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1984 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR IDAHO NATIONAL ENGINEERING LABORATORY SITE

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PREFACE

This report presents the offsite data collected in 1984 for the routine environmental monitoring program conducted by the Radiological and Environmental Sciences Laboratory (RESL/ID) of the Department of Energy (DOE) at the Idaho National Engineering Laboratory (INEL) Site. In some cases, onsite data may be reported if needed to clarify or interpret offsite monitoring results or to demonstrate compliance with environmental standards and regulations. The purpose of this routine program is to monitor radioactive and nonradioactive materials resulting from INEL Site operations which may reach the surrounding offsite environment and population. This report is prepared in accordance with the DOE requirements in DOE Order 5484.1 and is not intended to cover the numerous special environmental research programs being conducted at the INEL by RESL/ID and others. Generally, these latter programs are aimed at quantifying the effects of Site operations on the onsite environment.

Note: Use of commercial product names is for accuracy in technical reporting and does not constitute endorsement of the product by the United States Government.

SUMMARY

The results of the various monitoring programs for 1984 indicated that radioactivity from INEL Site operations could not be distinguished from worldwide fallout and natural radioactivity in the region surrounding the Site. Although some radioactive materials were discharged during Site operations, concentrations and doses to the surrounding population were of no health consequence and were far less than State of Idaho and Federal health protection guidelines. This report describes the air, water, and foodstuff samples routinely collected at the INEL boundary locations and at locations distant from the INEL Site; and it compares and evaluates the sample results, discussing implications, if any. The report also summarizes significant environmental activities at the INEL Site during 1984, nonradioactive and radioactive effluent monitoring at the Site, and the U.S. Geological Survey (USGS) groundwater monitoring program.

There was no statistical difference between particulate beta concentrations measured in air at Site boundary stations and at distant sampling stations, except at Mud Lake, Idaho. No evidence was found to link this difference at Mud Lake to Site operations. Air samples were also analyzed for specific radionuclides. Some radionuclides were detected; but their presence was attributable to natural sources, to worldwide fallout, or to statistical variations rather than to Site operations. Monitoring for SO_2 and NO_2 at an onsite location during the year showed that concentrations of these nonradiological pollutants were far below U.S. Environmental Protection Agency (EPA) standards.

None of the samples of offsite well water contained detectable concentrations of gross alpha activity, and only one of the samples had a detectable concentration of gross beta activity. This was probably due to natural radioactivity or statistical variation. Annual averages for all offsite water samples were considerably below the EPA maximum contaminant level for community drinking water systems. No offsite water samples contained detectable tritium concentrations.

None of the milk samples contained detectable concentrations of I-131. Some milk and wheat samples, and all lettuce samples, contained small amounts of Sr-90. A few wheat and lettuce samples also had detectable concentrations of Cs-137. The presence of both nuclides is probably due to the deposition of these nuclides on soil as a result of worldwide fallout. Some of the muscle and liver samples of beef cattle and sheep which had grazed onsite during 1984 contained Cs-137, Pu-239/240, or Am-241. The concentrations reported could not be distinguished from levels in control animals from areas far from the site, and presence of these nuclides is probably due to deposition in the past on soil and vegetation ingested by the animals as they grazed. All these nuclides were present as worldwide fallout following the last atmospheric nuclear weapons test in 1980.

Ionizing radiation measured simultaneously at Site boundary and distant locations showed only natural background levels.

For details on monitoring results, see the section "Summary of Environmental Monitoring Performed."

A measurable amount of radioactivity, primarily in the form of noble gases, is released into the atmosphere annually from various plant facilities and is subsequently carried offsite. Upon reaching the Site boundary, this radioactivity is in such a low concentration that its effect on direct radiation levels cannot be measured; but its potential contribution to offsite 50-year dose commitments is nevertheless calculated.

A hypothetical maximum 50-year whole-body dose commitment on the southern Site boundary was calculated to be 0.02 millirem (mrem). The calculation assumed continuous submersion in and inhalation of radioactivity in air and exposure to radioactive particulates deposited on soil at that location. (The hypothetical maximum dose commitment to an organ was 0.26 mrem to the bone surfaces.) The hypothetical whole-body dose commitment is about 0.14% of the natural background radiation dose rate of about 140 mrem per year in this area. The potential maximum dose commitment to an individual living nearest the Site was calculated to be 0.012 mrem at Atomic City, Idaho. This also represents the maximum potential dose commitment to a member of a population group. The maximum potential population dose commitment from submersion, inhalation, and deposition to the approximately 114,400 people residing within an 80-km (50-mi) radius from the center of the TRA-ICPP area of the INEL Site was estimated to

be 0.13 man-rem. This dose commitment is about 0.0008% of the population dose from natural background radioactivity, which is estimated to be 16,000 man-rem. These 50-year dose commitments and their implications are discussed in the section "Assessment of Potential Radiation Dose to the Public."

Calculations indicate that the maximum potential 50-year dose commitment to an individual from indirect exposure pathways due to ingestion of wild game animals is about 2% of the radiation protection standard for individuals at points of maximum probable exposure. See the section "Environmental Standards, Regulations, and Permits" for a listing of applicable standards. The potential man-rem dose commitment to all offsite populations from these exposure pathways would realistically be less than the dose commitment from submersion, inhalation, and deposition pathways, due to the very small probability that an individual in the population would consume an animal containing significant amounts of radioactivity.

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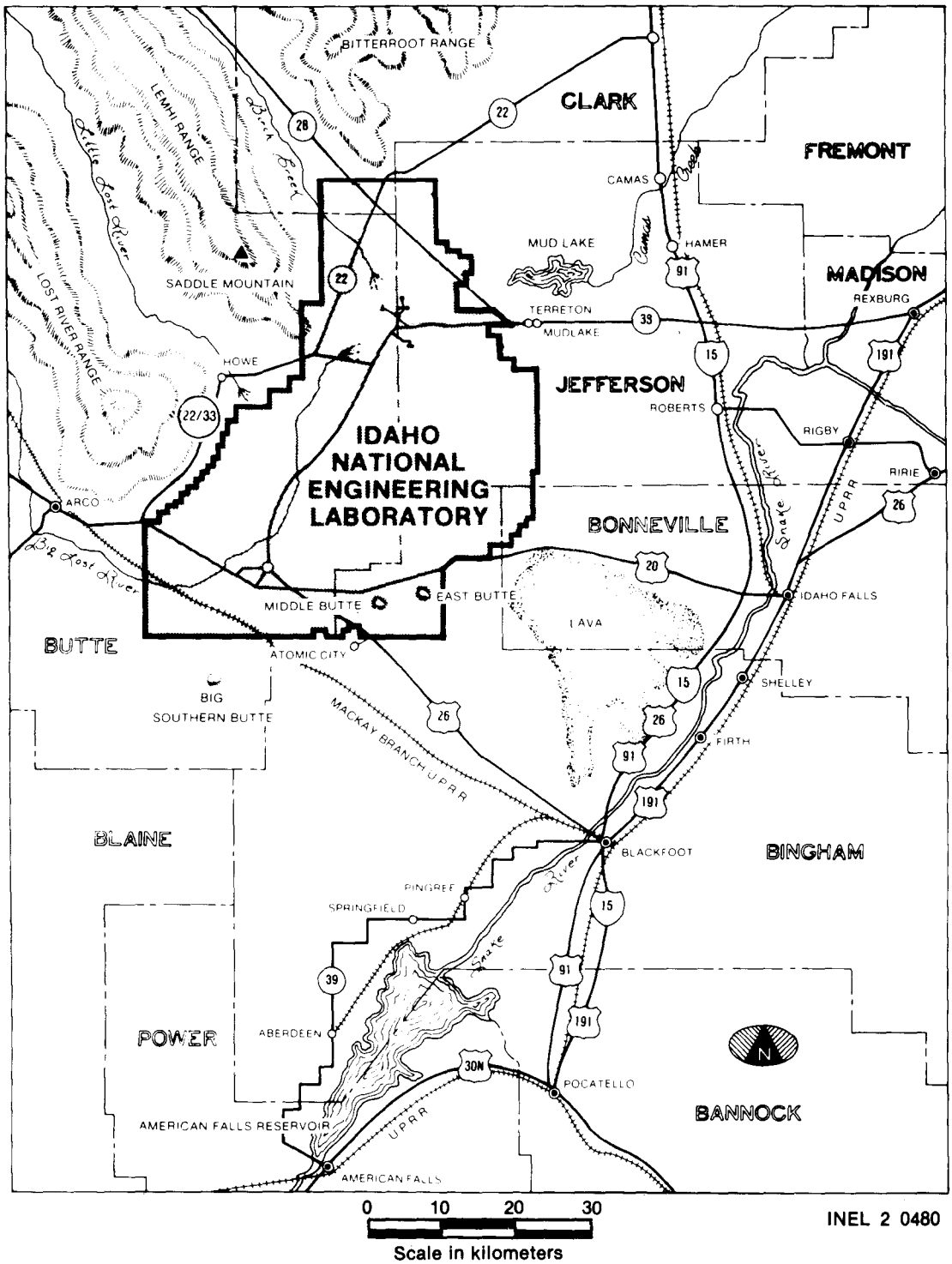

Figure 1. INEL Site vicinity map.

1984 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR IDAHO NATIONAL ENGINEERING LABORATORY SITE

INTRODUCTION

The Idaho National Engineering Laboratory (INEL) of the Department of Energy (DOE) was established by the Federal Government in 1949 to conduct research and further the development of nuclear reactors and ancillary equipment. Major DOE programs at the Site include test irradiation services, uranium recovery from highly enriched spent fuels, calcination of liquid radioactive waste solutions, light-water cooled reactor safety testing and research, operation of research reactors, and storage and surveillance of solid transuranic wastes. Major facilities at the INEL are operated by Argonne National Laboratory (ANL-W), EG&G Idaho, Inc. (EG&G), Exxon Nuclear Idaho Company (ENICO), Westinghouse Electric Corporation (WEC), and Westinghouse Idaho Nuclear Company (WINCO).

The 2300-km^2 (890-mi^2) Site is located on the Upper Snake River Plain in southeastern Idaho. The nearest INEL Site boundaries are 35 km (22 mi) west of Idaho Falls, 37 km (23 mi) northwest of Blackfoot, 71 km (44 mi) northwest of Pocatello, and 11 km (7 mi) east of Arco, Idaho (see Figure 1). With a population of about 1300, Arco is the largest boundary community in the area surrounding the Site. Approximately 114,400 people reside within a radius of 80 km (50 mi) of the Site's operational center, but there are no residents within 16 km (10 mi) of that center.

Vegetation and wildlife on the Site are typical of those found in a cool desert shrub biome. Figure 2 shows a part of the Site and its vegetation. In 1975, the Site was designated as one of the nation's five National Environmental Research Parks (NERP), where scientists from universities and from government and private agencies study changes caused by man's activities and obtain data used in making land-use decisions.

The surface of the plain is a combination of basaltic lava outcroppings and alluvial sedimentary deposits. There are no surface streams or rivers flowing from onsite to offsite locations; but the Snake River Plain aquifer, a large natural aquifer, lies beneath the plain. Water from the aquifer and from surface streams and rivers of the Snake River Plain is used for drinking water and for irrigation of crops.

A more detailed description of the Site location, environment, and current major activities is given in Appendix A.

Figure 2. Typical vegetation on the INEL Site

SIGNIFICANT ENVIRONMENTAL ACTIVITIES

A summary of significant environmental activities which occurred at the INEL during 1984 is given below.

- The use of a percolation pond in place of the injection well for disposal of service waste water at the Idaho Chemical Processing Plant (ICPP) was initiated on February 9, 1984.

- Six new aquifer monitoring wells and 44 new shallow monitoring wells were drilled and completed to assess the hydrological effects of the new service waste percolation pond at the ICPP.

- A new Coal-Fired Steam Generation Facility (CFSGF) was dedicated April 17, 1984. The CFSGF utilizes atmospheric fluidized bed combustion with limestone present to reduce sulfur dioxide emissions. Air emission source testing for the CFSGF, which demonstrated full compliance with requirements, was completed and accepted by the Environmental Protection Agency (EPA).

- Extensive emergency construction on diversion dikes was necessary in January, 1984. These dikes, which contain water diverted from the Big Lost River when peak flows or ice jams threaten flooding of INEL roads, were raised successfully to contain abnormally high flows from the river.

- Management and implementation plans were developed for hazardous waste regulated by the Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

- All noncompliance discharges of hazardous waste identified in the Hazardous Waste Management Plan were eliminated. The discharges (seven) were eliminated by (a) segregating nonhazardous waste from hazardous waste, (b) modifying operating parameters or utilizing excess equipment as primary treatment units to neutralize acidic and basic wastewater prior to discharge, and (c) substituting nonhazardous materials for hazardous materials.

- The Waste Experimental Reduction Facility (WERF), a facility to reduce the volume of radioactive waste through melting or incineration, began incinerating waste with low-level radioactive contamination on September 27, 1984. Waste melting had been initiated earlier.

- Construction of a hazardous waste storage facility was begun. This facility will be used for temporary storage of hazardous waste materials prior to shipment to an EPA-approved offsite disposal facility.

- The INEL Environmental Characterization Report was completed.[1]

No draft or final Environmental Assessments (EAs) or Environmental Impact Statements (EISs) were completed for INEL Site facilities in 1984.

ENVIRONMENTAL PROGRAM INFORMATION

Summary of Environmental Monitoring Performed

General. During normal operation of the reactors and the fuel reprocessing plant at the Site, some radioactivity is released to the environment. The environmental pathways by which radioactive materials may be transported from the Site to nearby populations are directly through atmospheric transport or indirectly through soils, foodstuffs, or animals. Radionuclides originating from Site operations have not been detected in the water of the Snake River Plain aquifer beyond the INEL southern boundary.

The environmental monitoring program for the Site and vicinity for 1984 included the collection and analysis of samples from potential exposure pathways. Table I gives a summary of the offsite program. Measurements at Site boundary locations are compared to measurements at distant locations to assess the impact of INEL Site operations on the offsite environment. Concentrations of radioactive

TABLE I
OFFSITE MONITORING PROGRAM SUMMARY

Medium Sampled	Type of Analysis	Frequency of Analysis	Number of Samples	Sample Size	Count Time (min)	~Minimum Detectable Concentration (MDC)
Air	Gross beta	Weekly	11	1 to 4 x 10^8 mL	20	8 x 10^{-15} μCi/mL
	HTO[a]	3 to 7 weeks	1	1 to 10 x 10^6 mL	100	1 x 10^{-11} μCi/mL
	Specific gamma	Quarterly	11	3 to 5 x 10^9 mL	60	1 to 10 x 10^{-15} μCi/mL
	Pu	Quarterly	4	3 to 5 x 10^9 mL	1000	6 x 10^{-18} μCi/mL
	Am	Quarterly	4	3 to 5 x 10^9 mL	1000	8 x 10^{-18} μCi/mL
	Sr-90	Quarterly	4	3 to 5 x 10^9 mL	20	1 x 10^{-15} μCi/mL
	Particulate matter	Quarterly	11	3 to 5 x 10^9 mL	NA[b]	10 μg/m^3
Water	Gross alpha	Semiannually	14	100 mL	60	3 x 10^{-9} μCi/mL
	Gross beta	Semiannually	14	250 mL	20	5 x 10^{-9} μCi/mL
	HTO	Semiannually	14	10 mL	20	4 x 10^{-7} μCi/mL
Milk	I-131	Monthly[c]	11	3800 mL	1000	1 x 10^{-9} μCi/mL
	Sr-90	Annually	11	1000 mL	20	2 x 10^{-9} μCi/mL
	H-3	Annually	11	10 mL	100	4 x 10^{-7} μCi/mL
	I-129	Annually[d]	3	3800 mL	10	6 x 10^{-11} μCi/mL
Wheat	Specific gamma	Annually	10	2500 g	1000	4 x 10^{-9} μCi/g
	Sr-90	Annually	10	500 g	20	4 x 10^{-9} μCi/g
Lettuce	Specific gamma	Annually	8	30 g (dry wt)	1000	2 x 10^{-7} μCi/g
	Sr-90	Annually	8	30 g (dry wt)	20	8 x 10^{-8} μCi/g
Soil	Specific gamma	Biennially	10	400 g[e]	1000	4 x 10^{-8} μCi/g
	Pu	Biennially	10	10 g[e]	1000	2 x 10^{-9} μCi/g
	Am	Biennially	10	10 g[e]	1000	3 x 10^{-9} μCi/g
	Sr-90	Biennially	10	10 g[e]	100	9 x 10^{-8} μCi/g
Direct radiation exposure	Thermoluminescent dosimeter	Semiannually	13	5 TLDs per dosimeter	NA	5 mR

a. Tritiated water.

b. N/A - not applicable.

c. One dairy is sampled weekly.

d. Three locations only, activation analysis.

e. Aliquant from a composited 2000-g sample.

and some nonradioactive pollutants in the environment are compared to applicable standards and guides and to background and natural radioactivity. Most radioactive concentrations in this report are compared to the concentration guides for uncontrolled areas listed in "Requirements for Radiation Protection," DOE Order 5480.1A, Chapter XI. (See the section on "Environmental Standards, Regulations, and Permits.")

Air and water were routinely monitored for radioactivity at a number of onsite, boundary, and distant locations. Concentrations of radionuclides in milk, wheat, and lettuce samples were measured at Site boundary and distant locations. Offsite soils, which are sampled biennially, were sampled in 1984. Environmental radiation exposure rates (cumulative from November 1983 to November 1984) were measured at Site boundary and distant locations.

A discussion of each routine program follows. For each program, a presentation and interpretation of the data are given, as are the location of each sampling station and the number of samples collected. The section on "Quality Assurance" gives a description and summary of the results of the quality control and assurance program maintained by the Radiological and Environmental Sciences Laboratory (RESL/ID). Appendix B gives a brief discussion of the statistics used to analyze the data in this report.

Air Sampling—Radiological. Airborne particulate radioactivity is monitored offsite by a network of 11 continuous air samplers at locations shown in Figure 3. Air samplers are located in the small communities close to the Site boundary and at the more distant locations of Blackfoot, the Craters of the Moon National Monument, Idaho Falls, and Rexburg, Idaho. These distant or background locations are in directions usually crosswind to the Site and are sufficiently remote to ensure that radioactivity detected is due to natural background or sources other than Site operations. The whole network provides comprehensive surveillance of atmospheric radioactivity and theoretically makes it possible to differentiate Site releases from worldwide fallout and long-lived natural radioactivity.

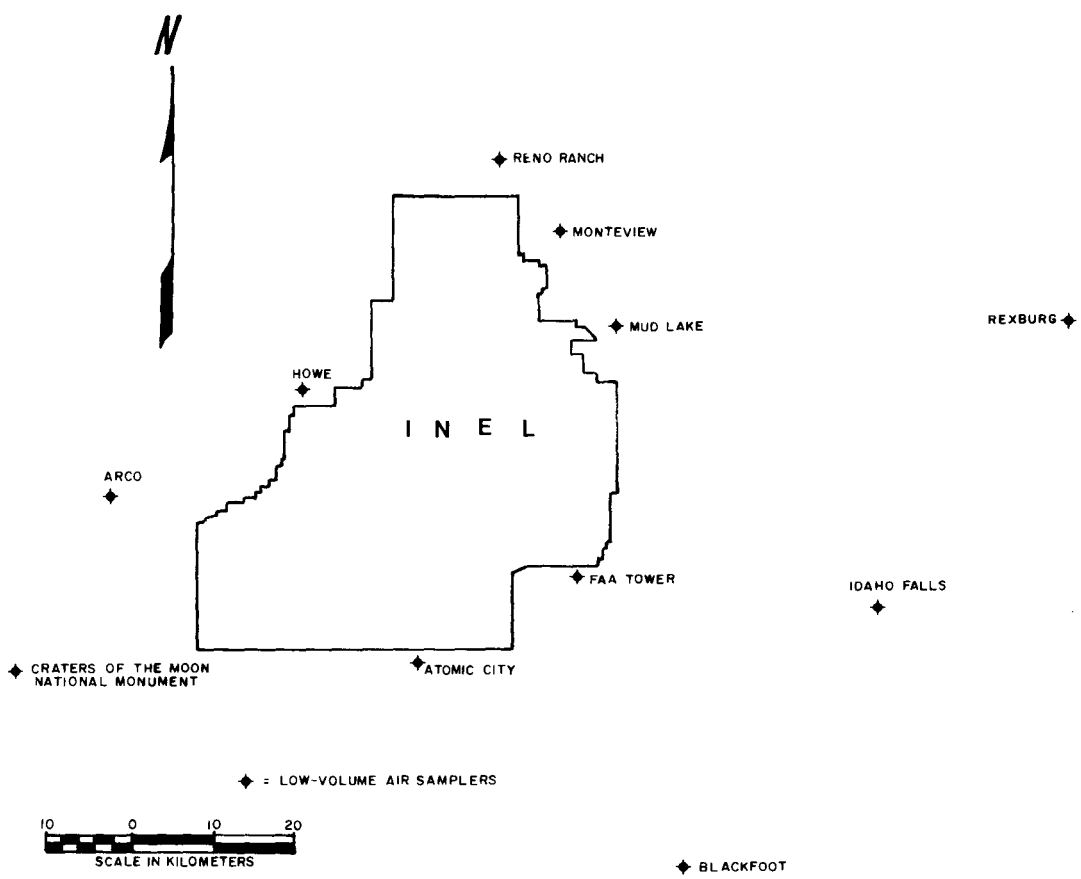

Figure 3. INEL Site air sampling network.

Each air sampler (see Figure 4) maintains an average air flow of about 40 L/min (1.5 ft^3/min) through a set of filters consisting of a membrane filter (Gelman Model VP-1200) followed by an activated charcoal-impregnated cellulose fiber filter (Gelman Model AC-1). The filters are 99% efficient for airborne particulate radioactivity and elemental iodine vapor.

One offsite and two onsite locations also have samplers for tritium in water vapor. In these samplers, air is passed through a column of silica gel at a rate of 0.3 L/min (0.65 ft^3/hr). Krypton-85 is monitored at one onsite location. Other noble gases, such as argon, xenon, and other krypton nuclides, are monitored at their onsite release points only.

The filters from the low-volume air samplers are collected weekly and analyzed after waiting a minimum of five days to allow the naturally occurring short-lived radon and thoron daughters to decay. Gross beta analysis is performed on each filter in a low background beta counter. If the beta activity on a membrane filter exceeds about 1×10^{-12} μCi/mL, the filter is analyzed by gamma spectrometry. All activity detected on the charcoal-impregnated filters is initially assumed to be I-131. If the beta activity on the charcoal filter exceeds about 7×10^{-14} μCi/mL, the filter is analyzed by gamma spectrometry to determine the I-131 component. At the end of each quarter, the membrane filters are composited according to location and analyzed for specific radionuclides by gamma spectrometry. The composite from one distant location is analyzed each quarter for specific alpha-emitting radionuclides, and the composite from another distant location is analyzed each quarter for Sr-90. Six other offsite location composites are analyzed on an alternating schedule for alpha-emitting nuclides and Sr-90. Analyses for the alpha-emitting nuclides utilize chemical separation techniques followed by alpha spectrometry; and for Sr-90, the chemical separation is followed by beta counting.

The particulate beta activity measured at each boundary location was statistically compared to beta activity measured at the group of distant locations for each month and for the entire year. Only at Mud Lake was the particulate beta activity greater than worldwide fallout and naturally occurring radioactivity as measured at the distant locations. For monthly comparisons, the Mud Lake mean beta activity was greater than the distant group mean activity only for December and for the annual mean. Consideration of Site operations information, meteorological conditions, and the statistical tools used led to no clear explanation for the difference in particulate beta activity seen at Mud Lake. As the Mud Lake average concentration was only 15% greater than the distant station average, and since particulate beta analysis is used primarily as a screening technique, results of the more accurate and more sensitive quarterly specific nuclide analyses were carefully reviewed. The specific nuclide analyses described later showed no differences between Mud Lake and distant locations, and it is concluded that the differences in particulate beta activity were not attributable to Site operations.

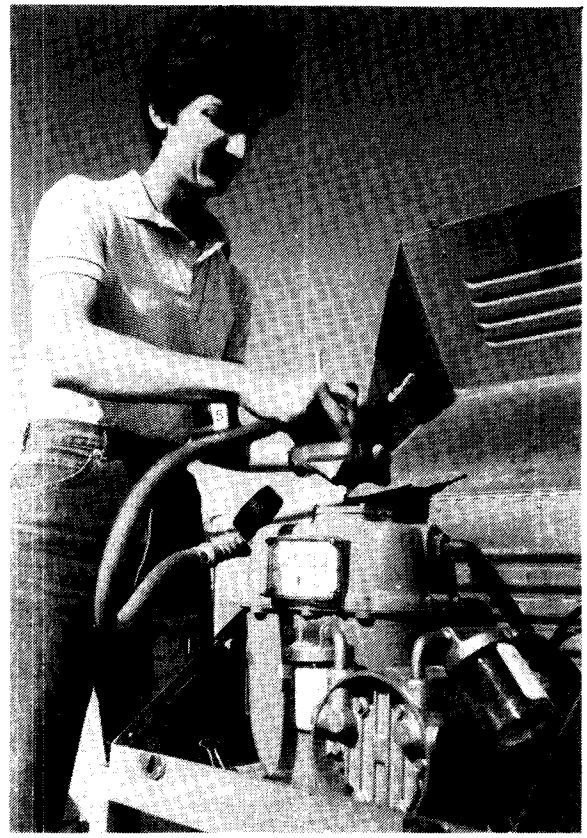

Figure 4. Low-volume air sampler used for the routine monitoring program.

Table II summarizes 1984 particulate beta activity concentrations. The average monthly concentrations of particulate beta for both boundary and distant location groups are shown in Figure 5 for 1979 through 1984. None of the charcoal filters at any offsite location had an activity above the action level of approximately 7×10^{-14} μCi/mL.

TABLE II
PARTICULATE BETA ACTIVITY IN AIR (1984)

Group	Locations	Number of Samples	Concentration (10^{-15} μCi/mL) Range	Annual Average[a]
Distant	Blackfoot	52	12-90	36 ± 5
	Craters of the Moon	52	17-72	39 ± 4
	Idaho Falls	52	13-90	33 ± 5
	Rexburg	50	12-53	30 ± 3
	Grand Mean[a]	—	—	34 ± 2
Boundary	Arco	52	13-63	31 ± 3
	Atomic City	50	12-94	32 ± 5
	FAA Tower	52	10-59	32 ± 3
	Howe	51	14-100	36 ± 5
	Monteview	51	11-110	34 ± 5
	Mud Lake	52	10-130	39 ± 7
	Reno Ranch	51	11-78	37 ± 4
	Grand Mean[a]	—	—	35 ± 2

a. Arithmetic means with the 95% confidence interval for the means. See Appendix B.

The quantity and identity of radionuclides released from Site facilities are reported monthly in the Radioactive Waste Management Information System (RWMIS) report. Specific radionuclide analyses are more sensitive indicators than beta analysis of the impact of Site operations on the environment. Thus, whenever any question exists as to Site impact, release data from the RWMIS report is compared to the specific radionuclide analyses.

Only four specific nuclides were detected in offsite composited filter samples in 1984. Cesium-134, at a concentration of $6 \pm 4 \times 10^{-16}$ μCi/mL, was reported at Blackfoot during the first quarter. Zirconium-95 was reported during the first quarter at two locations, Blackfoot and FAA Tower, at concentrations of $2.4 \pm 2.2 \times 10^{-15}$ and $2.7 \pm 2.2 \times 10^{-15}$ μCi/mL, respectively. Strontium-90 was reported during the second quarter at Rexburg at a concentration of $1.6 \pm 0.7 \times 10^{-16}$ μCi/mL. Antimony-124 was reported at a concentration of $5 \pm 4 \times 10^{-15}$ μCi/mL at the FAA Tower during the second quarter. These reported concentrations are all less than 0.001% of the uncontrolled area concentration guides.

A summary of the results of specific radionuclide analyses of the filter composites in 1984 is shown in Table III. Beryllium-7, a radionuclide produced by the interaction of cosmic radiation and nitrogen in the atmosphere, is excluded. All of the reported results of specific nuclides were very near the minimum detectable concentration. When the reported concentrations are so low, it is difficult to draw firm conclusions about the source of the radioactivity (see Appendix B). Statistical tools, meteorological data, and Site release information are all considered when interpreting or evaluating results that are near the minimum detectable concentration.

None of the nuclides detected at any offsite location had an annual boundary group mean concentration which was statistically different from the distant group mean concentration.

Atmospheric tritium in the form of tritiated water (HTO) is monitored at Idaho Falls (a background location) and at two locations onsite. No concentration of HTO at any location exceeded the approximate minimum detectable concentration of 1×10^{-11} μCi/mL.

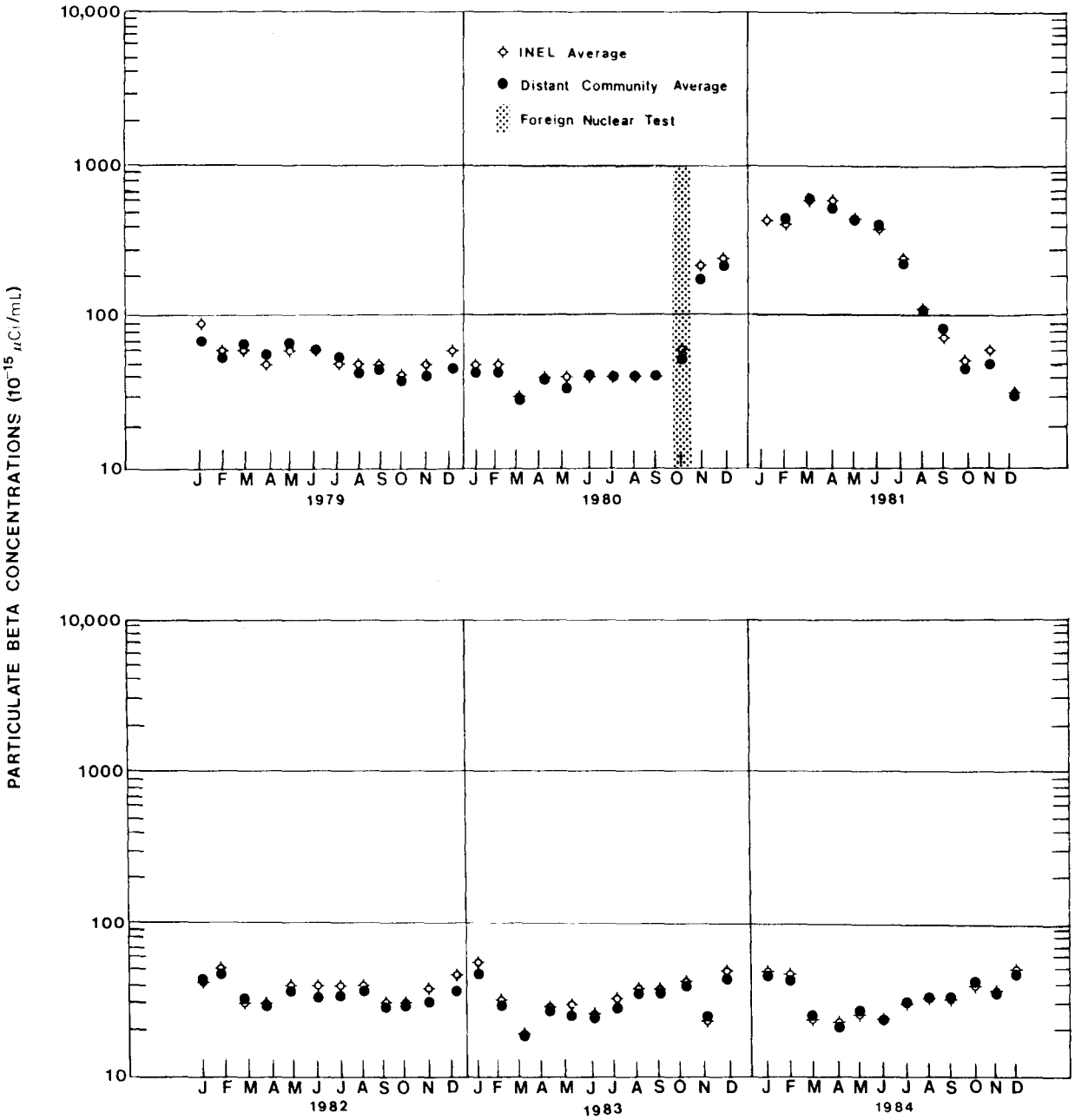

Figure 5. Particulate beta concentrations in air.

TABLE III
SPECIFIC RADIONUCLIDE ACTIVITY IN AIR (1984)

Radionuclide	Composite Group[a]	Concentration (10^{-15} μCi/mL) Minimum[b]	Maximum[b]	Mean[c]	Concentration Guide[d]	~MDC[e]
Cs-134	Distant	<MDC[f]	0.6 ± 0.4	NSS[g]	400,000	2
	Boundary	<MDC	<MDC	NSS		
Cs-137	Distant	<MDC	<MDC	NSS	500,000	1
	Boundary	<MDC	<MDC	0.18 ± 0.15		
Sb-125	Distant	<MDC	<MDC	0.16 ± 0.08	900,000	6
	Boundary	<MDC	<MDC	NSS		
Sr-90	Distant	<MDC	0.16 ± 0.14	0.16 ± 0.05	30,000	0.6
	Boundary	<MDC	0.17 ± 0.12	0.06 ± 0.05		
Zr-95	Distant	<MDC	2.4 ± 2.2	NSS	1,000,000	1
	Boundary	<MDC	2.7 ± 2.2	NSS		

a. Distant stations are Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg. Boundary stations are Arco, Atomic City, FAA Tower, Howe, Monteview, Mud Lake, and Reno Ranch.

b. Single quarterly composite sample analytical results ±2s, decay corrected assuming a constant concentration and buildup during the sampling period. See Appendix B.

c. Arithmetic mean with the 95% confidence interval for the mean. See Appendix B.

d. Concentration guides are based on *DOE Order 5480.1A*, Chapter XI guides for release to an uncontrolled area.

e. The minimum detectable concentrations (MDC) are approximate and are calculated for typical values for airflow volume, counting time, radionuclide composition of the sample, and time lapsed between collection and analysis. These values may vary slightly for actual samples.

f. Below minimum detectable concentration.

g. Mean is not statistically significant (NSS), or zero is included within the 95% confidence interval for the mean. See Appendix B.

Krypton-85 in ambient air was measured at the Central Facilities Area (CFA) by collecting compressed air samples. Samples covering 83% of 1984 showed an average Kr-85 concentration of $3.1 \pm 0.3 \times 10^{-11}$ μCi/mL. The two-week samples, analyzed by the Environmental Monitoring Systems Laboratory of the EPA in Las Vegas, ranged from $2.5 \pm 0.4 \times 10^{-11}$ to $3.5 \pm 0.3 \times 10^{-11}$ μCi/mL. The average concentration is somewhat higher than the average concentration measured by the EPA around the Nevada Test Site (2.6×10^{-11} μCi/mL), but it is the same statistically as the average concentration in Salt Lake City, Utah[3], of 2.9×10^{-11} μCi/mL. Only relatively small quantities of Kr-85 were released from INEL facilities in 1984 and should have had a very small effect, if any, on the monitoring results for the year. Thus, 1984 could be considered a good baseline year.

Air Sampling—Nonradiological. Atmospheric particulate matter is routinely monitored at the low-volume air sampling stations using the filters previously described. A summary of the results for 1984 is given in Table IV. The analysis involves determining the net weight of the particulate matter on the quarterly composite of weekly filters at each station. The concentrations of the samples ranged between the minimum detectable concentration and 174 μg/m^3. The boundary mean was

TABLE IV
PARTICULATE MATTER CONCENTRATIONS IN AIR (1984)

	Concentration ($\mu g/m^3$)	Group	Locations	Concentration ($\mu g/m^3$) Range	Concentration ($\mu g/m^3$) Average[a]
~Minimum Detectable Concentration	10	—	—	—	—
Concentration Guide[b]	60	—	—	—	—
		Distant	Blackfoot	<MDC[c]-39	19 ± 28
			Craters of the Moon	<MDC-16	0 ± 24
			Idaho Falls	4-174	112 ± 124
			Rexburg	3-51	31 ± 35
			Grand Mean[a]	—	41 ± 31
		Boundary	Arco	9-60	26 ± 39
			Atomic City	<MDC-37	16 ± 25
			FAA Tower	<MDC-16	6 ± 14
			Howe	4-41	24 ± 26
			Monteview	5-63	31 ± 39
			Mud Lake	6-32	23 ± 19
			Reno Ranch	<MDC-25	12 ± 17
			Grand Mean[a]	—	20 ± 2

a. Arithmetic mean with the 95% confidence interval for the mean. See Appendix B.

b. Concentration guide is based on the EPA's national secondary ambient air quality standards.

c. Below minimum detectable concentration.

20 $\mu g/m^3$, which was statistically the same as the distant mean of 41 $\mu g/m^3$ due to large variations between particulate matter concentrations at locations within both groups. Most of the airborne particulates in the Site vicinity are probably windblown dust from the desert floor.

The average sulfur dioxide and nitrogen dioxide concentrations at the Site boundary were calculated, using the total 1984 discharges and a computer model of the dispersive characteristics of the air for 1984. The calculation method is the same as described in the section "Assessment of Potential Radiation Dose to the Public—General," using mass units for releases instead of radioactivity units. The ambient monitoring station for sulfur dioxide and nitrogen oxides is located at the intersection of Van Buren Boulevard and U.S. Highway 20/26, two miles west of CFA. At this location, the average concentrations of these gases are calculated to be greater than at the southern Site boundary. The analyzers used are designated as EPA equivalent methods.

The total sulfur dioxide released in 1984 shown in Table IX of the section "Summary of Nonradioactive

Effluent Monitoring" was about 3.1 x 10^5 kg. The calculated maximum offsite concentration of sulfur dioxide near the southern Site boundary was 0.4 $\mu g/m^3$, which is well below the national primary ambient air quality standard of 80 $\mu g/m^3$. The sulfur dioxide analyzer at the Van Buren Boulevard location operated satisfactorily during 91% of 1984. The average sulfur dioxide concentration was 3.9 $\mu g/m^3$, which is 5% of the annual primary ambient air quality standard. The maximum daily average sulfur dioxide concentration during this period was 11 $\mu g/m^3$, which is 3% of the applicable primary standard. The maximum 3-hr average concentration was 25 $\mu g/m^3$, which is 2% of the applicable secondary air quality standard. Offsite sources and natural background of sulfur dioxide in the area contribute an undetermined amount to these concentrations.

The total nitrogen oxides released in 1984, shown in Table IX of the section "Summary of Nonradioactive Effluent Monitoring," were about 4.7 x 10^5 kg. From all INEL sources, the calculated maximum offsite concentration of nitrogen dioxide near the southern boundary of the Site was 0.6 $\mu g/m^3$. This concentration is well below the national primary ambient air quality standard of 100 $\mu g/m^3$. The analyzer for nitrogen oxides at the Van Buren Boulevard location operated satisfactorily during 84% of 1984. The average nitrogen dioxide concentration measured at this location was 5.8 $\mu g/m^3$, which is 5.8% of the primary ambient air quality standard.

Water Sampling. The Snake River Plain aquifer, which lies beneath the INEL Site, serves as the primary source for drinking water and irrigation of crops in the Snake River Basin. Onsite and offsite water samples are collected routinely to monitor for movement of waste substances, both radioactive and nonradioactive, through the aquifer. See the "Groundwater Monitoring Program" section for a summary of the onsite water sampling program.

Offsite water samples are collected semiannually from drinking water production wells and from the Snake River. Water is also collected at three U.S. Geological Survey (USGS) wells near the southern Site boundary (see Figure 6). All radioactivity detected in offsite water samples is reported and evaluated in this section. Gross alpha, gross beta, and tritium analyses are routinely performed on the water samples. For gross alpha analysis, a portion of the sample is evaporated on a stainless steel planchet and counted with a scintillation counter system. Another portion is evaporated and counted for gross beta activity in a low-background beta counter. Tritium concentrations are determined with a liquid scintillation counter. The minimum detectable concentrations for gross alpha, gross beta, and tritium are 3 x 10^{-9}, 5 x 10^{-9}, and 4 x 10^{-7} $\mu Ci/mL$, or about 10, 20, and 0.01%, respectively, of DOE concentration guides for an uncontrolled area. These minimum detectable concentrations are also 20, 10, and 2%, respectively, of regulations for community drinking water listed by the EPA in 1984.

None of the 38 offsite water samples contained detectable gross alpha activity in 1984. Gross beta activity was reported in only one of the 38 water samples. The May sample from Shoshone, Idaho, had a concentration of 7 ± 6 x 10^{-9} $\mu Ci/mL$, which is near the minimum detectable concentration. Annual averages for gross alpha and gross beta activity at all locations were below the EPA community drinking water standards.

Natural radioactivity is found in the Snake River Plain groundwater in areas upgradient, parallel to, and far distant from the INEL Site. One sample from each of the three offsite USGS wells mentioned earlier was submitted for gamma spectrometry. Only one of these wells beyond the southern Site boundary (southwest of Atomic City) had a reported concentration of Cs-137, 9 ± 8 x 10^{-8} $\mu Ci/mL$ in November, 1984. This concentration is near the minimum detectable concentration, and Cs-137 has not been detected in any onsite or offsite wells in the area. Therefore, it is most likely that the radioactivity reported in this sample is due to statistical variations (see Appendix B) and is not associated with Site activities.

Foodstuff Sampling. Milk, wheat, and leafy garden lettuce are sampled routinely, since they are part of the typical American diet. These three foodstuffs could be pathways to the public for radionuclides from nuclear weapons fallout or from Site operations. Boundary areas are compared to distant areas to assess possible impacts from Site operations. Milk and wheat sampling locations are shown in Figure 6. Lettuce was collected at Arco, Blackfoot, Carey, Howe, Idaho Falls, Mud Lake, and Pocatello, Idaho.

A total of 157 milk samples were collected from dairies around the Site. Samples are collected monthly, except in Idaho Falls where a sample is collected weekly. Two exceptions were Blackfoot and Lewisville, from which only four samples were

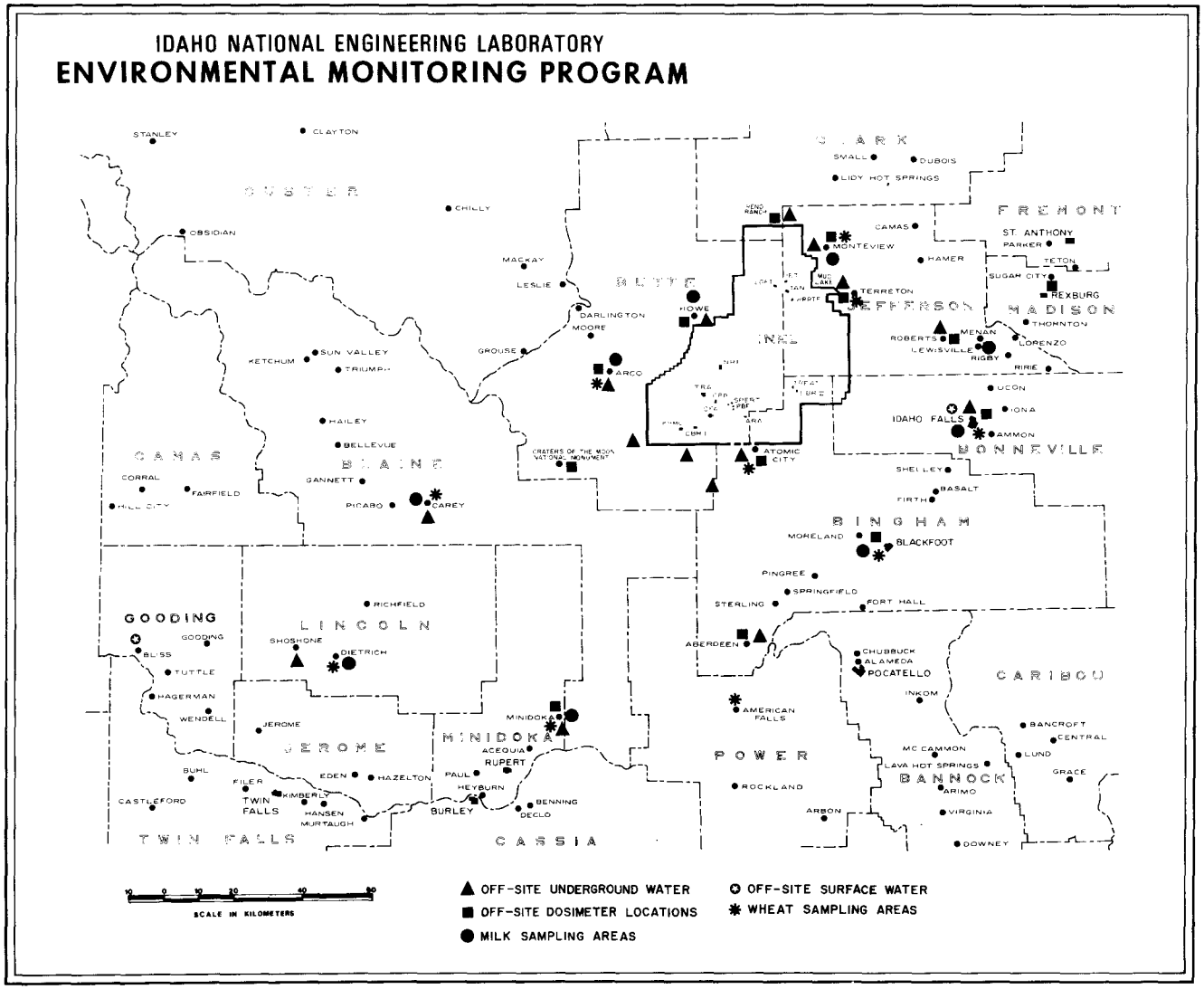

Figure 6. Offsite water, milk and wheat sampling locations and environmental dosimeter locations.

collected because these locations with family milk cows were added to the program in September, 1984. All milk samples are passed through anion exchange resins which are analyzed for I-131 by gamma spectrometry. Milk from each location is analyzed for Sr-90 and tritium once during each year. In addition, three September samples, one each from Carey, Idaho Falls, and Mud Lake, Idaho, are submitted for I-129 analysis.

In 1984, no milk samples from offsite areas (seven distant and four boundary) contained detectable concentrations of I-131.

Five of the seven milk samples from distant areas contained Sr-90 at detectable concentrations ranging from $1.8 \pm 1.6 \times 10^{-9}$ to $2.4 \pm 1.6 \times 10^{-9}$ μCi/mL. The distant group mean concentration was 1.8×10^{-9} μCi/mL. This mean is consistent with Sr-90 levels reported by the EPA for Region X, which includes Idaho, and for Region VIII, which includes Colorado, Montana, Utah, Wyoming, North Dakota, and South Dakota. (Because Region X includes Washington, Oregon, Alaska, and Hawaii, it seems more appropriate to compare Idaho results to those of nearby states.) EPA results for composite Region VIII samples for six quarters during 1983 and 1984 range from $1.1 \pm 1.0 \times 10^{-9}$ to $2.4 \pm 0.8 \times 10^{-9}$ μCi/mL.[4-9] Three of the four samples from Site boundary areas also had detectable concentrations of Sr-90 at $1.5 \pm 1.4 \times 10^{-9}$, $1.8 \pm 1.4 \times 10^{-9}$, and $2.1 \pm 1.6 \times 10^{-9}$ μCi/mL. The fourth boundary area was not sampled for Sr-90 in 1984. The group mean of 1.8×10^{-9} μCi/mL is not statistically different from the mean concentration of distant areas. The origin of the nuclide in the samples from the five areas was probably worldwide fallout.

None of the 10 samples submitted for tritium analyses showed detectable concentrations of that nuclide.

Results for 1983 analyses of three samples for I-129 were not available at the time of the 1983 report, and thus are being reported this year. None of the milk samples analyzed in either 1983 or 1984 had detectable concentrations of I-129.

Wheat and leafy garden lettuce sampling results are shown in Table V. Lettuce samples are washed with water to remove the obvious dirt, then dried and weighed. Lettuce samples are analyzed for Sr-90 and gamma-emitting radionuclides. Comparison of average concentrations of Sr-90 and Cs-137 for boundary and distant communities (background) showed no statistical difference between the two groups. Cesium-137 concentrations near the minimum detectable concentration were reported only at Howe, at $3.4 \pm 3.0 \times 10^{-7}$ μCi/g, and Mud Lake, at $5 \pm 4 \times 10^{-7}$ μCi/g dry weight.

Wheat samples are weighed prior to analysis but not washed. All wheat samples were analyzed for Sr-90 and Cs-137, and average concentrations were statistically the same for boundary and distant samples for both nuclides. Cesium-137 was reported only at Carey, at a concentration of $1.4 \pm 0.8 \times 10^{-8}$ μCi/g. It is unlikely that these concentrations are due to Site operations (see Appendix B).

Muscle and liver samples were taken from sheep which had grazed onsite in the northern and eastern grazing areas (two from each area) and from two sheep from the Rupert, Idaho, area which had not grazed near the Site in 1984. Cesium-137 was detected in the liver samples of one sheep which had grazed onsite at a concentration of $1.3 \pm 0.8 \times 10^{-8}$ μCi/g wet weight. These concentrations are comparable to those found in both onsite and offsite sheep in previous years.

Since concentrations of Sr-90 and Cs-137 in foodstuff samples from distant stations were statistically the same as those found in samples from boundary stations, it is assumed that the origin of these radionuclides is worldwide fallout.

Four beef cattle which had grazed onsite were sampled during 1984, two from the grazing area near the Radioactive Waste Management Complex (RWMC) (see Figure 7) and two from range near Mud Lake. Two additional cattle from near the Aberdeen, Idaho, area which had not grazed near the Site during 1984 were sampled as controls. Muscle and liver samples were taken from each animal and were submitted for Sr-90 analyses, gamma spectrometry, and alpha spectrometry.

Strontium-90 was not detected in any of the beef tissue samples. Cesium-137 was detected in one of the animals from the Mud Lake area, at a concentration of $1.6 \pm 0.8 \times 10^{-8}$ μCi/g wet tissue weight. None of the other muscle samples and none of the liver samples had detectable concentrations of Cs-137 or any other gamma-emitting radionuclides. Americium-241 was detected in the liver of one animal from the grazing area near the RWMC, at a concentration of $5 \pm 4 \times 10^{-11}$ μCi/g wet weight. Plutonium-239/240 was detected in liver tissues of

TABLE V
RADIONUCLIDE CONCENTRATIONS IN WHEAT AND LETTUCE (1984)

			Concentration[a] (10^{-9} μCi/g dry wt)			
			Wheat		Garden Lettuce	
	Group	Sample Location	Sr-90	Cs-137	Sr-90	Cs-137
~Minimum Detectable Concentration	—	—	4	4	80	200
	Distant	American Falls	10 ± 4	<MDC[b]	NA[c]	NA
		Blackfoot	12 ± 4	<MDC	100 ± 30	<MDC
		Carey	8 ± 4	14 ± 8	230 ± 40	<MDC
		Idaho Falls	9 ± 4	<MDC	190 ± 40	<MDC
		Minidoka	11 ± 4	<MDC	NA	NA
		Pocatello	NA	NA	190 ± 60	<MDC
		Average[d]	10 ± 2	NSS[e]	180 ± 80	NSS
	Boundary	Arco	8 ± 4	<MDC	90 ± 30	<MDC
		Atomic City	8 ± 4	<MDC	NA	NA
		Howe	NA	NA	150 ± 30	340 ± 300
		Monteview	4 ± 3	<MDC	NA	NA
		Mud Lake	<MDC	<MDC	200 ± 40	500 ± 400
		Average[d]	6 ± 4	NSS	150 ± 130	NSS

a. Analytical result ±2s. See Appendix B.

b. Below minimum detectable concentration.

c. No analysis or no sample collected.

d. Arithmetic mean with the 95% confidence interval for the mean. See Appendix B.

e. Mean is not statistically significant or 0 is included in the 95% confidence interval for the mean. See Appendix B.

three animals which had grazed onsite and in one of the control animals. The highest concentration of these four was in the same animal which had detectable Am-241. Its Pu-239/240 concentration was $5 \pm 3 \times 10^{-11}$ μCi/g wet weight. The Pu-239/240 concentration of the control animal was $3 \pm 2 \times 10^{-11}$ μCi/g wet weight.

All three of the nuclides detected in beef tissues are part of worldwide fallout as well as Site releases. Comparisons between control animals and animals which have grazed onsite revealed no significant differences between the two groups. Although the radionuclide concentrations present in beef tissues are probably not due to Site operations, to give perspective, doses have been calculated for two of the animals. If one assumes that an individual's entire yearly intake of meat (110 kg) came from the muscle of this steer, the whole body dose commitment would be about 0.09 mrem, which is about 0.018% of the standard for whole body dose commitment for an individual at a point of maximum probable exposure. If one assumes that an individual were to eat 11 kg of liver having the combined concentrations of Am-241 and Pu-239/240 in the onsite animal described above, the dose to bone surfaces from the two radionuclides would be about 0.03 mrem, or about 0.0002% of the standard for organ dose to the maximally exposed individual. These doses from beef cattle can, therefore, be considered inconsequential when compared to the health standards.

Figure 7. Beef cattle grazing on the INEL Site.

Environmental Radiation Measurements. Thermoluminescent dosimeters (TLDs) are used to measure ionizing radiation (beta greater than about 200 keV and gamma greater than 10 keV) exposures at six boundary community locations and six distant community locations (see Figure 6). Individual station data are presented, trends over time, if any, are analyzed, and the boundary and distant groups are compared. At each location, a dosimeter containing five individual Harshaw TLD-700 chips (3.18 x 3.18 x 0.89 mm) is placed 1 m above ground level. The dosimeter at each location is changed semiannually. The measured cumulative exposure for the time period from November, 1983, to November, 1984, is shown in Table VI. For purposes of comparison, annual exposures for 1981 through 1983 are also included for each location. Variations of ionizing radiation between locations are evident, but these variations have been relatively consistent at each location for the past four years.

During the May-to-November 1984 exposure period, new TLD locations were established at Rexburg, Idaho, and Idaho Falls near the low-volume air samplers. Exposures at these locations are not included in Table V, since they represent only six months' time.

The TLDs measure ionizing radiation exposures from natural radioactivity in the air and soil, cosmic radiation from outer space, fallout from nuclear weapons tests, radioactivity from fossil fuel burning, and radioactive effluents from Site operations and other industrial processes.

The mean annual TLD exposures for distant and boundary community locations were 116 and 120 mR, respectively (111 and 115 mrem). The distant and boundary mean exposures are statistically the same, so there were no significant contributions to ionizing radiation doses at boundary locations from INEL operations.

Table VII summarizes the calculated dose rate an individual receives on the Snake River Plain from various background radiation sources. This dose

TABLE VI
ENVIRONMENTAL RADIATION EXPOSURES (1981-1984)

	Location	Annual Exposures[a] (mR) 1981	1982	1983	1984
Distant Group	Aberdeen	120 ± 4	116 ± 7	112 ± 4	116 ± 7
	Blackfoot	119 ± 4	117 ± 6	119 ± 6	119 ± 7
	Craters of the Moon	123 ± 4	125 ± 4	113 ± 4	121 ± 6
	Idaho Falls	104 ± 4	104 ± 7	111 ± 8	101 ± 4
	Minidoka	106 ± 4	105 ± 8	104 ± 5	107 ± 5
	Roberts	134 ± 5	130 ± 7	130 ± 5	133 ± 10
	Average[b]	118 ± 12	116 ± 11	115 ± 9	116 ± 12
Boundary Group	Arco	113 ± 4	109 ± 4	110 ± 5	120 ± 6
	Atomic City	128 ± 4	119 ± 4	122 ± 4	125 ± 8
	Howe	113 ± 4	116 ± 3	112 ± 6	116 ± 5
	Monteview	113 ± 4	112 ± 6	114 ± 6	118 ± 4
	Mud Lake	126 ± 6	124 ± 4	122 ± 4	126 ± 6
	Reno Ranch	115 ± 4	110 ± 2	114 ± 5	112 ± 5
	Average[b]	118 ± 7	115 ± 6	116 ± 5	120 ± 6

a. Annual exposure ±2s. See Appendix B.

b. Arithmetic mean with the 95% confidence interval for the mean. See Appendix B.

TABLE VII
BACKGROUND RADIATION DOSE RATE (1984)

Source of Background Dose		Dose Rate (mrem/year) Estimated[a]	Measured (TLD)[b]
External	Terrestrial	67	—
	Cosmic (ionizing)	43	—
	Subtotal	110	111
	Cosmic (neutron)	6	
Internal	K-40 and others	27	
	Total	143	

a. Doses are estimated from charts and tables in NCRP Report No. 45.[10] Doses are not strictly additive since some are expressed as exposure in air and others are tissue doses.

b. For conversion from mR in air to mrem in tissue, f factor was 0.96, estimated from Johns and Cunningham.[11]

rate varies from year to year, depending on the amount of snow cover. For 1984, the background dose rate was about 140 mrem.

Soil Sampling. To establish background levels of natural and fallout radioactivity in surface soil and to assess any potential buildup of radioactivity from Site operations, soil samples have been collected from distant and boundary locations most years between 1970 and 1978 except 1972 and 1977. The biennial soil sampling program was established in 1978, and Figure 8 shows routine sampling locations. (A rotating seven-year schedule is used to sample onsite soils around major INEL facilities.) Soil samples collected in 1970, 1971, and 1973 represented a composite of five cores of soil from a 1-m^2 area. Each core was a cylinder 10 cm in diameter and 5 cm in depth. In all other years, the five cores were collected from a 100-m^2 area. A number of samples from the 5- to 10-cm depth were also collected. Figure 9 shows a technician collecting a soil sample.

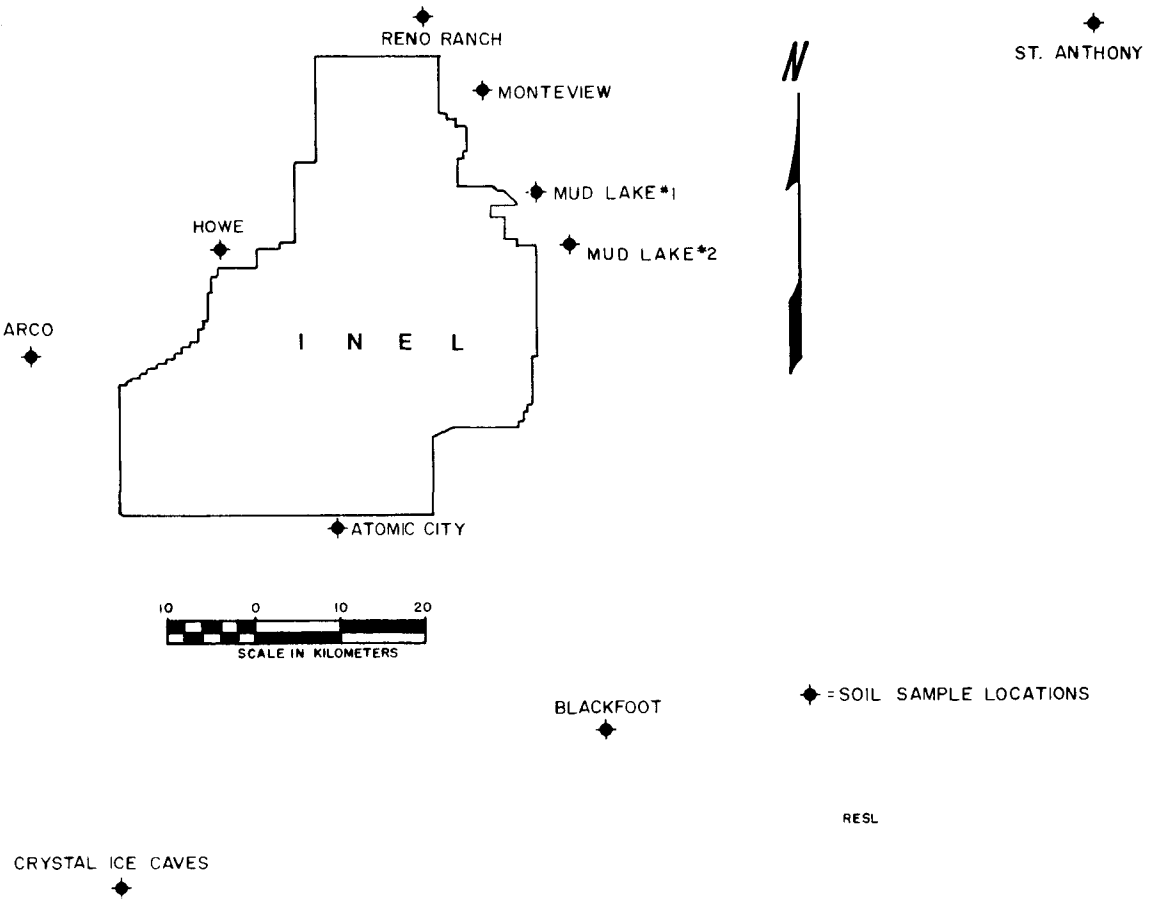

Figure 8. Soil sampling locations for the INEL Site vicinity.

All soil samples are analyzed for gamma-emitting radionuclides. Most are also analyzed for Sr-90 and alpha-emitting radionuclides. The soils are dried at least 3 hr at 120°C. Only soil particles less than 500 μm in diameter (35 mesh) are analyzed. The data are reported in units of activity per gram of soil (pCi/g dry weight) and also in units of areal activity (nCi/m^2), which is the total activity in each soil sample divided by the surface area (0.039 m^2) of the sample.

Concentrations of natural radioactivity in the surface soil were reported in 1977.[12] The Th-232 and U-238 activities were determined from those of the progeny radionuclides, Ac-228 and Pb-214. Oakley[13] indicated that the average concentrations of uranium, thorium, and K-40 in the earth's upper crust, when translated from ppm to pCi/g, are 0.9, 1.1, and 17 pCi/g, respectively. The local soils averaged about 1.5, 1.3, and 19 pCi/g, respectively, values which are higher in natural radioactivity than earth crustal averages. Although much of the surface rock on the plain is basalt, the local soil is largely derived from silicic volcanics which have higher uranium and thorium concentrations than basalt.

Estimates of the average yearly gamma ray dose received from U-238 plus daughters, Th-232 plus daughters, and K-40 in average Site area soil have been calculated to be 21, 28, and 27 mrem, respectively, for a total of 76 mrem. These calculations are based on conversion factors obtained from Reference 10. This reference also shows the decrease in gamma radiation from soil with depth of snow cover. The correction for snow cover for 1984 has already been applied to the terrestrial background dose in Table VII of the preceding section.

Concentrations of Cs-137, Sr-90, Pu-238, Pu-239/240, and Am-241 in surface soil, as found in 1970 through 1975, compared to 1978, 1980, 1982, and 1984 are shown in Table VIII. The 1976

Figure 9. Soil sampling technique used for environmental monitoring program..

data are not included, because the sampling locations used that year are not considered representative of the area; and the 1984 samples from Mud Lake No. 1, Mud Lake No. 2, and Crystal Ice Caves were not included, because the concentrations were uncharacteristically low compared to previous years. This may have been caused by disturbance (farming, erosion, vehicular traffic, etc.) of the sampling locations. These sampling locations are being reevaluated and may be moved to nearby undisturbed locations in the future. The concentrations of the remaining 1984 samples are similar to those from previous years and demonstrate no trends of increase or decrease. Distant and boundary location average concentrations are not statistically different for any nuclide. It is concluded, therefore, that all of the radionuclides detected are present as a result of worldwide fallout.

Game Species. Hunting and fishing are not allowed on the Site. Game animals do, however, migrate on and off the Site, representing a potential, but very small, exposure pathway. Two game animals which were killed on Site roads were sampled during 1984, and a total of nine doves were collected at two onsite areas. Data were obtained as part of DOE research programs rather than as a part of the routine environmental monitoring program. Many of these programs use the expertise of university faculty and graduate students to assist in the radioecology and ecology research at the INEL Site. These research programs, reported in the scientific literature, supplement the scheduled environmental monitoring reported here.

Muscle and liver tissues from one antelope killed on a Site road near ICPP were submitted for analysis by gamma spectrometry. Cesium-137 was detected in the muscle tissue, at a concentration of $3.2 \pm 0.2 \times 10^{-7}$ μCi/g wet weight, and in liver tissue, at $1.03 \pm 0.14 \times 10^{-7}$ μCi/g wet weight. These concentrations are higher than found in antelope from offsite areas and other onsite areas. Soil contamination with Cs-137 is known to be present near ICPP, so it is assumed the antelope ingested contaminated soil particles.

Muscle tissue from one Hungarian partridge killed near TRA was submitted for gamma spectrometry, and no manmade gamma-emitting nuclides were detected.

Of the mourning doves collected, a composite muscle tissue sample of four birds from the Naval Reactors Facility (NRF) area showed no manmade gamma-emitting radionuclides at detectable concentrations. The composite muscle tissue sample of the remaining five birds from the TRA Pond Area showed a concentration of Cs-137 of $5 \pm 2 \times 10^{-7}$ μCi/g wet weight.

Three fish were collected from the onsite portions of the Big Lost River during 1984; and two fish from the Big Lost River above the reservoir at Mackay, Idaho, were collected as controls. Edible portions of fish were submitted for gamma spectrometry, but no gamma-emitting radionuclides were detected in any of the fish.

TABLE VIII
RADIONUCLIDES IN OFFSITE SURFACE SOILS (1984)[a]

Radionuclide	Year	Geometric Average[b] (pCi/g)	Geometric Average[b] (nCi/m^2)	Number of Samples	~MDC[c] (pCi/g)	~MDC[c] (nCi/m^2)
Cs-137	1970-75[d]	0.94 x/÷ 1.2	54 x/÷ 1.1	60	0.01	1
	1978	0.94 x/÷ 1.3	58 x/÷ 1.3	10	0.01	1
	1980	0.64 x/÷ 1.4	41 x/÷ 1.4	10	0.01	1
	1982	0.90 x/÷ 1.4	44 x/÷ 1.4	10	0.01	1
	1984	0.69 x/÷ 1.4	43 x/÷ 1.4	7	0.01	1
Sr-90	1970-75	0.54 x/÷ 1.1	34 x/÷ 1.1	55	0.09	10
	1978	0.52 x/÷ 1.3	32 x/÷ 1.4	10	0.09	10
	1980	0.35 x/÷ 1.4	22 x/÷ 1.5	10	0.09	10
	1982	0.37 x/÷ 1.4	18 x/÷ 1.6	10	0.09	10
	1984	0.45 x/÷ 1.4	28 x/÷ 1.4	7	0.09	10
Pu-238	1970-75	0.0028 x/÷ 1.2	0.15 x/÷ 1.2	55	0.002	0.1
	1978	0.0010 x/÷ 2.0	0.06 x/÷ 1.9	10	0.002	0.1
	1980	0.0007 x/÷ 1.3	0.05 x/÷ 1.3	10	0.002	0.1
	1982	0.0011 x/÷ 1.5	0.05 x/÷ 1.6	10	0.002	0.1
	1984	0.0015 x/÷ 1.8	0.08 x/÷ 1.9	7	0.002	0.1
Pu-239/240	1970-75	0.020 x/÷ 1.2	1.06 x/÷ 1.1	54	0.002	0.1
	1978	0.018 x/÷ 1.4	1.09 x/÷ 1.4	10	0.002	0.1
	1980	0.010 x/÷ 1.7	0.63 x/÷ 1.7	10	0.002	0.1
	1982	0.022 x/÷ 1.4	1.06 x/÷ 1.4	10	0.002	0.1
	1984	0.016 x/÷ 1.4	1.02 x/÷ 1.4	7	0.002	0.1
Am-241	1970-75	0.0041 x/÷ 1.2	0.24 x/÷ 1.2	37	0.003	0.2
	1978	0.0062 x/÷ 1.4	0.38 x/÷ 1.3	10	0.003	0.2
	1980	0.003 x/÷ 1.3	0.20 x/÷ 1.4	10	0.003	0.2
	1982	0.004 x/÷ 1.5	0.21 x/÷ 1.6	10	0.003	0.2
	1984	0.004 x/÷ 1.8	0.26 x/÷ 1.7	7	0.003	0.2

a. Soil samples collected to a depth of 5 cm.

b. Geometric average x/÷ 2 standard geometric deviations of the mean. The 95% confidence interval may be determined by multiplying and dividing the mean by the standard geometric deviations shown.

c. Approximate minimum detectable concentration.

d. Excluding 1972. No samples taken.

Summary of Nonradioactive Effluent Monitoring

Nonradioactive airborne effluents originate from five primary sources at the INEL: calcination of high-level radioactive liquid waste at the New Waste Calcining Facility (NWCF), combustion of coal for steam generation at the CFSGF, combustion of fuel oil for heating at all INEL facilities, motor vehicle exhausts, and fugitive dusts from waste burial and construction activities.

Nitrogen oxide emissions are monitored at the NWCF, which operated under a variance from the State of Idaho for opacity requirements. (See the section on "Environmental Standards, Regulations, and Permits" for more information.) Visual determination of opacity is routinely made twice a week. The ICPP was in compliance with the opacity specified in the variance during 1984. The NWCF completed its first production run in June and had no nitrogen oxide emissions in the last half of 1984.

Sulfur dioxide, nitrogen oxides, and carbon oxides are monitored at the CFSGF. Emissions of sulfur dioxide from heating oils are calculated from sulfur content and the amount of fuel used. Motor vehicle exhausts and fugitive dusts are not monitored at their sources. Major nonradioactive airborne effluents for 1984 are given in Table IX.

Nonradioactive liquid effluents are primarily disposed of to a waste ditch at NRF, seepage ponds at the Loss-of-Fluid Test Facility (LOFT), Test Area North (TAN), Test Reactor Area (TRA), and the Water Reactor Research Test Facility (WRRTF), a lined evaporation pond at the Power Burst Facility (PBF), an injection well (through February 9) and a seepage pond (after February 9) at ICPP, an industrial waste pond at ANL-W, and through sewage treatment facilities at various locations.[1]

Routine, direct disposal of wastes to the Snake River Plain aquifer ceased at the ICPP in February, 1984, and at the WRRTF in September, 1984. The shallow injection well at PBF was sealed with cement in June, 1984. The only other injection wells on the INEL Site are used for storm runoff water. No waste is disposed of to the Big Lost River, the only surface stream on the INEL which might conceivably accept waste water.

The extent of effluent monitoring for liquid waste streams varies depending on the nature of the effluents. The largest effluent stream, that from the ICPP, is monitored by monthly composite samples analyzed for arsenic, barium, cadmium, chromium, fluoride, lead, mercury, selenium, silver, sodium, chloride, nitrate, sulfate, conductivity, total disolved solids (TDS), and pH. Results are reported quarterly.[14] Analysis for organic contaminants is performed on an annual basis. All analytical results for 1984 were less than concentrations defined as hazardous waste in 40 CFR 261.24.

A monthly composite of the LOFT effluent is analyzed for boron, total chromium, and phosphates. One sample per year is analyzed for arsenic, barium, cadmium, cyanide, fluoride, lead, selenium, and silver.[1]

TABLE IX
NONRADIOACTIVE AIRBORNE EFFLUENTS (1984)

	Emissions[a] (metric tonnes)		
Facility	NO	NO_2	SO_2
ANL-W	—	—	6
CFA	—	—	4
CFSGF[b]	28	—	20
ICPP (oil)	—	—	95
NRF	—	2	97
NWCF	29	406	—
TAN	—	—	35
TRA	—	—	46
WRRTF	—	—	2
Other	—	—	2
Totals	57	408	307

a. As reported in the Industrial Waste Management Information System.[10]

b. Calculated from CFSGF plant operating data.

ANL-W measures chloride, total chromium, hexaalent chromium, phosphate, sodium, sulfate, zinc, and pH in pond water.

Other waste effluents are calculated from the amounts of chemicals used for water treatment, for corrosion control, for demineralization, as cleansers, as algicides, and occasionally from waste acids. Sewage processed by treatment facilities is monitored for biochemical oxygen demand, dissolved oxygen, settleable solids, and pH. Results are reported in Reference 15.

Summary of Radioactive Effluent Monitoring

Radionuclides in airborne and liquid effluents released to the environment are carefully monitored at each release point. Effluent monitoring is summarized in Appendix H of Reference 1. Results of the effluent monitoring are reported by month, by facility, and by radionuclide in Reference 2.

A summary of the radionuclides released to the atmosphere from Site facilities is shown in Table X.

TABLE X
RADIONUCLIDE COMPOSITION OF AIRBORNE EFFLUENTS (1984)

			Airborne Effluent (Ci)[a]			
	Radionuclide	Half-Life	ANL-W	ICPP	TRA	Total[b]
Noble Gases	Ar-41	1.83 hr	95	—	1,800	1,900
	Xe-138	14.2 min	0.71	—	880	880
	Xe-135	9.09 hr	28	—	370	400
	Kr-88	2.84 hr	3.8	—	360	370
	Kr-87	1.27 hr	1.8	—	340	340
	Xe-133	5.25 da	82	—	94	180
	Xe-135m	15.3 min	0.52	—	170	170
	Kr-85m	4.48 hr	2.7	—	110	110
	Kr-85	10.7 yr	32	40	—	72
Particulates	Ba-139	1.39 hr	—	—	68	68
	Cs-138	32.2 min	—	—	6.1	6.1
	Rb-88	17.7 min	—	—	4.6	4.6
	Br-82	1.47 da	4.6×10^{-2}	—	—	4.6×10^{-2}
	Sb-125	2.73 yr	—	1.9×10^{-2}	8.0×10^{-6}	1.9×10^{-2}
	Cs-137	30.2 yr	—	8.0×10^{-3}	2.4×10^{-7}	8.4×10^{-3}
	Pu-238	87.7 yr	—	5.4×10^{-3}	—	5.4×10^{-3}
	Ru-106	1.01 yr	—	3.9×10^{-3}	—	3.9×10^{-3}
	Pu-239/240	2.4×10^{4} yr	—	2.3×10^{-3}	—	2.3×10^{-3}
	Sr-90/Y-90[c]	28.6 yr	—	1.5×10^{-3}	4×10^{-8}	1.6×10^{-3}
H-3, C-14, and Iodine Isotopes	H-3	12.3 yr	1.8	360	—	360
	I-129	1.6×10^{7} yr	—	0.45	—	0.45
	C-14	5.7×10^{3} yr	—	0.14	—	0.33
	I-131	8.04 da	—	—	5.2×10^{-4}	1.2×10^{-3}
All Others Total			6.2×10^{-7}	2.1×10^{-5}	4.5×10^{-6}	3.4×10^{-4}
Total			250	400	4,200	4,900

a. Radioactivity listed in 1984 Radioactive Waste Management Information System Report[2] and Reference14. Values are not corrected for decay after release. Data are preliminary.

b. Totals include small amounts from facilities not listed and are rounded to two significant figures.

c. Parent-daughter equilibrium assumed.

Due to radioactive decay of the short-lived radionuclides, the activity that would reach offsite areas is less than the 4,900 Ci indicated in Table X. The ICPP and TRA facilities together were the source of about 94% of the total radioactivity released to the atmosphere. Noble gases comprised about 90% of the total radioactive airborne effluent.

No liquids were released to the offsite environment.

Assessment of Potential Radiation Dose to the Public

General. The radiological impact of Site operations on the resident public surrounding the Site was too small to be measured by the routine monitoring program. Therefore, the impact was estimated by calculating

- The maximum "fence post," or 50-year, Site boundary dose commitment
- The maximum potential 50-year dose commitment to the nearest individual residing offsite
- The maximum potential 50-year dose commitment to a member of a population group
- The potential 50-year population dose commitment which could have been received by the public within an 80-km (50-mi) radius of the operations center of the Site (TRA and ICPP).

For simplicity, the term "50-year dose commitment" calculated for Site releases will be used interchangeably with the term "dose" in the following sections.

The possible exposure pathways by which radioactive materials from Site operations could be transported to offsite environs are shown diagrammatically in Figure 10. Atmospheric transport is the principal potential exposure pathway from the Site. There are no surface streams flowing from onsite to offsite locations. The leading edge of the tritium plume, the most mobile low-level radioactive waste in the aquifer, reached the Site boundary in 1983. Tritium from the Site has never been detected in any offsite wells.

Several indirect exposure pathways are being studied at the Site to determine their effect, if any, on the highest possible dose that could have been received by a member of the public. The principal indirect exposure pathway involves the eating of game species that have spent some time on the Site. Some radioactivity can be present in game species, depending upon the length of residence onsite, the time elapsed after migration from the Site, and the metabolism of the animal. Conservative estimates of the potential dose to a person consuming meat from different game animals is described in the section "Maximum Individual Dose Commitment."

The monitoring data presented in the previous sections indicated that at offsite sampling locations no particulate radioactivity in the air from Site operations was discernible from the preexisting levels due to natural and fallout radioactivity. As mentioned in the section on air sampling, the only noble gas sampled by the air monitoring system is Kr-85. Although no radiological impact of Site operations could be detected, an estimate of the hypothetical impact on the surrounding region has been made by using the known amounts of various radionuclides released during 1984 from Site facilities and a meteorological model for estimating the concentrations at selected locations in the vicinity. A summary of the radionuclides released to the atmosphere from Site facilities is shown in Table X of the preceding section.

The mesoscale meteorological map (Figure 11) shows the calculated 1984 concentrations normalized to a unit release rate for the INEL Site and vicinity. This map has been prepared by the National Oceanic and Atmospheric Administration (NOAA) at the INEL from data gathered continuously at 26 meteorological stations on and around the Site.[16] To facilitate the display, the dispersion coefficient values are given in whole numbers and must be multiplied by 10^{-9} hr^2/m^3. To obtain the average air concentration (Ci/m^3) for a radionuclide released from TRA or ICPP along any dispersion coefficient isopleth in Figure 11, the value of the 1984 average dispersion coefficient (e.g., 30×10^{-9} hr^2/m^3) was multiplied by the number of curies of the radionuclide released during 1984 and was divided by the number of hours in a year squared (7.67×10^7). Logarithmic interpolation between isopleths was used to obtain concentrations at other points.

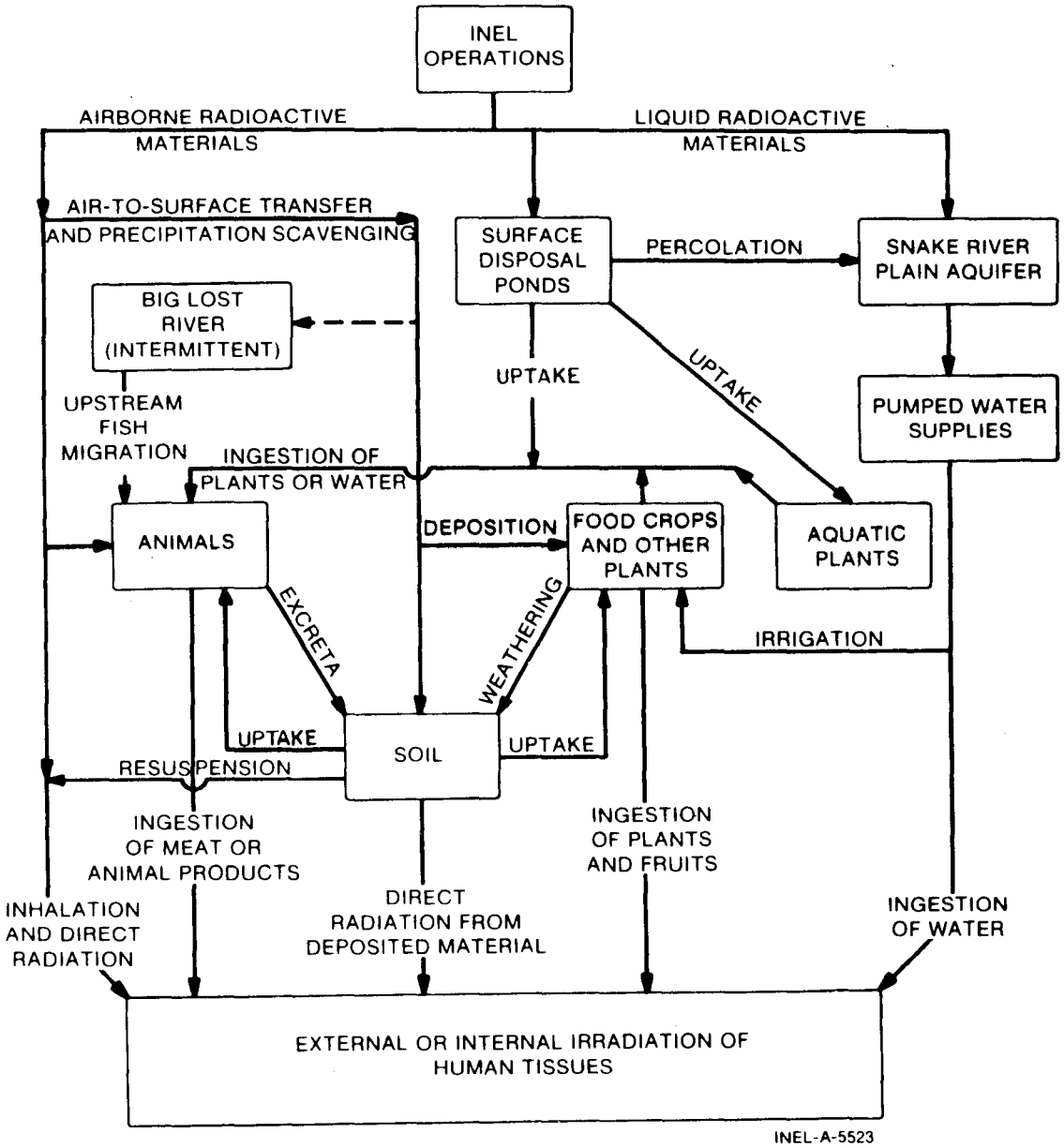

Figure 10. Possible exposure pathways of the INEL Site radioactive materials to humans within 80 km (50 mi) of ICPP and TRA.

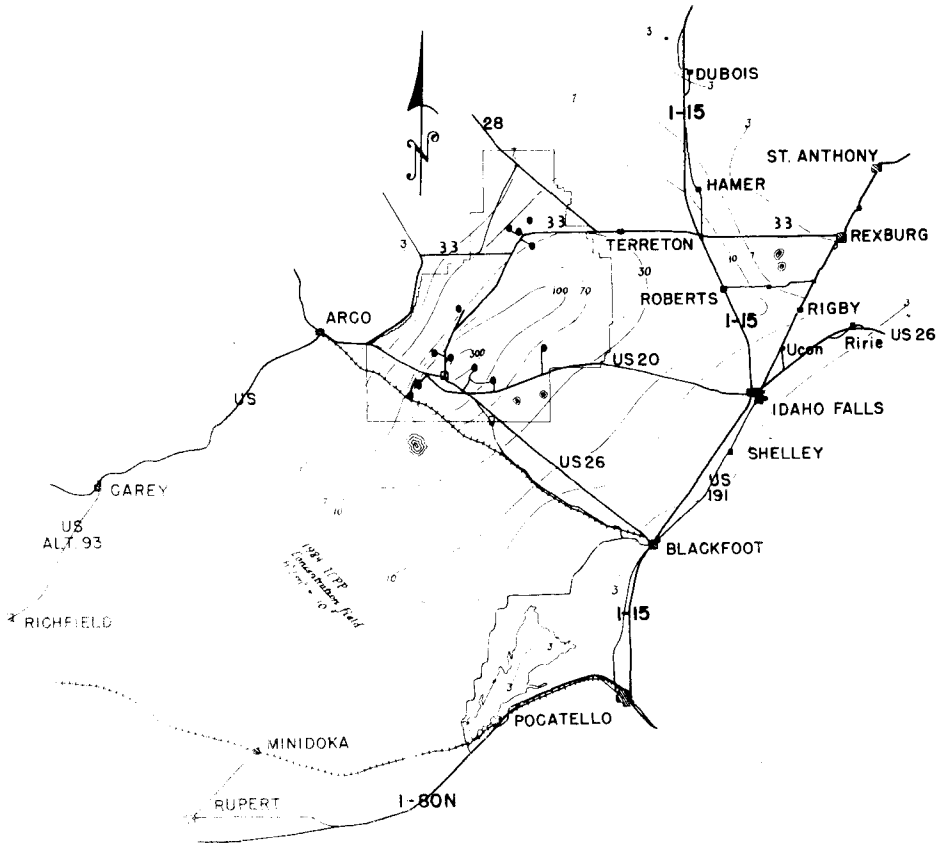

Figure 11. 1984 average of mesoscale dispersion isopleths of air concentrations at ground level, normalized to unit release rate.

Maximum Site Boundary Whole-Body Dose Commitment. The maximum hypothetical 50-year whole-body dose commitment to an adult from inhalation of air, submersion in air, and radiation due to deposition of particulates on soil was calculated, assuming that an individual resided continuously for a year at the point of maximum radionuclide concentration just outside the Site boundary (fence-post dose). The calculation was based on data presented in Table X and Figure 11. The maximum offsite concentration occurred along the southern Site boundary between the isopleths labeled "70" and "100" in Figure 11. The dispersion coefficient used for this point is 90 x 10^{-9} hr^2/m^3. The whole-body dose from each radionuclide in Table XI was computed using the dose conversion factors given in References 17 and 18. The maximum hypothetical whole-body dose estimated for an adult from Site airborne effluent is 0.02 mrem for 1984. About 74% of that computed dose was due to noble gases and particulates with half-lives of less than 10 hr. This dose is 0.004% of the radiation protection standard for exposure to an individual in an uncontrolled area (DOE Order 5480.1A, Chapter XI). Calculations were also made of doses to several body organs and tissues (lung, liver, kidney, red bone marrow, bone surfaces, thyroid, and skin). The largest dose to an organ or tissue was 0.26 mrem to the bone surfaces, which is 0.017% of the radiation protection standard for the bone surfaces.

The calculated potential whole-body dose (0.02 mrem) resulting from Site operations is very small compared to the estimated 140 mrem received from cosmic and terrestrial radiation during 1984. For interest, it may also be compared to the approximately 36 mrem from medical and radiological diagnostic procedures, to the estimated 25 mrem received each year from natural radionuclides in the body, to about 3.5 mrem received during a 5-hr transcontinental jet flight, or to the 0.05 to 0.10 mrem received annually by the average television viewer.[19]

Maximum Individual Dose Commitment. As indicated in Figure 11, Atomic City is the location nearest to the Site boundary where people actually

TABLE XI
MAXIMUM SITE BOUNDARY WHOLE-BODY DOSE COMMITMENT (1984)

Radionuclide[a]	Maximum Offsite Concentration[b] (μCi/mL)	Maximum Whole-Body Dose[c] (mrem)
Ar-41	1.5×10^{-12}	0.0096
Kr-88	3.4×10^{-13}	0.0051
Cs-137	9.4×10^{-18}	0.0048
Xe-138	7.2×10^{-14}	0.0017
Sb-125	2.2×10^{-17}	0.0012
Kr-87	2.4×10^{-13}	0.0010
Xe-135	4.3×10^{-13}	0.00049
H-3	4.2×10^{-13}	0.00022
Kr-85m	1.3×10^{-13}	0.00010
Total	—	0.024

a. Table includes only radionuclides which contribute a dose of 0.0001 mrem or more.

b. Estimate of radioactive decay obtained by using the 1984 average windspeed from 355-005° of 15.6 km/hr and a distance of 14.2 km from TRA-ICCP to point of maximum offsite concentration.

c. Whole-body dose estimated using parameters given in Kocher[17] and in ICRP-30.[18] Doses are 50-year dose commitments.

reside and thus represents the point of the greatest probable 50-year dose commitment from Site operations. Using 45×10^{-9} hr^2/m^3 as the dispersion coefficient for Atomic City and allowing for radioactive decay during the transit of the radionuclides to Atomic City, the potential individual dose from inhalation, submersion, and deposition was calculated to be 0.012 mrem. This dose is about 0.002% of the radiation protection standard for exposure to an individual at points of maximum probable exposure (DOE Order 5480.1A, Chapter XI). No allowance was made for shielding by housing materials or residence time in the community.

Potential dose to an individual from ingestion of meat from game animals continues to be investigated. One group of studies involves the calculation of potential doses to individuals who might eat ducks which reside briefly upon a liquid waste pond used for the disposal of low-level reactor effluents (Figure 12). The average potential whole body dose from consumption of a contaminated duck is 10 mrem.[20] This value is based on the assumption that the duck would be killed and eaten immediately after leaving the pond. Normally, immediate killing of the duck would not occur, so a lower dose would be more realistic due to biological elimination of the radioactivity. Because only about one duck in 4000 passing through this area has a chance of becoming contaminated, the probability of receiving this dose is further reduced.[21]

The highest estimated potential dose to a person eating the entire muscle mass of a sage grouse which summered near the TRA-ICPP area was 2 mrem.[22] Sage grouse which summered in other Site areas or offsite were calculated to provide estimated doses of 0.01 to 0.04 mrem.

The calculated maximum potential radiation dose to a person eating the muscle tissue of one mourning dove was 0.3 mrem. The average dose to people consuming doves migrating from the Site areas was 0.01 mrem, which is the same as for control birds collected far from the Site.[23]

A conservative estimate of the maximum potential dose which could have been received by a single

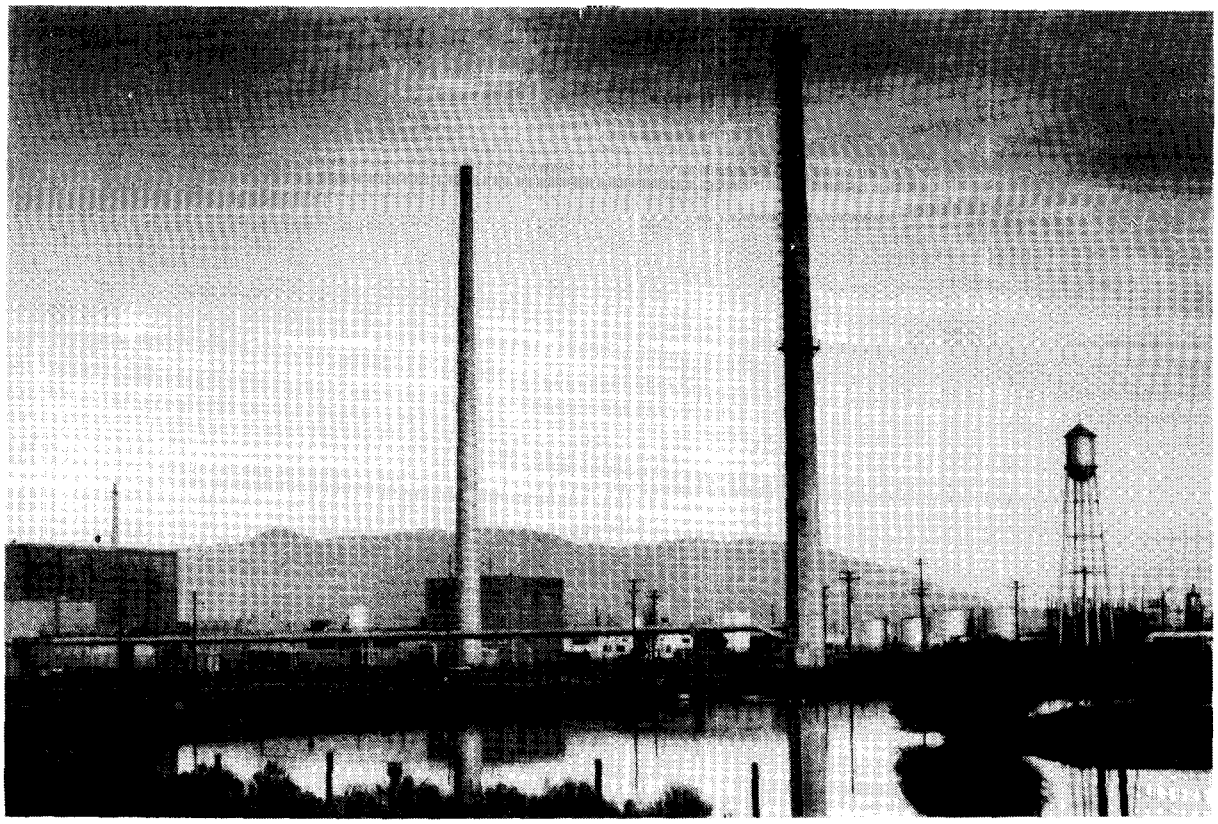

Figure 12. TRA Low-level waste disposal pond on the INEL Site.

individual eating the entire muscle and liver mass of an antelope (collected on the INEL after August, 1975) with the highest levels of radionuclides was less than 0.2 mrem.[24]

If an individual had eaten either the contaminated antelope or the five contaminated mourning doves described in the "Game Species" section, the whole body dose commitments would have been less than the estimated maximum dose commitments described in the preceding paragraphs.

Maximum Dose Commitment to a Member of a Population Group. Atomic City is the population group nearest to the point of maximum exposure on the Site boundary. Therefore, each resident of this community would have the same potential 50-year dose commitment as calculated in the section above. However, this would be compared to the standard for a suitable sample of the exposed population. The 0.012-mrem dose is about 0.007% of that standard.

80-Kilometer Population Dose Commitment. An estimate of the maximum 50-year whole-body dose commitment from inhalation, submersion, and deposition which could have been received by all members of the public within an 80-km (50-mi) radius of the TRA-ICPP complex[25] was made by summing the potential individual doses to the people of each census division within the 80-km (50-mi) radius. The dose to an individual of a particular division is a fraction of the maximum individual dose (fence-post dose) calculated in a previous section. The fraction is obtained by taking the ratio of the estimated dispersion coefficient for each census division from Figure 11 to the dispersion coefficient of 90×10^{-9} hr^2/m^3 which was used to calculate the maximum individual dose. The potential dose to the population of the division is the product of the potential dose to each resident times the division population. The calculation is conservative, since radioactive decay of the isotopes was not calculated during transport over distances greater than the 14 km (9 mi) from the TRA-ICPP midpoint to the southern Site boundary nor was residence time or shielding by housing taken into account. Idaho Falls, for example, is about 66 km (41 mi) from TRA-ICPP.

The 80-km (50-mi) population dose was the sum of population doses for the various census divisions.

The results are summarized in Table XII. The estimated potential population dose was 0.13 man-rem to a population of 114,400. When compared with an approximate population dose of 16,000 man-rem from natural background, this represents an increase of only about 0.0008%. The dose of 0.13 man-rem can also be compared to the following estimated whole-body population doses for the same size population: 4,100 man-rem for medical and radiological diagnostic procedures and 120 man-rem for a group of three common sources of miscellaneous radiation—air transport, self-luminescent consumer-products, and television viewing.[19]

The contribution of indirect exposure pathways to the population dose has not been considered because of uncertainties regarding the number of people exposed, the small probability of obtaining game animals migrating from the Site during hunting season, and the levels of different radionuclides in various animals. The dose contribution from these indirect exposure pathways would realistically be less than the dose from inhalation of air, submersion in air, and deposition on soil.

TABLE XII
80-KILOMETER POPULATION DOSE COMMITMENT (1984)

Census Division	Dispersion Coefficient[a]	Population[b] 1984	Population Dose[c] (man-rem)
Aberdeen	5×10^{-9}	2,850	0.0038
Alridge	2×10^{-9}	80	0.00004
American Falls	3×10^{-9}	90	0.00007
Arco	2×10^{-9}	2,900	0.0016
Atomic City (city)	45×10^{-9}	35	0.00042
Atomic City (division)	5×10^{-9}	2,230	0.0030
Blackfoot	2×10^{-9}	12,930	0.0069
Carey (part)	1×10^{-9}	110	0.00003
Challis (part)	1×10^{-9}	10	0.00000
Firth	3×10^{-9}	3,349	0.0027
Fort Hall (part)	2×10^{-9}	3,830	0.0020
Hamer	20×10^{-9}	2,330	0.012
Howe	5×10^{-9}	440	0.00059
Idaho Falls	4×10^{-9}	57,720	0.062
Idaho Falls, West	5×10^{-9}	1,840	0.0025
Leadore (part)	2×10^{-9}	15	0.00001
Lewisville-Menan (part)	8×10^{-9}	2,280	0.0049
Mackay (part)	1×10^{-9}	1,070	0.00029
Moreland	5×10^{-9}	8,540	0.011
Rigby (part)	7×10^{-9}	580	0.0011
Roberts	15×10^{-9}	1,320	0.0053
Shelley	4×10^{-9}	6,370	0.0068
Ucon (part)	6×10^{-9}	3,420	0.0055
West Clark (part)	8×10^{-9}	90	0.00019
Totals	—	114,430	0.13

a. Coefficient, obtained from Figure 11, is the 1984 average concentration normalized to unit release rate (hr^2/m^3). The value selected represents an estimated average based on the location of population centers in the census division.

b. Population for each division is based upon the 1980 Advance Census Reports for Idaho. The populations of urban areas have been increased slightly based upon population changes between 1970 and 1980. Estimates are made when only part of a division is located within the 80-km radius.

c. This population dose commitment does not include radioactive decay beyond 14.2 km.

GROUNDWATER MONITORING PROGRAM

In addition to the offsite groundwater monitoring performed by the USGS and RESL/ID outlined under "Water Sampling," the USGS extensively monitors groundwater on the INEL Site. They maintain more than 100 observation wells on or near the INEL. More than 100 auger holes are also available for sampling shallow-perched water. Water levels in wells and various radiological and nonradiological parameters of the aquifer are monitored. Reference 26 contains maps showing the frequency of water level measurements and of water sample collections, as well as information on the extent of various contaminants in the aquifer and perched water. Groundwater monitoring is summarized in Table XIII.

A brief description of the hydrogeology of the INEL Site and the movement of water in the Snake River Plain aquifer is given in Appendix A. Further information may be found in References 1, 26, and 27.

Tritium was detected in onsite wells near the southern Site boundary during 1983, but it was not detected in onsite wells near the boundary nor in offsite wells south of the boundary during 1984. This indicates that the tritium waste plume probably reached the Site boundary but has not traveled offsite and has now been diluted below minimum detectable concentration levels by recharge from surface streams. Iodine-129, which has a less extensive plume than tritium, is detectable about 6 km (3.7 mi) inside the nearest Site boundary.[26] Strontium-90 analyses were above the minimum detectable concentration only for those samples collected within 3 km (1.9 mi) of the release point at the ICPP disposal well, or approximately 10 km (6.2 mi) inside the nearest Site boundary.[26] The estimated minimum detectable concentrations for Sr-90 and I-129 are about 5×10^{-9} and 1×10^{-10} μCi/mL, respectively, or about 2 and 0.2% of the concentration guides for an uncontrolled area. Cesium and actinides are even less mobile in the aquifer than strontium.

Nonradiological wastes in the aquifer are determined by measuring the specific conductance and the chloride, sodium, nitrate, and total chromium content of the water (see References 26 and 27). All of these waste products were at background levels at least 3 km (1.9 mi) inside the nearest Site boundary, indicating that INEL groundwater nonradiological plumes had not migrated offsite by the end of 1984.

TABLE XIII
GROUNDWATER MONITORING PROGRAM SUMMARY

Radiological Monitoring:

Type of Analysis	Frequency of Analysis	Number of Samples	Sample Size (mL)	Count Time (min)	∿Minimum Detectable Concentration (MDC) (μCi/mL)
Gross alpha	Monthly	21	100	60	3×10^{-9}
Gross alpha	Semiannually	5	100	60	3×10^{-9}
Gross alpha	Annually	1	100	60	3×10^{-9}
Gross beta	Monthly	21	250	20	5×10^{-9}
Gross beta	Semiannually	5	250	20	5×10^{-9}
Gross beta	Annually	1	250	20	5×10^{-9}
HTO[a]	Monthly	21	10	20	4×10^{-7}
HTO	Quarterly	28	10	20	4×10^{-7}
HTO	Semiannually	82	10	20	4×10^{-7}
HTO	Annually	1	10	20	4×10^{-7}
Specific gamma	Quarterly	6	400	60	1 to 10×10^{-8}[b]
Specific gamma	Semiannually	12	400	60	1 to 10×10^{-8}
Specific gamma	Annually	18	400	60	1 to 10×10^{-8}
Sr-90	Monthly	1	3800	20	5×10^{-9}
Sr-90	Quarterly	14	400	20	5×10^{-9}
Sr-90	Semiannually	39	400	20	5×10^{-9}
Am	Semiannually	6	500	1000	5×10^{-11}
Pu	Semiannually	7	500	1000	4×10^{-11}
Pu	Annually	3	500	1000	4×10^{-11}
I-129	∿5 years	Varies	3800	10	6×10^{-11}

Nonradiological Monitoring:

Type of Analysis	Frequency of Analysis	Number of Samples	Analysis Method	∿Minimum Detectable Concentration (MDC) (mg/L)
Specific Conductance	Quarterly	28	Conductometric	N/A[c]
Specific Conductance	Semiannually	82	Conductometric	N/A
Specific Conductance	Annually	1	Conductometric	N/A
Sodium ion	Monthly	3	Selective ion electrode	5
Sodium ion	Quarterly	4	Selective ion electrode	5
Sodium ion	Semiannually	1	Selective ion electrode	5
Sodium ion	Annually	79	Selective ion electrode	5
Chromium (total)	Quarterly	14	Atomic absorption	0.05
Chromium (total)	Semiannually	23	Atomic absorption	0.05
Chloride ion	Monthly	3	Selective ion electrode	5
Chloride ion	Quarterly	28	Selective ion electrode	5
Chloride ion	Semiannually	82	Selective ion electrode	5
Chloride ion	Annually	1	Selective ion electrode	5
Nitrates	Annually	48	Ion chromatography	0.5
Major inorganic water quality constituents	∿5 years	Varies	Varies	Varies

a. Tritiated water.

b. Varies depending upon radionuclides present in the sample.

c. Not applicable.

QUALITY ASSURANCE

A quality control and assurance program is maintained by RESL/ID to assure consistent and reliable monitoring results. An internal quality control program is maintained by:

- Adherence to written procedures for sample collection and analytical methods [28]
- Documentation of program changes
- Routine calibration of instrumentation
- Frequent equipment performance checks for background and counting rates for standards
- Routine yield determinations of radiochemical procedures
- Duplicate samples to determine precision
- Analysis of quality control standards in appropriate matrix
- Analysis of reagent blanks to verify chemical purity
- Propagation of all random and systematic uncertainties.

The calibration of counting instruments is carefully performed and is traceable to the National Bureau of Standards (NBS). Six times per year, tracer solutions are submitted to RESL/ID for analysis by gamma spectrometry. Comparisons are also made for beta emitters, including Sr-90 and tritium, and for alpha emitters, such as Pu-238, Pu-239, and Am-241. The results, which are reported directly to the NBS, have repeatedly demonstrated traceability to the NBS. 1984 results for liquids are shown in Table XIV.

In past years, RESL/ID has also participated in the quality assurance program administered by the Environmental Measurements Laboratory of DOE, the American Society for Testing Materials' round-robin testing of standard methods, and in intercomparison with the U.S. Environmental Protection Agency in Las Vegas, Nevada (EMSL-LV). Results of the 1984 EMSL-LV intercomparison are given in Table XV.

RESL also participates in an INEL Site intercomparison program where samples with known concentrations are sent to INEL contractor analytical laboratories and are also analyzed by RESL. Results are then compared to known results (Table XVI), and an intercomparison of results from all laboratories is also made.

The ambient nitrogen oxide and sulfur dioxide analyzers undergo a multipoint calibration every six months, or whenever performance checks indicate poor instrument response. Performance checks are made at least every two weeks and include testing the response of the analyzer to purified air and to air with a known concentration. Gas standards used for multipoint calibrations and performance checks are designated protocol gases by the EPA and are traceable to the NBS.

To verify the quality of the environmental dosimetry program, RESL/ID has participated in six International Environmental Intercomparison Studies, originally organized by the Environmental Measurements Laboratory and the University of Texas School of Public Health. During 1981, RESL/ID became an organizer replacing the University of Texas. The RESL/ID applied-dosimetry section still participates in the program independently from the RESL/ID staff who conduct the intercomparison. The RESL/ID results have been within 10% of the test exposure values.

The calibration source for the environmental dosimetry program was included in the DOE Intercomparison of Radiological Standards in December of 1983 and found to agree with the reference instrument to within 0.2%.

TABLE XIV
NBS QUALITY ASSURANCE COMPARISON TEST RESULTS (1984)

Medium	Nuclide	RESL Result[a] (Bq/g)	NBS Result[a] (Bq/g)	Ratio RESL/NBS[b]
Liquid	Pu-239	254.1 ± 4.7	250.5 ± 1.1	1.01 ± 0.02
	H-3	1110 ± 30	1050 ± 10	1.06 ± 0.03
	Sr-89	879 ± 26	874 ± 8	1.01 ± 0.03
	Sr-90	430 ± 9	413 ± 5	1.04 ± 0.03
	Th-230	240 ± 4	239 ± 3	1.00 ± 0.02
	Ra-226	144 ± 3	146 ± 2	0.99 ± 0.02
	Ni-63	4940 ± 100	4880 ± 50	1.01 ± 0.02
	Nb-94	3580 ± 110	3630 ± 30	0.99 ± 0.03

a. Result ± overall uncertainty is given. The overall uncertainty is taken to be three times the combined uncertainty, which is the quadratic sum of all the random and systematic uncertainties at the one standard deviation level.

b. Ratio ± uncertainty is given.

TABLE XV
EMSL-LV QUALITY ASSURANCE COMPARISON TEST RESULTS (1984)

Medium	Nuclide	RESL Result[a] (Bq/g)	EMSL-LV Result[a] (Bq/g)	Ratio RESL/EMSL-LV[b]
Liquid	H-3	175 ± 3	168 ± 6	1.04 ± 0.04
	Ce-139	2070 ± 70	2070 ± 62	1.00 ± 0.05
	Am-241	167 ± 3	164 ± 5	1.02 ± 0.04

a. Result ± total uncertainty is given where the total uncertainty was propagated by adding in quadrature the derived random uncertainty (one standard deviation) to the upper limits of every conceivable source of systematic uncertainty.

b. Ratio ± uncertainty is given.

TABLE XVI
INEL QUALITY ASSURANCE COMPARISON TEST RESULTS (1984)

Medium	Nuclide	RESL Result[a] (Bq/g)	Known Value (Bq/g)	Ratio RESL/Known
Soil	Am-241	0.034 ± 0.002	0.0297 ± 0.0001	1.15 ± 0.07
	Cd-109	12.50 ± 1.0	12.9 ± 0.3	0.97 ± 0.08
	Co-57	0.54 ± 0.02	0.53 ± 0.01	1.02 ± 0.04
	Ce-139	0.76 ± 0.03	0.73 ± 0.03	1.04 ± 0.06
	Sn-113	2.49 ± 0.08	2.51 ± 0.08	0.99 ± 0.05
	Cs-137	2.32 ± 0.06	2.30 ± 0.06	1.01 ± 0.04
	Co-60	2.53 ± 0.06	2.56 ± 0.02	0.99 ± 0.03
	Y-88	5.00 ± 0.12	5.11 ± 0.14	0.98 ± 0.04

a. Result ± total uncertainty is given where the total uncertainty was propagated by adding in quadrature the derived random uncertainty (one standard deviation) to the upper limits of every conceivable source of systematic uncertainty.

b. Ratio ± uncertainty is given.

ENVIRONMENTAL STANDARDS, REGULATIONS, AND PERMITS

The following environmental standards and regulations are applicable at the INEL Site boundary.

U.S. Department of Energy, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," Chapter XI, DOE Order 5480.1A, August 1981 (applicable onsite and at the INEL Site boundary).

U.S. Federal Radiation Council, *Background Material for the Development of Radiation Protection Standard*, Report No. 1 (1960) and Report No. 2 (1961), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

U.S. Environmental Protection Agency, *National Primary and Secondary Ambient Air Quality Standards*, 40 CFR 50, 1984.

U.S. Environmental Protection Agency, *National Interim Primary Drinking Water Regulations*, 40 CFR 141, 1984.

Department of Health and Welfare, State of Idaho, *Rules and Regulations for the Control of Air Pollution in Idaho*, 1972 as amended through 1984.

Department of Health and Welfare, State of Idaho, *Idaho Regulations for Public Drinking Water Systems*, 1977.

The principal standards and guides for releases of radionuclides at the INEL are those of DOE Order 5480.1A, Chapter XI, dated August 13, 1981, entitled "Requirements for Radiation Protection." Radiation protection standards and selected radioactivity concentration guides from Chapter XI are listed in Tables XVII and XVIII. The most restrictive guide is listed when there is a difference between soluble and insoluble chemical forms. These listed guides are identical to those in the *Idaho Radiation Control Regulations*, Radiation Control Section, State of Idaho, 1982.

Ambient air quality standards are shown in Table XIX. Water quality standards are dependent on the type of drinking water system sampled. For public community drinking water systems, Table XX is a partial list of maximum contaminant levels set by the EPA. State of Idaho regulations are the same for those contaminants listed here.

Three permits issued to INEL facilities which were in effect in 1984 are described in Table XXI.

TABLE XVII
RADIATION PROTECTION STANDARDS DOE *ORDER 5480.1A*, CHAPTER XI

	Annual Dose Commitment (mrem/yr)	
Standards	Whole Body, Gonads, or Bone Marrow	Other Organs
Individuals at points of maximum probable exposure	500	1500
Suitable sample of the exposed population	170	500

TABLE XVIII
RADIOACTIVITY CONCENTRATION GUIDES FOR EFFLUENT RELEASES TO UNCONTROLLED AREAS *DOE ORDER 5480.1A*, CHAPTER XI

Radionuclide	Concentration Guide (μCi/mL) In Air	In Water
Gross Alpha	2×10^{-14}	3×10^{-8}
Gross Beta[a]	1×10^{-12}	3×10^{-8}
Am-241	2×10^{-13}	4×10^{-6}
Sb-125	9×10^{-10}	1×10^{-4}
Ar-41	4×10^{-8}	—
Ba-140	1×10^{-9}	2×10^{-5}
Cs-134	4×10^{-10}	9×10^{-6}
Cs-137	5×10^{-10}	2×10^{-5}
H-3	2×10^{-7}	3×10^{-3}
I-129	2×10^{-11}	6×10^{-8}
I-131	1×10^{-10}	3×10^{-7}
Kr-85	3×10^{-7}	—
Kr-85m	1×10^{-7}	—
Kr-87	2×10^{-8}	—
Kr-88	2×10^{-8}	—
Pu-238	7×10^{-14}	5×10^{-6}
Pu-239	6×10^{-14}	5×10^{-6}
Pu-240	6×10^{-14}	5×10^{-6}
Ru-106	2×10^{-10}	1×10^{-5}
Sr-90	3×10^{-11}	3×10^{-7}
Xe-133	3×10^{-7}	—
Xe-135	1×10^{-7}	—
Xe-138	3×10^{-8}	—

a. Based on the most restrictive beta emitter (Ra-228).

TABLE XIX
AMBIENT AIR QUALITY STANDARDS[a]

Pollutant	Type of Standard[a]	Sampling Period	U.S. EPA (μg/m^3)	State of Idaho (μg/m^3)
SO_2	S	3-hour Average	1300	1300
	P	24-hour Average	365	365
	P	Annual Average	80	80
NO_2	P&S	Annual Average	100	100
Total Particulates	S	24-hour Average	150	150
	S	Annual Average	60	60

a. National primary (P) ambient air quality standards define levels of air quality to protect the public health. Secondary (S) ambient air quality standards define levels of air quality to protect the public welfare from any known or anticipated adverse effects of a pollutant.

TABLE XX
MAXIMUM CONTAMINANT LEVELS FOR PUBLIC COMMUNITY DRINKING WATER SYSTEMS

Gross Alpha	15 pCi/L
Gross Beta	50 pCi/L
Man-made Radionuclides	Concentrations resulting in 4 mrem total body or organ dose equivalent
Tritium[a]	20,000 pCi/L
Strontium-90[a]	8 pCi/L
Nitrate (as N)[b]	10 mg/L
Chromium	0.05 mg/L

a. Based on a 2-L/day drinking water intake.

b. Applies to non-community water systems also.

TABLE XXI
PERMITS IN EFFECT (1984)

Type of Document	Issued By	Compliance Status	Expiration Date	Other Pertinent Information
Prevention of Significant Deterioration Permit for Coal-Fired Steam Generation Facility	USEPA	Compliance Source Test completed, passed, and accepted by EPA.	None	EPA is evaluating changes in the permit to make conditions more appropriate for a plant of this size. Original conditions were patterned after those for a large utility boiler which was inappropriate for this small plant.
Variance from Opacity Regulation for ICPP main stack to allow NWCF operation	State of Idaho	In Compliance	12/31/84	State of Idaho will issue an air pollution source permit to operate to replace the variance.
Air Pollution Source Permit to construct the Coal-Fired Steam Generation Facility	State of Idaho	In Compliance	None	Permit required notification of startup and opportunity to observe source test.

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APPENDIX A
MAJOR PROGRAMS, LOCATION, GEOLOGY, AND CLIMATOLOGY

The INEL Site was established in 1949 as the National Reactor Testing Station to provide an isolated station where various kinds of nuclear reactors and support facilities could be built and tested, primarily to demonstrate that nuclear energy could be safely harnessed for generating electricity and other peaceful uses. More nuclear reactors have been built at the INEL Site than at any other location in the world. A total of 52 reactors have been built, of which 15 are operating or operable. The broad mission of the INEL is to develop economic energy sources by applying its engineering and scientific expertise to DOE research and development programs. Major DOE programs currently underway at the INEL Site fall into six categories:

- Providing test irradiation services from the high-flux Advanced Test Reactor (ATR).
- Recovering uranium from highly enriched spent fuels and calcining liquid radioactive waste solutions into a solid form at the Idaho Chemical Processing Plant (ICPP).
- Conducting light-water-cooled reactor safety testing and research at the Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF).
- Operating the Experimental Breeder Reactor No. 2 (EBR-II).
- Operating the Naval Reactors Facility (NRF).
- Storing and monitoring solid transuranic wastes.

See Figure A-1 and Table A-I for the location of INEL Site facilities and an explanation of their acronyms.

The Site is situated on the Upper Snake River Plain in southeastern Idaho at an average elevation of 1500 m (4900 ft). The Site encompasses 2300 km^2 (890 mi^2); it extends 63 airline km (39 mi) from north to south and is about 58 km (36 mi) wide at its broader southern part. Land immediately beyond the boundaries of the Site is either desert or agricultural. Most of this nearby farming is concentrated northeast of the Site. Large areas of agricultural land are farmed in the Snake River Valley regions which are more distant from the Site.

The desert plain on which the INEL Site is located is part of a cool desert shrub biome. Average annual temperature at the Site is 5.6°C (42°F), with extremes of 39°C (103°F) and -44°C (-47°F). Vegetation is typical of a cool desert, with sagebrush conspicuous over 80% of the Site. Frequenting the Site are the pronghorn antelope, a few deer, various kinds of birds, reptiles, coyotes, bobcats, rabbits, and large populations of small mammals. The INEL has been made a National Environmental Research Park (NERP), where scientists from DOE, other federal and state agencies, universities, and private research foundations can study changes caused by man's activities and obtain data for use in making decisions on land use. At present, about 25 different environmental studies are being conducted.

The surface of the plain is a combination of basaltic lava outcroppings and alluvial sedimentary deposits. The sediments range from gravels and sands deposited by streams (as alluvial fans, channel fillings, and deltas) to silts and clays deposited in playas. The subsurface of the plain is principally composed of interbedded basalt flows, lucustrine, and alluvial sedimentary deposits to a depth of about 760 m (2500 ft). The most recent volcanism, 1600 years ago, is evident in the scenic basalt flows at Craters of the Moon National Monument, about 30 km (19 mi) to the southwest of the Site.

Annual precipitation in the Site area has averaged 22 cm (8.5 in) over the past 15 years. Underlying the desert plain is a natural aquifer in the basaltic lava rock. The lateral flow of this water is one billion gallons per day. Aquifer water is believed to be supplied by Henry's Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and west and sink into the porous soils of the Site area. The underground water moves laterally at an average rate between 1.5 to 6 m per day (5 to 20 ft per day) to the south and west, emerging in springs along the Snake River between Milner and Bliss, Idaho. Both aquifer and surface waters of the Snake River Plain are used for irrigation of crops.

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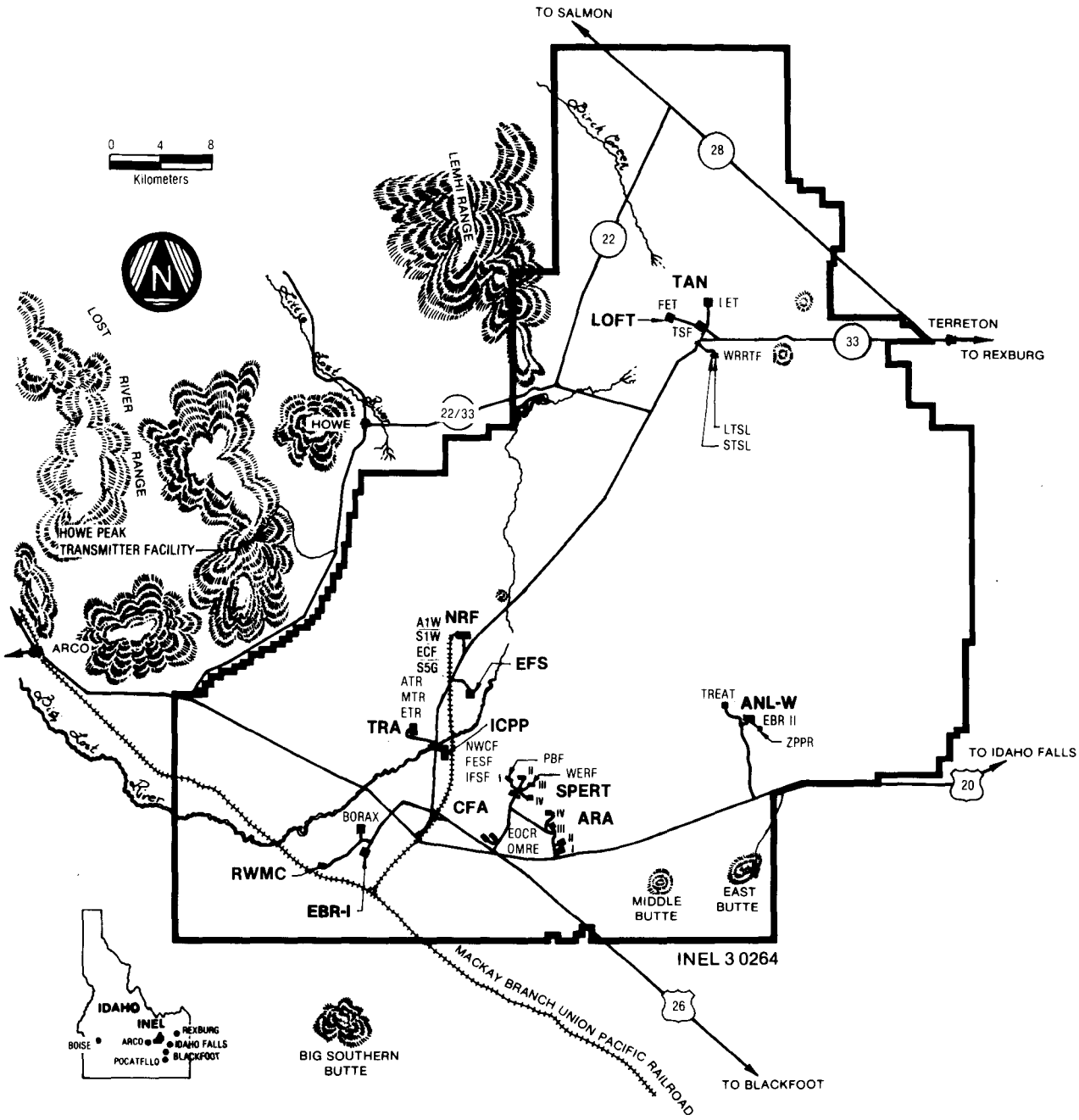

Figure A-1. INEL Site facility locations.

TABLE A-1
TABULATION OF FACILITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

Name	Abbreviation	Operating Contractor[a]
Reactors Operating or Operable as of December 1984		
Advanced Reactivity Measurement Facility No.1[b]	ARMF-I	EG&G
Advanced Test Reactor	ATR	EG&G
Advanced Test Reactor Critical	ATRC	EG&G
Argonne Fast Source Reactor	AFSR	ANL
Coupled Fast Reactivity Measurement Facility[b]	CFRMF	EG&G
Experimental Breeder Reactor No. 2	EBR-II	ANL
Large Ship Reactor "A"	A1W-(A)	WEC
Large Ship Reactor "B"	A1W-(B)	WEC
Loss-of-Fluid Test Facility	LOFT	EG&G
Natural Circulation Reactor	S5G	WEC
Power Burst Facility	PBF	EG&G
Submarine Thermal Reactor	S1W (STR)	WEC
Transient Reactor Test Facility	TREAT	ANL
Neutron Radiography Facility	NRAD	ANL
Zero Power Plutonium Reactor [b]	ZPPR	ANL
Reactors Dismantled, Transferred, or in Standby Status		
Boiling Water Reactor No. 1	BORAX-I	ANL
Boiling Water Reactor No. 2	BORAX-II	ANL
Boiling Water Reactor No. 3	BORAX-III	ANL
Boiling Water Reactor No. 4	BORAX-IV	ANL
Boiling Water Reactor No. 5	BORAX-V	ANL
Engineering Test Reactor	ETR	EG&G
Engineering Test Reactor Critical	ETRC	EG&G
Experimental Breeder Reactor No. 1	EBR-I	ANL
Experimental Organic Cooled Reactor (Mothballed before startup)	EOCR	PPCo
Materials Test Reactor	MTR	PPCo & INC
Organic Moderated Reactor Experiment	OMRE	AI
Special Power Excursion Reactor Test No. 1	SPERT-I	PPCo
Special Power Excursion Reactor Test No. 2	SPERT-II	PPCo & INC
Special Power Excursion Reactor Test No. 3	SPERT-III	PPCo & INC
Special Power Excursion Reactor Test No. 4	SPERT-IV	PPCo & INC
Spherical Cavity Reactor Critical Experiment	SCRCE	ANC
Zero Power Reactor No. 3[b]	ZPR-III	ANL
Other Facilities in Use		
Argonne National Laboratory-West	ANL-W	ANL
Auxiliary Reactor Area	ARA	EG&G
Central Facilities Area	CFA	EG&G
Chemical Engineering Laboratory	CEL	EG&G
Coal-Fired Steam Generating Facility	CFSGF	WINCO
Computer Science Center (Idaho Falls)	CSC	EG&G
Expended Core Facility	ECF	WEC
Other Facilities in Use (Continued)		
Experimental Field Station	EFS	DOE-ID
Field Engineering Test Facility	FET	EG&G
Fluorinel and Fuel Storage Facility	FAST	WINCO
Fuel Element Storage Facility	FESF	WINCO
Hot Fuel Examination Facilities	HFEF	ANL
Hot Pilot Plant	HPP	WINCO
Idaho Chemical Processing Plant	ICPP	WINCO
Idaho Laboratory Facility (Idaho Falls)	ILF	EG&G
Irradiated Fuel Storage Facility	IFSF	WINCO
LOFT Test Support Laboratory	LTSL	EG&G
Naval Reactors Facility	NRF	WEC
New Waste Calcining Facility	NWCF	WINCO
Radioactive Waste Management Complex	RWMC	EG&G
Radiological and Environmental Sciences Laboratory	RESL/ID	DOE-ID
Reactor Training Facility	RTF	EG&G
Semiscale Test Support Laboratory	STSL	EG&G
Standards Calibration Laboratory (CF-698)	—	EG&G
Technical Services Center (CF-688, 689)	TSC	EG&G
Technical Service Facility	TSF	EG&G
Test Area North	TAN	EG&G
Test Reactor Area	TRA	EG&G
Waste Experimental Reduction Facility	WERF	EG&G
Water Reactor Research Test Facility	WRRTF	EG&G
Willow Creek Building (Idaho Falls)	WCB	EG&G
Facilities Not Presently in Use		
Initial Engineering Test Facility	IET	EG&G
Waste Calcining Facility	WCF	WINCO
Major Programs at INEL		
Chemical Processing Program	—	WINCO
Liquid Metal Fast Breeder Reactor Program	—	ANL
Naval Propulsion Reactors Program	—	WEC
Reactor Materials Testing Program	—	EG&G
Special Manufacturing Capability	—	ENICO
Transuranic Waste Management Program	—	EG&G
Water Reactor Safety Program	—	EG&G

a. Operating contractor acronyms: Atomic International (AI), Aerojet Nuclear Company (ANC), Argonne National Laboratory (ANL), EG&G Idaho, Inc. (EG&G), Exxon Nuclear Idaho Company, Inc. (ENICO), Idaho Nuclear Corporation (INC), Phillips Petroleum Company (PPCo), Westinghouse Electric Corporation (WEC), Westinghouse Idaho Nuclear Company (WINCO).

b. Zero or low power reactor.

Winds are predominantly along the SW-NE axis of the plain, with the most frequent and strongest winds from the SW. The NE winds are mostly nocturnal. Spring is the windiest time of the year, and winter has more calm periods and more nighttime temperature inversions.

APPENDIX B
STATISTICAL METHODS

Individual analytical results are given in the report with plus or minus ($\pm$) two analytical standard deviations (2s), where all analytical uncertainties have been properly propagated and "s" is an estimate of the population standard deviation "σ." Many of the results were less than or equal to 2s (and, in fact, some were negative), which is considered to mean that they were below the minimum detectable concentration.

If the result lies in the range of two to three times its estimated analytical uncertainty (2s to 3s), and assuming that the result belongs to a Gaussian distribution, detection of the material by the analysis may be questionable due to statistical variations within the group of samples. Analyses with results in the questionable range are published in this report with the understanding that there may be some doubt as to whether the material was actually present.

There are many factors which can influence the result to some degree, and these factors are considered and included in the methods used to determine the estimated uncertainty of the measurement. If one of these factors is missed, it may not be particularly important when the size of the measurement is many times larger than the estimate of the uncertainty (e.g., 40 $\pm$ 2). However, it may become quite important when working near the minimum detectable concentration, where the uncertainty in the measurement is nearly equal to the measurement itself and the lower limit of the range of the measurement approaches zero. For example, 0.8 $\pm$ 0.7 means that one could predict with reasonable confidence that the actual value lies between 0.1 and 1.5. However, such a result may not be very reliable if a factor has not been included in the estimated uncertainty or, as is usually the case, if the actual probability distribution of the results is not known. In that case, the true value of the measurement may be zero; i.e., the material being measured may not be present. Therefore, when analytical results show a measurement very near the minimum detectable concentration, statistical tools, meteorological data, and Site release information are all considered when interpreting and evaluating the results.

If the result exceeds 3s, there is confidence that the material was detected by the analysis.

Arithmetic means were calculated using actual assay results, regardless of their being above or below the minimum detectable concentration. The uncertainty of the mean, or the 95% confidence interval, was determined by multiplying the standard deviation of the mean (also called the standard error of the mean) by the t statistic. Means for which the 95% confidence interval does not include zero were assumed to indicate detectable amounts of activity. In situations where the analytical results of a group of samples are near the minimum detectable concentration, the 95% confidence interval for the mean may not include zero and thus appears to be statistically significant even though, on the basis of the 2s to 3s criterion, no individual sample contained detectable radioactivity.

Unpaired t-tests were used to determine whether the annual means for the boundary stations were greater than the annual means for the distant stations. All statistical tests used a level of significance of 5% (α = 0.05).[B-1]

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