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1987 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR THE IDAHO NATIONAL ENGINEERING LABORATORY SITE

May 1988

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May 1988

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PREFACE

This report presents onsite and offsite data collected in 1987 for the routine environmental monitoring program conducted by the Radiological and Environmental Sciences Laboratory (RESL) of the Department of Energy (DOE) at the Idaho National Engineering Laboratory (INEL) Site. 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 draft DOE Order 5484.1 and is not intended to cover the numerous special environmental research programs being conducted at the INEL by RESL and others.

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 1987 indicate that radioactivity from the Idaho National Engineering Laboratory (INEL) Site operations could not, with the exception of Sb-125 in air, 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 monitoring program, the collection of foodstuffs at the INEL boundary and distant offsite locations, and the collection of air and water samples at onsite and offsite boundary and distant locations. The report also compares and evaluates the sample results, discussing implications, if any. Significant environmental activities at the INEL Site during 1987, nonradioactive and radioactive effluent monitoring at the Site, and the U.S. Geological Survey (USGS) ground-water monitoring program are also summarized.

There was no statistical difference between annual particulate beta concentrations measured in air at Site boundary stations and at distant sampling stations except at Atomic City, Idaho. The difference was due to Sb-125. The particulate beta concentrations at individual onsite locations, except ARA, were statistically greater than at distant sampling stations and were also greater for the onsite group as a whole. These onsite concentrations, the result of releases of Sb-125 during most of 1987, were well below derived concentration guides for radiation protection of members of the public.

Air samples were also analyzed for specific radionuclides. Some radionuclides were detected at offsite locations; but, with the exception of Sb-125, their presence was attributable to natural sources, to worldwide fallout, or to statistical variations rather than to Site operations. Antimony-125, from fuel reprocessing at the Fluorinel and Fuel Storage Facility (FAST), was detectable in one or more quarters at seven offsite locations. Several radionuclides which were detected at onsite locations were probably due to Site operations, but concentrations were well below the derived concentration guides for radiation protection.

Less than one-third of all drinking water samples collected contained detectable concentrations of gross alpha or gross beta activity, all near the minimum detectable concentration. Both gross alpha and gross beta concentrations were probably due to natural radioactivity or to statistical variation. Annual averages for all onsite and offsite drinking water samples were below the Environmental Protection Agency (EPA) maximum contaminant level for community drinking water systems. No offsite water samples contained detectable tritium concentrations. Four onsite production (drinking water) wells contain measurable concentrations of tritium. An effective dose equivalent of 0.5 mrem/yr was estimated for INEL workers at the location with the highest tritium concentrations. Concentrations of volatile organic compounds measured in four production wells were above the EPA maximum contaminant levels. Appropriate action has been taken. Between 1981 and 1986, concentrations of I-129 and nitrates in ground water decreased markedly in the ICPP area.

None of the milk samples contained detectable concentrations of I-131. Some milk, wheat, and lettuce samples contained small amounts of Sr-90. The presence of Sr-90 in food samples is probably due to its deposition on soil as a result of worldwide fallout. Small amounts of two nuclides were found in muscle and liver tissues of sheep sampled from onsite and distant areas.

Ionizing radiation measured simultaneously at the 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, tritium, and Sb-125, 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 dose equivalents is nevertheless calculated.

A hypothetical maximum individual dose equivalent (specifically, the effective dose equivalent) at Atomic City was calculated to be 0.54 mrem using the MESODIF air dispersion model. The calculation considered continuous submersion in and inhalation of radioactivity in air, ingestion of radioactivity in leafy vegetables, and exposure to radioactive particulates deposited on the ground

surface at that location. This calculated dose equivalent is about 0.4% of the natural background radiation dose equivalent rate of about 150 mrem per year in this area. The AIRDOS-EPA and RADRISK codes were used for comparison with EPA radiation protection standards. (See the section entitled "Maximum Individual Dose—Air Pathway Only.") The maximum calculated dose to an individual by any of the methods is clearly in compliance with the applicable radiation protection standards.

The maximum potential population dose from submersion, ingestion, inhalation, and deposition to the approximately 120,600 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 4.5 person-rem using the MESODIF air dispersion model. This population dose is about 0.03% of the estimated 18,000 person-rem population dose from natural background radioactivity. These calculations 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 ingestion of wild game animals is about 2% of the radiation protection standard for individuals at points of maximum probable exposure. A listing of applicable standards is given in the section "Environmental Standards, Regulations, and Permits." Due to the very small probability that an individual in the population would consume an animal containing significant amounts of radioactivity, the potential offsite population dose equivalent from ingestion of game animals would realistically be less than the population dose equivalent from submersion, inhalation, ingestion, and deposition pathways.

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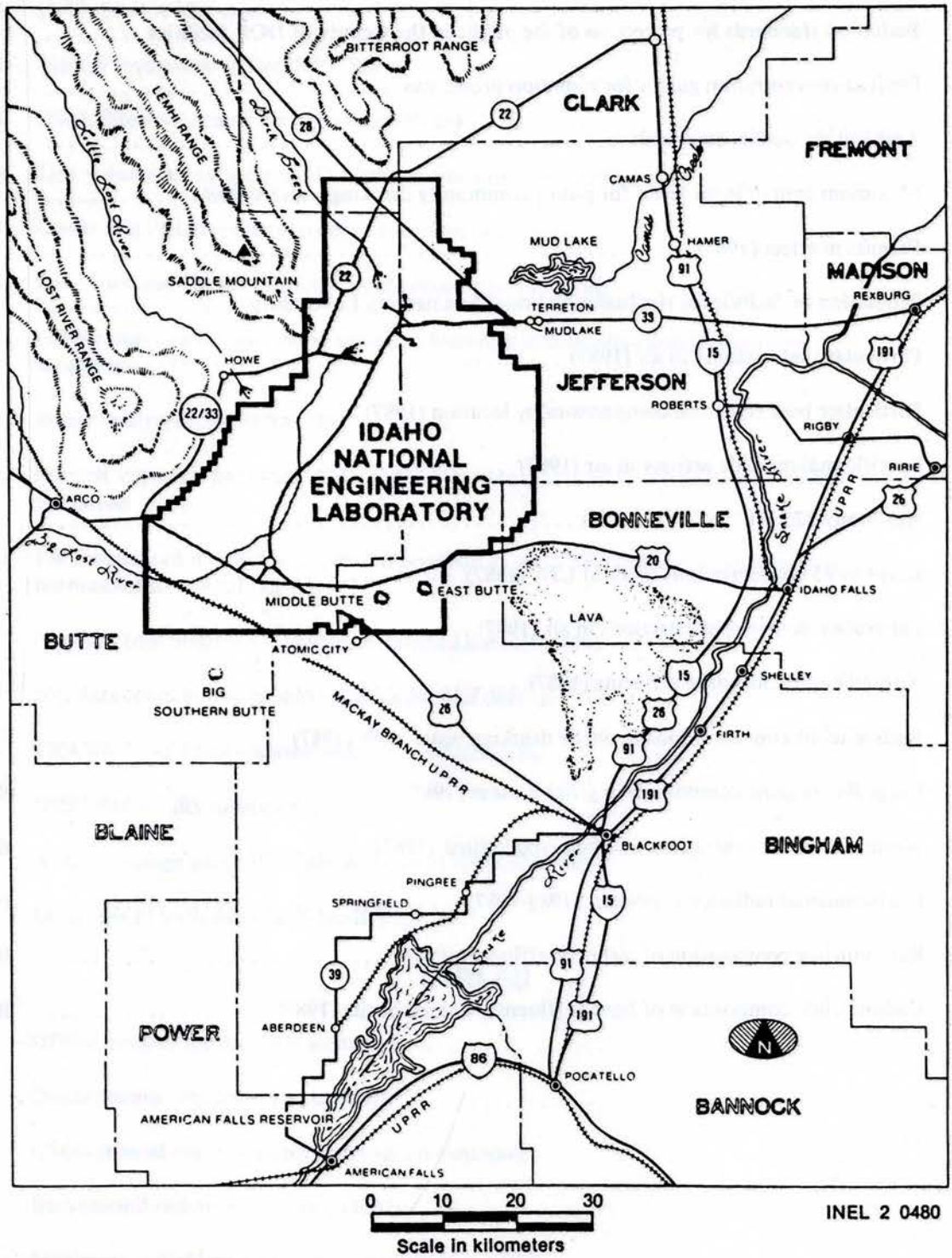

Figure 1. INEL Site vicinity map.

1987 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR THE 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 related 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), Rockwell-INEL, 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 1200, Arco is the largest boundary community in the area surrounding the Site. Approximately 120,600 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 INEL Site was the second area to be designated as one of the nation's six National Environmental Research Parks (NERP), where scientists from universities and from government and private agencies study environmental changes caused by man's activities and obtain data subsequently applied to making land-use decisions.

The surface of the plain is a combination of basalt (lava) outcrops and alluvial sedimentary deposits. There are no surface streams or rivers flowing from onsite to offsite locations, but the Snake River Plain 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.

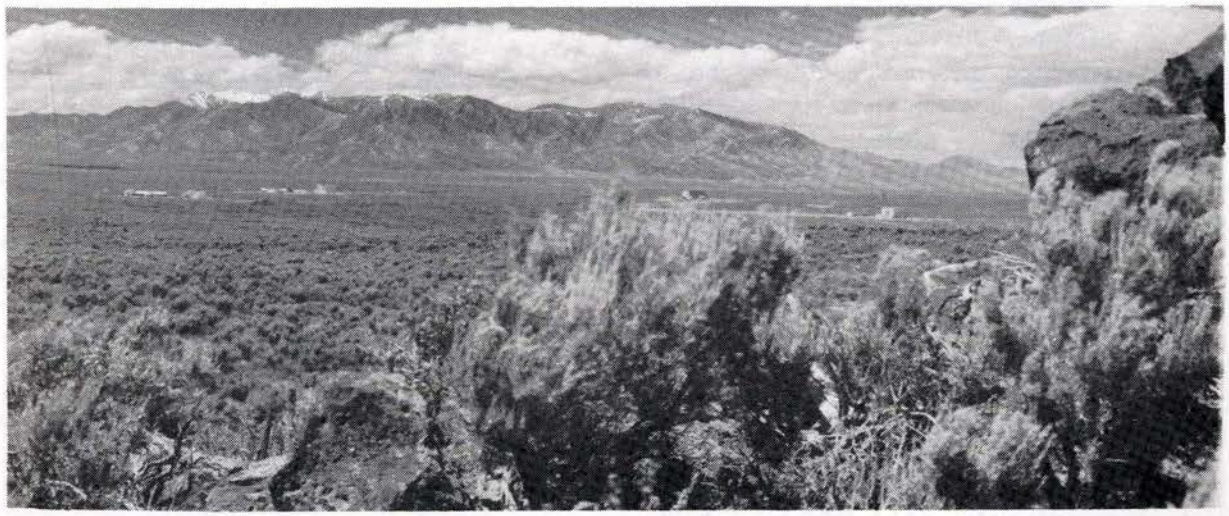

Figure 2. Typical vegetation on the INEL Site.

SIGNIFICANT ENVIRONMENTAL ACTIVITIES

A summary of significant environmental activities which occurred at the INEL during 1987 is given below. Included are the startup of major activities or facilities which may have some environmental impact, Environmental Assessments completed during the year, and important activities to meet environmental permit requirements or regulations. Results of studies of the fate and effect of pollutants from the Site may be found in publications of individual INEL organizations [EG&G, WEC, WINCO, ANL-W, DOE, and the U.S. Geological Survey (USGS)].

- The Environmental Assessment (EA) for the Fuel Processing Restoration (FPR) project at the INEL Site was issued in August 1987.[1] A proposed Finding of No Significant Impact (FONSI) was published in the Federal Register on August 28, 1987. The final FONSI was published on December 8, 1987.
- The Draft Environmental Impact Statement (DEIS) for the proposed Special Isotope Separation (SIS) plant was in preparation during 1987. Scoping meetings were held at Boise and Idaho Falls, Idaho, in February 1987.
- The Prevention of Significant Deterioration (PSD) air quality permit for the FPR from the State of Idaho was submitted in 1986 and was still pending at the end of 1987.
- The New Waste Calcining Facility (NWCF) recommenced hot operations on September 30, 1987. The facility had not processed high-level liquid waste into the dry granular calcine form since June 1984, when the first production run was completed. Maintenance and modifications were performed during the idle period.
- A Consent Order and Compliance Agreement (COCA) between the DOE, the Environmental Protection Agency (EPA), and the USGS was signed by DOE/ID and EPA Region 10 on July 10, 1987. The USGS acts as technical consultant to both EPA and DOE under the COCA and conducts independent reviews of all hydrogeological data. The COCA incorporates an action plan, which DOE began implementing 10 months before the signing of the COCA, by which DOE will address compliance with regulations governing past hazardous waste land disposal sites at the INEL. The ambitious schedule outlined in the action plan for 350 currently identified Resource Conservation and Recovery Act (RCRA) regulated units has been adhered to by the DOE and its INEL contractors.
- The first phase of a DOE Headquarters Environmental Survey was conducted at the INEL from September 14 through October 2, 1987. This phase of the survey was an intensive on-site inspection of all INEL activities which might have any effect on the environment or the health and safety of the public. The report of the survey findings was being drafted at year end. Potential problem areas were identified, which will be further investigated by a sampling team from Oak Ridge National Laboratory in May of 1988.
- The USGS was requested by the DOE/ID office to sample ground water under the Radioactive Waste Management Complex (RWMC) for carbon tetrachloride in June of 1987. Identification of carbon tetrachloride in samples from the Snake River Plain aquifer confirmed that migration had occurred to the aquifer. For the significance of releases of organic compounds to the aquifer, see the section on "Water Sampling." A Corrective Action Plan was submitted to the EPA in 1988.
- The presence of organics in the Snake River Plain aquifer prompted DOE/ID to monitor all production wells and important observation wells on the INEL. The USGS and EG&G conducted a sampling of ground water at the INEL for purgeable organic compounds from June to November 1987. A summary of results is given in the section on "Water Sampling" of this report. The complete results are available in DOE/ID-22074.[2]
- The sampling of production wells at Test Area North (TAN) showed concentrations of trichloroethylene above the new EPA maximum contaminant level (MCL) for non-transient, non-community drinking water supplies. Samples obtained at the point of

consumption were below the MCL. A decision has been made to treat the potable water supply at TAN. A Corrective Action Plan was submitted in 1988.

- Corrective action is also being pursued under an approved action plan for the Test Reactor Area (TRA) warm waste ponds.
- The General Accounting Office investigated the progress of the INEL and other DOE sites in complying with RCRA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations as they relate to remediation of closed and inactive hazardous waste sites. The report was being drafted at the end of the year.
- DOE/ID is discussing an agreement with EPA Region 10 to resolve RCRA/CERCLA overlap issues and to address INEL compliance with CERCLA.
- In December, 1987, there were two small nitric acid spills. Both were confined to the immediate vicinity of the spill. The approximately 50 gallons released at the Idaho Chemical Processing Plant (ICPP) was caused by a valve misalignment. The spill of about 200 gallons at the Specific Manufacturing Capability (SMC) plant was caused by incompatible materials and an underrated hydraulic hose. Both spills were cleaned up.
- Low concentrations of plutonium were found at the 110-ft level below the RWMC. These concentrations of plutonium are thought to be the result of snowmelt floods at the RWMC in the 1960's. Since that time, flood control measures and waste disposal practices have been significantly improved. The subsurface investigation program at the RWMC has been accelerated to better understand the migration of radionuclides beneath the RWMC.
- During 1987, 13 approvals were obtained by the INEL from Region 10 of the EPA for construction of new sources or modification of existing sources of radionuclide emissions. The approvals are now required by Title 40, Part 61, of the Code of Federal Regulations, National Emission Standards for Hazardous Air Pollutants (NESHAP). Three other approvals were pending at the end of the year. Most of the sources release very small quantities of radionuclides.

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 include passage 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; thus, the aquifer is not presently a pathway to offsite populations.

The environmental monitoring program for the Site and vicinity for 1987 included the collection and analysis of samples from potential exposure pathways. Table I summarizes the offsite program, and Table II summarizes the onsite program. Measurements at Site boundary and onsite locations are compared to measurements at distant locations to assess the impact of INEL Site operations on the environment. Concentrations of radioactive and some nonradioactive pollutants in the environment

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 × 10^8 mL	20	8 × 10^{-15} μCi/mL
	HTO[a]	3 to 7 weeks	1	1 to 2 × 10^7 mL	20	1 × 10^{-11} μCi/mL
	Specific gamma	Quarterly	11	3 to 5 × 10^9 mL	60	1 to 10 × 10^{-15} μCi/mL
	Pu	Quarterly	4	3 to 5 × 10^9 mL	1000	6 × 10^{-18} μCi/mL
	Am	Quarterly	4	3 to 5 × 10^9 mL	1000	8 × 10^{-18} μCi/mL
	Sr-90	Quarterly	4	3 to 5 × 10^9 mL	50	1 × 10^{-16} μCi/mL
	Particulate matter	Quarterly	11	3 to 5 × 10^9 mL	N/A[b]	10 μg/m^3
Water	Gross alpha	Semiannually	14	100 mL	60	3 × 10^{-9} μCi/mL
	Gross beta	Semiannually	14	250 mL	20	5 × 10^{-9} μCi/mL
	HTO	Semiannually	14	10 mL	20	4 × 10^{-7} μCi/mL
Milk	I-131	Monthly[c]	11	3800 mL	1000	1 × 10^{-9} μCi/mL
	Sr-90	Annually	11	1000 mL	20	2 × 10^{-9} μCi/mL
	H-3	Annually	11	10 mL	100	4 × 10^{-7} μCi/mL
	I-129	Annually[d]	3	3800 mL	10	3 × 10^{-10} μCi/mL
Wheat	Specific gamma	Annually	10	2500 g	1000	4 × 10^{-9} μCi/g
	Sr-90	Annually	10	500 g	20	4 × 10^{-9} μCi/g
Lettuce	Specific gamma	Annually	8	30 g (dry wt)	1000	2 × 10^{-7} μCi/g
	Sr-90	Annually	8	30 g (dry wt)	20	8 × 10^{-8} μCi/g
Soil	Specific gamma	Biennially	10	400 g[e]	1000	4 × 10^{-8} μCi/g
	Pu	Biennially	10	10 g[e]	1000	2 × 10^{-9} μCi/g
	Am	Biennially	10	10 g[e]	1000	3 × 10^{-9} μCi/g
	Sr-90	Biennially	10	10 g[e]	50	9 × 10^{-8} μCi/g
Direct radiation exposure	Thermoluminescent dosimeter	Semiannually	13	5 TLDs per dosimeter	N/A	5 mR

a. Tritiated water.

b. N/A - not applicable.

c. One dairy is sampled weekly.

d. Activation analysis method used.

e. Aliquant from a composited 2000-g sample.

TABLE II
ONSITE MONITORING PROGRAM SUMMARY

Medium Sampled	Type of Analysis	Frequency of Analysis	Number of Samples	Sample Size	Count Time (min)	~Minimum Detectable Concentration (MDC)
Air	Low-Volume Samplers:					
	Gross beta	Weekly	12	1 to 4 × 10^8 mL	20	8 × 10^{-15} μCi/mL
	Specific gamma	Quarterly	12	3 to 5 × 10^9 mL	60	1 to 10 × 10^{-15} μCi/mL
	Pu	Quarterly	6	3 to 5 × 10^9 mL	1000	6 × 10^{-18} μCi/mL
	Am	Quarterly	6	3 to 5 × 10^9 mL	1000	8 × 10^{-18} μCi/mL
	Sr-90	Quarterly	2	3 to 5 × 10^9 mL	50	1 × 10^{-16} μCi/mL
	Particulate matter	Quarterly	12	3 to 5 × 10^9 mL	N/A[a]	10 μg/m^3
	High-Volume Samplers:					
	Gross gamma	Daily	2	2 × 10^9 mL	10	N/A
	Specific gamma	Monthly	2	6 × 10^{10} mL	60	1 to 10 × 10^{-16} μCi/mL
	Kr-85 Sampler	Biweekly	1	6 to 10 × 10^5 mL	100	2 × 10^{-12} μCi/mL
	Tritium Samplers:					
	H-3 as HTO	3 to 7 weeks	2	1 to 2 × 10^7 mL	20	1 × 10^{-11} μCi/mL
	TSP Sampler	Weekly[b]	1	2 × 10^3 m^3	N/A	2 μg/m^3
Water	Drinking Water:					
	Gross Beta	Monthly	26	250 mL	20	5 × 10^{-9} μCi/mL
	Gross Alpha	Monthly	26	100 mL	60	3 × 10^{-9} μCi/mL
	Sr-90	Monthly	2	4000 mL	20	5 × 10^{-10} μCi/mL
	H-3 as HTO	Monthly	26	10 mL	20	4 × 10^{-7} μCi/mL
	Surface Water Ponds:[c]					
	Specific gamma	Monthly	2	50 mL	60	Varies[d]
	Sr-90	Monthly	2	50 mL	20	5 × 10^{-8} μCi/mL
	H-3 as HTO	Monthly	2	10 mL	20	4 × 10^{-7} μCi/mL
	I-129	Quarterly	1	4000 mL	20	4 × 10^{-10} μCi/mL
	U	Composite[e]	1	500 mL	1000	8 to 20 × 10^{-11} μCi/mL
	Am	Composite[e]	1	500 mL	1000	5 × 10^{-11} μCi/mL
	Pu	Composite[e]	1	500 mL	1000	4 × 10^{-11} μCi/mL
	pH	Monthly	2	50 mL	N/A	N/A
	Na^+, Cl^-	Monthly	2	100 mL	N/A	5 mg/L
	Chromium (total)	Quarterly	1	100 mL	N/A	5 × 10^{-2} mg/L
Soil	Specific gamma	Annually[f]	Varies[g]	400 g[h]	1000	4 × 10^{-8} μCi/g
	Pu	Annually	Varies	10 g	1000	2 × 10^{-9} μCi/g
	Am	Annually	Varies	10 g	1000	3 × 10^{-9} μCi/g
	Sr-90	Annually	Varies	10 g	50	9 × 10^{-8} μCi/g
Direct radiation exposure	Thermoluminescent dosimeter	Semiannually	135	5 TLDs per dosimeter	N/A	5 mR
	Gamma radiation surveys	Annually[i]	N/A	N/A	N/A	N/A

a. Not applicable.

b. Sampler operates for 24 hours every six days. Sampler was not operating for most of 1987.

c. TRA and ICPP infiltration ponds.

d. Considerable variation in ~MDC depending on which nuclides are present in the sample.

e. Portions of the three monthly samples are composited each quarter for these analyses.

f. Onsite soil sampling is performed each year at a different facility. Facilities are sampled on a rotating seven-year schedule.

g. The number of soil samples collected varies with the facility.

h. Aliquant from a composited 2000-g soil sample.

i. Surveys performed each year at different facilities on a rotating 3-year schedule.

are compared to applicable standards and guides (see the section "Environmental Standards, Regulations, and Permits") and to background and natural radioactivity. Most radioactive concentrations in this report are compared to the derived concentration guides provided in a DOE memorandum to field offices.[3]

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. Environmental radiation exposure rates (cumulative from November 1986 to November 1987) were measured at many onsite, boundary, and distant locations.

A discussion of each routine program follows. A brief summary of the results for each program is given in the text, and a more detailed data summary is presented in tables in Appendix B. The section on "Quality Assurance" provides information on some of the quality control and quality assurance activities conducted by the Radiological and Environmental Sciences Laboratory (RESL). Appendix C gives a brief discussion of the statistics used to analyze the data in this report.

Air Sampling—Radiological. Airborne particulate radioactivity is monitored continuously by a network of 12 air samplers onsite and 11 air samplers offsite at the locations shown in Figure 3. Locations of onsite samplers were selected to give adequate coverage in the event of facility releases of radioactivity. Seven offsite air samplers are located near the Site boundary in communities when possible, or at noncommunity locations when needed to encompass the perimeter of the Site. Four samplers are located at the distant communities of Blackfoot, the Craters of the Moon National Monument, Idaho Falls, and Rexburg to provide background measurements for comparison with data from boundary or onsite samplers which might be affected by Site operations. The background (distant) locations are in directions usually crosswind to the Site and are sufficiently remote to ensure that radioactivity detected is primarily 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.

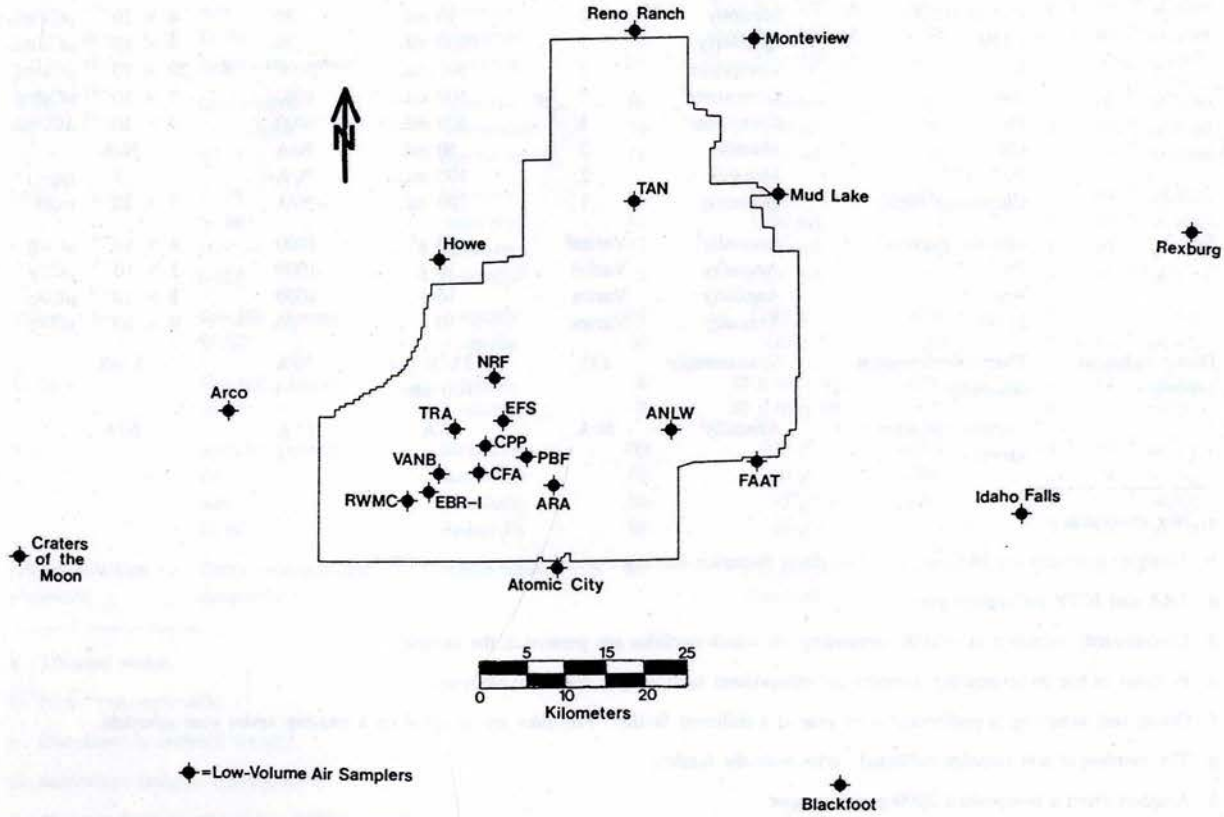

Figure 3. INEL Site and vicinity air sampling network.

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 V-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.

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

Samplers for tritium in water vapor are located offsite in Idaho Falls and onsite at the the Experimental Field Station (EFS) and Van Buren. 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, the Central Facilities Area (CFA). Ambient air is collected continuously in a large Tedlar bag. Twice a month the sample, about 0.75 m^3 of air, is compressed into a cylinder. Two cylinders are shipped each month to the EPA Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) for analysis.

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 (particulate beta) analysis is performed on each filter in a low background beta counter. If the beta activity on a membrane filter exceeds an action level of about 1×10^{-12} μCi/mL, or if a Site release is suspected, 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 an action level of 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 composites from one distant location and four onsite locations are analyzed each quarter for specific alpha-emitting radionuclides. The composites from another distant location and four other onsite locations are analyzed each quarter for Sr-90. Six offsite and four onsite location composites are analyzed on alternating schedules. During one quarter, five composites are submitted for alpha-emitting nuclides and five for Sr-90; during the next quarter, the groups are reversed for the other analyses.

Analyses for the alpha-emitting nuclides utilize chemical separation techniques followed by alpha spectrometry; for Sr-90, the chemical separation is followed by beta counting. Tritium concentrations are determined by liquid scintillation counting of water extracted from the silica gel columns. EMSL-LV analyzes for Kr-85 by condensing the samples at liquid nitrogen temperature and using gas chromatography to separate the krypton gas. The separated gas is dissolved in a scintillation cocktail and counted in a liquid scintillation counter.[4]

The quantity and identity of radionuclides released from Site facilities are reported monthly in the Radioactive Waste Management Information System (RWMIS) report.[5] Specific radionuclide analyses are more sensitive indicators than beta analyses of the impact of Site operations on the environment. Therefore, whenever any question exists as to Site impact, release data from the RWMIS report is compared to the specific radionuclide analyses.

The particulate beta activity is determined weekly for both filters as a screening technique to give timely information in the event of Site releases or worldwide fallout. This information may be difficult to interpret, however, due to local variations in particulate beta levels at any given time or location. Any of several factors may be responsible for the variations observed. Dust or soot loading on individual filters, varying concentrations of natural radioactivity at different locations, and uneven

distribution of worldwide fallout radioactivity as a result of diverse local meteorological conditions are examples of these factors. When interpreting air sampling data, more reliance is placed upon the results and comparisons of specific nuclide data than upon particulate beta concentrations because the source of the radioactivity on the filters can be more easily determined from the specific nuclide concentrations. Specific nuclide analyses are generally more sensitive than particulate beta analyses.

Results of particulate beta activity on the membrane filters for 1987 are summarized in Table B-1, Appendix B.

The particulate beta activity measured at each onsite and each boundary location was statistically compared to beta activity measured at the group of distant locations for each month and for the entire year. Table B-2, Appendix B, shows 1987 results of the monthly and annual statistical comparisons of boundary and onsite locations to the distant community group mean particulate beta activity. Site operations information and meteorological data were considered in each case where a location or group was demonstrated to be statistically greater than the distant location group.

Through early October, 32 selected weekly onsite filters with particulate beta concentrations that were higher than usual were submitted for gamma spectrometry. In all cases, those filters showed detectable concentrations of Sb-125, one of the effluents of the fuel-dissolution process at the Fluorinel and Fuel Storage Facility (FAST) at the ICPP. One-half of the monthly average onsite particulate beta concentrations were statistically greater than at the distant locations, due primarily to the Sb-125 released from the FAST facility. This process was shut down from mid-October to mid-December, and no monthly averages were statistically greater in November than at the distant locations. In December, one-half of the onsite stations had monthly average particulate beta concentrations statistically greater than the distant location average. This was primarily due to higher concentrations onsite in the last two weeks of December, especially in the last week of the month. Although none of the weekly low-volume particulate filters were submitted for gamma spectrometry in December, the presence of Sb-125 was confirmed by the December composite of the high-volume particulate filters from EFS and CFA. The patterns seen in onsite stations with statistically significant particulate beta concentrations are consistent with specific nuclide analyses for Sb-125 and are therefore attributable to the fuel dissolution process at FAST. The onsite group mean was also statistically greater than the distant group for January, May, August, September, and December.

Two boundary locations, Atomic City and Howe, had monthly mean particulate beta concentrations which were statistically greater than the distant group for two months at each location (see Table B-2, Appendix B). The boundary group mean particulate beta concentration for April was also statistically greater than the distant group. Annual mean concentrations were statistically greater for all onsite stations (except ARA) and for the Atomic City boundary station. The higher particulate beta concentrations again appear to be due to Sb-125 releases, which will be discussed further in the paragraph on specific nuclide analyses.

The average monthly concentrations of particulate beta activity for onsite, boundary, and distant location groups are shown in Figures 5 and 6 for 1979 through 1987. The shaded bar represents an atmospheric nuclear weapons test by a foreign nation, and the figured bar represents the Chernobyl accident. It can be seen that particulate beta activity usually increased markedly as a result of the fallout from weapons tests and also peaked dramatically after the Chernobyl accident. In recent years, there also appears to be a pattern of variation, with higher concentrations occurring near the end and the beginning of each year, except for the end of 1987. Reasons for this variation are unknown but may be related to wood smoke loading of the filters during cooler months and/or to meteorological conditions. The 1987-1988 winter was quite mild in the vicinity of the INEL.

Only one of the charcoal-impregnated filters (at ICPP) had a gross beta activity above the action level of approximately 7×10^{-14} μCi/mL, thus requiring gamma spectrometry analysis. However, some of the other filters had detectable beta concentrations. Two of these, one from ICPP and one from TRA, were also examined for specific nuclides; and all three filters had only Sb-125.

Results of the quarterly specific radionuclide analyses of membrane filter composites are summarized in Table B-3, Appendix B. Beryllium-7, a radionuclide produced by the interaction of cosmic radiation and nitrogen in the atmosphere, is excluded. Radionuclides included in Table B-3 are those which could potentially be released from INEL Site operations. The following radionuclides were measured at concentrations near the minimum detectable concentration at only one offsite location during the year and were nondetectable at all other offsite locations: Ce-141 and Co-60, first

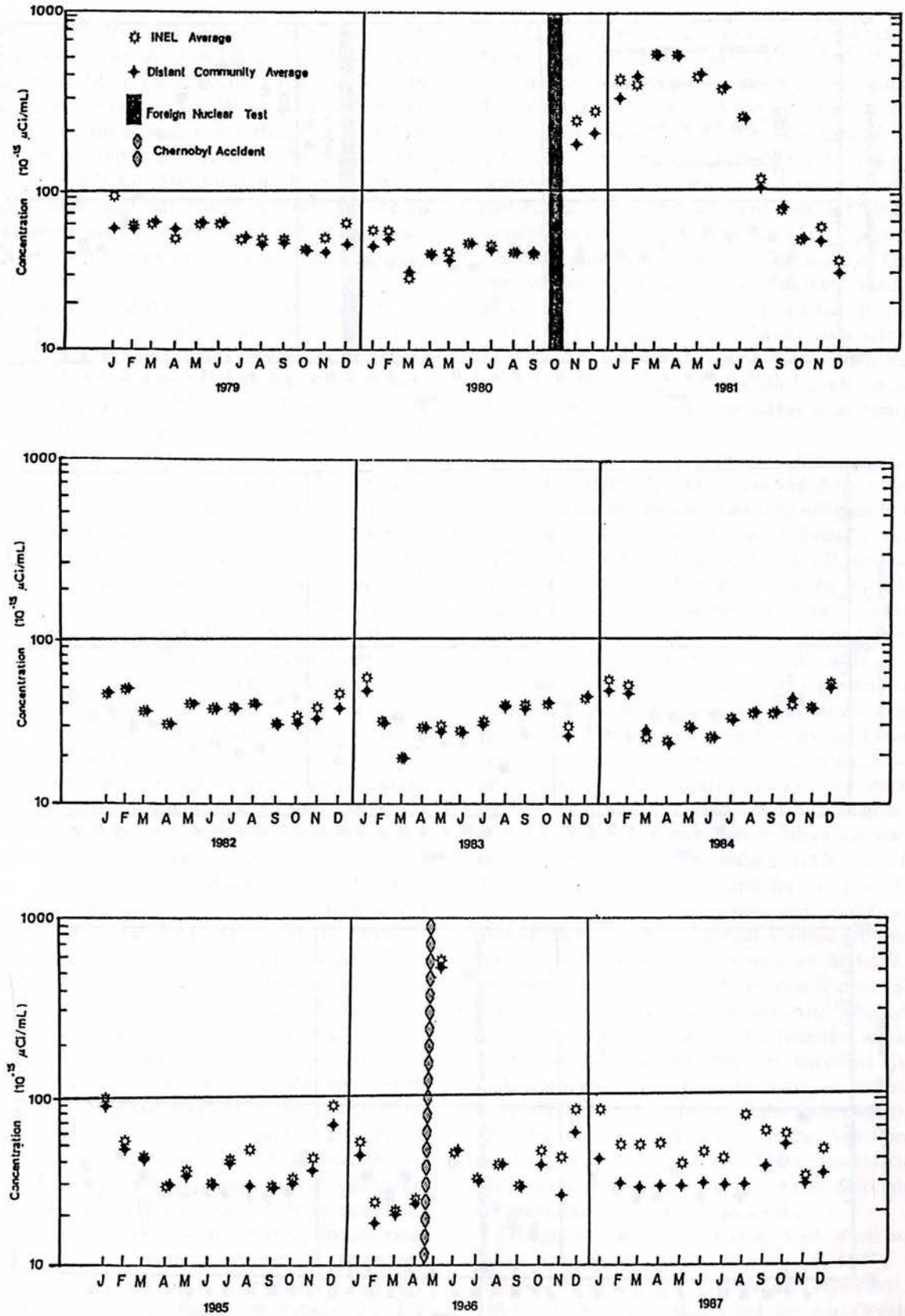

Figure 5. Onsite and distant particulate beta concentrations in air.

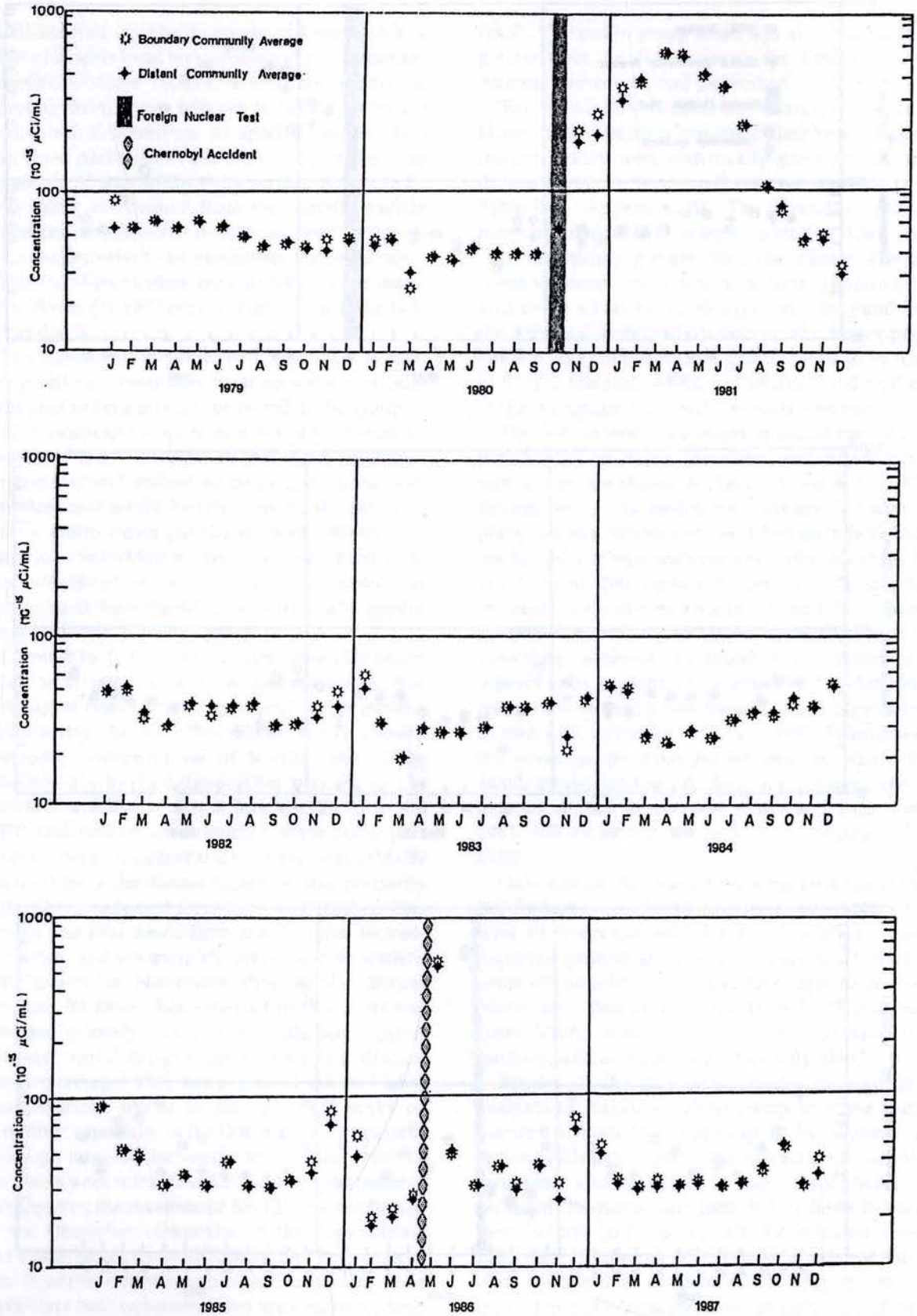

Figure 6. Boundary and distant particulate beta concentrations in air.

quarter at Craters of the Moon; Ru-103, first quarter at Blackfoot; and Am-241 and Pu-238, second quarter at Mud Lake. None are believed to be related to Site operations. When the reported concentrations are so low, it is difficult to draw firm conclusions about the source of the radioactivity (see Appendix C). Statistical methods, meteorological data, and Site release information are all considered when interpreting or evaluating results that are near the minimum detectable concentration.

Three radionuclides were detected in low concentrations on one or two onsite filter composites: Cs-134, Mn-54, and Zr-95. Although investigations did not reveal any particular source, these may be due to Site operations. All were at or less than 0.001% of the appropriate derived concentration guide.

Four radionuclides, Ce-141, Cs-137, Am-241, and Pu-239, were detected onsite three, four, five, and two times respectively. These are probably related to Site operations, although most were not linked to a particular facility or release. Detectable concentrations of Am-241 and Pu-239/240 frequently occur at the RWMC due to resuspension of contaminated soil in the area. However, none of the concentrations were above 0.4% of the appropriate derived concentration guide.

During the first half of 1987, Sr-90 was detected in 11 of 12 analyses (onsite and offsite). The uniform deposition would indicate a source distant from the INEL. In the last half of 1987, Sr-90 was only detected once, at the Naval Reactors Facility (NRF). The maximum concentrations measured were 0.002% of the derived concentration guides.

As discussed earlier, Sb-125 was released during fuel reprocessing at the FAST facility. The analytical results for Sb-125 for all of the quarterly filter composites are shown in Table B-4, Appendix B. Table B-4 includes results considered below the minimum detectable concentration and negative results to aid in computing averages. Antimony-125 was detectable at almost all onsite stations in each of the first three quarters and at two-thirds of the onsite stations in the fourth quarter. The FAST facility did not reprocess fuel from mid-October to mid-December. During the year, Sb-125 was found on 11 out of 27 filter composites from boundary stations and on two of 16 filters from distant locations. Figure B-1, Appendix B, depicts the annual averages geographically. The highest average annual Sb-125 concentration was measured at the ICPP at 9.7×10^{-14} μCi/mL (0.01% of the derived concentration guide). The maximum Sb-125 measured at a boundary station was at Howe, northwest of the ICPP, at 4.8×10^{-15} μCi/mL (0.0005% of the derived concentration guide). The average annual Sb-125 concentration at Craters of the Moon National Monument was 2.2×10^{-15} μCi/mL (0.0002% of the derived concentration guide). As mentioned earlier, 32 weekly particulate filters were also analyzed for Sb-125. Concentrations ranged up to 7.3×10^{-13} μCi/mL measured on a filter from the ICPP station. Three charcoal-impregnated filters were also analyzed for Sb-125. The ratio of Sb-125 on the particulate filter to that on the charcoal filter ranged from 1.1:1 to 2.5:1. These few data indicate that a significant fraction of the Sb-125, at least close to the source, was still in the gaseous state rather than being a particulate.

Comparisons of onsite group mean concentrations to boundary group means and distant community means revealed no statistical differences for any quarter for any nuclide detected onsite except Zr-95 and Sb-125. Differences for Sb-125 were seen in the first and second quarters, but the statistical tests did not show a higher onsite or boundary group mean concentration in the third and fourth quarters of 1987. The Sb-125 annual onsite group mean concentration was statistically greater than both the boundary group mean concentration and the distant community mean. The annual boundary group mean concentration of Sb-125 was greater than the distant community mean. Zirconium-95 was detected during the first quarter of 1987 at ARA. The onsite group mean was statistically greater than the boundary group mean for Zr-95 for the first quarter and for the year. The annual boundary group mean was statistically greater than the annual distant community mean for Cs-134, although Cs-134 was not detected at any boundary location. After considering Site releases of Zr-95 and Cs-134 and their infrequent detection onsite, the statistical differences are not attributable to Site operations (see Appendix C).

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

Compressed air samples from CFA were analyzed for Kr-85 from January 5, 1987, to January 4, 1988; and results are reported in Table B-5, Appendix B. Except for mid-October through mid-December, samples reflected effluents from fuel processing. The annual average

concentration of 1.73×10^{-10} μCi/mL is only 0.006% of the derived concentration guide for radiation protection of the public. (See the section entitled "Environmental Standards, Regulations, and Permits.)

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 1987 is given in Table B-6, Appendix B. 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 from 8 to 170 $\mu g/m^3$. The distant mean was 39 $\mu g/m^3$, the boundary mean was 45 $\mu g/m^3$, and the onsite mean was 28 $\mu g/m^3$. The distant mean is statistically greater than the onsite mean, which is probably due to the amount of resuspended dust from agricultural operations near the distant sampling locations. Most of the airborne particulates in the Site vicinity are windblown dust from the desert floor. The above concentrations may be compared to the EPA national secondary ambient air quality standard for particulate matter of 60 $\mu g/m^3$. On July 1, 1987, the EPA revised the standard for particulate matter to 50 $\mu g/m^3$. The new standard is a primary and secondary standard, but it applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers."[6] Measurements of total suspended particulates, such as those reported here, will overestimate particulate concentrations in comparison with the new standard.

The average sulfur dioxide and nitrogen dioxide concentrations at the Site boundary were calculated using the total 1987 discharges as reported in the Industrial Waste Management Information System Report (IWMIS)[7] and a computer model (MESODIF) of the dispersive characteristics of the air for 1987. The calculational 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, located at the intersection of Van Buren Boulevard and U.S. Highway 20/26, was not operated during 1987; but the nitrogen oxides analyzer is being reactivated.

Total sulfur dioxide released in 1987, shown in Table B-7, Appendix B, was about 1.7×10^5 kg. The maximum offsite concentration of sulfur dioxide, where the MESODIF model predicted the highest concentration, was 0.5 $\mu g/m^3$, which is well below the national primary ambient air quality standard of 80 $\mu g/m^3$.

The releases of nitrogen oxides during 1987 are also shown in Table B-7, Appendix B. When the nitrogen oxide is converted to nitrogen dioxide, the total of the latter released was about 4.8×10^5 kg. The calculated maximum offsite concentration of nitrogen dioxide was 1.4 $\mu g/m^3$ from all INEL sources. This concentration is well below the national primary ambient air quality standard of 100 $\mu g/m^3$.

Water Sampling. There are no streams or rivers flowing from onsite to offsite locations. Therefore, water sampling is limited to ground-water monitoring onsite and offsite plus samples from the Snake River, which flows entirely offsite at a considerable distance from the Site boundaries. The Snake River Plain aquifer, which lies beneath the INEL Site, serves as a primary source for drinking water and irrigation of crops in the Snake River Basin. Onsite and offsite water samples are collected routinely to monitor the movement of waste substances, both radioactive and nonradioactive, through the aquifer. RESL collects offsite drinking water and Snake River water samples, as summarized in Table I cited earlier. Approximate locations of these samples are shown in Figure 7. Onsite drinking water samples are collected monthly from production (drinking water) wells in use at active Site facilities.

In addition to the production well monitoring performed by RESL, the USGS extensively monitors ground water on the INEL Site and at a few locations beyond the southern and western Site boundaries. The USGS maintains more than 120 observation wells on or near the INEL, and more than 100 wells and auger holes are available for sampling perched ground-water bodies. Water levels in wells and various radiological and nonradiological substances in the aquifer are monitored. Reference 8 contains maps showing the frequency of water level measurements and of water sample collections, as well as information on the shape and extent of waste plumes (i.e., the spread of various contaminants in the aquifer and perched water from INEL facilities). The routine USGS groundwater monitoring program is summarized in Table III.

In addition to the routine samples described in Table III, 29 production well samples and 5 monitoring well samples were submitted by the USGS to RESL for analysis of sodium, chloride, gamma

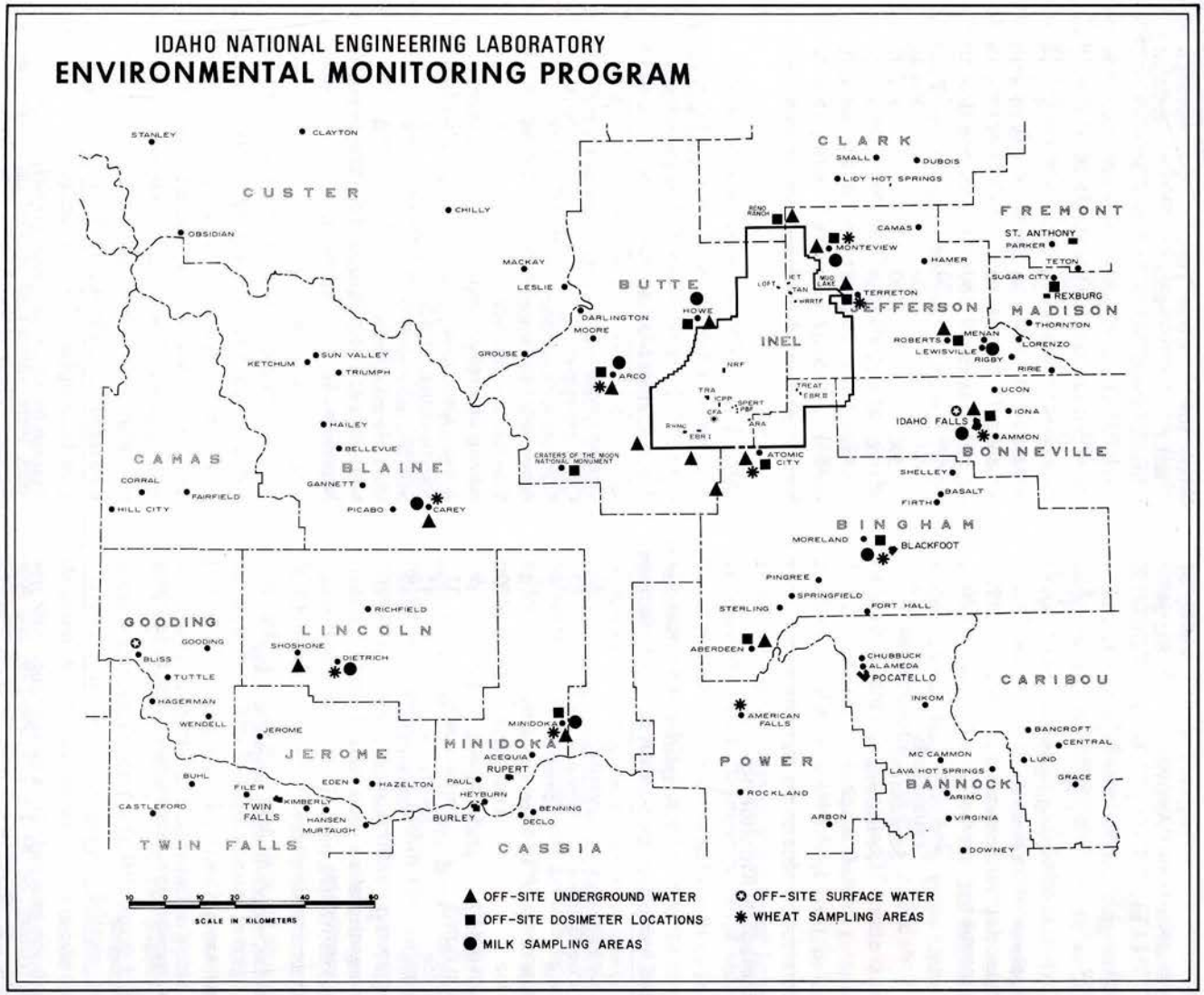

Figure 7. Offsite water, milk, and wheat sampling locations and environmental dosimeter locations.

TABLE III
USGS GROUND-WATER 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	Semiannually[a]	5	100	60	3×10^{-9}
Gross beta	Semiannually[a]	5	250	20	5×10^{-9}
HTO[b]	Quarterly	45	10	20	4×10^{-7}
HTO	Semiannually[a]	82	10	20	4×10^{-7}
Specific gamma	Quarterly	6	400	60	1 to 10×10^{-8}[c]
Specific gamma	Semiannually	17	400	60	1 to 10×10^{-8}
Specific gamma	Annually	26	400	60	1 to 10×10^{-8}
Sr-90	Quarterly	27	400	20	5×10^{-9}
Sr-90	Semiannually	26	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	20-35	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	45	Conductometric	N/A[d]
Specific Conductance	Semiannually[a]	82	Conductometric	N/A
Sodium ion	Quarterly	5	Selective ion electrode	5
Sodium ion	Semiannually	2	Selective ion electrode	5
Sodium ion	Annually	100	Selective ion electrode	5
Chromium (total)	Quarterly	19	Atomic absorption	0.05
Chromium (total)	Semiannually	33	Atomic absorption	0.05
Chloride ion	Quarterly	45	Selective ion electrode	5
Chloride ion	Semiannually[a]	82	Selective ion electrode	5
Nitrates (as NO_3)	Annually	60	Ion chromatography	0.5
Major inorganic water quality constituents	~ 5 years	65	Methods and MDC's listed in USGS Open File Report 86-232	

a. In addition, one offsite well is sampled annually.

b. Tritiated water.

c. Varies depending upon radionuclides present in the sample.

d. Not applicable.

emitters, tritium, Sr-90, Pu-238, Pu-239, and Am-241. USGS personnel also collected samples during 1987 which were submitted to other laboratories for special analyses. Four water samples were submitted to the USGS National Water Quality Laboratory in Arvada, Colorado, for analysis for 18 parameters (metals and common ions); 93 samples were submitted to the same laboratory for analysis for 9 parameters (primarily trace metals); and 24 extra samples (84 total) were submitted to the WINCO laboratory at ICPP for nitrate analyses.

Sampling for purgeable organic compounds in ground water was conducted by the USGS and

EG&G at the INEL Site during June to November 1987. Water samples from 30 production wells and 51 ground-water quality monitoring wells that tap the Snake River Plain aquifer and that are equipped with dedicated pumps were collected and analyzed for 36 purgeable organic compounds. The ground-water samples were analyzed at the USGS National Water Quality Laboratory. In addition, 39 duplicate samples were analyzed at the Environmental Chemistry Laboratory operated by the DOE's contractor, EG&G. Methods used to collect the water samples, results of analyses, and quality assurance instituted for the sampling program are described in detail in the USGS report entitled "Purgeable Organic Compounds in Ground Water at the Idaho National Engineering Laboratory, Idaho," DOE/ID-22074.[2]

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 8 and 9.

All radioactivity detected in offsite and onsite drinking water samples collected by RESL is evaluated in this report. USGS results are published periodically in documents such as References 8 and 9 and are briefly discussed here. Contractor personnel collect drinking water samples for bacteriological tests monthly. Results of these analyses are included in this report only when a contamination problem occurs.

In addition to the gross alpha, gross beta, and tritium analyses that are routinely performed on the water samples collected by RESL, Sr-90 analyses are also performed each month on samples from drinking water wells in the ICPP area. 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. Strontium-90 is separated from the sample chemically. After an ingrowth period, its Y-90 daughter is separated chemically and counted in a low-background beta counter to determine the amount of Sr-90 present initially in the sample. Iodine-129 is separated from a 4-liter water sample by sorption onto a column of anion exchange resin. It is back-extracted and redeposited on another resin column. The I-129, now in a small capsule, is activated by neutron irradiation in the Advanced Test Reactor to I-130. The I-130 is measured by gamma spectrometry. The minimum detectable concentrations for gross alpha, gross beta, tritium, and Sr-90 are 3×10^{-9}, 5×10^{-9}, 4×10^{-7}, and 5×10^{-10} μCi/mL, or about 10%, 5%, 0.02%, and 0.05%, respectively, of the DOE derived concentration guides for members of the public. These minimum detectable concentrations are also 20%, 10%, 2%, and 6%, respectively, of limits or derived concentrations for community drinking water listed by the EPA in 1987.

Less than one-third of all drinking water samples collected in 1987 contained detectable concentrations of gross alpha or gross beta activity. Three of the 43 offsite water samples collected by RESL or USGS in 1987 contained detectable gross alpha activity, and only two of the 285 onsite drinking water samples had detectable gross alpha activity. All concentrations were at $3 \pm 2 \times 10^{-9}$ μCi/mL or lower. Eighty-four of the 285 onsite samples and 14 of the 43 offsite samples showed gross beta concentrations of $8 \pm 4 \times 10^{-9}$ μCi/mL or lower, i.e., near the minimum detectable concentration. At these low concentrations, it is difficult to draw firm conclusions about the presence of the radioactivity (see Appendix C). Natural radioactivity is found in the Snake River Plain aquifer in areas upgradient, parallel to, and far distant from the INEL Site, which may explain the presence of low concentrations of gross alpha and gross beta activity. Annual averages for gross alpha and gross beta activity at all locations were below the EPA community drinking water standards.

Offsite water samples did not contain detectable concentrations of tritium. Some samples from onsite wells which lie within the tritium plume[8] consistently contain detectable concentrations of tritium. Data from these wells are presented in Table B-8, Appendix B. Samples from two of the ICPP production wells usually have detectable concentrations of Sr-90. These data are also presented in Table B-8. The highest annual average concentration of tritium in onsite drinking water (at CFA) is 1.5% of the derived concentration guide for radiation protection. For Sr-90, the highest annual average concentration (at ICPP) was 0.15% of the derived concentration guide. Tritium was first detected in some of the wells just inside the southern Site boundary in 1983, but was not detected in samples from those wells collected during 1987. It has never been detected in the nearest offsite well, which is about 0.8 km (0.5 mi) south of the Site boundary. This appears to indicate that the tritium waste plume has reached the Site boundary but has not yet traveled offsite in measurable concentrations.

Ground-water samples were collected from 35 wells in August 1986 for I-129 analyses. The results were not available in time to be included in the 1986 report. Concentrations of I-129 ranged from less than the minimum detectable concentration of about 3×10^{-10} μCi/mL to $3.6 \pm 0.4 \times 10^{-9}$ μCi/mL (0.7% of the derived concentration guide), near the ICPP. The 1986 results represent a marked decrease from the 1981 concentrations for most of the wells sampled in both years, particularly near the ICPP. None of the three production wells at ICPP had detectable I-129 concentrations in 1986. The CFA-1 production well sample contained $4.9 \pm 1.2 \times 10^{-10}$ μCi/mL I-129. The CFA-2 sample did not contain detectable I-129. The above concentrations of I-129 at CFA, together with the tritium concentrations discussed earlier, are estimated to provide an effective dose equivalent of only 0.5 mrem/year to a Site worker at CFA. The I-129 plume was detectable about 9 km (5.6 mi) inside the nearest Site boundary in 1986. A USGS report is being prepared.

As stated above, 29 production well samples and 5 monitoring well samples were analyzed for sodium, chloride, gamma emitters, tritium, Sr-90, Pu-238, Pu-239, and Am-241. Radioactivity has been detected in the past in the abandoned TAN disposal well, and the October sample contained the listed radionuclides as well as Cs-137 and Co-60. In three production well samples, analyses for one radionuclide each were just above the minimum detectable concentration (see Appendix C). In a fourth sample, one radionuclide was indicated at about twice the minimum detectable concentration, but that radionuclide was not detected in a February 1988 sample or in a larger April 1988 sample. All of the four production well concentrations, if valid, were much less than the derived concentrations producing a 4-mrem dose equivalent, the EPA maximum contaminant level for community drinking water systems. In addition, four production wells had measurable tritium, within or lower than the ranges in Table B-8, Appendix B. No other radionuclides were detected in any of the other wells sampled.

Strontium-90 analyses were above the minimum detectable concentration only for those samples collected within 3.2 km (2.0 mi) of the former disposal well at ICPP, or approximately 9.8 km (6.1 mi) inside the nearest Site boundary.[10] The estimated minimum detectable concentration for Sr-90 is about 5×10^{-9} μCi/mL, or about 0.5% of the derived concentration guide. Isotopes of cesium and plutonium are even less mobile in the aquifer than strontium.[8]

Two samples from each of five offsite USGS wells beyond the southern and western Site boundaries were submitted for gamma spectrometry. Only one sample indicated detectable manmade radioactivity. The analysis of the April 8 sample from Cerro Grande, just south of the Site, indicated Cs-137 at a concentration of $7 \pm 6 \times 10^{-8}$ μCi/mL. (See Appendix C for a discussion of measurements near the minimum detectable concentration.) Cerro Grande is far south of the onsite wells in which Cs-137 is occasionally detected, and samples from wells at CFA (between ICPP and Cerro Grande) have never contained detectable concentrations of Cs-137. It is, therefore, very unlikely that Cs-137 is present in the Cerro Grande well.

Nonradiological wastes in the aquifer are determined by measuring the specific conductance and the sodium, total chromium, chloride, and nitrate content of USGS water samples (see References 8 and 9). All of these waste products were at background levels at least 4 km (2.5 mi) inside the nearest Site boundary, indicating that INEL ground-water nonradiological plumes had not migrated offsite by the end of 1986.[10]

In the USGS sampling, 12 of 36 purgeable organic compounds were detected (above 0.2 μg/L), including carbon tetrachloride, chloroform, 1,1,1-trichloroethane, trichloroethylene, tetrachloroethylene, and toluene. Concentrations equal to or greater than 1.0 μg/L (parts per billion) for the individual wells are reproduced in Table B-9, Appendix B. The corresponding well locations are shown in Figure B-2, Appendix B. About half of the wells sampled had at least one organic compound detected in the sample, and about 3% of the 4000 analyses showed detectable concentrations. The highest levels of organic contamination were found in water pumped from a discontinued injection well at TAN (TSF-Injection) and a perched water well at the RWMC (#92), which was sampled with a thief sampler. The limited quantity of water in the wellbore of well #92 and its slow recovery after sampling preclude getting a pumped sample. The TSF injection well, now used only for monitoring, may have been the source of some of the organics found in aquifer samples at TAN. Investigations to determine the source of the contaminants are continuing, and a Corrective Action Plan has been submitted to the EPA in 1988. Samples obtained at the wellhead from the production wells at TAN were slightly above the newly promulgated EPA maximum contaminant level (MCL) for trichloroethylene (TCE). However, samples obtained at the point of

use in the drinking water system were below the EPA MCLs. As an added precaution, water treatment is being pursued to further reduce TCE concentrations. At the RWMC, the carbon tetrachloride is due to solvents in containers of radioactive waste buried prior to 1970. DOE accelerated the RWMC Subsurface Investigation Program in 1987 and submitted a Corrective Action Plan to the EPA in 1988.

Production wells at the Water Reactor Research Test Facility (WRRTF) and TRA also had TCE concentrations above the EPA MCL. An alternate source of drinking water is being provided for the three workers at WRRTF. A split sample and a 1988 sample at TRA showed TCE concentrations below the EPA MCL. For purgeable organic compounds, the concentration is reduced after the water has passed through a storage tank and into the distribution system. In addition, workers at the INEL consume about one-third of their total drinking water while working on the INEL (assumes one-half of daily consumption is onsite for 240 days per year).

Results of nitrate analyses for 1986 samples indicate large decreases in concentrations near the ICPP compared to 1981 samples. Concentrations south of the ICPP are similar to those shown in Reference 8. Nitrate concentrations in CFA-1 and CFA-2 production wells in 1986 were 17 and 11 mg/L, respectively. Converted to concentrations of nitrate as nitrogen for comparison to the EPA MCL for drinking water of 10 mg/L, CFA-1 and CFA-2 concentrations were 3.8 and 2.4 mg/L, respectively, nitrates as nitrogen. Results from 1987 samples will be reported in the 1988 report.

Foodstuff Sampling. Milk, wheat, leafy garden lettuce, and muscle and liver samples from sheep are sampled annually. Muscle and liver samples from beef cattle are sampled biennially and were not sampled in 1987. Because they are part of the typical American diet, these foodstuffs could be pathways to the public for radionuclides from 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 7. Lettuce was collected at Arco, Atomic City, Blackfoot, Carey, Howe, Idaho Falls, Mud Lake, and Pocatello.

Milk samples (146 total) were collected from dairies and single-family milk cows around the Site. Samples are normally collected monthly except in Idaho Falls, where a sample is collected weekly. All milk samples are passed through an anion exchange resin which is then 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 October samples, one each from Carey, Idaho Falls, and Mud Lake, are submitted for I-129 analysis.

In 1987, no milk samples contained detectable concentrations of I-131. Two of the six milk samples from distant areas contained Sr-90 at detectable concentrations of $2.1 \pm 1.6 \times 10^{-9}$ and $1.6 \pm 0.4 \times 10^{-9}$ μCi/mL. The distant group mean concentration was 1.0×10^{-9} μCi/mL. None of the three samples from Site boundary areas had a detectable concentration of Sr-90. The boundary group mean was zero. The distant group mean concentration is consistent with Sr-90 levels reported by the EPA for both Regions VIII and X. Region VIII includes Colorado, Montana, Utah, Wyoming, North Dakota, and South Dakota; and Region X includes Idaho, Alaska, Hawaii, Oregon, and Washington. It seems more appropriate to compare southeastern Idaho results to those of nearby Colorado, Montana, Utah, and Wyoming than to those of Region X. EPA results for their composite samples from Region VIII for four quarters during 1986 and 1987 range from $1.4 \pm 0.4 \times 10^{-9}$ to $1.8 \pm 0.5 \times 10^{-9}$ μCi/mL.[11-14] The origin of Sr-90 in the samples from the Idaho area was probably worldwide fallout.

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

Results for 1987 analyses of milk samples for I-129 showed no detectable concentrations of that nuclide.

Wheat and leafy garden lettuce sampling results are shown in Table B-10, Appendix B.

Lettuce samples were washed with water to remove any soil, as would be done in normal food preparation, then dried and weighed. All lettuce samples were analyzed for Sr-90 and gamma-emitting radionuclides. No manmade gamma-emitting radionuclides were detected, but Sr-90 was reported in most samples at approximately the same levels as in past years. Comparison of average concentrations of Sr-90 for boundary and distant communities (background) showed no statistical difference between the two groups.

Wheat samples were weighed prior to analysis but not washed. All wheat samples were analyzed for Sr-90 and gamma-emitting radionuclides. Average concentrations of Sr-90 in wheat were statistically the same for boundary and distant samples, and there were no important differences in concentrations when compared to recent years. No

manmade gamma-emitting radionuclides were detected in the wheat samples.

Muscle and liver samples were taken from sheep which had grazed onsite (Figure 8). During 1987, three sheep were sampled from the southern area and two were taken from the northeastern area of the INEL Site. Two control sheep were sampled from the U.S. Sheep Experiment Station near Dubois, Idaho.

Cs-137 was detected in the muscle tissue of one onsite animal at a concentration of $2.6 \pm 1.6 \times 10^{-8}$ μCi/g wet weight. Cs-137 was found in the livers of one onsite sheep at $4.1 \pm 1.8 \times 10^{-8}$ μCi/g and one control sheep at $1.8 \pm 1.4 \times 10^{-8}$ μCi/g. These concentrations are similar to those seen in both onsite and offsite sheep in previous years.

In addition, Ag-110m was found in the livers of three onsite sheep (two from the southern area and one from the eastern area) at concentrations ranging from $2.5 \pm 1.2 \times 10^{-8}$ μCi/g to $5.1 \pm 1.8 \times 10^{-8}$ μCi/g. The one liver sample from the southern area which did not contain Ag-110m was from a lamb which had obviously fed differently than the other sheep. Ag-110m has not been detected in any air samples since the Chernobyl accident (May 1986). The origin of this nuclide in the sheep samples is unknown.

Since concentrations of radionuclides in foodstuff samples (other than Ag-110m in sheep) were normal or statistically the same at distant and boundary locations, it is assumed that the origin of these radionuclides is worldwide fallout.

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 both onsite and offsite. 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.

At each location, a dosimeter containing five individual Harshaw TLD-700 chips (3.18 x 3.18 x 0.89 mm) is placed 1 meter above

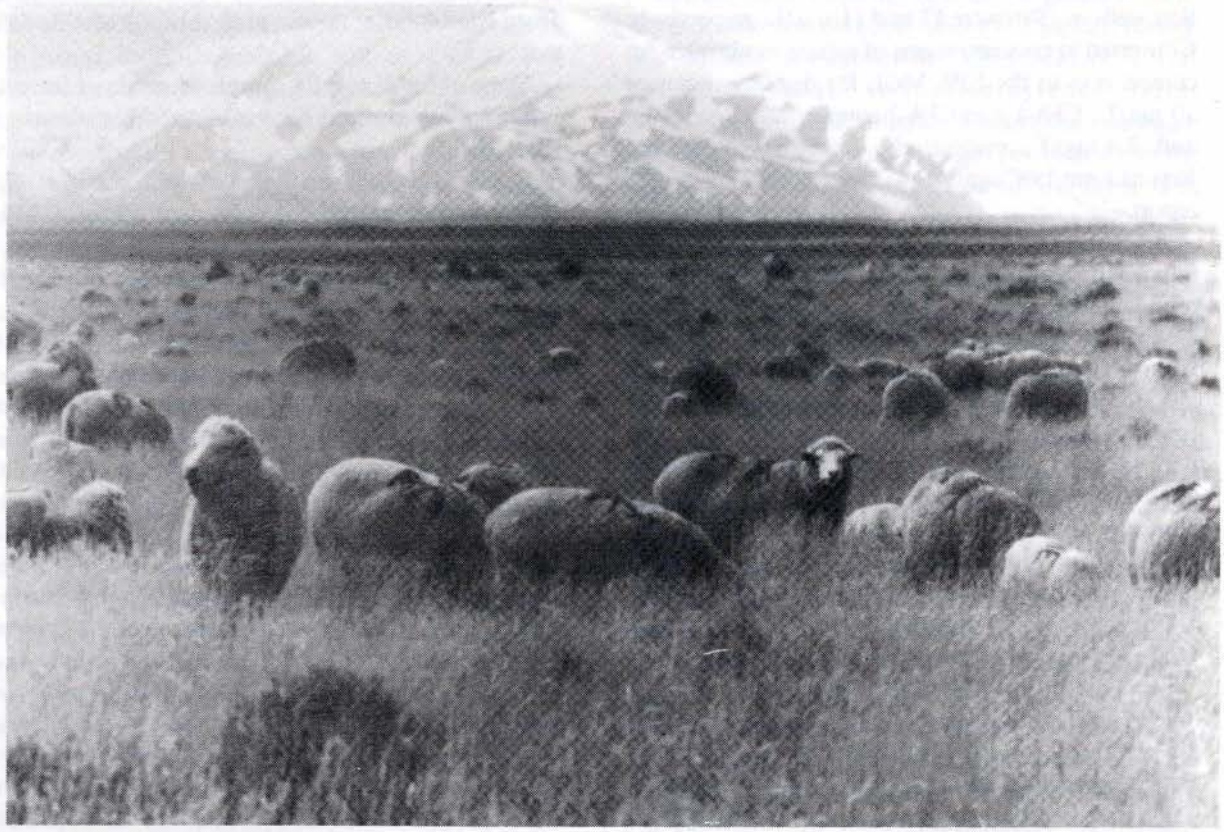

Figure 8. Sheep grazing on the INEL Site.

ground level. The dosimeter at each location is changed semiannually. There are seven distant community locations and six boundary locations (see Figure 7). The measured cumulative exposure for the time period from November 1986 to November 1987 for offsite dosimeters is shown in Table B-11, Appendix B. For purposes of comparison, annual exposures for 1984 through 1986 are also included for each location.

Dosimeter exposures for 1987, as a group, appeared lower than in previous years. An investigation revealed that due to TLD reader drift some of the field dosimeter readings were on the average 11% lower than they should have been. A correction factor cannot be applied, since dosimeter processing occurred both before and after the reader response drift. The distant and boundary mean exposure rates shown below are similar, but statistical tests were not made because of the higher uncertainty in the 1987 results.

The mean annual exposures for distant and boundary community locations were 101 ± 7 mR and 98 ± 4 mR, respectively, as measured by TLDs. These exposures are approximately equivalent to 96 mrem when an "f" factor of 0.96 (Reference 15) is used to convert from mR in air to mrem in tissue.

Table IV summarizes the calculated dose equivalent rate an individual receives on the Snake River Plain from various background radiation sources. This value varies from year to year, depending on the amount of snow cover.[16] For 1987, the light snow cover provided only about 0.6% dose reduction; the background dose equivalent rate was calculated to be about 150 mrem. As noted in Table IV, the contributions from radon (Rn-222) and its decay products are estimated at an average of 100 mrem/yr in the U.S.[17] Since no specific estimate for the Site and its vicinity has been made and measurements in homes in this area are just beginning, this segment of the dose equivalent from natural radioactivity has been omitted. The background dose equivalent rate calculations shown are consistent with those of previous years but are, in reality, lower than the actual dose equivalent rate.

Game Species. Hunting and fishing are not allowed on the Site. By migrating to and from the Site, game animals represent a potential, but very small, exposure pathway. Data from game species are generally obtained as part of DOE research programs rather than as part of the routine environmental monitoring program, although analyses of tissues of road-killed animals are reported here. Results from the radioecology and ecology research programs, which use the expertise of university faculty and graduate students, are reported in the scientific literature and supplement the results of the routinely scheduled environmental monitoring included in this report.

Muscle and liver samples from 6 mule deer and 12 pronghorn antelope killed on Site roads were submitted for analysis by gamma spectrometry. None of the pronghorn samples contained detectable amounts of manmade gamma-emitting radionuclides. One mule deer sampled in August had Cs-137 in the muscle tissue at a concentration of $1.4 \pm 1.0 \times 10^{-8}$ μCi/g. Cs-137 is present in the soil of the INEL and surrounding areas as a result of fallout from nuclear weapons tests and Site

TABLE IV
BACKGROUND RADIATION DOSE RATE (1987)

Source of Background Dose Equivalent		Dose Equivalent Rate (mrem/year) Estimated[a]	Measured (TLD)[b]
External	Terrestrial	76	—
	Cosmic (ionizing)	43	—
	Subtotal	119	97
	Cosmic (neutron)	6	
Internal	K-40 and others	27	
	Rn-222 and daughters	NE[c]	
	Total[d]	152	

a. Dose equivalents are estimated from charts and tables in NCRP Report No. 45. Dose equivalents are not strictly additive, since some are expressed as exposure in air and others are tissue doses. See also NCRP Report No. 93.

b. For conversion from mR in air to mrem in tissue, the f factor used was 0.96.

c. No estimate (NE) has been made specifically for the INEL vicinity. The EPA has estimated that the inhalation of Rn-222 and its decay products produces an average effective dose equivalent of about 100 mrem/yr in the United States.

d. Does not include any estimate for Rn-222 and daughters; therefore, actual background dose equivalent rate would be greater than the total shown here.

operations, and this concentration is similar to those in onsite and offsite deer sampled in the past.

Another deer killed near CFA in November contained Cs-137 in the muscle at $1.05 \pm 0.30 \times 10^{-7}$ μCi/g and in the liver at $4.9 \pm 2.4 \times 10^{-8}$ μCi/g. Cobalt-60 was also found in the liver at a concentration of $7.0 \pm 1.8 \times 10^{-8}$ μCi/g. No definitive explanation can be offered for the origin of these radionuclides; however, deer were seen in the TRA radioactive waste infiltration pond area during the summer and it is possible that the deer consumed pond water or contaminated plant material next to the pond. Radionuclides consumed by animals eating contaminated vegetation may remain incorporated in tissues for a period of time before they are eliminated.

No fish were collected from the onsite portion of the Big Lost River during 1987, since it was dry most of the year.

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 NWCF; combustion of coal for steam generation at the Coal-Fired Steam Generating Facility (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 routinely monitored at the NWCF. 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. Emissions of nitrogen oxides from fuel are calculated using emission factors developed by the EPA[18] and the amount and type of fuel burned at each facility as reported in the IWMIS.[7] Motor vehicle exhausts and fugitive dusts are not monitored at their sources. Major nonradioactive airborne effluents for 1987 are given in Table B-7, Appendix B.

Nonradioactive liquid effluents are disposed of primarily to a waste ditch at the NRF; seepage ponds at the Contained Test Facility (CTF), TAN, TRA, ICPP, and WRRTF; a lined evaporation pond at the Power Burst Facility (PBF), an industrial waste pond at ANL-W; and through sewage treatment facilities at various locations.[19]

Routine direct disposal of wastes to the Snake River Plain aquifer ceased in 1984. The only other injection wells on the INEL Site are used for storm runoff water. No waste is discharged 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, lead, mercury, selenium, silver, chloride, fluoride, nitrate, sulfate, conductivity, total dissolved solids, and pH. All analytical results for 1987 were less than concentrations defined as hazardous waste in 40 CFR 261.24. Analysis for organic contaminants is performed on an annual basis.

Other waste effluents are calculated from the amounts of chemicals used for water treatment, corrosion control, and demineralization; as cleansers and 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 7.

Summary of Radioactive Effluent Monitoring

Radionuclides in airborne and liquid effluents released to the environment are carefully monitored at potentially significant release points. Effluent monitoring is summarized in Appendix H of Reference 19. Reference 5 reports the results of the effluent monitoring by month, facility, and radionuclide.

A summary of the radionuclides released to the atmosphere from Site facilities in 1987 is shown in Table B-12, Appendix B. Due to radioactive decay of the short-lived radionuclides and the overestimation of Kr-85 releases for classification reasons, the activity that would reach offsite areas is less than the 165,000 Ci indicated in Table B-12. The ICPP and TRA facilities together were the source of about 99% of the total radioactivity released to the atmosphere. Noble gases comprised more than 99% of the total airborne radioactive effluent.

The total annual airborne radioactive effluent varies from year to year depending on which processes are active at INEL facilities. The 1987 annual total of less than 165,000 Ci was greater than the 1986 total. The difference is primarily due to an

increase in the releases of Kr-85 from ICPP. For purposes of comparison, total airborne radioactive effluent releases for the past five years were: 1983—12,000 Ci; 1984—4,900 Ci; 1985—77,000 Ci; 1986—14,500 Ci; 1987—less than 165,000 Ci.

No liquids were released directly to the offsite environment. Onsite releases are summarized in Table B-13, Appendix B. Most liquid radioactive effluents are discharged into seepage ponds. The effluent listed for CFA is discharged through a sewage treatment facility. Site-related radioactive liquids have never been detected offsite.

Assessment of Potential Radiation Dose to the Public

General. Usually the radiological impact of Site operations on the resident public surrounding the Site has been too small to be measured by the routine monitoring program. Therefore, the radiological impact of Site operations by the air pathway on the surrounding region has traditionally been estimated using the known amounts of various radionuclides released during the year from Site facilities and the MESODIF meteorological model for estimating the concentrations at selected locations in the vicinity. During 1987, this was done for the radionuclides released from Site facilities to the atmosphere, as summarized in Table B-12, Appendix B.

Because of the different applicable standards for radiation protection of the public (see the "Environmental Standards, Regulations, and Permits" section) and reasons discussed below, two different air dispersion models and different dose conversion factors were used to calculate

- The total-body and organ dose equivalent to the maximally exposed individual residing offsite using the AIRDOS-EPA and RADRISK models.
- The effective dose equivalent to the maximally exposed individual residing offsite using the MESODIF dispersion model and DOE dose conversion factors.[20,21]
- The collective effective dose equivalent (population dose) within an 80-km (50-mi) radius of the operations center of the Site (TRA and ICPP) using the MESODIF dispersion model and DOE dose conversion factors.

For simplicity, the term "dose" will be used to mean "effective dose equivalent" in the following dose assessment sections, unless another term is specifically stated. The effective dose equivalent (EDE) was calculated by summing the committed dose equivalents to organs, each multiplied by a weighting factor which is proportional to the organ's radiosensitivity. The EDE includes doses received from both external and internal sources and represents the same risk as if an individual's whole body were irradiated uniformly. For calculations using DOE dose conversion factors, a 50-year integration period is used both for internally deposited radionuclides and for radionuclides deposited on ground surfaces. A 70-year integration period is used by the AIRDOS/RADRISK codes. No allowance was made for shielding by housing materials or residence time in the community in any of the dose calculations.

The possible exposure pathways by which radioactive materials from Site operations could be transported to offsite environs are shown diagrammatically in Figure 9. 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 at low concentrations; but tritium from the INEL has never been detected in any of the offsite wells south of the boundary. Thus, atmospheric transport is the principal potential exposure pathway from the Site and is described in the section "Maximum Individual Dose—Air Pathway Only."

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 time on the Site. Radioactivity present in game species depends upon the length of residence onsite, the Site location at which the animals spent time, the time elapsed since migration from the Site, and the metabolism of the animal. Estimates of the maximum potential dose to a person consuming meat from different game animals is described in the section "Maximum Individual Dose—Game Ingestion Pathway."

Maximum Individual Dose—Air Pathway Only. The EPA has published regulations which limit the amount of airborne radionuclides released from DOE facilities to that which will produce a whole-body dose equivalent of 25 mrem/yr

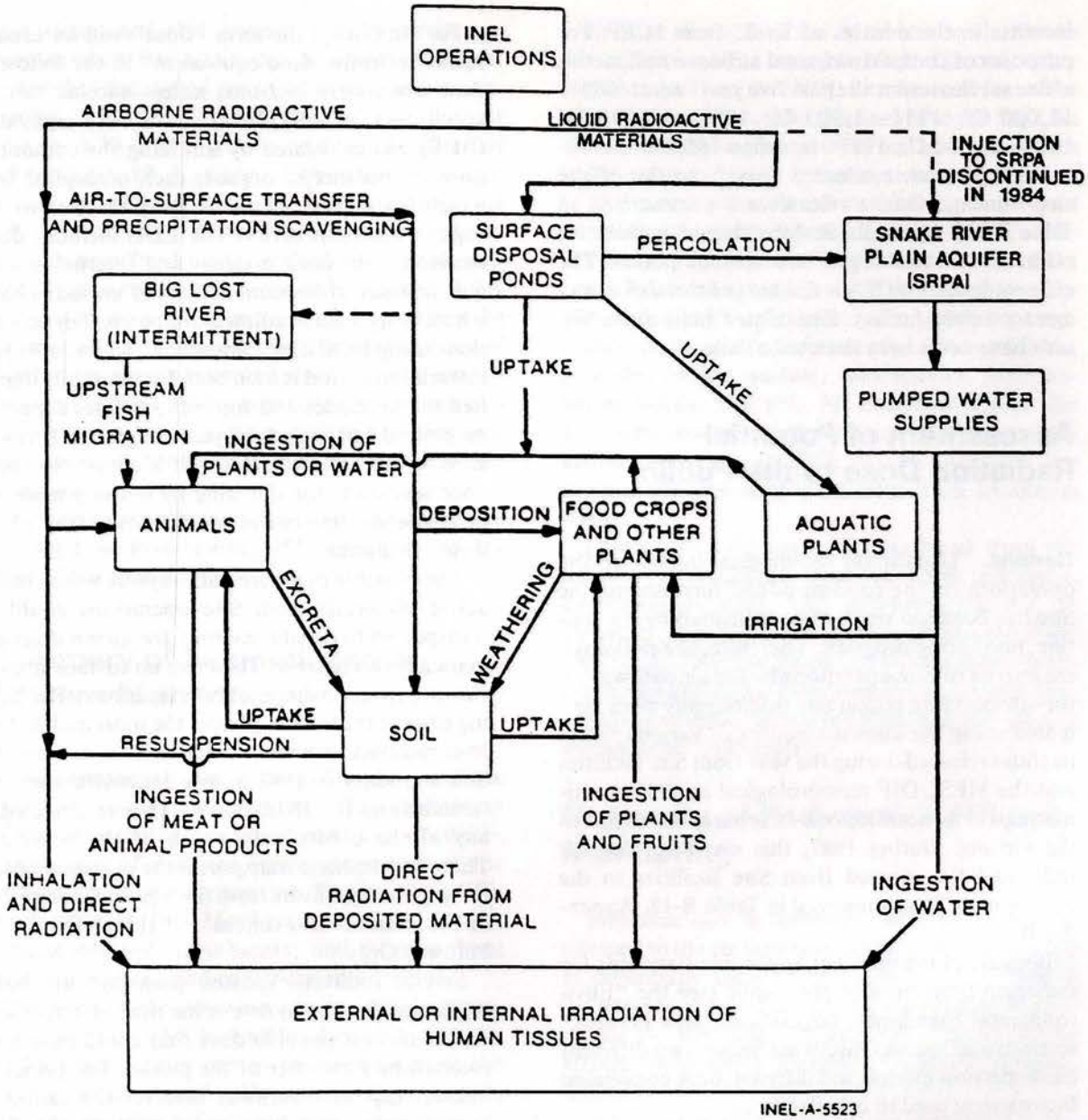

Figure 9. Possible exposure pathways of the INEL Site radioactive materials to members of the public.

(75 mrem/yr to the critical organ) to any member of the public. The EPA has specified that the AIRDOS-EPA computer program shall be used to demonstrate compliance unless an alternate model has been approved by the Administrator of the EPA.

Using the AIRDOS-EPA and RADRISK codes, a total-body dose equivalent of 0.034 mrem for 1987 has been calculated for "members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides or abides (40 CFR 61, Subpart H)." This dose equivalent is 0.1% of the EPA airborne radionuclide emission standard. The critical organ, the thyroid in this case, is calculated to receive a dose equivalent of 0.36 mrem for 1987, 0.5% of the standard. Although not required by this regulation, the effective dose equivalent calculated using the AIRDOS-EPA code is 0.06 mrem for 1987. The member of the public receiving the maximum dose equivalent in 1987 as calculated by the AIRDOS-EPA code would have been located near Mud Lake, Idaho, 46 km (29 mi) northeast of the operations center of the INEL Site.

The MESODIF air dispersion model[22] has been used for 15 years to calculate doses to offsite individuals. It is included here to allow some comparison to previous years. In addition, for reasons discussed in the 1986 report,[23] the MESODIF model offers significant advantages over the dispersion portion of the AIRDOS-EPA model for assessing doses to the public from INEL Site operations.

The mesoscale meteorological map (Figure 10) shows the calculated 1987 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 using the MESODIF model and data gathered continuously at meteorological stations on and around the Site. Through May, the data set from 26 stations was used; after May, the data from seven onsite stations were used due to an equipment problem in one of the systems. 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 10, the value of the 1987 average dispersion coefficient (e.g., 30×10^{-9} hr^2/m^3) was multiplied by the number of curies of the radionuclide released during 1987 and

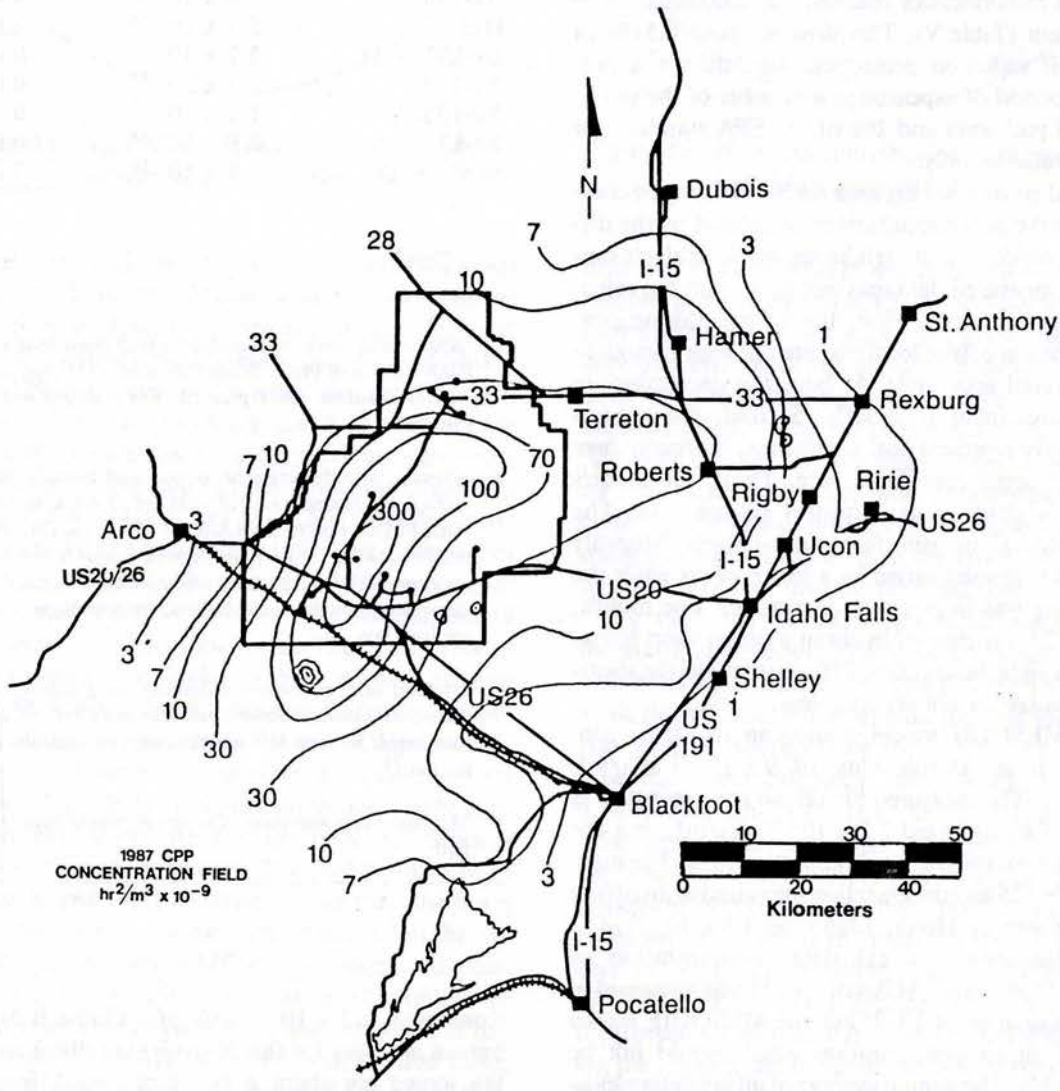

Figure 10. 1987 average of mesoscale dispersion isopleths of air concentrations at ground level, normalized to unit release rate.

was divided by the number of hours in a year squared (7.67×10^7).

As indicated in Figure 10, the MESODIF model predicts that the highest concentrations of radionuclides in air for an inhabited area would occur at Atomic City. The maximum hypothetical dose was calculated for an adult resident of Atomic City from inhalation of air, submersion in air, ingestion of radioactivity on leafy vegetables, and exposure due to deposition of particulates on the ground surface. The calculation was based on data presented in Table B-12 and Figure 10. Using 44×10^{-9} hr^2/m^3 as the dispersion coefficient for Atomic City and allowing for radioactive decay during the 19-km (12-mi) transit of the radionuclides from the TRA-ICPP complex to Atomic City, the potential effective dose equivalent from all radionuclides released was calculated to be 0.54 mrem (Table V). This dose is about 0.54% of the DOE radiation protection standard for a prolonged period of exposure to a member of the public from all pathways and 2% of the EPA standard for the air pathway only.

Actual air monitoring data for Sb-125 may be compared to the air concentrations calculated by the dispersion models, although there are several reasons why the measured data may not agree with the calculated concentrations. First, the air monitoring concentrations at offsite locations are not high enough to be measured accurately. At best, the uncertainty in the measurement is ±30%. Second, the models imperfectly represent real conditions, especially over the large areas considered here. Third, the models assume a continuous, uniform release rate. The Sb-125 emissions were far from uniform. Monthly quantities released varied by a factor of six while the processing was in progress. During any one month, the Sb-125 was emitted in about a dozen short bursts of about eight hours each. Efforts to model the short-term releases are not yet complete.

The MESODIF model predicts an Sb-125 air concentration at Atomic City of 9×10^{-15} μCi/mL (Table V). The measured Sb-125 air concentration at Atomic City averaged 2.2×10^{-15} μCi/mL, but the measurement uncertainty is about ±100%. The maximum Sb-125 air concentration measured at an offsite location was at Howe, Idaho, at 4.8×10^{-15} μCi/mL, compared to a calculated concentration of 6×10^{-15} μCi/mL. At Arco, Sb-125 was measured in the first quarter of 1987; but the MESODIF model predicts an air concentration which would not be measurable. The annual average of all boundary location Sb-125 concentrations using the MESODIF model was about 4.5×10^{-15} μCi/mL. The annual average measured concentration for boundary locations was 2.2×10^{-15} μCi/mL (Table B-3). The annual averages for the 20- to 30-km distances from the source are about a factor of two different for 1987. The concentrations calculated by the MESODIF model are generally higher than the measured concentrations.

TABLE V
MAXIMUM INDIVIDUAL EFFECTIVE DOSE EQUIVALENT (1987)

Radionuclide[a]	Maximum Offsite Concentration[b] (μCi/mL)	Maximum Effective Dose Equivalent[c] (mrem)
Sb-125 + D	9.2×10^{-15}	0.5190
I-129	1.1×10^{-16}	0.0061
Ar-41	8.4×10^{-13}	0.0056
Co-60	6.9×10^{-18}	0.0038
Kr-85[d]	9.2×10^{-11}	<0.0024
Kr-88 + D	4.9×10^{-14}	0.0013
Xe-138 + D	3.0×10^{-15}	0.0011
H-3	5.3×10^{-13}	0.0003
Cs-137 + D	3.2×10^{-19}	0.0003
Xe-133	3.5×10^{-13}	0.0001
Xe-135	1.1×10^{-13}	0.0001
Kr-87	2.9×10^{-14}	0.0001
Sr-90 + D	1.5×10^{-19}	0.0001
Total		0.5406

a. Table includes only radionuclides which contribute a dose of 0.0001 mrem or more. When indicated (+D), the contribution of daughter decay products was included in the dose calculations.

b. Estimate of radioactive decay obtained by using the 1987 average windspeed from 315°-325° of 13.4 km/hr and a distance of 19.1 km from TRA-ICPP to Atomic City, the community with the hypothetical maximum offsite concentration. For nuclides where parent-daughter equilibria were used in dose calculations, concentration of the parent is shown.

c. Effective dose equivalent estimated using dose conversion factors for inhalation and ingestion from Corley[20] and dose conversion factors for sumbersion and deposition from Kocher.[21]

d. Maximum concentration. The actual release data are classified.

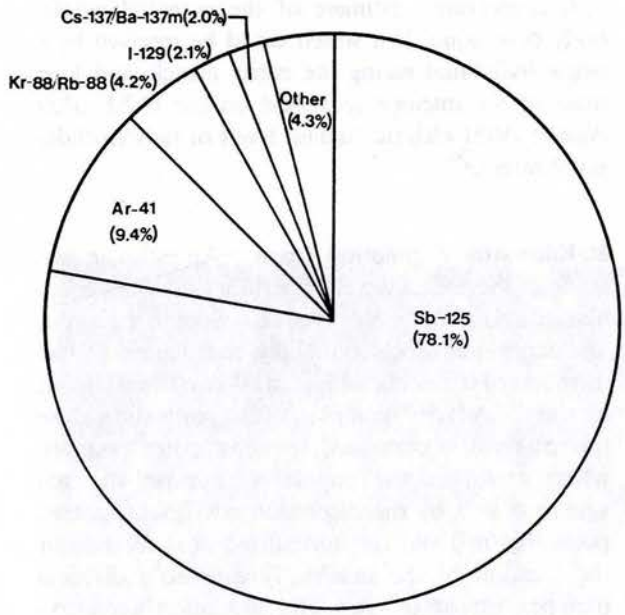

Figure 11. Nuclides contributing to maximum individual dose in 1986.

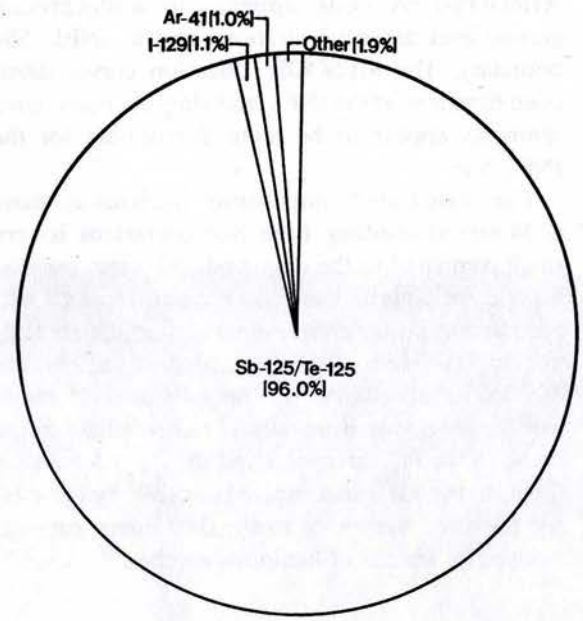

Figure 12. Nuclides contributing to maximum individual dose in 1987.

About 96% of the 0.54-mrem computed dose was due to Sb-125 in 1987. Figures 11 and 12 illustrate the proportion of dose due to specific nuclides for 1986 and 1987, respectively. Increased quantities of Sb-125 and I-129 have increased the total calculated dose by a factor of five. The dispersion coefficient (Figure 10) for Atomic City is lower than in previous years and is a factor of 2.7 less than in 1986. The lower dispersion coefficient is probably due to the less extensive meteorological data set available in 1987. The quantities of H-3, Co-60, and Kr-85 released in 1987 were higher than normal, Cs-137 was lower than normal, but all these result in relatively low doses. The other radionuclide quantities are similar to those released in prior years. Review of control technology to reduce releases of Sb-125 is in progress by ICPP and DOE personnel.

One of the parameters necessary to convert air concentrations of Sb-125 into dose equivalents is the deposition velocity, the rate at which the Sb-125 deposits on the surface of the ground. The Sb-125 dose due to surface deposition is 200 times higher than the doses from inhalation, ingestion, or immersion. For the calculations based on the MESODIF model, a deposition velocity of 1 cm/sec was used, similar to 0.64 cm/sec calculated for the sum of wet and dry deposition by the AIRDOS-EPA code at Mud Lake, Idaho. To test the appropriateness of this value, shallow depth soil samples were collected near the end of the third quarter, 1987. Three replicates were taken at each of seven onsite and three boundary locations, near air samplers. Sb-125 was measurable in the soil samples primarily at the ICPP. As another test, a horizontal piece of contact paper (gummed side up) was deployed each week for about five months at locations with the highest air concentrations. Measurable deposition again occurred only at the ICPP sampler. Although the data are preliminary, a deposition velocity of 0.1 cm/sec appears more appropriate, at least close to the source of the Sb-125. The doses calculated using the higher number may, therefore, be too high by a factor of ten. Investigations are continuing.

For 1987, the AIRDOS-EPA model predicts that the maximally exposed individual would have resided near Mud Lake, Idaho, northeast of the INEL Site, while the MESODIF model indicates that location at Atomic City, southeast of the ICPP. The effective dose equivalent calculated using AIRDOS-EPA is 0.06 mrem, and the dose using MESODIF is 0.54 mrem. There are major differences in some of the dose conversion factors and in the atmospheric dispersion portions of the two codes. These differences were discussed in the 1986 report.[23] The difference in the thyroid weighting factor is important in 1987. The EPA uses a weighting factor of 0.099 for the thyroid rather than 0.03 used by the DOE following the recommendations of the International Commission on Radiological Protection. The effective dose equivalent calculated by AIRDOS-EPA is primarily due to I-129, not Sb-125, because of the difference in weighting factors. Again in 1987, the

AIRDOS-EPA code appears to underpredict ground-level air concentrations at the INEL Site boundary. The MESODIF diffusion curves developed from tests at the INEL and Hanford desert environments appear to be more appropriate for the INEL Site.

The calculated maximum individual dose (0.54 mrem) resulting from Site operations is very small compared to the estimated 150 mrem received from cosmic and terrestrial radiation during 1987. For interest, it may also be compared to the approximately 100 mrem from medical and radiological diagnostic procedures, to the estimated 25 mrem received each year from natural radionuclides in the body, to the 0.7 mrem received during a 5-hour jet flight, to the 1.0 mrem received annually by the average television viewer, or to the 0.03 mrem per year received by wearers of luminous watches.[24]

Maximum Individual Dose—Game Ingestion Pathway. Potential dose to an individual from occasional 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 liquid waste ponds used for the disposal of low-level reactor effluents (Figure 13). The average potential whole body dose equivalent from consumption of a contaminated duck is 10 mrem.[25] This value is based on the assumption that the duck would be killed and eaten immediately after leaving the pond. Normally, the duck would not actually be killed immediately, 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 part of Idaho is likely to spend time on Site ponds, there is a low probability of a hunter receiving this dose.[26]

The highest estimated potential whole-body dose equivalent to a person eating the entire muscle mass of a sage grouse which summered near the TRA-ICPP area is 2 mrem.[27] The maximum whole-body dose equivalent from consumption of sage grouse from other Site locations and offsite areas ranges from 0.01 to 0.04 mrem.

The maximum potential whole-body dose equivalent to a person eating the muscle tissue of one mourning dove from the TRA pond area is 0.3 mrem. The average whole-body dose equivalent to people consuming doves migrating from the Site areas is 0.01 mrem, which is the same as for control birds collected far from the Site.[28]

A conservative estimate of the potential whole-body dose equivalent which could be received by a single individual eating the entire muscle and liver mass of an antelope (collected on the INEL after August 1975) with the highest levels of radionuclides is 0.2 mrem.[29]

80-Kilometer Population Dose. An estimate was made of the collective effective dose equivalent (population dose) from inhalation, submersion, ingestion, 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. This population dose (person-rem) is calculated by a computer program which multiplies the population number in each square mile[30] by the dispersion coefficient at that point (hr^2/m^3) and the normalized dose received at the location of the maximally exposed individual (rem per year/hr^2 per m^3). The calculation is conservative, since radioactive decay of the isotopes was not calculated during transport over distances greater than the 19.1 km (12 mi) from the TRA-ICPP midpoint to Atomic City. Idaho Falls, for example, is about 66 km (41 mi) from TRA-ICPP. Neither residence time nor shielding by housing was taken into account.

The population dose within each census division (Table VI) was obtained by summing the results from appropriate areas contained within those divisions. The total 80-km (50-mi) population dose was the sum of population doses for the various census divisions. The estimated potential population dose was 4.5 person-rem to a population of about 120,600. When compared with an approximate population dose of 18,000 person-rem from natural background, this represents an increase of only about 0.03%. The dose of 4.5 person-rem can also be compared to the following estimated population doses for the same size population: 12,000 person-rem for medical and radiological diagnostic procedures, 3000 person-rem for natural radionuclides in the body, and 120 person-rem for television viewing.[24]

The contribution of game animal consumption 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 total population dose contribution from these pathways would realistically be less than the population dose from inhalation of air, submersion in air, and deposition on soil.

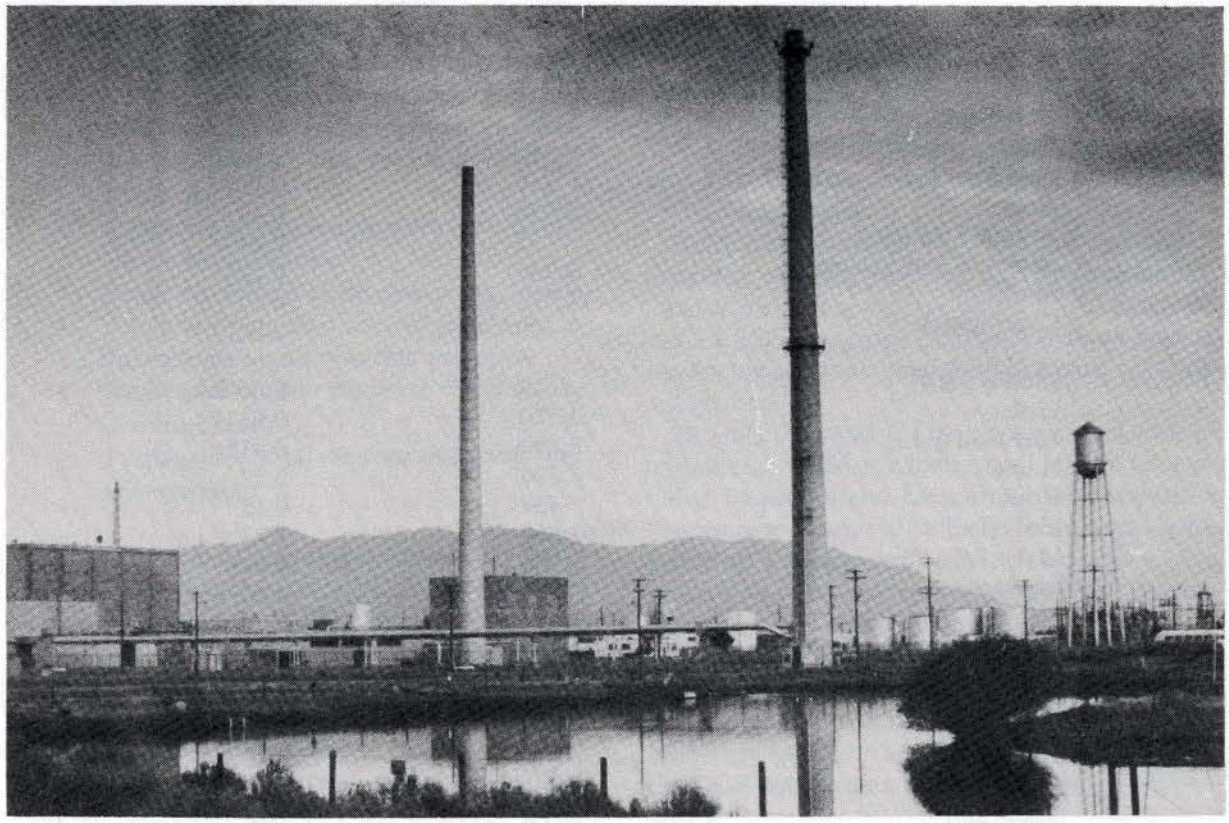

Figure 13. TRA low-level waste disposal pond on the INEL Site.

TABLE VI
80-KILOMETER POPULATION DOSE (1987)

Census Division	Population[a] 1987	Population Dose[b] (person-rem)
Aberdeen	2,850	0.17
Alridge (part)	160	0.0026
American Falls (part)	110	0.0041
Arco	2,950	0.11
Atomic City (city)	35	0.019
Atomic City (division)	2,300	0.024
Blackfoot	13,250	0.22
Carey (part)	120	0.0017
Challis (part)	10	0.00004
Firth	3,720	0.037
Fort Hall (part)	3,890	0.013
Hamer	2,590	0.73
Howe	450	0.15
Idaho Falls	62,060	1.73
Idaho Falls West	1,960	0.041
Leadore	15	0.0019
Lewisville-Menan (part)	2,370	0.21
Mackay (part)	1,100	0.0066
Moreland	8,410	0.42
Rigby (part)	620	0.025
Roberts	1,390	0.31
Shelley	6,550	0.18
Ucon (part)	3,580	0.13
West Clark (part)	90	0.0018
Totals	120,580	4.5

a. Population for each division was based upon the 1980 Advance Census Reports for Idaho adjusted to estimated 1987 levels. Populations for predominantly rural areas were adjusted using subjective estimates based on knowledge of economic factors in the areas.

b. These population doses do not include radioactive decay beyond 19.1 km.

QUALITY ASSURANCE

A quality control and assurance program is maintained by RESL 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[31]
- Documentation of program changes
- Routine calibration of instrumentation
- Frequent equipment performance checks for background and counting rates of standards
- Routine yield determinations of radiochemical procedures
- Replicate samples to determine precision
- Analysis of quality control standards in appropriate matrices to test accuracy
- Analysis of reagent blanks to verify radiochemical 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 the RESL 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, are generally traceable to within 5% of the standard value. Three nuclides and one gamma ray energy were not within the ±5% range required for traceability, but were within ±10%. Corrections have been made. Results for liquids previously unreported through 1987 are shown in Table VII.

RESL 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 VIII). An intercomparison of results from all laboratories is also made but is not reported here. RESL participates in a similar intercomparison with U.S. Nuclear Regulatory Commission (NRC) laboratories.

RESL also participates in the quality assurance program administered by the Environmental Measurements Laboratory of DOE. As time permits, RESL participates in the American Society for Testing Materials' round-robin testing of standard methods.

To verify the quality of the environmental dosimetry program, RESL has participated in eight International Environmental Dosimeter Intercomparison Studies now conducted by the Environmental Measurements Laboratory. The RESL results have been within 10% of the test exposure values. The intercomparison was not conducted in 1987.

The calibration source for the RESL environmental dosimetry program was calibrated using a reference quality transfer standard calibrated by the NBS. The RESL calibration source 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%. Tests are performed every three months with the reference quality standard to determine consistency.

TABLE VII
NBS QUALITY ASSURANCE COMPARISON TEST RESULTS[a]

Reference Date	Radionuclide	RESL Result[b] (Bq/g)	NBS Result[b] (Bq/g)	Ratio RESL/NBS[c]
9-1-86[d]	1173.2	3159 ± 3	3079.5 ± 1.4	1.03
	122.1	346.5 ± 3.1	343.6 ± 1.9	1.01
	1332.5	3215 ± 3	3092.9 ± 1.1	1.04
	165.9	245.6 ± 3.8	244.8 ± 1.4	1.00
	1836	1682 ± 3	1641.6 ± 1.5	1.03
	391.7	607.8 ± 4.2	603.2 ± 2.6	1.01
	661.6	2467 ± 3	2421.1 ± 1.7	1.02
	898	1590 ± 4	1562.1 ± 1.5	1.02
	88	472.3 ± 3.2	468.6 ± 2.4	1.01
3-11-87	Pu-238	2415 ± 2	2402.7 ± 0.4	1.01
6-1-87	Ag-110m	6437 ± 3	6676.0 ± 1.2	0.96
7-16-87	H-3	1057 ± 3	996.6 ± 0.9	1.06
7-17-87	Ni-63	4770 ± 3	4762.0 ± 1.8	1.00
7-20-87[d]	1173.2	3015 ± 3	3135.3 ± 1.4	0.96
	122.1	385 ± 3	388.2 ± 1.9	0.99
	1332.5	2995 ± 3	3145.7 ± 1.1	0.95
	165.9	295.6 ± 3.1	297.2 ± 1.4	0.99
	1836	2106 ± 3	2182.7 ± 1.5	0.97
	279.2	169.6 ± 4.0	160.3 ± 2.7	1.06
	391.7	761.2 ± 3.0	771.2 ± 2.6	0.99
	514	627 ± 3	645.3 ± 3.1	0.97
	661.6	2391 ± 3	2465.5 ± 1.7	0.97
	88	494.9 ± 3.1	490.1 ± 2.4	1.01
	898	1983 ± 3	2074.8 ± 1.5	0.96
7-27-87[d]	145.3	834.0 ± 5.5	841.1 ± 4.1	0.99
	172.1	4960 ± 5	4921.0 ± 2.6	1.01
	202.9	13300 ± 5	13194 ± 2	1.01
	375	3350 ± 5	3356.0 ± 2.5	1.00
	514	3720 ± 5	3723.0 ± 2.4	1.00
	81	28300 ± 5	28080 ± 5	1.01
8-25-87	Ce-144	9122 ± 4	8398.6 ± 5.1	1.09
	Cs-134	13780 ± 3	13882 ± 3	0.99
	Ru-106	4342 ± 4	4457.9 ± 2.7	0.97
	Se-75	896.9 ± 8.9	894.3 ± 2.8	1.00
9-8-87	Sr-89	1507 ± 2	1545.0 ± 1.3	0.98
	Sr-90	359 ± 2	332.8 ± 1.8	1.08

a. Analyses from 1986 listed above have not been previously reported. Comparison data may be delayed beyond report deadlines in any given year. All comparison samples were liquids.

b. Results ± overall uncertainty are 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. One Bq equals 2.7×10^{-5} μCi.

c. Ratios of RESL to NBS results are given.

d. Specific gamma ray energy in keV.

TABLE VIII
INEL QUALITY ASSURANCE COMPARISON TEST RESULTS

Reference Date	Sample Medium	Radionuclide	Reporting Units	RESL Result[a]	Known Value	Ratio[b] RESL/Known
3-30-87	Charcoal Cartridge	Ba-133	μCi/sample	5.56 ± 0.20 E−2	5.63 ± 0.15 E−2	0.99 ± 0.04
		Cs-137		6.48 ± 0.28 E−3	6.66 ± 0.14 E−3	0.97 ± 0.05
		Co-58		3.20 ± 0.26 E−3	3.10 ± 0.12 E−3	1.03 ± 0.09
		Mn-54		1.60 ± 0.12 E−3	1.59 ± 0.05 E−3	1.01 ± 0.08
		Zn-65		6.10 ± 0.38 E−3	5.96 ± 0.12 E−3	1.02 ± 0.07
		Co-60		2.36 ± 0.14 E−3	2.44 ± 0.12 E−3	0.97 ± 0.08
7-28-87	Gas	Kr-85	μCi/sample	2.36 ± 0.12 E+1	2.34 ± 0.09 E+1	1.01 ± 0.06
		Xe-127		5.10 ± 0.16 E−1	5.16 ± 0.15 E−1	0.99 ± 0.04
		Xe-133		1.85 ± 0.07 E−0	1.80 ± 0.06 E−0	1.03 ± 0.05

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, in whole or in part, on the INEL Site or at the INEL Site boundary.

U.S. Department of Energy, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A, August 1981.

U.S. Environmental Protection Agency, National Primary and Secondary Ambient Air Quality Standards, 40 CFR 50, 1986.

U.S. Environmental Protection Agency, National Interim Primary Drinking Water Regulations, 40 CFR 141, 1986.

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, 1985.

Additional standards are listed in DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards, May 1984.

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." Chapter XI is currently being revised. The revised Radiation Standards for Protection of the Public,[32] shown in Table IX, have been adopted as an interim standard for DOE facilities. Draft derived concentration guides[3] based on the interim standard have been calculated using new models and parameters[20] and are shown in Table X. Derived concentration guides for noble gases (submersion) have been calculated from Kocher.[21] The most restrictive guide is listed when there is a difference between the soluble and insoluble chemical forms. The derived concentration guides consider only the inhalation of air, the ingestion of water, or submersion in air. All derived concentration guides shown are similar to the concentration guides previously shown in Attachment 1, Table II of Chapter XI. For the radionuclides shown in Table X, the previous concentration guides of Chapter XI were identical to those in the Idaho Radiation Control Regulations, Radiation Control Section, State of Idaho, 1982.

TABLE IX
RADIATION STANDARDS FOR PROTECTION OF THE PUBLIC IN THE VICINITY OF DOE FACILITIES

	Effective Dose Equivalent[a]	
All Pathways	(mrem/yr)	(mSv/yr)
Occasional annual exposures	500	5
Prolonged period of exposure[b]	100	1
	Dose Equivalent	
Air Pathway Only[c]	(mrem/yr)	(mSv/yr)
Whole body	25	0.25
Any organ	75	0.75

a. The effective dose equivalent for any member of the public from all routine DOE operations (natural background and medical exposures excluded) shall not exceed the values. Routine operations means normal planned operations and does not include actual or potential accidental or unplanned releases.

b. A prolonged exposure is one that lasts, or is predicted to last, longer than 5 years.

c. Limits of 40 CFR 61, Subpart H.

Ambient air quality standards are shown in Table XI. Water quality standards are dependent on the type of drinking water system sampled. Table XII is a partial list of maximum contaminant levels set by the EPA for public community drinking water systems. New regulations were promulgated by the EPA for volatile organic compounds in the Federal Register on July 8, 1987.[33] State of Idaho regulations are the same for the first five contaminants listed.

Permits issued to INEL facilities which were in effect in 1987 are described in Table XIII.

TABLE X
DERIVED CONCENTRATION GUIDES FOR RADIATION PROTECTION

Radionuclide	Derived Concentration Guide[a] (μCi/mL) In Air	In Water
Gross Alpha[b]	2×10^{-14}	3×10^{-8}
Gross Beta[c]	3×10^{-12}	1×10^{-7}
H-3	1×10^{-7}	2×10^{-3}
Na-24[d]	4×10^{-9}	1×10^{-4}
Ar-41	1×10^{-8}	—
Cr-51	5×10^{-8}	1×10^{-3}
Mn-54	2×10^{-9}	5×10^{-5}
Co-60	8×10^{-11}	5×10^{-6}
Kr-85	3×10^{-6}	—
Kr-85m	1×10^{-7}	—
Kr-87	2×10^{-8}	—
Kr-88	9×10^{-9}	—
Rb-88[d]	3×10^{-8}	8×10^{-4}
Sr-90	9×10^{-12}	1×10^{-6}
Zr-95	6×10^{-10}	4×10^{-5}
Ru-103	2×10^{-9}	5×10^{-5}
Ru-106	3×10^{-11}	6×10^{-6}
Sb-125	1×10^{-9}	5×10^{-5}
I-129	7×10^{-11}	5×10^{-7}
I-131	4×10^{-10}	3×10^{-6}
Xe-131m	2×10^{-6}	—
Xe-133	5×10^{-7}	—
Xe-135	8×10^{-8}	—
Xe-135m	5×10^{-8}	—
Xe-138	2×10^{-8}	—
Cs-134	2×10^{-10}	2×10^{-6}
Cs-137	4×10^{-10}	3×10^{-6}
Cs-138	1×10^{-7}	9×10^{-4}
Ba-139	7×10^{-8}	3×10^{-4}
Ba-140	3×10^{-9}	2×10^{-5}
Ce-141	1×10^{-9}	5×10^{-5}
Ce-144	3×10^{-11}	7×10^{-6}
Ir-192	5×10^{-10}	3×10^{-5}
Hg-203	2×10^{-9}	1×10^{-5}
Pu-238	3×10^{-14}	4×10^{-8}
Pu-239	2×10^{-14}	3×10^{-8}
Pu-240	2×10^{-14}	3×10^{-8}
Am-241	2×10^{-14}	3×10^{-8}

a. Derived concentration guides are from the draft DOE derived concentration guides.[3] The derived concentration guides are based on an effective dose equivalent of 100 mrem/yr.

b. Based on Am-241, Pu-239, and Pu-240.

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

d. Submersion in a cloud of gas is more restrictive than the inhalation pathway.

TABLE XI
AMBIENT AIR QUALITY STANDARDS

Pollutant	Type of Standard[a]	Sampling Period	EPA[b] ($\mu g/m^3$)
SO_2	S	3-hour Average	1300
	P	24-hour Average	365
	P	Annual Average	80
NO_2	S&P	Annual Average	100
Total Particulates[c]	S	24-hour Average	150
	S	Annual Average	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.

b. The State of Idaho has adopted these same ambient air quality standards.

c. The standard for particulate matter was revised on July 1, 1987. The primary and secondary standard for the annual average is now 50 $\mu g/m^3$, but only for "particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers."

TABLE XII
MAXIMUM CONTAMINANT LEVELS FOR PUBLIC COMMUNITY DRINKING WATER SYSTEMS

Gross Alpha	1.5×10^{-8} μCi/mL
Gross Beta	5.0×10^{-8} μCi/mL
Manmade Radionuclides	Concentrations resulting in 4 mrem total body or organ dose equivalent
Nitrate (as N)[a]	10 mg/L
Chromium	0.05 mg/L
Trihalomethanes	0.1 mg/L
Carbon Tetrachloride[b]	0.005 mg/L
1,1,1 - trichloroethane[b]	0.20 mg/L
Trichloroethylene[b]	0.005 mg/L

a. Applies to non-community water systems also.

b. Applies to non-transient non-community water systems also.

TABLE XIII
PERMITS IN EFFECT (1987)

Type of Document	Issued By	Compliance Status	Expiration Date	Other Pertinent Information
Prevention of Significant Deterioration Permit for Coal-Fired Steam Generation Facility	EPA	In Compliance	None	
Permit to Construct an Air Pollution Source (Small Incinerator)	State of Idaho	In Compliance	None	For burning classified documents at TAN.
Permit to Construct an Air Pollution Source (Boilers at TAN)	State of Idaho	In Compliance	None	
Permit to Construct an Air Pollution Source (PREPP)	State of Idaho	In Compliance	None	Process Experimental Pilot Plant (PREPP)
Permit to Construct an Air Pollution Source (WERF)	State of Idaho	In Compliance	None	Waste Experimental Reduction Facility (WERF)
Permit to Construct an Air Pollution Source (Boiler at CFA 609)	State of Idaho	In Compliance	None	
Permit to Construct an Air Pollution Source (Boiler Modification at ICPP)	State of Idaho	In Compliance	None	
Permit to Construct an Air Pollution Source (Drum Venting Facility at RWMC)	State of Idaho	In Compliance	None	

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APPENDIX A

MAJOR PROGRAMS, LOCATION, GEOLOGY, AND CLIMATOLOGY

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. Fifty-two reactors have been built at this Site, of which 13 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 for storage at the Idaho Chemical Processing Plant (ICPP).
- Conducting light-water-cooled reactor safety testing and research.
- Operating the Experimental Breeder Reactor No. 2 (EBR-II).
- Operating the Naval Reactors Facility (NRF).
- Storing, processing, and monitoring radioactive wastes.

See Figure A-1 and Table A-1 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 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 the 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 the Great Basin, with sagebrush conspicuous over 80% of the Site. Frequenting the Site are the pronghorn antelope, a few deer and elk, coyotes, bobcats, rabbits, large populations of small mammals, and various kinds of birds and reptiles. 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 human activities and obtain data for use in making decisions on land use. At present, about 40 different environmental studies are being conducted.

The surface of the plain is a combination of basaltic lava outcrops 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 basalt flows interbedded with lacustrine and alluvial sedimentary deposits to a depth of about 760 m (2500 ft). The most recent volcanism, occurring about 2000 years ago,[A-1] 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 rock. 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. Discharge volumes from springs in this region are

IDAHO NATIONAL ENGINEERING LABORATORY

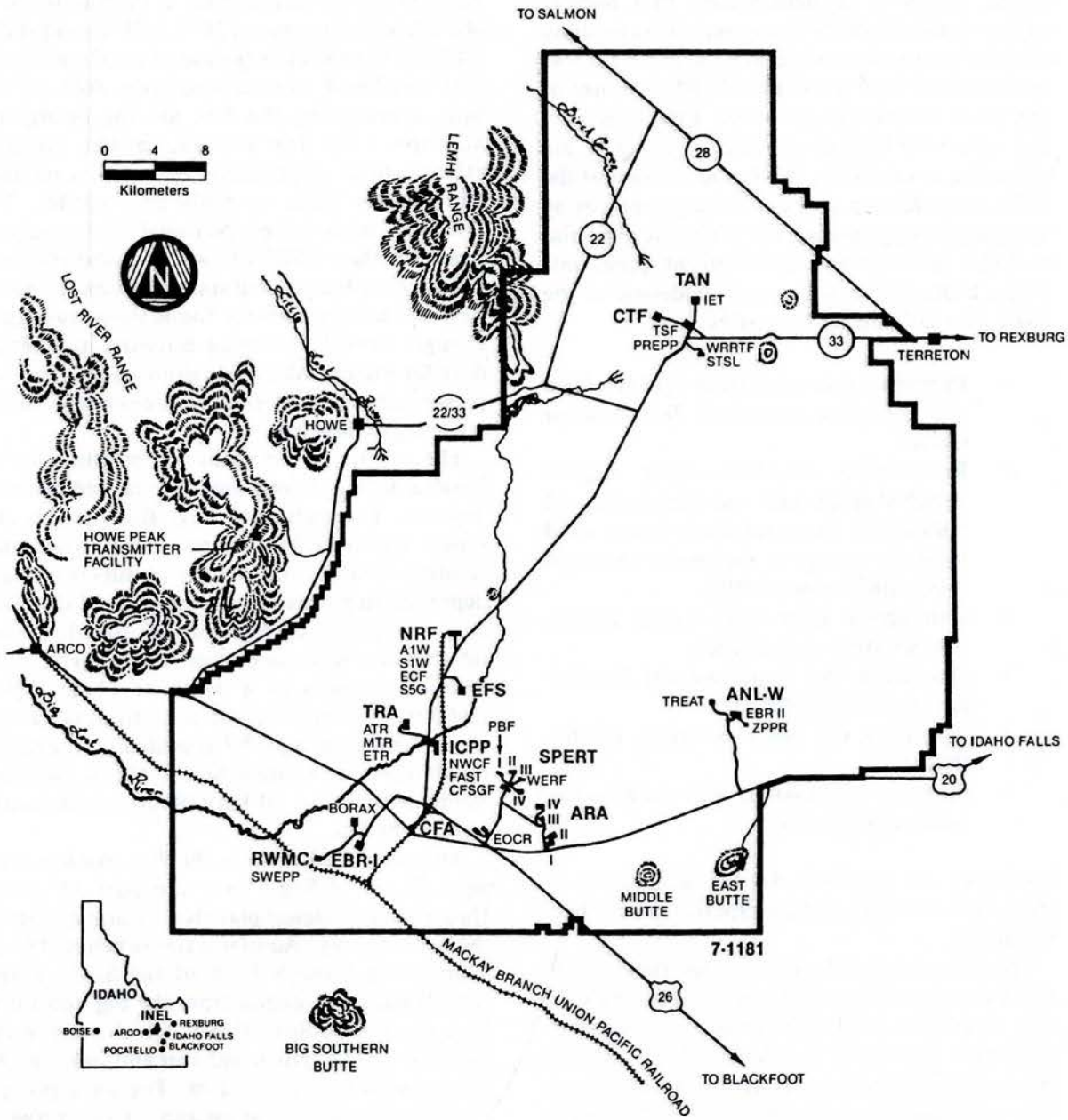

Figure A-1. INEL Site facility locations.

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
Natural Circulation Reactor	S5G	WEC
Submarine Thermal Reactor	S1W (STR)	WEC
Transient Reactor Test Facility	TREAT	ANL
Neutron Radiography Facility	NRAD	ANL
Zero Power Physics 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
Loss-of-Fluid Test Facility	LOFT	EG&G
Materials Test Reactor	MTR	PPCo & INC
Organic Moderated Reactor Experiment	OMRE	AI
Power Burst Facility	PBF	EG&G
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
Contained Test Facility	CTF	EG&G
Expended Core Facility	ECF	WEC
Experimental Field Station	EFS	DOE-ID
Fluorinel and Fuel Storage Facility	FAST	WINCO
Fuel Manufacturing Facility	FMF	ANL
Other Facilities in Use (Continued)		
Hot Cell Facility (TRA)	—	EG&G
Hot Fuel Examination Facilities	HFEF	ANL
Hot Shop Facilities (TAN)	—	EG&G
Idaho Chemical Processing Plant	ICPP	WINCO
INEL Research Center (Idaho Falls)	IRC	EG&G
Naval Reactors Facility	NRF	WEC
New Waste Calcining Facility	NWCF	WINCO
Process Experimental Pilot Plant	PREPP	EG&G
Radiation Measurements Laboratory	RML	EG&G
Radioactive Waste Management Complex	RWMC	EG&G
Radiological and Environmental Sciences Laboratory	RESL/ID	DOE-ID
Reactor Training Facility	RTF	EG&G
Remote Analytical Laboratory	RAL	WINCO
Semiscale Test Support Laboratory	STSL	EG&G
Standards Calibration Laboratory (CF-698)	—	EG&G
Stored Waste Examination Pilot Plant	SWEPP	EG&G
Technical Services Center (CF-688, -689)	TSC	EG&G
Technical Service Facility	TSF	EG&G
Technical Support Buildings A&B (Idaho Falls)	TSA;TSB	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
Field Engineering Test Facility	FET	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
Radioactive Waste Management Program	—	EG&G
Reactor Materials Testing Program	—	EG&G
Specific Manufacturing Capability	—	R-INEL
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), Rockwell-INEL (R-INEL), Rockwell International (RI), Westinghouse Electric Corporation (WEC), Westinghouse Idaho Nuclear Company (WINCO).

b. Zero or low power reactor.

approximately 4.3×10^9 m^3 (3.5×10^6 acre-ft) per year. Both aquifer and surface waters of the Snake River Plain are used for irrigation of crops.

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, while winter has more calm periods and more nighttime temperature inversions.

Reference

A-1. M.A. Kuntz, et al., "Holocene Basaltic Volcanism Along the Great Rift, Central and Eastern Snake River Plain, Idaho," *Utah Geological and Mineral Survey Special Studies 61, 1983, Guidebook, Part-3*, GSA Rocky Mountain and Cordilleran Sections Meeting: Salt Lake City, Utah, May 1983.

APPENDIX B

ENVIRONMENTAL MONITORING PROGRAM DATA SUMMARIES

APPENDIX B

ENVIRONMENTAL MONITORING PROGRAM DATA SUMMARIES

This appendix contains data summary tables (B-1 through B-13) and maps (Figures B-1 and B-2) for the environmental monitoring program at the INEL Site for 1987.

TABLE B-1
PARTICULATE BETA ACTIVITY IN AIR (1987)

Group	Locations	Number of Samples	Concentration (10^{-15} μCi/mL) Range	Annual Average[a]
Distant	Blackfoot	51	8-93	35 ± 4
	Craters of the Moon	51	12-57	32 ± 3
	Idaho Falls	45	10-62	31 ± 4
	Rexburg	52	10-53	29 ± 3
	Grand Mean[a]	—	—	32 ± 2
Boundary	Arco	52	12-74	34 ± 3
	Atomic City	52	13-75	36 ± 4
	FAA Tower	51	11-95	34 ± 4
	Howe	51	9-81	34 ± 4
	Monteview	38	10-59	29 ± 3
	Mud Lake	51	13-70	34 ± 4
	Reno Ranch	52	10-80	32 ± 4
	Grand Mean[a]	—	—	33 ± 1
Onsite	ANL-W	52	10-80	35 ± 4
	ARA	52	12-62	33 ± 3
	CFA	51	10-260	46 ± 13
	EBR-I	51	14-290	57 ± 13
	EFS	48	16-99	47 ± 6
	ICPP	52	12-570	109 ± 33
	NRF	51	16-95	40 ± 4
	PBF	46	15-152	43 ± 7
	RWMC	52	12-151	41 ± 7
	TAN	51	12-85	36 ± 4
	TRA	46	22-156	50 ± 8
	VANB	51	21-230	58 ± 11
	Grand Mean[a]	—	—	50 ± 4

a. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-2
PARTICULATE BETA STATISTICAL COMPARISONS[a] BY LOCATION (1987)

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
ARCO	—	—	—	—	—	—	—	—	—	—	—	—	—
ATOM	—	—	—	—	—	+	—	—	—	—	—	+	+
FAAT	—	—	—	—	—	—	—	—	—	—	—	—	—
HOWE	—	—	—	+	—	—	—	—	—	—	—	+	—
MONT	—[b]	—[b]	—[b]	—	—	—	—	—	—	—	—	—	—
MUDL	—	—	—	—	—	—	—	—	—	—	—	—	—
RENO	—	—	—	—	—	—	—	—	—	—	—	—	—
Boundary Group[c]	—	—	—	+	—	—	—	—	—	—	—	—	—
ANL-W	—	—	—	—	+	+	+	—	—	—	—	—	+
ARA	—	—	—	—	—	—	—	—	—	—	—	—	—
CFA	+	—	—	+	—	—	+	+	—	—	—	—	+
EBR-I	+	+	+	+	+	+	+	+	+	+	—	+	+
EFS	—	+	—	+	+	+	—	+	+	+	—	+	+
ICPP	+	—	+	+	+	+	+	+	+	+	—	+	+
NRF	+	—	—	+	—	—	—	+	—	—	—	+	+
PBF	+	+	—[b]	—	—	+	+	+	—	—	—	+	+
RWMC	—	+	—	—	—	—	+	—	—	—	—	—	+
TAN	—	—	—	—	—	+	—	—	—	—	—	—	+
TRA	+	+	+	+	+	+	+	+	—	—	—	—	+
VANB	+	+	+	+	+	+	+	+	—	—	—	+	+
Onsite Group[c]	+	—	—	—	+	—	—	+	+	—	—	+	+

a. Comparison used was unpaired t-test ($\alpha = 0.05$) between means of individual locations and the distant communities (background) group mean. Means that were statistically greater than the background mean are indicated by "+" in the array (see Appendix C).

b. No data for this month at this location.

c. Group mean was compared to the background group mean for a comparable time period.

TABLE B-3
SPECIFIC RADIONUCLIDE ACTIVITY IN AIR (1987)

Radionuclide	Composite Group[a]	Minimum[b]	Maximum[b]	Mean[c]	Derived Concentration Guide[d]	~MDC[e]
		Concentration ($10^{-15}\mu$Ci/mL)				
Ce-141	Distant	<MDC[f]	1.1 ± 1.0	NSS[g]	1,000,000	2
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	9 ± 4	0.8 ± 0.6		
Co-60	Distant	<MDC	0.18 ± 0.16	NSS	80,000	2
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	<MDC	NSS		
Cs-134	Distant	<MDC	<MDC	NSS	200,000	2
	Boundary	<MDC	<MDC	0.16 ± 0.08		
	Onsite	<MDC	2.0 ± 0.6	NSS		
Cs-137	Distant	<MDC	<MDC	NSS	400,000	1
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	1.8 ± 1.0	NSS		
Mn-54	Distant	<MDC	<MDC	NSS	2,000,000	1
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	1.4 ± 0.8	NSS		
Ru-103	Distant	<MDC	1.8 ± 1.6	NSS	2,000,000	1
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	<MDC	NSS		
Sb-125	Distant	<MDC	3.3 ± 2.4	NSS	1,000,000	6
	Boundary	<MDC	7.2 ± 2.2	2.2 ± 0.8		
	Onsite	<MDC	229 ± 12	21 ± 11		
Sr-90	Distant	<MDC	0.36 ± 0.18	0.14 ± 0.12	9,000	0.1
	Boundary	<MDC	0.39 ± 0.18	NSS		
	Onsite	<MDC	0.41 ± 0.18	0.15 ± 0.13		
Zr-95	Distant	<MDC	<MDC	NSS	600,000	1
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	2.4 ± 2.0	NSS		
		Concentration ($10^{-18}\mu$Ci/mL)				
Am-241	Distant	<MDC	<MDC	NSS	20,000	6
	Boundary	<MDC	19 ± 16	NSS		
	Onsite	<MDC	74 ± 14	NSS		
Pu-238	Distant	<MDC	<MDC	NSS	30,000	6
	Boundary	<MDC	11 ± 10	NSS		
	Onsite	<MDC	<MDC	NSS		
Pu-239/240	Distant	<MDC	<MDC	NSS	20,000	6
	Boundary	<MDC	<MDC	NSS		
	Onsite	<MDC	21 ± 6	NSS		

a. Sampling stations are shown in Figure 3 of this report.

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

c. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

d. Annual derived concentration guides given in Reference 3.

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 elapsed 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 C).

TABLE B-4
ANTIMONY-125 ACTIVITY IN AIR (1987)

Location[b]	Sb-125 Concentration (10^{-15} μCi/mL)[a]				
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Annual Mean
Distant					
Blackfoot	1.3 ± 2.6	−1.5 ± 2.2	−1.4 ± 2.6	0.2 ± 2.6	−0.4 ± 2.1
Craters of the Moon	2.3 ± 0.6	3.3 ± 2.4	2.2 ± 2.4	1.0 ± 2.6	2.2 ± 1.5
Idaho Falls	1.0 ± 4.2	0.1 ± 1.4	0.1 ± 2.6	2.6 ± 3.2	1.0 ± 1.9
Rexburg	−0.3 ± 1.2	−0.1 ± 2.2	0.0 ± 2.2	−0.6 ± 1.2	−0.3 ± 0.4
Boundary					
Arco	5.2 ± 2.6	1.9 ± 2.4	1.5 ± 1.6	1.6 ± 2.4	2.6 ± 2.8
Atomic City	2.7 ± 1.8	3.0 ± 4.0	1.8 ± 2.4	1.1 ± 2.0	2.2 ± 1.4
FAA Tower	−1.2 ± 2.0	0.8 ± 2.2	0.0 ± 2.2	1.3 ± 2.0	0.2 ± 1.7
Howe	3.0 ± 2.0	7.2 ± 2.2	5.5 ± 2.4	3.5 ± 2.0	4.8 ± 3.1
Monteview	Invalid	2.8 ± 2.4	0.0 ± 2.2	−0.3 ± 2.2	0.8 ± 2.1
Mud Lake	0.9 ± 2.2	3.5 ± 2.4	1.9 ± 2.2	3.4 ± 2.0	2.4 ± 2.0
Reno Ranch	3.2 ± 1.6	3.2 ± 1.8	1.4 ± 2.2	−0.4 ± 1.8	1.9 ± 2.7
Onsite					
ANL-W	2.8 ± 2.2	1.4 ± 2.2	2.6 ± 2.6	2.9 ± 2.0	2.4 ± 1.1
ARA	4.9 ± 3.0	0.5 ± 2.4	3.7 ± 2.6	2.7 ± 1.8	3.0 ± 3.0
CFA	47 ± 4	6.9 ± 2.6	12.9 ± 2.8	1.0 ± 1.6	17 ± 33
EBR-I	63 ± 6	19 ± 4	32 ± 4	3.0 ± 2.0	29 ± 41
EFS	22 ± 4	25 ± 4	13 ± 4	4.2 ± 3.2	16 ± 15
ICPP	42 ± 6	95 ± 8	229 ± 12	21 ± 4	97 ± 149
NRF	7.8 ± 2.6	7.9 ± 2.6	3.4 ± 2.6	4.5 ± 2.6	5.9 ± 3.7
PBF	36 ± 6	2.4 ± 2.0	4.6 ± 2.6	1.8 ± 2.4	11.2 ± 26.4
RWMC	26 ± 4	4.4 ± 2.6	26 ± 4	6.0 ± 2.6	16 ± 19
TAN	1.9 ± 2.2	4.2 ± 2.2	1.0 ± 2.4	−0.8 ± 2.0	1.6 ± 3.3
TRA	27 ± 6	8.5 ± 2.8	30 ± 4	3.2 ± 2.6	17 ± 21
VANB	49 ± 6	24 ± 4	56 ± 6	0.8 ± 2.4	32 ± 40

a. Single quarterly composite sample analytical results ±2s, decay corrected assuming a constant concentration and buildup during the sampling period. Annual mean is the arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

b. Sampling stations are shown in Figure 3 of this report.

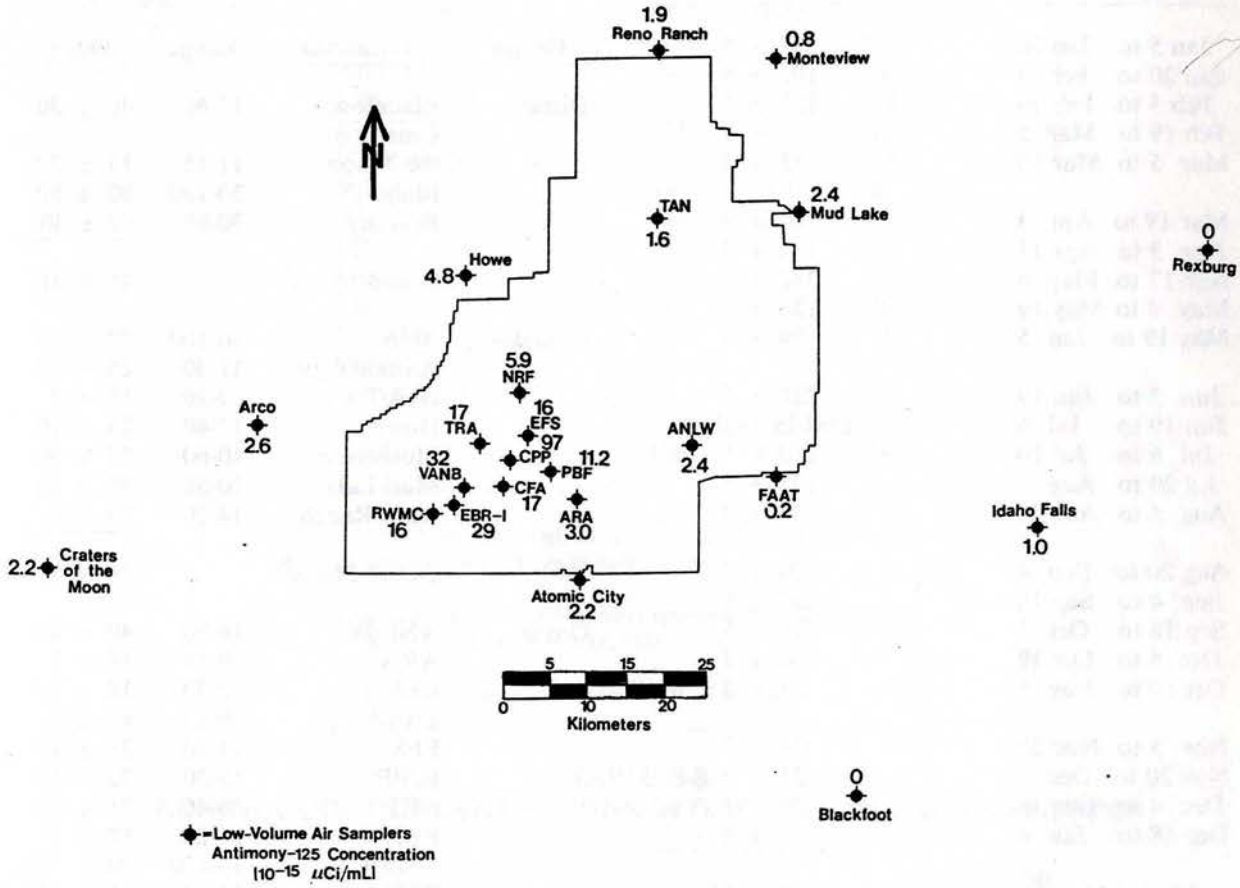

Figure B-1. Annual average particulate concentrations of Sb-125 (1987).

TABLE B-5
KRYPTON-85 CONCENTRATIONS IN AIR AT CFA (1987)

Sample Dates	Concentration[a] (10^{-12} μCi/mL)
Jan 5 to Jan 20	257 ± 5
Jan 20 to Feb 5	191 ± 5
Feb 5 to Feb 19	251 ± 5
Feb 19 to Mar 5	68 ± 3
Mar 5 to Mar 19	33 ± 3
Mar 19 to Apr 3	113 ± 4
Apr 3 to Apr 17	174 ± 5
Apr 17 to May 4	382 ± 6
May 4 to May 19	126 ± 4
May 19 to Jun 5	94 ± 4
Jun 5 to Jun 19	221 ± 5
Jun 19 to Jul 6	Lost in analysis
Jul 6 to Jul 20	210 ± 5
Jul 20 to Aug 5	178 ± 5
Aug 5 to Aug 20	140 ± 4
Aug 20 to Sep 4	450 ± 7
Sep 4 to Sep 18	230 ± 5
Sep 18 to Oct 5	110 ± 5
Oct 5 to Oct 19	30 ± 3
Oct 19 to Nov 5	25 ± 3
Nov 5 to Nov 20	25 ± 3
Nov 20 to Dec 4	25 ± 4
Dec 4 to Dec 18	29 ± 3
Dec 18 to Jan 4	635 ± 8
Annual Mean[b]	173 ± 66

a. Results ± 2s analytical uncertainty reported by USEPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

b. Arithmetic mean with the 95% confidence interval for the mean.

TABLE B-6
PARTICULATE MATTER CONCENTRATIONS IN AIR (1987)

Group	Locations	Concentration[a] (μg/m^3) Range	Mean[b]
Distant	Blackfoot	17-60	40 ± 30
	Craters of the Moon	11-15	13 ± 3
	Idaho Falls	30-100	80 ± 50
	Rexburg	30-80	50 ± 30
	Grand Mean[b]		45 ± 16
Boundary	Arco	30-100	70 ± 50
	Atomic City	11-40	25 ± 19
	FAA Tower	9-20	16 ± 8
	Howe	17-40	26 ± 19
	Monteview	40-60	50 ± 30
	Mud Lake	30-50	40 ± 16
	Reno Ranch	14-20	19 ± 6
	Grand Mean[b]		34 ± 8
Onsite	ANL-W	16-80	40 ± 40
	ARA	9-18	14 ± 7
	CFA	9-30	18 ± 11
	EBR-I	9-17	13 ± 6
	EFS	14-40	31 ± 19
	ICPP	15-30	22 ± 12
	NRF	20-40	31 ± 12
	PBF	14-20	17 ± 5
	RWMC	30-170	90 ± 100
	TAN	18-40	27 ± 12
	TRA	17-40	27 ± 12
	VANB	8-20	16 ± 9
	Grand Mean[b]		28 ± 8

a. The approximate minimum detectable concentration (~MDC) is 10 μg/m^3. The EPA's national secondary ambient air quality standard is 60 μg/m^3, annual average.

b. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-7
NONRADIOACTIVE AIRBORNE EFFLUENTS (1987)

Facility	Emissions (metric tonnes) NO	NO_2[a]	SO_2
ANL-W	—	2	4
CFA	—	3	9
CFSGF[b]	75	—	12
ICPP (oil)	—	1	9
NRF	—	19	61
NWCF[c]	31	274	—
PBF	—	—	1
TAN	—	10	37
TRA	—	11	40
WRRTF	—	—	1
Other (ARA, RWMC)	—	—	—
Totals	106	320	174

a. Calculated from fuel oil usage reported in IWMIS[7] and emission factors given in Reference 18.

b. Calculated from CFSGF plant operating data. Letter from K. R. Krivanek, March 14, 1988.

c. Personal communication with K. R. Krivanek.

TABLE B-8
RADIONUCLIDE CONCENTRATIONS IN ONSITE DRINKING WATER (1987)

	H-3 Concentration ($10^{-7}\mu Ci/mL$)				Sr-90 Concentration ($10^{-9}\mu Ci/mL$)			
Well Code	No. Samples[a]	Range	Annual Mean[b]	% DCG	No. Samples[a]	Range	Annual Mean[b]	% DCG
CFA #1	12	327-389	353 ± 12	1.8	0	—	—	—
CFA #2	12	196-252	226 ± 11	1.1	0	—	—	—
ICPP #1	4	<MDC[c]-<MDC	3.0 ± 2.9	0.02	4	0.9-1.9	1.5 ± 0.7	0.15
ICPP #2	8	<MDC-<MDC	1.1 ± 0.5	0.01	7	<MDC-0.5	NSS[d]	—
ICPP #4	12	<MDC-<MDC	NSS	—	11	<MDC-<MDC	NSS	—
OMRE	9	31-44	36 ± 3	0.18	0	—	—	—
RWMC	12	20-38	27 ± 3	0.14	0	—	—	—

a. RESL collects samples only from wells actually in use at collection time. Tritium and Sr-90 results from samples collected by USGS from these wells appear periodically in USGS reports.[8]

b. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

c. <MDC refers to concentrations less than the minimum detectable concentration.

d. Mean is not statistically significant, or zero is included within the 95% confidence interval.

TABLE B-9
PURGEABLE ORGANIC COMPOUNDS IN GROUND WATER (1987)[a]

Well Number	Date Sampled	Concentration[b] (μg/L) Carbon Tetra-chloride	Chloro-form	1,1,1-Tri-chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Toluene	Others
RWMC Area								
88	06-03-87	6.6	—	—	—	—	—	—
	07-08-87[c]	2.7-3.2	—	—	1.1-1.2	—	—	—
	07-15-87	4.4	1.0	—	1.4	—	—	—
	08-11-87	2.1	—	—	1.2	—	—	—
	09-22-87	2.9	—	—	1.1	—	—	—
92[d]	10-23-87	1200	650	140	860	110	—	1,1-Dichloroethane, 13 1,1,2,2-Tetrachloroethane, 1.0 1,2-Dichloropropane, 5.9
119	11-06-87	—	—	—	—	—	1.2	—
	11-06-87	—	—	—	—	—	1.0	—
120	11-18-87	1.5	—	—	—	—	—	—
		1.4	—	—	—	—	—	—
RWMC	08-11-87	1.0	—	—	—	—	—	—
	09-23-87	1.3	—	—	—	—	—	—
	10-14-87	1.5	—	—	—	—	—	—
TAN								
ANP-8	10-25-87	—	—	—	7.5	4.2	—	—
IET-1	10-27-87	—	—	—	1.3	1.2	—	1,2-Dichlorobenzene, 1.9
TAN-1	10-23-87	—	—	—	7.7	2.0	—	—
TAN-2	10-23-87	—	—	—	5.4	1.1	—	—
TAN-Disp.	10-27-87	—	—	—	35,000	170	—	1,1-Dichloroethylene, 49 1,2-trans-Dichloroethylene, 22,000
TRA								
65	10-14-87	—	—	1.1	—	—	—	—
TRA-4	10-30-87	—	—	—	6.7	—	3.4	—
TRA-Disp.	10-28-87	—	—	—	4.0	—	—	—
Other Areas								
109	10-05-87	—	—	—	—	—	1.0	—
114	10-09-87	—	—	1.1	—	—	—	—
ARA-2	10-28-87	—	—	—	—	—	1.7	—
Badging Facility	10-24-87	—	—	1.0	—	—	—	—
Fire Station 2	11-03-87	—	—	2.6	—	—	—	—
NRF-2	10-29-87	—	—	—	1.3	—	—	—
OMRE	10-30-87	—	—	—	—	—	2.2	—
MCL[e]		5	100	200	5	None	None	—

a. For more information regarding these samples, see the USGS report DOE/ID-22074.[2]

b. Concentrations shown are those measured which were equal to or above 1.0 μg/L. For most analyses, the reporting level was 0.2 μg/L.

c. Concentrations shown are the range of five samples taken over a four-hour period.

d. Samples from this well were obtained with a thief sampler. Well 92 samples perched water, not the Snake River Plain aquifer.

e. Maximum contaminant level for drinking water promulgated by the U.S. Environmental Protection Agency on July 8, 1987, except for chloroform. Chloroform is a trihalomethane regulated under 40CFR141. Production wells where the MCL is applicable are RWMC, ANP-8, TAN-1, TAN-2, TRA-4, ARA-2, Badging Facility, Fire Station 2, NRF-2, and OMRE.

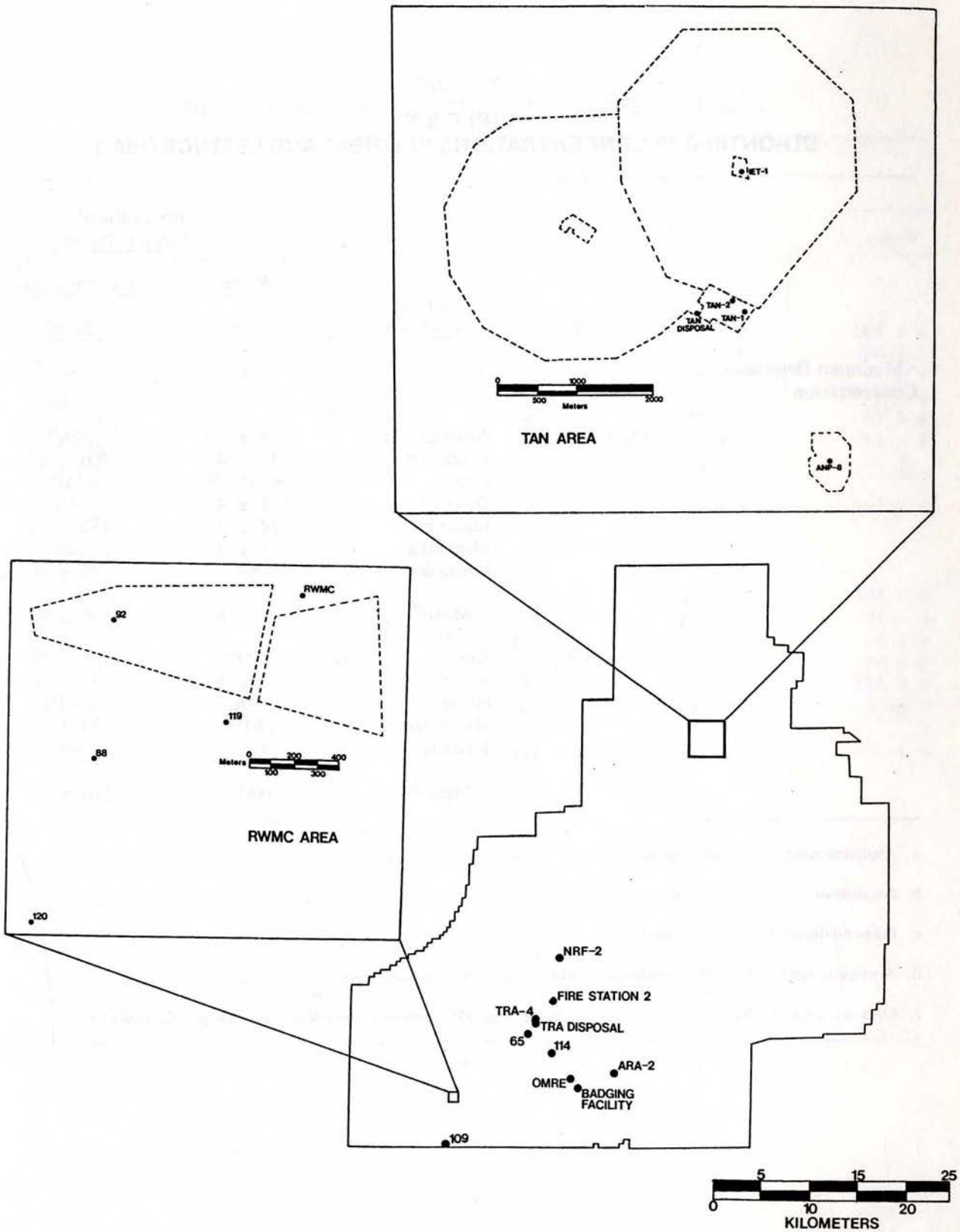

Figure B-2. Locations of wells listed in Table B-9.

TABLE B-10
STRONTIUM-90 CONCENTRATIONS IN WHEAT AND LETTUCE (1987)

			Concentration[a] (10^{-9} μCi/g dry wt)	
			Wheat	Garden Lettuce
	Group	Sample Location	Sr-90	Sr-90
~Minimum Detectable Concentration	—	—	4	80
	Distant	American Falls	8 ± 4	NA[b]
		Blackfoot	17 ± 4	100 ± 60
		Carey	<MDC[c]	<MDC
		Dietrich	8 ± 4	NA
		Idaho Falls	14 ± 4	150 ± 80
		Minidoka	5 ± 4	NA
		Pocatello	NA	90 ± 60
		Mean[d]	9 ± 6	100 ± 60
	Boundary	Arco	<MDC	120 ± 60
		Atomic City	7 ± 4	140 ± 40
		Howe	NA	<MDC
		Mud Lake	<MDC	120 ± 60
		Terreton	5 ± 4	NA
		Mean[d]	NSS[e]	110 ± 50

a. Analytical results ± 2s (see AppendixC).

b. No analysis.

c. Below minimum detectable concentration.

d. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

e. Mean is not statistically significant, or zero is included in the 95% confidence interval for the mean (see Appendix C).

TABLE B-11
ENVIRONMENTAL RADIATION EXPOSURES (1984-1987)

Location	Annual Exposures (mR)[a] 1984	1985	1986	1987[b]
Distant Group:				
Aberdeen	116 ± 7	111 ± 5	111 ± 6	104 ± 4
Blackfoot	119 ± 7	111 ± 5	113 ± 6	100 ± 2
Craters of the Moon	121 ± 6	113 ± 5	111 ± 6	98 ± 4
Idaho Falls	101 ± 4	112 ± 7[c]	120 ± 8	113 ± 4
Minidoka	107 ± 5	98 ± 4	97 ± 6	95 ± 4
Rexburg	—	103 ± 4[d]	111 ± 6	94 ± 3
Roberts	133 ± 10	107 ± 5	124 ± 8	—[e]
Mean[f]	116 ± 12	108 ± 5	112 ± 8	101 ± 7
Boundary Group:				
Arco	120 ± 6	117 ± 7	109 ± 9	100 ± 4
Atomic City	125 ± 8	116 ± 5	121 ± 7	95 ± 4
Howe	116 ± 5	112 ± 6	110 ± 8	98 ± 4
Monteview	118 ± 4	111 ± 4	114 ± 6	98 ± 4
Mud Lake	126 ± 6	122 ± 6	113 ± 7	104 ± 4
Reno Ranch	112 ± 5	105 ± 4	107 ± 7	93 ± 3
Mean[f]	120 ± 6	114 ± 6	112 ± 5	98 ± 4

a. Annual exposure ± 2s (see Appendix C.)

b. Some or all annual exposures listed for 1987 may be 11% low. See text.

c. Dosimeter moved from former Idaho Falls location to new location at Faust road in November 1984.

d. 1985 was first full year for dosimeter at Rexburg location.

e. Dosimeter missing at May 1987 collection time.

f. Arithmetic mean with the 95% confidence interval for the mean (see Appendix C).

TABLE B-12
RADIONUCLIDE COMPOSITION OF AIRBORNE EFFLUENTS (1987)

			Airborne Effluent (Ci)[a]				
	Radionuclide	Half-Life	ANL-W	ICPP	NRF	TRA	Total[b]
Noble Gases	Kr-85	10.7 yr	7.0	<160,000[c]	5.7×10^{-2}	3.0	<160,000
	Ar-41	1.83 hr	120	—	—	2400	2,500
	Xe-133	5.25 da	600	—	—	11	610
	Xe-138	14.2 min	4.2	—	—	330	340
	Xe-135	9.10 hr	110	—	—	110	220
	Kr-88	2.84 hr	19	—	—	99	120
	Kr-87	1.27 hr	9.3	—	—	100	110
	Xe-135m	15.3 min	1.2	—	—	59	60
	Kr-85m	4.48 hr	16	—	—	28	44
Particulates	Sb-125	2.73 yr	—	16	—	3.1×10^{-7}	16
	Rb-89	15.4 min	—	—	—	0.21	0.21
	Cs-138	32.2 min	—	—	—	0.19	0.19
	Rb-88	17.7 min	—	—	—	0.13	0.13
	Ba-139	1.39 hr	—	—	—	1.7×10^{-2}	1.7×10^{-2}
	Co-60	5.26 yr	—	8.6×10^{-7}	1.2×10^{-2}	4.4×10^{-5}	1.2×10^{-2}
	Br-82	1.49 da	8.3×10^{-3}	—	—	—	8.3×10^{-3}
	Cr-51	27.8 da	—	—	—	5.8×10^{-3}	5.8×10^{-3}
	Na-24	15.0 hr	—	—	—	1.7×10^{-3}	1.7×10^{-3}
	Hg-203	46.6 da	—	—	—	6.5×10^{-4}	6.5×10^{-4}
	Cs-137	30.2 yr	—	4.1×10^{-4}	1.8×10^{-7}	8.4×10^{-5}	5.5×10^{-4}
	Ru-106	372 da	—	3.7×10^{-4}	—	—	3.7×10^{-4}
	Ir-192	73.8 da	—	—	—	2.6×10^{-4}	2.6×10^{-4}
	Sr-90 + D[d]	28.6 yr	—	1.9×10^{-4}	—	7.2×10^{-5}	2.6×10^{-4}
	Cs-134	2.07 yr	—	1.0×10^{-6}	—	3.1×10^{-5}	3.2×10^{-5}
	Pu (total)	—	—	2.0×10^{-5}	—	—	2.0×10^{-5}
H-3, C-14 and Iodine Isotopes	H-3	12.3 yr	2.6	920	6.0×10^{-2}	—	920
	C-14	5.7×10^{3} yr	—	3.8	0.19	—	4.0
	I-129	1.6×10^{7} yr	—	0.2	—	—	0.2
	I-131	8.04 da	—	—	4.4×10^{-4}	8.5×10^{-5}	5.3×10^{-4}
	I-133	20.8 hr	—	—	—	6.7×10^{-5}	6.7×10^{-5}
All Other Total			2.7×10^{-5}	2.0×10^{-4}	2.6×10^{-6}	1.5×10^{-3}	1.8×10^{-3}
Grand Totals			890	<161,000	0.32	3100	<165,000

a. Radioactivity listed in 1987 Radioactive Waste Management Information System Report as amended by the ICPP (Letter, K. Krivanek, March 14, 1988). Values are not corrected for decay after release. Data are preliminary.

b. Totals include small amounts from facilities not listed.

c. The actual number of curies is classified information.

d. Parent-daughter equilibrium assumed.

TABLE B-13
RADIONUCLIDE COMPOSITION OF LIQUID EFFLUENTS RELEASED ONSITE (1987)

		Liquid Effluent (Ci)[a]				
Radionuclide	Half-Life	ANL-W	CFA	ICPP	TRA	Total[b]
H-3	12.3 yr	0.33	2.2[c]	220	130	350
Cr-51	27.8 da	—	—	—	8.0	8.0
Cs-137	30.2 yr	—	—	0.14	0.65	0.79
Na-24	15.0 hr	—	—	—	0.25	0.25
Sr-90	28.6 yr	—	1.1×10^{-4}	9.0×10^{-2}	8.2×10^{-2}	0.17
Co-60	5.26 yr	—	—	2.8×10^{-3}	0.13	0.13
Ce-144	2.84 da	—	—	1.9×10^{-2}	2.8×10^{-2}	4.7×10^{-2}
I-131	8.04 da	—	—	—	2.4×10^{-2}	2.4×10^{-2}
Pu (total)	—	—	—	9.6×10^{-3}	—	9.6×10^{-3}
I-129	1.6×10^{7} yr	—	—	7.7×10^{-3}	1.9×10^{-11}	7.7×10^{-3}
All Others	—	—	—	0.16	2.0	2.1
Grand Totals		0.33	2.2	220	140	360

a. Radioactivity listed in 1987 Radioactive Waste Management Information System Report.[5] Values are not corrected for decay after release. Data are preliminary.

b. Totals include small amounts from facilities not listed.

c. Tritium in the effluent is due to tritium in the water supply at CFA.

APPENDIX C

STATISTICAL METHODS

APPENDIX C

STATISTICAL METHODS

Individual analytical results are given in the report with plus or minus (±) 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 as meaning that they were below the minimum detectable concentration (MDC). Gamma spectrometric analyses differ from other types because the radionuclide is not considered detectable unless the net count in the peak is equal to or greater than three times its estimated analytical uncertainty (3s). A deliberate search for specific nuclides can be made and results reported, but such results might include negative values.

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. Uncertainties in measurements near the MDC are due primarily to counting statistics. For low concentrations near the MDC, the uncertainty in the measurement is nearly equal to the measurement itself, and the lower limit of the range of the measurement approaches "zero." Such a result might not be very reliable because the uncertainty is only an estimate and the actual probability distribution of the results is not usually known. In reality, the material being measured may not actually be present in the sample. Therefore, when analytical results show a measurement very near the MDC, 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 MDC. 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, or $s/(n)^{1/2}$ by the t(0.05) 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 MDC, 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.

Geometric means were calculated by summing the natural logarithms (ln) of the positive analytical results, dividing by the number of samples (n), and then transforming the quotient. If the result was either a negative number or a zero, the ln of the smallest positive, nonzero measurement in the group was used. The 95% confidence interval was determined by multiplying the standard deviation of the geometric mean by the t(0.05) statistic and then transforming the result. The actual interval is determined by dividing the transformed mean by the transformed 95% confidence interval term for the lower limit, then multiplying the mean by the confidence interval term for the upper limit.

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% ($\alpha = 0.05$).[C-1]

Reference

C-1. L. Ott, *An Introduction to Statistical Methods and Data Analysis*, Boston, Massachusetts: Duxbury Press, 1977.

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