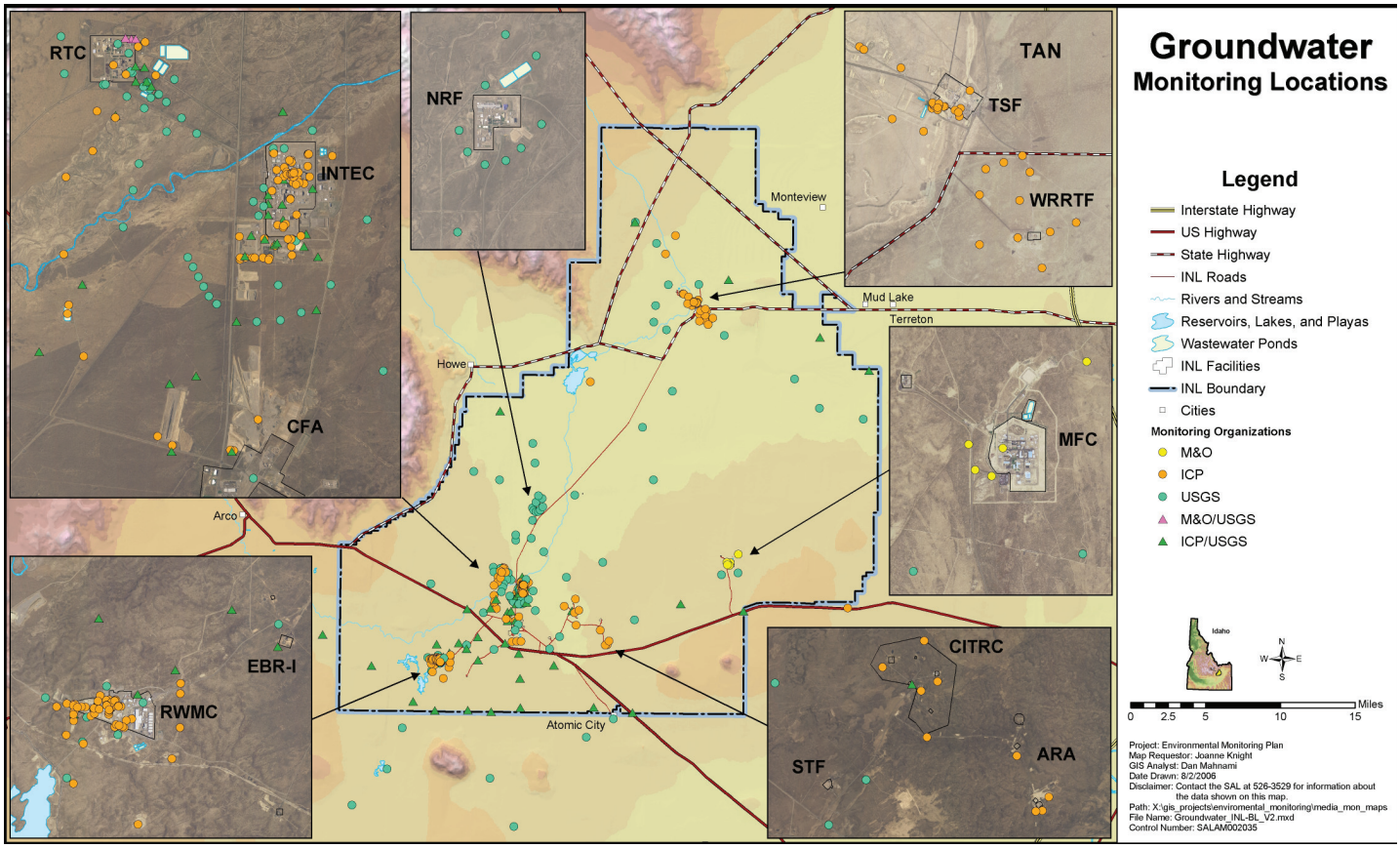


Figure 6-2. INL Site Groundwater Monitoring Locations.

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 ESRP 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. Northeast–southwest directed extension of the ESRP 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 >200 m thick (650 ft) 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 ESRPA is to the south/southwest (Figure 6-3) with velocities ranging from 1.5 to 6.1 m/day (5-20 ft/day). This is much faster than most studied aquifers and is attributed to the ESRP architecture and porous media.

Table 6-1. Groundwater and Surface Water Related Monitoring at the INL Site and Surrounding Area.

Area/Facility[a]	Media				
	Groundwater (Radiological)	Groundwater (Nonradiological)	Groundwater (CERCLA)	Surface Water	Drinking Water
INL/ICP Contractor					
CFA	●	●	●	●[b]	●[c]
INTEC	●	●	●		
MFC	●	●	●	●	●[c]
RTC	●	●	●	●[b]	●[c]
TAN	●	●	●	●[b]	●[c]
RWMC	●	●	●	●[b]	●[c]
PBF/CITR				●[b]	●[c]
Environmental Surveillance, Education and Research Program					
INL Site/Regional				●	●
U.S. Geological Survey					
INL Site/Regional	●	●		●[d]	

a. CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, RTC = Reactor Technology Complex, TAN = Test Area North, RWMC = Radioactive Waste Management Complex, and PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range.

b. See Chapter 5 for details of surface water (liquid effluent and stormwater) monitoring.

c. The offsite surveillance of drinking water is addressed in this chapter. Compliance monitoring of drinking water can be found in Chapter 5.

d. Surface water samples are collected by the regional office of the USGS and are not discussed in this report.

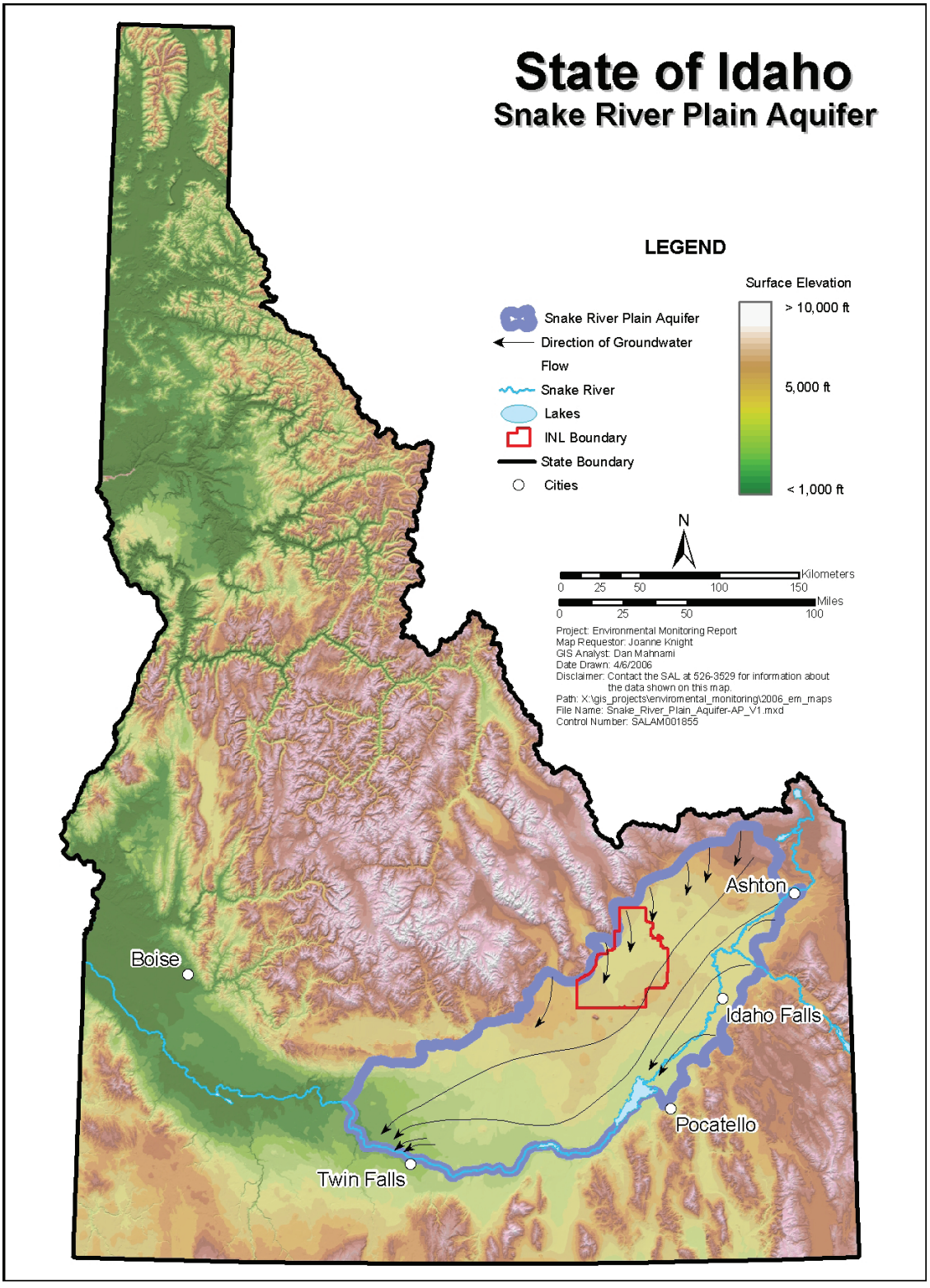


Figure 6-3. Location of the INL Site in Relation to the ESRP Aquifer.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site has been collected by a number of organizations, including the USGS, the ICP contractor, and other site contractors. One of the functions of the INL Site Hydrogeologic Data Repository (HDR) is to maintain and make the data generated by these varied groups available to users and researchers. The HDR was established as a central location for the storage and retrieval of hydrologic and geologic information at the INL Site. The HDR is used to maintain reports, data files, maps, historic records, subcontractor reports, engineering design files, letter reports, subsurface information, and other data in many formats. This information is related to the hydrology and geology of the INL Site, the ESRP, and the ESRPA. The HDR is also used to maintain the INL Site Comprehensive Well Inventory, with records of well construction, modification, abandonment, and logging. The HDR also maintains databases of historic and current water analysis, water levels, and special studies.

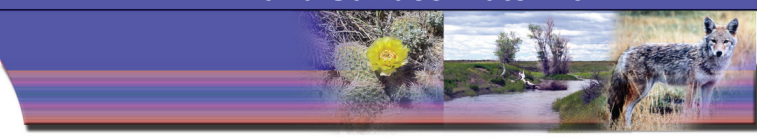
The INL Site Sample and Analysis Management (SAM) Program was established to provide consolidated environmental sampling activities and analytical data management. The SAM provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records. The SAM develops statement(s) of work, procedures, and guidance documents to establish and maintain analytical and validation contracts. The consolidated approach is based on the need for Site-wide reporting compliance, comprehensive technical analyses, and increased consistency in the manner in which analytical data are managed at the INL Site. The SAM also participates in monitoring laboratory performance and annual onsite laboratory audits to ensure quality and compliance. The USGS utilizes the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory.

6.4 Aquifer Studies

The ESRPA 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 the movement of water in the ESRPA is given in Section 6.2. Further information may be found in numerous publications of the USGS. Copies of these publications can be requested from the USGS INL Project Office by calling 208-526-2438. During 2006, personnel of the USGS INL Project Office published eight documents covering hydrogeologic conditions at the INL Site, on the ESRP, and in other areas of interest around the world. The abstracts to each of these reports are presented in Appendix C.

6.5 Radiological Groundwater Monitoring

Historic waste disposal practices have produced localized areas of radiochemical contamination in the ESRPA beneath the INL Site. The Idaho Nuclear Technology and Engineering Center (INTEC) facility used direct injection as a disposal method up to 1984. This wastewater contained high concentrations of tritium, strontium-90 (^{90}Sr) and iodine-129 (^{129}I). Injection at the INTEC was discontinued in 1984 and the injection well sealed in 1990. When direct injection ceased, wastewater from INTEC was directed to a pair of shallow percolation ponds, where the water infiltrates 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 clean closed, and the new INTEC percolation ponds went into operation in August 2002. The Reactor Technology Complex (RTC), formerly known as the Test Reactor Area, also had a disposal well



but primarily discharged contaminated wastewater to a shallow percolation pond. The RTC pond was replaced in 1993 by a flexible plastic (hypalon) lined evaporative pond, which stopped the input of tritium to groundwater.

The average combined rate of tritium wastewater disposal at the RTC and INTEC was highest between 1952 to 1983 (910 Ci/year), decreased during 1984 to 1991 (280 Ci/year), and continued to decrease during 1992 to 1995 (107 Ci/year). From 1952 to 1998, the INL Site disposed about 93 Ci of ^{90}Sr at RTC and about 57 Ci at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the ESRPA at RTC; however, at INTEC a portion of the ^{90}Sr was injected directly to the ESRPA. From 1996 to 1998, the INL Site disposed about 0.03 Ci of ^{90}Sr to the INTEC infiltration ponds (Bartholomay et al. 2000).

Presently, only ^{90}Sr continues to be detected by the ICP contractor and the USGS at levels above the PCS value in some surveillance wells between INTEC and Central Facilities Area (CFA). Other radionuclides (i.e., gross alpha) have been detected above their PCS values in wells monitored by individual WAGs.

U.S. Geological Survey

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 data (2001), are shown in Figure 6-4 (Davis 2006). 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 (approximately 20 mi^2) in 1998 (Bartholomay et al. 2000).

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

Two monitoring wells downgradient of RTC (Well 65) and INTEC (Well 77) have continually shown the highest tritium concentrations in the aquifer over time. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in Well 65 near RTC decreased from $(7.2 \pm 0.3) \times 10^3$ pCi/L in 2005 to $(6.3 \pm 0.6) \times 10^3$ pCi/L in 2006; the tritium concentration in Well 77 south of INTEC was not received from the analytical laboratory in time for inclusion in this annual report.

The Idaho groundwater PCS value for tritium (20,000 pCi/L) is the same as the EPA MCL for tritium in drinking water. The values in both Well 65 and Well 77 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.3 years), a cessation of tritium disposal, advective dispersion, and dilution within the ESRPA (See Figure 6-5).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Davis 2006). The contamination originates from INTEC as a remnant of the earlier injection of wastewater. No ^{90}Sr in groundwater was detected in the vicinity of RTC during 2006. All ^{90}Sr at RTC was disposed to infiltration ponds in contrast to the direct injection that occurred at the INTEC. At RTC, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and in the perched groundwater zones. The area of the ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

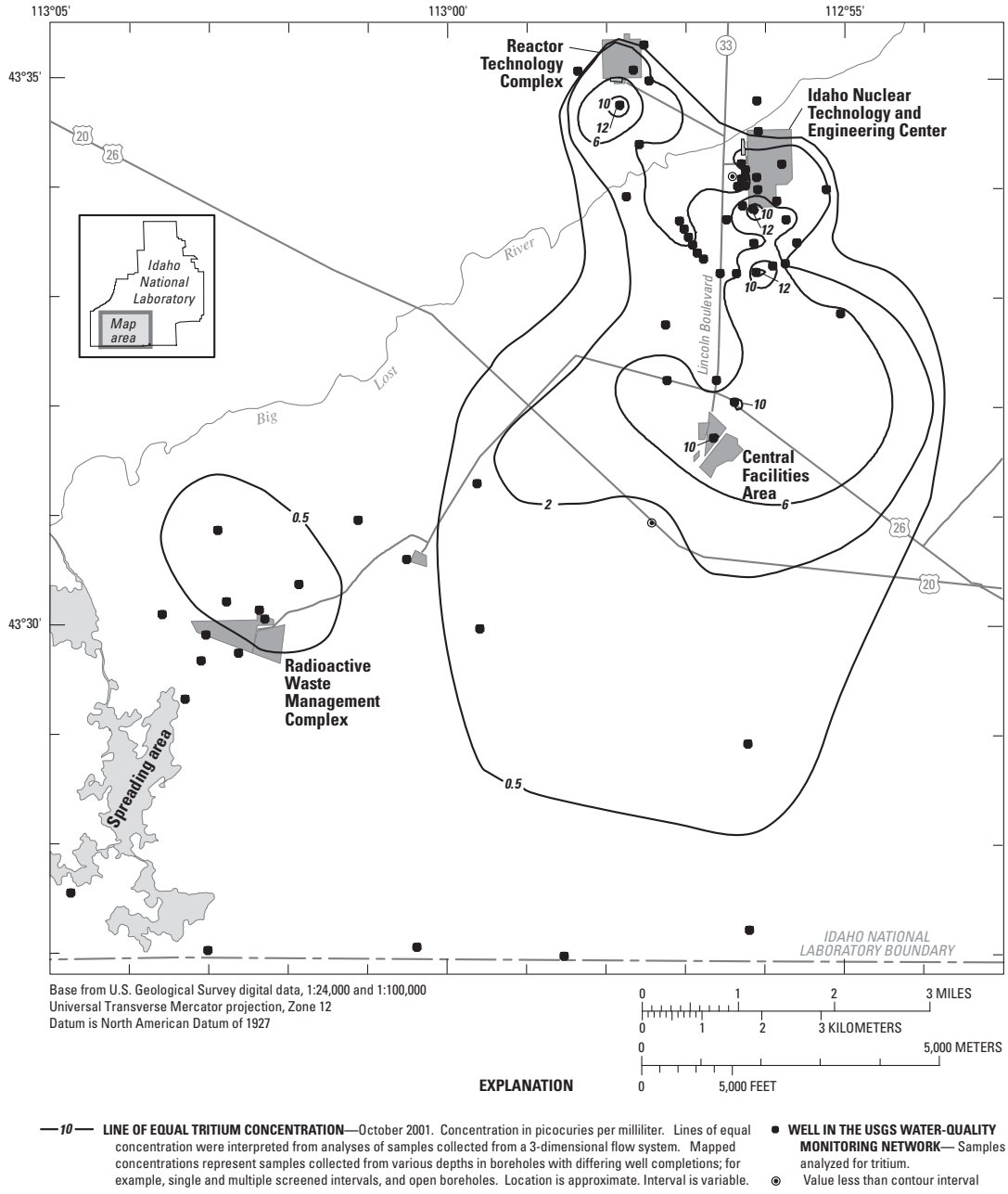


Figure 6-4. Distribution of Tritium in the Snake River Plain Aquifer on the INL Site (2001) (Davis 2006).

Mean concentrations of ^{90}Sr in INL Site monitoring wells have remained at about the same concentrations since 1989. However, the annual average concentration in Well 65 at RTC in 2006 was undetectable. Concentrations in Well 77 south of INTEC were not received from the analytical laboratory in time for inclusion for this report.

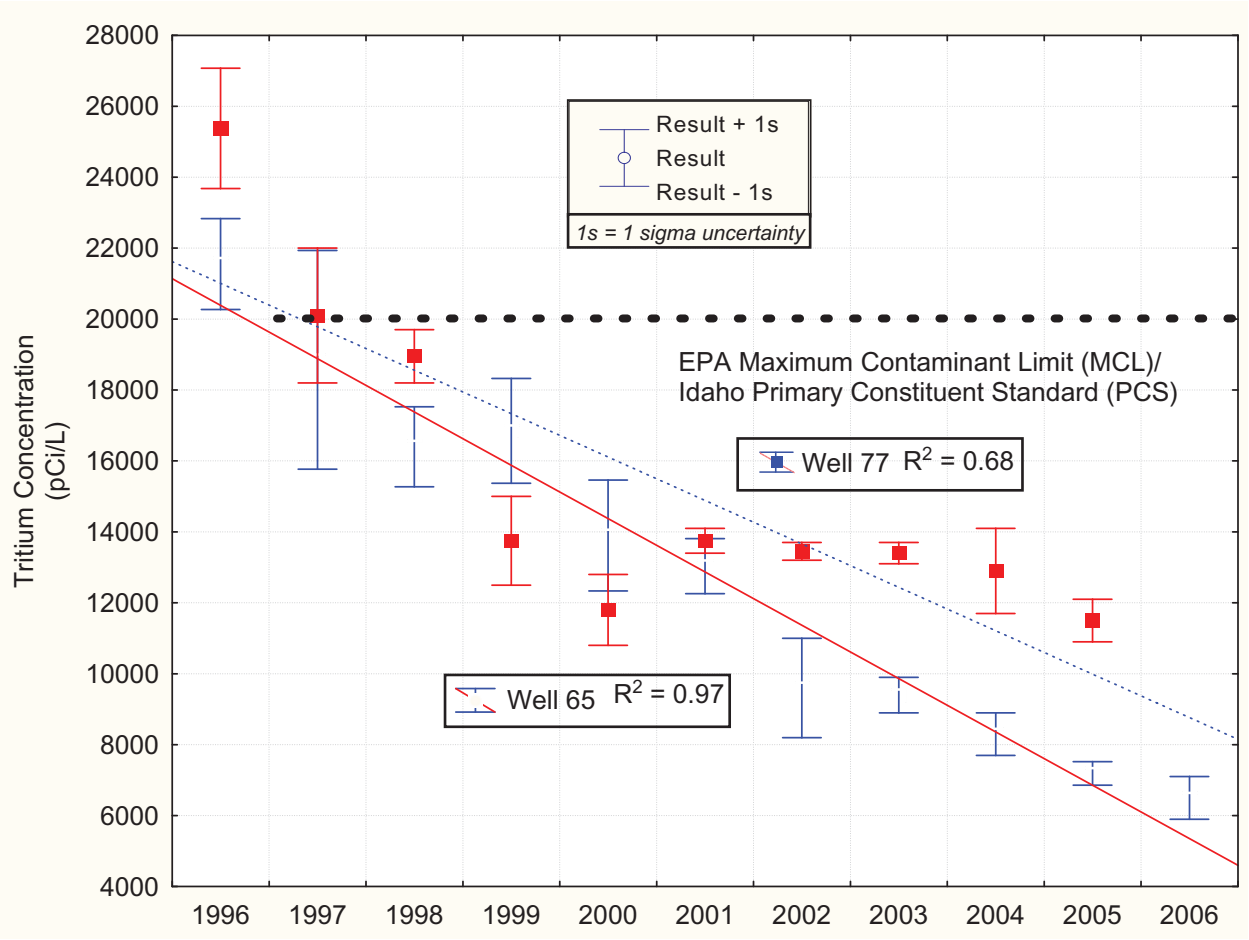


Figure 6-5. Long-Term Trend of Tritium in USGS Wells 65 and 77 (1996-2006).

The trend of ^{90}Sr over the past ten years (1996-2005) in Wells 65 and 77 is shown in Figure 6-7. No clear trends are seen in the data with one (Well 65) increasing and the other (Well 77) decreasing; moreover, the statistical fit is weak. The increases seen prior to the last few years were thought to be due, in part, to a lack of recharge from the Big Lost River that would act to dilute the ^{90}Sr. Other reasons may also include an increase in the 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).

6.6 Nonradiological Groundwater Monitoring

U.S. Geological Survey

Sampling for purgeable (volatile) organic compounds in groundwater was conducted by the USGS at the INL Site during 2006. Water samples from an onsite production well and five groundwater monitoring wells were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 28 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). Thirteen

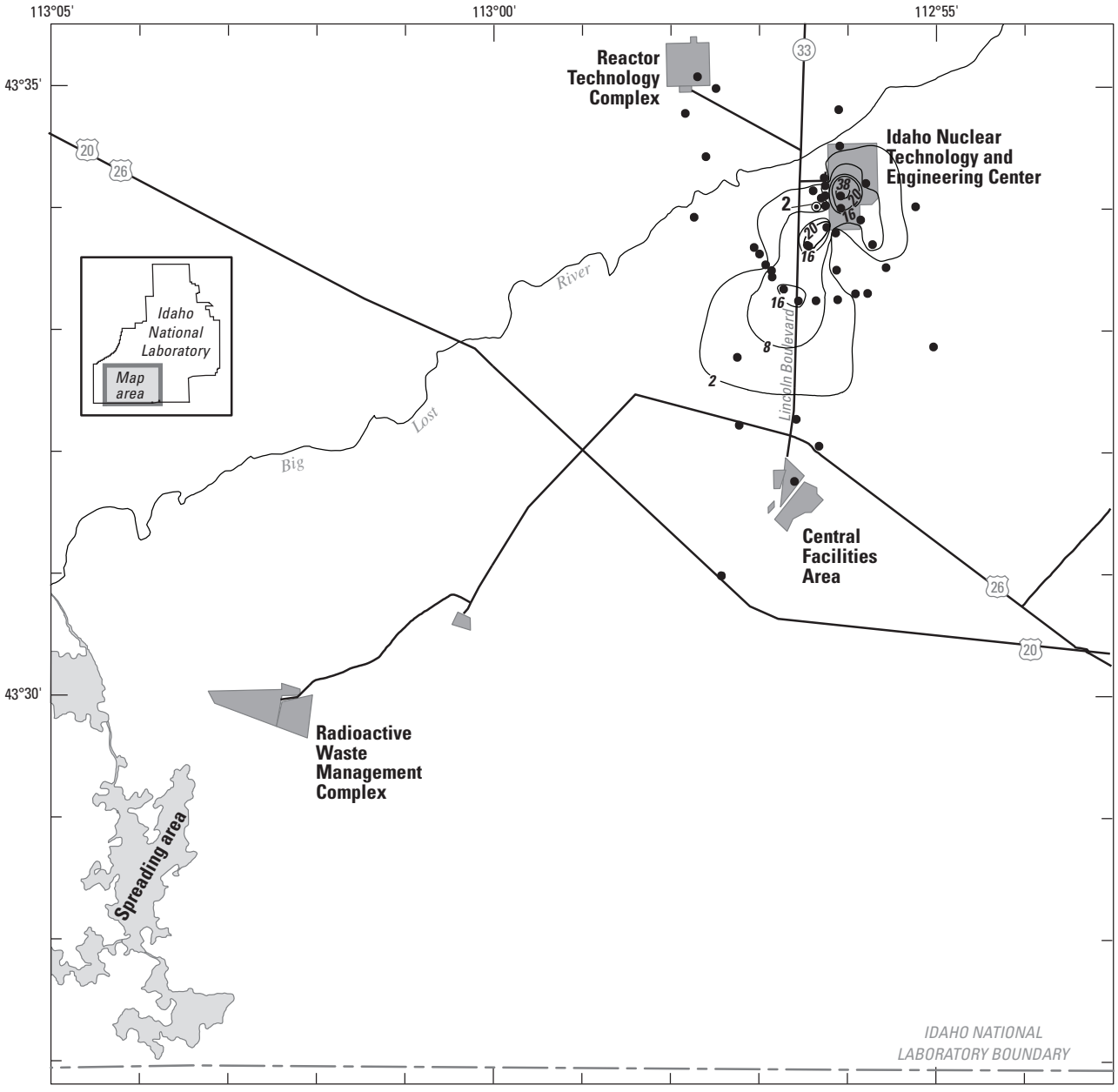


Figure 6-6. Distribution of ^{90}Sr in the Snake River Plain Aquifer on the INL Site (2001) (Davis 2006).

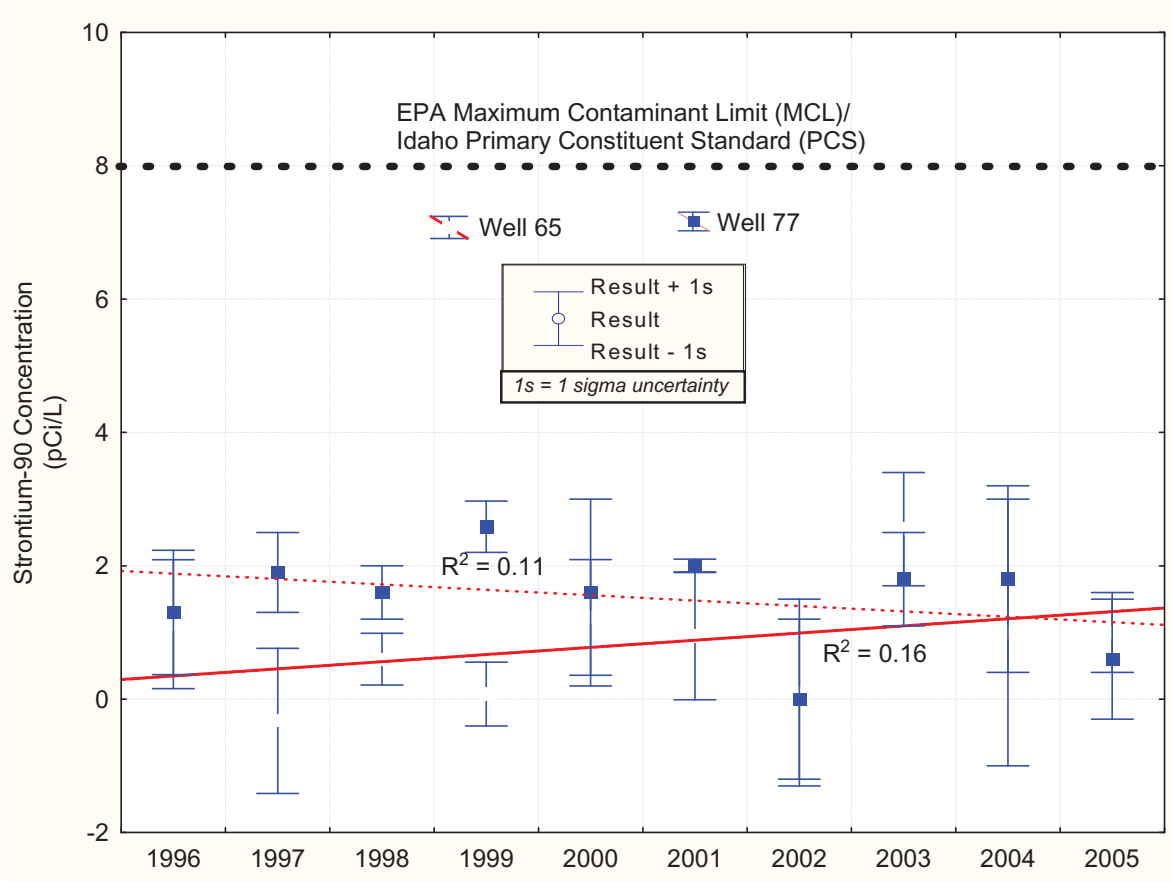


Figure 6-7. Long-Term Trend of ^{90}Sr in USGS Wells 65 and 77 (1996-2005).

purgeable organic compounds were detected at concentrations 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). None of the measured constituents were above their respective PCS.

The RWMC production well contained detectable concentrations of eleven of these purgeable organic compounds. Annual average concentrations of these compounds in this well remained essentially unchanged from those observed in 2004; however, the 2006 average concentration for trichloroethene (3.33 µg/L) was slightly above the average concentration of 2005 (2.97 µg/L).

6.7 Summary of CERCLA Groundwater Monitoring Activities for Calendar Year 2006

CERCLA activities at the INL Site are divided into WAGs that roughly correspond the major facilities at the site plus the site-wide WAG 10. The locations of the various WAGs are found on Figure 6-8. The following sub-sections 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.

Table 6-2. Concentrations of Purgeable Organic Compounds in USGS Well Samples (2006).[a]

USGS Well ID	Date	Bromo dichloro methane	Tetrachloro methane	Tribromo methane	Dibromo chloro methane	Trichloro methane	Toluene	Ethyl benzene	Tetrachloro ethene	1,1-Dichloro ethene	1,1,1-Trichloro ethane	Dichloro difluoro methane	Trichloro ethene	Xylenes
RWMC PROD	12-Jan	ND[b]	5.706	0.3405	ND	1.56	ND	ND	0.285	ND	0.5279	ND	3.142	ND
RWMC PROD	9-Feb	ND	5.934	0.335	ND	1.309	ND	ND	0.2644	ND	0.4501	ND	2.806	ND
RWMC PROD	9-Mar	ND	7.253	ND	ND	1.27	ND	ND	0.3093	ND	0.5024	ND	3.113	ND
RWMC PROD	13-Apr	0.1951	8.649	2.038	0.5638	1.845	ND	ND	0.3204	ND	0.5995	ND	3.722	ND
RWMC PROD	11-May	0.1148	6.321	0.7882	0.2612	1.539	ND	ND	0.2486	ND	0.4849	ND	3.092	ND
RWMC PROD	8-Jun	ND	11.88	0.3884	0.171	2.051	ND	ND	0.3969	ND	0.6811	ND	4.34	ND
RWMC PROD	13-Jul	ND	6.768	0.2468	0.2	1.469	ND	ND	0.2862	ND	0.5377	ND	2.96	ND
RWMC PROD	15-Aug	ND	7.833	0.4906	0.2	1.633	ND	ND	0.3029	ND	0.5958	ND	3.185	ND
RWMC PROD	14-Sep	ND	7.268	0.3145	0.2	1.632	ND	ND	0.3103	ND	0.5679	ND	3.355	ND
RWMC PROD	12-Oct	1.131	6.26	2.762	2.3	2.014	0.1594	0.1564	0.2219	ND	0.4791	ND	2.864	0.864
RWMC PROD	9-Nov	2.019	8.306	1.474	2.289	4.002	ND	ND	0.3451	ND	0.6081	ND	3.406	ND
RWMC PROD	14-Dec	0.2312	8.909	2.244	0.5688	2.005	ND	ND	0.3332	ND	0.5822	ND	4.061	ND
87 (N of RWMC)	24-Apr	ND	2.338	ND	ND	0.1734	0.2226	ND	ND	ND	0.1552	0.8733	0.562	ND
88 (S of RWMC)	19-Oct	ND	0.6528	ND	ND	0.441	ND	ND	ND	ND	ND	ND	0.4324	ND
65 (S of RTC)	24-Apr	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1271	ND	ND	ND
38 (SW of INTEC	13-Apr	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1142	ND	ND	ND
77 (S of RTC)	17-Oct	ND	ND	ND	ND	ND	ND	ND	ND	0.1559	0.1932	0.1291	ND	ND
PCS[c]									5	7	200		5	10

a. All values are in micrograms per Liter (µg/L).

b. ND = Not Detected.

c. PCS = Primary constituent standard values from IDAPA 58.01.11.

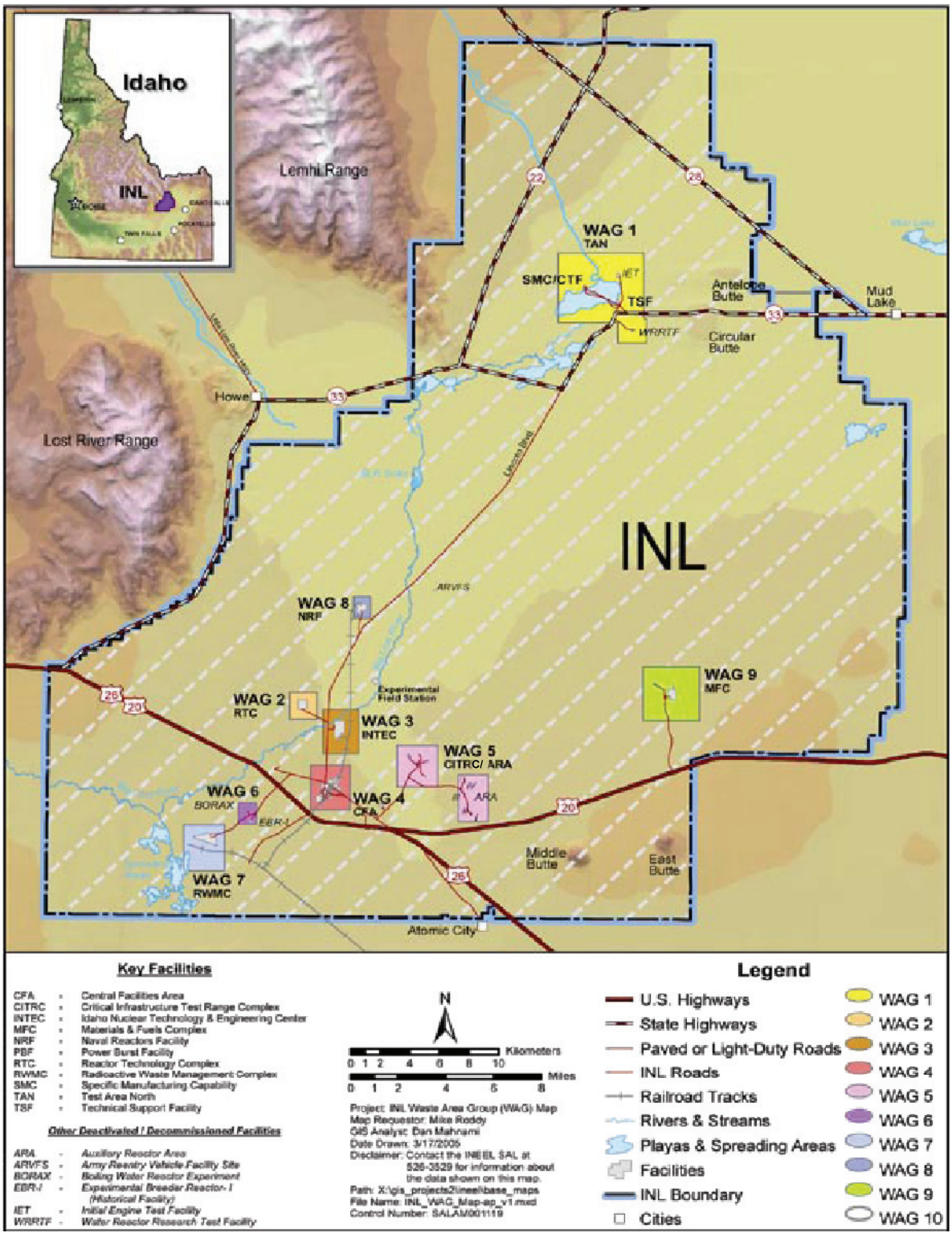


Figure 6-8. Map of the INL Showing Locations of the Facilities and Corresponding WAGs.

Summary of WAG 1 Groundwater Monitoring Results

Groundwater monitoring is performed at WAG 1 to measure the progress of the remedial action at Test Area North (TAN). The groundwater plume at TAN has been divided into three zones to facilitate remediation. 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) is used in the hot spot to promote bacterial growth by supplying essential nutrients to bacteria that occur naturally in the aquifer and are able to break down contaminants. An amendment (such as whey) is injected into well TSF-05 or other wells in the immediate vicinity. Amendment injections increase the rate at which the microbes break down the organic compounds into harmless compounds by supplying needed nutrients. The amendment supply is distributed, as needed, and the treatment system operates year-round.

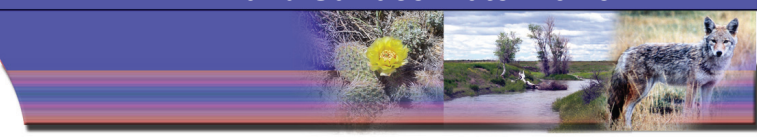
In general, activities performed during 2006 included periodic whey injections, groundwater sampling and analysis, well maintenance, and minor construction activities. Groundwater samples were collected monthly from 12 sampling locations and quarterly from 6 locations in the treatment cell to track the progress of ISB. Results of groundwater monitoring indicated that the ISB remedy continues to be effective at reducing the concentration of volatile organic compounds (VOCs) in the hot spot zone (RPT-372).

Medial Zone (TCE concentrations between 1000 and 20,000 µg/L) – Pump-and-treat is used in the medial zone. This process involves extraction of contaminated groundwater, treatment through air strippers, and reinjection of treated groundwater into the aquifer. Air stripping is a process that brings clean air into close contact with contaminated liquid, allowing the VOCs to pass from the liquid into the air.

On March 1, 2005, the New Pump and Treat Facility (NPTF) was placed into standby mode to conduct a 24-month medial zone rebound test. The purpose of this test is to evaluate the effectiveness of the NPTF in remediating the medial zone of the plume. A performance monitoring strategy has been implemented to assess the degree of rebound in TCE concentrations while the NPTF is in standby mode. The test will be dynamic in the sense that data analysis and interpretation following each sampling event will be used to determine if the NPTF needs to be re-started to treat TCE concentrations that have reached a pre-determined restart concentration criteria before the end of the 24-month test. Based on modeling, the rebound test will not have an adverse effect on the on-going remedial action. During 2006, the concentration of contaminants in the medial zone remained below the re-start threshold and the NPTF remained on standby throughout the year. The NPTF will resume operations no later than March 1, 2007 (ICP 2005).

Distal Zone (TCE concentrations between 5 and 1000 µg/L) – Monitored natural attenuation (MNA) is the treatment for the distal zone of the plume. MNA is the sum of the 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. During the early part of the restoration time frame, the contaminant plume may continue to increase slowly in size until the natural attenuation process overtakes it.

The primary MNA activities performed during 2006 were groundwater sampling and data analysis. Groundwater samples were collected for VOCs and/or radiological parameters from 60 sampling locations using 18 monitoring wells. Several of these locations were equipped with FLUTe™ systems and were



sampled at multiple discrete depths below land surface. TCE concentration data and other data related to TCE degradation indicate that MNA will meet the remedial action objectives for the distal zone of the plume. Radionuclide groundwater monitoring in 2006 indicates that the natural attenuation mechanisms, as defined in the MNA Remedial Action Work Plan for the radionuclides tritium, Cesium-137 (^{137}Cs), ^{90}Sr, and Uranium-234 (^{234}U), continue to be functional within the contaminant plume (DOE-ID 2003a). Future groundwater monitoring, as outlined in the MNA Operations, Monitoring, and Maintenance Plan, will be sufficient to track the progress of the MNA remedy for radionuclides at Test Area North Operable Unit (OU) 1-07B (RPT-383).

Summary of WAG 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for WAG-2 during calendar year 2006. The locations of the wells are shown on Figure 6-9, except for Highway 3 well (a public access potable water well), which is shown on the figure for WAG 10 sampling locations. Six of the wells were sampled in both March and October of 2006. TRA-08 was not sampled in March 2006 and USGS-065 was not sampled in October 2006. Aquifer samples were analyzed for chromium (filtered and unfiltered), ^{90}Sr, gamma-emitting radionuclides, gross alpha, gross beta and tritium. The data for the March 2006 sampling event can be found in the Fiscal Year 2006 Annual Report for WAG 2 (DOE-ID 2007a) and the data for the October 2006 sampling event will be in the Fiscal Year 2007 annual report for WAG 2 (not yet published). The data for the March 2006 and October 2006 sampling events are summarized in Table 6-3. Chromium and ^{90}Sr were detected above their respective MCLs in one well each.

Chromium concentrations in well TRA-07 were greater than the 100 µg/L MCL in both 2006 sampling events, with a maximum filtered concentration of 133 µg/L (Figure 6-9). Previously, USGS-065 had been above the chromium MCL but chromium concentrations were below the MCL for the one time that the well was sampled in 2006. Except for the Highway-3 well, chromium concentrations were above background at all other aquifer wells sampled in WAG 2. Chromium concentrations are declining in both USGS-065 and TRA-07.

Table 6-3. WAG 2 Groundwater Quality Summary for 2006 Sampling Events.

Analyte	Background [a]	Maximum	Number of Wells with Detections above MCL	MCL
Strontium-90	<1	13.4	1	8 pCi/L
Chromium Filtered	2 to 3	133	1	100 µg/L
Chromium (unfiltered)		143	1	100 µg/L
Tritium	75 to 150	14,800	0	20,000 pCi/L

a. Background concentrations are from Knobel, Orr, and Cecil (1992).

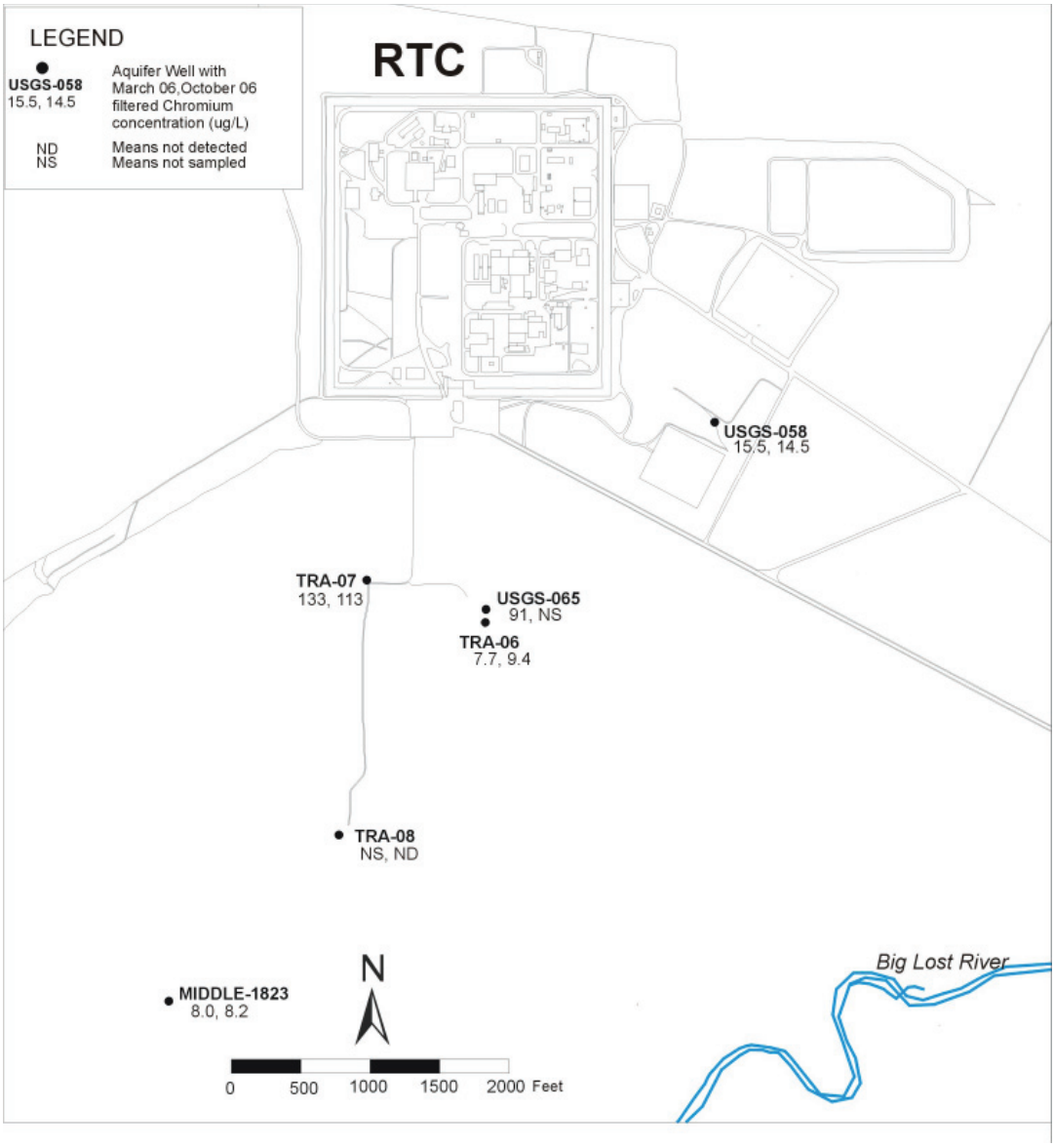


Figure 6-9. Locations of WAG 2 Monitoring Wells and Chromium Concentrations for 2006 (note: Highway 3 well not shown on this map).

Strontium-90 occurred at a concentration of 13.4 pCi/L and above its MCL of 8 pCi/L in the October 2006 sample from TRA-08. This well was not sampled in March 2006 because the pump was not working. Strontium-90 has only been detected in TRA-07 once before in October 2005. This occurrence of ^{90}Sr in this well is uncertain since aquifer wells located between this well and RTC do not have ^{90}Sr.

Summary of WAG 3 Groundwater Monitoring Results

During 2006, groundwater samples were collected from a total of 22 Snake River Plain Aquifer (SRPA) monitoring wells, plus six aquifer wells sampled for the Idaho CERCLA Disposal Facility (ICDF)

monitoring program (Figure 6-10). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents that included ^{90}Sr, ^{99}Tc, ^{129}I, nitrate, tritium, plutonium isotopes, uranium isotopes, and mercury.

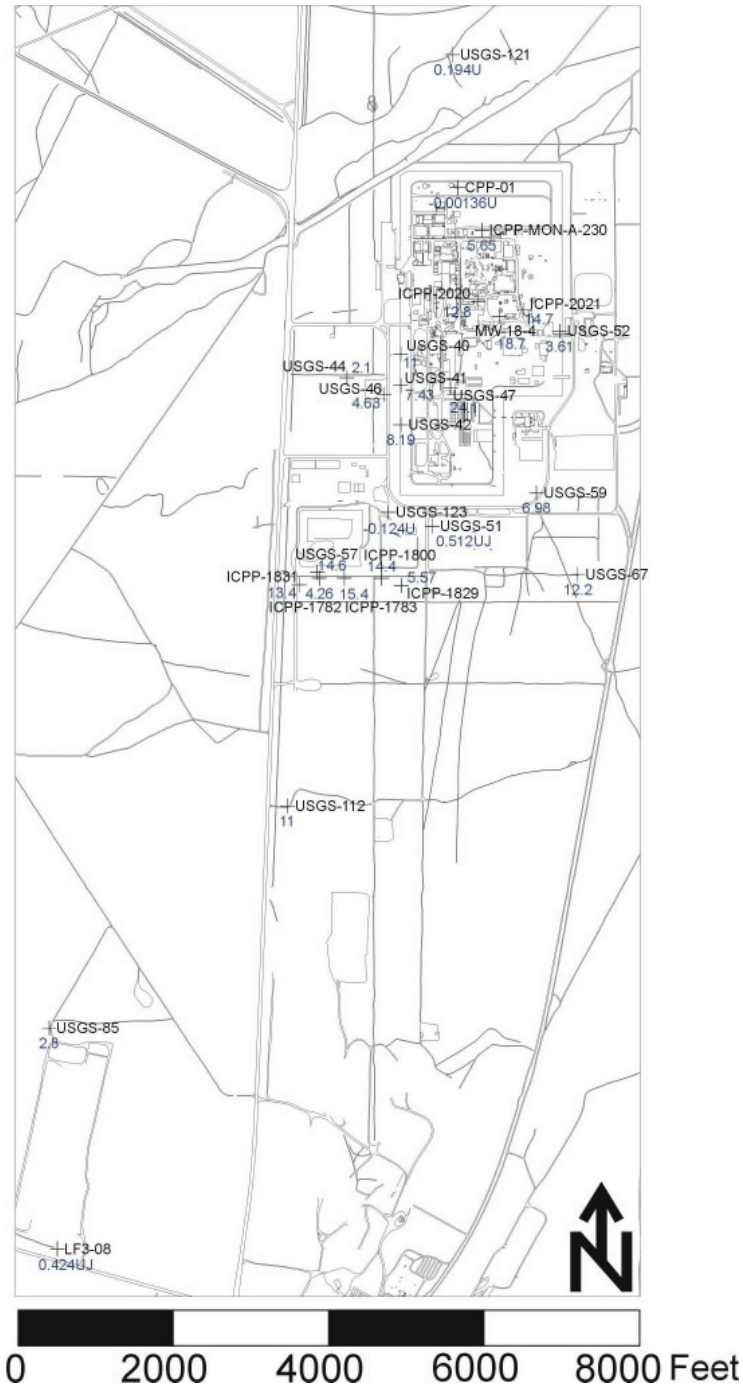


Figure 6-10. WAG –3 Locations of Wells Sampled and Distribution of ^{90}Sr (pCi/L) in the SRPA in April 2006.

For each of the primary constituents of concern (COC), Table 6-4 summarizes the maximum COC concentration observed during 2006 in the SRPA groundwater at INTEC, along with the number of MCL exceedances. Highlights of the 2006 monitoring results are presented below.

Table 6-4. Comparison of WAG 3 2006 Sampling Results for Groundwater Samples from the ESRPA to Regulatory Levels.[a]

			SRPA Groundwater		
Constituent	MCL	Units	Maximum Value[a]	# Results	# Results >MCL
Gross Alpha	15	pCi/L	5.28	21	0
Gross Beta	NA	pCi/L	1,180	21	NA
Cs-137	200	pCi/L	17.4 UJ	21	0
Sr-90	8	pCi/L	24.1	27	12
Tc-99	900	pCi/L	2,150 J	27	2
I-129	1	pCi/L	0.649 J	27	0
Tritium	20,000	pCi/L	8,930	21	0
Am-241	15	pCi/L	0.333	21	0
Np-237	15	pCi/L	0.0466 U	21	0
Pu-238	15	pCi/L	1.33	27	0
Pu-239/240	15	pCi/L	1.42	27	0
Pu-241	300	pCi/L	5.7	21	0
U-233/234	15	pCi/L	3.67 J	27	0
U-235	15	pCi/L	0.168	27	0
U-238	15	pCi/L	2.8	27	0
Alkalinity	NA	mg/L	159	21	NA
Calcium	NA	mg/L	72.2	26	NA
Chloride	250	mg/L	129	27	0
Fluoride	4	mg/L	0.289	21	0
Magnesium	NA	mg/L	25.3	26	NA
Mercury	2	µg/L	0.065	26	0
Nitrate (as N)	10	mg/L	16.4	27	1
Potassium	NA	mg/L	5.36	26	NA
Sodium	NA	mg/L	57.5	26	NA
Sulfate	250	mg/L	48.6	27	0
TDS	500	mg/L	464	21	0

a. Data flags have the following meanings: J – estimated value; U – analyte is considered to not be present in the sample; UJ – the analyte might or might not be present. The associated value is an estimate and might be inaccurate or imprecise. The result is considered a nondetect

Strontium-90, ^{99}Tc, and nitrate exceeded their respective drinking water MCLs in one or more of the aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remain above the MCL (8 pCi/L) at nine of the 22 monitoring wells sampled in 2006, and ^{90}Sr concentrations remained nearly constant (within ±2 sigma) in nine out of 14 monitoring wells that were sampled in both 2005 and 2006. Six of 22 wells showed ^{90}Sr declines during this period, and only one well located southeast of INTEC showed a slight increase (USGS-67).

Technetium-99 was detected above the MCL (900 pCi/L) in two wells within INTEC, but concentrations were below the MCL at all other locations. As in the past, the highest ^{99}Tc level was at the ICPP MON A 230 monitoring well (2150 pCi/L) located north of the INTEC tank farm. Technetium-99 concentrations declined between 2005 and 2006 at seven of the wells, and ^{99}Tc levels at nine of the 16 aquifer wells sampled overlapped the results from the previous year. USGS-67 was the only well that showed an increase in ^{99}Tc from 2005 to 2006.

Iodine-129 concentrations at all aquifer well locations were less than the MCL, with the highest concentration reported at well USGS-67 (0.65 pCi/L). This is the same well that has shown rising concentrations of ^{99}Tc over the past several years. The ^{129}I results for 15 out of 16 aquifer wells were similar to the results from the previous year. One well showed a decline in ^{129}I during this interval (USGS-47), and none of the aquifer wells showed increases in ^{129}I.

Tritium concentrations have been below the MCL in all aquifer wells sampled during 2003–2006. The highest tritium concentration in groundwater during 2006 was at well MW-18-4 (8930 pCi/L) located near the former Waste Calcining Facility. The tritium results for 12 of the 16 wells were similar between 2005 and 2006. One well showed a tritium increase during this period (USGS-42), and three wells showed declines in tritium. Examination of longer-term trends indicates that tritium concentrations in groundwater have continued to decline during the period from 2000 through 2006.

Plutonium-238 was detected in a single SRPA groundwater sample from well USGS-112 (1.33 pCi/L). Similarly, $^{239/240}$Pu was detected only at well USGS-112 (1.42 pCi/L), as was ^{241}Am (0.333 pCi/L). The gross alpha MCL that applies to Pu isotopes is 15 pCi/L. In addition, ^{241}Pu (beta emitter) was detected in the groundwater sample from MW-18-4 (5.7 pCi/L). The derived MCL for ^{241}Pu is 300 pCi/L. Neptunium-237 was not detected in any of the groundwater samples collected during 2006.

Uranium-238 was detected in SRPA groundwater at all sampling locations; however, with the exception of well USGS-112 located midway between INTEC and CFA, the reported concentrations of ^{238}U are generally consistent with background concentrations reported for total uranium in SRPA groundwater elsewhere (Knobel, Orr, and Cecil 1992). Uranium-233/234 was also detected in all samples at concentrations similar to SRPA groundwater elsewhere, and ^{234}U/^{238}U ratios were similar to background ^{234}U/^{238}U ratios for the eastern SRPA. Uranium-235 was not detected in any of the WAG 3, Group 5 aquifer monitoring wells but was reportedly detected in several ICDF aquifer monitoring wells at concentrations ranging from 0.1 to 0.168 pCi/L.

Mercury was detected at a single location in SRPA groundwater (ICPP-2020; 0.065 µg/L). This value is below the mercury MCL of 2 µg/L.

Nitrate was detected in all of the wells sampled during 2006, but the only aquifer well that exceeded the MCL for nitrate-nitrogen of 10 mg/L was well ICPP-2021 (16.4 mg/L as N) located southeast of the tank farm.

The 2006 groundwater contour map is similar in shape to the maps prepared for 2003–2005. Groundwater levels declined during 2000-2005 as a result of drought during this time period. However, as a result of above-normal precipitation during 2005 and 2006 and corresponding periods of flow of the Big Lost River (BLR) during those 2 years, the aquifer well hydrographs show a slight rise in groundwater levels during 2006.

Summary of WAG 4 Groundwater Monitoring Results

Groundwater monitoring for the CFA landfills consisted of sampling eight wells for volatile organic compounds, metals, and anions in October 2006 in accordance with the Field Sampling Plan (INEL 2006). The locations of the CFA monitoring wells are shown on Figure 6-11. Because of falling water levels in the aquifer, 4 wells, LF2-08, LF2-09, LF2-11 and LF3-10, had insufficient water for sampling. In addition, Well CFA-1932 south of CFA Landfill I was not sampled because of a malfunctioning pump. Wells were sampled for metals (filtered and unfiltered), VOCs, and anions (nitrate, chloride, fluoride and sulfate). Analytes detected in groundwater are compared to regulatory levels in Table 6-5. A complete listing of the groundwater sampling results is contained in RPT-362.

The groundwater data indicated that nitrate and thallium were the only analytes detected above a U.S. Environmental Protection Agency maximum contaminant level. Nitrate was detected above its maximum

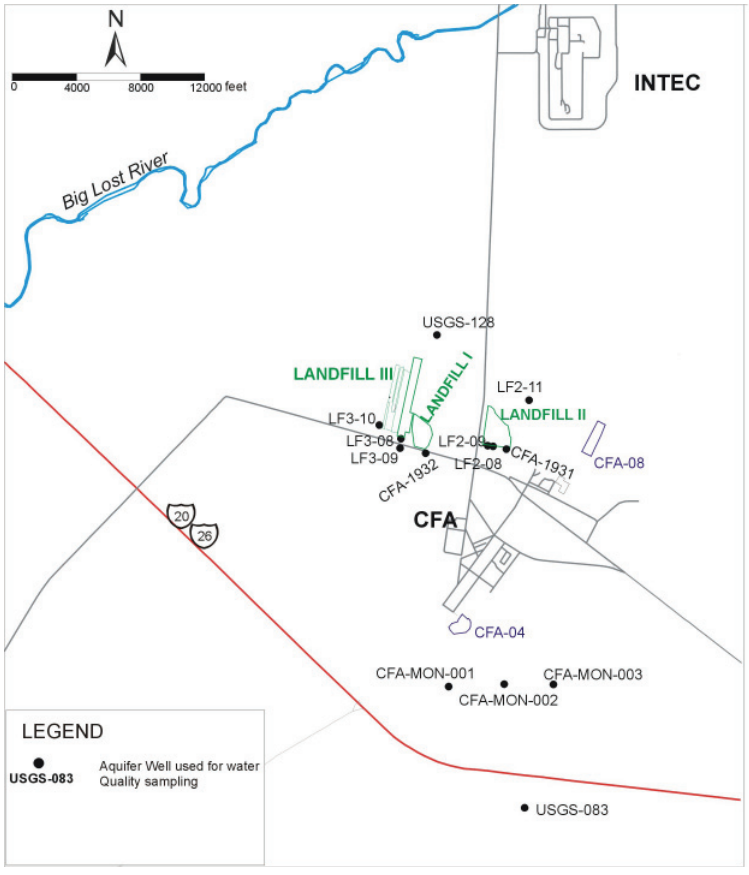


Figure 6-11. Location of WAG 4/CFA Monitoring Wells Sampled for 2006.

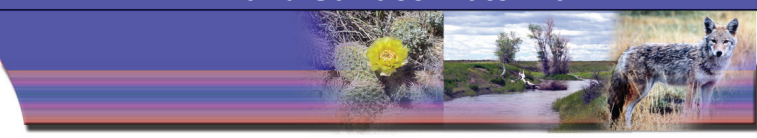


Table 6-5. Comparison of 2006 WAG 4 Groundwater Sampling Results to Regulatory Levels.

Compound	Units	Maximum Detected Value	MCL or SMCL[a]	Number of Wells With Detections Above MCL or SMCL
Anions				
Alkalinity-bicarbonate	mg/L	160	None	NA
Chloride	mg/L	128	*250*	0
Fluoride	mg/L	0.246	*2*	0
Nitrate/nitrite	mg-N/L	20.2	10	2
Sulfate	mg/L	39.6	*250*	0
Organic Analytes				
Methane	µg/L	172	None	NA
Inorganic Analytes[b,c]				
Antimony	µg/L	ND, ND	6	0, 0
Aluminum	µg/L	319, ND	*50–200*	2, 0
Arsenic	µg/L	ND, ND	10	0, 0
Barium	µg/L	114, 112	2,000	0, 0
Beryllium	µg/L	ND, ND	4	0, 0
Cadmium	µg/L	1.2, 1.2	5	0, 0
Chromium	µg/L	92.4, 23.2	100	0, 0
Copper	µg/L	5.2, ND	1,300/*1,000*	0, 0
Iron	µg/L	1520, 54.6	*300*	4, 0
Lead	µg/L	ND, ND	15[d]	0, 0
Manganese	µg/L	165, 162	50	1, 1
Mercury	µg/L	ND, ND	2	0, 0
Nickel	µg/L	877, 876	None	NA
Selenium	µg/L	ND, ND	50	0, 0
Thallium	µg/L	11.1, 11.9	2	4, 4
Vanadium	µg/L	10.7, 8.9	None	NA
Zinc	µg/L	378, 236	*5,000*	0, 0

a. Numbers in italics here are for the SMCL.
b. The number of detections above MCL or SMCL are given for unfiltered, filtered metals concentrations.
c. Maximum unfiltered and filtered value shown for metals.
d. The action level for lead is 15 µg/L.
MCL = maximum contaminant level
NA = not applicable
ND = not detected
SMCL = secondary maximum contaminant level. Numbers in italics are for the SMCL.

contaminant level (MCL) of 10 mg/L in Wells CFA MON A 002 (20.2 mg/L N) and CFA MON A 003 (11 mg/L N). Except for the recent spike in CFA-MON-A-003, nitrate concentrations in CFA MON-A-002 and 003 have remained relatively steady since monitoring began in 1995. Thallium was detected above its MCL in four wells, but its occurrence may be an artifact of the analytical method because of the high detection limit (5 µg/L) for the analytical method used. The analytical method for thallium will be changed to a method with a lower detection limit for the 2007 sampling event for WAG 4.

Iron, aluminum, and manganese occurred above secondary maximum contaminant levels (SMCLs). Iron was detected above its SMCL of 300 µg/L in unfiltered samples from four wells, and aluminum was detected above its SMCL of 200 µg/L in two unfiltered samples. The occurrence of both iron and the aluminum above their respective SMCLs is likely the result of suspended particulates since filtered samples were well below the SMCLs. Manganese exceeded its SMCL in one well, but the cause or source of the manganese is uncertain.

The 2006 water-level data for the CFA landfill wells suggest that water levels may be stabilizing. Groundwater gradients and groundwater flow directions are consistent with previous years and indicate that elevated nitrate concentrations in CFA-MON-A-002 and -003 should not affect the CFA production wells.

Summary of WAG 5 Groundwater Monitoring Results

Groundwater monitoring for WAG 5 in 2006 was completed in November 2006 in accordance with the WAG 5 ROD (DOE-ID 2000), the Groundwater Monitoring Plan (DOE ID 2004b) and recommendations from the first 5-year review (DOE-ID 2005). The three wells, PBF-MON-A-001, SPERT-I, and PBF-MON-A-003, were sampled for volatile organic compounds. The locations of the WAG 5 wells are shown on Figure 6-12. The number of wells sampled for WAG 5 was reduced from nine to three because the analytical results for metals in 2005 were below maximum contaminant levels, secondary maximum contaminant levels, or action levels. Consequently, the sampling of Waste Area Group 5 wells for metals was discontinued after the late 2005 sampling event and the number of wells sampled reduced to three, as agreed upon in the first five-year review.

In 2006, no target analyte was detected; consequently, no analyte exceeded a maximum contaminant level. The complete listing of analytical results for 2006 can be found in RPT-382.

Summary of WAG 7 Groundwater Monitoring Results

More than 4000 analyses were performed on samples collected from 15 RWMC aquifer monitoring wells in FY 2006. The location of aquifer monitoring wells sampled at the RWMC are shown on Figure 6-13. Reportable contaminants detected above reporting thresholds in FY 2006 include carbon tetrachloride, trichloroethylene, tritium, and uranium isotopes (RPT-339).

Carbon tetrachloride and trichloroethylene concentrations in seven wells consistently exceeded background reporting limits in FY 2006, and carbon tetrachloride exceeded the MCL in two of the wells. Since 2002, carbon tetrachloride concentrations at Well M7S have been above the MCL and are steadily increasing. Trichloroethylene concentrations are also increasing in Well M7S. Other wells in the vicinity of M7S (i.e., M3S, M15S, and USGS RWMC Production) also exhibit increasing concentrations of carbon tetrachloride and trichloroethylene. Increasing VOC concentrations in aquifer wells north northeast of the SDA are likely the result of migration from the SDA. While concentrations of carbon tetrachloride and

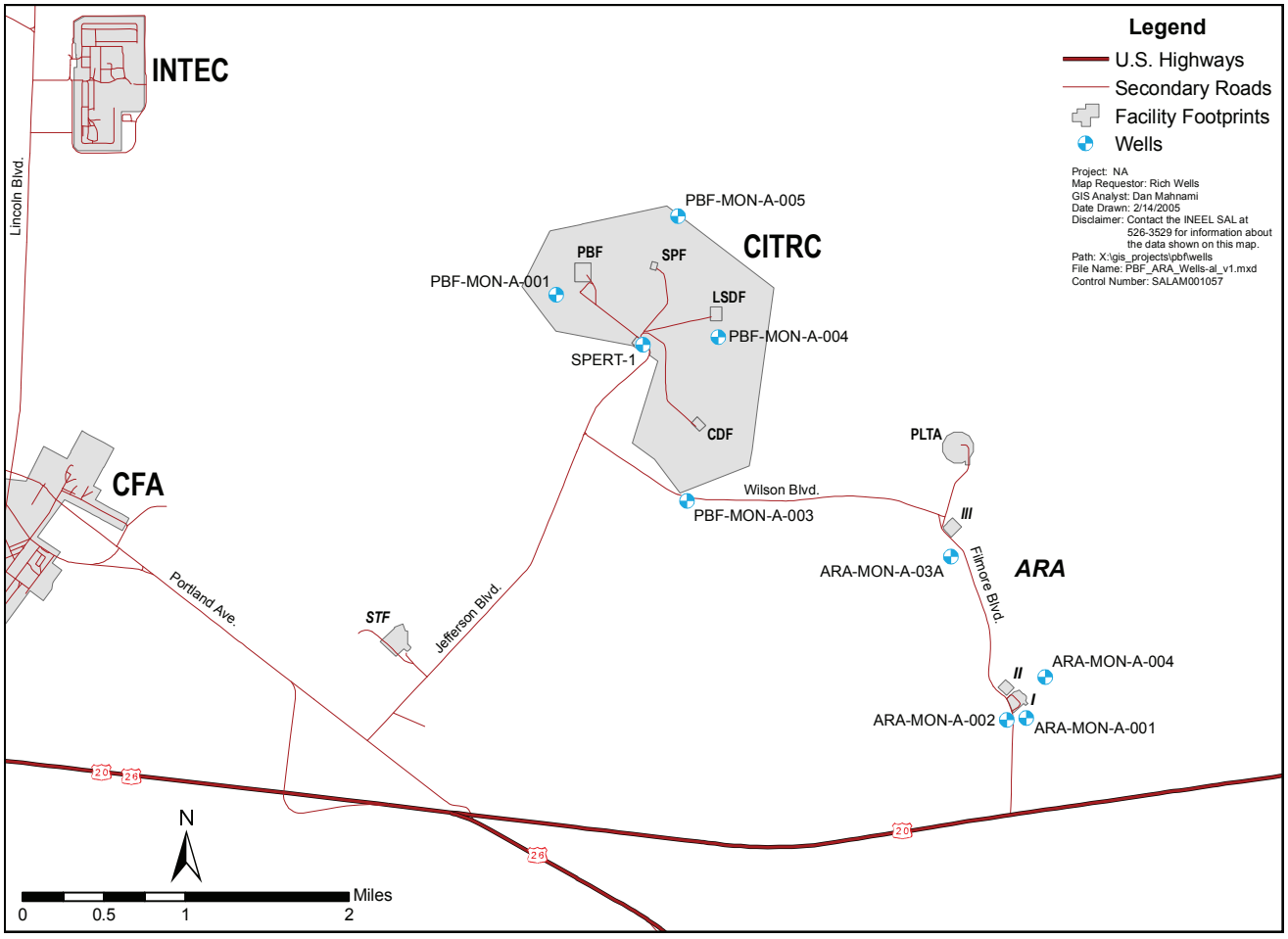


Figure 6-12. Location of Wells Sampled for WAG 5.

trichloroethylene are increasing at locations north of the SDA, they are decreasing in wells south of the SDA (i.e., A11A31, OW2 USGS-88, and USGS-120).

Slightly elevated concentrations of tritium were detected in wells north-northeast of the SDA (M3S, M7S, M14S, M16S); however, concentrations are substantially below the drinking water MCL. Elevated concentrations have been measured in these wells since about 1975 and have not decreased as expected from effects of dilution, dispersion, and radioactive decay, suggesting a source of tritium is continually replenishing the area. Recent studies conducted by WAG 10 indicate that tritium found in RWMC wells north-northeast of the SDA are likely associated with plumes originating at INTEC and RTC (DOE-ID 2007a).

Uranium concentrations at three monitoring locations (M7S, M14S, OW2) slightly exceeded background reporting thresholds in FY 2006. Detections above background thresholds at M7S and M14S

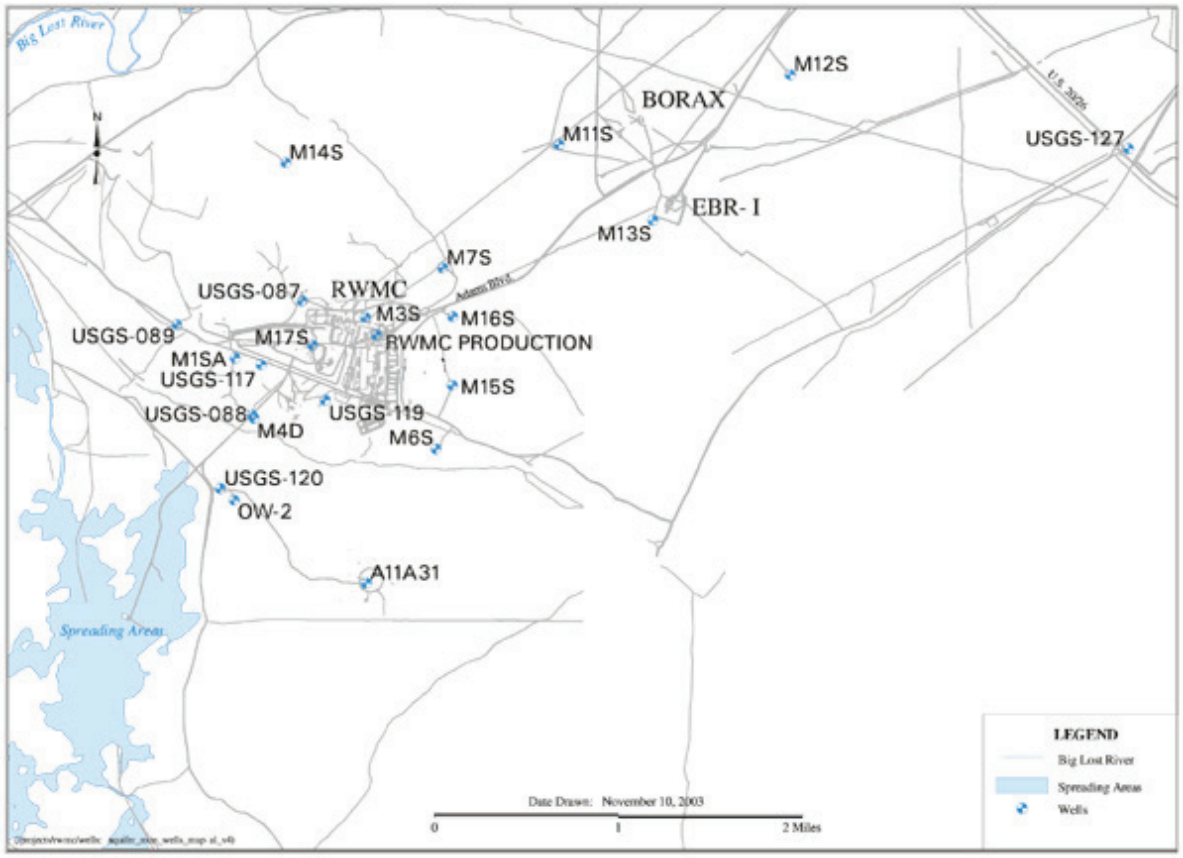


Figure 6-13. Locations of Aquifer-Monitoring Wells at RWMC WAG 7.

are rare; however, detections at OW2 often exceed background limits by a small amount. Slightly elevated uranium levels at OW2 are expected because of the well location and construction.

Detections of relevant analytes with concentrations above reporting thresholds are summarized in Table 6-6.

Summary of WAG 9 Groundwater Monitoring Results

MFC samples five wells (four monitoring and one production) (Figure 6-14) twice a year for selected radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters as required under the WAG 9 ROD (ANL-W, 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-7.

Summary of WAG 10 Groundwater Monitoring Results

Groundwater sampling was conducted in accordance with the Groundwater Monitoring and Field Sampling Plan (DOE-ID 2006). Eighteen wells and two multi-level Westbay wells with five sampling intervals in each were sampled for volatile organic compounds (contact laboratory program target analyte list), metals (filtered), anions (including alkalinity), and radionuclides (^{129}I, tritium, ^{99}Tc, gross alpha, gross beta, and ^{90}Sr) during June and July 2006. The locations of the wells are shown in Figure 6-15. The results

Table 6-6. Summary of WAG 7 Aquifer Sampling and Analyses Data for Relevant Analytes in FY 2006.

Relevant Analyte	Monitoring Wells Sampled	Number of Analyses	Number of Detections Greater Than Background Reporting Threshold	Number of Detections Greater Than Maximum Contaminant Level[a]	Concentration Exceeding Background		Name of Monitoring Well Exceeding Maximum Contaminant Level
					Maximum Concentration	Concentration Units	
Ac-227[b]	NA	NA	NA	NA	NA	NA	NA
Am-241	15	33	0	0	NA	NA	NA
C-14	15	33	0	0	NA	NA	NA
Cl-36	15	33	0	0	NA	NA	NA
Cs-137	15	33	0	0	NA	NA	NA
Gross Alpha	15	33	0	0	NA	NA	NA
Tritium	15	33	17	0	1,380 ± 85	pCi/L ± 1σ	NA
I-129	15	33	0	0	NA	NA	NA
Nb-94	15	33	0	0	NA	NA	NA
Np-237	15	33	0	0	NA	NA	NA
Pb-210[b]	NA	NA	NA	NA	NA	NA	NA
Pa-231[b]	NA	NA	NA	NA	NA	NA	NA
Pu-238	15	33	0	0	NA	NA	NA
Pu-239/240	15	33	0	0	NA	NA	NA
Ra-226[b]	15	33	0	0	NA	NA	NA
Ra-228[b]	NA	NA	NA	NA	NA	NA	NA
Sr-90[b]	4	4	NA	NA	NA	NA	NA
Tc-99	15	33	0	0	NA	NA	NA
Th-228[b]	NA	NA	NA	NA	NA	NA	NA
U-233/234	15	33	1[c]	NA[d]	1.81 ± 0.17	pCi/L ± 1σ	NA
U-235/236	15	33	0[c]	NA[d]	NA	NA	NA
U-238	15	33	3[c]	NA[d]	0.86 ± 0.08	pCi/L ± 1σ	NA
Total uranium[d]	15	33	3[d]	0[d]	2.6 ± 0.2	µg/L ± 1σ	NA
Carbon tetrachloride	15	33	17	5	8.3	µg/L	M7S, M16S
1,4-Dioxane[e]	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	15	33	0	0	NA	NA	NA
Tetrachloroethylene	15	33	0	0	NA	NA	NA
Trichloroethylene	15	33	8	0	2.9	µg/L	NA
Nitrate[f]	15	33	0	0	NA	NA	NA

a. The maximum contaminant level (MCL) is from "Environmental Protection Agency National Primary Drinking Water Standards" (40 CFR 141 2002) and *Implementation Guidance for Radionuclides* (EPA 2002). The MCL for Pu-239/240 is based on total alpha concentration.

b. Monitoring is not routinely performed for these analytes. However, Ra-226 is analyzed indirectly by gamma spectrometry analysis, and Sr-90 analysis is performed if gross beta exceeds 5 pCi/L.

c. Uranium-234, -235, -238, and total uranium are naturally occurring in the environment, and the number of detections shown is for results that exceeded aquifer background reporting thresholds. Background reporting thresholds currently applied to isotopic uranium results are 1.69 pCi/L for U-233/234, 0.15 pCi/L for U-235/236, and 0.78 pCi/L for U-238. The background reporting threshold for total uranium is 2.36 µg/L.

d. Total uranium is derived by converting isotopic uranium results (pCi/L) to mass units (µg/L) and adding the results. Primary drinking-water MCL is not applicable to each individual uranium isotope, but to total uranium only.

e. 1,4-Dioxane was added to the analytical target list the latter part of 2006; therefore, future monitoring data will include 1,4-Dioxane results.

f. Nitrate occurs naturally in the environment, and the number of detections shown is for results that exceeded the aquifer background reporting threshold of 2.0 mg/L.

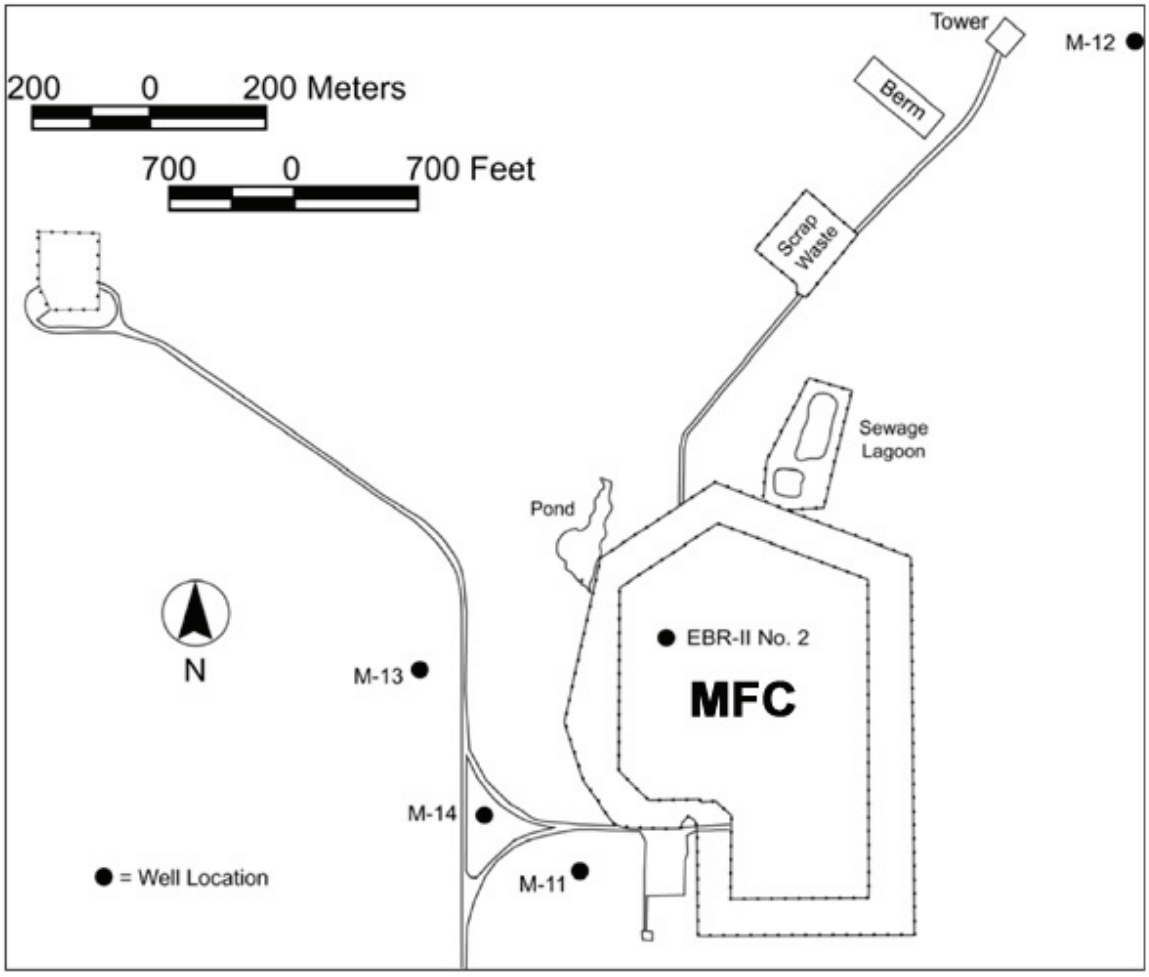


Figure 6-14. WAG 9 MFC Well Monitoring Locations.

are summarized on Table 6-8 and briefly described below. The complete listing of results can be found in the WAG 10 RI/FS Annual Report (DOE-ID, 2007b).

No contaminant exceeded an MCL in a well along the southern boundary of the INL Site or downgradient of the Site in the FY 2006 groundwater monitoring.

The primary radiological analytes detected in the boundary, guard, and distal wells included gross alpha, gross beta, and tritium (Table 6-8). These analytes were below their respective maximum contaminant levels (MCLs). The concentrations of gross alpha, and gross beta in the WAG 10 wells were similar to background, based on background values from Knobel, Orr, and Cecil (1992). Tritium was detected in two wells, USGS-104 and USGS-106, and both of these wells have a history of tritium detections. Over the past 20 years, both wells exhibit a downward trend in tritium concentration. The tritium concentrations in these wells currently are less than 1,100 pCi/L and considerably less than the MCL of 20,000 pCi/L (Table 6-8).

Table 6-7. Comparison of 2006 Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parantheses.

Well		M-11		M-12		M-13		M-14		EBR-II No. 2		MCL/SMCL[a]
Sample Date		5/23/06	11/8/06	7/18/06	11/7/06	5/22/06	11/7/06	5/22/06	11/7/06	5/23/06	11/8/06	
Parameter	Units					Radionuclides[b]						
Gross Alpha	pCi/L	1.65 ± 0.558 J (1 ± 0.451 UJ)	2.44 ± 1.31 U (1.73 ± 1.14 U)	4.45 ± 2.04 J	2.25 ± 1.22 U	2.03 ± 0.59	2.66 ± 1.35 U	1.07 ± 0.474 UJ	2.55 ± 1.21 J	1.06 ± 0.47 UJ	1.82 ± 1.15 U	15
Gross Beta	pCi/L	2.61 ± 0.613 (2.2 ± 0.643)	4.3 ± 1.67 J (3.39 ± 1.42 J)	6.44 ± 1.66	3.85 ± 1.35 J	3.38 ± 0.67	4.08 ± 1.62 J	2.3 ± 0.661	4.32 ± 1.61 J	2.72 ± 0.69	3.28 ± 1.2 J	50[c]
U-233/234	pCi/L	1.57 ± 0.153 (1.31 ± 0.131)	1.44 ± 0.126 (1.38 ± 0.118)	1.25 ± 0.139	1.48 ± 0.127	1.56 ± 0.15	1.25 ± 0.115	1.39 ± 0.138	1.32 ± 0.115	1.23 ± 0.13	1.47 ± 0.126	186,000
U-235	pCi/L	0.0172 ± 0.0148 U (0.0363 ± 0.0204 U)	0.0197 ± 0.0137 U (0.00911 ± 0.00896 U)	0.0236 ± 0.0205 U	0.073 ± 0.0224	0.007 ± 0.011 U	0.0087 ± 0.0141 U	0.0348 ± 0.0193 U	0.027 ± 0.0138 U	0.014 ± 0.02 U	0.0276 ± 0.0141 U	66
U-238	pCi/L	0.699 ± 0.0877 (0.566 ± 0.0743)	0.611 ± 0.0677 (0.667 ± 0.0696)	0.605 ± 0.087	0.609 ± 0.0675	0.67 ± 0.085	0.718 ± 0.0781	0.512 ± 0.0715	0.531 ± 0.0603	0.603 ± 0.08	0.619 ± 0.0678	9.9
						Metals						
Aluminum	µg/L	130 R (118 R)	25 U (25 U)	19.7	14.8 U	133 R	25 U	148 R	18.9 U	138 R	25 U	50 to 200
Antimony	µg/L	1.1 U (0.95 U	1.2 U (1.2 U)	5 U	0.664 R	0.54 U	1.2 U	0.38 U	1.2 U	5 U	1.2 U	6
Arsenic	µg/L	2.26 (1.92)	1.89 (1.97)	1.52 R	2	1.84	1.93	1.79	1.74	1.74	1.73	10
Barium	µg/L	36.4 (36.4)	34.2 (34.6)	1 UJ	41.3	36.9	34.2	37.7	33.9	37.6	34.7	2000
Beryllium	µg/L	0.3 U (0.3 U)	0.8 U (0.8 U)	0.44	0.8 U	0.3 U	0.8 U	0.3 U	0.8 U	0.3 U	0.8 UR	4
Cadmium	µg/L	0.8 (0.69)	0.5 U (0.5 U)	1 UR	0.5 U	0.49	0.5 U	0.62	0.5 U	0.55	0.5 U	5
Calcium	mg/L	38 (38.4)	41.2 (39.7)	38.7	44.6	37.8	43.2	38.4	42.8	38.8	43.1	NE[d]
Chromium	µg/L	2 (2)	2.16 (2.19)	0.72 R	1.85	4	2.93	4	2.76	2	1.71	100
Cobalt	µg/L	5 U (5 U)	0.3 UR (50 U)	5 U	0.28 U	0.41	50 U	5 U	50 U	5 U	0.26 U	NE
Copper	µg/L	10.7 U (10.7 U)	1.26 (1.26)	9.71 UJ	1.23	10.8 U	1.7	10.2 U	1.24	22.9	2.69	1300/1000
Iron	µg/L	101 R (111 R)	22.7 J (20.6 J)	46.9 UJ	60 UJ	52.4 R	20.3 J	51.3 R	48.4 J	40.6 R	60 UJ	300
Lead	µg/L	0.09 (0.12)	0.106 U (0.122 U)	1 U	0.216 U	0.05	0.091 U	0.1 U	0.126 U	1.21	1.45	15

Table 6-7. Comparison of 2006 Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells. Results of Duplicate Samples are in Parantheses. (continued)

Well		M-11		M-12		M-13		M-14		EBR-II No. 2		MCL/SMCL[a]
Sample Date		5/23/06	11/8/06	7/18/06	11/7/06	5/22/06	11/7/06	5/22/06	11/7/06	5/23/06	11/8/06	
Magnesium	mg/L	12.4 (12.5)	13.2 (12.7)	11.2	13	12.2	13.7	12.3	13.5	12.3	13.7	NE
Manganese	µg/L	3.64 (3.67)	0.758 U (0.694 U)	2.63	1.62	3.45	1.32	3.3	2.38	3.54	0.365 U	50
Mercury	µg/L	0.2 U (0.2 U)	0.2 U (0.035)	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2
Nickel	µg/L	1.9 (1.89)	0.786 (0.806)	0.31	1.16	2.11	1.44	1.68	1.09	1.58	1.86	NE
Potassium	mg/L	3.13 J (3.22 J)	3.11 J (3.07 J)	3.54	3.53 J	3.21 J	3.08 J	3.09 J	3.1 J	3.15 J	3.02 J	NE
Selenium	µg/L	0.85 U (0.8 U)	0.574 R (0.698 R)	0.34	0.732 R	0.5 U	0.629 R	0.67 U	0.554 R	0.52	0.538 R	50
Sodium	mg/L	17.6 (17.7)	19.2 (18.6)	16.8	20.2	17.9	20.6	17.7	19.9	18.2	21.3	NE
Thallium	µg/L	0.18 U (0.06 U)	0.4 UR (0.4 UR)	0.3 U	0.147 R	0.3 U	0.4 UR	0.3 U	0.4 UR	0.3 U	0.4 UR	2
Vanadium	µg/L	7 (8)	1.35 U (2.53 U)	5 UR	2.94 U	8	2.78 U	7	1.51 U	7	1.42 U	NE
Zinc	µg/L	9.69 U (2.34 U	1.67 (3.9)	2.49 R	6.6	8.47 U	2	1.19 U	3.07	39	18.2	5000
Anions												
Chloride	mg/L	20.2 (19.7)	20.4 (20.3)	18.2	17.5	18.1	17.8	18.7	17.8	20.5	22.6	250
Nitrate	mg/L	2 (2)	1.8 (1.8)	1.8	1.9	1.9	2	1.9	1.9	1.9	1.8	10
Nitrite	mg/L	0.2 U (0.2 U)	0.36 R (0.27 R)	0.2 U	0.53	0.2 U	0.55	0.2 U	0.56	0.2 U	0.31 R	1
Sulfate	mg/L	17.2 J (17.3 J)	17.2 (17)	16.2	16.6	18.4 J	17.8	18.1 J	17.8	18 J	18.6	250
Water Quality Parameters												
Alkalinity	mg/L	136 (134)	127 (140)	146	125	140	124	132	137	140	125	NE
Bicarbonate Alkalinity	mg/L	136 (130)	149 (130)	140	127	138	144	136	132	136	130	NE
Total Dissolved Solids	mg/L	241 (235)	262 (208)	339	242	242	262	247	267	250	257	500
Total Organic Carbon	mg/L	1 UJ (1 UJ)	50 U (50 U)	5.1 J	50 U	1 UJ	50 U	1 UJ	50 U	1 UJ	50 U	NE
Total Organic Halides	µg/L	21.6 (14.8)	14.4 J (10.8 J)	60 UJ	12.7 J	14.2 U	10.8 J	19.5 U	8.7 J	8.3	13.3 J	NE

a. MCL = maximum contaminant level; SMCL = secondary maximum contaminant level.
b. Counting error for radionuclides is one standard deviation.
c. The MCL for gross beta activity is four mrem/yr. A value of 50 pCi/L has been established as a screening level concentration.
d. NE = not established. A primary or secondary constituent standard has not yet been established for this constituent.
e. J = result is an estimate; R = result was rejected; U = not detected at the concentration shown.

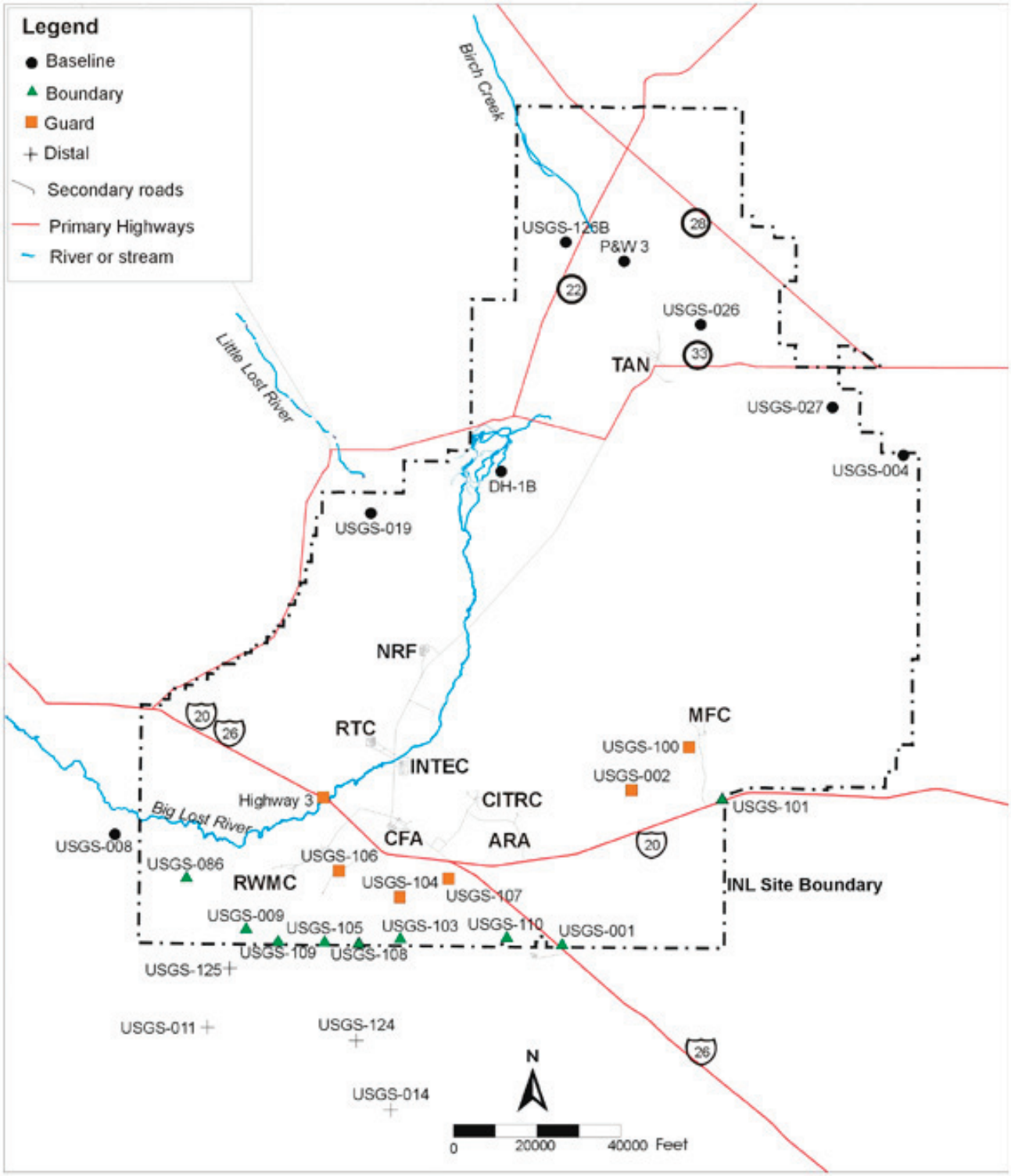


Figure 6-15. WAG 10 Baseline, Boundary, and Guard Wells Sampled in June-July 2006.

Table 6-8. Comparison of Detected Analytes in 2006 with MCLs or SMCLs for WAG 10.

Analyte	Sample Units	Max Concentration	MCL or SMCL[a]	Detections above MCL or SMCL
Radionuclides				
Gross Beta	pCi/L	6.61	NA	NA
Gross Alpha	pCi/L	2.86	15	0
Iodine-129	pCi/L	ND	1	0
Technetium-99	pCi/L	ND	900	0
Strontium-90	pCi/L	ND	8	0
Tritium	pCi/L	1080	20000	0
VOCs				
Toluene	µg/L	4.8	1,000	0
Chloromethane	µg/L	0.35	NA	NA
Carbon tetrachloride	µg/L	0.15	5	0
Anions				
Alkalinity	mg/L	204	None	NA
Chloride	mg/L	23.7	*250*	0
Fluoride	mg/L	0.92	*2*	0
Nitrate/Nitrite as N	mg/L	1.88	10	0
Sulfate	mg/L	28	*250*	0
Common Cations				
Calcium	µg/L	57,300	None	NA
Magnesium	µg/L	19,600	None	NA
Potassium	µg/L	3,210	None	NA
Sodium	µg/L	16,700	None	NA
Metals				
Aluminum	µg/L	39.3	*50 to 200*	0
Antimony	µg/L	0.66	6	0
Arsenic	µg/L	2.8	10	0
Barium	µg/L	116	2,000	0
Beryllium	µg/L	U	4	0
Cadmium	µg/L	1.4	5	0
Chromium	µg/L	40	100	0
Cobalt	µg/L	4.3	None	NA
Copper	µg/L	3.8	1,300/*1,000*	0
Iron	µg/L	209	*300*	0
Lead	µg/L	12.2	15[b]	0
Manganese	µg/L	424	*50*	1
Mercury	µg/L	0.17	2	0
Nickel	µg/L	8.5	None	NA
Selenium	µg/L	5.5	50	0
Silver	µg/L	U	None	NA
Strontium	µg/L	388	None	NA
Thallium	µg/L	0.56	2	0
Uranium	µg/L	2.6	30	0
Vanadium	µg/L	6.6	None	NA
Zinc	µg/L	1790	*5,000*	0

a. Numbers in italics are for secondary maximum contaminant level.

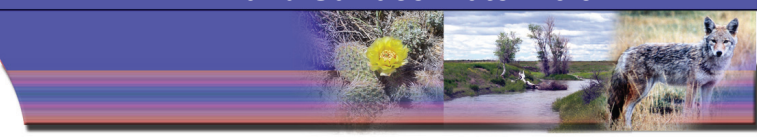
b. The action level for lead is 15 mg/L.

MCL = maximum contaminant level

NA = not applicable

ND = not detected

SMCL = secondary maximum contaminant level



In the Westbay wells, tritium, gross alpha and gross beta were also the primary radiological analytes detected. Gross alpha and gross beta were at background concentrations. Tritium was detected in four intervals, 748 ft, 834 ft, 1048 ft and 1148 ft bgs, from MIDDLE-2051 in 2006 at concentrations less than 600 pCi/L. Strontium-90 was detected in 2006 in the two deepest intervals from MIDDLE-2050A, but the reported ^{90}Sr concentrations were below the MDA. The occurrence of ^{90}Sr in these samples below its MDA is questionable.

Three volatile organic compounds-toluene, carbon tetrachloride, and chloromethane-were detected at concentrations well below their respective MCLs. Toluene was detected in samples from two wells at concentrations of 2.9 µg/L (USGS-108) and 4.8 µg/L (USGS-105). Toluene was also detected in packer samples from USGS-108 (627 ft, 0.25 µg/L) and USGS-105 (769 ft, 2 µg/L). All the toluene detections were below the MCL for toluene of 1000 µg/L. The source of the toluene is uncertain, but the lack of other hydrocarbons at the locations with the toluene detections is not consistent with fuel migration. Toluene is a common laboratory contaminant and that source cannot be ruled out. Carbon tetrachloride was detected at 0.15 µg/L in USGS-109, located directly south of the RWMC on the INL boundary. The carbon tetrachloride concentration in USGS-109 is an estimated value or J flagged and is close to the method detection limit. A carbon tetrachloride plume originates at the RWMC and this carbon tetrachloride detection could represent migration from the RWMC. Chloromethane was detected in the deepest sample from MIDDLE-2051, but the concentration was near the detection limit.

In the Westbay wells, only manganese was above its secondary MCL of 50 µg/L in one sample. The elevated manganese concentration of 424 µg/L occurred in the deepest sample from MIDDLE-2051. However, this elevated manganese detection is not consistent with the previous sample from this depth in 2005. The inconsistent manganese detections above the secondary MCL make the occurrence suspect and are not traceable back to any known source at INL.

Although not above its secondary MCL, zinc concentrations in the groundwater samples from USGS 011, USGS-086, USGS-100, USGS-103, USGS-104, USGS 106, USGS-108, USGS-109, and the Highway 3 well were elevated. The elevated zinc concentrations in these groundwater monitoring wells are probably the result of corroding galvanized discharge/riser pipe used in their construction. Elevated zinc concentrations in groundwater have been correlated to galvanized riser pipes for other wells at the INL Site (INEEL 2003; ICP 2004).

6.8 Offsite Water Sampling

Offsite Drinking Water Sampling

As part of the offsite monitoring performed by the ESER contractor, radiological analyses are performed on drinking water samples taken at offsite locations. In 2006, the ESER contractor collected 30 drinking water samples from 14 offsite locations.

Gross alpha activity was detected in one sample from Howe in May. The measured concentration of 1.58 pCi/L was below the EPA MCL of 15 pCi/L. Gross alpha activity was also detected in two samples from Atomic City and Howe in November. The concentrations, 1.81 pCi/L and 1.03 pCi/L, respectively, were also below the EPA MCL.

As in years past, measurable gross beta activity was present in most offsite drinking water samples (26 of the 30 samples). Detectable concentrations ranged from 1.51 pCi/L to 7.83 pCi/L (Table 6-9). The upper value of this range is appreciably below the EPA screening level for drinking water of 50 pCi/L.

Concentrations in this range are normal and cannot be differentiated from the natural decay products of thorium and uranium that dissolve into water as the water passes through the basalt terrain of the Snake River Plain.

Tritium was measured in two drinking water samples during November 2006, at Mud Lake and Shoshone (Table 6-9). The maximum level, 92.60 pCi/L, is significantly below the EPA MCL of 20,000 pCi/L for tritium in water.

Offsite Surface Water Sampling

As part of the offsite monitoring performed by the ESER contractor, radiological analyses are performed on surface water samples taken at offsite locations. Locations outside of the INL Site boundary are sampled twice a year for gross alpha, gross beta, and tritium. In 2006, the ESER contractor collected 13 surface water samples from six offsite locations, including the Big Lost River in May. The Big Lost River is usually dry when surface water samples are collected.

Gross alpha activity was detected in two surface water samples during 2006, below the EPA MCL of 15 pCi/L. Gross beta activity was detected in all surface water samples collected in 2006, ranging in concentrations from 1.64 pCi/L to 8.82 pCi/L. These results are well below the EPA MCL of 50 pCi/L. Gross alpha and beta concentrations that were measured are consistent with those measured in the past and cannot be differentiated from natural decay products of thorium and uranium that dissolve into water as the water passes through the surrounding basalts of the Snake River Plain.

Tritium was detected in two offsite surface water samples collected in November 2006. The sample collected at Mud Lake had a concentration of 92.0 pCi/L. The sample collected in Shoshone had a concentration of 92.6 pCi/L (Table 6-10). These concentrations were well below the PCS and EPA MCL of 20,000 pCi/L.

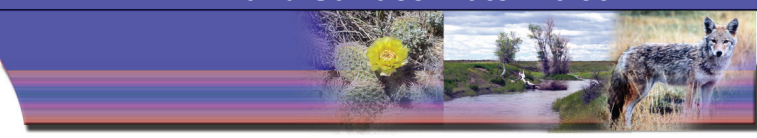


Table 6-9. Radionuclides Detected in 2006 ESER Offsite Drinking Water Samples.

Location	Sample Results Result ± 1s[a]	Limit for Comparison EPA MCL[b]
Gross Alpha		
	May 2006	
Howe	1.58 ± 0.41	15
	November 2006	
Atomic City	1.81 ± 0.39	15
Howe	1.03 ± 0.33	15
Gross Beta		
	May 2006	
Aberdeen	4.79 ± 0.58	50[c]
Atomic City	4.87 ± 0.55	50
Fort Hall	2.65 ± 0.54	50
Howe	2.45 ± 0.49	50
Idaho Falls	1.85 ± 0.53	50
Minidoka	3.12 ± 0.55	50
Monteview	3.31 ± 0.56	50
Moreland	5.07 ± 0.61	50
Mud Lake	3.83 ± 0.55	50
Roberts	3.83 ± 0.55	50
Shoshone	2.51 ± 0.53	50
Taber	3.34 ± 0.53	50
	November 2006	
Aberdeen	5.43 ± 0.57	50
Arco	1.51 ± 0.48	50
Atomic City	3.93 ± 0.52	50
Carey	2.65 ± 0.54	50
Fort Hall	7.83 ± 0.64	50
Howe	1.90 ± 0.48	50
Idaho Falls	3.16 ± 0.52	50
Minidoka	5.31 ± 0.59	50
Monteview	4.36 ± 0.53	50
Moreland	6.33 ± 0.55	50
Mud Lake	5.46 ± 0.59	50
Roberts	3.83 ± 0.55	50
Shoshone	4.70 ± 0.55	50
Taber	4.31 ± 0.52	50
Tritium		
	November 2006	
Mud Lake	92.00 ± 29.44	20,000
Shoshone	92.60 ± 29.40	20,000

a. All values shown are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation [1s]).

b. MCL = maximum contaminant level.

c. The MCL for gross beta is established as a dose of 4 mrem/yr. A screening concentration of 50 pCi/L is used to simplify comparison.

Table 6-10. Radionuclides Detected in 2006 ESER Offsite Surface Water Samples.

Location	Sample Results Result ± 1s[a]	Limits for Comparison PCS[b]	EPA MCL[c]
Gross Alpha			
	May 2006		
EFS	1.58 ± 0.41	4 mrem/yr	15
	November 2006		
Hagerman	1.81 ± 0.39	4 mrem/yr	15
Gross beta			
	May 2006		
Bliss	4.80 ± 0.53	4 mrem/yr	50
Buhl	3.95 ± 0.53	4 mrem/yr	50
EFS (Big Lost River)	8.82 ± 0.57	4 mrem/yr	50
Hagerman	2.12 ± 0.48	4 mrem/yr	50
Idaho Falls	1.64 ± 0.52	4 mrem/yr	50
Twin Falls	6.89 ± 0.60	4 mrem/yr	50
Twin Falls (duplicate)	6.14 ± 0.60	4 mrem/yr	50
	November 2006		
Bliss	5.24 ± 0.56	4 mrem/yr	50
Buhl	4.15 ± 0.53	4 mrem/yr	50
Buhl (duplicate)	5.24 ± 0.57	4 mrem/yr	50
Hagerman	4.34 ± 0.52	4 mrem/yr	50
Idaho Falls	2.55 ± 0.46	4 mrem/yr	50
Twin Falls	7.71 ± 0.57	4 mrem/yr	50
Tritium			
	November 2006		
Buhl	90.10 ± 29.60	20,000	20,000
Hagerman	92.50 ± 29.70	20,000	20,000

a. All values shown are in picocuries per liter (pCi/L), plus or minus the uncertainty (one standard deviation [1s]).

b. PCS = Primary constituent standard values from IDAPA 58.01.11. Value for tritium is pCi/L.

c. MCL = maximum contaminant level. Values are pCi/L.

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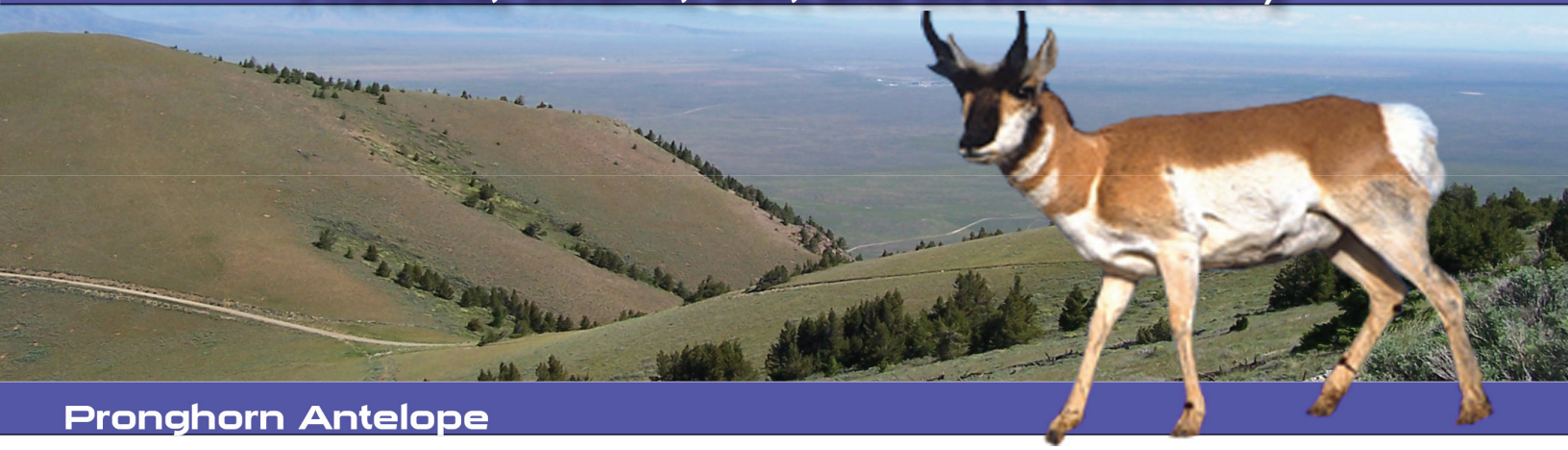
Chapter 7 - Environmental Monitoring Programs (Agricultural Products, Wildlife, Soil, and Direct Radiation)



Pronghorn Antelope

M. Case - S. M. Stoller Corporation
R. Mitchell - RM Technical Services
M. Verdoorn - Battelle Energy Alliance
R. Wilhelmsen - CH2M-WG Idaho

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

This chapter provides a summary of the various environmental monitoring activities currently being conducted on and around the Idaho National Laboratory (INL) Site (Table 7-1). These media are potential pathways for transport of INL Site contaminants to nearby populations.

The INL and Idaho Cleanup Project (ICP) contractors monitored soil, vegetation, and direct radiation on the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The contractors collect over 400 soil, vegetation, and direct radiation samples for analysis each year.

The Environmental Surveillance, Education and Research Program (ESER) contractor conducted offsite environmental surveillance and collected samples from an area of approximately 23,308 km^2 (9000 mi^2) of southeastern Idaho at locations on, around, and distant to the INL Site. The ESER contractor collected approximately 300 agricultural products, wildlife, and direct radiation samples for analysis in 2006.

Section 7.1 presents the agricultural products and biota surveillance results sampled under the ESER Program. Section 7.2 presents the results of soil sampling by both the ESER contractor and the INL and ICP contractors. The direct radiation surveillance results are presented in Section 7.3. Results of the waste management surveillance activities are discussed in Section 7.4.

7.1 Agricultural Products and Biota Sampling

Milk

During 2006, 159 milk samples (109 monthly and 50 weekly) were collected under the ESER Program. All of the samples were analyzed for gamma-emitting radionuclides including iodine-131 (^{131}I). During the second and fourth quarters, samples were analyzed either for strontium-90 (^{90}Sr) or tritium.

Iodine-131 was not detected in any sample in 2006. Cesium-137 (^{137}Cs) was detected in two weekly samples collected in Ucon and in two monthly samples from Dietrich and Moreland. The highest result, 4.1 pCi/L, is well below the DOE derived concentration guide (DCG) for ^{137}Cs in water of 3000 pCi/L.

Table 7-1. Other Environmental Monitoring Activities at the INL Site.

Area/Facility[a]	Media			
	Agricultural Products	Soil	Biota	Direct Radiation
INL and ICP Contractors				
MFC		•	•	•
RWMC		•	•	•
Sitewide		•		•[b]
Environmental Surveillance, Education and Research Program				
INL Site/Regional	•	•	•	•

a. MFC = Materials and Fuels Complex, RWMC = Radioactive Waste Management Complex.

b. Sitewide includes thermoluminescent dosimeters located at major facilities.

Strontium-90 was detected in nine out of ten samples (one weekly and eight monthly), ranging from 0.26 pCi/L at Howe to 1.05 pCi/L at Carey. All levels of ^{90}Sr in milk were consistent with those data previously reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by ingestion of grass by cows (EPA 1995). The maximum value is far lower than the DOE DCG for ^{90}Sr in water of 1000 pCi/L.

Tritium was detected in three of the nine samples analyzed at concentrations ranging from 98 to 115 pCi/L, with the maximum value found at Idaho Falls. These concentrations are consistent with those from previous years and are similar to those found in precipitation and atmospheric moisture samples.

Lettuce

ESER Program personnel collect lettuce samples every year from the areas adjacent to the INL Site. The collection of lettuce from home gardens around the INL Site typically depends on availability. To make this sampling more reliable, ESER has added prototype lettuce planters in conjunction with other sampling locations. These locations are relatively remote and have no access to water, requiring that a self-watering system be developed. This method allows for the placement and collection of lettuce at areas previously unavailable to the public, such as on the INL Site. The boxes are set out in the spring with the lettuce grown from seed. This new method also allows for the accumulation of deposited radionuclides on the plant surface throughout the growth cycle.

Seven lettuce samples, including one duplicate, were collected from private gardens at Blackfoot and Idaho Falls and from portable lettuce gardens placed at Atomic City, the Experimental Field Station, the Federal Aviation Administration (FAA) Tower, and Monteview (Figure 7-1).

Strontium-90 was detected above the 3s level in six of the seven samples collected. Strontium-90 in lettuce results from plant uptake of this isotope in soil as well as deposition from airborne dust containing ^{90}Sr. Strontium-90 is present in soil as a residual of fallout from aboveground nuclear weapons testing, which took place between 1945 and 1980. The maximum concentration of 4.8×10^{-2} pCi/g was within concentrations detected historically (Table 7-2) and was most likely from weapons testing fallout. No other manmade radionuclides were detected in any of the samples.

Wheat

One of the 12 wheat samples (including one duplicate) collected during 2006 (Figure 7-1) contained a measurable concentration of ^{90}Sr above the 3s uncertainty level. This sample came from Idaho Falls and had a concentration of 7.77×10^{-3} pCi/g, which is well within the range found during the past five years (Table 7-3). No other anthropogenic radionuclides were detected.

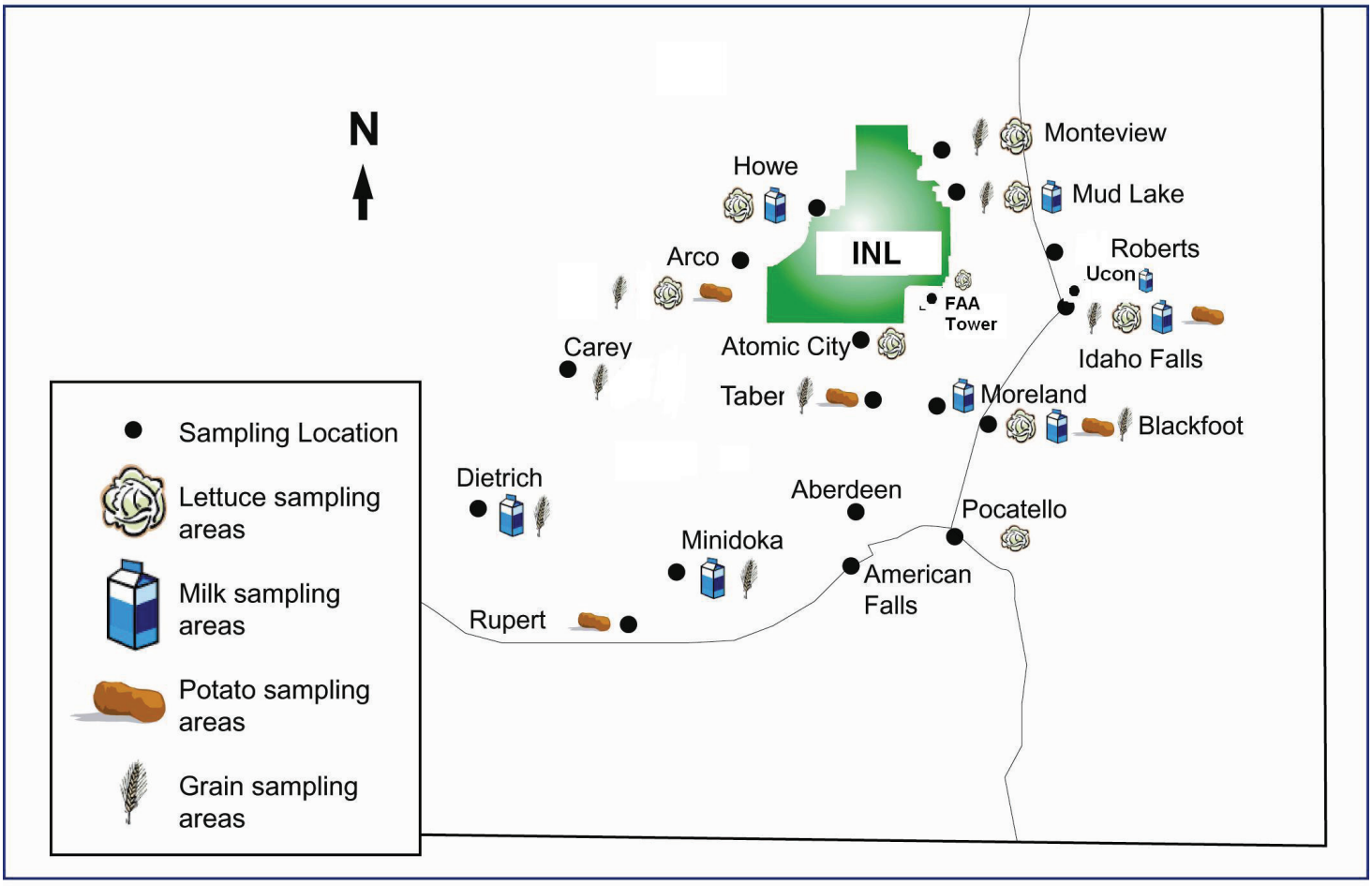


Figure 7-1. Locations of Agricultural Produce Samples Taken During 2006.

Table 7-2. Strontium-90 Concentrations in Garden Lettuce (2001-2006).[a,b,c]

Location	2001	2002	2003	2004	2005	2006
Distant Group						
Blackfoot	160 ± 55	116 ± 81	228 ± 83	97 ± 56	-17 ± 15	26 ± 8
Carey	144 ± 55	283 ± 79	220 ± 180	97 ± 66	NS[d]	NS
Idaho Falls	114 ± 55	41 ± 25	254 ± 170	328 ± 110	26 ± 24	69 ± 8
Pocatello	59 ± 50	NS	NS	135 ± 110	93 ± 26	NS
Grand Mean[e]	**119 ± 27**	**145 ± 39**	**234 ± 87**	**164 ± 44**	**35 ± 15**	**48 ± 6**
Boundary Group						
Arco	88 ± 55	93 ± 23	126 ± 160	154 ± 85	111 ± 37	NS
Atomic City	110 ± 55	NS	282 ± 130[e]	155 ± 130[e]	57 ± 30[e]	35 ± 6[e]
FAA Tower	NS	NS	NS	NS	NS	18 ± 10[e]
Howe	21 ± 55	65 ± 28	25 ± 81	NS	49 ± 25	NS
Monteview	74 ± 55	85 ± 22	214 ± 140	NS	NS	29 ± 9[e]
Mud Lake (Terreton)	41 ± 55	109 ± 26	NS	148 ± 79	55 ± 26	NS
Grand Mean[e]	**67 ± 25**	**88 ± 12**	**162 ± 66**	**152 ± 58**	**68 ± 15**	**27 ± 5**
INL Site						
Experimental Field Station	NS	NS	442 ± 130[e]	225 ± 86[f]	SD[f]	48 ± 9[e]

a. Analytical results are x 10^{-3} picocuries per gram (pCi/g).
b. Analytical results are for dry weight plus or minus one standard deviation (± 1s).
c. Approximate minimum detectable concentration (MDC) of ^{90}Sr in lettuce is 2 x 10^{-4} pCi/g dry weight.
d. NS indicates no sample collected or sample was lost before analysis.
e. Sample grown in portable lettuce garden.
f. SD indicates that the sample was destroyed, in this case, by yellow jackets.

Potatoes

Eight potato samples, including one duplicate, were collected during 2006: four samples and one duplicate from distant locations; two samples from boundary locations; and one sample from an out-of-state location (Colorado) (Figure 7-1). The Idaho samples were collected from Arco, Blackfoot, Idaho Falls, Monteview, Rupert, and Taber. Cesium-137 was detected in one of the Idaho samples (Rupert) at a concentration of 1.8 pCi/kg and in the Colorado sample at a concentration of 1.6 pCi/g. Cesium-137 is present in soil as a result of fallout from aboveground nuclear weapons testing, and these detections were most likely from that fallout. No other anthropogenic radionuclides were detected in potatoes.

Sheep

Certain areas of the INL Site are open to grazing under lease agreements managed by the U.S. Bureau of Land Management. Every year, during the second quarter, ESER personnel collect samples from sheep

Table 7-3. Strontium-90 Concentrations in Wheat (2001-2006).[a,b]

Location	2001[c]	2002	2003	2004	2005	2006
Distant Group						
Aberdeen[d] (American Falls)	-20 ± 15	36 ± 130	84 ± 62	-1 ± 25	12 ± 18	0.7 ± 3.3
				32 ± 29		
Blackfoot	61 ± 45	69 ± 66	NS[e]	16 ± 25	16 ± 25	-0.4 ± 2.8
		81 ± 130				
Carey	50 ± 90	28 ± 66	-53 ± 47	65 ± 27	NS	2.3 ± 2.7
Dietrich	NS	NS	NS	17 ± 17	-27 ± 17	6.0 ± 2.7
Idaho Falls	-37 ± 132	50 ± 82	121 ± 64	46 ± 22	15 ± 24	7.8 ± 2.5
				26 ± 27		
Minidoka	218 ± 145	0 ± 97	61 ± 48	NS	4 ± 24	NS
Roberts (Menan)[d]	193 ± 115	19 ± 65	54 ± 55	NS	7 ± 16	NS
	29 ± 95				-11 ± 18	
Rockford	NS	-220 ± 130	195 ± 68	NS	NS	NS
Rupert (Burley)[d]	-69 ± 101	90 ± 130	-26 ± 52	NS	NS	8.3 ± 3.5
Taber	NS	111 ± 150	NS	NS	NS	3.2 ± 3.3
Grand Mean[f]	53 ± 36	26 ± 35	62 ± 22	29 ± 9	-0.9 ± 7	4.0 ± 1.1
Boundary Group						
Arco	96 ± 130	41 ± 190	2 ± 55	16 ± 25	109 ± 38	2.0 ± 2.9
	59 ± 44					7.0 ± 2.6
Howe	NS	18 ± 76	-19 ± 49	-4 ± 19	5 ± 18	3.0 ± 2.9
Monteview	50 ± 49	220 ± 98	NS	NS	-41 ± 22	2.9 ± 2.8
Mud Lake	20 ± 37	54 ± 87	8 ± 56	21 ± 18	-5 ± 20	6.5 ± 2.5
Terreton	64 ± 65	86 ± 99	5 ± 43	-6 ± 22	NS	NS
Grand Mean	58 ± 33	84 ± 52	-1 ± 26	7 ± 11	17 ± 13	4.3 ± 1.2

a. Concentrations are picocuries per kilogram.
b. Analytical Results are for dry weight, plus or minus 1 standard deviation (± 1s).
c. Approximate MDC of ^{90}Sr in wheat from 2001 through 2005 was 20-100 pCi/kg dry weight. In 2006, the MDC decreased to approximately 10 pCi/kg.
d. Samples were collected from multiple locations in this area during certain years.
e. NS = no sample collected.

grazed in these areas, either just before or shortly after they leave the INL Site. Muscle, liver, and thyroid samples were collected from each animal. For the calendar year 2006, six sheep were sampled. Four were from INL Site land, and two were from Dubois to serve as control samples. Cesium-137 was detected above 3s in the muscle tissue of one onsite sample at a level of 5.6 pCi/kg, but was not detected in offsite muscle samples. All ^{137}Cs concentrations measured in 2006 were similar to those found in both onsite and offsite sheep samples in previous years and are within historical values. Cesium-137 concentrations in both sheep liver and muscle have been essentially the same (error bars overlap) since 2002 (Figure 7-2).

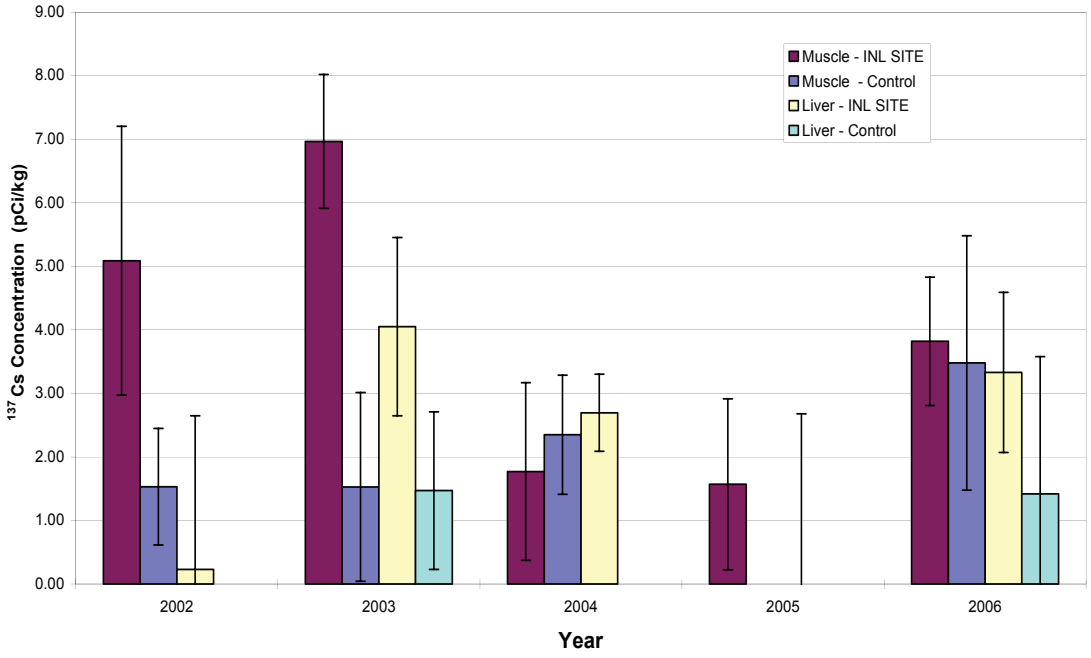


Figure 7-2. Average Cesium-137 Concentrations in Muscle and Liver of Sheep Collected from the INL Site and Control Areas (2002-2006). Averages include all laboratory results, even those below the 3s uncertainty level (nondetectable) as well as negative results.

Levels of ^{131}I are of particular interest in thyroids because of this organ's ability to accumulate iodine. Iodine-131 did not exceed the 3s uncertainty in any sample.

Game Animals

Muscle samples were collected from three pronghorn and two mule deer which were accidentally killed on INL Site roads or died from natural causes. When available, liver and thyroid samples were also collected. There was detectable ^{137}Cs radioactivity above 3s in the muscle of one pronghorn taken on or near the INL Site. The result was 5.5 pCi/kg. No tissue samples contained detectable ^{131}I above 3s.

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: three from central Idaho; three from Wyoming; three from Montana; four from Utah; and one each from New Mexico, Colorado, Nevada, and Oregon. Each background sample had small, but detectable, ^{137}Cs concentrations in its muscle ranging from 5.1 to 15 pCi/kg.

The concentration of ^{137}Cs detected in the muscle sample collected in 2006 was at the lower end of this range. The 2006 results were also within the range of historical values. These values can be attributed to the ingestion of radionuclides in plants from worldwide fallout associated with aboveground nuclear weapons testing. No ^{131}I was detected in any of the thyroid gland samples.

Seventeen ducks were collected during 2006. Nine were collected from wastewater ponds located at the Reactor Technology Complex (RTC) facility, five came from wastewater ponds near the Materials and Fuels Complex (MFC) facility, and three control samples were collected near American Falls. Each duck sample was divided into three sub-samples: one consisting of edible tissue (muscle, gizzard, heart and liver); viscera; and a remainder sample that includes all remaining tissue (bones, feathers, feet, bill, head, and residual muscle). All were analyzed for gamma emitting radionuclides, ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am. Concentrations of radionuclides measured in 2006 waterfowl are shown in Table 7-4.

Several manmade radionuclides were detected in the samples taken from the RTC ponds. These included ^{241}Am, ^{137}Cs, Chromium-51 (^{51}Cr), Cobalt-60 (^{60}Co), ^{238}Pu, Plutonium-239/240 ($^{239/240}Pu$), ^{90}Sr, and Zinc-65 (^{65}Zn). Of these eight, four (^{137}Cs, ^{60}Co, ^{90}Sr, and ^{241}Am) were found in the edible tissues. Six radionuclides, ^{241}Am, ^{137}Cs, ^{60}Co, $^{239/240}Pu$, ^{90}Sr, and ^{65}Zn, were also detected in the birds from the MFC ponds. Two manmade radionuclides (^{241}Am and ^{90}Sr) were found in the control samples.

Since manmade radionuclides were found more frequently and at higher concentrations in ducks taken from the INL Site, it is assumed that the INL Site is the source of these detections. Concentrations of the detected radionuclides from RTC were similar to, or significantly lower in the case of ^{137}Cs, than those found in 2005. Measured concentrations were also lower than those in ducks taken during a 1994-1998 study (Warren et al. 2001). The ducks were not taken directly from the two-celled hypalon-lined radioactive wastewater RTC Evaporation Pond but from an adjacent sewage lagoon. However, it is likely that the birds also used the RTC Evaporation Pond.

Waterfowl hunting is not allowed on the INL Site, but a maximum potential exposure scenario to humans would be someone collecting a contaminated duck directly from the ponds and immediately consuming all muscle, liver, heart, and gizzard tissue (average 225 g). The maximum potential dose from eating 225 g (8 oz) of meat from the most contaminated waterfowl collected in 2006 was estimated to be 0.013 mrem (0.00013 mSv) (Chapter 8). This dose is lower than dose estimates for some previous periods. The maximum dose estimated for the period from 1993 through 1998 was 0.89 mrem (0.009 mSv) and from 2000 through 2004 was 0.08 mrem (0.0008 mSv). In the late 1970s, when the percolation ponds were still in use, the maximum dose from eating a contaminated duck was estimated to be 54 mrem (0.54 mSv).

7.2 Soil Sampling

Soils are sampled to determine if long-term deposition of airborne materials from the INL Site have resulted in a buildup of radionuclides. The sampling also supports the Wastewater Land Application Permit (WLAP) for the Central Facilities Area (CFA) Sewage Treatment Plant.

Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, and certain actinides. Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am (which potentially could be released from INL Site operations) are of particular interest because of their abundance owing to nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment because of long half-lives (e.g., $^{239/240}Pu$, with a half-life of 24,390

Table 7-4. Radionuclide Concentrations Detected in Waterfowl Using INL Site Wastewater (Sewage) Disposal Ponds and Waterfowl from Background Locations (2006).[a]

	Waterfowl Location		
	RTC (Nine samples)	MFC (Five samples)	American Falls (Three samples)
Nuclide			
	Edible		
Americium-241	Sample #7: 2.1 ± 0.3 Sample #8: 1.1 ± 0.2	Sample #4: 0.86 ± 0.11	Sample #3: 0.59 ± 0.19
Cesium-137	Sample #3: 26 ± 8 Sample #5: 515 ± 20 Sample #6: 258 ± 9 Sample #7: 1090 ± 17 Sample #8: 468 ± 14 Sample #9: 314 ± 11	Sample #5: 378 ± 17	No detections
Cobalt-60	Sample #6: 28 ± 4 Sample #7: 70 ± 7 Sample #8: 30 ± 7	Sample #5: 29 ± 8	No detections
Strontium-90	Sample #5: 6.4 ± 1.8	No detections	No detections
	Viscera		
Americium-241	Sample #5: 6.4 ± 1.8	Sample #2: 2.8 ± 0.6 Sample #4: 1.0 ± 0.2	No detections
Cesium-137	Sample #2: 35 ± 9 Sample #5: 391 ± 21 Sample #6: 223 ± 18 Sample #7: 240 ± 11 Sample #8: 248 ± 15 Sample #9: 1200 ± 22	Sample #5: 131 ± 9	No detections
Cobalt-60	Sample #5: 92 ± 14 Sample #6: 127 ± 11 Sample #7: 30 ± 8 Sample #8: 46 ± 11 Sample #9: 100 ± 10	Sample #4: 460 ± 7 Sample #5: 78 ± 7	No detections
Plutonium-238	Sample #1: 1.2 ± 0.2	No detections	No detections
Plutonium-239/240	No detections	Sample #4: 0.55 ± 0.14	No detections
Strontium-90	Sample #5: 15 ± 2 Sample #6: 9 ± 3 Sample #7: 31 ± 3	No detections	No detections
Zinc-65	Sample #5: 52 ± 17	No detections	No detections
	Remainder		
Cesium-137	Sample #5: 201 ± 7 Sample #6: 207 ± 11 Sample #7: 124 ± 7 Sample #8: 248 ± 7 Sample #9: 136 ± 6	Sample #5: 132 ± 9	No detections
Chromium-51	Sample #4: 1700 ± 500	No detections	No detections
Cobalt-60	Sample #8: 17 ± 4 Sample #9: 13 ± 4	Sample #5: 24 ± 4	No detections
Plutonium-238	Sample #1: 0.70 ± 0.16 Sample #5: 0.29 ± 0.06	No detections	No detections
Plutonium-239/240	Sample #5: 0.18 ± 0.05	Sample #2: 0.95 ± 0.16	No detections
Strontium-90	Sample #1: 8.2 ± 0.7 Sample #2: 15.8 ± 0.6 Sample #3: 2.6 ± 0.5 Sample #4: 5.3 ± 0.6 Sample #5: 10.1 ± 0.5 Sample #6: 6.3 ± 0.5 Sample #7: 4.9 ± 1.2 Sample #8: 14.8 ± 0.8 Sample #9: 5.0 ± 0.7	Sample #1: 10.8 ± 0.7 Sample #2: 12.3 ± 0.7 Sample #4: 6.9 ± 0.9 Sample #5: 27.1 ± 1.1	Sample #2: 15.0 ± 1.5
Zinc-65	No detections	Sample #5: 99 ± 17	No detections

a. All values are $\times 10^{-3}$ picocuries per gram.

years). Levels found around INL Site facilities are consistent with fallout levels. Soil sampling locations are shown in Figure 7-3.

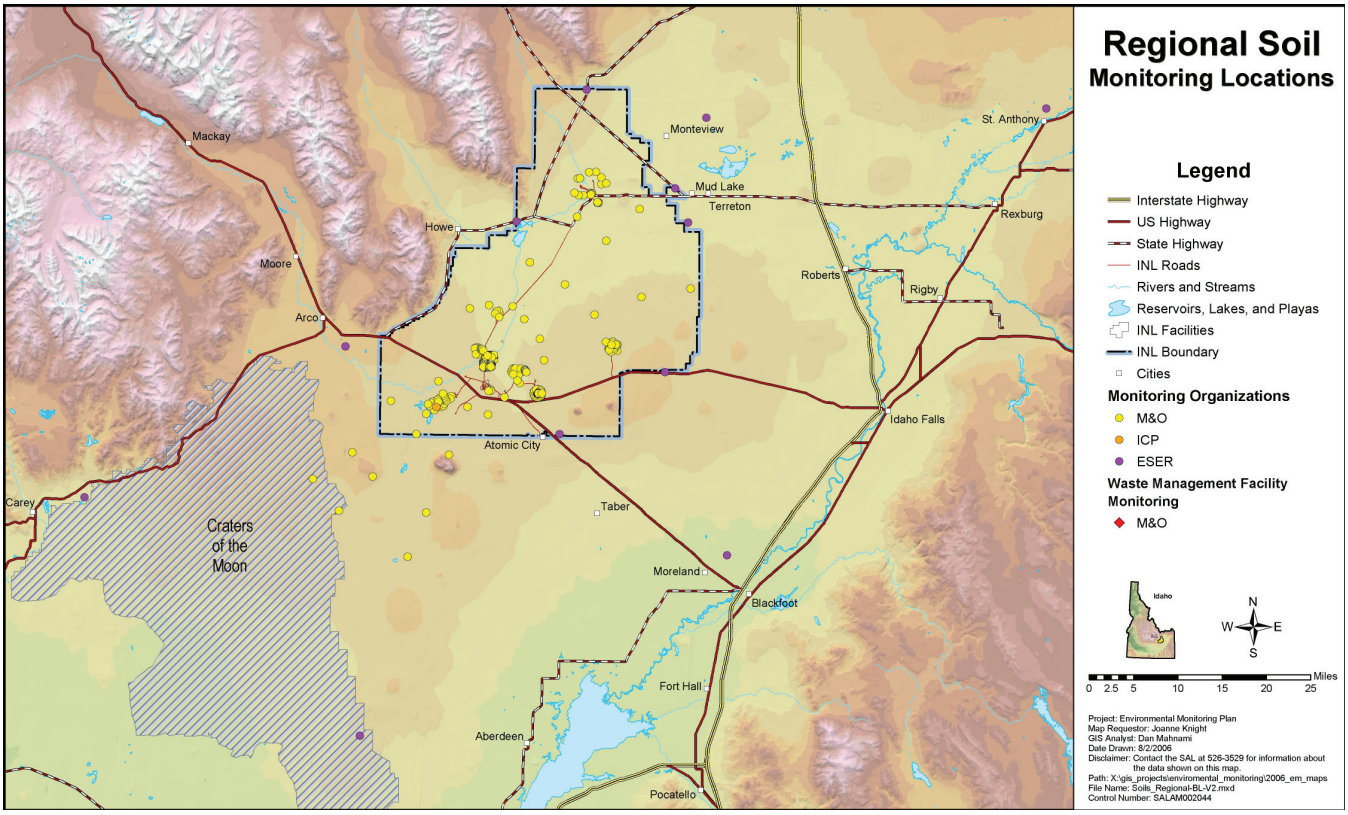
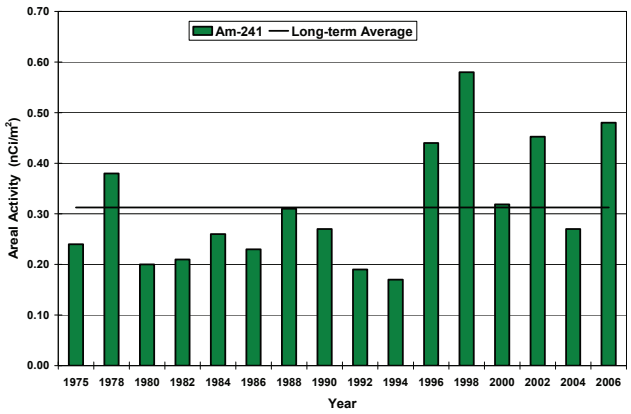
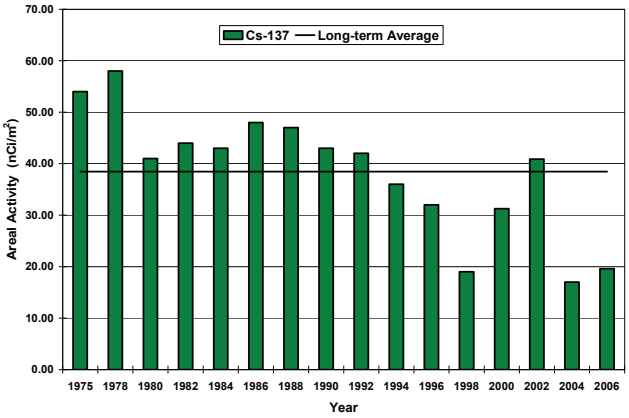


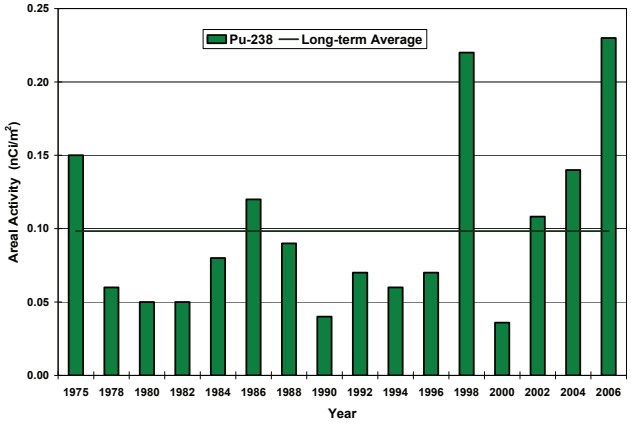
Figure 7-3. Soil Sampling Locations.

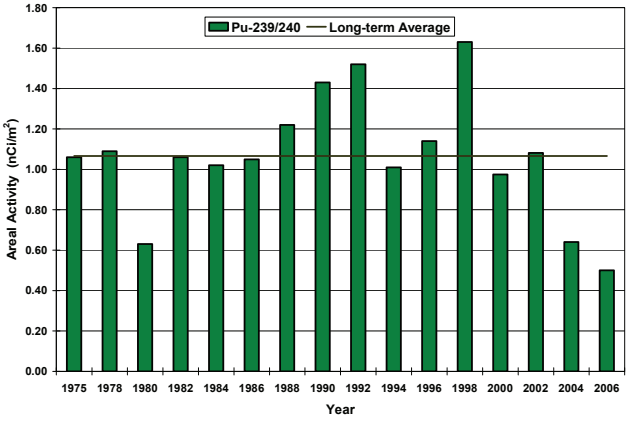
The ESER contractor collects offsite soil samples every two years (in even years); thus, soil sampling was conducted in 2006. Results from 1975 to 2006 are presented in Figure 7-4. The geometric means were used because the data were log-normally skewed. The shorter-lived radionuclides (^{90}Sr and ^{137}Cs) show overall decreases through time. Concentrations of $^{239/240}$Pu, a long-lived radionuclide, demonstrate a decreasing trend similar to that of ^{90}Sr. However, concentrations of ^{238}Pu and ^{241}Am, which are also long-lived radionuclides, show no apparent trend. This may be a function of their inhomogeneous distribution in soil and/or a reflection of the specific laboratory and procedure used. For example, the samples collected in 2006 were analyzed using an extraction procedure which resulted in greater radionuclide yields than previous analyses.

The INL Contractor performed 326 field-based in situ gamma spectrometry measurements and 12 roadway and facility perimeter measurements in 2006. See Appendix E for a more in-depth discussion. Table 7-5 provides a summary of the measurements performed. In addition to the in situ gamma spectrometry measurements, six additional grab samples were collected from 0-5 cm (0-2 in.) at selected locations. Table 7-6 summarizes the analytical laboratory gamma and radiochemistry results. The results are compared with INL Site-specific soil concentration guidelines, the Environmental Concentration Guides (ECGs). The ECGs were derived assuming a subsistence farming scenario and a 100 mrem dose









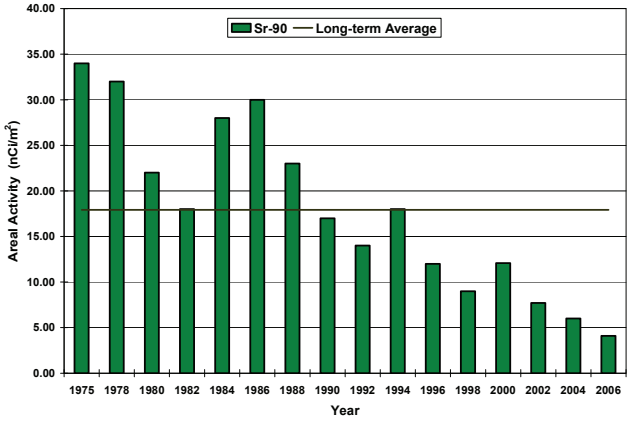


Figure 7-4. Geometric Mean Areal Activity in Offsite Surface (0-5 cm [0-2 in.]) Soils (1975-2006).

Table 7-5. In-Situ Gamma Results Measured by the INL Contractor (2006).

Location[a]	Radionuclide	Concentration (picocuries per gram) Minimum	Maximum	Mean	Comment
Auxiliary Reactor Area (ARA)	Cesium-137	0.0629	17.3	2.28	The mean concentrations are within background measurements for the INL Site and surrounding areas and attributable to past fallout. However, maximum concentrations are above background measurements for the INL Site, but consistent with historical concentrations at ARA.
Idaho Nuclear Technology and Engineering Center	Cesium-137	0.0003	8.79	0.88	Concentrations are above background for the INL Site, but consistent with historical concentrations at INTEC.
Large Grid	Cesium-137	0.0267	0.387	0.0849	Concentrations within background for the INL and surrounding areas and attributable to past fallout.
Reactor Technology Complex	Cesium-137	0.0782	0.407	0.202	Concentrations within background for the INL and surrounding areas and attributable to past fallout.
Radioactive Waste Management Complex	Cesium-137	0.0724	0.149	0.112	Concentrations within background for the INL and surrounding areas and attributable to past fallout.
Test Area North	Cesium-137	0.0706	0.492	0.141	Concentrations within background for the INL and surrounding areas and attributable to past fallout.
		Concentration (picocuries per m^2)[b]			
Critical Infrastructure Test Range Complex	Cesium-137	10900	20100	15500	Concentrations within background measurements for the INL Site and surrounding areas and attributable to past fallout.
Materials and Fuels Complex	Cesium-137	12700	25600	18700	Concentrations within background measurements for the INL Site and surrounding areas and attributable to past fallout.
Naval Reactors Facility	Cesium-137	11500	31800	22200	Concentrations within background for the INL and surrounding areas and attributable to past fallout.

a. In situ data were collected outside the fenced facility areas by the INL contractor.

b. Concentrations at these facilities are reported in pCi/m^2 because the Cesium-137 depth profile calculations for these sites were shown to be planar (i.e. just on the ground surface).

Table 7-6. Site Surveillance Soil Sampling Laboratory Results Measured by the INL Contractor (2006).

Location	Radionuclide	Minimum Concentration[a]	Maximum Concentration[a]	%ECG[b]
Reactor Technology Center	Cesium-137	0.46 ± 0.04	0.58 ± 0.05	15.09
	Americium-241	0.0056 ± 0.0017	0.0113 ± 0.0017	0.03
	Plutonium-238	0.043 ± 0.0015	0.0059 ± 0.0018	<0.01
	Plutonium-239/240	0.0170 ± 0.0032	0.0218 ± 0.0035	0.04
	Strontium-90	NA	0.0582± 0.0181	0.01
Test Area North	Cesium-137	0.30 ± 0.03	0.69 ± 0.05	18.05
	Americium-241	0.0032 ± 0.0021	0.0057 ± 0.0015	0.02
	Plutonium-239/240	0.0125 ± 0.0026	0.0174 ± 0.0032	0.03

a. Units are picocuries per gram ±1s.

b. ECG = Environmental Concentration Guide (EG&G 1986).

to the individual exposed to the contaminated soil (EG&G 1986). Uranium isotopes were detected in all samples at levels that indicated they were from natural sources.

WLAP Soil Sampling at CFA

The Wastewater Land Application Permit (WLAP) for the CFA Sewage Treatment Facility allows for nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation. Soils are sampled at ten locations within the CFA land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.), 30 to 61 cm (12 to 24 in.), and 61-91 cm (24 to 36 in.) at each location and composited for each depth interval, yielding three samples, one from each depth. These samples are analyzed for pH, electrical conductivity, sodium absorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the WLAP, to determine whether wastewater application is adversely affecting soil chemistry. The analytical results for the soil samples are summarized in Table 7-7. The analytical results for 2005 are included for comparison.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures to ambient ionizing radiation. The TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. The 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 (approximately 3 ft) above the ground at specified locations. The four chips provide replicate measurements at each location. The TLD packets are replaced in May and November of each year. The sampling periods for 2006 were from November 2005 through April 2006 (spring) and from May 2006 through October 2006 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2005 through October 2006 is shown in Table 7-8 for two adjacent sets of dosimeters maintained by the ESER

Table 7-7. Soil Monitoring Results for the CFA Sewage Treatment Facility Wastewater Land Application Area (2005-2006).

Parameter	Depth (in.)	2005	2006[a]
pH	0–12	8.02	8.29
	12–24	7.94	8.05
	24–36	8.03	8.15
Electrical Conductivity (mmhos/cm)	0–12	1.93	0.86
	12–24	2.86	3.20
	24–36	2.10	3.54
Organic Matter (%)	0–12	1.49	1.76
	12–24	0.79	0.933
	24–36	0.46	0.562
Nitrate as Nitrogen (ppm)	0–12	5.44	3.07
	12–24	1.66	1.003 U[b]
	24–36	1.73	0.998 U
Ammonium Nitrogen (ppm)	0–12	0.49 U	1.99
	12–24	0.48U	0.501 U
	24–36	0.49 U	0.501 U
Extractable Phosphorus (ppm)	0–12	13.10	10.60
	12–24	3.26	1.94
	24–36	1.72	0.99 U
Sodium Adsorption Ratio	0–12	5.64	9.68
	12–24	3.94	7.45
	24–36	3.12	10.00

a. The 24–36 in. sample at location #4 was not collected because of "refusal."

b. U flag indicates that the result was reported as below the detection limit.

and Site contractors. For purposes of comparison, annual exposures from 2002-2005 are also included for each location.

The mean annual exposures from distant locations in 2006 were 113 milliroentgens (mR) as measured by the ESER dosimeters and 113 mR as measured by the INL contractor dosimeters (Table 7-8). For boundary locations, the mean annual exposures were 111 mR as measured by ESER contractor dosimeters and 110 mR as measured by INL contractor dosimeters. Using both ESER and INL contractors' data, the average dose equivalent of the distant group was 116 millirem (mrem), when a dose equivalent conversion factor of 1.03 was used to convert from milliroentgens to millirem in tissue (NRC 1997). The average dose equivalent for the boundary group was 114 mrem.

Onsite TLDs maintained by the INL contractor representing the same exposure period as the offsite dosimeters are shown in Appendix D, Figures D-1 through D-10. Onsite dosimeters were placed on facility perimeters, concentrated in areas likely to show the highest gamma radiation readings. Other onsite dosimeters are located in the vicinity of radioactive materials storage areas. At some facilities, elevated exposures result from areas of soil contamination around the perimeter of these facilities.

Table 7-8. Annual Environmental Radiation Exposures (2002-2006).[a]

Distant Group	2002		2003		2004		2005		2006	
	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors	ESER	Site Contractors
Distant Group										
Aberdeen	141 ± 10	126 ± 9	123 ± 4	122 ± 9	130 ± 9	127 ± 9	124 ± 7	130 ± 9	126 ± 9	124 ± 9
Blackfoot	125 ± 9	119 ± 9	117 ± 4	111 ± 8		109 ± 8	129 ± 9	113 ± 8	115 ± 8	104 ± 7
Blackfoot (CMS)[b]	113 ± 8		101 ± 4		108 ± 8		117 ± 2		106 ± 7	
Craters of the Moon	121 ± 9	124 ± 9	116 ± 4	122 ± 9	118 ± 8	NS[c]	138 ± 8	122 ± 8	111 ± 7	112 ± 8
Dubois[b]	109 ± 8		98 ± 3		105 ± 7		117 ± 5		95 ± 7	
Idaho Falls	126 ± 9	112 ± 8	126 ± 9	111 ± 8	124 ± 9	114 ± 8	122 ± 2	116 ± 8	119 ± 8	110 ± 8
Jackson[b]	97 ± 7		97 ± 7		100 ± 7		106 ± 7		90 ± 6	
Minidoka	111 ± 8	107 ± 8	111 ± 8	104 ± 7	108 ± 8	107 ± 7	116 ± 3	112 ± 8	107 ± 7	103 ± 7
Rexburg	144 ± 10	115 ± 8	136 ± 5	116 ± 8	137 ± 10	118 ± 8	152 ± 2	121 ± 8	134 ± 9	113 ± 8
Roberts	134 ± 13	132 ± 9	126 ± 4	133 ± 9	133 ± 9	132 ± 9	126 ± 11	NS	126 ± 9	123 ± 9
Mean	**120 ± 3**	**119 ± 3**	**114 ± 2**	**117 ± 3**	**118 ± 3**	**118 ± 3**	**121 ± 3**	**119 ± 3**	**113 ± 2**	**113 ± 3**
Boundary Group										
Arco	126 ± 9	120 ± 9	113 ± 4	118 ± 8	124 ± 9	126 ± 9	124 ± 9	120 ± 8	115 ± 8	111 ± 8
Atomic City	130 ± 9	124 ± 9	120 ± 4	124 ± 9	132 ± 9	NS	132 ± 9	NS	119 ± 8	112 ± 8
Blue Dome[b]	106 ± 8		103 ± 4		104 ± 7		104 ± 7		101 ± 7	
Howe	121 ± 9	NS	109 ± 4	110 ± 8	121 ± 8	114 ± 8	121 ± 8	116 ± 8	108 ± 8	105 ± 7
Monteview	118 ± 8	115 ± 8	106 ± 4	112 ± 8	119 ± 8	116 ± 8	119 ± 8	121 ± 8	110 ± 8	107 ± 7
Mud Lake	136 ± 10	129 ± 9	124 ± 4	122 ± 8	130 ± 9	133 ± 9	130 ± 9	130 ± 8	119 ± 8	120 ± 8
Birch Creek Hydro	110 ± 8	104 ± 7	105 ± 4	105 ± 7	112 ± 8	108 ± 8	112 ± 8	NS	104 ± 7	103 ± 7
Mean	**124 ± 4**	**118 ± 4**	**113 ± 2**	**115 ± 3**	**120 ± 3**	**119 ± 4**	**120 ± 3**	**119 ± 4**	**111 ± 3**	**110 ± 3**

a. All values are in milliroentgens with ± 1 standard deviation.
b. The INL contractor does not sample at this location.
c. Dosimeter was missing at one of the collection times.
NS = Not Sampled.

The maximum exposure onsite recorded during 2006 was 457 mR at location RWMC 41. This dosimeter is located near active waste storage and management areas. The 2006 exposure is somewhat higher than that of the previous year.

Locations RTC 2, 3, and 4 are adjacent to the former radioactive disposal ponds, which have been drained and covered with clean soil and large rocks. The levels at RTC 2 and 3 are less than one fourth of the values in 2002 (DOE-ID 2003).

The Idaho Nuclear Technology and Engineering Center (INTEC) 20 TLD is located near a radioactive material storage area with an exposure of 257 mR. Exposures at INTEC 20 and the INTEC Tree Farm for 2006 were all comparable to historical exposures.

Table 7-9 summarizes the calculated effective dose equivalent an individual receives on the Snake River Plain from various background radiation sources.

The terrestrial portion of natural background radiation exposure 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 are not expected to change significantly over this relatively short time period. Data indicated the average concentrations of uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above average area soil concentrations were 21, 28, and 27 mrem/year, respectively, for a total of 76 mrem/year. Because snow cover can reduce the effective dose equivalent Idaho residents receive from the soil, a correction factor must be made each year to the above estimate of 76 mrem/year. For 2006, this resulted in a corrected dose of 69 mrem/year because of snow cover, which ranged from 2.54 to 25.4 cm (1 to 10 in.) in depth with an average of 16.4 cm (6.48 in.) over 101 days with recorded snow cover (Table 7-9).

Table 7-9. Calculated Effective Dose Equivalent from Background Sources (2006).

Source of Radiation Dose Equivalent		Total Average Annual Dose[a]	
		Calculated	Measured
External			
	Terrestrial	69	NA[b]
	Cosmic	48	NA
	Subtotal	117	116
Internal			
	Cosmogenic	1	
	Inhaled Radionuclides	200	
	^{40}K and others	39	
	Subtotal	240	
Total		**357**	

a. All values are in millirem.
b. NA indicates terrestrial and cosmic radiation parameters were not measured individually.

The cosmic component varies primarily with altitude increasing from about 26 mrem at sea level to about 48 mrem at the elevation of the INL Site at approximately 1500 m (4900 ft) (NCRP 1987). Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2006 was 117 mrem (Table 7-9). This is nearly identical to the 116 mrem measured at distant locations by the ESER and INL Contractor TLDs after conversion from mR to mrem in tissue. Measured values are very close, and within normal variability, of the calculated background doses (Table 7-8 and Table 7-9). Therefore, it is unlikely that INL Site operations contribute to background radiation levels at distant locations.

The component of background dose that varies the most is inhaled radionuclides. According to the National Council on Radiation Protection and Measurements, the major contributor of external dose equivalent received by a member of the public from ^{238}U plus decay products are short-lived decay products of radon (NCRP 1987). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of the soil and rock of the area. This also varies between 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 200 mrem was used in Table 7-9 for this component of the total background dose because no specific estimate for southeastern Idaho has been made and few specific measurements have been made of radon in homes in this area. Therefore, the effective dose equivalent from natural background radiation for residents in the INL Site vicinity may actually be higher or lower than the total estimated background dose of about 357 mrem shown in Table 7-9 and will vary from one location to another.

7.4 Waste Management Surveillance Sampling

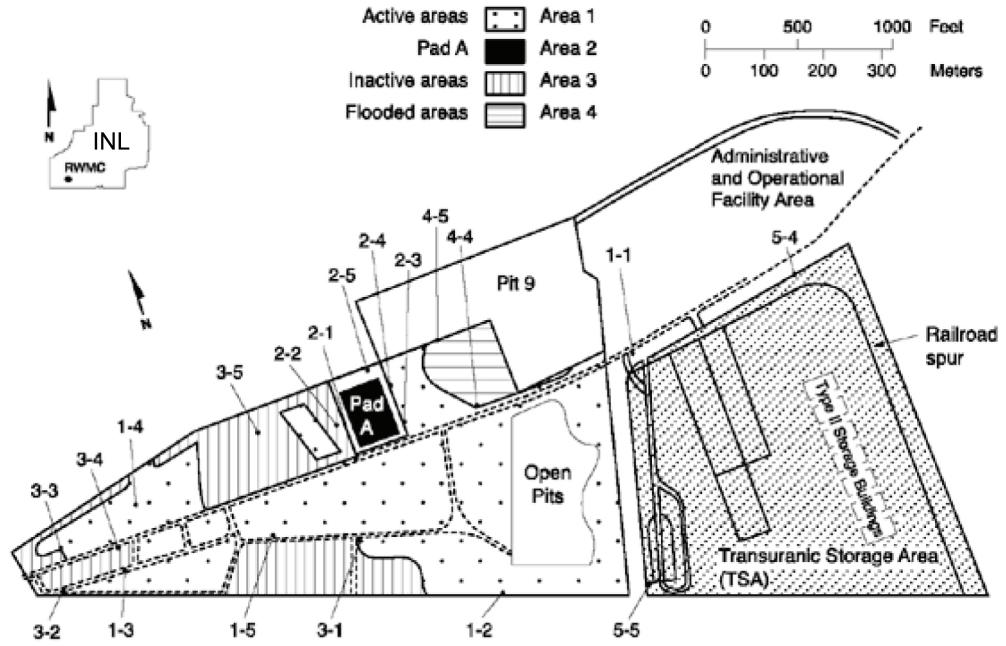
Vegetation and soil are sampled, and direct radiation is measured at Radioactive Waste Management Complex (RWMC). These surveillance activities are performed to comply with DOE Order 435.1, "Radioactive Waste Management" (DOE 2001).

Vegetation Sampling

At RWMC, vegetation is collected from four major areas. Russian thistle (an invasive species) is collected in even-numbered years if it is available. Due to recontouring and construction activities at the RWMC, Russian thistle was not available for sampling in 2006.

Soil Sampling

Biennial soil sampling was conducted during 2006. Soil samples were collected to a depth of 5 cm (2 in.) at the RWMC locations shown in Figure 7-5. The soils were analyzed for gamma-emitting radionuclides. The maximum ^{137}C sample concentration was 0.35 pCi/g (3.5 percent of Environmental Concentration Guide [EG&G 1986]). Selected samples were analyzed for specific alpha-emitting and beta-emitting radionuclides. Table 7-10 summarizes the results of human-made radionuclides. Cesium-137 and ^{90}Sr concentrations are within background for the INL Site and surrounding areas and are attributable to past fallout. Americium-241 and $^{239/240}Pu$ concentrations are above background for the INL Site but are consistent with historical concentrations at RWMC and are attributable to past operational conditions and fallout.



Location	General Reference
1-1	Discharge Channel
1-2	6th pole on South side
1-3	Trench 13 West monument
1-4	Middle of Pit 2
1-5	Southwest end of Pit 10, near road
2-1	South end of Pad A culvert
2-2	West side of Pad A
2-3	Southeast, mid-slope
2-4	Northeast, bottom of slope
2-5	North, bottom of slope
3-1	Trench 34 near LMITCO Well 76-4A
3-2	Between West Trench 4 & 6 monuments
3-3	Near LMITCO Well 93

Location	General Reference
3-4	Monitoring Station 25
3-5	Monitoring Station 19
4-4	Pit 8 Southeast Monument
4-5	Pit 8 Northwest Monument
5-4	Channel draining East side of Pad
5-5	West side of ILTSF

Figure 7-5. RWMC Soil Sampling Locations.

Table 7-10. RWMC Soil Sampling Results (2006).

Parameter	Minimum Concentration[a]	Maximum Concentration[a]	%ECG[b]
Cesium-137	0.044 ± 0.012	0.345 ± 0.037	3.5
Americium-241	0.010 ± 0.0028	0.378 ± 0.043	0.47
Plutonium-239/240	0.008 ± 0.002	0.304 ± 0.035	0.10
Strontium-90	0.113 ± 0.020	0.113 ± 0.020	0.56

a. Concentrations are in picocuries per gram ± 1 standard deviation.

b. ECG = Environmental Concentration Guide (EG&G 1986) in picocuries per gram.

Direct Radiation

The global positioning radiometric scanner system was used to conduct soil surface radiation (gross gamma) surveys at the Subsurface Disposal Area to complement soil sampling. The radiometric scanner is mounted on a four-wheel drive vehicle. The system includes two plastic scintillators that measure gross gamma radiation in counts per second (cps) with no coincidence corrections or energy compensation (elevated count rates indicate possible areas of contamination or elevated background). Both the global positioning system and radiometric data are continuously recorded.

Figure 7-6 shows the radiation readings from the 2006 RWMC annual survey. The survey around the active low-level waste pit was comparable to, or lower than, historical measurements for that area (see Table 7-11). The maximum gross gamma radiation was 22,725 cps measured at the western end of the SVR-7 soil vault row.

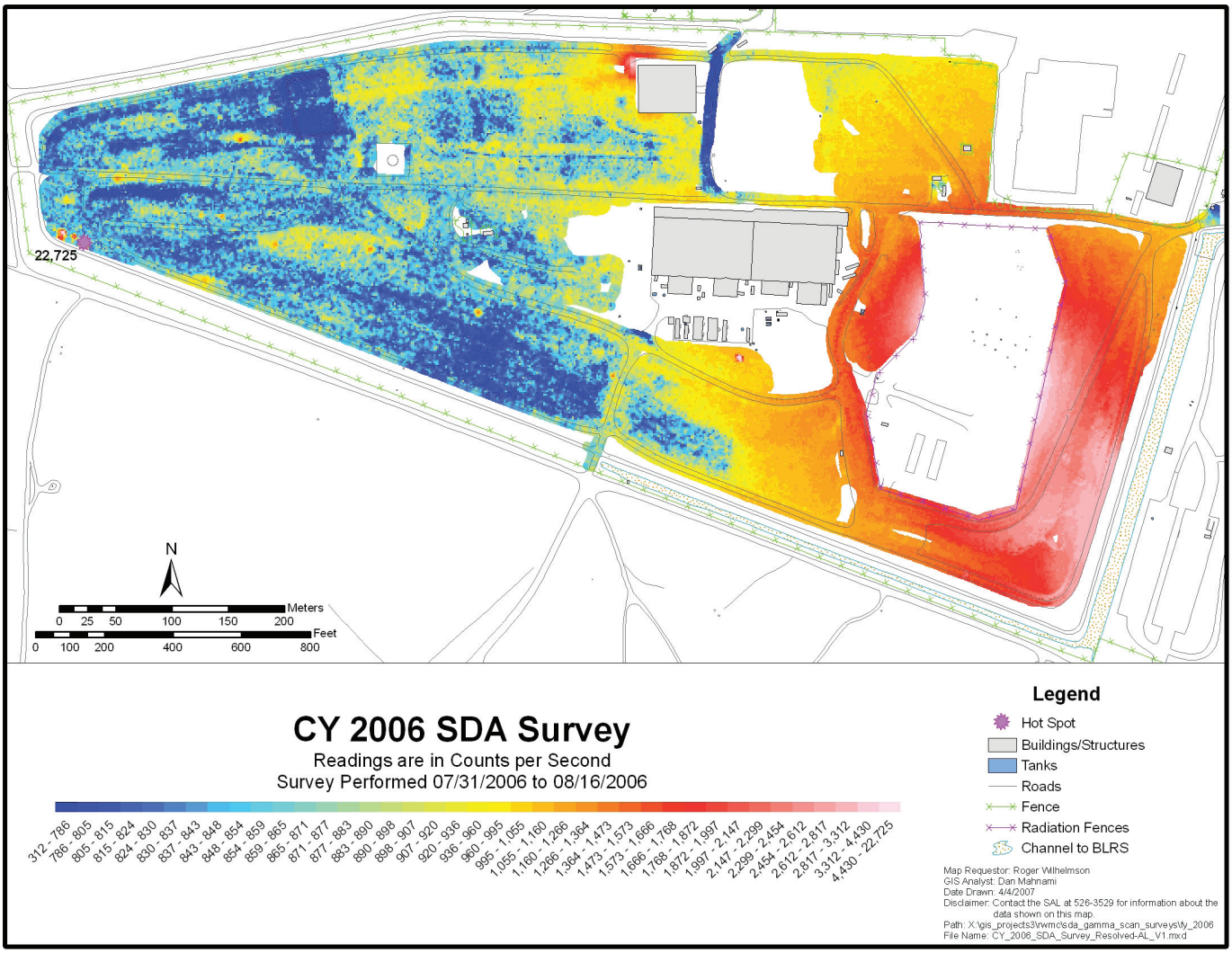


Figure 7-6. RWMC Surface Radiation Survey (2006).

Table 7-11. RWMC Survey Comparison to Previous Years (cps).

Location	2002	2003	2004	2005	2006
Soil Vault Row-7	34,200	30,000	25,600	24,800	22,725
Active Pit	23,000	13,800	15,000	30,200	13,463

Although readings vary slightly from year to year, the results are comparable to previous years' measurements, with the exception of elevated readings at the northwestern corner of WMF-698, which are caused by Accelerated Retrieval Project waste drum storage during 2006.

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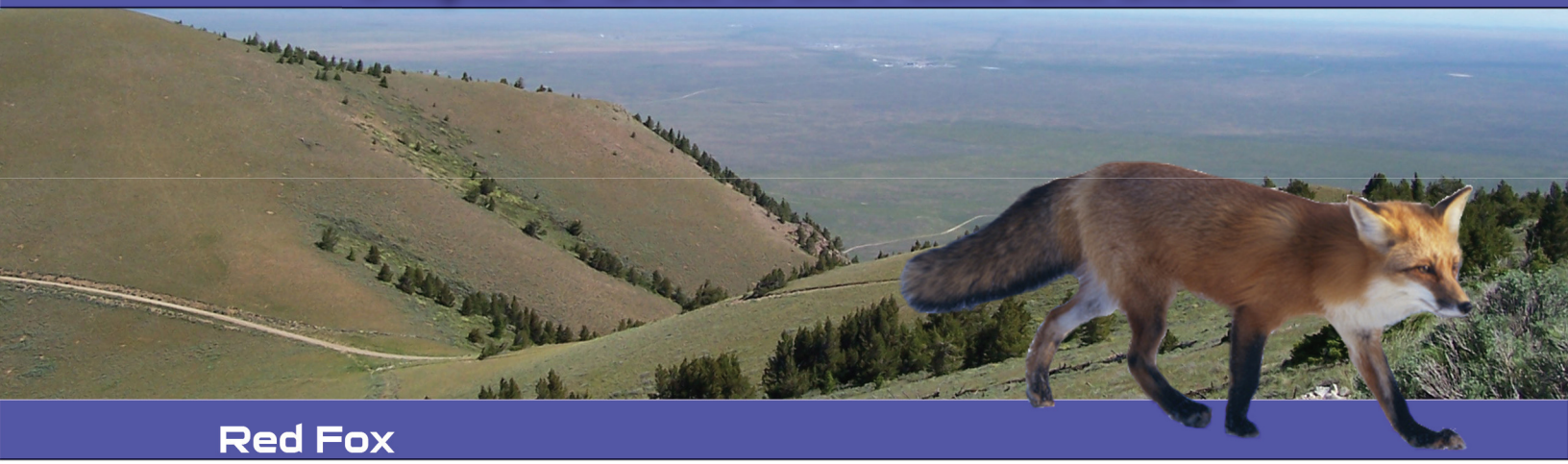
Mule Deer

Chapter 8 - Dose to the Public and Biota



Red Fox

M. Case - S. M. Stoller Corporation
R. Mitchell - RM Technical Services
K. Clawson and R. Eckman - National Oceanic and Atmospheric Administration

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 2003). DOE Order 5400.5 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..." (DOE 1993). This chapter describes the dose to members of the public and to the environment based on the 2006 radionuclide concentrations from operations at the Idaho National Laboratory (INL) Site.

8.1 General Information

Individual radiological impacts to the public surrounding the INL Site remain too small to be measured by available monitoring techniques. To show compliance with federal regulations established to ensure public safety, the dose from INL Site operations was calculated using the reported amounts of radionuclides released during the year from INL Site facilities (see Chapter 4) and appropriate air dispersion computer codes. During 2006, this was accomplished for the radionuclides summarized in Table 4-2.

The following estimates were calculated:

- The effective dose equivalent to the hypothetical maximally exposed individual (MEI), as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, using the Clean Air Act Assessment Package, 1988 (CAP-88) computer code as required by the regulation (Cahki and Parks 2000)
- The effective dose equivalent to the MEI residing offsite using dispersion values from the mesoscale diffusion (MDIFF) model (Sagendorf et al. 2001) to comply with DOE Orders.

The collective effective dose equivalent (population dose) for the population within 80 km (50 mi) of any INL Site facility to comply with DOE Order 5400.5 (DOE 1993). The estimated population dose was based on the effective dose equivalent calculated from the MDIFF air dispersion model for the MEI.

In this chapter, the term dose refers to effective dose equivalent unless another term is specifically stated. Dose was calculated by summing the effective dose equivalents from immersion, inhalation, ingestion, and deposition. Effective dose equivalent includes doses received from both external and internal sources and represents the same risk as if an individual's body were uniformly irradiated. U.S. Environmental Protection Agency (EPA) dose conversion factors and a 50-year integration period were used in calculations in combination with the MDIFF air dispersion model for internally deposited radionuclides (Eckerman et al. 1988) and for radionuclides deposited on the ground surface (Eckerman and Ryman 1993). The CAP-88 computer code uses dose and risk tables developed by the EPA. No allowance is made in the dose calculations using MDIFF for shielding by housing materials, which is estimated to reduce the dose by about 30 percent, or less than year-round occupancy time in the community. The CAP 88 computer code does not include shielding by housing materials, but it does include a factor to allow for shielding by surface soil contours from radioactivity on the ground surface.

Of the potential exposure pathways by which radioactive materials from INL Site operations could be transported offsite (see Figure 3-1), atmospheric transport is the principal potential pathway for exposure to the surrounding population. This is because winds can carry airborne radioactive material rapidly and some distance from its source. The water pathways are not considered major contributors to dose because no surface water flows off the INL Site and no radionuclides from the INL Site have been found in drinking water wells offsite. Because of these factors, the MEI dose is determined through the use of computer codes of atmospheric dispersion of airborne materials.

8.2 Maximum Individual Dose - Airborne Emissions Pathway

Summary of Computer Codes

The NESHAP, as outlined in Title 40, Code of Federal Regulations (CFR), Part 61 (40 CFR Part 61), Subpart H, requires the demonstration 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/year (EPA 2006). This includes releases from stacks and diffuse sources. The EPA requires the use of an approved computer code to demonstrate compliance with 40 CFR Part 61. The INL Site uses the code CAP 88 as recommended in 40 CFR 61 to demonstrate NESHAP compliance.

The National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division (NOAA ARL-FRD) developed a mesoscale air dispersion model called MDIFF (formerly known as MESODIF) (Sagendorf et al. 2001) around 1970. The MDIFF diffusion curves were developed by the NOAA ARL-FRD from tests in arid environments (e.g., the INL Site and the Hanford Site in eastern Washington). The MDIFF curves are more appropriate for estimating dose to the public caused by INL Site emissions than those used by the CAP-88 code. The MDIFF code is a dispersion model only and does not account for plume depletion and radioactive decay.

The MDIFF model is used to calculate total integrated concentrations (TICs) that are then used to calculate the dose to members of the public residing near the INL Site. In previous years, doses calculated from the MDIFF TICs have been somewhat higher than doses calculated using CAP-88. Differences between the two computer codes were discussed in detail in the 1986 annual report (Hoff et al. 1987). The primary difference is the atmospheric dispersion portion of the codes. CAP-88 makes its calculations based on the joint frequency of wind conditions from a single wind station located near the source in a straight line from

that source and ignores recirculation. MDIFF calculates the trajectories of a puff using wind information from 36 towers in the Upper Snake River Plain. This allows for more accurate and site-specific modeling of the movement of a release using prevailing wind conditions between time of the release and the time that the plume leaves the INL Site boundary. For this reason, the two computer codes may not agree on the location of the MEI or the magnitude of the maximum dose.

The offsite concentrations calculated using both computer codes were compared to actual monitoring results using the radionuclide antimony-125 at offsite locations in 1986, 1987, and 1988 (Hoff et al. 1987, Chew and Mitchell 1988, Hoff et al. 1989). Concentrations calculated for several locations using the MDIFF TICs showed good agreement (within a factor of 2) with concentrations from actual measurements, with the model calculations generally predicting concentrations higher than those measured. The original computer code (MESODIF) was extensively studied and validated, and compared to other models in the mid-1980s (Lewellen, et al. 1985, Start et al. 1985, Sagendorf and Fairobent 1986).

CAP–88 Computer Code

The dose from INL Site airborne releases of radionuclides calculated to demonstrate compliance with NESHAP are published in the National Emissions Standards for Hazardous Air Pollutants-Calendar Year 2006 INL Report for Radionuclides (DOE-ID 2007). For these calculations, 63 potential maximum locations were evaluated. The CAP-88 computer code predicted the highest dose to be at Frenchman's Cabin, located at the southern boundary of the INL Site. This location is only inhabited during portions of the year, but it must be considered as a potential MEI location according to the NESHAP. At Frenchman's Cabin, an effective dose equivalent of 0.039 mrem (0.39 μSv) was calculated. The dose of 0.039 mrem (0.39 μSv) is well below the whole body dose limit of 10 mrem (100 μSv) for airborne releases of radionuclides established by 40 CFR 61.

MDIFF Model

Using data gathered continuously at 36 meteorological stations on and around the INL Site and the MDIFF model, the NOAA ARL-FRD prepares a mesoscale map (Figure 8-1) showing the calculated 2006 time integrated concentrations (TICs). These TICs are based on a unit release rate weighted by percent contribution for each of six INL Site facilities: Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC), Reactor Technology Complex (RTC), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN). To create the isopleths shown in Figure 8-1, the TIC values are contoured. Average air concentrations (in curies per cubic meter [Ci/m^3]) for a radionuclide released from a facility are estimated from a TIC isopleth (line of equal air concentration) in Figure 8-1. To calculate the average air concentration, the TIC is multiplied by the quantity of the radionuclide released (in curies [Ci]) during the year and divided by the number of hours in a year squared (8760 hour)^2 or 7.67 x 10^7 hour^2. This does not account for plume depletion, radioactive decay, or in-growth or decay of radioactive progeny.

The average air concentrations calculated by MDIFF were input into a Microsoft Excel spreadsheet program developed by the Environmental Surveillance, Education and Research (ESER) Program to calculate doses using methods outlined in U.S. Nuclear Regulatory Commission (NRC 1977) and dose conversion factors provided by EPA (EPA 2002). In 2000, a revision to the methods and values used for the calculation of the MEI dose using the MDIFF TIC values was undertaken. Values for the deposition

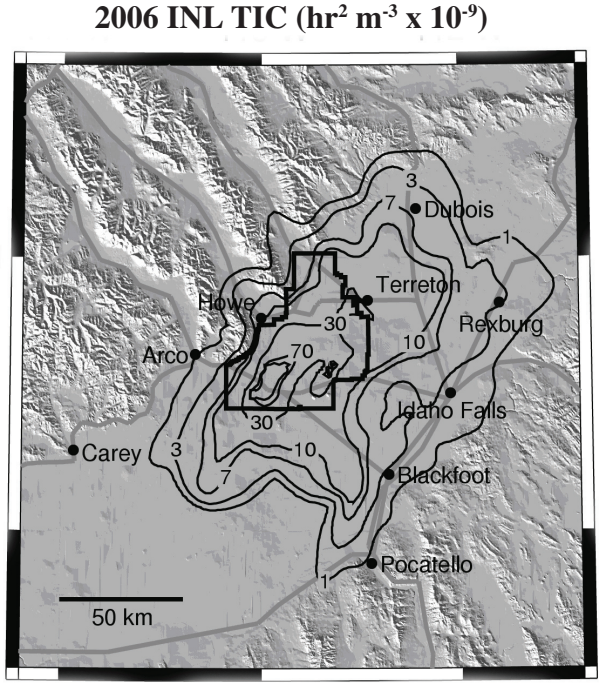


Figure 8-1. Average Mesoscale Isopleths of Total Integrated Concentrations at Ground Level Normalized to Unit Release Rates from all INL Site Facilities.

and plant uptake rates of radionuclides, most noticeably radioiodines, were modified to reflect present operations and current values in use. The most notable change, mathematically, is the increase of the iodine-129 (^{129}I) deposition velocity from 0.01 m/second (0.03 ft/second) to 0.035 m/second (0.11 ft/second), as the emitted radioiodines went from predominantly organic in nature to elemental. These changes resulted in a mathematical increase in the amount of radionuclides deposited on the ground and available for plant uptake. This increase in deposited radionuclides leads to a corresponding net increase in the ingestion dose.

The MDIFF model predicted that the highest TIC for radionuclides in air at a location with a year-round resident during 2006 would have occurred northwest of Mud Lake. The maximum hypothetical dose was calculated for an adult resident at that location from inhalation of air, submersion in air, ingestion of radioactivity on leafy vegetables, and exposure because of deposition of radioactive particles on the ground. The calculation was based on data presented in Table 4-2 (Sections A, B, C, and D) and the grid used to produce Figure 8-1.

Using the largest calculated TIC for each facility (Table 8-1) at the location inhabited by a full-time resident, and allowing for radioactive decay and plume depletion during the transit of the radionuclides from each facility to the location of the MEI (northwest of Mud Lake), the potential annual effective dose equivalent from all radionuclides released was calculated to be 0.050 mrem (0.50 μSv) (Table 8-2). This dose is well below the whole body dose limit of 10 mrem set in the 40 CFR 61 for airborne releases of radionuclides.

For 2006, the ingestion pathway was the primary route of exposure and accounted for 74 percent of the total dose, followed by inhalation at 24 percent, and immersion at 2 percent. Deposition accounted for only 0.05 percent of the dose.

Table 8-1. Total Integrated Concentration (TIC), Travel Time, and Distance from Each Facility to the MEI Location (2006).

Facility	Total Integrated Concentration (hr^2/m^3)	Travel Time hours	Distance km (miles)
CFA	3.24×10^{-8}	2.30	45.5 (28.2)
INTEC	2.84×10^{-8}	2.99	42.3 (26.3)
MFC	3.29×10^{-8}	1.89	30.5 (18.9)
RTC	2.82×10^{-8}	2.20	42.4 (26.4)
RWMC	2.74×10^{-8}	3.33	54.7 (34.0)
TAN	2.14×10^{-7}	0.73	10.1 (6.3)

Table 8-2. Maximum individual effective dose equivalent as calculated from MDIFF model results (2006).

Radionuclide[a]	Radionuclide Concentration in Air at Maximum Offsite Location[b] (Ci/m^3)	Maximum Effective Dose Equivalent	
		mrem	mSv
^{137}Cs + D[c,d]	5.82×10^{-16}	2.45×10^{-2}	2.45×10^{-4}
^{90}Sr + D[d]	4.34×10^{-17}	1.11×10^{-2}	1.11×10^{-4}
^{239}Pu	7.62×10^{-19}	4.36×10^{-3}	4.36×10^{-5}
^{240}Pu	5.30×10^{-19}	3.22×10^{-3}	3.22×10^{-5}
^{129}I[c]	8.05×10^{-18}	2.64×10^{-3}	2.64×10^{-5}
^{41}Ar	8.66×10^{-14}	6.57×10^{-4}	6.57×10^{-6}
^{241}Am	8.24×10^{-20}	5.50×10^{-4}	5.50×10^{-6}
^{241}Pu	4.83×10^{-18}	5.13×10^{-4}	5.13×10^{-6}
^{226}Ra	5.04×10^{-20}	4.21×10^{-4}	4.21×10^{-6}
^{238}Pu	9.28×10^{-20}	4.21×10^{-4}	4.21×10^{-6}
^{131}I	6.49×10^{-17}	3.43×10^{-4}	3.43×10^{-6}
^{3}H (tritium)	3.69×10^{-13}	2.02×10^{-4}	2.02×10^{-6}
^{152}Eu	2.13×10^{-17}	1.57×10^{-4}	1.57×10^{-6}
^{154}Eu	1.22×10^{-17}	1.27×10^{-4}	1.27×10^{-6}
All Others	NA	5.70×10^{-4}	5.70×10^{-6}
Total		**4.98×10^{-2}**	**4.98×10^{-4}**

a. Table includes only radionuclides that contribute a dose of 1.0×10^{-4} mrem or more.
b. Estimate of radioactive decay is based on a transport time from each facility using the distance to MEI location and the average wind speed in that direction from each facility.
c. Concentration adjusted for plume depletion.
d. When indicated (+D), the contribution of progeny decay products was also included in the dose calculations.

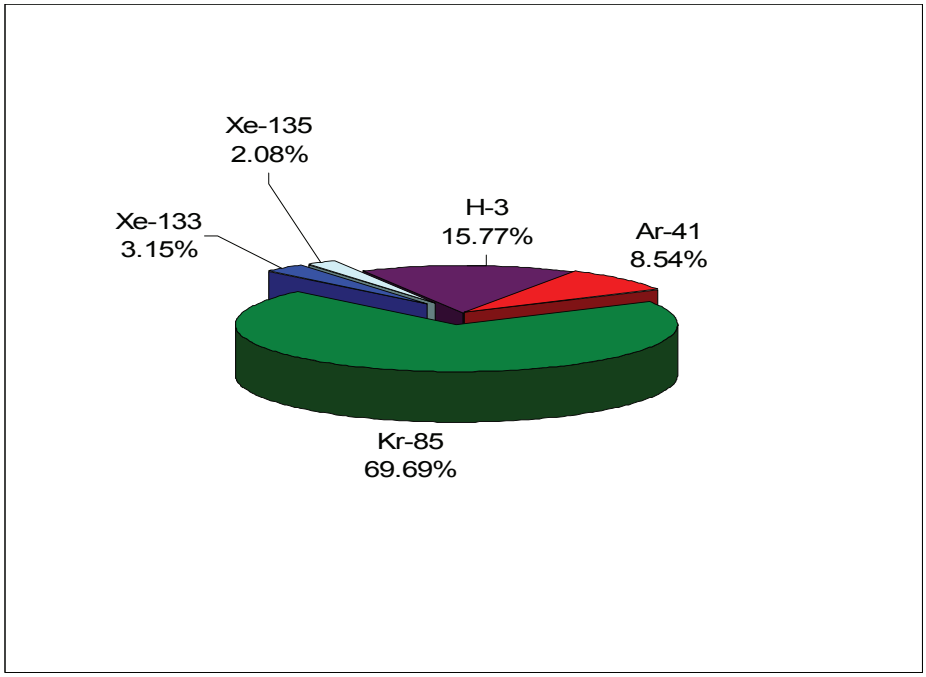


Figure 8-2. Airborne Radionuclides Released to the Environment (2006).

Radionuclide releases for 2006 are presented in Figure 8-2. The noble gas krypton-85 (^{85}Kr) accounted for approximately 70 percent of the total release, followed by tritium with 16 percent, and argon-41 (^{41}Ar) at 9 percent of the total. The noble gases xenon-133 (^{133}Xe) and -135 (^{135}Xe) contributed 3 and 2 percent, respectively. However, because these are noble gases they contribute very little to the cumulative dose (affecting immersion only). Other than ^{41}Ar and tritium (^{3}H), the radionuclides contributing to the overall dose were 0.01 percent of the total radionuclides released.

The largest contributor to the MEI dose was cesium-137 (^{137}Cs), accounting for 49.2 percent of the total dose (Figure 8-3). This was followed by strontium-90 (^{90}Sr) at 22.3 percent. Isotopes of plutonium (plutonium-238 [^{238}Pu], plutonium-239 [^{239}Pu], plutonium-240 [^{240}Pu], and plutonium-241 [^{241}Pu]) contributed a total of 13.7 percent to the dose.

The respective contribution to the overall dose by facility is as follows: TAN (78 percent), INTEC (17 percent), RTC (4 percent), and RWMC (1 percent). MFC and CFA accounted for only 0.02 percent of the dose. The calculated maximum dose resulting from INL Site operations is still a small fraction of the average dose received by individuals in southeastern Idaho from cosmic and terrestrial sources of naturally occurring radiation found in the environment. The total annual dose from all natural sources is estimated at approximately 357 mrem (Table 7-9).

Table 8-3 summarizes the calculated annual effective dose equivalents for 2006 from INL Site operations using both the CAP 88 and MDIFF air dispersion computer codes. A comparison is shown between these doses and the EPA airborne pathway standard and the estimated dose from natural background.

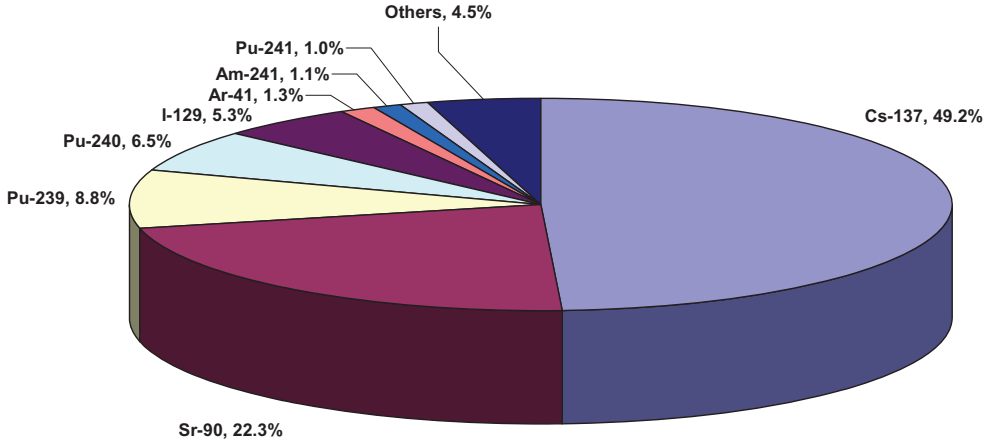


Figure 8-2. Airborne Radionuclides Released to the Environment (2006)
(as calculated using the MDIFF air dispersion model) (2006).

Table 8-3. Summary of Annual Effective Dose Equivalents Because of INL Site Operations (2006).

	Maximum Dose to an Individual[a]		Population Dose
	CAP-88[b]	MDIFF[c]	MDIFF
Dose	0.039 mrem (3.9×10^{-4} mSv)	0.050 mrem (5.0×10^{-4} mSv)	0.611 person-rem (6.1×10^{-3} person-Sv)
Location	Frenchman's Cabin	Northwest of Mud Lake	Area within 80 km (50 mi) of any INL Site facility
Applicable radiation protection standard[d]	10 mrem (0.1 mSv)	10 mrem (0.1 mSv)	No standard
Percentage of standard	0.39 percent	0.50 percent	No standard
Natural background	357 mrem (3.6 mSv)	357 mrem (3.6 mSv)	103,822 person-rem (1,038 person-Sv)
Percentage of background	0.011 percent	0.014 percent	0.0006 percent

a. Hypothetical dose to the maximally exposed individual residing near the INL Site.
b. Effective dose equivalent calculated using the CAP-88 code.
c. Effective dose equivalent calculated using the MDIFF air dispersion model. MDIFF calculations do not consider occupancy time or shielding by buildings.
d. Although the DOE standard for all exposure models is 100 mrem/yr as given in DOE Order 5400.5, DOE guidance states that DOE facilities will comply with the EPA standard for the airborne pathway of 10 mrem/year.

8.3 80 Kilometer (50 Mile) Population Dose

As with the calculation of the maximum individual dose, the determination of the population dose also underwent changes in 2000. Using the power of a geographical information system (ArcView), annual population no longer needs to be distributed using growth estimations and a specialized computer code. In addition to this simplification, the population dose is now calculated for the population within an 80 km (50 mi) radius of any INL Site facility. This takes into account the changes in facility operations, in that the INTEC is not always the single largest contributor of radionuclides released.

An estimate was made of the collective effective dose equivalent, or population dose, from inhalation, submersion, ingestion, and deposition resulting from airborne releases of radionuclides from the INL Site. This collective dose included all members of the public within 80 km (50 mi) of an INL Site facility. The population dose was calculated in a spreadsheet program that multiplies the average TIC for the county census division (in hours squared per cubic meter) by the population in each census division within that county division and the normalized dose received at the location of the MEI (in rem per year per hour squared per meter cubed). This gives an approximation of the dose received by the entire population in a given county division (Table 8-4).

The dose received per person is obtained by dividing the collective effective dose equivalent by the population in that particular census division. This calculation overestimates dose because the model conservatively does not account for radioactive decay of the isotopes during transport over distances greater than the distance from each facility to the residence of the MEI located northwest of Mud Lake. Idaho Falls, for example, is about 50 km (31 mi) from the nearest facility (MFC) and 80 km (50 mi) from the farthest. Neither residence time nor shielding by housing was considered when calculating the MEI dose on which the collective effective dose equivalent is based. The calculation also tends to overestimate the population doses because they are extrapolated from the dose computed for the location of the potential MEI. This individual is potentially exposed through ingestion of contaminated leafy garden vegetables grown at that location.

The 2006 MDIFF TIC used for calculation of the population dose within each county division were obtained by averaging the results from appropriate census divisions contained within those county divisions. The total population dose is the sum of the population doses for the various county divisions (Table 8-4). The estimated potential population dose was 0.611 person-rem (6.1×10^{-3} person-Sv) to a population of approximately 290,819. When compared with an approximate population dose of 103,822 person-rem (1038 person-Sv) from natural background radiation, this represents an increase of only about 0.0006 percent. The largest collective doses are found in the Idaho Falls and Pocatello census divisions due to their greater populations.

8.4 Individual Dose - Game Ingestion Pathway

The potential dose an individual may receive from the occasional ingestion of meat from game animals continues to be investigated at the INL Site. Such studies include the potential dose to individuals who may eat (1) waterfowl that reside briefly at wastewater disposal ponds at RTC and MFC that are used for the disposal of low-level radioactive wastes and (2) game birds and game animals that may reside on or migrate across the INL Site.

Table 8-4. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2006).

Census Division[a]	Population[b]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,450	1.34×10^{-3}	1.34×10^{-5}
Alridge	715	1.28×10^{-4}	1.28×10^{-6}
American Falls	3,703	5.88×10^{-4}	5.88×10^{-6}
Arbon (part)	31	2.89×10^{-5}	2.89×10^{-7}
Arco	2,385	4.12×10^{-2}	4.12×10^{-4}
Atomic City (division)	3,459	3.19×10^{-2}	3.19×10^{-4}
Blackfoot	13,454	2.11×10^{-2}	2.11×10^{-4}
Carey (part)	1,202	1.63×10^{-3}	1.63×10^{-5}
East Clark	74	1.30×10^{-4}	1.30×10^{-6}
Firth	3,511	4.14×10^{-3}	4.14×10^{-5}
Fort Hall (part)	1,955	1.65×10^{-3}	1.65×10^{-5}
Hailey-Bellevue (part)	5	9.86×10^{-11}	9.86×10^{-13}
Hamer	2,355	6.00×10^{-2}	6.00×10^{-4}
Howe	344	7.87×10^{-3}	7.87×10^{-5}
Idaho Falls	81,328	1.15×10^{-1}	1.15×10^{-3}
Idaho Falls, west	1,846	7.59×10^{-3}	7.59×10^{-5}
Inkom (part)	600	2.43×10^{-4}	2.43×10^{-6}
Island Park (part)	84	1.46×10^{-4}	1.46×10^{-6}
Leadore (part)	4	8.88×10^{-8}	8.88×10^{-10}
Lewisville-Menan	4,266	1.99×10^{-2}	1.99×10^{-4}
Mackay (part)	1,146	4.14×10^{-6}	4.14×10^{-8}
Moody (part)	5,213	5.38×10^{-3}	5.38×10^{-5}
Moreland	9,786	5.02×10^{-2}	5.02×10^{-4}
Pocatello (part)	81,932	8.83×10^{-2}	8.83×10^{-4}
Rexburg (part)	22,061	4.59×10^{-2}	4.59×10^{-4}
Rigby	13,462	3.91×10^{-2}	3.91×10^{-4}
Ririe	1,548	8.27×10^{-4}	8.27×10^{-6}
Roberts	1,748	1.24×10^{-2}	1.24×10^{-4}
Shelley	7,561	1.19×10^{-2}	1.19×10^{-4}
South Bannock (part)	305	3.07×10^{-4}	3.07×10^{-6}
St. Anthony (part)	2,318	4.81×10^{-3}	4.81×10^{-5}
Sugar City	5,899	1.76×10^{-2}	1.76×10^{-4}
Swan Valley (part)	5,372	5.34×10^{-4}	5.34×10^{-6}
Ucon	6,310	1.53×10^{-2}	1.53×10^{-4}
West Clark	1,387	3.50×10^{-3}	3.50×10^{-5}
Totals	**290,819**	**0.611**	**6.1×10^{-3}**

a. (Part) means only a part of the county census division lies within the 80-km (50-mi) radius of a major INL Site facility.

b. Population based on 2000 Census Report for Idaho and updated to 2007 based on county population growth from 1960 to 2000.

Waterfowl

In the summer of 2006, nine ducks were collected from the RTC wastewater ponds, five were collected from wastewater ponds at the MFC, and three were collected from an offsite location (near American Falls, Idaho) as controls. The maximum potential dose from eating 225 g (8 oz) of meat from ducks collected in 2006 is presented in Table 8-5. Radionuclide concentrations used to determine these doses are reported in Table 7-4. Doses from consuming waterfowl are based on the assumption that ducks are eaten immediately after leaving the ponds.

The maximum potential dose of 0.013 mrem (0.13 μSv) from these waterfowl samples is substantially below the 0.89 mrem (8.9 μSv) committed effective dose equivalent estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001). The ducks were not collected directly from the hypalon-lined radioactive wastewater ponds but from the adjacent sewage lagoons. However, the birds likely used the radioactive wastewater ponds during the approximate two-week period they were observed in the area.

Table 8-5. Maximum annual potential dose from ingestion of edible waterfowl tissue using INL Site wastewater disposal ponds in 2006.[a]

Radionuclide	RTC Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
^{241}Am	3.53×10^{-4}	1.47×10^{-4}	1.01×10^{-4}
^{60}Co	1.97×10^{-4}	8.15×10^{-5}	0
^{137}Cs	1.23×10^{-2}	4.27×10^{-3}	0
^{90}Sr	1.47×10^{-4}	0	0
Total Dose	**1.30×10^{-2}**	**4.50×10^{-3}**	**1.01×10^{-4}**

a. Committed (50-yr) effective dose equivalent from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from EPA Federal Guidance Report No. 13 (EPA-402-R-99-001).

b. Doses are calculated on maximum radionuclide concentrations in three different waterfowl collected at RTC and MFC wastewater disposal ponds and control areas, and are therefore worst case doses.

Big Game Animals

A conservative estimate of 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 estimated at 2.7 mrem in a study on the INL Site from 1976-1986 (Markham et al. 1982). Game animals collected at the INL Site during the past few years have shown much lower concentrations of radionuclides. Only one game animal collected during 2006 had a detectable concentration of ^{137}Cs in the muscle; none had a detectable concentration in liver tissue. Based on the concentration of ^{137}Cs found in the muscle of this game animal, the potential dose was approximately 0.007 mrem (0.07 μSv).

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.

8.5 Biota Dose Assessment

Introduction

The impact of environmental radioactivity at the INL on nonhuman biota was assessed using the graded approach procedure detailed in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (ISCORS 2004). The graded approach evaluates the impacts of a given set of radionuclides on aquatic and terrestrial ecosystems by comparing available concentration data in soils and water with biota concentration guides (BCGs). A BCG is defined as 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/day (10 mGy/day) to aquatic animals or terrestrial plants or 0.1 rad/day (1 mGy/day) to terrestrial animals. If the sum of the measured environmental concentrations divided by the BCGs (the combined sum of fractions) is less than one, no negative impact to populations of plants or animals is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary.

The approach is graded because it begins the evaluation using conservative default assumptions and maximum values for all currently available data. Failure at this initial screening step does not necessarily imply harm to organisms. Instead, it is an indication that more realistic model assumptions may be necessary. Several specific steps for adding progressively more realistic model assumptions are recommended. After applying the recommended changes at each step, if the combined sum of fractions is still greater than one, the graded approach recommends evaluating the next step. The steps can be summarized as:

- Consider using mean concentrations of radionuclides rather than maxima
- Consider refining the evaluation area
- Consider using site-specific information for lumped parameters, if available
- Consider using a correction factor other than 100 percent for residence time and spatial usage in favor of more realistic assumptions

- Consider developing and applying more site-specific information about food sources, uptake, and intake
- Conduct a complete site-specific dose analysis. This may be a large study, measuring or calculating doses to individual organisms, estimating population level impacts, and, if doses in excess of the limits are present, culminating in recommendations for mitigation.

Each step of this graded approach requires appropriate justification before it can be applied. For example, before using the mean concentration, assessors must discuss why the maximum concentration is not representative of the radionuclide concentration to which most members of the plant or animal population are exposed.

Evaluations beyond the initial general screening require assessors to make decisions about assessment areas, organisms of interest, and other factors. Of particular importance for the terrestrial evaluation portion of the 2006 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types (Figure 8-4). Details and justification are provided in Morris (2003).

The graded approach (DOE 2002) and RESRAD-Biota (ISCORS 2004) are designed to evaluate certain common radionuclides. Thus, this biota dose assessment evaluated potential doses from radionuclides detected in soil or water on the INL that are also included in the graded approach (Table 8-6).

Aquatic Evaluation

For this analysis, maximum effluent data were used because actual pond water samples were not available. These data are assumed to overestimate actual pond water concentrations because of dilution in the larger volume of the pond. In the absence of measured pond sediment concentrations, the software calculates sediment concentrations based on a conservative sediment distribution coefficient. The only available radionuclide-specific concentrations detected in 2006 were for ^{129}I and tritium in CFA effluents, and ^{137}Cs and total Sr (assumed conservatively to be ^{90}Sr) in INTEC effluents (Table 8-7) (see Morris 2003 for a detailed description of the assessment procedure). These data were combined in a Site-wide general screening analysis. The combined sum of fractions was less than one (0.1) and passed the general screening test.

Terrestrial Evaluation

For the initial terrestrial evaluation, we used maximum concentrations from the INL Site contractors 2006 soil sampling (see Morris 2003 for a detailed description of the assessment procedure). The combined sum of fractions was less than one (0.865) and passed the general screening test (Table 8-8).

Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil or water is harming populations of plants or animals.

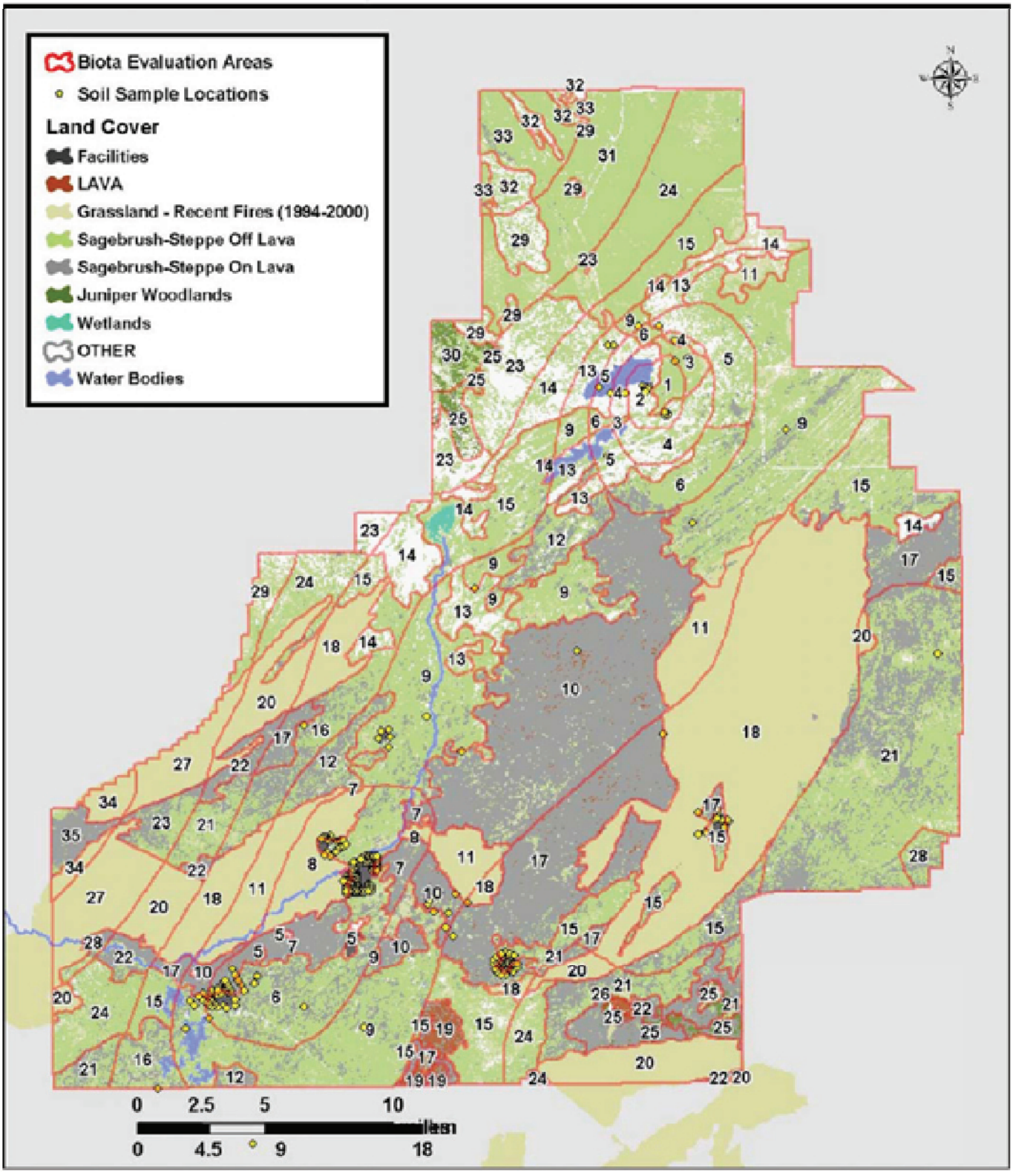


Figure 8-4. Evaluation Areas and Current Soil Sampling Locations on the INL.
(Areas with the same number are in the same evaluation area (Morris 2003).

Table 8-6. Radionuclides that can currently be evaluated using the graded approach (DOE 2003) compared to those detected in soil or water on the INL Site in 2003-2006.

Graded Approach	Detected
^{241}Am[a]	**^{241}Am**
^{144}Ce	**^{60}Co**
^{135}Cs	**^{137}Cs**
^{137}Cs	**^{3}H**
^{60}Co	**^{129}I**
^{154}Eu	**$^{239/240}$Pu**[b]
^{155}Eu	**^{226}Ra**
^{3}H	**^{90}Sr**
^{129}I	**^{232}Th**
^{131}I	**$^{233/234}$U**[c]
^{239}Pu	**^{235}U**
^{226}Ra	**^{238}U**
^{228}Ra	
^{125}Sb	
^{90}Sr	
^{99}Tc	
^{232}Th	
^{233}U	
^{234}U	
^{235}U	
^{238}U	
^{65}Zn	
^{95}Zr	

a. Radionuclides in **bold type** are present in both lists and were included in this assessment.
b. Analyzed as ^{239}Pu.
c. Analyzed as ^{233}U.

Table 8-7. Biota Dose Assessmemt of Aquatic Ecosystems on the INL Site (2006).

Nuclide	Effluent Concentration (pCi/L)	Water BCG[a] (pCi/L)	Partial Fraction[b]	Sediment Concentration[c] (pCi/g)	Sediment BCG (pCi/g)	Partial Fraction[d]	Sum of Fractions[e]
			First Screening[f]				
Cs-137	4.18E+00	4.26E+01	9.80E-02	6.69E-04	3.12E+03	6.69E-04	9.80E-02
H-3	4.51E+03	2.65E+08	1.70E-05	1.20E-08	3.74E+05	1.20E-08	1.70E-05
I-129	3.07E-01	3.84E+04	7.98E-06	1.07E-07	2.86E+04	1.07E-07	7.98E-06
Sr-90	2.05E+00	2.78E+02	7.36E-03	1.06E-04	5.82E+02	1.06E-04	7.36E-03
					Combined Sum of Fractions		**1.05E-01**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Calculated by the RESRAD-BIOTA software (DOE 2004) based on the effluent concentration.
d. Calculated sediment concentration/sediment BCG
e. Sum of the partial fractions.
f. See the text for the rationale for the various screenings.
g. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

Table 8-8. Biota Dose Assessmemt of Terrestrial Ecosystems on the INL Site (2006).

Nuclide	Effluent Concentration (pCi/L)	Water BCG[a] (pCi/L)	Partial Fraction[b]	Soil Concentration (pCi/g)	Soil BCG[a] (pCi/g)	Partial Fraction[c]	Sum of Fractions[d]
Am-241	0.00E+00	2.02E+05	0.00E+00	1.20E-02	3.89E+03	3.08E-06	3.08E-06
Cs-137	4.18E+00	5.99E+05	1.95E-05	1.73E+01	2.08E+01	8.33E-01	8.33E-01
H-3	4.51E+03	2.31E+08	5.38E-08	0.00E+00	1.74E+05	0.00E+00	5.38E-08
I-129	3.07E-01	5.70E+06	3.02E-08	0.00E+00	5.67E+03	0.00E+00	3.02E-08
Pu-238	0.00E+00	1.89E+05	0.00E+00	5.90E-02	5.27E+03	1.12E-05	1.12E-05
Pu-239	0.00E+00	2.00E+05	0.00E+00	2.90E-02	6.11E+03	4.74E-06	4.74E-06
Sr-90	2.05E+00	5.45E+04	0.00E+00	7.10E-01	2.25E+01	3.16E-02	3.16E-02
						Combined Sum of Fractions[e]	**8.65E-01**

a. Biota concentration guide.
b. Effluent concentration/water BCG.
c. Soil concentration/soil BCG
d. Sum of the partial fractions.
e. Sum of the sums of fractions. If the combined sum of fractions is less than one, the site passes the screening evaluation.

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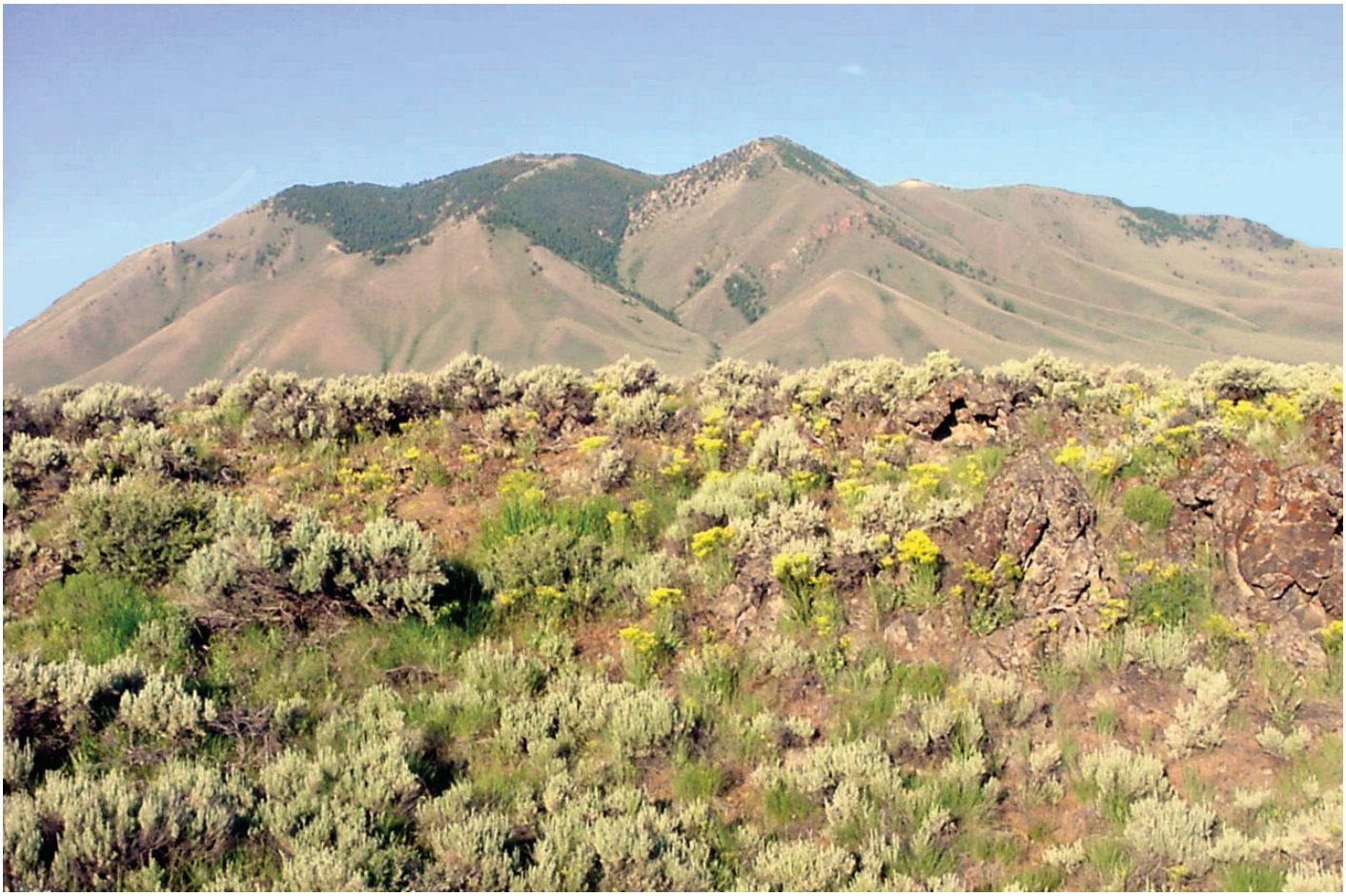
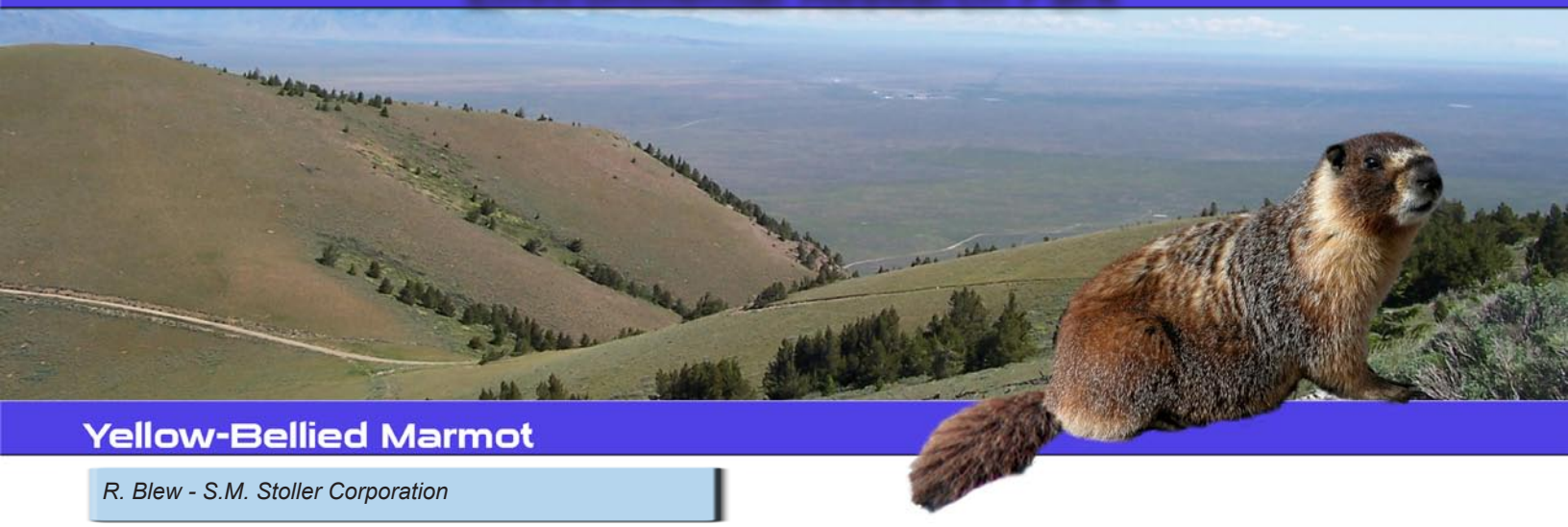


Big Southern Buttes

Chapter 9 - Ecological Research at the Idaho National Environmental Research Park



Yellow-Bellied Marmot

R. Blew - S.M. Stoller Corporation

9. ECOLOGICAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK

The Idaho National Laboratory (INL) Site was designated as a National Environmental Research Park (NERP) in 1975. The NERP 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 protect land on a national scale for ecosystem preservation, research, and education. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems.

There are five basic objectives guiding activities on the Research Parks. They are to:

- Develop methods for assessing and documenting the environmental consequences of human actions related to energy development.
- Develop methods for predicting the 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.
- Use the NERPs for educating the public on environmental and ecological issues.

The NERPs 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.

Establishment of NERPs was not the beginning of ecological research at Federal laboratories. Ecological research at the INL Site began in 1950 with the establishment of the long-term vegetation transect study. This is perhaps DOE's oldest ecological data set and one of the most significant vegetation datasets for the sagebrush steppe ecosystem. Other long-term studies conducted on the Idaho NERP include the reptile monitoring study initiated in 1989, which is the longest continuous study of its kind in the

world; as well as the protective cap biobarrier experiment initiated in 1993, which evaluates the long-term performance of evapotranspiration caps and biological intrusion barriers.

Ecological research on the NERPs 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.

The Idaho NERP provides a coordinating structure for ecological research and information exchange at the INL. The Idaho NERP facilitates ecological research on the INL by attracting new researchers, providing background data to support new research project development, and providing logistical support for assisting researcher access to the INL. The Idaho NERP provides infrastructure support to ecological researchers through the Experimental Field Station and museum reference collections. The Idaho NERP tries to foster cooperation and research integration by encouraging researchers using the INL to collaborate, develop interdisciplinary teams to address more complex problems, and encourage data sharing, and by leveraging funding across projects to provide more efficient use of resources. The Idaho NERP has begun to develop a centralized ecological database to provide an archive for ecological data and facilitate retrieval of data to support new research projects and land management decisions. The Idaho NERP can also be a point of synthesis for research results that integrates results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho NERP also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act (NEPA) process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The following sections describe ecological research activities that took place at the Idaho NERP during 2006.

9.1 Monitoring Amphibian and Reptile Populations on the Idaho National Laboratory: Indicators of Environmental Health and Change.

Investigators and Affiliations

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Charles R. Peterson, Professor, Herpetology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

Idaho State University Graduate Student Research and Scholarship Committee

U.S. Department of Energy Idaho Operations Office

Background

Many amphibian and reptile species have characteristics that make them sensitive environmental indicators. The main research goal of this project is to provide indicators of environmental health and change by monitoring the distribution and population trends of amphibians and reptiles on the INL. This information is important to the DOE for several reasons:

1. as an indicator of environmental health and change;
2. for management of specific populations of sensitive species;
3. meeting NEPA requirements regarding the siting of future developments;
4. avoiding potentially dangerous snake-human interactions; and
5. providing a foundation for future research into the ecological importance of these species.

Objectives

The main objective of this project is to monitor amphibian and reptile distribution on the INL. Specific objectives for 2006 included the following:

- Continue monitoring snake and lizard populations at the three main den complexes (Figure 9-1);
- Expand monitoring program to include a 170 km driving loop to complement the den data (Figure 9-1). This has been added because Denim Jochimsen's data showed that the proportion of gopher snakes on the roads is higher than at the main den sites;
- Continue to monitor breeding sites for Great Basin Spadefoot "toads" (*Spea intermontana*);
- Continue entering current herpetological information into a geographic information system (GIS) database;
- Provide herpetological expertise, as needed;
- Provide snake safety workshops; and
- Provide educational opportunities for undergraduate and graduate students.

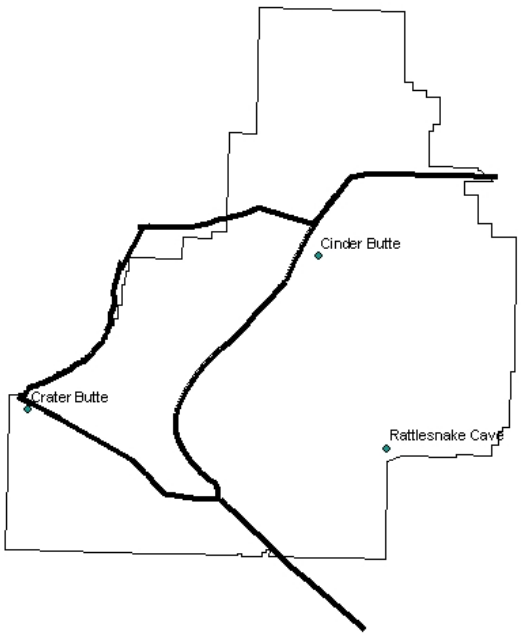

Figure 9-1. Map of the INL with the Three Main Den Complexes and the 170 km Drive Loop.

Accomplishments Through 2006

Specific accomplishments for 2006 include the following:

- Continued monitoring of snake populations at three den complexes (Cinder Butte [CINB], Crater Butte [CRAB], and Rattlesnake Cave [RCAV]) allowed us to increase the total number of snakes captured by 463 snakes, 241, of which were new marks (Figure 9-2). Calculated population estimates for Rattlesnake Cave (Figure 9-3).
- Determined body condition for the rattlesnakes at the three den sites for 2006 (Figure 9-4) and cumulatively for rattlesnakes from 1994 through 2006 (Figure 9-5). Looked at the spatial and temporal variation and estimated what environmental characteristics might play a role in determining snake body condition and ultimately survival.
- Found 27 snakes during 10 road cruising trips.
- Confirmed spadefoot toad breeding activity at the Big Lost River sinks in 2006.

Results

- The number of marked snakes on the INL was increased to 3919 in 2006, which includes all snakes PIT-tagged since 1994 and marking data collected at CINB from 1989 to 1994 (Table 9-1).
- We found that in 2006, 54 percent of females were gravid at CINB, 37 percent were gravid at CINB, and 23 percent were gravid at RCAV (Figure 9-6).
- Two observations of a leopard lizard (*Gambelia wislizenii*) were made at CINB in 2006. Western skinks (*Eumeces skiltonianus*) were found in funnel traps at RCAV. Sagebrush lizards (*Sceloporus graciosus*) were found across the entire INL.
- We found 20 gopher snakes (one alive), four rattlesnakes, and three garter snakes during our road cruising surveys (Figure 9-7).

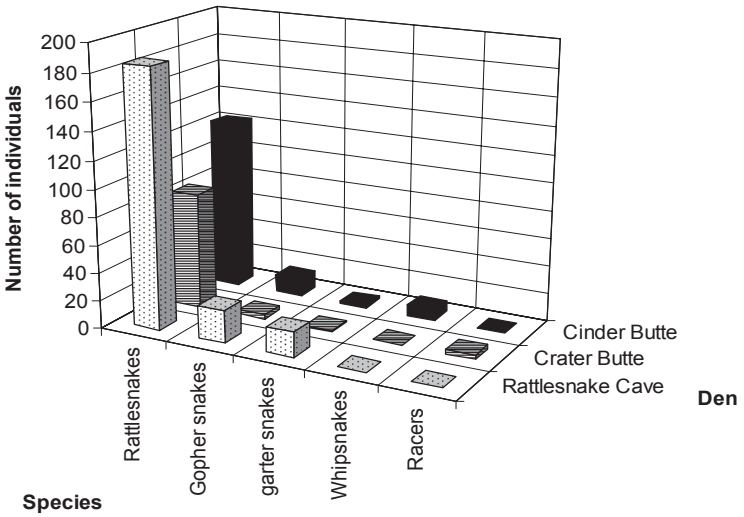

Figure 9-2. The Number of Captures from Each Species Caught at Each Den Site Over the 2006 Field Season.

- Spadefoot toad (*Spea intermontana*) breeding was observed in the Big Lost River sinks, and tadpole, adults and recently metamorphosed spadefoots were located.
- Provided herpetological expertise in the form of snake safety talks for the INL, as well as, at the Idaho Falls Earth Day celebration and to elementary school children at different schools and libraries. This monitoring program was the subject of a talk at the Idaho Herpetological Society in November 2006.
- Through the continuation of Scott Cambrin's Masters Degree research he has also started to look at some of the factors affecting body condition and pregnancy rates. He found there was a positive correlation with yearly precipitation and body condition with an R^2 value of 0.37 and a p-value of 0.035 (Figure 9-8). He also found a significant relationship between body condition and percent gravid females with an R^2 value of 0.36 and a p-value of 0.039 (Figure 9-9).

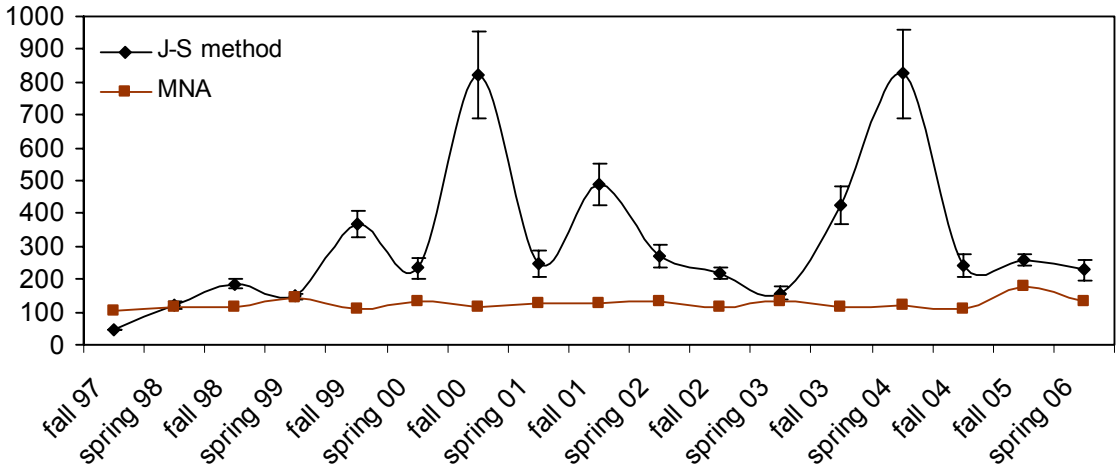

Figure 9-3. Population Estimates for Jolly-Seber method (± 1 SE) and Minimum Number Alive Method for Rattlesnakes at RCAV.

The Jolly-Seber method is estimated by the number of new and recaptured snakes. The minimum number alive is the total number known to be alive at that time period. We feel that the large spikes in fall 2000 and spring 2004 were not accurate estimates because of the unusually high number of recaptures that were captured that year.

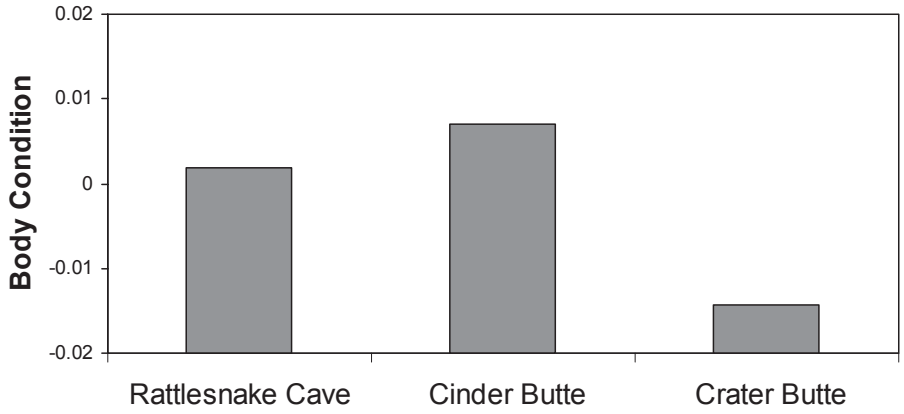

Figure 9-4. Average Body Condition for Rattlesnake for all Three Den Sites (2006).

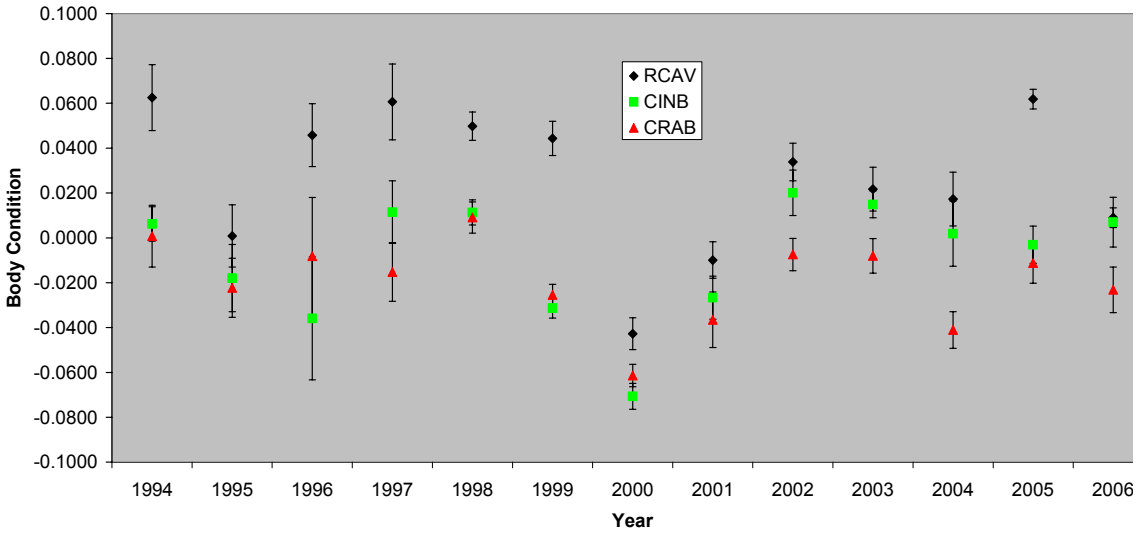

Figure 9-5. Average Body Condition for RCAV, CINB, and CRAB Sites from 1994 to 2006.

Table 9-1. Total Number Captured, Marked, Recaptured, Females Marked, and Males Marked for Each Species of Snake at Each of the Three Den Sites. *RCAV – Rattlesnake cave, CRAB – Crater Butte, CINB – Cinder butte, CROR – western rattlesnake, PICA – gopher snake, THEL – terrestrial garter snake, COCO – racer, HYTO – night snake, MATA – stripped whipsnake, NM – Not Marked, and RC - Recapture.*

Den	RCAV	CRAB	CINB	RCAV	CRAB	CINB	RCAV	CRAB	CINB	CRAB	CRAB	CINB
species	CROR	CROR	CROR	PICA	PICA	PICA	THEL	THEL	THEL	COCO	HYTO	MATA
total	1291	1015	2017	138	97	332	285	59	135	39	12	62
NM	628	765	1430	93	94	317	212	57	124	37	12	150
RC	673	250	588	45	3	15	73	2	9	2	0	12
Female NM	280	405	634	22	49	156	102	31	47	20	7	59
Male NM	348	360	627	61	42	143	91	26	77	13	3	84

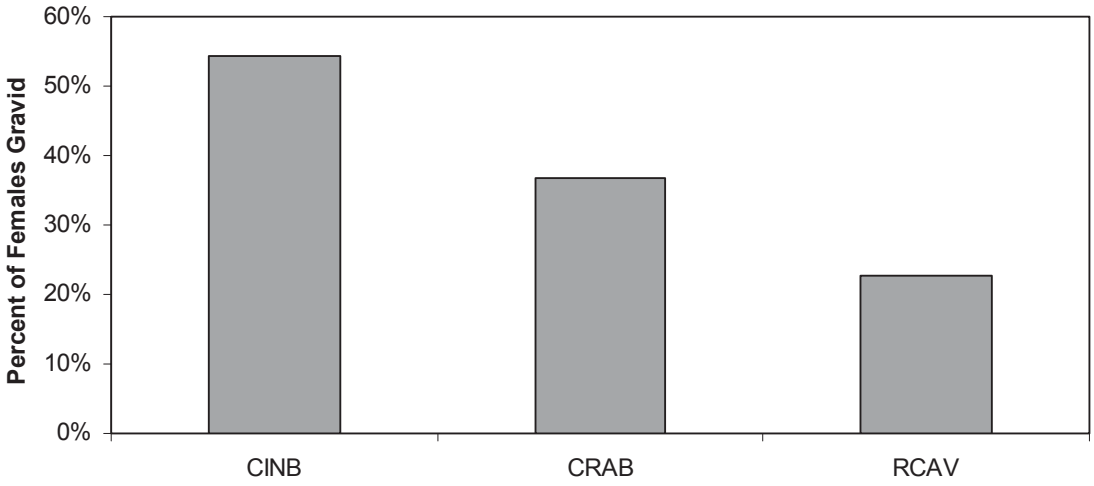

Figure 9-6. Percent of Females at RCAV, CINB, and CRAB that were Found Gravid in 2006.

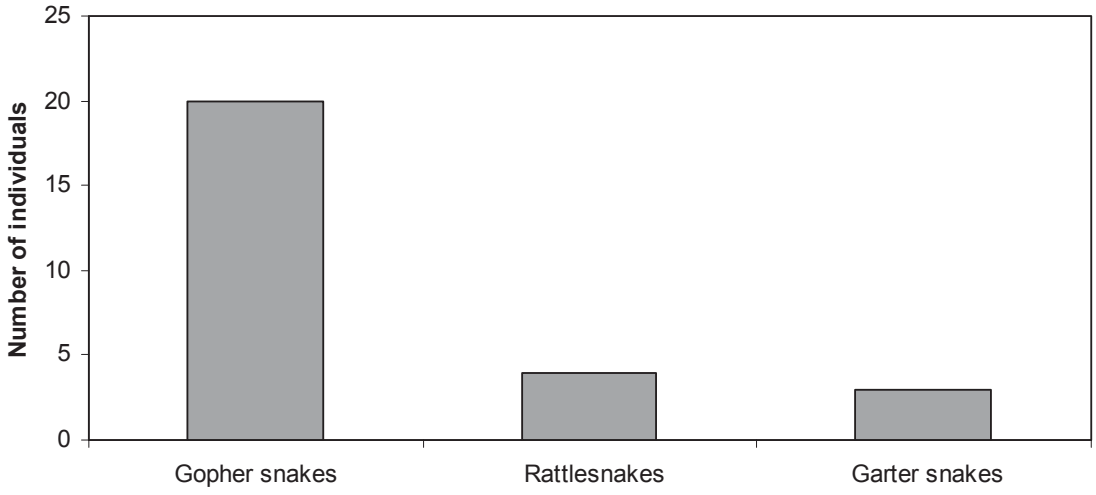

Figure 9-7. Number of Snakes Found During the Road Cruising Survey on the INL. All but one Gopher Snake were Found Dead.

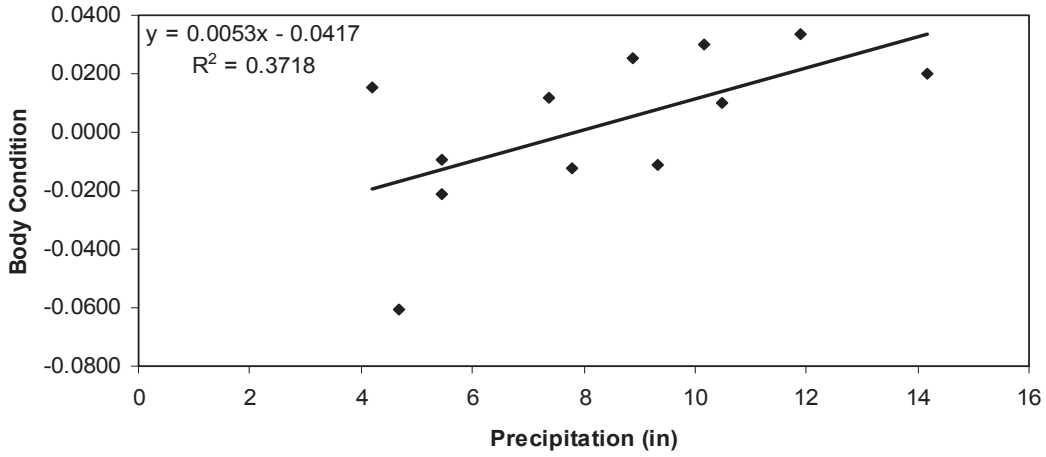

Figure 9-8. This Graph Shows the Relationship Between Body Condition and Average Yearly Precipitation with a One Year Lag (p= 0.035 df= 10). So Precipitation from 1994 was Compared to Body Condition of 1995.

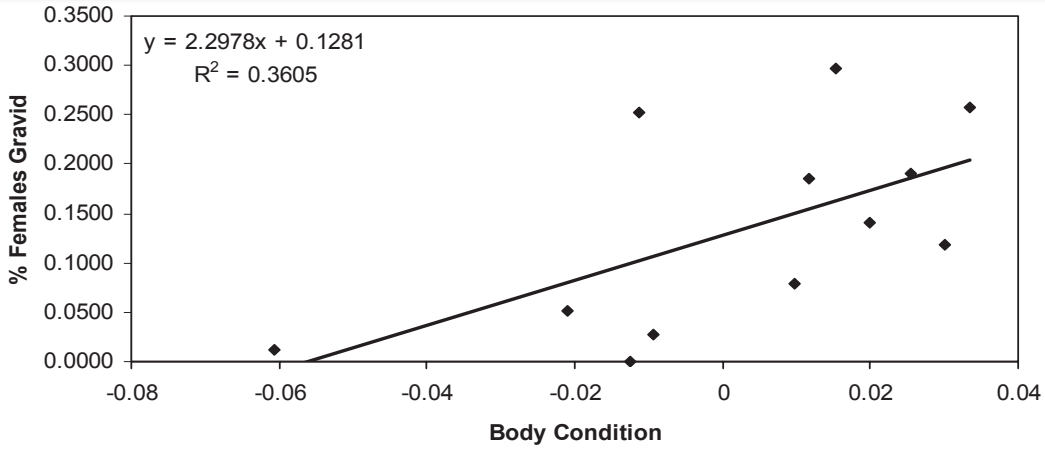

Figure 9-9. This Graph Shows the Relationship Between Body Condition and the Number of Gravid Females per Year with a One Year Lag (p= 0.039 df= 10). So Body Condition from 1994 was Compared to the Percent Pregnant Females of 1995.

Plans for Continuation

An M.S. thesis is expected to be completed in 2007 by S. Cambrin based on this work. Monitoring herpetofauna is one part of the wildlife monitoring task in the Environmental Surveillance, Education and Research program and is expected to continue.

9.2. Annotated Checklist of the Ants on the Idaho National Laboratory (*Hymenoptera:Formicidae*).

Investigators and Affiliations

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Paul E. Blom, Division of Entomology, Dept. of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, (Present affiliation: USDA-ARS, Prosser, WA)

Funding Sources

U.S. Department of Energy Idaho Operations Office

Orma J. Museum of Natural History, Albertson College of Idaho

W. Clark and P. Blom

Background and Accomplishments through 2006

The need for basic information on INL's ant fauna became evident during the course of other waste management-related research at the INL. With this realization an annotated survey of INL ants was initiated in 1986. The resulting field and laboratory work spanned 20 years and culminated in a monograph published in Sociobiology (Clark, W.H., and P.E. Blom. 2007).

Abstract

Many invertebrates, including ants, tunnel and nest in soils. Because of these habits they are potentially important at the INL where they may tunnel into and disturb buried waste. Ants are very important components of the desert ecosystem based on their distribution, habitat preferences, food habits, and relative abundance. For these reasons the ant taxa present at the INL were investigated. A cursory survey of the ants at the site was published in 1971 which reported 22 species. A more thorough examination was needed.

Our research in the northeastern portion of the Snake River Plain at the INL from 1986 to 1996 produced thousands of ant collections, of which 1,115 (mostly nest series) are used in this manuscript. These collections contained 46 species in 19 genera from three subfamilies. This more than doubles the number of the species previously reported from the INL. Of the ant species found, 18 (39 percent) are considered rare on the site, 12 (26 percent) are present but not common, 11 (24 percent) are common, and only five (11 percent) are found to be abundant. All but three ant genera known for the state of Idaho can be found at the INL. Additionally, four species collected during this research are reported from Idaho for the first time: *Liometopum luctuosum*, *Formica gynocrates*, *Formica spatulata*, and *Myrmica sp*. (a new species).

Formicoxenus diversipilosus was only found within the nests of the *Formica rufa* group, *Formica planipilis* and *Formica subnitens*. These represent new host records for the species. *Formicoxenus hirticornis* was found nesting with the thatch ants: *Formica planipilis, Formica ciliata, Formica laeviceps,* and *Formica subnitens*, all of which represent new host records for this species.

The goal of this investigation is to provide a more thorough survey of the INL ant fauna for both biodiversity and waste management purposes. The objectives were: (1) to produce an updated checklist of the INL ants, (2) to summarize the pertinent published information and literature on the INL ants, and (3) to present keys, distribution maps, illustrations, and ecological information on each taxon. This information should allow for the identification of ants encountered at the site and be of use to ecologists and other scientists working at the site. Much new information concerning the biology, ecology, and natural history of many of the species found on INL is presented. The literature on the ants of the INL is summarized. This work paves the way for more detailed ecological studies of the INL ant fauna.

9.3 Ecology and Conservation of Rattlesnakes in Sagebrush Steppe Ecosystems: Landscape Disturbance, Small Mammal Communities, and Great Basin Rattlesnake Reproduction

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

INL Education Outreach Program (Bechtel)

Idaho State University (CERE Lab and Graduate Research Committee)

Bureau of Land Management

Idaho Department of Fish and Game

Background

This project was designed to assess the impact of landscape disturbance on western rattlesnakes by examining trophic interactions among habitat, small mammals, and snakes. The synergistic effect of livestock grazing, invasive plants and fire is changing sagebrush steppe ecosystems in the Upper Snake River Plain. It is hypothesized that this phenomenon is affecting the prey base of top-level predators in the system. The main research goal is to determine if changes in habitat are altering prey availability and subsequently life history characteristics of western rattlesnakes.

Information from this project is important to the DOE for several reasons:

1. as an indicator of how habitat change is influencing small mammal biomass;
2. as an indicator of how trophic interactions affect western rattlesnakes;
3. providing recommendations for the management and conservation of predators on the INL;
4. for utilizing a long term mark recapture data set gathered by the Idaho State University Herpetology Laboratory to further an understanding of community ecology on the INL;

5. assisting in the training of graduate and undergraduate students in environmental research.

Objectives

The overall goal of this project is to determine if current landscape patterns in habitat and prey on the INL are influencing rattlesnake life histories. Specific objectives included the following:

- Quantify spatial variation in rattlesnake life histories.
- Determine if spatial variation in rattlesnake life histories correlate with coarse scale patterns in habitat and small mammal biomass.
- Determine if rattlesnakes are selecting habitats with greater small-mammal biomass.
- Determine if disturbance to sagebrush steppe systems affects small-mammal biomass.
- Determine if changes in small mammal communities influence body condition of female rattlesnakes.

Accomplishments

This research was conducted as part of a doctoral program and has been completed.

Dissertation Abstract

Widespread disturbance in sagebrush steppe ecosystems is threatening Great Basin rattlesnake populations. The sagebrush steppe ecosystem is experiencing a variety of disturbances including mining, human development, livestock grazing, invasive plants, and changing fire regimes. Great Basin rattlesnakes (*Crotalus oreganus lutosus*) are capital breeding snakes that acquire energy over multiple years for reproduction. Disturbances in sagebrush steppe may be influencing rattlesnake reproductive output by limiting the amount of energy (i.e., food) they can acquire during the active season. The goal of this dissertation was to determine to what extent and how disturbance influences populations of Great Basin rattlesnakes.

The following were sampled: substrate, vegetation, small mammals, and operative temperatures. Mark-recapture; radio telemetry; and a common garden were conducted on rattlesnakes. These studies occurred at three large overwintering complexes (CRAB, CINB, and RCAV as defined in Section 9.1) on the INL. The INL is a DOE nuclear research facility. Portions of the INL are grazed by livestock and some fires have occurred in the area.

Results suggest that broad patterns in landscape disturbance are indirectly influencing rattlesnake reproduction by altering prey availability. First, a significant microgeographic variation in reproduction was found. Specifically, the CRAB Butte population had lower reproductive output due to lower body condition, slower growth, later ages to maturity, longer intervals between pregnancies and lower fecundity. Second, an approach was developed to determine the factors influencing reproduction that links broad scale landscape disturbance such as grazing and fire to rattlesnake ecology through a series of trophic interactions. Finally, using this approach, it was determined that prey availability was higher in a landscape with less disturbance and greater precipitation. Snakes using areas with higher prey availability meandered more during movements and gained less weight. When comparing two of the sites, CRAB had more landscape disturbance, lower prey availability, snakes moved more linearly, gained less weight, and had lower reproductive output relative to RCAV. In addition, RCAV received approximately 4 centimeters more

precipitation from May to September than the rest of the sites. There was no difference in estimated available foraging times between study sites or disturbance categories and no evidence for local adaptation of growth rates although due to low sample sizes there was relatively low power (0.30) for detecting a difference.

Results from these studies suggest that natural and human caused patterns on the landscape influence prey availability and subsequently that rattlesnake ecology is influenced by prey availability. Specifically, relatively high precipitation likely provides high prey availability at RCAV relative to CRAB. Disturbance lowers prey availability levels at both sites. Likely in response to low prey availability, snakes are making more linear movements as they search for prey and are gaining less weight. Less weight gain is likely resulting in lower body condition and growth. Snakes in areas where they gain less weight also have lower reproductive output. These findings have applied implications for the conservation of sagebrush steppe, predators, and rattlesnakes. For example, wildlife management programs interested in maintaining rattlesnake populations need to consider broad patterns of landscape disturbance and their resulting impacts on prey availability.

9.4 The Protective Cap/Biobarrier Experiment

Investigators and Affiliations

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Brandy C. Janzen, Graduate Student, Department of Biological Sciences, Idaho State University, Pocatello, ID

Matthew J. Germino, Associate Professor, Department of Biological Sciences, Idaho State University, Pocatello, ID

Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

Shallow land burial is the most common method for disposing of industrial, municipal, and low-level radioactive waste, but in recent decades it has become apparent that conventional landfill practices are often inadequate to prevent movement of hazardous materials into ground water or biota (Suter et al. 1993, Daniel and Gross 1995, Bowerman and Redente 1998). Most waste repository problems result from hydrologic processes. When wastes are not adequately isolated, water received as precipitation can move through the landfill cover and into the wastes (Nyhan et al. 1990, Nativ 1991). Presence of water may cause plant roots to grow into the waste zone and transport toxic materials to aboveground foliage (Arthur 1982, Hakonson et al. 1992, Bowerman and Redente 1998). Likewise, percolation of water through the waste zone may transport contaminants into ground water (Fisher 1986, Bengtsson et al. 1994).

In semiarid regions, where potential evapotranspiration greatly exceeds precipitation, it is theoretically possible to preclude water from reaching interred wastes by (1) providing a sufficient cap of soil to store precipitation that falls while plants are dormant and (2) establishing sufficient plant cover to deplete soil moisture during the growing season, thereby emptying the water storage reservoir of the soil.

The Protective Cap/Biobarrier Experiment (PCBE) was established in 1993 at the Experimental Field Station, INL to test the efficacy of four protective landfill cap designs. The ultimate goal of the PCBE is to design a low maintenance, cost effective cap that uses local and readily available materials and natural ecosystem processes to isolate interred wastes from water received as precipitation. Four evapotranspiration (ET) cap designs, planted in two vegetation types, under three precipitation regimes have been monitored for soil moisture dynamics, changes in vegetative cover, and plant rooting depth in this replicated field experiment.

Objectives

From the time it was constructed, the PCBE has had four primary objectives which include; (1) comparing the hydrologic performance of four ET cap designs, (2) examining the effects of biobarriers on water movement throughout the soil profile of ET caps, (3) assessing the performance of alternative ET cap designs under current and future climatic scenarios, and (4) evaluating the performance of ET caps planted with a diverse mix of native species to those planted with a monoculture of crested wheatgrass.

Specific tasks for the PCBE in 2006 included maintenance of the study plots, continuation of the irrigation treatments, and collection of soil moisture and plant cover data. An update to the 2003 PCBE summary report (Anderson and Forman 2003) was also scheduled to be drafted in 2006. Data were analyzed for the updated summary report according to the four major objectives listed above, focusing on long-term cap performance. Four additional objectives, which address emerging landfill-capping issues, were also considered in the summary report. The additional objectives include; (1) comparing plant cover and soil moisture dynamics from the 1994-2000 study period with the relatively more droughty 2002-2006 study period, (2) assessing the stability of total vegetation cover both spatially and temporally, (3) understanding the invasibility of the native and crested wheatgrass plant communities planted on the PCBE, and (4) quantifying the relationship between vegetation cover and evapotranspiration.

Accomplishments through 2006

Three supplemental irrigation treatments were completed on the PCBE in 2006. The fall/spring supplemental irrigation treatment initiated in late September 2005 could not be completed due to a failure of the deep well. Therefore, the deep well was repaired and the balance of the fall/spring irrigation treatment was applied in April of 2006. A summer irrigation treatment was also performed, as scheduled, in 2006. Fifty millimeters of water was applied to the summer irrigated plots once every other week from the end of June through the beginning of August for a total of 200 mm. Finally, the fall/spring 2006 irrigation treatment was completed in mid-October. Soil moisture measurements were collected once every two weeks from beginning of April through mid-October. Vegetation cover data were collected throughout the month of July and into August.

Soil moisture and vegetation cover data from 1994-2006 were analyzed according to the objectives described above. A draft of the updated summary report was completed at the end of 2006 and was published in February 2007. A copy of the report, entitled “PCBE Revisited: Long-Term Performance of Alternative Evapotranspiration Caps for Protecting Shallowly Buried Wastes under Variable Precipitation” (Janzen et al. 2007) is available at www.stoller-eser.com.

Results and Discussion

During the 2002-2006 study period, an alternative ET cap design with a gravel/cobble biobarrier placed at a depth of one meter below the soil surface prevented potential water breakthrough to the simulated waste zone better than the other three designs tested. The capillary break created by the change in substrate texture at the interface of soil and gravel at the top of the biobarrier appears to enhance cap function by forcing the soil above the biobarrier to reach field capacity before water will percolate below the biobarrier, limiting unsaturated flow and preferential flow pathways. These results were similar to those reported for the 1994-2000 study period. In contrast to results reported from the earlier study period, the performance of an alternative design consisting of a two meter soil monolith began declining over the past four years. Two additional cap designs, one based on Resource Conservation and Recovery Act (RCRA) guidelines and the other an alternative ET design with a biobarrier placed at 0.5 m below the soil surface, performed during the second study period much as they had in the first. Water often collected on the flexible membrane liner of the RCRA cap and often percolated below the biobarrier on the design with the shallowly placed biobarrier. In both cases, this percolation didn't necessarily lead to potential breakthrough at the bottom of a cap, but it does indicate that more soil is needed to prevent water from reaching these physical barriers.

The caps planted with a diverse mix of native vegetation continued to perform better than those planted with a crested wheatgrass monoculture. In fact, crested wheatgrass does not appear to provide adequate transpiration to maintain long-term ET cap function. Poor performance of caps planted with crested wheatgrass may be related to relatively low vegetative cover overall and relatively high variation in vegetation cover spatially and temporally. Caps planted with crested wheatgrass tended to have lower average plant cover that caps planted with native vegetation. The stability of the crested wheatgrass plant community tended to be lower than that of the native plant community as evidenced by the relatively high variability in vegetative cover among caps planted with crested wheatgrass. Additionally, the crested wheatgrass caps had a high incidence of encroachment of species that were not originally planted when compared to encroachment of crested wheatgrass into the native vegetation caps.

When performance of the four cap designs was compared in response to ambient precipitation and two climate change scenarios, all of the cap designs experienced at least one potential breakthrough event under an augmented fall/spring precipitation scenario during the 2002-2006 study period (Figure 9-10). This result was not observed during the 1994-2000 study period and indicates that none of the cap designs would function properly under extreme climate change in which the INL received twice current ambient precipitation during the winter months. As with the first study period, potential breakthroughs were rare under ambient precipitation and augmented summer irrigation. The potential breakthrough events that did occur under those precipitation scenarios occurred only on the caps planted with crested wheatgrass (Figure 9-10). Thus, when planted with native vegetation, all four cap designs precluded water from percolating through the bottom of the cap under current climatic conditions.

Plans for Continuation

Over the next two growing seasons we will monitor vegetation cover and soil moisture as we continue to assess long-term alternative ET cap performance. Weak correlations between vegetation cover and evapotranspiration in analyses conducted for the updated summary report indicate that simple paradigms of soil-plant water relationships may not be adequate to explain the performance of ET caps. Therefore,

we will also collect some finer time-scale vegetation cover measurements and direct transpiration measurements throughout the growing season in 2006. These additional measurements will be used to better characterize and quantify the soil-plant water relationship on the PCBE, which will be useful for modeling long-term cap performance, as well as improving cap performance through directed revegetation design.

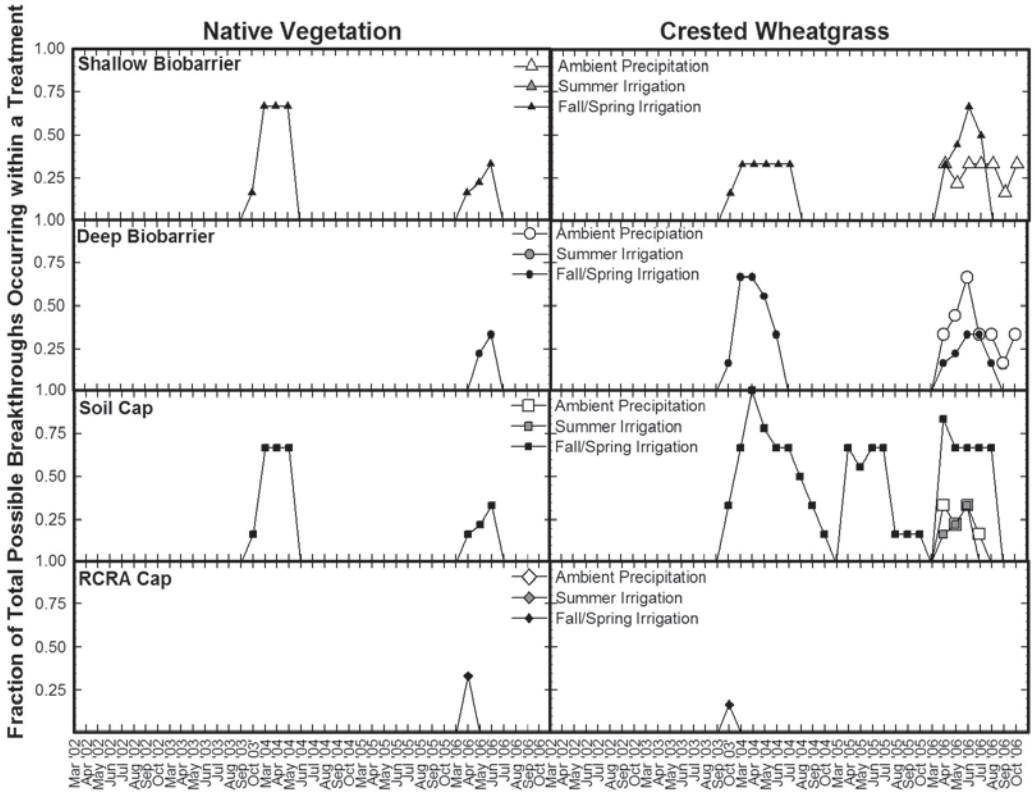

Figure 9-10. Fraction of the Total Number of Possible (Potential) Breakthroughs, Defined as Volumetric Water Content Greater than 28 Percent at the Bottom of the Cap, for Shallow-biobarrier, Deep-biobarrier, Soil-only, and RCRA Cap Types under Ambient, Summer, and Fall/Spring Precipitation Regimes in Native Vegetation and Crested Wheatgrass Subplots. We can only Assess the Possibility of Breakthrough, and not Whether Breakthrough Actually Occurred, because Volumetric Water Content was not Measured Underneath the ET Caps.

9.5 Developing a Conservation Management Plan for the Idaho National Laboratory

Investigators and Affiliations

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Funding Sources

United States Department of Energy, Idaho Operations Office

Background

The sagebrush steppe of western North America is one of the most endangered ecosystems in the world. Sagebrush steppe is threatened by soil disturbance (especially associated with overgrazing) that promotes invasion by exotic annual vegetation (such as cheatgrass, *Bromus tectorum*) which in turn alters natural fire regimes. These types of landscape changes are having significant effects on sagebrush steppe wildlife. Despite the widespread nature of the threats to sagebrush steppe, the INL has experienced only limited disturbance and is likely the most intact example of sagebrush steppe remaining.

Without an adequate management plan in place the biodiversity of sagebrush habitats on the INL are at a greater risk of being degraded. Localized threats to biodiversity on the INL include livestock grazing in peripheral areas, invasion of cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum*), fire, raven depredation, and road and facility development. In addition, complex interactions can exist between threats.

Developing a conservation management plan for the INL is important because it will help preserve one of the best remaining sagebrush steppe ecosystems in the world. A conservation management plan is also important to DOE because it will facilitate land use planning on the INL. For example, with a conservation management plan in place and an understanding of the distribution of important biological resources DOE will save time and money when planning projects such a new construction.

Objectives

The overall goal of the project is to conserve sagebrush steppe ecosystems while facilitating land use planning on the INL. Specific objectives include:

1. Determine the distribution and abundance of pygmy rabbits on the INL.
2. Determine the distribution and abundance of sage grouse on the INL.
3. Conduct a biodiversity inventory of the INL Development Zone.
4. Develop a vegetation map for the INL.
5. Set conservation priorities on the INL.
6. Develop an interactive GIS for the INL.
7. Prepare a conservation management plan for the INL.

Some of the objectives above will be focused on the entire INL (Pygmy Rabbit Studies, Sage Grouse Studies, and Vegetation Mapping) while the Biodiversity Inventory will be focused in two smaller areas in the south central part of the INL designated the Development Corridor and Development Zone (Figure 9-11). Thus, conservation priorities, the interactive planning tool, and the Conservation Management Plan (CMP) will only completely cover all important biological resources within these two areas.

Accomplishments

Pygmy Rabbit Surveys. In 2006 we conducted, developed and applied a novel ground surveying technique for pygmy rabbits. Specifically, we developed an approach where observers on snowshoes survey plots along a series of belt transects. Within each transect observers are keying in on rabbit microhabitat characteristics (e.g., relatively tall sagebrush) and searching for signs of pygmy rabbit occupancy such as tracks, burrows, or pellets. Detection probabilities varied based on the presence of snow and other factors

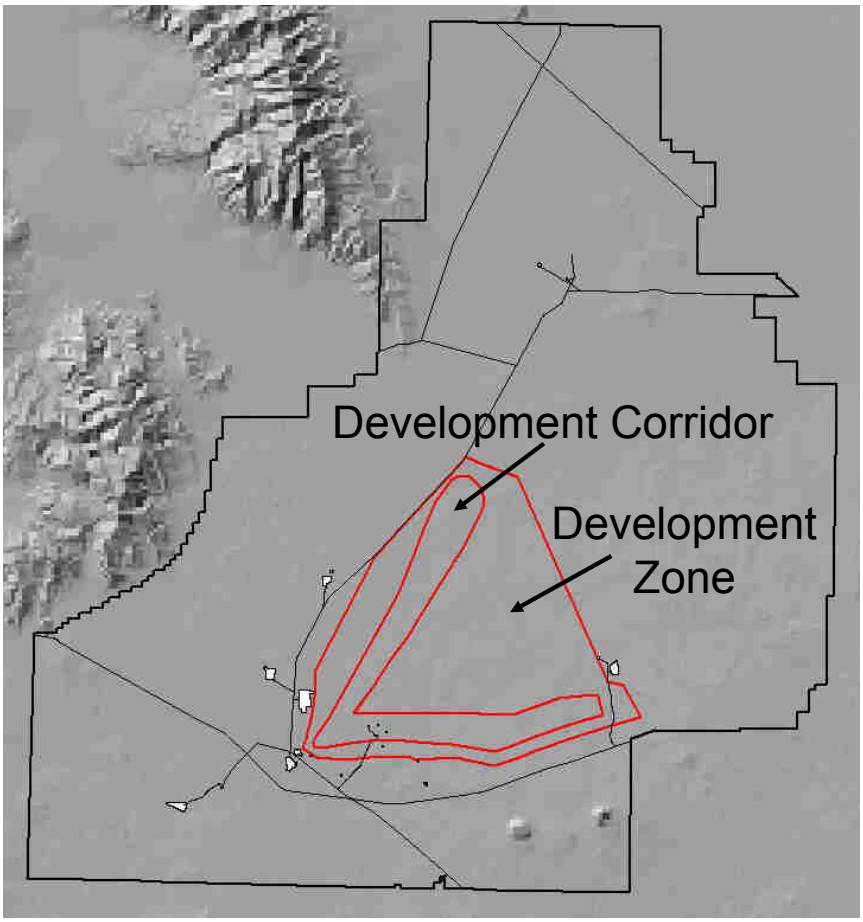

Figure 9-11. Map Displaying the Location of the Development Corridor and Development Zone on the INL.

but detection probabilities for the technique were consistently of 0.70. Using this technique we identified pygmy rabbit presence in 52 percent of the plots surveyed and we located a total of 130 burrows systems.

Sage Grouse Surveys

In 2006 we conducted aerial and ground surveys for sage grouse leks. We found a total of four new leks during these surveys.

Biodiversity Inventory

As part of the biodiversity inventory we selected a suite of indicator taxa including vegetation, reptiles, passerine birds, raptors, bats, small mammals, mammalian mesocarnivores, and ungulates. Accomplishments in 2006 by taxa are as follows:

Vegetation. We sampled 55 modified Whitaker plots.

Reptiles. We sampled reptiles using 14 trapping arrays, 28 visual surveys, and a series of road surveys. We found a total of 410 individual reptiles of six species. Sagebrush lizards and horned lizards were the most commonly sampled species.

Breeding Birds. We sampled 77 plots for breeding birds using point counts.

Burrowing Owls. We sampled the entire Development Zone for burrowing owls using call back surveys. We found a total of ten burrowing owl burrows.

Bats. We sampled bats using acoustic sampling in the summer and cave surveys in the winter. We found a total of nine bat species during summer surveys five of which are species of conservation concern as identified in the Idaho Bat Conservation Plan. We found a total 712 bats overwintering in the three caves that were surveyed. The majority of overwintering bats were Townsend's big eared bats which are a species of conservation concern.

Small Mammals. We sampled a total of 57 plots for small mammals using Sherman live traps and Havahart traps.

Plans for Continuation

In 2007 we plan to continue surveys for all species mentioned above and begin surveys for mammalian carnivores and raptors. In addition, we will be beginning radio telemetry projects on sage grouse and pygmy rabbits, a study on raven depredation of sage grouse nests, and a rattlesnake population genetics project.

9.6 Cesium in Soils and Plants in the Sagebrush Steppe Ecosystem

Investigators and Affiliations

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Terence P. McGonigle, Associate Professor, Department of Botany, Brandon University, Brandon, Manitoba, Canada

Funding Sources

The Idaho State University Department of Biological Sciences

The Idaho State University Center for Ecological Research and Education

The Inland Northwest Research Alliance

The Idaho State University Graduate Student Research and Scholarship Committee

A Bechtel Educational Outreach Program grant awarded to Richard Inouye

Sigma Xi

Accomplishments

This research was conducted as part of a doctoral program and has been completed.

Dissertation Abstract

Cesium (Cs) movement in ecosystems is important due to Cs radioisotopes introduced via nuclear technologies. Stable Cs uptake by plants is comparable to Cs radioisotopes. Three lines of investigation were used to determine stable Cs movement in the sagebrush steppe ecosystem of the eastern Snake River Plain. First, 27 sites were surveyed to determine Cs concentrations in 28 soil and 330 plant samples. Titanium (Ti) was used to indicate soil contamination on plant samples. Cesium in soils correlated with quartz and cation exchange capacity. Cesium in plants correlated with Ti. Transfer factors, i.e., the concentration ratio of plant Cs to soil Cs, were on the order of 10^{-3}.

Second, the validity of Ti to indicate soil contamination was assessed. Milling inert filter paper indicated that background Ti levels account for concentrations to 10 mg Ti•kg plant^{-1}. Concentrations of Ti and Cs associated with seedlings grown in a dust-free environment increased significantly with moderate dusting. Washing dust-laden plants with seven washing agents revealed none as superior in removing soil from seven species and none was effective in removing all soil from any one species. Energy dispersive spectrometry showed plant surface elemental signatures consistent with soil coatings.

Third, four grasses were evaluated as phytoremediation candidates via greenhouse experiments. The species were *Agropyron spicata* (bluebunch wheatgrass), *A. cristatum* (crested wheatgrass), *Leymus cinerus* (Great Basin wildrye), and *Bromus tectorum* (cheatgrass). Plant Cs concentrations were higher in Cs-spiked soil. Total Cs per seedling was greatest in the high Cs, high fertility, and high moisture soil treatment combination.

These studies indicated: (1) the uptake of Cs by regional plants is low and much of the Cs is in soil adhering to plant surfaces, (2) Ti is a reliable indicator of soil contamination for plant samples slated for trace element analysis and should be used when assessing trace element composition of field samples, and (3) Great Basin wildrye, bluebunch wheatgrass, crested wheatgrass, and cheatgrass are viable phytoremediation agents when used in a strategy combining soil fertilization and irrigation and possibly stable Cs addition. Preference should be given to the native bluebunch wheatgrass and Great Basin wildrye because they do not negatively impact regional biodiversity.

9.7 Minimizing Risk of Cheatgrass Invasion and Dominance at the Idaho National Laboratory

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Nevada Arid Rangeland Initiative and the Nevada Agricultural Experiment Station

Background

Predicting plant community susceptibility to invasion by introduced species and determining mechanisms of resistance are fundamental concerns of ecology and ecosystem management. In the Great Basin, the invasive introduced annual cheatgrass (*Bromus tectorum*) currently dominates 3 million acres, with another 14 million acres heavily infested and 60 million acres considered at risk for potential domination (Pellant and Hall 1994). However, the eastern portion of the Snake River Plain, including the INL, has largely escaped the cheatgrass dominance found in the western portions of the Snake River Plain and in northern Nevada.

Anderson and Inouye (2001) concluded that maintenance of cover of native species may make the vegetation of the INL resistant to invasion. However, the eastern Snake River Plain also differs climatically from most cheatgrass-invaded areas: winter temperatures are colder and there is more late spring precipitation. The relatively minor extent of cheatgrass invasion at the INL in comparison with surrounding areas provides a unique opportunity to identify environmental conditions, community characteristics, or management practices conferring ecosystem resistance to invasion.

Objectives

The goal of this project is to use a combination of field surveys and mechanistic hypothesis-driven greenhouse experiments to determine the influences of environment, plant community, and land management on invasion success.

Comparative surveys - We will conduct comparative surveys along a latitudinal climatic gradient from north central Nevada, where cheatgrass dominates much of the landscape, to the INL. We will establish sampling plots at several hundred locations in four areas along this ‘mega-transect’ taking care to adequately sample sites with different types of disturbance and management histories as well as different vegetation composition and temperature and precipitation regimes. We will sample intensively at the INL; at sites near INL (and therefore climatically similar) but with different land use and ownership; at sites in far southern Idaho and northern Nevada (Owyhee Plateau) with a range of disturbance and community

composition; and in north central Nevada near a set of permanent experimental plots that were established to assess restoration success of cheatgrass-dominated rangeland (Allcock et al. 2006). We will use information ranging in scale from microscopic (nutrients and microbes) to landscape (climate and land use patterns) to parameterize a structural equation model (SEM) (Grace 2006) and specifically test hypotheses about how site characteristics affect invasion success of cheatgrass.

SEM is a powerful statistical way to infer causality: specifically we will use it to determine why cheatgrass is more abundant in certain locations and less abundant in others. An additional benefit of SEM is that we can include variables based on 'expert opinion' rather than relying on strictly empirical data. This means we can include a wealth of invaluable information that would not be otherwise useable in a quantitative model. We will be collecting observational data from the field and combining it with site specific variables.

Controlled greenhouse studies – We will use controlled-environment experiments that involve individual species and constructed communities to establish a mechanistic understanding of competition between cheatgrass and native species. We will investigate competitive relationships, effects of diversity, density, and disturbance, and response to variation in water regime (timing and pulse size). Preliminary single-species trials indicate that cheatgrass and perennial species differ in their abilities to respond to water pulses depending on size and frequency of watering events, and that moisture at the right time in the life cycle of cheatgrass could promote high competitive ability and possibly invasion (K. Allcock, unpublished data). A mesocosm experiment is currently underway to test the interactions of precipitation timing and community composition in determining invasion success.

Accomplishments through 2006

Comparative surveys – In September 2006, we visited the INL and traveled the length of our proposed 'mega-transect' to identify potential sampling locations. We have obtained and are processing fire history, soil maps, vegetation classification data and digital elevation models for the sampling areas we identified. We will convert the information to digital GIS layers and use the GIS to help with the selection of exact data collection points. The GIS will also provide information that will be used in the final SEM model.

Controlled greenhouse studies – In September and October of 2006 we began establishing an experiment to test the effects of community composition, precipitation amount, and precipitation timing on establishment and success of cheatgrass. We collected individuals of six perennial grass species from a field location near Reno, NV. We used these to create a series of two-species 'communities' in 50-gallon barrels in a greenhouse on the University of Nevada campus. These communities are composed of species that are active earlier in the growing season (*Poa secunda*, *Acnatherum hymenoides*, and *Elymus elemoides*), later in the growing season (*Hesperostipa comata*, *A. thurberiana*, and *Pseudoroegneria spicata*), or a combination (one early species and one late species). One quarter of the barrels contain no perennial plants. Between April 2007 and June 2007 these communities will receive either a total amount of water based on the long-term average precipitation for the Reno area, or an elevated amount of precipitation (in line with climate change predictions; 50 percent more than the long term average). This total amount of water will be administered either primarily in the 'early season' (April-May) or in the 'late season' (May-June). All communities have been seeded with cheatgrass at a rate of 2000 seeds per m^2. In summary, there are four community types (early, late, mixed, no perennials); two total water levels (ambient, elevated); and two precipitation timings (early, late). We have six replicates for each treatment combination, giving a total of

96 barrels. We will monitor soil moisture; cheatgrass density, biomass, seed production and photosynthetic rates; and the growth, reproduction, and photosynthetic rates of the perennial plants.

Results

This project was still in its developmental stage in 2006, and we have not collected any field or experimental data. We have begun to compile site-related information including fire history, climate variables, soil survey data, and topographic variables into a GIS database. We will begin collecting data on our greenhouse studies in May 2007.

Plans for Continuation

This project will continue through 2009. We will begin collecting field data from the comparative field plots at INL and other areas starting in late-May and June 2007. In subsequent seasons, we will continue to collect vegetation, soil and climate data from additional survey plots in order to obtain as much data as possible for parameterization of the SEM. SEMs may require a minimum of 100 data points in order for the algorithms used to identify reliable parameter values (Tanaka 1987), and we aim to sample approximately 400 individual plots among the four locations through the course of the study.

As outlined in the previous section, our mechanistic greenhouse study is just getting underway and this experiment will continue through the end of June 2007. We will use the results from this first experimental iteration to refine our understanding of how precipitation timing, precipitation amount and community composition affects cheatgrass performance. We will perform additional greenhouse studies over the next several years to test and refine further our understanding of the mechanisms of plant interaction and cheatgrass establishment in perennial grass ecosystems.

Publications, reports, theses, etc.

We anticipate several peer reviewed publications (e.g. the results of the SEMs and the results of the greenhouse experiments) and conference proceedings in addition to the Ph.D. dissertation to be completed by Lora Perkins in 2009.

9.8 Sagebrush Demography on the Idaho National Laboratory

Investigators and Affiliations

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

As more and more sagebrush steppe habitat in good ecological condition is lost, it becomes increasingly important to understand the ecosystem dynamics of that vegetation type, especially the biology of the dominant species, sagebrush. An understanding of the population dynamics, or demography, of sagebrush

should allow land managers to make better decisions about remaining healthy sagebrush steppe vegetation. An understanding of what the historical population dynamics of a sagebrush stand may have been like will also allow land managers to begin to understand how to make improvements in sagebrush steppe communities that are in somewhat degraded conditions.

At the INL, the DOE is responsible for the stewardship of 2300 km^2 of relatively pristine sagebrush steppe habitat. This land comprises one of the largest remnants of this type of ecosystem that has been largely exempt from anthropogenic disturbance. Some of the primary issues DOE must address as a land manager include: fire risk and fuel management, post-fire vegetation recovery, rangeland health, wildlife habitat management (including habitat critical to the survival of threatened, endangered, and sensitive species), and land use planning. Sagebrush is an important component of managing for all of these issues. Unfortunately, the population biology of sagebrush is not well understood. In particular, very little information is available on the typical age structure of sagebrush stands, the frequency of recruitment events, the dynamics of shrub die-off, and the typical lifespan of sagebrush.

The overarching goal of this proposed study is to describe sagebrush stand age structure for a representative sample of sagebrush stands and to identify the population dynamics that influence that structure at the INL. Characterizing sagebrush stand age structure is a critical component to managing sagebrush steppe ecosystems, and understanding some of the basic biology of sagebrush can add tremendously to DOE's ability to make knowledgeable land management and land use decisions. A simple study to establish a working knowledge of the age dynamics of sagebrush stands can yield information useful to those land management issues listed above. Many of the results from this study may also be applied to sagebrush stands with similar climatic conditions and disturbance regimes range-wide, allowing range managers throughout the West to use these data.

Objectives

The working knowledge of the dynamics of stand age structure gained from this study will allow managers to better address all of the land management issues mentioned above. The specific objectives for this project are:

1. To determine the typical stand age structure or range of stand age structures for mature sagebrush stands.
2. To investigate how stand age structure relates to stand condition and shrub die-off for sagebrush.
3. To examine the dynamics of sagebrush stand replacement in the absence of wildland fire.

By addressing these goals, the proposed study will facilitate a comprehensive understanding of sagebrush population biology on the INL and on climatically similar rangelands. That improved understanding of sagebrush ecology will include the normal age structure of sagebrush stands, the typical range of variation of sagebrush stand age structure, how age structure of a sagebrush stand relates to stand condition, the dynamics of shrub die-off, the typical lifespan of sagebrush, the frequency of recruitment events, and the relationship between recruitment and disturbance.

The expected deliverables for the project will support the development of the Conservation Management Plan and include (1) specific habitat management recommendations for sagebrush at the INL and, (2) guidance for assessing the status of sagebrush habitat health on the INL.

Accomplishments through 2006

During 2006, 14 stands of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) were sampled. The vegetation data collected as a component of this study included; shrub cover, sagebrush density, and individual shrub rank data for use in developing criteria for measuring stand condition. At each stand, cross section samples of sagebrush were also collected. The cross sections were labeled and archived in preparation for sanding and ring counts.

Results

Because data collection was initiated in 2006 and no data analyses have yet been completed, no results are reported here.

Plans for Continuation

Funding for this project has been discontinued.

9.9 Long-Term Vegetation Trends on the Idaho National Laboratory

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Funding Sources

U.S. Department of Energy Idaho Operations Office

Background

In 1950 at the request of the Division of Biology and Medicine of the Atomic Energy Commission requested a background survey for naturally occurring radioactive materials in the vicinity of what is now known at the INL. One of the legacies of that background survey in 1950 remains today in the form of the Long-Term Vegetation (LTV) plots. The LTV plots originally consisted of 110 plots on and near the INL. Over the years some of the plots have been lost due to agricultural and other development activities and 92 plots remain. These plots were surveyed in 1950, 1957, 1965, 1975, 1985, 1995 and 2001. A subset of 35 or 36 plots were also surveyed in 1978, 1983, and 1990.

The plots originally consisted of two transects 50 ft (15.24 m) in length. Vegetative cover of shrub crown and grass basal area was measured using line intercept and density was measured in quadrats placed at intervals of 5 ft (1.52 m) along the two transects. In 1985, a third transect 65.6 ft (20 m) in length was added to each plot to support measurement of cover using point interception. Also, a photographic record of each plot has been made during each survey beginning in 1957.

Although the original intent of the LTV plots was to provide information on presence of naturally occurring radioactive materials in the environment, the data from these plots have also been used to assess the potential impact of nuclear energy research and development and other activities on ecological resources native to the INL. The LTV plots have provided important background information for assessing potential impact to ecological resources in numerous Environmental Assessments and Environmental Impact Statements at the INL.

Also, the LTV data have become an invaluable resource for research on the structure and function of native sagebrush steppe vegetation communities. The INL LTV plots represent one of the most intensive (in terms of the amount and kinds of data available for each plot) and one of the most extensive (in terms of its geographical and temporal extents) datasets for the sagebrush steppe ecosystem type. The significance of this dataset to the broader scientific and natural resource management communities is further amplified when considering that it represents the largest remnant of good condition sagebrush steppe. This significance is illustrated by the paper by Anderson and Inouye (2001) that provided a summary of this dataset through 1995. In the first five years following publication, this paper was cited more than 40 times in the scientific literature.

Objectives

There are three primary goals for current activities associated with the LTV project. They include surveying plots in 2006, analyzing data and preparing reports and manuscripts in 2007, and archive all data collected since 1959 and incorporating that archive into the CMP Ecological Data Management System. Research objectives for this effort include investigating methods for studying the population ecology of native bunchgrasses, the role of annual forbs in the ecology of sagebrush steppe communities and environmental controls on diversity of forbs.

Accomplishments through 2006

Data collection began in June 2006 and continued through July. We surveyed all of the 92 remaining LTV plots. Field crews were trained in late May and early June on survey methods and plant identification. We conducted Quality Assurance/Quality Control audits on all data collected as they were brought in from the field. There was a lag of no more than one week between data collection and these audits.

Once the field data collection was completed, we began data analysis. Because of the short amount of time between the completion of data collection and the end of the fiscal year, data analysis in 2006 was limited to transforming the data so that it is in a format consistent with the needs of the statistical analysis.

Results

Because only limited data manipulation was completed in 2006, no results are available to be reported here.

Plans for Continuation

In 2007 we plan to complete the data analysis and report preparation. We also plan to begin work on at least two manuscripts based on the results of the study. In 2007 and continuing into 2008, we will begin the process of archiving the LTV data into the CMP data management system. This will include converting all of the photographic negatives into digital format.

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Great Basin Rattlesnake

Chapter 10 - Quality Assurance

Mule Deer

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10. QUALITY ASSURANCE

Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses.

The purpose of a quality assurance and quality control program is to ensure precise, accurate, representative, and reliable results, and to maximize data completeness. Another key issue of a quality program is to ensure that data collected at different times are comparable to previously collected data. Elements of typical quality assurance programs include, but are not limited to the following (ASME 2001, ASME 1989, EPA 1998):

- Adherence to peer-reviewed written procedures for sample collection and analytical methods
- Documentation of program changes
- Periodic calibration of instruments with standards traceable to the National Institute of Standards and Technology (NIST)
- Chain of custody procedures
- Equipment performance checks
- Routine yield determinations of radiochemical procedures
- Replicate samples to determine precision
- Analysis of blind, duplicate, and split samples
- Analysis of quality control standards in appropriate matrices to test accuracy
- Analysis of reagent and laboratory blanks to measure possible contamination occurring during analysis
- Analysis of blind spike samples (samples containing an amount of a constituent known to the sampling organization, but not the analytical laboratory) to verify the accuracy of a measurement
- Internal and external surveillance to verify quality elements
- Data verification and validation programs.

10.1 Laboratory Intercomparison Programs

Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. In 2006, the Idaho Cleanup Project (ICP) contractor used General Engineering Laboratories (GEL) and Sanford Cohen and Associates for radiological and inorganic analyses. The Idaho National Laboratory (INL) Site Drinking Water Program used GEL for radiological analyses, Microwise Laboratories (now Energy Laboratories) of Idaho Falls for inorganic and bacteriological analyses, and Environmental Health Laboratories (now Underwriters Laboratory) for inorganic and organic analyses. The air monitoring program also used Severn-Trent St. Louis and the Liquid Effluent Program also used Southwest Research Institute for some analyses.

The Environmental Surveillance, Education and Research Program (ESER) contractor used the Environmental Assessments Laboratory located at Idaho State University for gross radionuclide analyses (gross alpha, gross beta, and gamma spectrometry). Teledyne Brown Engineering of Knoxville, TN was used for specific radionuclide analyses (e.g., strontium-90 [^{90}Sr], americium 241 [^{241}Am], plutonium-238 [^{238}Pu], and plutonium 239/240 [$^{239/240}$Pu]). The U.S. Department of Energy's (DOE's) Radiological and Environmental Sciences Laboratory (RESL) performed radiological analyses for the U.S. Geological Survey (USGS). The USGS National Water Quality Laboratory conducted nonradiological analyses. All these laboratories participated in a variety of programs to ensure the quality of their analytical data. Some of these programs are described below.

Quality Assessment Program/Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program (MAPEP) is administered by DOE's RESL. The DOE has mandated since 1994 that all laboratories performing analyses in support of the Office of Environmental Management shall participate in MAPEP. The program generally distributes samples of air, water, vegetation, and soil for analysis during the first and third quarters. Both radiological and nonradiological constituents are included in the program. Results can be found at http://www.inl.gov/resl/mapep/reports.html (DOE 2006).

2006 MAPEP Results

Comparisons of the air and water MAPEP results for the laboratories used by INL Site environmental monitoring organizations in 2006 are presented in Figures 10-1 and 10-2 for gross alpha/beta and actinides. Results for all laboratories were qualified as acceptable for these analyses.

National Institute of Standards and Technology

The DOE RESL participates in a traceability program administered through the NIST. 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, generally in liquid media, for analysis by RESL to confirm their analytical capabilities. RESL maintained NIST certifications in both preparation and analysis in 2006.

Dosimetry

To verify the quality of the environmental dosimetry program conducted by the INL contractor and the ESER contractor, the Operational Dosimetry Unit participates in International Environmental Dosimeter Intercomparison Studies. The Operational Dosimetry Unit's past results have been within ± 30 percent of

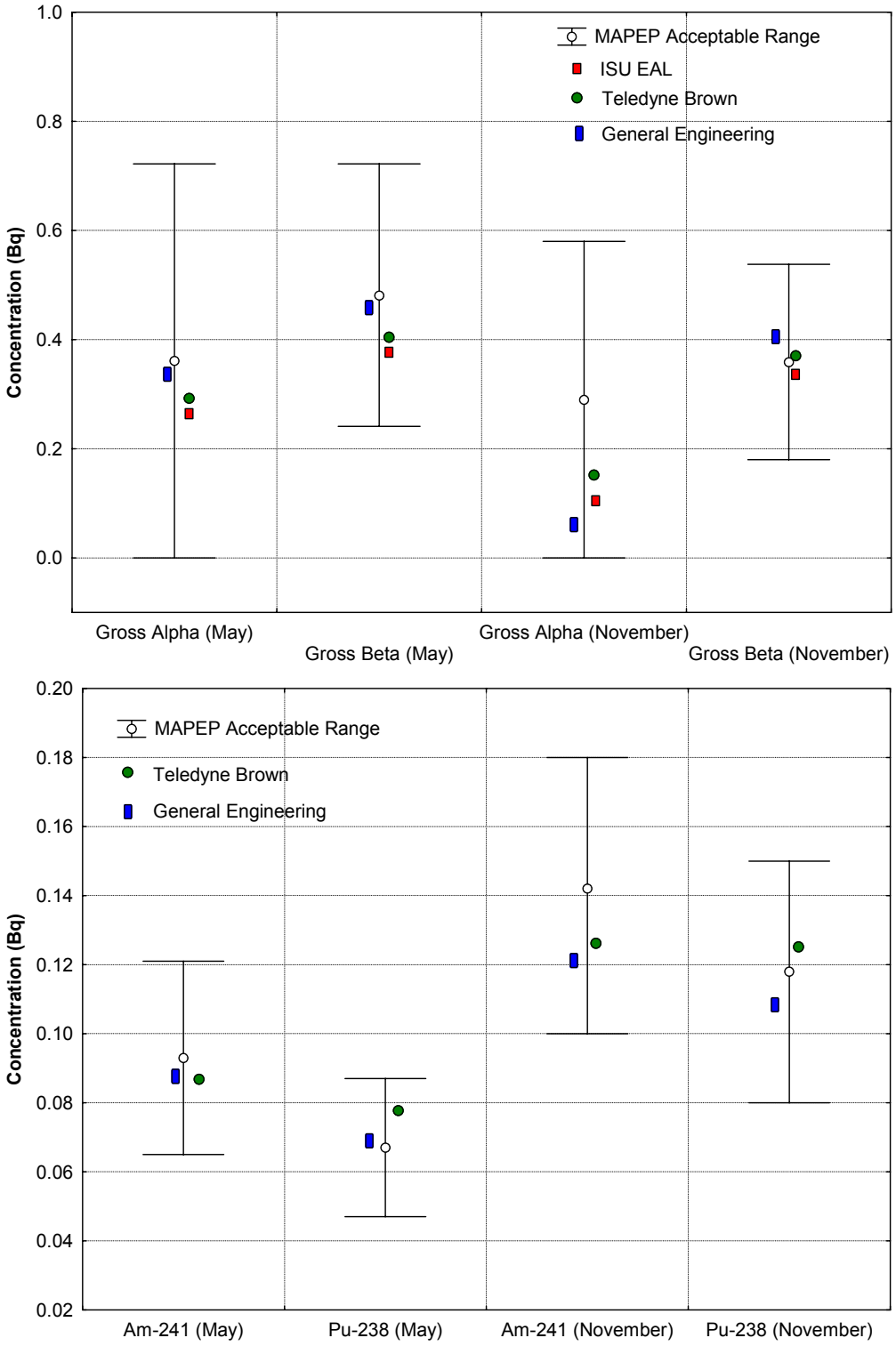


Figure 10-1. INL, ICP and ESER Surveillance Laboratory Air Sampling Results from the MAPEP Intercomparisons (2006).

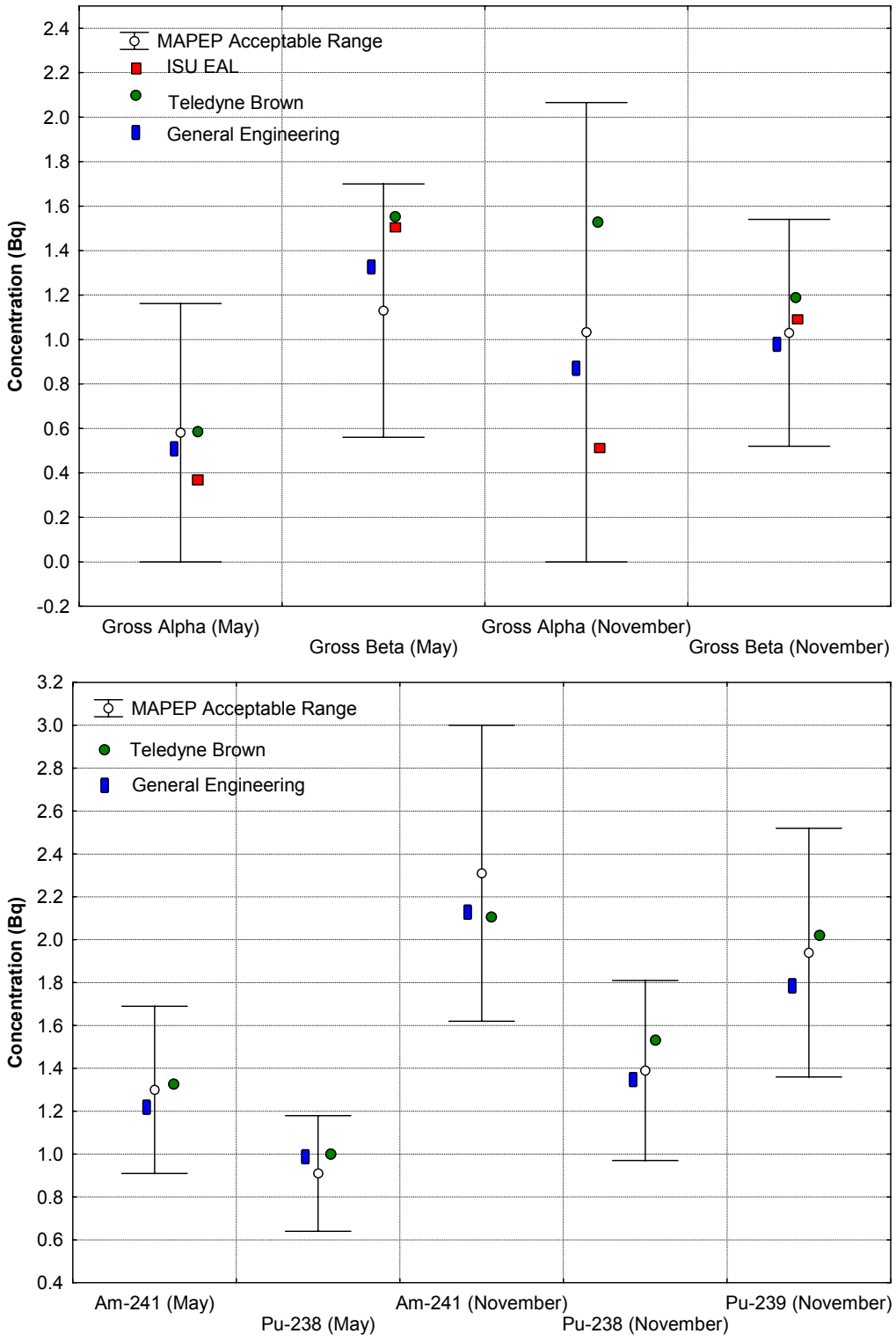


Figure 10-2. INL, ICP and ESER Surveillance Laboratory Water Sampling Results from the MAPEP Intercomparisons (2006).

the test exposure values on all intercomparisons. This is an acceptable value that is consistent with other analysis that range from ± 20 percent to ± 35 percent.

The Operational Dosimetry Unit of the INL Contractor also conducts in-house quality assurance testing during monthly and quarterly environmental thermoluminescent dosimeter (TLD) processing periods. The quality assurance (QA) test dosimeters were prepared by a QA program administrator. The delivered irradiation levels were blind to the TLD processing technician. The results for each of the QA tests have remained within the 20 percent acceptance criteria during each of the testing periods.

Other Programs

INL Site contractors participate in additional performance evaluation programs, including those administered by the International Atomic Energy Agency, the U.S. Environmental Protection 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 State Department of Environmental Quality oversees the certification program and maintains a listing of approved laboratories. Where possible (i.e., the laboratory can perform the requested analysis) the contractors use such state-approved laboratories for all environmental monitoring analyses.

10.2 Data Precision and Verification

As a measure of the quality of data collected, the ESER contractor, the INL contractor, the ICP contractor, the USGS, and other contractors performing monitoring use a variety of quality control samples of different media. Quality control samples include blind spike samples, duplicate samples, and split samples.

Blind Spikes

Groups performing environmental sampling use blind spikes to assess the accuracy of the laboratories selected for analysis. Contractors purchase samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to the NIST. These samples are then submitted to the laboratories with regular field samples, with the same labeling and sample numbering system. The analytical results are expected to compare to the known value within a set of performance limits.

Duplicate Sampling within Organizations

Monitoring organizations also collect a variety of quality control samples as a measure of the precision of sampling and analysis activities. One type is a duplicate sample, where two samples are taken from a single location at the same time. A second type is a split sample, where a single sample is taken and later divided into two portions that are analyzed separately. Contractors specify in quality assurance plans the relative differences expected to be achieved in reported results for both types of quality assurance samples.

Both the ESER contractor and the INL contractor maintained duplicate air samplers at two locations during 2006. The ESER contractor operated duplicate samplers at the locations in Mud Lake and at the Experimental Field Station. The INL contractor duplicate samplers were located at the Materials and Fuels Complex and at the Van Buren Boulevard Gate. Filters from these samplers were collected and analyzed

in the same manner as filters from regular air samplers. Graphs of gross beta activity for the duplicate samplers are shown in Figures 10-3 and 10-4. The figures show that duplicate sample results tracked each other well.

Duplicate Sampling between Organizations

Another measure of data quality can be made by comparing data collected simultaneously by different organizations. The ESER contractor, the INL contractor, and the state of Idaho's INL Oversight Program collected air monitoring data throughout 2006 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. Data from these sampling locations for gross beta compared favorably and are shown in Figure 10-5.

The ESER contractor collects semiannual samples of drinking and surface water jointly with the INL Oversight Program at five locations in the Magic Valley area and two shared locations near the INL Site. Table 10-1 contains intercomparison results of the gross alpha, gross beta, and tritium analyses for the 2006 samples taken from these locations. The paired results were statistically the same for 95 percent (40 of 42) of the comparisons made.

The USGS routinely collects groundwater samples simultaneously with the INL Oversight Program. Comparison results from this sampling are regularly documented in reports prepared by the two organizations.

10.3 Program Quality Assurance

Liquid Effluent Program Quality Assurance/Quality Control

The ICP contractor's Liquid Effluent Monitoring Program has specific quality assurance/quality control objectives for monitoring data. All effluent sample results were usable. Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. The Liquid Effluent Monitoring Program submits three types of quality control samples:

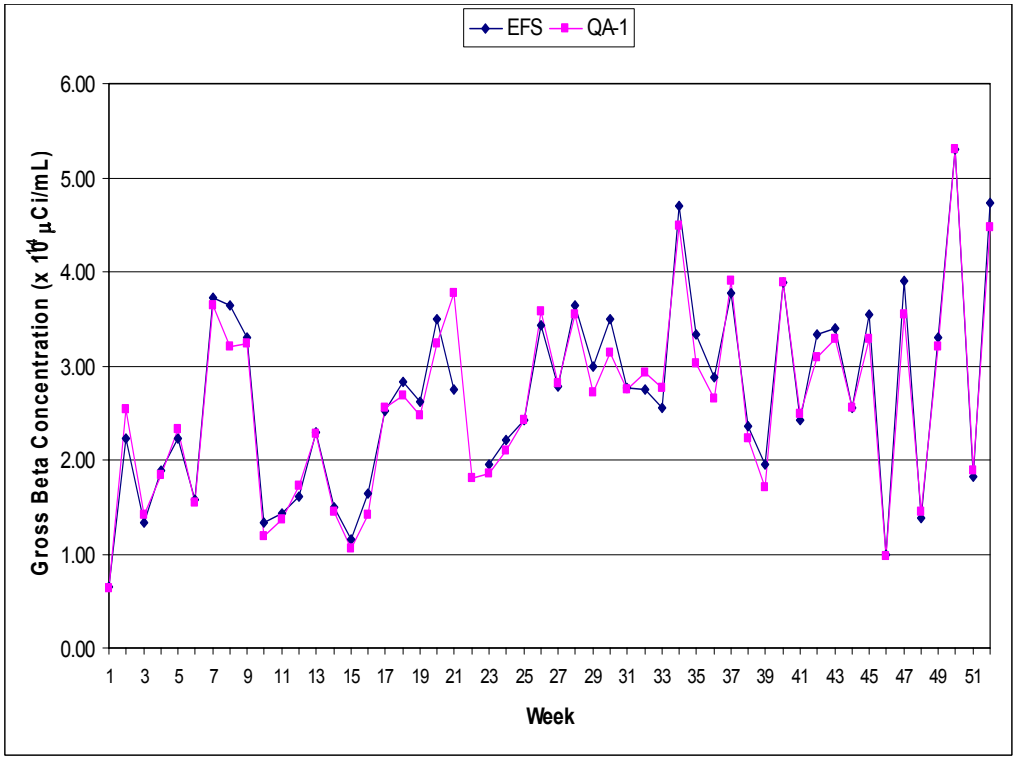
(1) Performance evaluation (PE) samples (submitted as field blind spikes) are required to assess analytical data accuracy. At a minimum, performance evaluation samples are required quarterly.

(2) Field duplicates (splits) provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures. One duplicate sample is collected each quarter at a randomly selected location.

(3) Rinsate samples are collected to evaluate the effectiveness of equipment decontamination. One rinsate sample is collected each year.

During 2006, four sets of PE samples were submitted to the laboratory along with routine monitoring samples. Most results were within performance acceptance limits. Table 10-2 shows the number of results outside the performance acceptance limits. The laboratory was notified of the results so they could evaluate whether corrective action was required.

The relative percent difference (RPD) between the duplicate samples is used to assess data precision. Table 10-3 shows the results for 2006. Variations in the reported concentrations in the field duplicates are most likely the result of sample heterogeneity caused by variations in the amount of solids in the sample.



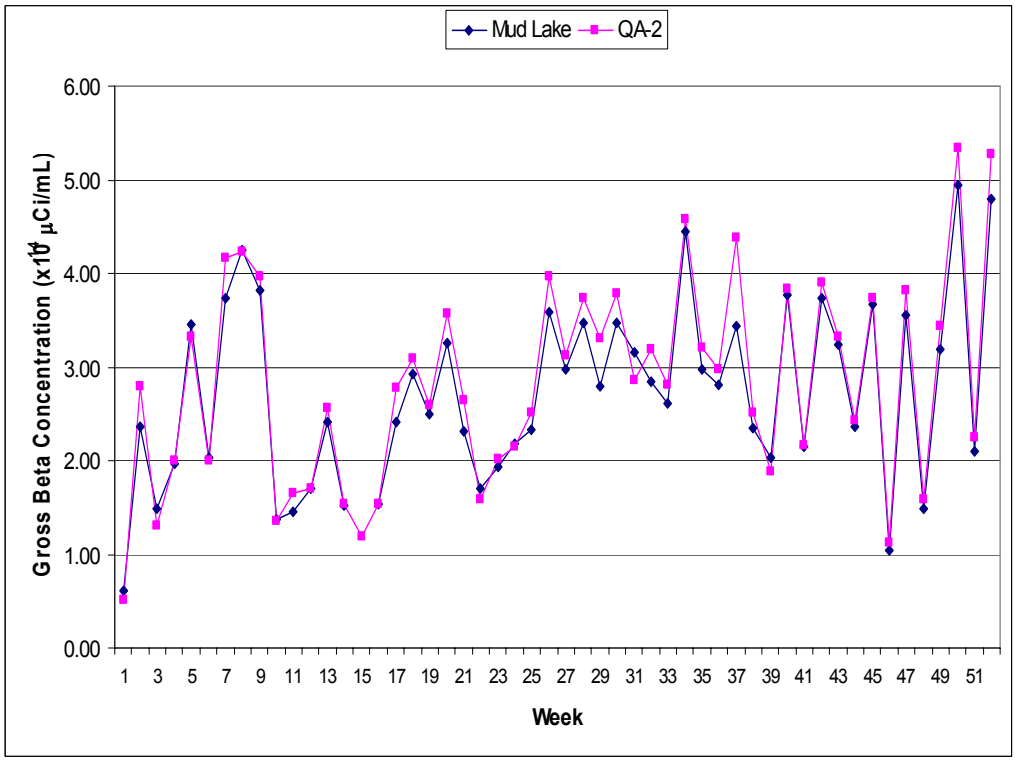
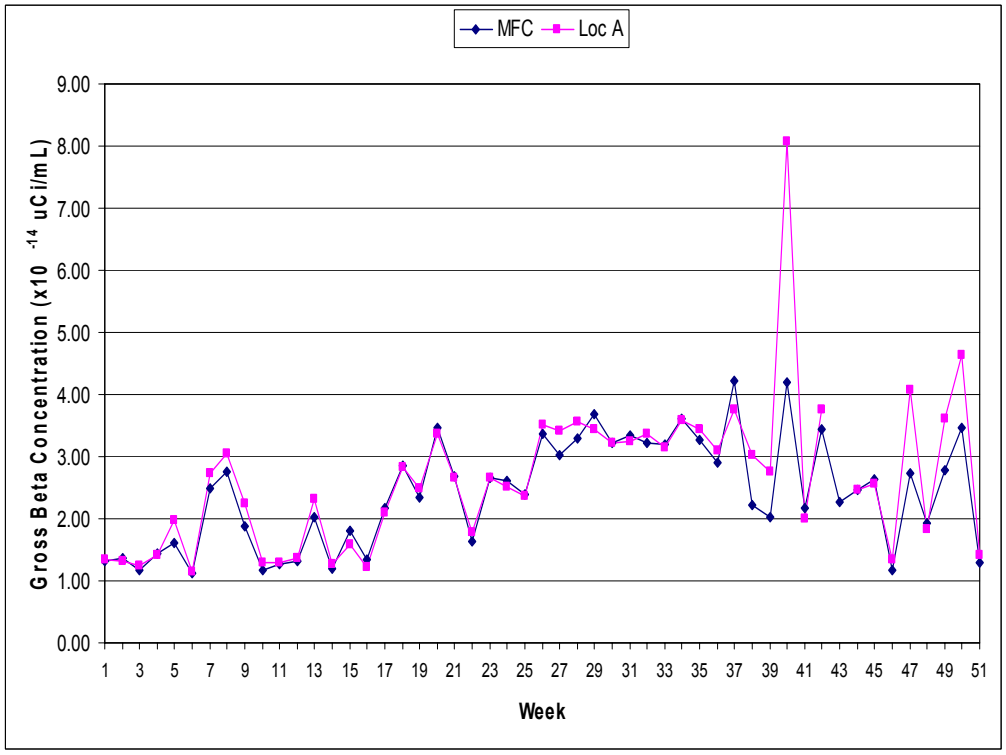


Figure 10-3. ESER Contractor Duplicate Air Sampling Gross Beta Results (2006).



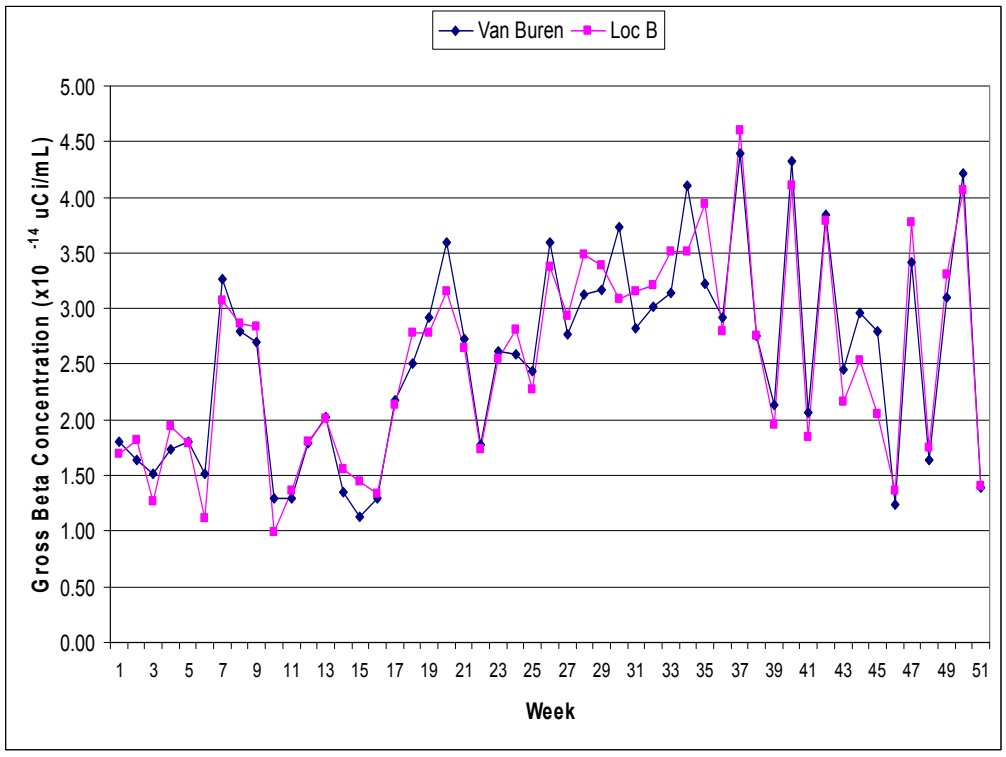


Figure 10-4. INL Contractor Duplicate Air Sampling Gross Beta Results (2006).

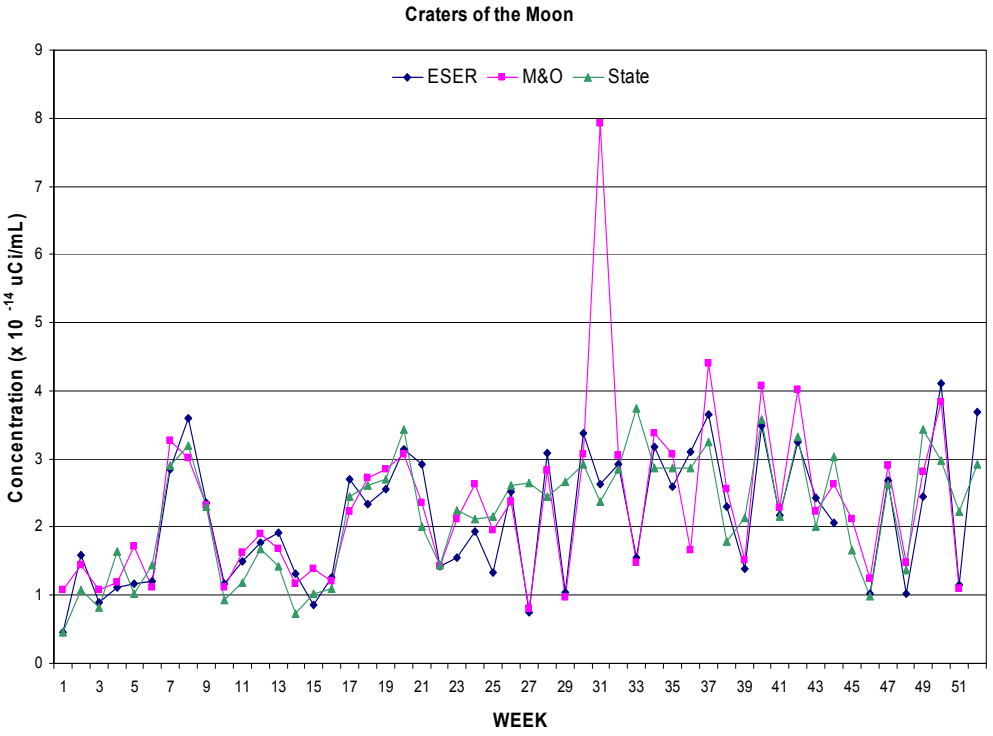
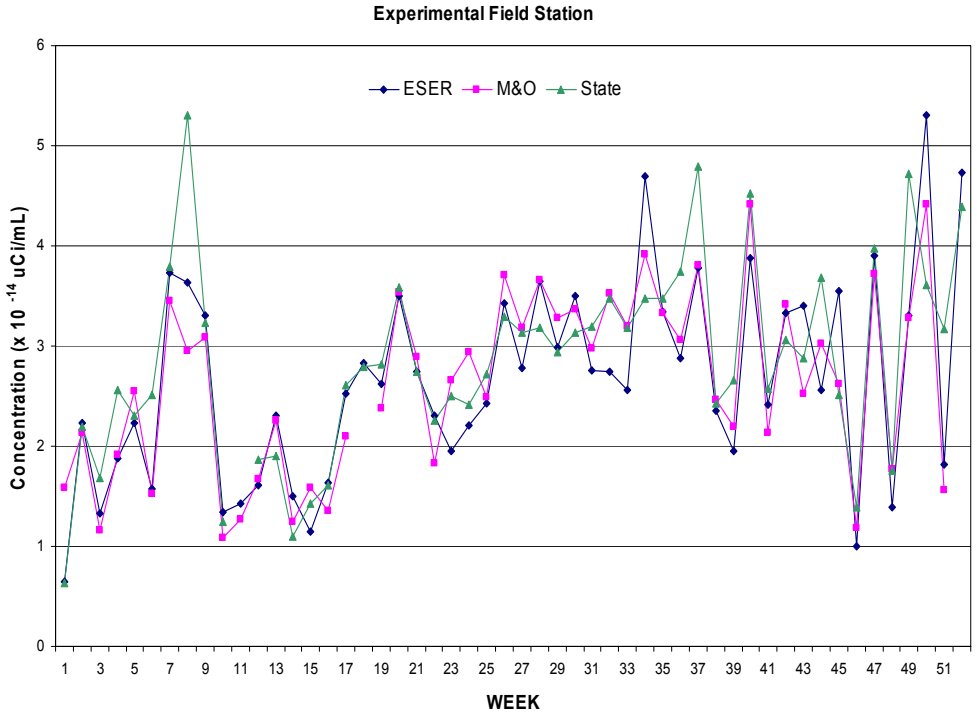


Figure 10-5. Comparison of Gross Beta Concentrations Measured by ESER Contractor, INL Contractor, and State of Idaho (2006).



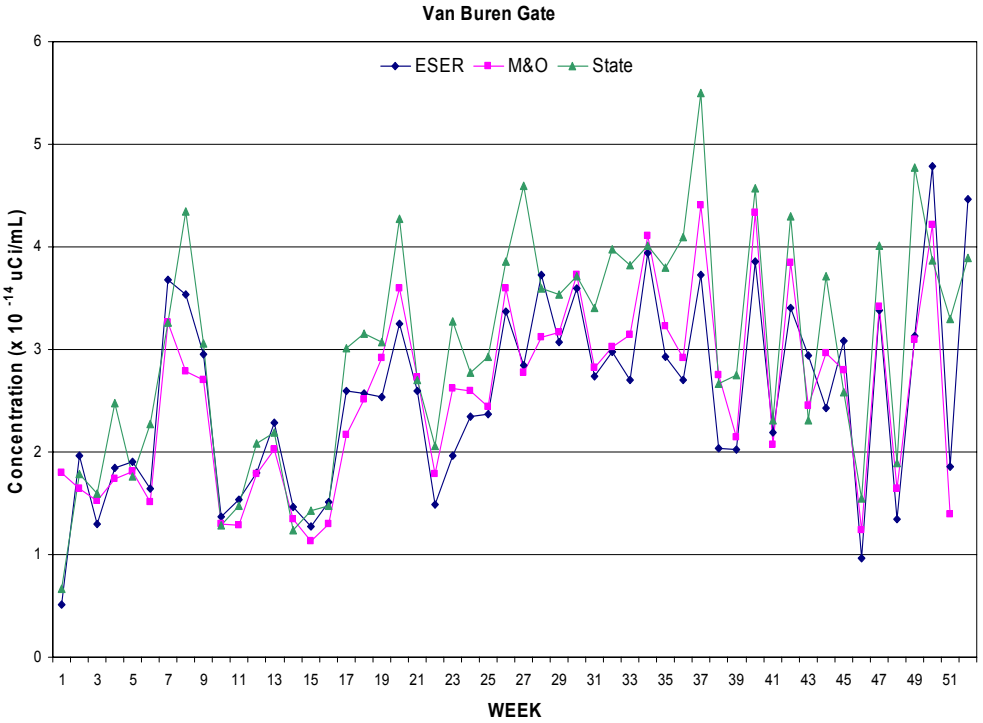


Figure 10-5. Comparison of Gross Beta Concentrations Measured by ESER Contractor, INL Contractor, and State of Idaho (2006). (continued)

Table 10-1. Comparison of ESER and INL Oversight Program Water Monitoring Results (2006).[a]

Location	Date	Gross Alpha (pCi/L) ESER	Gross Alpha (pCi/L) State	Gross Beta (pCi/L) ESER	Gross Beta (pCi/L) State	Tritium (pCi/L) ESER	Tritium (pCi/L) State
Drinking Water							
Atomic City	05/16	0.5 ± 0.4	0.3 ± 0.9	4.9 ± 0.6	2.4 ± 0.5	25 ± 30	-40 ± 40
	11/20	1.8 ± 0.4	2.0 ± 1.1	3.9 ± 0.5	2.4 ± 0.6	30 ± 30	40 ± 40
Minidoka	05/09	-0.2 ± 0.5	2.8 ± 1.2	3.1 ± 0.6	4.2 ± 0.6	10 ± 30	-40 ± 35
	11/15	0.3 ± 0.3	1.5 ± 0.9	5.3 ± 0.6	2.4 ± 0.5	-15 ± 25	-70 ± 40
Mud Lake	05/16	-0.3 ± 0.3	0.9 ± 0.8	3.8 ± 0.6	5.0 ± 0.5	30 ± 30	10 ± 40
	11/16	0.4 ± 0.3	0.3 ± 0.4	5.5 ± 0.6	3.6 ± 0.5	90 ± 30	10 ± 45
Shoshone	05/09	0.5 ± 0.5	2.9 ± 1.0	2.5 ± 0.5	3.9 ± 0.5	-40 ± 30	-30 ± 35
	11/14	0.3 ± 0.4	1.5 ± 1.1	4.7 ± 0.6	4.0 ± 0.6	90 ± 30	-10 ± 40
Surface Water							
Buhl	05/09	0.4 ± 0.4	1.5 ± 1.2	4.0 ± 0.5	4.1 ± 0.6	50 ± 30	-50 ± 35
	11/14	0.7 ± 0.4	0.7 ± 1.1	4.2 ± 0.5	4.1 ± 0.6	30 ± 30	30 ± 40
Hagerman	05/09	1.0 ± 0.3	-0.2 ± 0.9	2.1 ± 0.5	2.1 ± 0.5	45 ± 30	0 ± 35
	11/14	1.2 ± 0.3	2.1 ± 1.0	5.2 ± 0.6	4.4 ± 0.6	90 ± 30	20 ± 40
Twin Falls	05/09	0.6 ± 0.5	1.5 ± 1.4	6.9 ± 0.6	6.4 ± 0.6	-20 ± 30	30 ± 30
	11/14	-0.3 ± 0.3	-0.4 ± 1.5	7.7 ± 0.6	5.0 ± 0.7	80 ± 30	0 ± 40

a. Values are shown as the result ± 1 standard deviation, where the standard deviation is the total uncertainty.

The analytical results for the equipment blank sample indicated that decontamination procedures are adequate.

The goal for completeness is to collect 100 percent of all required compliance samples. During 2006, this goal was met.

Wastewater Land Application Permit Groundwater Monitoring Quality Assurance/Quality Control

The groundwater sampling activities associated with Wastewater Land Application Permit (WLAP) compliance sampling follow established procedures and analytical methodologies.

During 2006, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center (INTEC) and Test Area North (TAN) WLAP monitoring wells that had sufficient water. Samples were not collected from aquifer well ICPP-MON-A-167, which was dry during April and October 2006, perched well ICPP MON-V-191, which was dry in October 2006, and perched well TSFAG-05, which was dry during both April 2006 and October 2006. All of the samples required for permit compliance were collected.

All groundwater sample results were usable, except for some April 2006 sample results that were rejected as unusable during data validation because of quality control issues. Table 10-4 shows the April 2006 groundwater sample results that were rejected. The analytical laboratory was notified of the missed holding times, and the laboratory implemented corrective action to prevent recurrence. The Liquid

Table 10-2. Performance Evaluation Samples Outside Performance Acceptance Limits (2006).

Parameter	Number of Performance Evaluation Samples outside Performance Acceptance Limits
Antimony	1
Mercury	4
Nitrate-nitrite as nitrogen	1
Selenium	1
Silver	1
Sodium	1

Table 10-3. Liquid Effluent Program Relative Percent Difference Results (2006).

Parameter	Relative Percent Difference Result
Inorganic and metals	96% within the program goal of less than or equal to 35%.
Radiological	Not applicable: duplicate results had no detectable quantities.

Note: The RPD is calculated only if both results are detected (greater than instrument's detection limit).

Effluent Monitoring QA Program did not require notifying the analytical laboratory of the other rejected results.

Field quality control samples were collected or prepared during the sampling activity in addition to regular groundwater samples. Laboratories qualified by the ICP Sample and Analysis Management Organization performed all ICP groundwater analyses during 2006. Because TAN and INTEC are regarded as separate sites, quality control samples (duplicate samples, field blanks, and equipment blanks) were prepared for each site.

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, five percent of the total number of samples collected. Duplicates were collected using the same sampling techniques and preservation as regular groundwater samples. Duplicates have precision goals within 35 percent as determined by the relative percent difference measured between the paired samples. In 2006, for the 84 duplicate pairs with detectable results, 94 percent had RPDs less than 35 percent. This high percentage of acceptable duplicate results indicates little problem with laboratory operations and good overall precision.

Field blanks are collected to assess the potential introduction of contaminants during sampling activities. They were collected at the same frequency as the duplicate samples. Results from the field blanks did not indicate field contamination.

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. Again, results from the equipment blanks indicate proper decontamination procedures.

Results from the duplicate, field blank, and equipment blank (rinsate) samples indicate that laboratory procedures, field sampling procedures, and decontamination procedures were used effectively to produce high quality data.

During the April 2006 groundwater sampling event, two PE samples were analyzed for total coliform and fecal coliform. These samples were within the quality control (QC) Performance Acceptance Limits.

During the April 2006 sampling event, one PE sample was analyzed for metals. The results were as follows:

- Results for arsenic, barium, beryllium, cadmium, chromium, lead, manganese, and zinc were within the Performance Acceptance Limit
- Results for aluminum, iron, and selenium were greater than the upper Performance Acceptance Limit
- The result for mercury was less than the lower Performance Acceptance Limit.

During the October 2006 groundwater sampling event, one PE sample was analyzed for metals. The metals PE sample results were within the QC Performance Acceptance Limits.

Drinking Water Program Quality Assurance/Quality Control

The Drinking Water Program's completeness goal is to collect, analyze, and verify 100 percent of all compliance samples. This goal was met during 2006.

The Drinking Water Program requires that 10 percent of the samples (excluding bacteria) collected be quality assurance/quality control samples to include duplicates, field blanks, trip blanks, blind spikes, and splits. This goal was met in 2006 for all parameters.

The RPD between the duplicate samples is used to assess data precision. The INL and ICP contractor met the precision results for the Drinking Water Program in 2006, and results are shown in Table 10-5. Variations in the reported concentrations in the field duplicates are most likely the result of sample heterogeneity caused by variations in the amount of solids in the sample. Relative percent difference was not calculated if either the sample or its duplicate were reported as nondetects.

ESER Program Quality Assurance/Quality Control

The ESER program met its completeness goals for 2006, which requires that 98 percent of scheduled samples are collected and analyzed. For air sampling, less than 0.5 percent of scheduled samples did not meet the required volume to be considered a valid sample, due to equipment malfunctions and power outages. For most sample types, 100 percent of samples were collected as scheduled.

Spike samples were used to test the accuracy of the laboratories performing analyses for the program. During 2006, samples of air, water, and milk were submitted to each of the analytical laboratories and analyzed for gross alpha/beta, tritium, gamma-emitting radionuclides, actinides, and ^{90}Sr. Each laboratory also conducted an internal spike sample program using standards traceable to NIST.

Precision was measured using duplicate and split samples and laboratory recounts. In 2006, 98.6 percent of the results were within the criteria specified for these types of comparisons.

Table 10-4. Wastewater Land Application Permit Rejected Groundwater Results (2006).

Parameter	Well	Sample Date	Reason Rejected
Aluminum	ICPP-MON-A-165 (GW-013006)	4/24/2006	Poor laboratory serial dilution sample precision
	ICPP-MON-V-191 (GW-013008)	4/25/2006	
	ICPP-MON-V-200 (GW-013009)	4/25/2006	
	ICPP-MON-V-212 (GW-013010)	4/25/2006	
	TANT-MON-A-001 (GW-015301)	4/24/2006	
Aluminum-filtered	ICPP-MON-A-165 (GW-013006)	4/24/2006	Poor laboratory serial dilution sample precision
	ICPP-MON-V-200 (GW-013009)	4/25/2006	
	ICPP-MON-V-212 (GW-013010)	4/25/2006	
Biochemical oxygen demand	ICPP-MON-A-166 (GW-013007)	4/13/2006	Missed holding time by analytical laboratory
Iron	ICPP-MON-A-165 (GW-013006)	4/24/2006	Poor laboratory serial dilution sample precision
Iron-filtered	ICPP-MON-A-165 (GW-013006)	4/24/2006	Poor laboratory serial dilution sample precision and poor laboratory duplicate sample precision
Manganese	ICPP-MON-A-166 (GW-013007)	4/13/2006	Poor laboratory serial dilution sample precision
	TANT-MON-A-002 (GW-015304)	4/19/2006	
	TAN-13A (GW-015302)	4/19/2006	
Manganese-filtered	ICPP-MON-A-166 (GW-013007)	4/13/2006	Poor laboratory serial dilution sample precision
Nitrate, as nitrogen	ICPP-MON-A-165 (GW-013006)	4/24/2006	Missed holding time by the analytical laboratory
	ICPP-MON-A-166 (GW-013007)	4/13/2006	
Nitrite, as nitrogen	ICPP-MON-A-165 (GW-013006)	4/24/2006	Missed holding time by the analytical laboratory
	ICPP-MON-A-166 (GW-013007)	4/13/2006	
Selenium	ICPP-MON-V-191 (GW-13008)	4/25/2006	Poor laboratory duplicate sample precision
	ICPP-MON-V-200 (GW-013009)	4/25/2006	
	ICPP-MON-V-212 (GW-013010)	4/25/2006	
	TANT-MON-A-001 (GW-015301)	4/24/2006	
Selenium-filtered	ICPP-MON-V-200 (GW-013009)	4/25/2006	Poor laboratory duplicate sample precision
	ICPP-MON-V-212 (GW-013010)	4/25/2006	
Total Kjeldahl nitrogen	ICPP-MON-A-165 (GW-013006)	4/24/2006	Poor laboratory duplicate sample precision
	ICPP-MON-V-191 (GW-013008)	4/25/2006	
	ICPP-MON-V-200 (GW-013009)	4/25/2006	Poor laboratory matrix spike percent recovery
	ICPP-MON-V-212 (GW-013010)	4/25/2006	
Zinc	TANT-MON-A-002 (GW-015304)	4/19/2006	Poor laboratory duplicate sample precision
	TAN-13A (GW-015302)	4/19/2006	

Table 10-5. Drinking Water Program Relative Percent Difference Results (2006).

Parameter	RPD Result
Inorganic and Organic	100% of Battelle Energy Alliance and CH2M-WG Idaho's RPD results were within the program goal of less than or equal to 35%.
Radionuclide	CH2M-WG Idaho had three sets of duplicate results with detectable quantities. Of those, two met the program goal of less than or equal to 35%. Battelle Energy Alliance had four sets of duplicate results with detectable quantities. Of those, three met the program goal of less than or equal to 35%.

Both field blanks and laboratory blanks were used by the ESER contractor and analytical laboratories to detect the presence of contamination through the sampling and analysis process. No major problems were reported in 2006.

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 quality assurance 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 (NCER) Quality Assurance Program. The laboratories met the performance objectives specified by the MAPEP and NCER.

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 control samples as required with routine samples for analyses.

ICP Environmental Services Waste Management Surveillance Quality Assurance/Quality Control

The ICP contractor analytical laboratories analyzed all Waste Management Surveillance Program samples as specified in the statements of work. These laboratories participate in a variety of intercomparison quality assurance programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA NCER Quality Assurance Program. The laboratories met the performance objectives specified by the MAPEP and NCER.

PE samples for soils, vegetation, and run-off water were submitted to the contract laboratory for analysis in March 2006 for Waste Management Surveillance Programs. PE sample results showed satisfactory agreement.

The Waste Management Surveillance Program met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. The Waste Management Surveillance Program submitted duplicate and blank samples to the contract laboratory as required with routine samples for analyses. In 2006, the results for these samples were within the acceptable range.

REFERENCES

American Society of Mechanical Engineers (ASME), 1989, "NQA-3-1989: Quality Assurance Requirements for the Collection of Scientific and Technical Information for Site Characterization of High-Level Nuclear Repositories, Supplement SW-1," American National Standard; New York.

American Society of Mechanical Engineers (ASME), 2001, "NQA-1-2000: Quality Assurance Requirements for Nuclear Facility Applications, Part I," American National Standard; New York.

U.S. Department of Energy (DOE), 2005, "Mixed Analyte Performance Evaluation Program," http://www.inl.gov/resl/mapep/reports.html.

U.S. Environmental Protection Agency (EPA), 1998, EPA QA/G-5, "EPA Guidance for Quality Assurance Project Plans," Appendix B, EPA/600/R-98/018, February.

Appendix A - Environmental Statutes and Regulations

The following environmental statutes and regulations are applicable, in whole or in part, on the Idaho National Laboratory (INL) or at the INL boundary:

- U.S. Environmental Protection Agency (EPA), "National Primary and Secondary Ambient Air Quality Standards," 40 CFR 50, 2005;
- U.S. Environmental Protection Agency (EPA), "National Emission Standards for Hazardous Air Pollutants," 40 CFR 61, 2005;
- U.S. Environmental Protection Agency (EPA), "Oil Pollution Prevention," 40 CFR 112, 2005;
- U.S. Environmental Protection Agency (EPA), "National Pollutant Discharge Elimination System," 40 CFR 122, 2005;
- U.S. Environmental Protection Agency (EPA), "National Interim Primary Drinking Water Regulations," 40 CFR 141, 2005;
- U.S. Environmental Protection Agency (EPA), "Hazardous Waste Management System: General," 40 CFR 260, 2005;
- U.S. Environmental Protection Agency (EPA), "Identifying and Listing of Hazardous Wastes," 40 CFR 261, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Generators of Hazardous Waste," 40 CFR 262, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards Applicable to Transporters of Hazardous Waste," 40 CFR 263, 2005;
- U.S. Environmental Protection Agency (EPA), "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 264, 2005;
- U.S. Environmental Protection Agency (EPA), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," 40 CFR 265, 2005;
- U.S. Environmental Protection Agency (EPA), "Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities," 40 CFR 267, 2005;
- U.S. Department of Commerce, "Designated Critical Habitat," National Marine Fisheries Service, 50 CFR 226;
- U.S. Department of Energy (DOE), Order 450.1, " Environmental Protection Program," January 2003;
- U.S. Department of Energy (DOE), Order 5400.5, "Radiation Protection of the Public and the Environment," January 1993;
- U.S. Department of Energy (DOE), Order 435.1, "Radioactive Waste Management," August 2001;
- U.S. Department of Energy (DOE), Order 231.1A, 2003a, "Environment, Safety, and Health Reporting," August 2003;
- U.S. Department of the Interior (DOI), "Protection of Archeological Resources," National Park Service, 43 CFR 7;
- U.S. Department of the Interior (DOI), "Endangered and Threatened Wildlife and Plants," Fish and Wildlife Service, 50 CFR 17;

- U.S. Department of Interior (DOI), “Integrated Cooperation – Endangered Species Act of 1973 U.S. Amended,” Fish and Wildlife Service, 50 CFR 402;
- U.S. Department of the Interior (DOI), "Listing Endangered and Threatened Species and Designating Critical Habitat," Fish and Wildlife Service, 50 CFR 424;
- U.S. Department of the Interior (DOI), "Endangered Species Exemption Process," Fish and Wildlife Service, 50 CFR 450–453;
- U.S. Department of the Interior (DOI), "Curation of Federally-Owned and Administered Archeological Collections," National Park Service, 43 CFR 79;
- Idaho Department of Environmental Quality (DEQ), "Rules and Regulations for the Control of Air Pollution in Idaho," IDAPA 58.01.01;
- Idaho Department of Environmental Quality (DEQ), "Water Quality Standards and Wastewater Treatment,” IDAPA 58.01.02;
- Idaho Department of Environmental Quality (DEQ), "Individual/Subsurface Sewage Disposal,” IDAPA 58.01.03;
- Idaho Department of Environmental Quality (DEQ), "Hazardous Waste, IDAPA 58.01.05;
- Idaho Department of Environmental Quality (DEQ), “Solid Waste Management Rules and Standards,” IDAPA 58.01.06;
- Idaho Department of Environmental Quality (DEQ), “Idaho Regulations for Public Drinking Water Systems,” IDAPA 58.01.08;
- Idaho Department of Environmental Quality (DEQ), “Ground Water Quality Rules,” IDAPA 58.01.11;
- Idaho Department of Environmental Quality (DEQ), “Cleaning of Septic Tanks,” IDAPA 58.01.15;
- Idaho Department of Environmental Quality (DEQ), “Wastewater Land Application Permits,” IDAPA 58.01.17;
- Executive Order 11988, "Floodplain Management," May 1977;
- Executive Order 11990, "Protection of Wetlands," May 1977;
- Executive Order 12580, "Superfund Implementation," January 1987;
- Executive Order 12856, "Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements," August 1993;
- Executive Order 12873, "Federal Acquisition, Recycling, and Waste Prevention," October 1993; and
- Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition," September 1998.

The Derived Concentration Guides (DCGs) are based on the U.S. Department of Energy (DOE) standard (DOE 1993) and have been calculated using DOE models and parameters for internal (DOE 1988a) and external (DOE 1988b) exposure. These are shown in Table A-1. The most restrictive guide is listed when there is a difference between the soluble and insoluble chemical forms. The DCGs consider only the

inhalation of air, the ingestion of water, and submersion in air. The principal standards and guides for release of radionuclides at the INL are those of DOE Order 5400.5, "Radiation Protection of the Public and the Environment." The DOE standard is shown in Table A-2 along with the EPA statute for protection of the public, airborne pathway only.

Ambient air quality statutes are shown in Table A-3. Water quality statutes are dependent on the type of drinking water system sampled. Tables A-4 through A-7 are a list of maximum contaminant levels set by the EPA for public drinking water systems in 40 CFR 141 (EPA 2002) and the Idaho groundwater quality values from IDAPA 58.01.11 (2003).

Table A-1. Derived Concentration Guides for Radiation Protection.

Derived Concentration Guide[a,b]			Derived Concentration Guide		
Radionuclide	In Air	In Water	Radionuclide	In Air	In Water
Gross Alpha[c]	2×10^{-14}	3×10^{-8}	^{125}Sb	1×10^{-9}	5×10^{-5}
Gross Beta[d]	3×10^{-12}	1×10^{-7}	^{129}I	7×10^{-11}	5×10^{-7}
^{3}H	1×10^{-7}	2×10^{-3}	^{131}I	4×10^{-10}	3×10^{-6}
^{14}C	5×10^{-7}	7×10^{-2}	^{132}I	4×10^{-8}	2×10^{-4}
^{24}Na[e]	4×10^{-9}	1×10^{-4}	^{133}I	2×10^{-9}	1×10^{-5}
^{41}Ar	1×10^{-8}	--	^{135}I	1×10^{-8}	7×10^{-5}
^{51}Cr	5×10^{-8}	1×10^{-3}	^{131m}Xe	2×10^{-6}	--
^{54}Mn	2×10^{-9}	5×10^{-5}	^{133}Xe	5×10^{-7}	--
^{58}Co	2×10^{-9}	4×10^{-5}	^{133m}Xe	6×10^{-7}	--
^{60}Co	8×10^{-11}	5×10^{-6}	^{135}Xe	8×10^{-8}	--
^{65}Zn	6×10^{-10}	9×10^{-6}	^{135m}Xe	5×10^{-8}	--
^{85}Kr	3×10^{-6}	--	^{138}Xe	2×10^{-8}	--
^{85m}Kr[f]	1×10^{-7}	--	^{134}Cs	2×10^{-10}	2×10^{-6}
^{87}Kr	2×10^{-8}	--	^{137}Cs	4×10^{-10}	3×10^{-6}
^{88}Kr	9×10^{-9}	--	^{138}Cs	1×10^{-7}	9×10^{-4}
^{88d}Rb	3×10^{-8}	8×10^{-4}	^{139}Ba	7×10^{-8}	3×10^{-4}
^{89}Rb	9×10^{-9}	2×10^{-3}	^{140}Ba	3×10^{-9}	2×10^{-5}
^{89}Sr	3×10^{-10}	2×10^{-5}	^{141}Ce	1×10^{-9}	5×10^{-5}
^{90}Sr	9×10^{-12}	1×10^{-6}	^{144}Ce	3×10^{-11}	7×10^{-6}
^{91m}Y	4×10^{-7}	4×10^{-3}	^{238}Pu	3×10^{-14}	4×10^{-8}
^{95}Zr	6×10^{-10}	4×10^{-5}	^{239}Pu	2×10^{-14}	3×10^{-8}
^{99m}Tc	4×10^{-7}	2×10^{-3}	^{240}Pu	2×10^{-14}	3×10^{-8}
^{103}Ru	2×10^{-9}	5×10^{-5}	^{241}Am	2×10^{-14}	3×10^{-8}
^{106}Ru	3×10^{-11}	6×10^{-6}			

a. Derived concentration guides (DCGs) are from DOE Order 5400.5 and are based on committed effective dose equivalent of 100 mrem/yr for ingestion or inhalation of radionuclide during one year.
b. All values are in microcuries per milliliter (µCi/mL).
c. Based on the most restrictive alpha emitter (^{241}Am).
d. Based on the most restrictive beta emitter (^{228}Ra).
e. Submersion in a cloud of gas is more restrictive than the inhalation pathway.
f. An "m" after the number refers to a metastable form of the radionuclide.

Table A-2. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

	Effective Dose Equivalent	
	mrem/yr	mSv/yr
DOE Standard for routine DOE activities (all pathways)	100[a]	1
EPA Standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

Table A-3. EPA Ambient Air Quality Standards.

Pollutant	Type of Standard[a]	Sampling Period	EPA[b,c]
Sulfur Dioxide	Secondary	3-hour average	1300
	Primary	24-hour average	365
	Primary	Annual average	80
Nitrogen Dioxide	Primary and Secondary	Annual average	100
	Secondary	24-hour average	150
Total Particulates[d]	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 same ambient air quality standards.

c. All values are in micrograms per cubic meter ($\mu g/m^3$).

d. The primary and secondary standard to the annual average applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers."

Table A-4. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Gross alpha	15 pCi/L	15 pCi/L
Gross beta	4 mrem/year[b]	4 mrem/year
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/year effective dose equivalent
Radium-226 plus -228	5 pCi/L	5 pCi/L
Strontium-90	8 pCi/L	8 pCi/L
Tritium	20,000 pCi/L	20,000 pCi/L
Uranium	30 µg/L	
Arsenic	0.01	0.05
Antimony	0.006	0.006
Asbestos	7 million fibers/L	7 million fibers/ L
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium	0.1	0.1
Copper[c]	1.3	1.3
Cyanide	0.2	0.2
Fluoride	4	4
Lead	0.015	0.15
Mercury	0.002	0.002
Nitrate (as N)	10	10
Nitrite (as N)	1	1
Total Nitrate and Nitrite	10	10
Selenium	0.05	0.05
Thallium	0.002	0.002

a. All values are in milligrams per liter (mg/L) unless otherwise noted.
b. As a matter of practicality a screening level concentration of 50 pCi/L is used for comparison.
c. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Table A-5. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Benzene	0.005	0.005
Carbon Tetrachloride	0.005	0.005
m-Dichlorobenzene		0.6
o-Dichlorobenzene	0.6	0.6
para-Dichlorobenzene	0.075	0.075
1,2 – Dichloroethane	0.005	0.005
1,1 – Dichloroethylene		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	10
Bromate	0.01	
Bromodichloromethane		0.1
Chlorobromomethane		0.1
Chloroform		0.002
Chlorite	1.0	
Haloacetic acids (five)	0.0.6	
Trihalomethanes (Chloroform)	0.08	0.1

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

Table A-6. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards Synthetic Organic Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Alachlor	0.002	0.002
Aldicarb	0.003	
Aldicarb sulfoxide	0.004	
Aldicarb sulfone	0.002	
Atrazine	0.003	0.002
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
Picrolam	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

Table A-7. EPA Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards Secondary Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Aluminum	0.05 to 0.2	0.2
Chloride	250	250
Color	15 color units	15 color units
Corrosivity	Non-corrosive	
Foaming agents	0.5	0.5
Iron	0.3	0.3
Manganese	0.05	0.05
Odor	3 threshold odor number	3.0 threshold odor number
pH	6.5 to 8.5	6.5 to 8.5
Silver	0.1	0.1
Sulfate	250	250
Total dissolved solids (TDS)	500	500
Zinc	5	5

a. All values are in milligrams per liter (mg/L) unless otherwise noted.

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U.S. Department of Energy (DOE), 1988a, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, July.

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Appendix B - Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report

Relatively simple statistical procedures are used to analyze the data collected by the Idaho National Laboratory (INL) Environmental Surveillance, Education and Research (ESER) program. This appendix presents the methods used to evaluate sample results.

GUIDELINES FOR REPORTING RESULTS

The results reported in the quarterly and annual reports are assessed in terms of data quality and statistical significance with respect to laboratory analytical uncertainties, sample locations, reported INL releases, meteorological data, and worldwide events that might conceivably have an effect on the INL environment.

Initial Radiological Screening

First, field collection and laboratory information are reviewed to determine identifiable errors that would invalidate or limit use of the data. Examples of field observations which could invalidate the result include insufficient sample volume, torn filters, or mechanical malfunction of sampling equipment.

The analytical laboratory also qualifies the results and may reject them for reasons such as:

- uncertainty is too high to be accepted by the analyst
- radionuclide has no supporting photopeaks to make a judgment
- photopeak width is unacceptable by the analyst
- result is below the decision critical level
- other radionuclides display gamma-ray interferences
- a graphical display of analyzed photopeaks showed unacceptable fitting results
- there is no parent activity, therefore the state of equilibrium is unknown and the radionuclide could not be quantified
- radionuclide is a naturally-occurring one with expected activity.

Evidence of laboratory cross-contamination or quality control issues could also disqualify a result (see Chapter 10).

Data that pass initial screening are further evaluated prior to reporting.

Reporting Levels

It is the goal of the ESER program to minimize the error of reporting a constituent is absent in a sample population when it is actually present. This is accomplished through the use of the uncertainty term, which is reported by the analytical laboratory with the sample result. For radiological data, individual analytical results are usually presented in this report with plus or minus one sample standard deviation (± 1s). The sample standard deviation is obtained by propagating sources of analytical uncertainty in laboratory measurements. The uncertainty term, "s," is an estimate of the population standard deviation "σ," assuming a Guassian or normal distribution. The approach used by the ESER program to interpret individual analytical results is based on guidelines outlined by the U.S. Geological

Survey (USGS) in Bartholomay et al. (2000), which are based on methodology proposed by Currie (1984). Most of the following discussion is from Bartholomay et al. (2000).

Laboratory measurements are made on a target sample and on a laboratory-prepared blank. Instrument signals for the sample and blank vary randomly about the true signals. Two key concepts characterize the theory of detection: the "critical value" (or "critical level" or "criterion of detection") and the "minimum detectable value" (or "detection limit" or "limit of detection"). The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. Figure B-1 illustrates these terms.

The critical level (L_C) is the minimum significant value of an instrument signal or concentration that can be discriminated from the signal or concentration observed for the blank such that the decision can be made that the radionuclide was detected. The decision "detected" or "not detected" is made by comparison of the estimated quantity ($\hat{L}$) with L_C. A result falling below L_C triggers the decision "not detected." That is when the true net signal, zero, intersects L_C such that the fraction 1-α, where α is the error of the first kind (false positive), corresponds to the correct decision "not detected." Typically, α is set equal to 0.05. Using algorithms in Currie (1984) that are appropriate for our data, the L_C is 1.65s or approximately 2s. At this

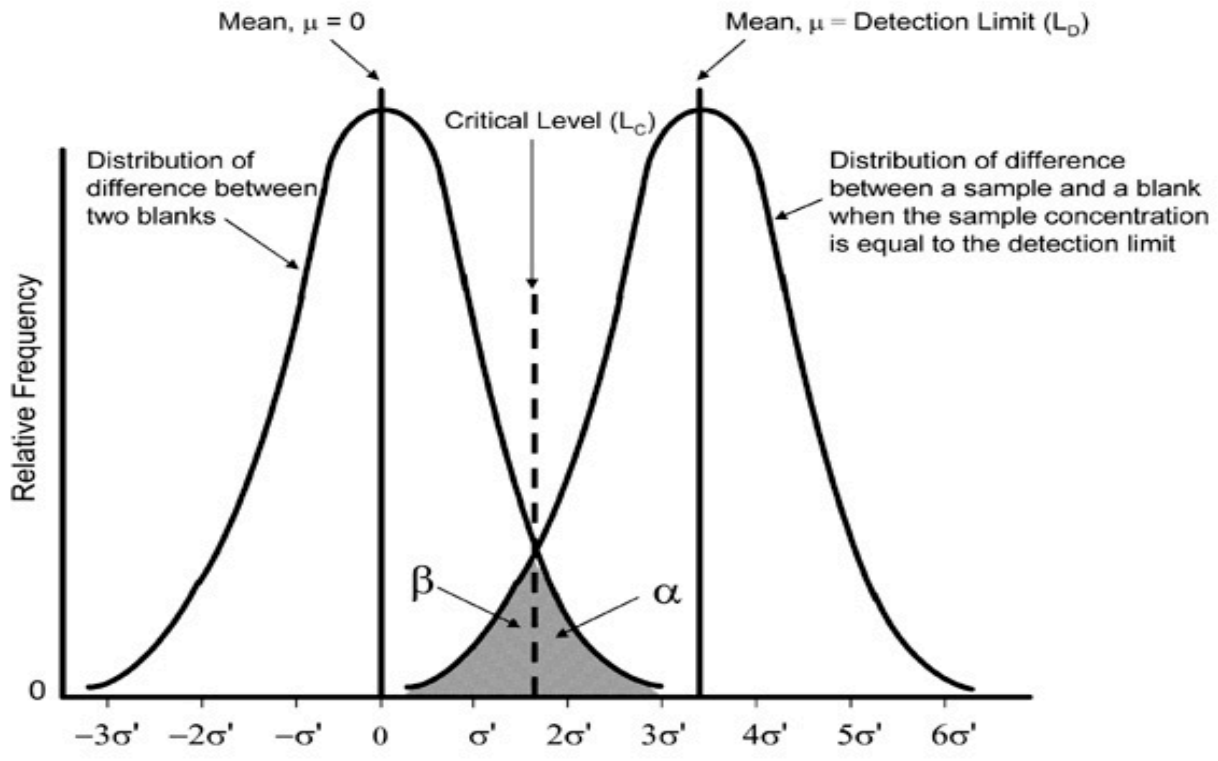

Figure B-1. Illustration of the Relation of the Criterion of Detection (Critical Level) and the Limit of Detection (Detection Limit). Errors of the First Kind (False Negatives) are Represented by the Value of α, Whereas Errors of the Second Kind (False Positives) are Represented by the Value of β. (from Currie 1988)

level, there is about a 95-percent probability that the correct decision—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentration larger than or equal to 2s, which were concluded as being detected, might not contain the radionuclide (i.e., a false positive).

Once the critical level has been defined, the minimum detectable concentration (MDC), or detection level (L_D), may be determined. Using the equations in Currie (1984), concentrations that equal 3.29s, or approximately 3s, represent a measurement at the minimum detectable concentration. For true concentrations of 3s or larger, there is 95-percent or larger probability that the radionuclide was detected in a sample. In a large number of samples, the conclusion—not detected—will be made in 5 percent of the samples that contain true concentrations at the minimum detectable concentration of 3s. These are referred to as false negatives or errors of the second kind.

True radionuclide concentrations between 2s and 3s have larger errors of the second kind. That is, there is a larger-than-five-percent probability of false negative results for samples with true concentrations between 2s and 3s. Although the radionuclide might have been detected, such detection may not be considered reliable; at 2s, the probability of a false negative is about 50 percent.

In this report, radionuclide concentrations less than 3s are considered to be below a "reporting level." Concentrations above 3s are considered to be detected with confidence. Results between $2\sigma_S$ and $3\sigma_S$ are considered to be "questionable" detections. Each result is reported with the associated $1\sigma_S$ uncertainty value for consistency with other INL reports

STATISTICAL TESTS USED TO ASSESS DATA

An example dataset is presented here to illustrate the statistical tests used to assess data collected by the ESER contractor. The dataset is the gross beta environmental surveillance data collected from January 8, 1997, through December 26, 2001. The data were collected weekly from several air monitoring stations located around the perimeter of the INL and air monitoring stations throughout the Snake River Plain (SRP). The perimeter locations are termed "boundary" and the SRP locations are termed "distant." There are seven boundary locations: Arco, Atomic City, Birch Creek, FAA Tower, Howe, Monteview, and Mud Lake; and five distant locations: Blackfoot, Blackfoot Community Monitoring Station (CMS), Craters of the Moon, Idaho Falls, and Rexburg CMS. The gross beta data are of the magnitude 10^{-15}. To simplify the calculations and interpretation, these have been coded by multiplying each measurement by 10^{15}.

Only portions of the complete gross beta dataset will be used. The purpose of this task is to evaluate and illustrate the various statistical procedures, and not a complete analysis of the data.

Test of Normality

The first step in any analysis of data is to test for normality. Many standard statistical tests of significance require that the data be normally distributed. The most widely used test of normality is the Shapiro-Wilk W-Test (Shapiro and Wilk 1965). The Shapiro-Wilk W-Test is the preferred test of normality because of its good power properties as compared to a wide range of alternative tests (Shapiro et al. 1968). If the W statistic is significant ($p<0.00001$), then the hypothesis that the respective distribution is normal should be rejected.

Graphical depictions of the data should be a part of any evaluation of normality. The following histogram (Figure B-2) presents such a graphical look along with the results of the Shapiro-Wilk W Test. The data used for the illustration are the five years of weekly gross beta measurements for the Arco boundary location. The W statistic is highly significant ($p<0.0001$) indicating that the data are not normally distributed. The histogram shows that the data are asymmetrical with right skewness. This suggests that the data may be lognormally distributed. The Shapiro-Wilk W-Test can be used to test this distribution by taking the natural logarithms of each measurement and calculating the W statistic. Figure B-3 presents this test of lognormality. The W statistic is not significant ($p=0.80235$) indicating that the data are lognormal.

To perform parametric tests of significance such as Student's T-Test or One-Way Analysis of Variance (ANOVA), it is required that all data be normally (or lognormally) distributed. Therefore, if one desires to compare gross beta results of each boundary location, tests of normality must be performed before such comparisons are made. Table B-1 presents the results of the Shapiro-Wilk W-Test for each of the seven boundary locations.

From Table B-1, none of the locations consist of data that are normally distributed and only some of the data sets are lognormally distributed. This is a typical result and a common problem when one desires to use a parametric test of significance. When many comparisons are to be made, attractive alternatives are nonparametric tests of significance.

Table B-1. Tests of Normality for Boundary Locations.

Location	Normal		Lognormal	
	W statistic	p-value	W statistic	p-value
Arco	0.9172	<0.0001	0.9963	0.8024
Atomic City	0.9174	<0.0001	0.9411	<0.0001
Birch Creek	0.8086	<0.0001	0.9882	0.0530
FAA Tower	0.9119	<0.0001	0.9915	0.1397
Howe	0.8702	<0.0001	0.9842	0.0056
Monteview	0.9118	<0.0001	0.9142	<0.0001
Mud Lake	0.6130	<0.0001	0.9704	<0.0001

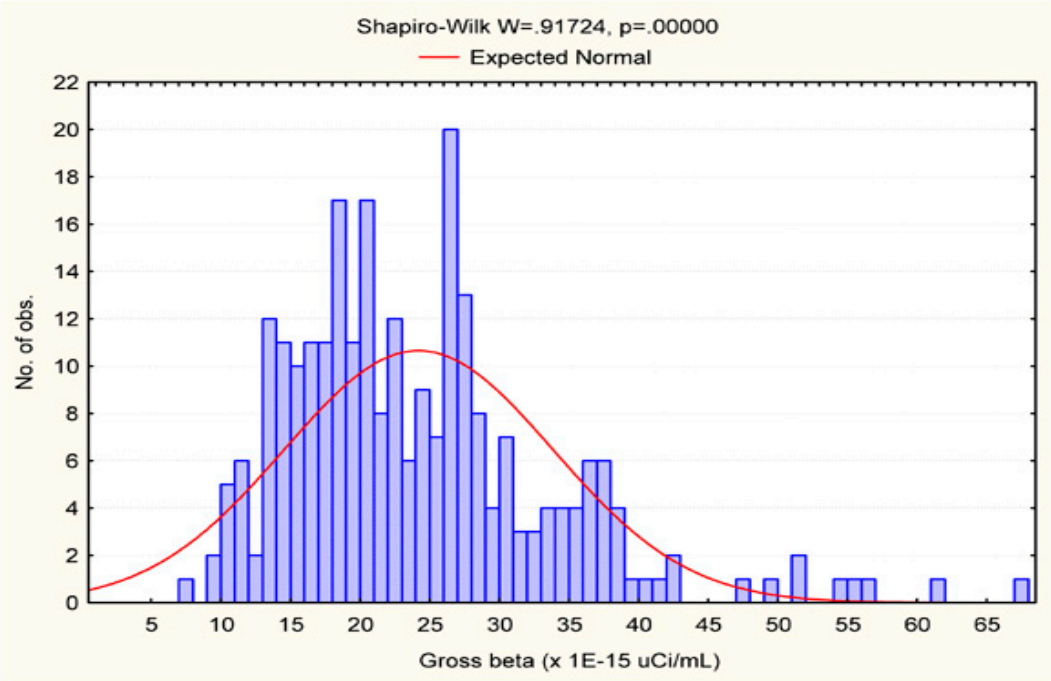

Figure B-2. Test of Normality for Arco Gross Beta Data.

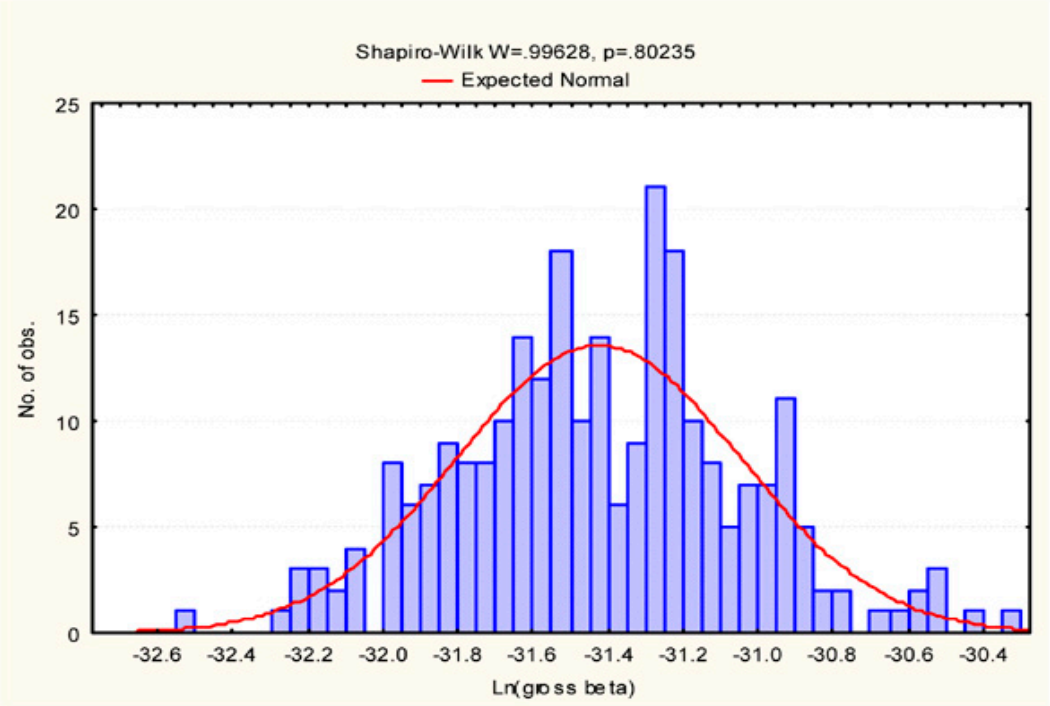

Figure B-3. Test of Lognormality for Arco Gross Beta.

Comparison of Two Groups

For comparison of two groups, the Mann-Whitney U-Test (Hollander and Wolfe 1973) is a powerful nonparametric alternative to the Student's T-Test. In fact, the U-Test is the most powerful (or sensitive) nonparametric alternative to the T-Test for independent samples; in some instances it may offer even greater power to reject the null hypothesis than the T-Test. The interpretation of the Mann-Whitney U-Test is essentially identical to the interpretation of the Student's T-Test for independent samples, except that the U-Test is computed based on rank sums rather than means. Because of this fact, outliers do not present the serious problem that they do when using parametric tests.

Suppose we wish to compare all boundary locations to all distant locations. Figure B-4 presents the box plots for the two groups. The median is the measure of central tendency most commonly used when there is no assumed distribution. It is the middle value when the data are ranked from smallest to largest. The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile and 75 percent of the measurements are less than the 75th percentile. The large distance between the medians and the maximums seen in Figure B-4 indicate the presence of outliers. It is apparent that the medians are of the same magnitude indicating graphically that there is probably not a significant difference between the two groups.

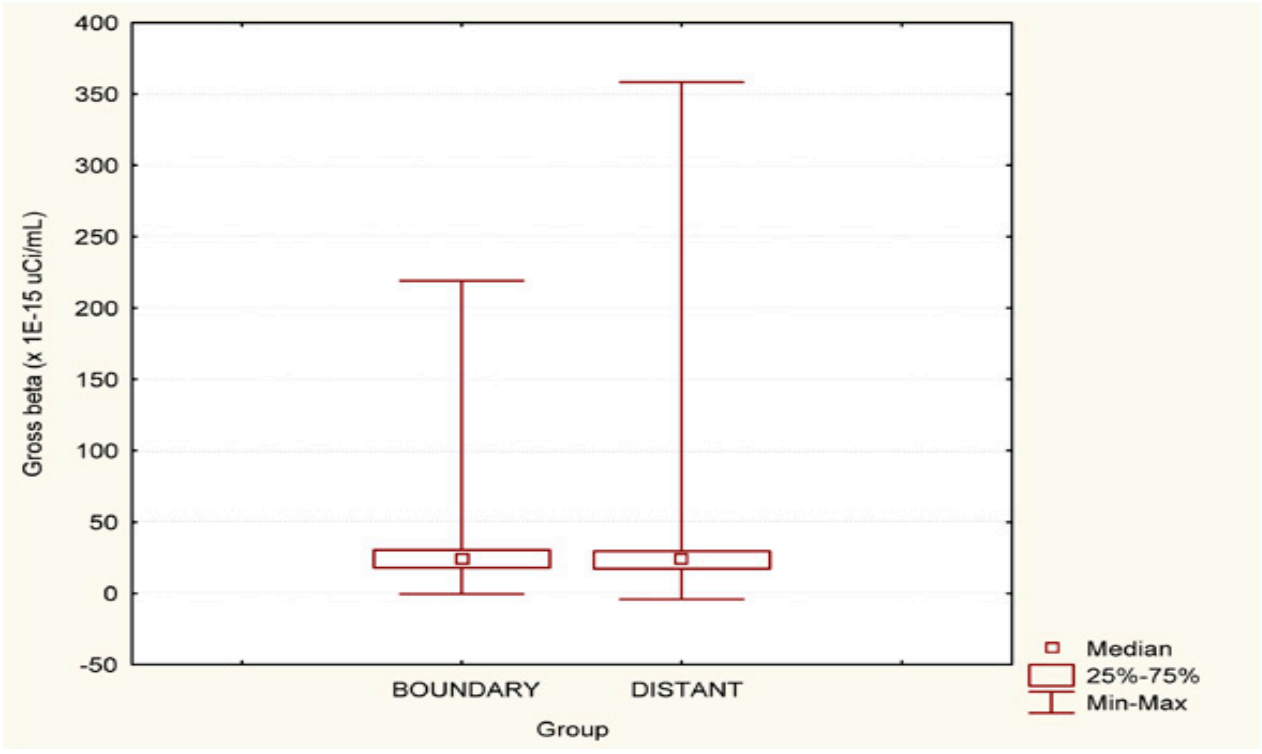

Figure B-4. Box Plot of Gross Beta Data from Boundary and Distant Locations.

The Mann-Whitney U-Test compares the rank sums between the two groups. In other words, for both groups combined, it ranks the observations from smallest to largest. Then it calculates the sum of the ranks for each group and compares these rank sums. A significant p-value ($p<0.05$) indicates a significant difference between the two groups. The p-value for the comparison of boundary and distant locations is not significant ($p=0.0599$). Therefore, the conclusion is that there is not strong enough evidence to say that a significant difference exists between boundary and distant locations.

Comparison of Many Groups

Now suppose we wish to compare the boundary locations amongst themselves. In the parametric realm, this is done with a One-Way Analysis of Variance (ANOVA). A nonparametric alternative to the One-Way ANOVA is the Kruskal-Wallis ANOVA (Hollander and Wolfe 1973). The test assesses the hypothesis that the different samples in the comparison were drawn from the same distribution or from distributions with the same median. Thus, the interpretation of the Kruskal-Wallis ANOVA is basically identical to that of the parametric One-Way ANOVA, except that it is based on ranks rather than means.

Figure B-5 presents the box plot for the boundary locations. The Kruskal-Wallis ANOVA test statistic is highly significant ($p<0.0001$) indicating a significant difference amongst the seven boundary locations. Table B-2 gives the number of samples, medians, minimums, and maximums for each boundary location. The Kruskal-Wallis ANOVA only indicates that significant differences exist between the seven locations

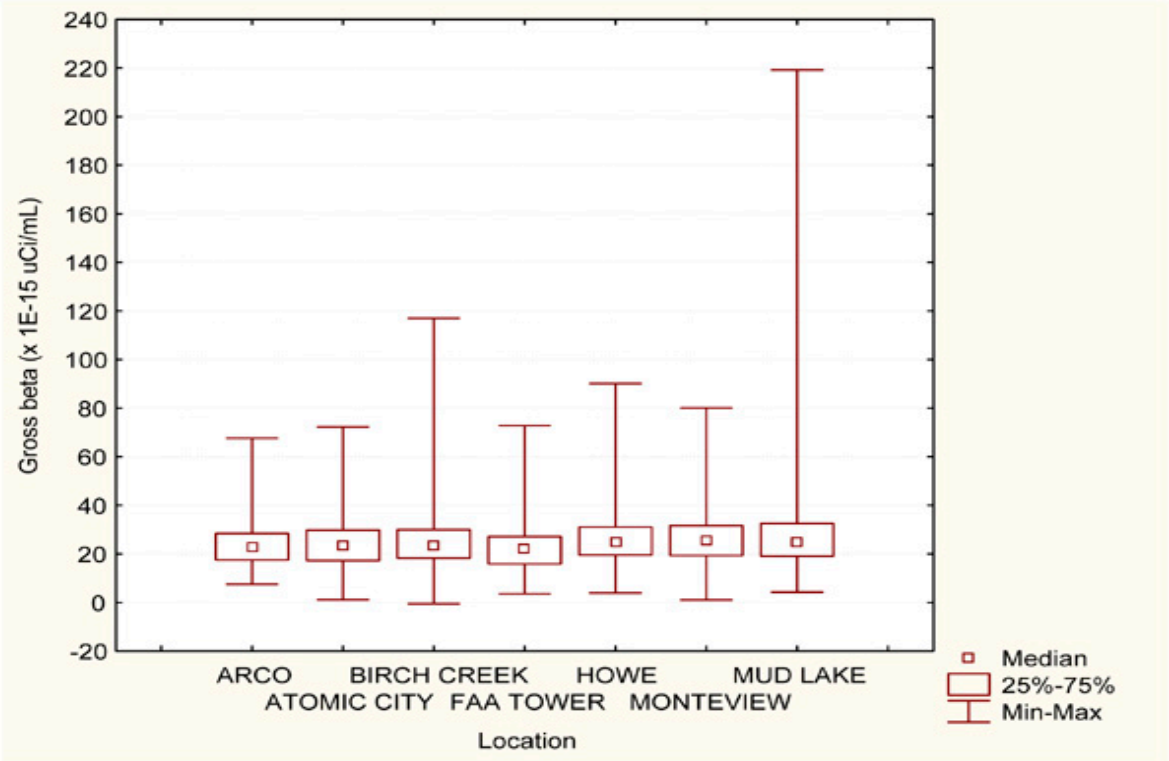

Figure B-5. Box Plot of Gross Beta Data for Each Boundary Location.

and not the individual occurrences of differences. If desired, the next step is to identify pairs of locations of interest and test those for significant differences using the Mann-Whitney U-Test. It is cautioned that all possible pairs should not be tested, only those of interest. As the number of pairs increases, the probability of a false conclusion also increases.

Suppose a comparison between Arco and Atomic City is of special interest due to their close proximity to each other. A test of significance using the Mann-Whitney U-Test results in a p-value of 0.7288 indicating that a significant difference does not exist between gross beta results at Arco and Atomic City. Other pairs can similarly be tested, but with the caution given above.

Tests for Trends over Time

Regression analysis is used to test whether or not there is a significant positive or negative trend in gross beta concentrations over time. To illustrate the technique, the regression analysis is performed for the boundary locations as one group and the distant locations as another group. The tests of normality performed earlier indicated that the data were closer to lognormal than normal. For that reason, the natural logarithms of the original data are used in the regression analysis. Regression analysis assumes that the probability distributions of the dependent variable (gross beta) have the same variance regardless of the level of the independent variable (collection date). The natural logarithmic transformation helps in satisfying this assumption.

Table B-2. Summary Statistics for Boundary Locations.

Location	Number of Samples	Median	Minimum	Maximum
Arco	258	22.49	7.53	67.66
Atomic City	260	23.61	1.13	72.20
Birch Creek	234	23.15	-0.52	117.00
FAA Tower	260	21.90	3.59	72.78
Howe	260	24.55	3.95	90.10
Monteview	260	25.30	1.03	80.10
Mud Lake	260	24.85	4.30	219.19

a. All values are × 10^{-15} microcuries per milliliter (µCi/mL).

Figure B-6 presents a scatterplot of the boundary data with the fitted regression line superimposed. Figure B-7 presents the same for the distant data. Table B-3 gives the regression equation and associated statistics. There appears to be slightly increasing trends in gross beta over time for both the boundary and distant locations. A look at the regression equations and correlation coefficients in Table B-3 confirm this. Notice that the slope parameter of the regression equation and the correlation coefficient are equal. This is true for any linear regression fit. So, a test of significant correlation is also a test of significant trend. The p-value associated with testing whether or not the correlation coefficient is different from zero is the same as for testing if the slope of the regression line is different from zero. For both the boundary and distant locations, the slope is significantly different from zero and positive indicating an increasing trend in gross beta over time.

Another important point of note in Figures B-6 and B-7 is the obvious existence of a cyclical trend in gross beta. It appears as if the gross beta measurements are highest in the summer months and lowest in the winter months. Since the regression analysis performed above is over several years, we are still able to detect a positive trend over time even though it is confounded somewhat by the existence of a cyclical trend. This is important because a linear regression analysis performed over a shorter time period may erroneously conclude a significant positive or negative trend, when in fact, it is a portion of the cyclical trend.

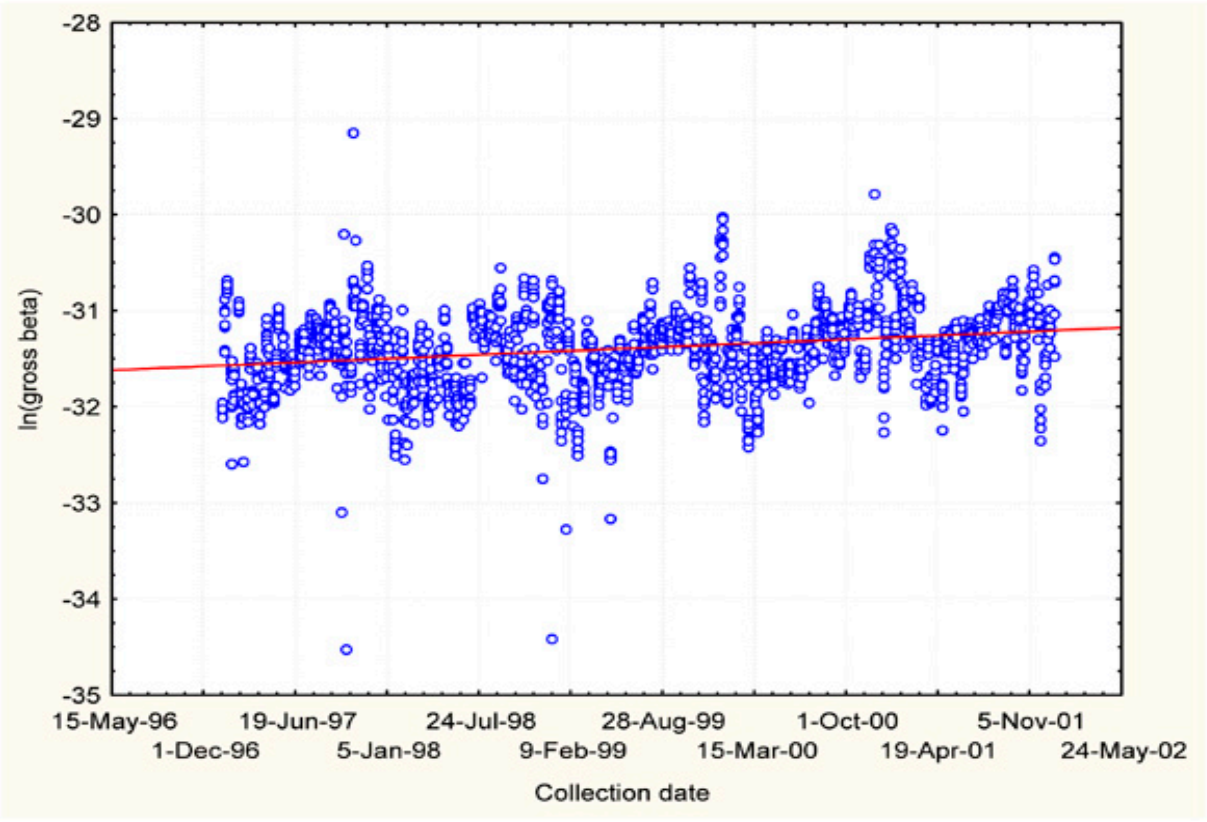

Figure B-6. Scatter Plot and Regression Line for ln(Gross Beta) from Boundary Locations.

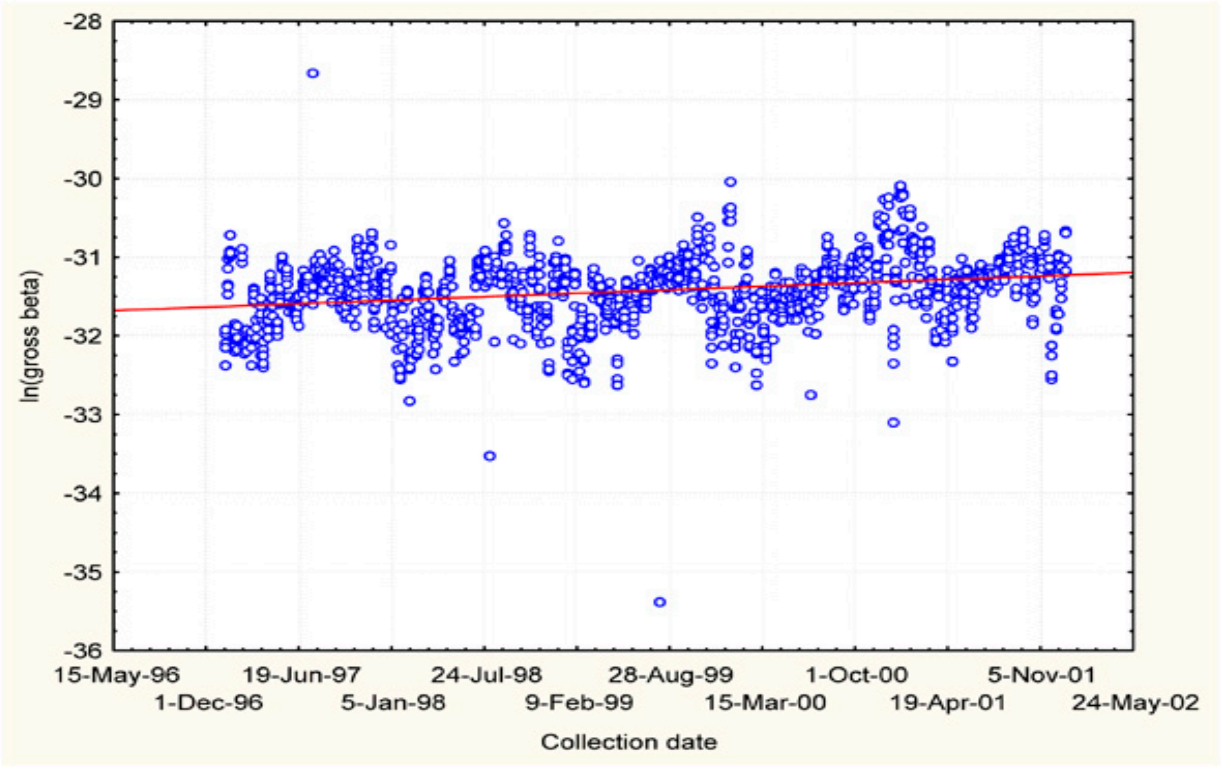

Figure B-7. Scatter Plot and Regression Line for ln(Gross Beta) from Distant Locations.

Table B-3. Regression Equations and Associated Statistics for Boundary and Distant Locations.

Sample Group	Regression Equation	Correlation Coefficient	p-value
Boundary	ln(gross beta) = -38.7 + 0.245×(date)	0.245	<0.0001
Distant	ln(gross beta) = -39.4 + 0.253×(date)	0.253	<0.0001

Comparison of Slopes

A comparison of slopes between the regression lines for the boundary locations and distant locations will indicate if the rate of change in gross beta over time differs with location. The comparison of slopes can be performed by constructing 95 percent confidence intervals about the slope parameter (Neter and Wasserman 1974). If these intervals overlap, we can conclude that there is no evidence to suggest a difference in slopes for the two groups of locations.

A confidence interval for the slope is constructed as

$$b - t_{0.025,n-2} s_b \le \beta \le b + t_{0.025,n-2} s_b$$

where

b = point estimate of the slope

$t_{0.025,n-2}$ = the Student's t-value associated with two-sided 95 percent confidence and n-2 degrees of freedom

s_b = the standard deviation of the slope estimate, b

β = the true slope, which is unknown.

Table B-4 gives the values used in constructing the confidence intervals and the resulting confidence intervals. As seen in the fifth column of Table B-4, the confidence intervals for the slope overlap and we can conclude that there is no difference in the rate of change in gross beta measurements for the two location groupings, boundary and distant.

Table B-4. Ninety-five Percent Confidence Intervals on the True Slope.

Sample group	b	z[a]	s_b	95% C.I.[b]
Boundary	0.245	1.96	0.0229	[0.200, 0.290]
Distant	0.253	1.96	0.0269	[0.200, 0.306]

a. For large sample sizes, the standard normal z-value is used instead of the Student's t-value.

b. C.I. = confidence interval.

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Appendix C - U.S. Geological Survey 2006 INL Publication Abstract

A Conceptual Model of Ground-Water Flow in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory and Vicinity with Implications for Contaminant Transport *(Daniel J. Ackerman, Gordon W. Rattray Joseph P. Rousseau, Linda C. Davis, and Brennon R. Orr)*

Ground-water flow in the west-central part of the eastern Snake River Plain aquifer is described in a conceptual model that will be used in numerical simulations to evaluate contaminant transport at the Idaho National Laboratory (INL) and vicinity. The model encompasses an area of 1,940 square miles (mi^2) and includes most of the 890 mi^2 of the INL. A 50-year history of waste disposal associated with research activities at the INL has resulted in measurable concentrations of waste contaminants in the aquifer. A thorough understanding of the fate and movement of these contaminants in the subsurface is needed by the U.S. Department of Energy to minimize the effect that contaminated ground water may have on the region and to plan effectively for remediation.

Three hydrogeologic units were used to represent the complex stratigraphy of the aquifer in the model area. Collectively, these hydrogeologic units include at least 65 basalt-flow groups, 5 andesite-flow groups, and 61 sedimentary interbeds. Three rhyolite domes in the model area extend deep enough to penetrate the aquifer. The rhyolite domes are represented in the conceptual model as low permeability, vertical pluglike masses, and are not included as part of the three primary hydrogeologic units. Broad differences in lithology and large variations in hydraulic properties allowed the heterogeneous, anisotropic basalt-flow groups, andesite-flow groups, and sedimentary interbeds to be grouped into three hydrogeologic units that are conceptually homogeneous and anisotropic. Younger rocks, primarily thin, densely fractured basalt, compose hydrogeologic unit 1; younger rocks, primarily of massive, less densely fractured basalt, compose hydrogeologic unit 2; and intermediate-age rocks, primarily of slightly-to-moderately altered, fractured basalt, compose hydrogeologic unit 3. Differences in hydraulic properties among adjacent hydrogeologic units result in much of the large-scale heterogeneity and anisotropy of the aquifer in the model area, and differences in horizontal and vertical hydraulic conductivity in individual hydrogeologic units result in much of the small-scale heterogeneity and anisotropy of the aquifer in the model area.

The inferred three-dimensional geometry of the aquifer in the model area is very irregular. Its thickness generally increases from north to south and from west to east and is greatest south of the INL. The interpreted distribution of older rocks that underlie the aquifer indicates large changes in saturated thickness across the model area.

The boundaries of the model include physical and artificial boundaries, and ground-water flows across the boundaries may be temporally constant or variable and spatially uniform or nonuniform. Physical boundaries include the water-table boundary, base of the aquifer, and northwest mountain-front boundary. Artificial boundaries include the northeast boundary, southeast-flowline boundary, and southwest boundary. Water flows into the model area as (1) underflow (1,225 cubic feet per second (ft^3/s)) from the regional aquifer (northeast boundary—constant and nonuniform), (2) underflow (695 ft^3/s) from the tributary valleys and mountain fronts (northwest boundary—constant and nonuniform), (3) precipitation recharge (70 ft^3/s) (constant and uniform), streamflow-infiltration recharge (95 ft^3/s) (variable and nonuniform), wastewater return flows (6 ft^3/s) (variable and nonuniform), and irrigation-infiltration recharge (24 ft^3/s) (variable and nonuniform) across the water table (water-table boundary—variable and nonuniform), and (4) upward flow across the base of the aquifer (44 ft^3/s) (uniform and constant). The southeast-flowline boundary is represented as a no-flow boundary. Water flows out of the model area

as underflow (2,037 ft^3/s) to the regional aquifer (southwest boundary—variable and nonuniform) and as ground-water withdrawals (45 ft^3/s) (water table boundary—variable and nonuniform).

Ground-water flow increases progressively in a direction downgradient of the northeast boundary. This increased flow is the result of tributary-valley and mountain-front underflows along the northwest boundary and precipitation recharge and streamflow-infiltration recharge across the water-table boundary. Ground water flows in all three hydrogeologic units beneath the INL. South of the INL, the younger rocks, hydrogeologic units 1 and 2, are either not present or are above the water table and all flow occurs through the intermediate-age rocks, hydrogeologic unit 3.

The direction of regional ground-water flow is from northeast to southwest. Flow directions beneath the INL vary locally from southeast to southwest and fluctuate in response to episodic recharge from streamflow infiltration. Water-table gradients immediately upgradient of the northeast boundary are 27 to 60 feet per mile (ft/mi); and southwest of the INL gradients are 4 to 30 ft/mi. Beneath the INL gradients are much flatter, 1 to 8 ft/mi, and precise definition of flow direction is difficult to determine.

Long-term monitoring of contaminant movement in the aquifer at the INL indicates that ground-water velocities in the thin, fractured basalts of hydrogeologic unit 1, the uppermost hydrogeologic unit of the aquifer, range from 4 to 20 feet per day (ft/d) south of the Test Reactor Area and the Idaho Nuclear Technology and Engineering Center. These velocities probably indicate preferential flow along the many interflow zones of the thin, fractured basalt flows composing the uppermost hydrogeologic unit. Hydraulic conductivities (500 to 5,000 ft/d) estimated from velocity measurements were consistent with those derived from aquifer tests conducted in this hydrogeologic unit. Almost two-thirds of the hydraulic conductivities derived from aquifer-test measurements in hydrogeologic unit 1 were larger than 100 ft/d and about one third were larger than 1,000 ft/d.

Most contaminant movement beneath the INL probably takes place in the thin, densely fractured, and highly conductive basalts and interbedded sediments of hydrogeologic unit 1, which compose most of the upper 200 ft of the aquifer beneath most of the INL. This hypothesis is based on interpretation of a generalized northeast-to-southwest cross section of ground-water flow across the model area that depicts the effects of the hydrogeologic framework on flow in each of the hydrogeologic units used to represent the aquifer. This interpretation indicates that head decreases and then increases with depth with thickening and thinning of the aquifer in a direction downgradient of the northeast boundary. Beneath the INL, the smaller conductivity of the massive, less densely fractured basalts and interbedded sediments of hydrogeologic unit 2 restricts the downward movement of contaminants from hydrogeologic unit 1. The largest changes in water-table gradients are upgradient of where the massive basalts of hydrogeologic unit 2 are inferred to intersect the water table south of the INL. Water probably flows downward through hydrogeologic unit 2 into hydrogeologic unit 3 at this location, implying deeper circulation of contaminants that migrate offsite.

Features of the conceptual model that most affect interpretations of contaminant transport are (1) implicit representation of infiltration recharge through the unsaturated zone, (2) preferential flow along highly conductive interflow zones, primarily in the thin, densely fractured basalts of hydrogeologic unit 1, implying large horizontal to vertical anisotropy, (3) restricted downward movement of flow and contaminants in hydrogeologic unit 1 into the less conductive basalts of hydrogeologic unit 2 beneath the INL, (4) the inferred downward movement and deeper circulation of water upgradient of where the massive, less densely fractured basalt of hydrogeologic unit 2 intersects the water table southwest of the INL, and (5) enhanced

dispersion of contaminants resulting from the spatial and temporal variability of streamflow-infiltration recharge that is in close proximity to contaminated ground water.

Comparison of Local Meteoric Water Lines in Southeastern Idaho, Western Wyoming, and South-Central Montana and the Associated Hydrologic Implications *(L. DeWayne Cecil, L. Flint Hall, Lyn Benjamin, LeRoy L. Knobel, and Jaromy R. Green)*

Linear regression analysis is routinely applied to stable hydrogen (H) and oxygen (O) isotope data from precipitation-water samples to determine a local meteoric water line. Several local meteoric water lines have been determined for southeastern Idaho and the adjacent Yellowstone National Park from data sets that represent winter precipitation conditions, summer precipitation conditions, evaporated surface water, and ground water. For example, two local meteoric water lines calculated for this report from full ranges of seasonal precipitation data for rain and snow samples are represented by the equations, $\delta 2H = 7.48\ \delta 18O - 0.04$ and $\delta 2H = 7.94\ \delta 18O + 3.15$. Another equation developed in 1988, $\delta 2H = 6.42\ \delta 18O - 21$, was constructed from surface-water data under the assumption that the surface water was entirely derived from local precipitation.

In this paper, we compare a range of reported local meteoric water lines for southeastern Idaho with the Global Meteoric Water Line ($\delta 2H = 8\ \delta 18O + 10$) and discuss some of the hydrologic implications. We then construct a local meteoric water line for southeastern Idaho by combining precipitation data from two sources; the resultant equation for this local meteoric water line is $\delta 2H = 7.61\ \delta 18O + 0.84$. Finally, we analyze the precipitation data for seasonal signals; winter was represented by samples collected between October and April, and summer was represented by samples collected from May through September. This analysis suggests that the average $\delta 18O$ of ground water from the eastern Snake River Plain aquifer is dominated by recharge derived from winter precipitation.

The equations and the associated hydrologic implications presented here will be useful as reference points for future studies on the eastern Snake River Plain in southeastern Idaho and the adjacent recharge areas in Wyoming and Montana. The results of this analysis might be used to determine sources of ground-water recharge, to study water-rock chemical reactions, to evaluate surface-water and ground-water interaction and residence times, and to study other geochemical and hydrologic topics.

An Update of Hydrologic Conditions and Distributions of Selected Constituents in Water, Snake River Plain Aquifer, Idaho National Laboratory, Idaho, Emphasis 1999-2001 *(Linda Davis)*

Radiochemical and chemical wastewater discharged since 1952 to infiltration ponds, evaporation ponds, and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the Snake River Plain aquifer underlying the INL. The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, maintains ground-water monitoring networks at the INL to determine hydrologic trends, and to delineate the movement of radiochemical and chemical wastes in the aquifer. This report presents an analysis of water-level and water-quality data collected from wells in the USGS ground-water monitoring networks during 1999–2001.

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The

aquifer is recharged principally from infiltration of irrigation water, infiltration of streamflow, ground-water inflow from adjoining mountain drainage basins, and infiltration of precipitation. Water levels in wells rose in the northern and west-central parts of the INL by 1 to 3 feet, and declined in the southwestern parts of the INL by up to 4 feet during 1999–2001.

Detectable concentrations of radiochemical constituents in water samples from wells in the Snake River Plain aquifer at the INL generally decreased or remained constant during 1999–2001. Decreases in concentrations were attributed to decreased rates of radioactive-waste disposal, radioactive decay, changes in waste-disposal methods, and dilution from recharge. Tritium concentrations in water samples decreased as much as 8.3 picocuries per milliliter (pCi/mL) during 1999–2001, ranging from 0.43±0.14 to 13.6±0.6 pCi/mL in October 2001. Tritium concentrations in five wells near the Idaho Nuclear Technology and Engineering Center (INTEC) increased a few picocuries per milliliter from October 2000 to October 2001. Strontium-90 concentrations decreased or remained constant during 1999–2001, ranging from 2.1±0.6 to 42.4±1.4 pCi/L in October 2001. During 1999–2001, concentrations of cesium-137, plutonium-238, and plutonium-239, -240 (undivided) were less than the reporting level in water samples from all wells sampled at the INL. The concentration of americium-241 in one sample was 0.003±0.001 pCi/L, the reporting level for that constituent. Cobalt-60 was not detected in any samples collected during 1999–2001.

Changes in detectable concentrations of nonradioactive chemical constituents in water from the Snake River Plain aquifer at the INL varied during 1999–2001. In October 2001, water from one well south of the Reactor Technology Complex (RTC) [known as the Test Reactor Area (TRA) until 2005] contained 139 micrograms per liter (µg/L) of chromium, a decrease from the concentration of 168 µg/L detected in October 1998. Other water samples contained from less than 16.7 to 21.3 µg/L of chromium. In October 2001, concentrations of sodium in water samples from most of the wells in the southern part of the INL were larger than the background concentration of 10 mg/L, but were similar to or slightly less than October 1998 concentrations. The largest sodium concentration was 75 milligrams per liter (mg/L) in water from well USGS 113.

In 2001, chloride concentrations in most water samples from the INTEC and the Central Facilities Area (CFA) exceeded ambient concentrations of 10 and 20 mg/L, respectively. Chloride concentrations in water from wells near the RTC were less than 20 mg/L. At the Radioactive Waste Management Complex (RWMC), chloride concentrations in water from wells USGS 88, 89, and 120 were 81, 40, and 23 mg/L, respectively. Concentrations of chloride in all other wells near the RWMC were less than 19 mg/L. During 2001, concentrations of sulfate in water from two wells near the RTC, two wells near the RWMC, and one well near the CFA exceeded 40 mg/L, the estimated background concentration of sulfate in the Snake River Plain aquifer at the INL.

In 2001, concentrations of nitrate in water from wells USGS 40, 43, 77, and CFA 1 were 16, 21, 16, and 14 mg/L as nitrate, respectively. These generally were smaller concentrations than those in 1998, with the exception of the concentration in water from well USGS 40, which had slightly increased. However, since 1981, there has been an overall decrease in nitrate concentration in water from these wells.

During 1999–2001, water samples from 12 wells were analyzed for fluoride; detected concentrations ranged from 0.2 to 0.3 mg/L. These concentrations are similar to background concentrations, indicating that wastewater disposal has not had an appreciable affect on fluoride concentrations in the Snake River Plain aquifer near the INTEC.

During 1999–2001, 10 purgeable organic compounds (POCs) were detected in water from wells at the INL. Water samples from 17 wells contained from 1 to 5 of these POCs in October 2001. Concentrations of 1,1,1-trichloroethane were greater than the reporting level in samples from four wells near the INTEC. Concentrations of several POCs exceeded their minimum reporting levels in wells at or near the RWMC.

An update of the Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water, Idaho National Laboratory, Idaho, Emphasis 1999-2001 *(Linda C. Davis)*

Radiochemical and chemical wastes generated at facilities at the Idaho National Laboratory (INL) were discharged since 1952 to infiltration ponds at the Reactor Technology Complex (RTC) (known as the Test Reactor Area [TRA] until 2005), and the Idaho Nuclear Technology and Engineering Center (INTEC) and buried at the Radioactive Waste Management Complex (RWMC). Disposal of wastewater to infiltration ponds and infiltration of surface water at waste burial sites resulted in formation of perched ground water in basalts and in sedimentary interbeds above the Snake River Plain aquifer. Perched ground water is an integral part of the pathway for waste-constituent migration to the aquifer.

The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, maintains ground-water monitoring networks at the INL to determine hydrologic trends, and to monitor the movement of radiochemical and chemical constituents in wastewater discharged from facilities to both perched ground water and the aquifer. This report presents an analysis of water-quality and water-level data collected from wells completed in perched ground water at the INL during 1999–2001, and summarizes historical disposal data and water-level-and water-quality trends.

At the RTC, tritium, strontium-90, cesium-137, dissolved chromium, chloride, sodium, and sulfate were monitored in shallow and deep perched ground water. In shallow perched ground water, no tritium was detected above the reporting level. In deep perched ground water, tritium concentrations generally decreased or varied randomly during 1999–2001. During October 2001, tritium concentrations ranged from less than the reporting level to 39.4±1.4 picocuries per milliliter (pCi/mL). Reportable concentrations of tritium during July October 2001 were smaller than the reported concentrations measured during July–December 1998. Tritium concentrations in water from wells at the RTC were likely affected by: well's distance from the radioactive waste infiltration ponds (commonly referred to as the warm waste ponds); water depth below the ponds; the amount of tritium discharged to radioactive-waste infiltration ponds in the past; discontinued use of radioactive-waste infiltration ponds; radioactive decay; and dilution from disposal of nonradioactive water.

During 1999–2001, the strontium-90 concentrations in two wells completed in shallow perched water near the RTC exceeded the reporting level. Strontium-90 concentrations in water from wells completed in deep perched ground water at the RTC varied randomly with time. During October 2001, concentrations in water from five wells exceeded the reporting level and ranged from 2.8±0.7 picocuries per liter (pCi/L) in well USGS 63 to 83.8±2.1 pCi/L in well USGS 54. No reportable concentrations of cesium-137, chromium-51, or cobalt-60 were present in water samples from any of the shallow or deep wells at the RTC during 1999–2001.

Dissolved chromium was not detected in shallow perched ground water at the RTC during 1999–2001. Concentrations of dissolved chromium during July–October 2001 in deep perched ground water near the

RTC ranged from 10 micrograms per liter (µg/L) in well USGS 61 to 82 µg/L in well USGS 55. The largest concentrations were in water from wells north and west of the radioactive-waste infiltration ponds. During July–October 2001, dissolved sodium concentrations ranged from 7 milligrams per liter (mg/L) in well USGS 78 to 20 mg/L in all wells except well USGS 68 (413 mg/L). Dissolved chloride concentrations in shallow perched ground water ranged from 10 mg/L in wells CWP 1, 3, and 4 to 53 mg/L in well TRA A 13 during 1999–2001. Dissolved chloride concentrations in deep perched ground water ranged from 5 mg/L in well USGS 78 to 91 mg/L in well USGS 73. The maximum dissolved sulfate concentration in shallow perched ground water was 419 mg/L in well CWP 1 during July 2000. Concentrations of dissolved sulfate in water from wells USGS 54, 60, 63, 69, and PW 8, completed in deep perched ground water near the cold-waste ponds, ranged from 115 to 285 mg/L in July–October 2001. The maximum concentration of dissolved sulfate in water during July–October 2001 was 1,409 mg/L in well USGS 68 west of the chemical-waste pond.

At the INTEC, tritium, strontium-90, cesium-137, dissolved sodium, chloride, sulfate, and nitrite plus nitrate (as nitrogen) were monitored in shallow and deep perched ground water. No reportable concentrations of tritium were measured in shallow perched ground water during 1999–2001. The tritium concentration in water from wells completed in deep perched ground water beneath the infiltration ponds ranged from less than the reporting level in wells PW 1 and PW 5 to 9.7±0.5 pCi/mL in well PW 6 during 1999–2001. The strontium-90 concentration in water from well SWP 8, completed in shallow perched ground water, was 2.1±0.7 pCi/L in July 2001. In October 2001, strontium-90 concentrations in deep perched ground water in wells closest to the ponds were less than the reporting level, not sampled because of access problems, or the wells were dry.

Dissolved sodium, chloride, and sulfate concentrations in shallow and deep perched ground water at the INTEC infiltration ponds during 1999–2001 were similar to or less than the average annual effluent monitoring data.

At the RWMC, tritium, strontium-90, cesium-137, plutonium-238, plutonium-239, -240 (undivided), americium-241, dissolved chloride, and a suite of volatile organic compounds were monitored in deep perched ground water at well USGS 92. Radiochemical constituents in all water samples from well USGS 92 were less than the reporting level with the exception of the April 2000 and October 2001 samples analyzed for tritium. The tritium concentration was at the reporting level at 0.3±.0.1 pCi/mL in April 2000 and slightly above the reporting level at 0.45±0.14 pCi/mL in October 2001. Samples contained concentrations greater than the minimum reporting levels of 15 volatile organic compounds.

Evaluation of Well-Purging Effects on Water-Quality Results for Samples Collected from the Eastern Snake River Plain Aquifer Underlying the Idaho National Laboratory, Idaho *(Leroy L. Knobel)*

This report presents qualitative and quantitative comparisons of water-quality data from the Idaho National Laboratory, Idaho, to determine if the change from purging three wellbore volumes to one wellbore volume has a discernible effect on the comparability of the data. Historical water-quality data for 30 wells were visually compared to water-quality data collected after purging only 1 wellbore volume from the same wells. Of the 322 qualitatively examined constituent plots, 97.5 percent met 1 or more of the criteria established for determining data comparability. A simple statistical equation to determine if water-quality

data collected from 28 wells at the INL with long purge times (after pumping 1 and 3 wellbore volumes of water) were statistically the same at the 95-percent confidence level indicated that 97.9 percent of 379 constituent pairs were equivalent.

Comparability of water-quality data determined from both the qualitative (97.5 percent comparable) and quantitative (97.9 percent comparable) evaluations after purging 1 and 3 wellbore volumes of water indicates that the change from purging 3 to 1 wellbore volumes had no discernible effect on comparability of water-quality data at the INL. However, the qualitative evaluation was limited because only October-November 2003 data were available for comparison to historical data. This report was prepared by the U.S. Geological Survey in cooperation with the U.S. Department of Energy.

Geostatistical Modeling of Sediment Abundance in a Heterogeneous Basalt Aquifer at the Idaho National Laboratory, Idaho *(John A. Welhan, Renee L. Farabaugh, Melissa J. Merrick, and Steven J. Anderson)*

The spatial distribution of sediment in the eastern Snake River Plain aquifer was evaluated and modeled to improve the parameterization of hydraulic conductivity (K) for a subregional-scale ground-water flow model being developed by the U.S. Geological Survey. The aquifer is hosted within a layered series of permeable basalts within which intercalated beds of fine-grained sediment constitute local confining units. These sediments have K values as much as six orders of magnitude lower than the most permeable basalt, and previous flow-model calibrations have shown that hydraulic conductivity is sensitive to the proportion of intercalated sediment.

Stratigraphic data in the form of sediment thicknesses from 333 boreholes in and around the Idaho National Laboratory were evaluated as grouped subsets of lithologic units (composite units) corresponding to their relative time-stratigraphic position. The results indicate that median sediment abundances of the stratigraphic units below the water table are statistically invariant (stationary) in a spatial sense and provide evidence of stationarity across geologic time, as well. Based on these results, the borehole data were kriged as two-dimensional spatial data sets representing the sediment content of the layers that discretize the ground-water flow model in the uppermost 300 feet of the aquifer.

Multiple indicator kriging (mIK) was used to model the geographic distribution of median sediment abundance within each layer by defining the local cumulative frequency distribution (CFD) of sediment via indicator variograms defined at multiple thresholds. The mIK approach is superior to ordinary kriging because it provides a statistically best estimate of sediment abundance (the local median) drawn from the distribution of local borehole data, independent of any assumption of normality. A methodology is proposed for delineating and constraining the assignment of hydraulic conductivity zones for parameter estimation, based on the locally estimated CFDs and relative kriging uncertainty. A kriging-based methodology improves the spatial resolution of hydraulic property zones that can be considered during parameter estimation and should improve calibration performance and sensitivity by more accurately reflecting the nuances of sediment distribution within the aquifer.

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Appendix D - Onsite Dosimeter Measurements and Locations

Table D-1. Environmental Dosimeter Measurements at the Materials and Fuels Complex (MFC) (2006).

Location	Exposure[a]
MFC 7	132 ± 9
MFC 8	122 ± 8
MFC 9	144 ± 10
MFC 10	125 ± 9
MFC 11	126 ± 10
MFC 12	105 ± 7
MFC 13	126 ± 9
MFC 14	119 ± 8
MFC 15	131 ± 9
MFC 16	141 ± 10
MFC 17	122 ± 8
MFC 18	141 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

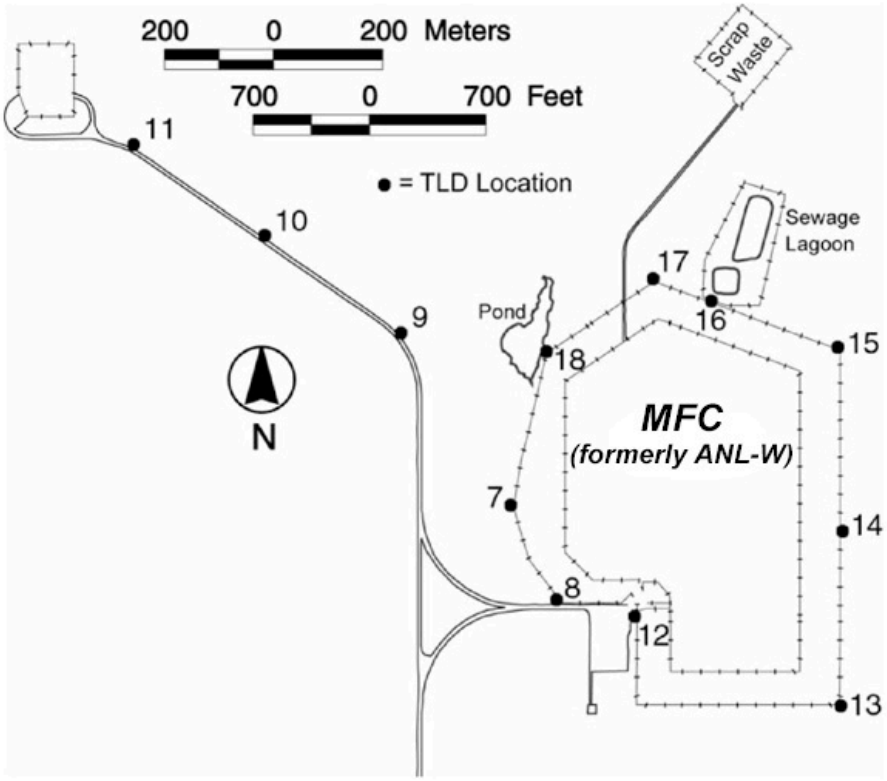

Figure D-1. Environmental Dosimeter Locations at the MFC (2006).

Table D-2. Environmental Dosimeter Measurements at the Auxiliary Reactor Area (ARA) (2006).

Location	Exposure[a]
ARA 1	126 ± 9
ARA 2	125 ± 9
ARA 3	[b]
ARA 4	[b]

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. These TLD locations were eliminated due to D&D activities.

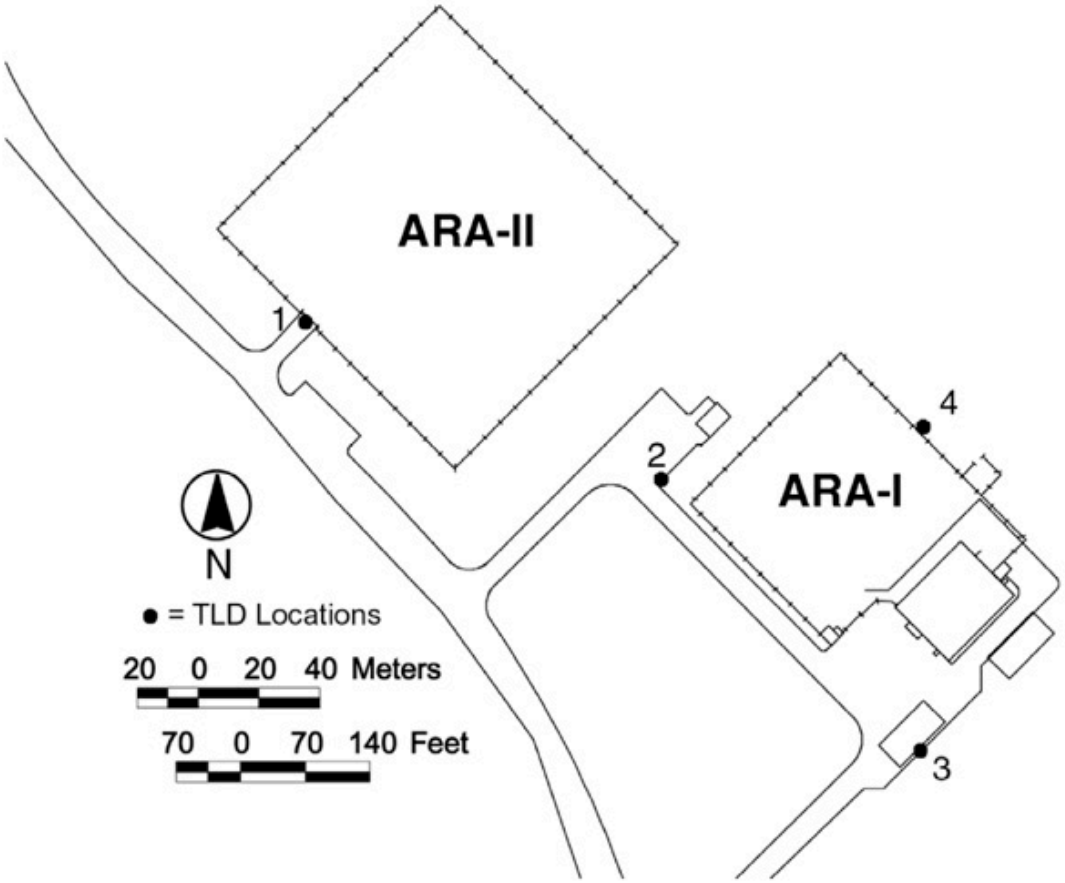

Figure D-2. Environmental Dosimeter Locations at the ARA (2006).

Table D-3. Environmental Dosimeter Measurements at the Central Facilities Area (CFA) (2006).

Location	Exposure[a]
CFA 1	132 ± 9
CFA 2	117 ± 8
CFA 3	135 ± 9
CFA 4	130 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

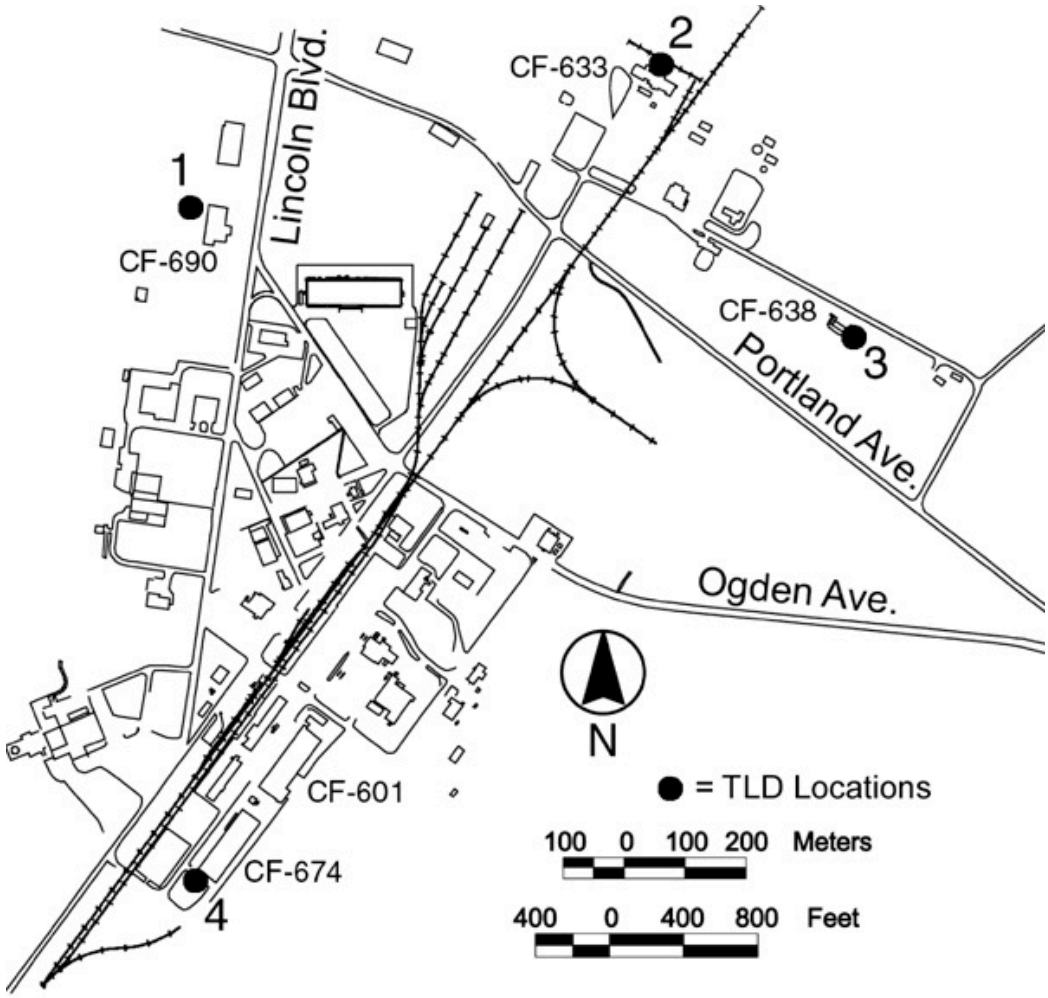

Figure D-3. Environmental Dosimeter Locations at the CFA (2006).

Table D-4. Environmental Dosimeter Measurements at the Idaho Nuclear Technology and Engineering Center (INTEC) (2006).

Location	Exposure[a]
INTEC 1	156 ± 11
INTEC 9	168 ± 12
INTEC 14	155 ± 11
INTEC 15	161 ± 11
INTEC 16	141 ± 10
INTEC 17	132 ± 9
INTEC 18	121 ± 8
INTEC 19	140 ± 10
INTEC 20	257 ± 18
INTEC 21	167 ± 12
INTEC 22	196 ± 14
INTEC 23	147 ± 10
INTEC 24	136 ± 9
INTEC 25	129 ± 9
INTEC 26	--[b]
TREE FARM 1	179 ± 12
TREE FARM 2	157 ± 11
TREE FARM 3	159 ± 11
TREE FARM 4	194 ± 13

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.

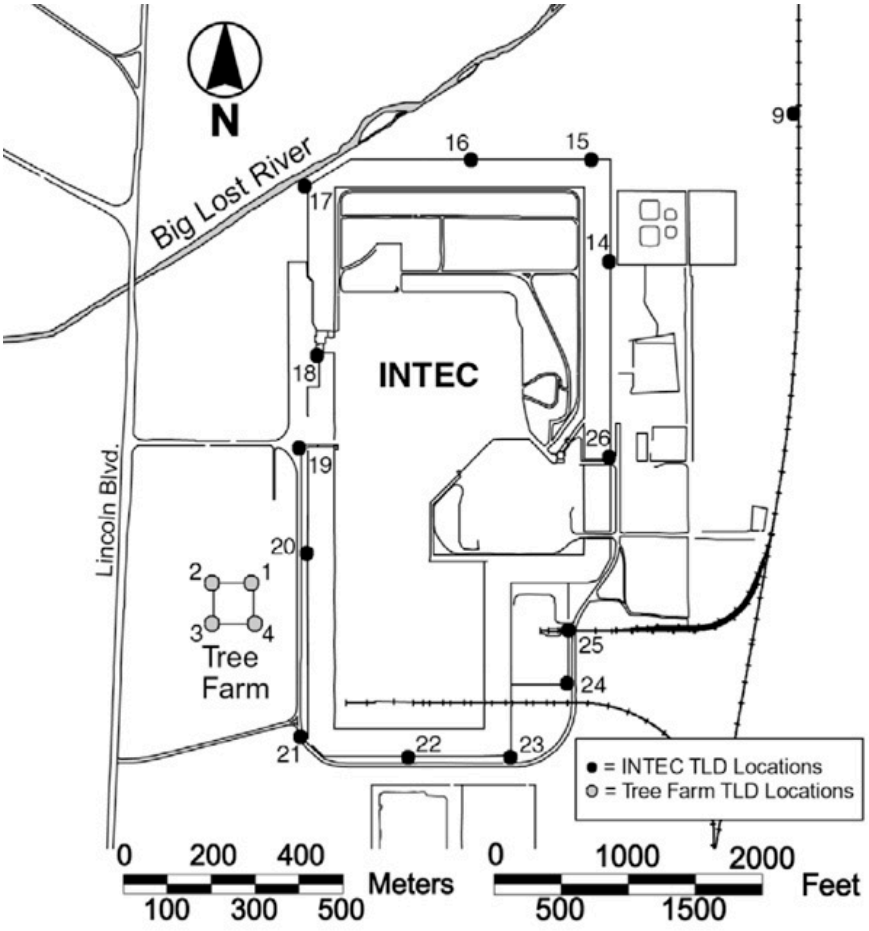

Figure D-4. Environmental Dosimeter Locations at the INTEC (2006).

Table D-5. Environmental Dosimeter Measurements at the Naval Reactors Facility (NRF) (2006).[a]

Location	Exposure[b]
NRF 4	128 ± 9
NRF 5	135 ± 9
NRF 11	130 ± 9
NRF 12	121 ± 8
NRF 13	127 ± 9
NRF 16	129 ± 9
NRF 17	--[c]
NRF 18	133 ± 9
NRF 19	131 ± 9
NRF 20	128 ± 9
NRF 21	--[c]

a. The INL contractor (BEA) manages dosimeters at NRF.
b. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
c. These locations were eliminated by construction activities.

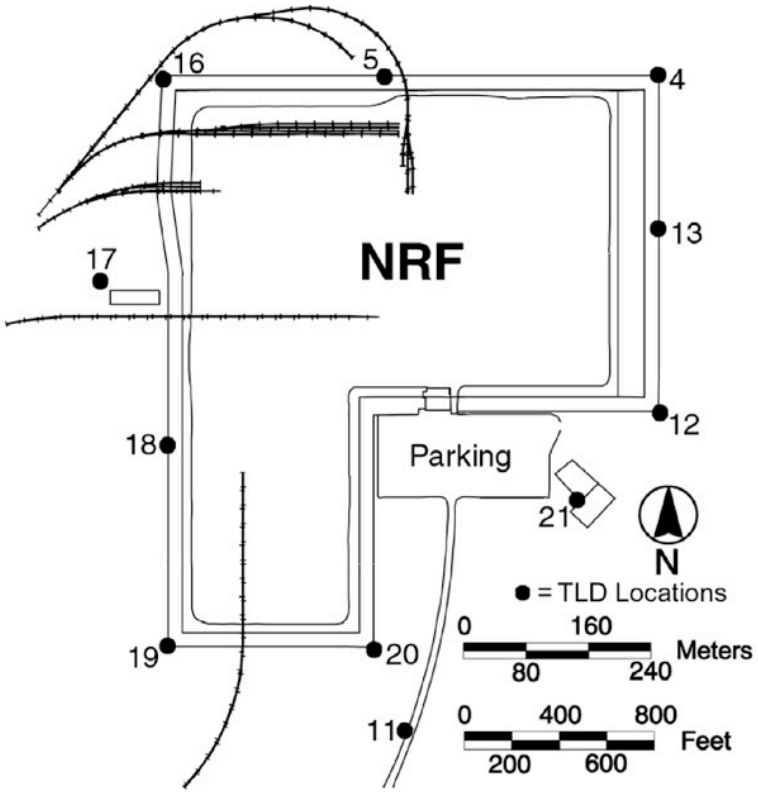

Figure D-5. Environmental Dosimeter Locations at the NRF (2006).

Table D-6. Environmental Dosimeter Measurements at the Critical Infrastructure Test Range Complex (CITRC) (2006).

Location	Exposure[a]
CITRC/SPERT 1	125 ± 9
CITRC/SPERT 2	125 ± 9
CITRC/SPERT 3	127 ± 9
CITRC/SPERT 4	135 ± 9
CITRC/SPERT 5	--[b]
CITRC/SPERT 6	133 ± 9
CITRC/WERF1	124 ± 9
CITRC/WERF2	113 ± 8
CITRC/WERF3	126 ± 9
CITRC/WERF4	129 ± 9
CITRC/WERF5	129 ± 9
CITRC/WERF6	116 ± 8
CITRC/WERF7	131 ± 9

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.
SPERT = Special Power Excursion Reactor Test
WERF = Waste Experimental Reduction Facility.

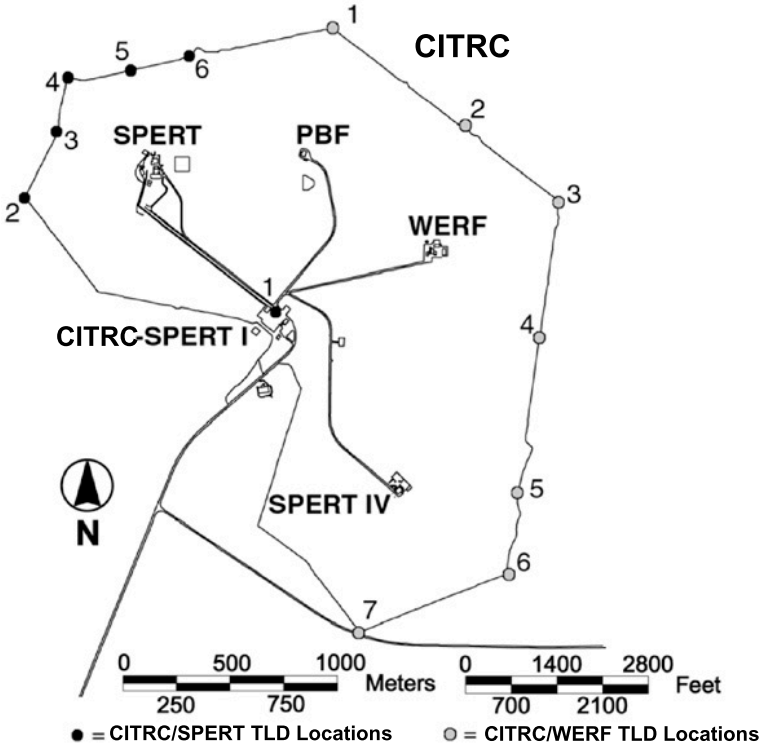

Figure D-6. Environmental Dosimeter Locations at the CITRC (2006).

Table D-7. Environmental Dosimeter Measurements at the Radioactive Waste Management Complex (RWMC) (2006).

Location	Exposure[a]
RWMC 3a	130 ± 9
RWMC 5a	123 ± 9
RWMC 7a	130 ± 9
RWMC 9a	165 ± 11
RWMC 11a	137 ± 10
RWMC 13a	130 ± 9
RWMC15a	125 ± 9
RWMC 17a	126 ± 9
RWMC 19a	119 ± 8
RWMC 21a	132 ± 9
RWMC 23a	130 ± 9
RWMC 25a	132 ± 9
RWMC 27a	159 ± 11
RWMC 29a	224 ± 16
RWMC 31a	234 ± 16
RWMC 37a	120 ± 8
RWMC 39	136 ± 9
RWMC 40	140 ± 10
RWMC 41	457 ± 32
RWMC 42	136 ± 9
RWMC 43	140 ± 10
RWMC 45	222 ± 15
RWMC 46	124 ± 9
RWMC 47	118 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

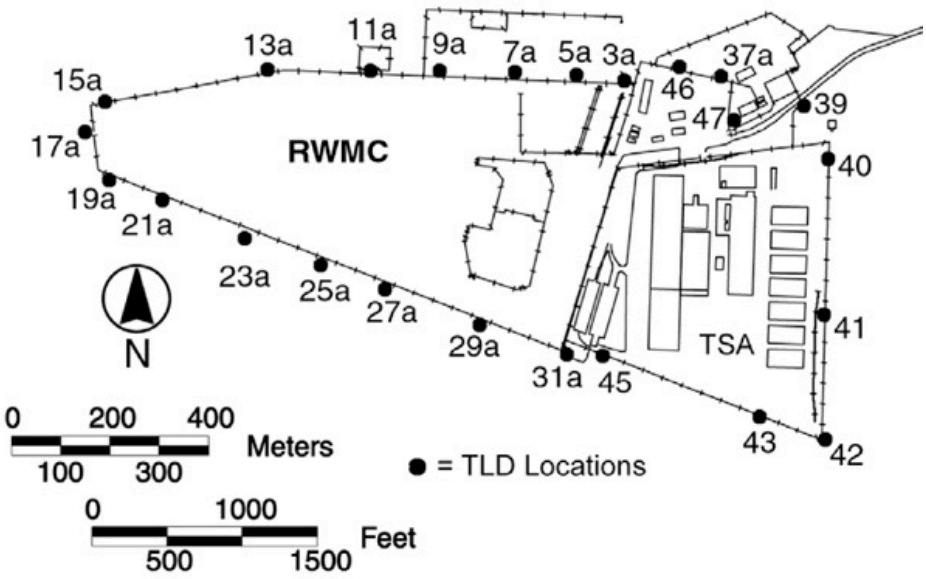

Figure D-7. Environmental Dosimeter Locations at the RWMC (2006).

Table D-8. Environmental Dosimeter Measurements at the Test Area North (TAN) (2006).

Location	Exposure[a]
TAN/TSF 1	110 ± 8
TAN/TSF 2	128 ± 9
TAN/TSF 3	115 ± 8
TAN/TSF 4	123 ± 9
TAN/LOFT 1	129 ± 9
TAN/LOFT 2	--[b]
TAN/LOFT 3	109 ± 8
TAN/LOFT 4	111 ± 8
TAN/LOFT 5	114 ± 8
TAN/LOFT 6	133 ± 9
TAN/LOFT 7	133 ± 9
TAN/WRRTF1	124 ± 9
TAN/WRRTF2	--[b]
TAN/WRRTF3	--[b]
TAN/WRRTF4	112 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.
TSF = Technical Support Facility
LOFT = Loss of Fluid Test Facility
WRRTF = Water Reactor Research Test Facility

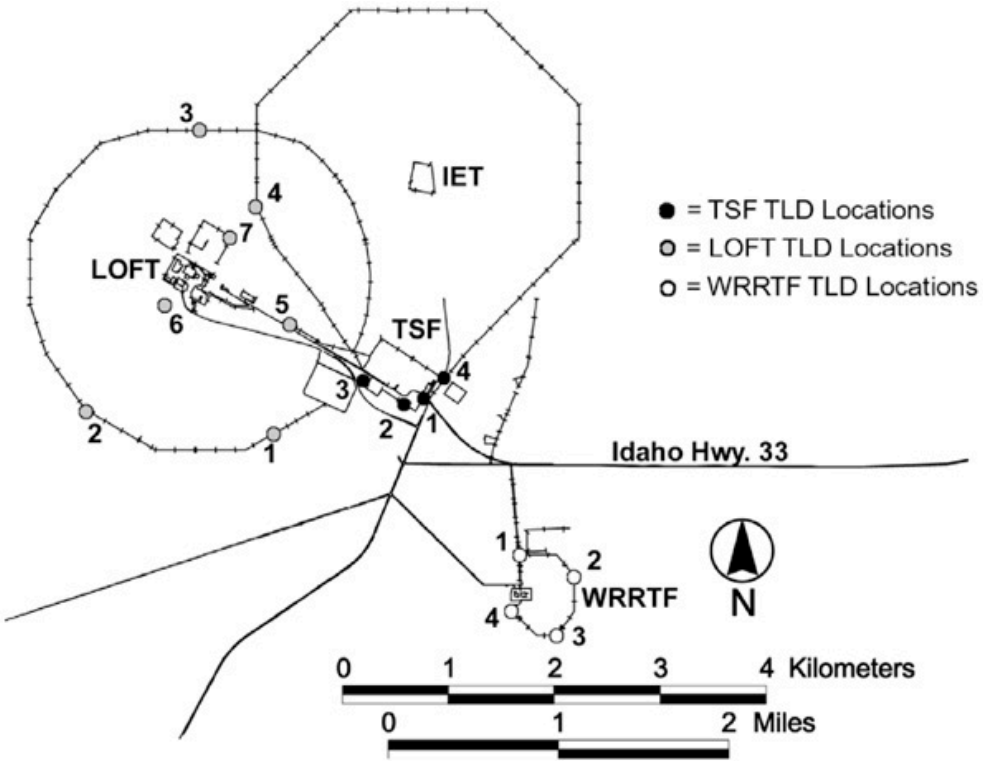

Figure D-8. Environmental Dosimeter Locations at the TAN (2006).

Table D-9. Environmental Dosimeter Measurements at the Reactor Technology Complex (RTC) (2006).

Location	Exposure[a]
RTC 1	140 ± 10
RTC 2	--[b]
RTC 3	145 ± 10
RTC 4	163 ± 11
RTC 5	143 ± 10
RTC 6	142 ± 10
RTC 7	134 ± 9
RTC 8	152 ± 11
RTC 9	140 ± 10
RTC10	147 ± 10
RTC11	147 ± 10
RTC12	150 ± 10
RTC13	147 ± 10

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).
b. Dosimeter missing at one of the collection times.

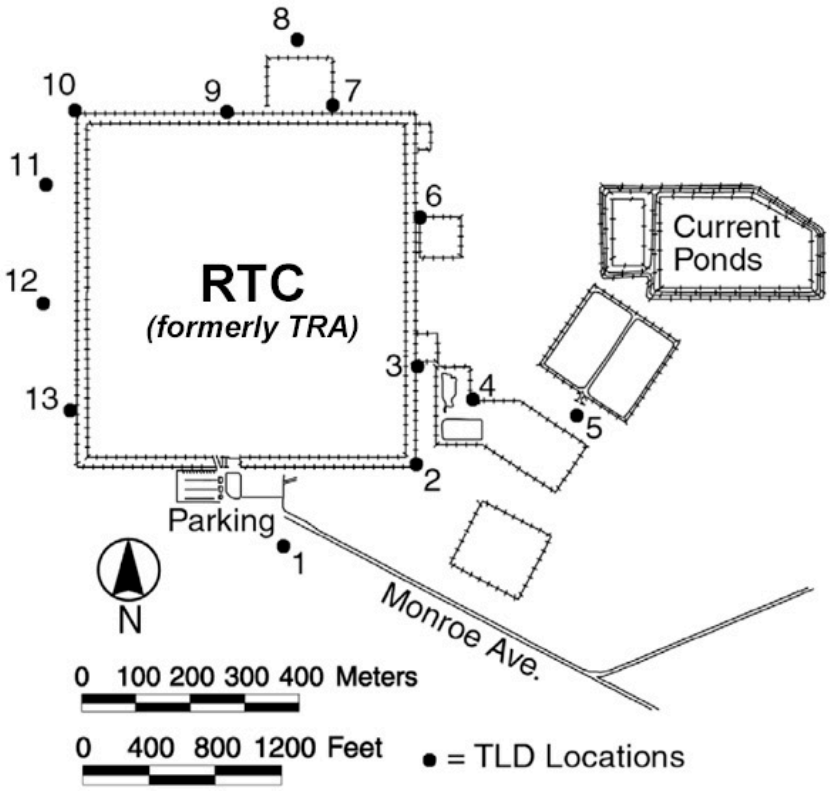

Figure D-9. Environmental Dosimeter Measurements at the RTC (2006).

Table D-10. Environmental Dosimeter Measurements along Lincoln Blvd. and US Highway 20 (2006).

Location	Exposure[a]
LINCOLN BLVD 1	128 ± 9
LINCOLN BLVD 3	136 ± 9
LINCOLN BLVD 5	137 ± 10
LINCOLN BLVD 7	130 ± 9
LINCOLN BLVD 9	138 ± 10
LINCOLN BLVD 11	125 ± 9
LINCOLN BLVD 13	126 ± 9
LINCOLN BLVD 15	123 ± 9
LINCOLN BLVD 17	125 ± 9
LINCOLN BLVD 19	139 ± 10
LINCOLN BLVD 21	136 ± 9
LINCOLN BLVD 23	133 ± 9
LINCOLN BLVD 25	132 ± 9
HWY 26-266	129 ± 9
HWY 26-268	125 ± 9
HWY 26-270	129 ± 9
HWY 20-264	126 ± 9
HWY 20-266	119 ± 8
HWY 20-268	122 ± 8
HWY 20-270	125 ± 9
HWY 20-272	116 ± 8
HWY 20-274	106 ± 7
HWY 20-276	121 ± 8
EBR 1	116 ± 8

a. All values are in milliroentgen (mR) plus or minus one standard deviation (± 1s).

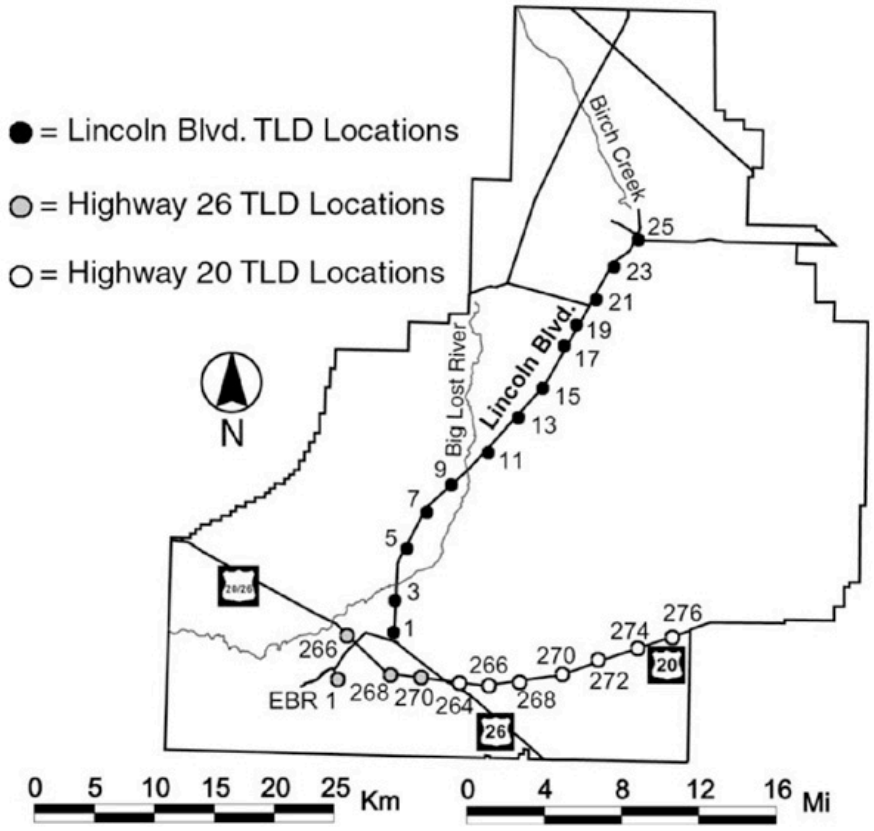

Figure D-10. Environmental Dosimeter Locations along Lincoln Blvd. and US Highway 20 (2006).

Appendix E - Field Measurements of Gamma Radiation and Radionuclides in Surface Soil

C. Oertel and J. Giles - Battelle Energy Alliance

INTRODUCTION

Battelle Energy Alliance (BEA), the Idaho National Laboratory (INL) contractor, is responsible for performing annual soil radiation (gamma) measurements at the INL Site. In 2006, field measurements for radioactive materials and radiation in soils and on roadways at the INL Site were performed using two types of systems: field-portable gamma ray spectrometry systems, and a vehicle-based radiation measurement system. These two measurement systems are shown in Figure E-1.

Figure E-1. Global Positioning Radiometric Scanner (GPRS) and In Situ Gamma-Ray Spectrometry System.

Field (in situ) gamma-ray spectrometry is used for monitoring of man-made radionuclides in the environment. Each radionuclide of interest is identified by its signature gamma spectrum acquired by a gamma detector coupled to a spectrometer. The in situ technique is particularly well-suited for monitoring work because it quickly determines levels and types of contamination over large areas. This method can significantly reduce the number of laboratory analytical samples required and more clearly define the areal extent of radionuclide contamination. Field spectrometry is particularly useful for determining the distribution and concentrations of ^{137}Cs in soil because this gamma-emitting radionuclide is ubiquitous in the environment and is readily detected via spectrometry.

Roadway and facility perimeter surveys were completed using vehicle-mounted plastic scintillators. The plastic scintillators are mounted in shielded enclosures on the front of a HUMVEE all-terrain vehicle, along with a differentially-corrected global positioning system (GPS). This system is identified as the Global Positioning Radiometric Scanner (GPRS). The mobile radiation measurement system can characterize direct radiation over the large areas and long distances associated with the INL Site and its facilities.

In 2006, BEA performed 326 in situ gamma-ray spectroscopy measurements, and 12 roadway and facility perimeter measurements. The in situ measurements were performed at predetermined locations

across the INL Site. These locations included points which border INL Site facilities, and a set of regional points that cover onsite and offsite locations from the southwest to northeast of the INL Site boundaries. Vehicle-based measurements were performed along seven major facility-to-facility roads and around five facility perimeters.

METHODOLOGY

In Situ Gamma-Ray Spectroscopy System

The in situ gamma-ray spectrometry measurements were performed using a n-type and p-type, high-purity germanium (HpGe) detector connected to commercially available, state-of-the-art digital spectrometer. These measurements follow the protocols of the U.S. Department of Energy Environmental Measurements Laboratory, HASL-300 method for Field Gamma-ray Spectrometry (DOE 1997). (The Environmental Measurements Laboratory is now under the purview of the U.S. Department of Homeland Security.)

Using the HASL-300 measurement method, gamma-emitting radionuclides are identified by the specific energies of the gamma rays which they emit. These gamma-rays interact in the detector and they are converted to electronic signals proportional to the energy of the initial gamma-ray. The electronic pulses are then registered as spectral peaks in the instrumentation. Figure E-2 shows the gamma spectrum for ^{137}Cs. The total number of electronic pulses that are recorded for each spectral peak for a given time period (i.e., the peak count rate) is related to the full absorption of unscattered gamma rays. If the detector is properly calibrated, the activities per unit mass of any radionuclide can be derived from the peak count rate using parameters that describe the soil characteristics (i.e., density) and the depth profile of the distribution.

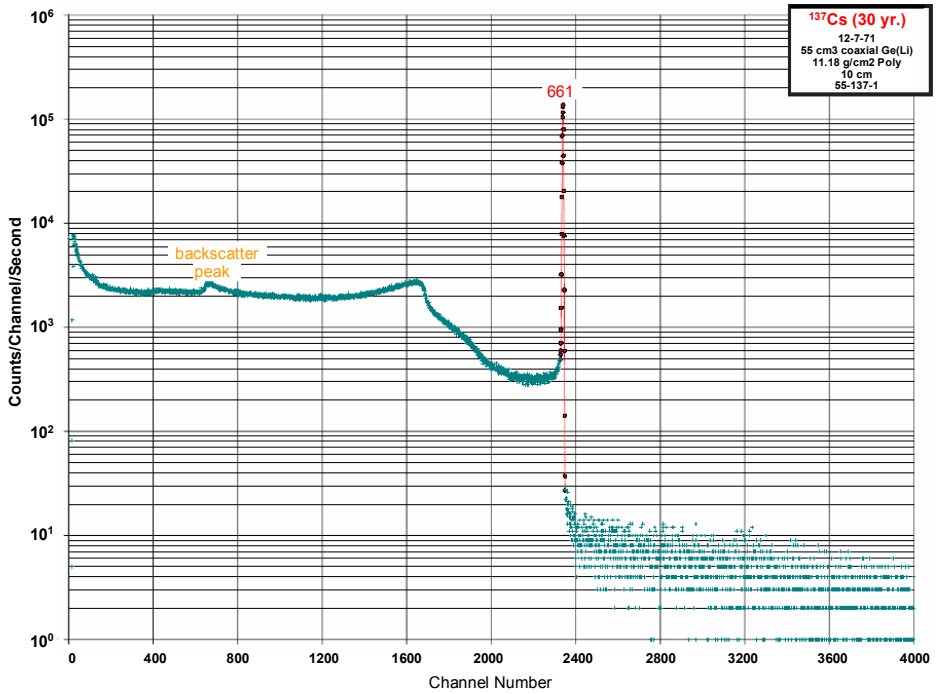

Figure E-2. Cesium-137 Gamma-Ray Spectrum Showing Diagnostic Peak at 661 KeV. Spectrum Provided by the BEA Gamma-Ray Spectrometry Center. (http://www.inl.gov/gammaray/catalogs/pdf/gecat.pdf)

The measurements were performed by placing a detector on a tripod such that the detector was one meter above the ground surface. At this height, the detector has a circular field of view with a diameter of approximately 18 meters (60 ft). In this configuration, each measurement provides a radionuclide concentration that is a weighted average over the detector field of view. At each measurement location, the HPGe detector system was positioned and set to count the radioactivity in the soil. Count times for all field measurement points ranged from 1,800 seconds to 3,600 seconds. Also for each site facility, approximately 10% of the points were recounted in order to perform quality assurance (QA) checks. These QA counts had count times of 3,600 seconds.

A series of long counts were performed at select locations at each facility. These long counts were performed exclusively with n-type germanium detectors, and the data was analyzed using a commercial software package in order to assess the depth profile of the ^{137}Cs for each facility. The measured depth profile was then used as input for the analysis of the data from the 326 field measurement locations.

Global Positioning Radiometric Scanner System

The GPRS is utilized to perform radiological surveys over large areas. As previously stated, the system is comprised of radiation detectors and a differentially corrected GPS mounted on a HUMVEE. Custom software provides a real-time display of the radiological and position information as the data are acquired. The system is controlled through a single computer interface. The detectors are positioned at a height of one meter (36 inches) above the ground, and the GPS receiver is located directly above the detectors. During the roadway and facility perimeter surveys, the speed of the GPRS is maintained at approximately five miles per hour.

RESULTS AND DISCUSSION

In Situ Gamma-Ray Spectroscopy System

Analysis of the in situ measurement data show that ^{137}Cs is the only anthropogenic, gamma-emitting radionuclide that is measurable above background. The depth profile analysis provided through the measurement software indicated that there were two distinct patterns of vertical distribution of the ^{137}Cs in the INL soils: 1) shallow exponential, where ^{137}Cs is distributed exponentially (highest concentration on surface) within a shallow soil column, and 2) planar, where ^{137}Cs is detected on the soil surface only. Table E-1 summarizes the results for each of the eight major facilities and the large grid points for 2006. Individual results for each area are presented in Figures E-2 through E-10. Concentrations are reported in units of pCi/g for those areas in which ^{137}Cs was determined to be exponentially distributed within the soil column (i.e., Auxilary Reactor Area [ARA], Test Area North [TAN], Radioactive Waste Management Complex [RWMC], Reactor Technology Complex [RTC], Idaho Nuclear Technology and Engineering Center [INTEC], and the Large Grid areas). Concentrations are reported in units of pCi/m^2 for those areas in which ^{137}Cs was determined to be surficially deposited (i.e., Critical Infrastructure Test Range Complex [CITRC], Naval Reactors Facility [NRF], and Materials and Fuels Complex [MFC] areas).

For those sites showing an exponential distribution of ^{137}Cs, concentrations ranged from 2.8 E-04 pCi/g at INTEC to 17.3 pCi/g at ARA. The mean ^{137}Cs concentration of all sites was 0.61 ± 0.87 pCi/g. The maximum individual area mean was 2.28 pCi/g at ARA. These results are not surprising as ARA is the site

of the 1961 Stationary Low-Power Reactor 1 (SL-1) accident and subsequent cleanup, which left residual contamination in the form of "hot particles" throughout soil surrounding the facility.

Measurements of those areas showing surface distribution of ^{137}Cs resulted in concentrations ranging from 1.09 E+04 pCi/m^2 at CITRC to 3.18E+04 pCi/m^2 at NRF. The relatively narrow range of concentrations indicates that ^{137}Cs is fairly evenly distributed over the surface and is not indicative of any localized contamination events, such as spills. The mean concentration for these sites was calculated to be (1.88 ± 0.33) E+04 pCi/m^2. The ^{137}Cs data was further characterized in order to determine the relevant upper confidence limit (UCL) values. In order to accomplish this, the program ProUCL (USEPA) was used. This program performs two main functions: 1) the data is first examined in order to determine the correct probability distribution, and 2) the UCL values are then calculated using an appropriate statistical calculation.

Table E-1. Summary of 2006 In Situ Gamma Scan Results for ^{137}Cs at INL Sites and Large Grid.

Facility surveyed:	ARA	TAN	RWMC	RTC	NRF	CITRC	INTEC	MFC	Large Grid
Number of measurements:	78	18	46	24	5	16	95	12	28
Descriptive statistics	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/m^2)	(pCi/m^2)	(pCi/g)	(pCi/m^2)	(pCi/g)
Mean	2.28E+00	1.41E-01	1.12E-01	2.02E-01	2.22E+04	1.55E+04	8.82E-01	1.87E+04	8.49E-02
Median	6.12E-01	1.20E-01	1.13E-01	1.64E-01	2.48E+04	1.56E+04	5.45E-01	1.69E+04	6.95E-02
Minimum	6.29E-02	7.06E-02	7.24E-02	7.82E-02	1.15E+04	1.09E+04	2.84E-04	1.27E+04	2.67E-02
Maximum	1.73E+01	4.92E-01	1.49E-01	4.07E-01	3.18E+04	2.01E+04	8.79E+00	2.56E+04	3.87E-01
Range (max – min)	1.72E+01	4.21E-01	7.61E-02	3.29E-01	2.04E+04	9.28E+03	8.78E+00	1.30E+04	3.60E-01
Standard deviation	3.68E+00	9.47E-02	1.88E-02	9.76E-02	7.90E+03	2.09E+03	1.14E+00	4.51E+03	8.11E-02
Variance	1.36E+01	9.16E-03	3.52E-04	9.33E-03	6.25E+07	4.36E+06	1.31E+00	2.03E+07	6.58E-03
Standard Error	4.17E-01	2.26E-02	2.77E-03	1.97E-02	3.53E+03	5.22E+02	1.18E-01	1.30E+03	1.53E-02
Lower 95% C.I.[a]	1.45E+00	9.35E-02	1.07E-01	1.61E-01	1.24E+04	1.44E+04	6.38E-01	1.58E+04	5.44E-02
Upper 95% C.I.	3.11E+00	1.89E-01	1.18E-01	2.43E-01	3.20E+04	1.66E+04	1.11E+00	2.15E+04	1.17E-01

a. C.I. = confidence interval.

The statistical distribution determination results for sites with shallow exponential ^{137}Cs distributions are shown in Table E-2. Examination of Table E-2 shows that the mean and 95% UCL values for the nonparametric overall site data set are likely biased by the higher ARA results. A Grubb's test for outliers was performed on the means to determine whether the most extreme mean value in the list is a significant outlier from the rest The result was that the ARA data mean was determined to be a significant outlier ($P<0.05$). The ARA site was excluded in the final average. As stated previously, ARA has extensive soil contamination around this facility as a direct result of the SL-1 accident that occurred in January of 1961. (DOE-ID 1999). Thus, it is appropriate to compare the overall and individual site means to historic means and UCL data without using the ARA data set.

For comparison, the mean INL site background value for ^{137}Cs, based on data in Rood et al (1994) is 0.44 pCi/g, and the 95% UCL is 0.82 pCi/g. A significance test on the overall site mean data, without using the ARA set, shows that there is no statistically significant difference ($p=0.74$) between the site mean ^{137}Cs concentration in soil and the historical ^{137}Cs soil concentration in the 1994 report. There is also excellent agreement between the 2006 (0.83) and historical (0.82) 95% UCL values.

Table E-3 shows the ProUCL results for those sites where the ^{137}Cs was determined to be in a planar or surface distribution. There are no historical reference values for those sites which assume a surface distribution for ^{137}Cs.

Table E-2. Distribution, Mean, Standard Deviation, and 95% Upper Confidence Level Values for 2006 Data Measured at Sites with Shallow Exponential Distribution of ^{137}Cs.[a]

Location	Distribution[b]	Mean	SD[c]	95% UCL[c]
Overall	Nonparametric	0.95	2.19	1.76
ARA	Lognormal	2.28	3.68	3.84
INTEC	Nonparametric	0.88	1.14	1.61
Large Grid	Nonparametric	0.08	0.08	0.15
RTC	Lognormal	0.20	0.10	0.23
RWMC	Normal	0.11	0.02	0.12
TAN/SMC	Nonparametric	0.14	0.09	0.18
Overall w/o ARA	Nonparametric	0.46	0.85	0.83

a. All values are in units of pCi/g^2.
b. See Appendix B for an explanation of terms.
c. SD = standard deviation; UCL = upper confidence level

Table E-3. Distribution, Mean, Standard Deviation, and 95% Upper Confidence Level Values for 2006 Data Collected at Sites with Planar Distribution of ^{137}Cs. All values are in units of pCi/m^2.

Site	Distribution:	Mean:	SD	95%UCL
Overall	Lognormal	1.77E4	4.77E3	1.91E4
MFC	Normal	1.87E4	4.50E3	2.10E4
NRF	Normal	2.13E4	7.38E3	2.74E4
CITRC	Normal	1.55E4	2.07E3	1.64E4

Global Positioning Radiometric Scanner System

The routes surveyed using the GPRS are shown in Figure E-11. The results from the roadway and facility perimeter surveys are shown in Table E-4.

The road and perimeter survey data presented in Table E-4 show that for all roads, the average count rates are negative, i.e., they are below background count rates. The high minimum and maximum count rates on the NRF-TAN road were acquired during periods of transport of contaminated soil from TAN to ICDF. Passage of these vehicles near the GPRS scintillator detectors resulted in these high count rate spikes.

In the perimeter surveys, all average count rate values were higher than local background count rates. In particular, the small area on the northeast corner of INTEC was much higher than background. This corresponds with the elevated ^{137}Cs concentrations denoted in Figure E-4.

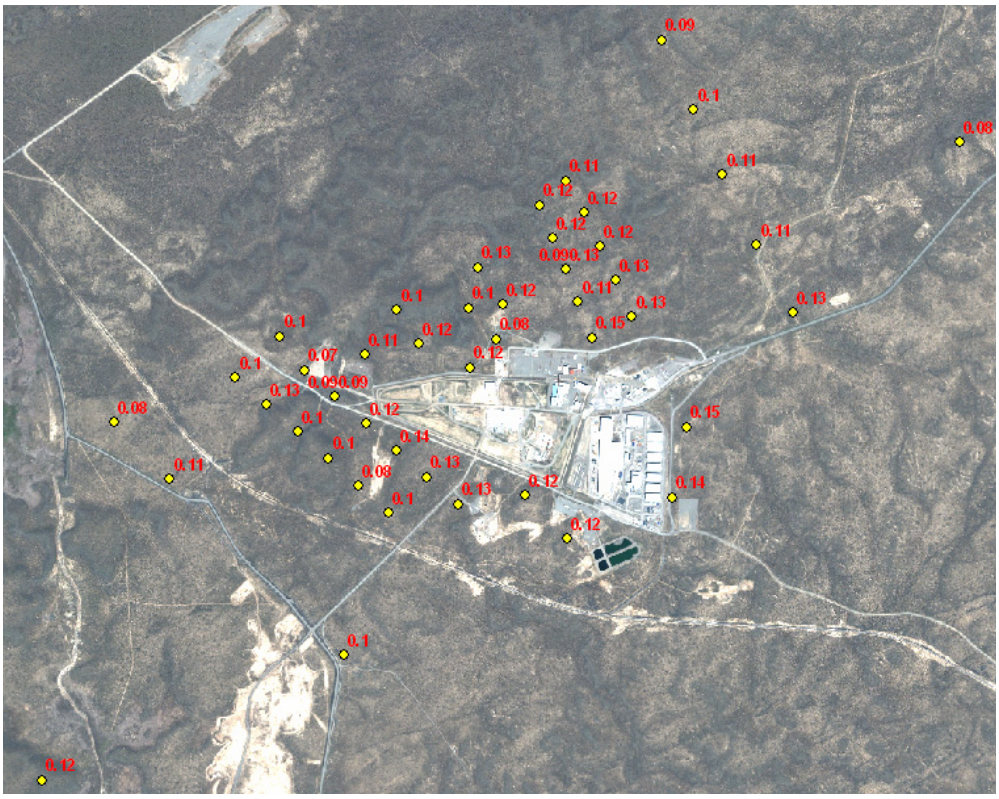

Figure E-3. In Situ Gamma Scan Results (×1E04 pCi/m^2) for ^{137}Cs at CITRC.

Figure E-4. 2006 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at INTEC.

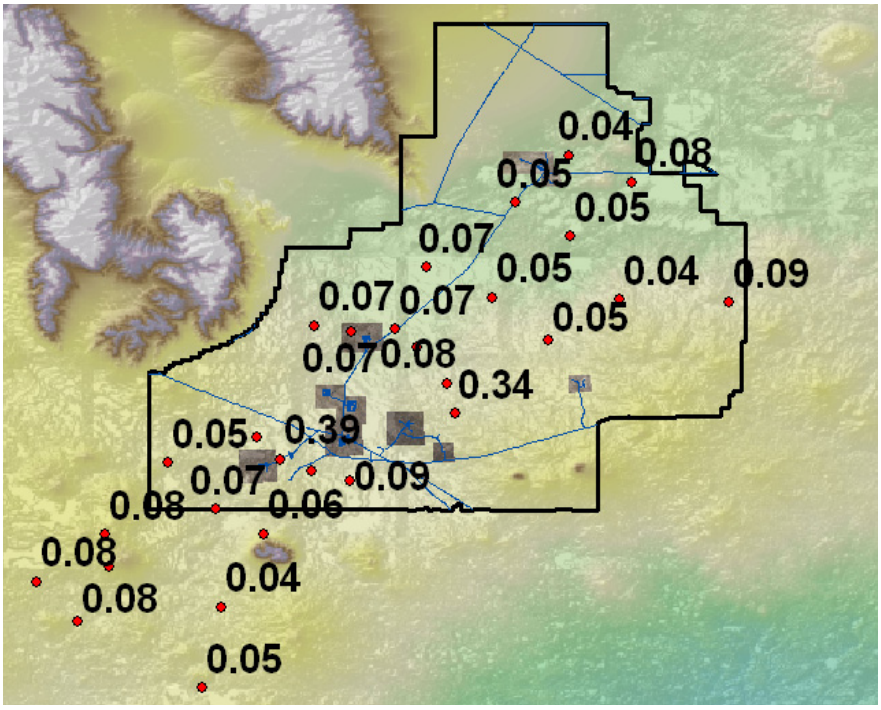

Figure E-5. 2006 In Situ Gamm Scan Results (pCi/g) for ^{137}Cs on Large Grid.

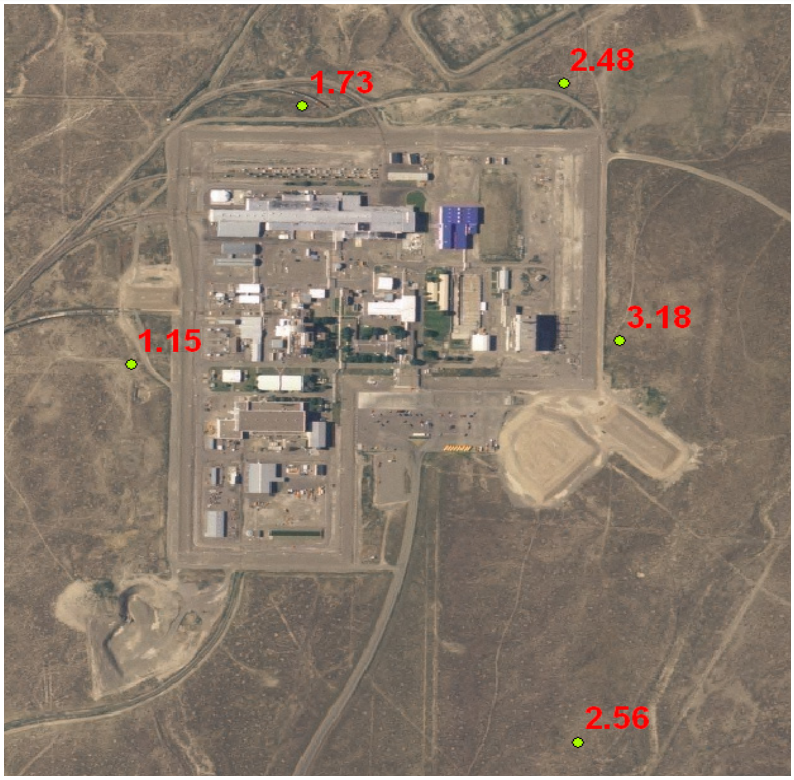

Figure E-6. 2006 In Situ Gamma Scan Results (x1E04 pCi/m^2) for ^{137}Cs at NRF.

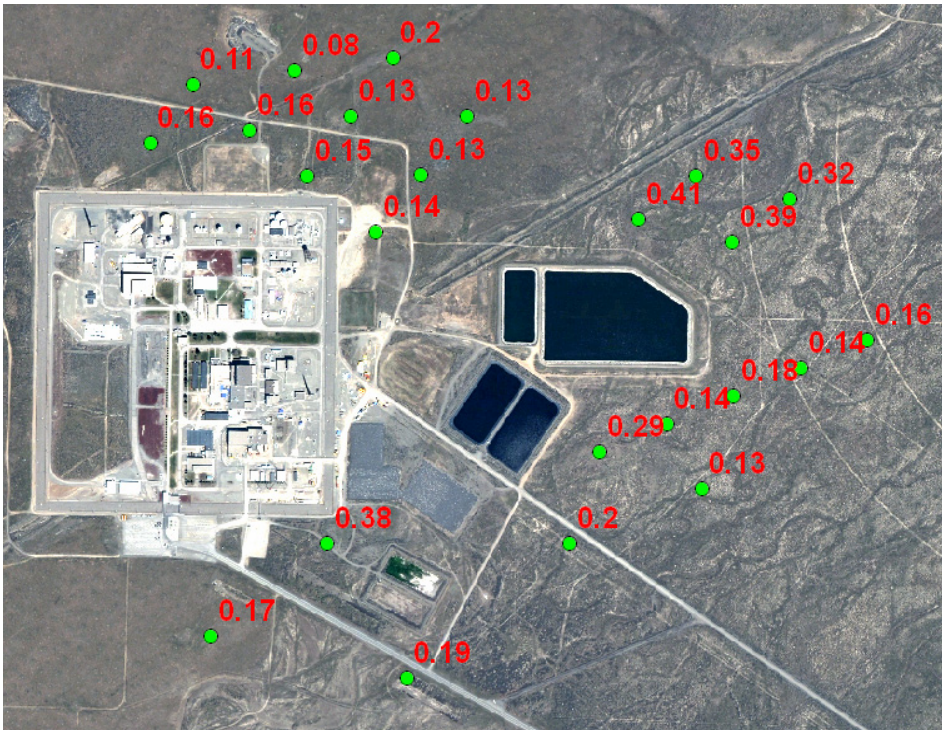

Figure E-7. 2006 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at RTC.

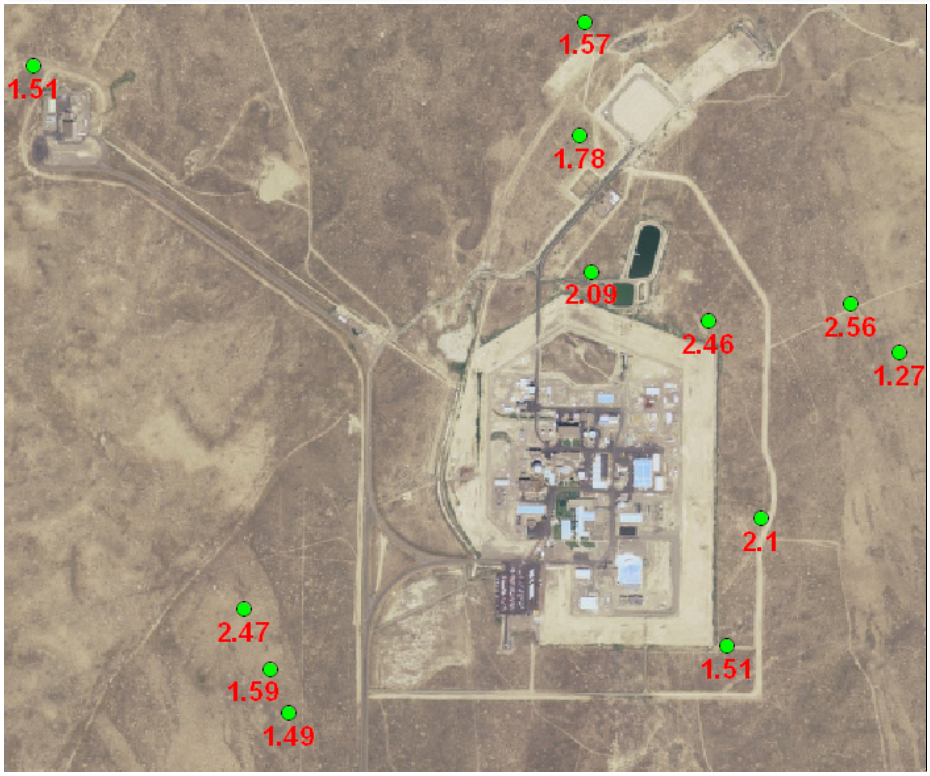

Figure E-8. 2006 In Situ Gamma Scan Results (x1E04 pCi/m^2) for ^{137}Cs at MFC.

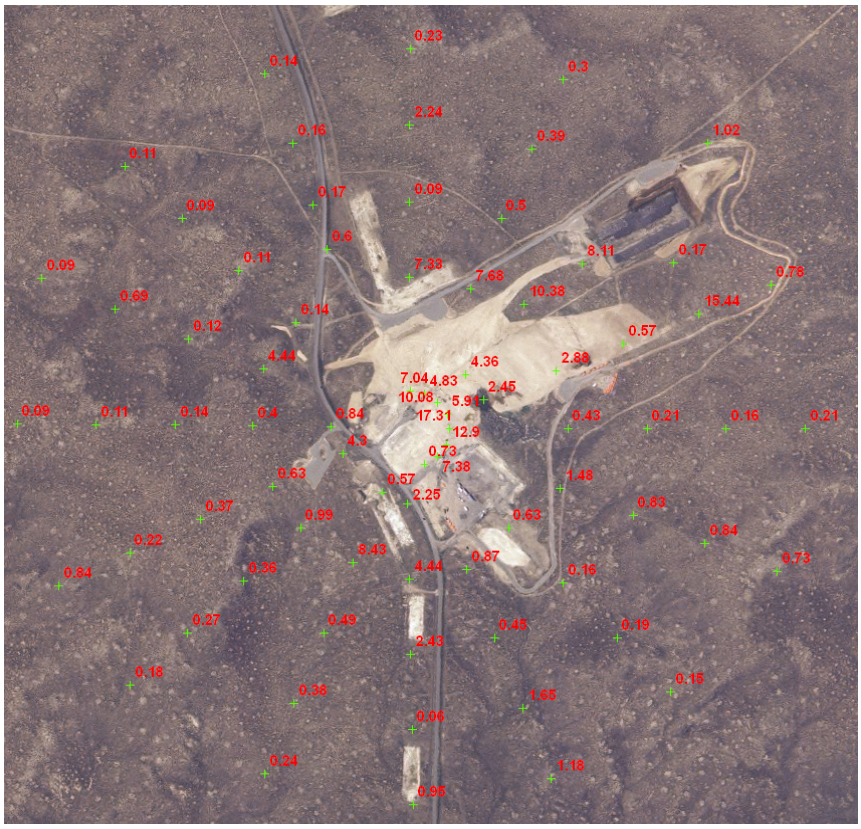

Figure E-9. 2006 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at ARA.

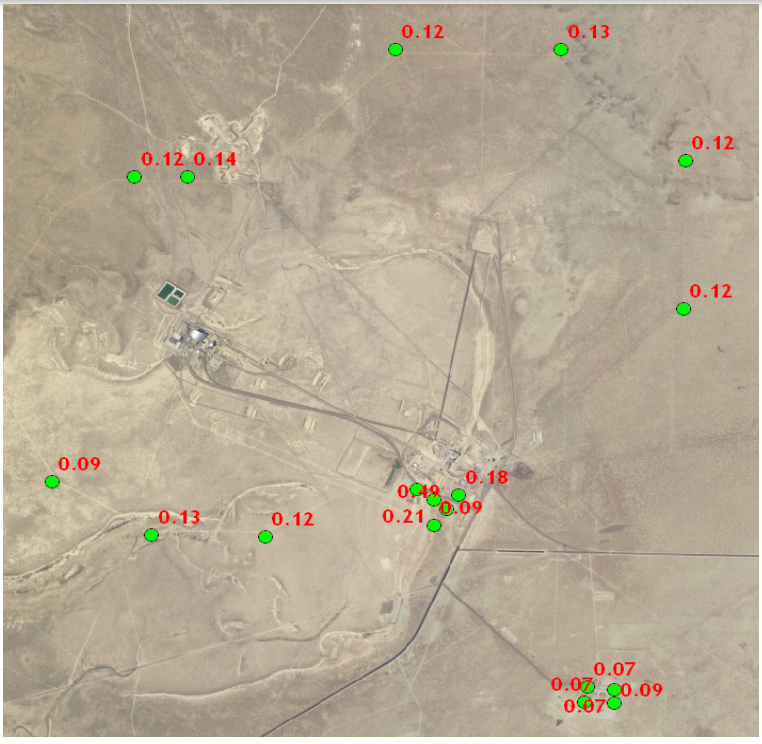

Figure E-10. 2006 In Situ Gamma Scan Results (pCi/g) for ^{137}Cs at TAN/SMC.

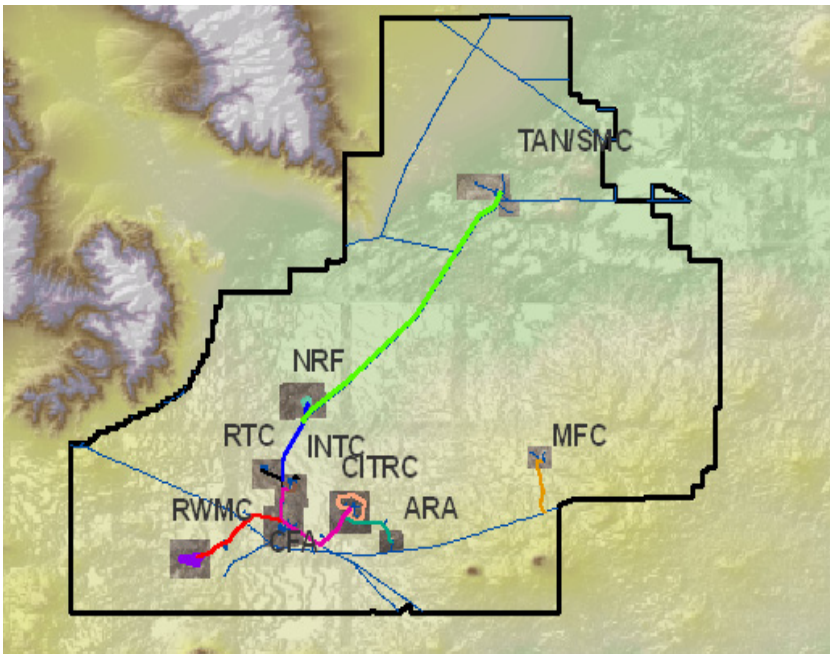

Figure E-11. 2006 Roadways and Facility Perimeters Measured by GPRS.

QUALITY CONTROL OF IN SITU GAMMA-RAY SPECTROSCOPY SYSTEM

At 31 locations, a second measurement was performed using in-situ gamma spectroscopy as a quality control check. These results are shown in Table E-5. For each INL site, about 10% of the points were chosen in order to perform this second measurement. The percent differences between the initial and quality control measurements for both anthropogenic ^{137}Cs and naturally occurring ^{40}K are shown. The mean percent difference for ^{137}Cs is -3.2 ± 22.7 % and the mean difference for ^{40}K is 1.2 ± 15.7%. The percent differences for both ^{137}Cs and ^{40}K were both tested and found to be statistically insignificant (p=0.44 for ^{137}Cs, p=0.53 for ^{40}K).

Table E-4. Roadway and Perimeter Survey Data for 2006.

ROAD	ARA	TRA-NRF	NRF-TAN	ICDF-TRA	CITRC	MFC	RWMC-CFA	INTEC NE Corner	NRF Perimeter	CITRC Perimeter	RWMC Perimeter	INTEC Perimeter
Count	5735.0	8202.0	27009.0	2844.0	12171.0	5457.0	8361.0	23795.0	1379.0	5450.0	3989.0	2375.0
Average	-103.9	-35.1	-81.9	-230.0	-418.6	26.6	-54.7	536.7	54.7	92.3	36.4	70.9
Minimum	-309.0	-344.0	-17359.0	-484.0	-712.0	-95.0	-330.0	-44.0	-279.0	-298.0	-297.0	-332.0
Maximum	182.0	94.0	30105.0	-71.0	-39.0	138.0	89.0	1200.0	204.0	310.0	836.0	547.0
Standard Deviation	37.8	438.0	302.8	52.9	54.1	29.3	57.1	236.3	68.1	94.3	192.2	122.0
Variance	1429.6	41.5	91663.8	2798.7	2924.6	856.4	3263.2	55819.2	4638.2	8898.3	36953.1	14883.3
Standard Error	0.5	1723.1	1.8	1.0	0.5	0.4	0.6	1.5	1.8	1.3	3.0	2.5

Table E-5. Quality Control Results for In Situ Gamma Spectroscopy.

ID	Cs-137	Uncertainty (1s)	Cs-137-QC	Uncertainty (1s)	% Diff	K-40	Uncertainty (1s)	K-40-QC	Uncertainty (1s)	% Diff
L2-76	0.13	0.07	0.11	0.06	-15.4	14.7	0.6	14.6	0.7	-0.7
WRRTF-6	0.12	0.02	0.11	0.01	-8.3	16.2	0.5	12.3	0.5	-24.1
ARA-32	0.48	0.14	0.38	0.19	-20.8	15.1	0.4	15.7	0.5	4.0
ARA-53	0.18	0.1	0.21	0.09	16.7	13	0.4	12.8	0.3	-1.5
ARA-56	0.31	0.18	0.17	0.1	-45.2	13.4	0.4	13.8	0.4	3.0
ARA-72	2.45	0.16	1.86	0.07	-24.1	11.4	0.3	14.6	0.6	28.1
ARA-4	1.8	0.1	1.9	0.12	5.6	16.2	0.7	17.9	0.1	10.5
TRT-4	1.23E+04	2.10E+03	9.31E+03	3.44E+03	-24.3	14.5	0.3	14.4	0.3	-0.7
EBRII-12	1.24E+04	1.50E+03	1.19E+04	2.40E+03	-4.0	13	0.5	12.8	0.3	-1.5
PBF-3	1.61E+04	1.50E+03	1.63E+04	1.40E+03	1.2	15.7	0.7	15.5	0.4	-1.3
TRA 8.2	0.16	0.02	0.17	0.02	6.3	19.9	0.5	20	0.5	0.5
TRA A3.3	0.15	0.01	0.16	0.02	6.7	19.5	0.5	19.6	0.5	0.5
TRA -1.4	0.17	0.01	0.14	0.02	-17.6	15.4	0.3	16.4	0.4	6.5
A16	0.87	0.02	0.89	0.02	2.3	15.3	0.5	19.5	0.4	27.5
C36	0.32	0.01	0.32	0.02	0.0	15.7	0.3	15.5	0.3	-1.3
D69	0.21	0.01	0.26	0.02	23.8	15.1	0.2	16.9	0.4	11.9
B51	0.38	0.01	0.35	0.07	-7.9	15.9	0.3	16.5	0.3	3.8
A67	0.39	0.02	0.38	0.01	-2.6	16.9	0.3	15.9	0.3	-5.9
B94	0.72	0.02	0.68	0.09	-5.6	16.3	0.4	15.6	0.3	-4.3
B95	0.79	0.02	0.83	0.02	5.1	17.7	0.5	18.3	0.4	3.4
C25	0.45	0.01	0.36	0.03	-20.0	18.5	0.4	14.7	0.3	-20.5
A15	1.16	0.02	1	0.01	-13.8	15.8	0.3	15.5	0.3	-1.9
3-4	0.12	0.02	0.096	0.01	-20.0	12.3	0.4	11.9	0.3	-3.3
5-15	0.13	0.01	0.12	0.09	-7.7	12.5	0.4	10.1	0.3	-19.2
6-2	0.13	0.01	0.12	0.04	-7.7	14.5	0.4	13.6	0.3	-6.2
8-4	0.11	0.01	0.11	0.01	0.0	15.8	0.4	15.1	0.4	-4.4
4-2	0.11	0.006	0.1	0.007	-9.1	19.1	0.5	13.7	0.4	-28.3
NRF-8	1.70E+04	2.00E+03	1.10E+04	5.00E+02	-35.3	15.6	0.4	15.3	0.5	-1.9
LG 6-2	0.067	0.005	0.07	0.006	4.5	12.3	0.3	12.4	0.4	0.8
LG 24-8	0.044	0.007	0.06	0.004	36.4	14	0.1	15.1	0.3	7.9
LG 6-10	0.027	0.002	0.049	0.008	81.5	11.6	0.3	18.1	0.6	56.0

REFERENCES

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Appendix F - 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 make up 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.

anthropogenic radionuclides: 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 ground water to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation present in the environment as a result of naturally occurring radioactive materials, cosmic radiation, or human-made radiation sources, including fallout, from nonsite sources.

basalt: A fine-grained dark igneous rock.

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 Ci.

beta radiation: Beta radiation is 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.

biobarrier: A zone/layer of a cap that consists of some material to prevent intrusion of burrowing animals.

bioremediation: The process of using various natural and/or introduced microbes to degrade, destroy, or otherwise permanently bond contaminants contained in soil and/or water.

biota concentration guide (BCG): 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: A blank is used to demonstrate that cross contamination has not occurred. See field blank and laboratory blank.

blind sample: A blind sample contains a known quantity of some of the analytes of interest added to a sample of the 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 an individual'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.

collective effective dose equivalent: A measure of health risk to a population exposed to radiation. It is the sum of the total effective dose equivalents of all individuals within a defined population. The unit for collective effective dose equivalent is person-rem or person-sieverts.

committed effective dose equivalent: The total effective dose equivalent received over a 50-year period following the internal deposition of a radionuclide. It is expressed in rem or sieverts.

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 period of time. The samples may be collected from the same location or different locations. They may or may not be collected at equal time intervals over a predefined period of time (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 numerical range within which the true value of a measurement or calculated value lies. Typically, radiological values are reported with a 95 percent confidence interval (i.e., there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range).

contaminant: Any physical, chemical, biological, radiological substance, or matter in a location or concentration that is not naturally occurring.

contaminants of concern: Contaminants 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, those contaminants that are 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.

curie (Ci): A quantitative measure of radioactivity. One Ci equals 3.7×10^{10} nuclear decays per second.

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 the above 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 product: A nuclide resulting from the radioactive disintegration of a radionuclide, being formed either directly or as a result of successive transformation in a radioactive series. A decay product may be either radioactive or stable.

deposition velocity: An empirical rate constant that relates the concentration of a radionuclide in air to that on ground or plant surfaces.

derived concentration guide (DCG): 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/immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The U.S. Department of Energy, though Order 5400.5, "Radiation Protection of the Public and the Environment" has established these values.

diffuse sources: 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 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 model, prepared the dispersion coefficients for this report.

dispersion: The process of molecular movement by physical processes.

dose: Also known as dose equivalent, this is a value for comparing the biological effectiveness of different kinds of radiation on a common scale. Technically, it is the product of the absorbed dose, the quality factor, and any other modifying factors. The unit for dose is the rem. One millirem is one one-thousandth of a rem.

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 reserves in the United States, it lies beneath the Snake River plain. Water comes from rivers surrounding the plain (the Snake River, Henry's Fork, Big Lost River, Little Lost River, Birch Creek, and Camas Creek) and from rain and snow that soaks down through the soils and rock. This water moves through the cracks in the rocks of the Snake River plain and flow out into the Snake River in the Thousand Springs area between Twin Falls and King Hill.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effective dose equivalent (EDE): A value used to express the health risk from radiation exposure to a tissue in terms of an equivalent whole body exposure. It is a normalized value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole body exposure. It is equal to the sum of products of the dose to each tissue or organ multiplied by their respective weighting factor for each tissue or organ. The weighting factor is used to put the dose to the different tissue and organs on an equal basis in terms of health risk. The EDE is expressed in units of rem or sieverts.

effluent: Any liquid discharged to the environment, including stormwater 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: Samples 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: Refers to 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.

extremely hazardous chemicals: An extremely hazardous substance listed in the appendices to 40 CFR Part 355 "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of above ground 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: Material capable of starting and sustaining a nuclear chain reaction.

fission: The nuclear reaction resulting from the splitting of atoms.

flood plain: Lowlands bordering a river that are subject to flooding. Flood plains are 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 radation, 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 found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The amount of time it takes for the radioactivity of a radioactive material to be reduced by half.

halogenated: A compound containing one or more of the halogen elements (fluorine, chlorine, bromine, iodine).

hazardous air pollutant: See hazardous substance.

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200, (Hazard Communications), and 40 CFR 370.2 (Definitions).

hazardous materials: Materials 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 a 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 drawn on a map connecting points having the same numerical value of some variable (in this instance the dispersion coefficient).

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. An example 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 and/or analysis. Laboratory blanks are 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) and/or composition (soil, filter, groundwater, 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, ground water, drinking water supplies, and other such resources belongs 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 non-community water system is either a transient non-community water system or a nontransient non-community 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.

P

perched water well: A well that obtains its water from a water body above that water table.

performance evaluation sample: Performance evaluation samples are prepared by adding a known amount of a U.S. Environmental Protection Agency reference compound to reagent water and submitting them 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 laboratory's analytical method.

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.

phytoremediation: The process of using various plants to extract contaminants from soil and water.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

PM_{10}: Particles with an aerodynamic diameter less than or equal to 10 microns.

pollutants: 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 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 deformations, 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.

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.

polychlorinated biphenyl: A polychlorinated biphenyl is 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.

pollution: Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation.

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.

R

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 process of a material giving off particles to reach a stable state.

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 happens to emit 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.

raw water hardness: Equivalent to the carbonate concentration of water.

reagent blank: A sample to 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:

$$RPD = (x_1 - x_2) \times 100$$

$$0.5x(x_1 - x_2)$$

where X_1 and X_2 are 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: Stands for roentgen equivalent man, a unit by which human radiation dose is assessed. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.

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 Part 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 fine grained light-brown to gray igneous rock.

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 individual people or society of using the chemical in the amount and manner proposed an all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

S

sediment distribution coefficient: The ratio of the mass of solute species absorbed or precipitated on the sediment to the solute concentration in water.

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.

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

Snake River Plain: A wide (64 to 12 km [40 to 80 mi]) plain of rolling topography extended some 308 km (191 mi) from Ashton to King Hill/Twin Falls. The plain was formed by repeated volcanic eruptions that were the result of the passage of a geologic hot spot beneath the Earth's crust.

sodium absorption ratio (SAR): A measure of the concentration of sodium in soils relative to that of calcium magnesium. Soils with a high SAR (12 to 15) have low permeability and are unsuitable for plant growth.

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}}$$

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 that are used for flood control by dispersing and evaporating/infiltrating water from the Big Lost River.

stabilization: The planting of rapid growing plants for the purpose of holding bare soil in place.

standards: A sample containing a known quantity of various analytes. Standards may be prepared and certified by commercial vendors, but they must have traceability to the National Institute of Standards and Technology.

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 (streams, rivers, lakes, oceans).

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.

threshold planning quantity: The quantity of a material listed in Appendices A and B of 40 CFR 355 (Emergency Planning and Notification) that must be present at a site for use in emergency planning preparations.

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.

total organic halogens: A measure of the total organic halogenated compounds in a sample. Will not detect a specific constituent (e.g., trichloroethylene), but will detect the presence of a halogenated compound.

toxic chemicals: Chemicals 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 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

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.

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.

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 parameters: Parameters that are commonly measured to determine the quality of a water body/sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

weighting factor: A factor that, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body.

wetlands: Those areas that are inundated or saturated by surface- 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 included playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

Big Lost River