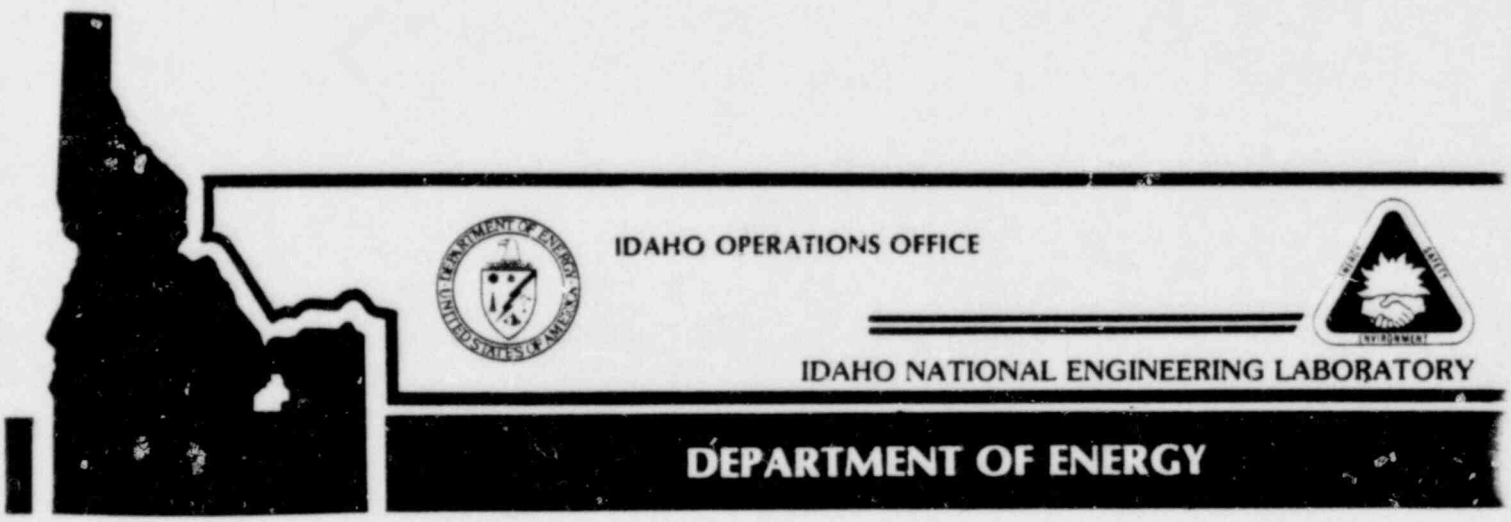
IDO-12082(80)

1980 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR IDAHO NATIONAL ENGINEERING LABORATORY SITE

May 1981



IDAHO OPERATIONS OFFICE

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
NTIS Price Codes: Printed Copy A03
Microfiche A01

IDO-12082(80)
Special Distribution

1980 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR IDAHO NATIONAL ENGINEERING LABORATORY SITE

May 1981

Prepared by the Environmental Sciences Branch
Radiological and Environmental Sciences Laboratory
Idaho Operations Office
U.S. Department of Energy
550 Second Street
Idaho Falls, Idaho 83401

PREFACE

This report presents the offsite data collected in 1980 for the routine environmental monitoring program conducted by the Department of Energy's Radiological and Environmental Sciences Laboratory (RESL/ID) 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 Department of Energy requirements DOE Order 5480.1 (ERDAM 0513) and is not intended to cover the numerous special environmental research programs being conducted at the INEL by the RESL/ID and others. Generally, these latter programs are aimed at quantifying the effects of Site operations on the onsite environment.

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

SUMMARY

The results of the various monitoring programs for 1980 indicated 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 the State of Idaho and the Federal Government health protection guidelines. This report describes the air, water, and foodstuff samples routinely collected at INEL boundary locations and at locations distant from the INEL Site. The report also compares and evaluates the significance of the sample results.

There was no statistical difference in particulate beta concentrations in air as measured at Site boundary stations and those measured at distant sampling stations. The concentrations of one nuclide, Sb-125 in air, at six of the seven boundary stations for the fourth quarter of 1980 were statistically greater than concentrations at the distant stations. However, the annual concentrations were far below (0.0002%) the health protection guide. Only one of the offsite well water or surface water samples contained any gross alpha activity, and none contained any gross beta or tritium activity above the detection limits of the analyses. These detection limits are well below the health protection guides. The gross alpha detected in one sample of a private water supply (upgradient from the INEL Site) was considerably below the Environmental Protection Agency (EPA) maximum contaminant level for community drinking water systems; however, this gross alpha was not due to Site operations. Iodine-131 was detected in some milk samples, but was not attributed to Site operations. Some of the milk, wheat, and lettuce samples contained small amounts of Sr-90, probably due to worldwide fallout. Penetrating radiation measured simultaneously at Site boundary and distant locations showed only natural background levels. For more details, see the section "Monitoring Data Collection, Analyses, and Evaluation."

Measured amounts of radioactivity, primarily in the form of inert gases, are released from various plant facilities and subsequently travel offsite. When they reach the Site boundary, these gases are in such small concentrations that they cannot be measured; but their hypothetical contributions to offsite doses are nevertheless calculated.

A hypothetical maximum whole-body dose from continuous submersion in and inhalation of airborne radioactivity that could have been received by an individual if he had lived continuously for the entire year at the immediate southern boundary of the Site was calculated to be 0.05 millirem (mrem). This hypothetical dose is about 0.03% of the natural background radiation dose of about 150 mrem per year in this area. The maximum potential dose to a member of a population group from Site effluents was calculated to be 0.04 mrem at Atomic City, Idaho. The maximum potential population dose from continuous submersion in and inhalation of airborne radioactivity to the approximately 102,300 people residing within an 80-km (50-mi) radius from the center of INEL was estimated to be 0.14 man-rem. This dose is less than 0.001% of the population dose from natural background radioactivity, which is calculated to be about 15,500 man-rem. These doses and their significance are discussed in the section "Radiological Impact of INEL Site Operations."

Calculations indicate that the maximum potential dose to an individual from exposure pathways due to ingestion of wild game animals would be less than 10% of the radiation standard. The potential population dose from these exposure pathways would realistically be less than the dose from submersion and inhalation.

CONTENTS

FIGURES

TABLES

1980 ENVIRONMENTAL MONITORING PROGRAM REPORT FOR IDAHO NATIONAL ENGINEERING LABORATORY SITE

INTRODUCTION

The Department of Energy's (DOE) Idaho National Engineering Laboratory (INEL) was established by the Federal Government in 1949 to conduct research and development on nuclear reactors and ancillary plants and equipment. The 2300-km^2 (890-mi^2) Site is located west of Idaho Falls, Idaho on a high desert plain (see Figures 1 and 2). In 1975 the Site was also designated as one of the nation's four National Environmental Research Park (NERP). A more detailed description of the Site location, environment, and current major activities is given in Appendix A.

Figure 1. North facing view of part of the Idaho National Engineering Laboratory Site.

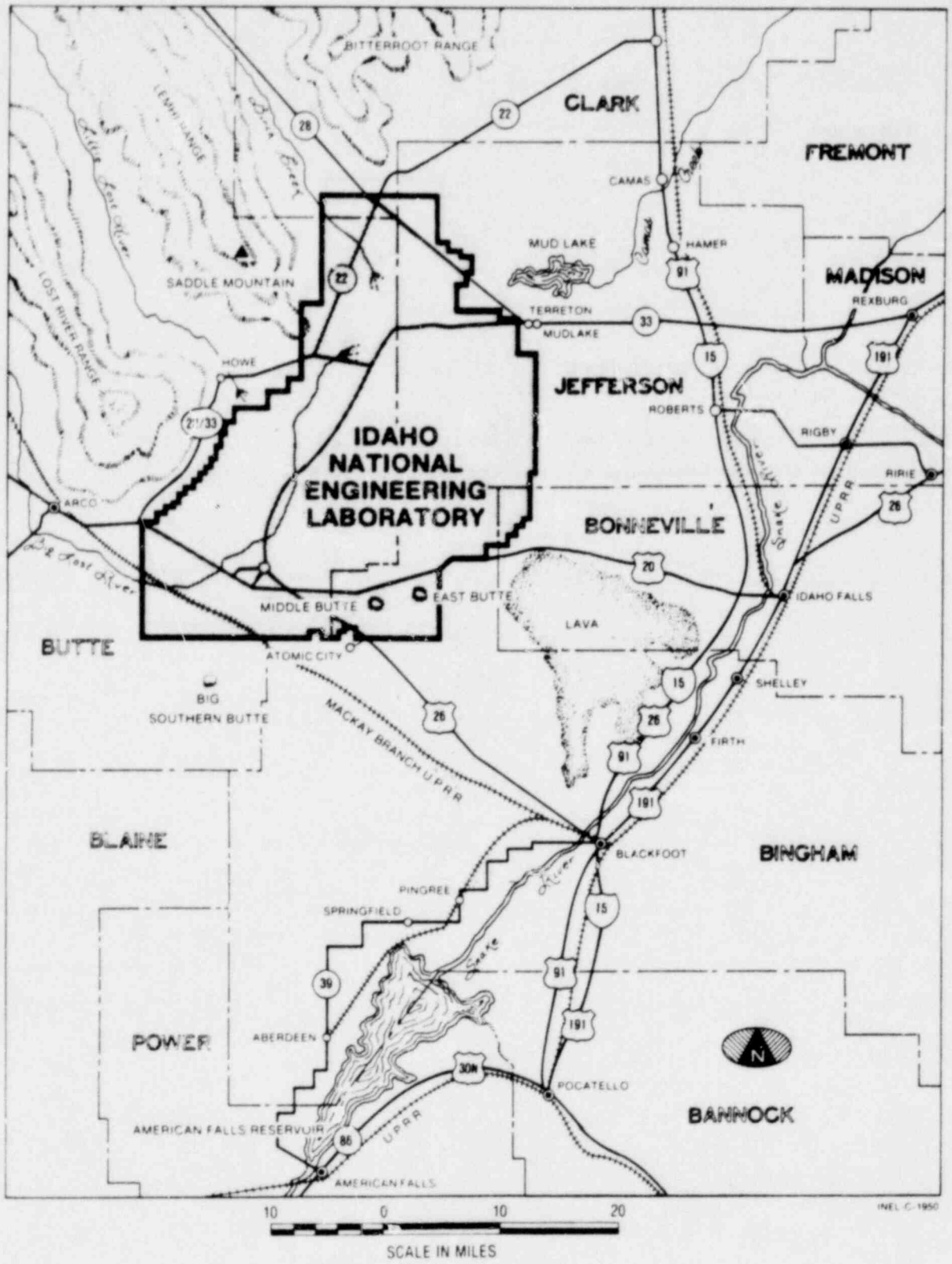


Figure 2. Idaho National Engineering Laboratory Site vicinity map.

MONITORING DATA COLLECTION, ANALYSES, AND EVALUATION

General

During the normal operation of the reactors and the fuel reprocessing plant at the Site, some radioactivity is released to the environment. The potential environmental pathways from the Site to nearby populations are by atmospheric transport or indirectly through soils, foodstuffs, or animals. There is no evidence that radionuclides in water in the Snake River Plain aquifer have reached the INEL southern boundary, so this is not considered a pathway. Computer model projections indicate that trace concentrations of radioactivity will migrate offsite in the future.

The environmental monitoring program for the Site and vicinity for 1980 included the sampling and analysis of the mentioned potential pathways. Table I gives a summary of the program. Air and water were routinely monitored for radioactivity at a number of onsite, perimeter, and distant locations. Levels of radioactivity in milk, wheat, and lettuce samples were routinely measured at Site boundary and distant locations. Penetrating radiation exposure rates (cumulative from November 1979 to November 1980) were measured at Site boundary and distant locations. See Appendix B for a description of the quality control and assurance program maintained by DOE's Radiological and Environmental Sciences Laboratory (RESL/ID).

A discussion of each routine program follows. For each program a presentation and interpretation of the data are given, as are the location of each sampling station and the number of samples collected. Several different statistical methods were used in analyzing the data. See Appendix C for a discussion of the statistics used in this report.

Air Sampling

Radiological. Levels of airborne particulate radioactivity are monitored offsite by a network of 10 continuous air samplers at locations shown in Figure 3. 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 prefilter (Gelman Model AN-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. Three locations also have samplers for tritium in water vapor, in which air is passed at 0.3 L/min through a column of silica gel. Noble gases (argon, krypton, and xenon) are monitored at their onsite release points only. Air samplers are located in the small communities close to the Site boundary and at the more distant communities of Idaho Falls, Blackfoot, and Pocatello, Idaho. These distant or background locations are in directions usually crosswind of the Site and are sufficiently remote to ensure that radioactivity detected is due to natural background or sources other than Site operations. The whole network provides comprehensive surveillance of atmospheric radioactivity and theoretically makes it possible to differentiate Site releases from worldwide fallout and long-lived natural radioactivity.

The filters are collected weekly and analyzed after waiting a minimum of 5 days to allow the naturally occurring short-lived radon and thoron daughters to decay. Gross beta analysis is performed on each filter in a low-background beta counter. If the beta activity on a membrane filter exceeds about 1×10^{-12} μCi/mL, the filter is analyzed by gamma spectrometry. All activity detected on the charcoal-impregnated filters is initially assumed to be I-131. If the beta activity on the charcoal filter exceeds about 7×10^{-14} μCi/mL, the filter is analyzed by gamma spectrometry to determine unequivocally the I-131 component. At the end of each quarter, the membrane filters are composited according to location. The composited samples from each location are analyzed for specific radionuclides by gamma spectrometry. Six of the composites are analyzed semiannually, on a rotating basis, for specific alpha-emitting radionuclides by chemical separation followed by alpha spectrometry. Six of the composites are analyzed semiannually, also on a rotating basis, for Sr-90 by chemical separation followed by beta counting.

Results of particulate beta activity measurements for 1980 are shown in Table II. The amounts of particulate beta activity measured at the boundary locations were not distinguishable

TABLE 1

MONITORING PROGRAM SUMMARY

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

a. Tritiated water.

b. One dairy is sampled weekly.

c. Aliquot from a composited 2000-g sample.

d. NA - not applicable.

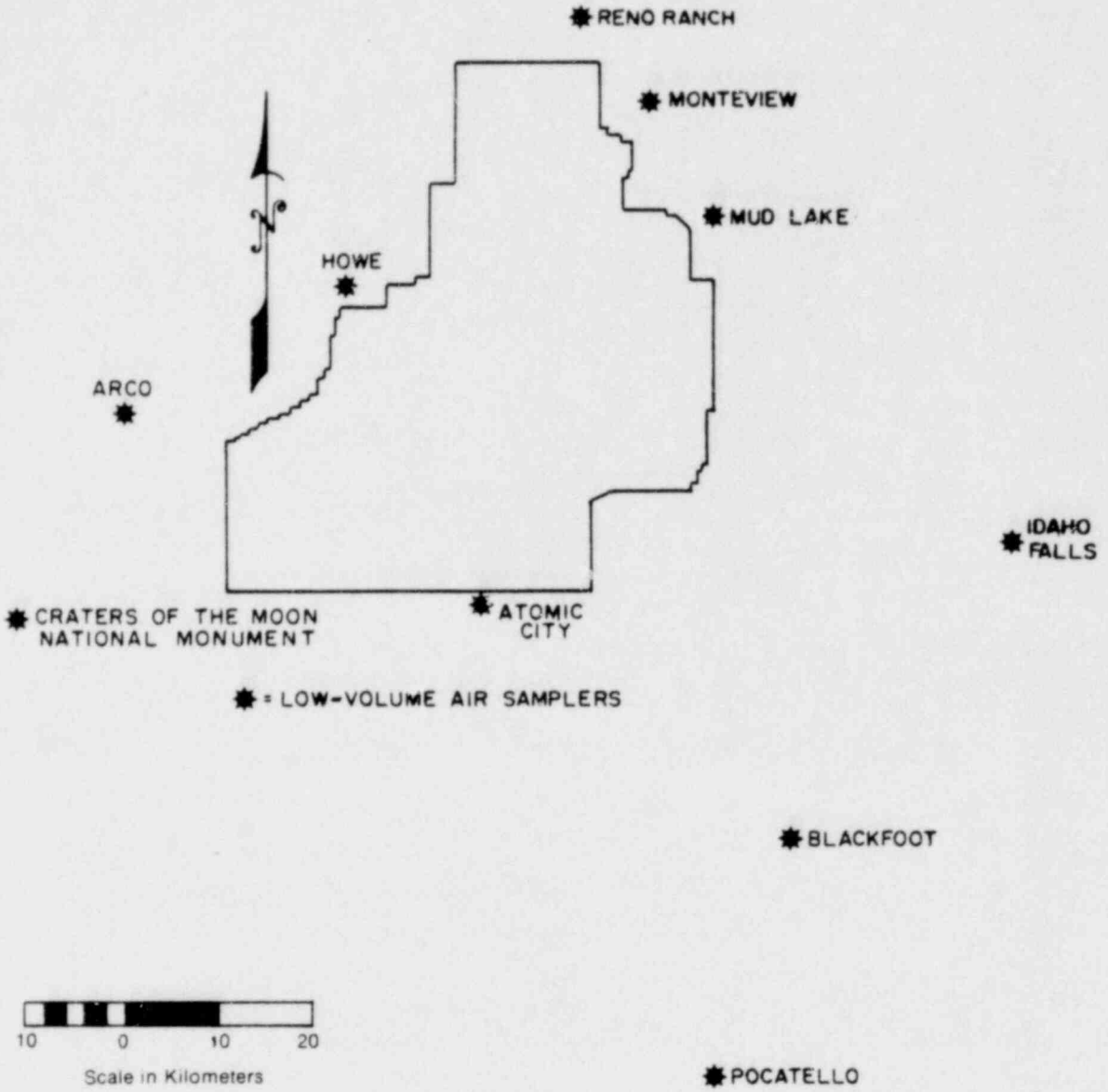


Figure 3. Idaho National Engineering Laboratory Site air sampling network.

from worldwide fallout and naturally occurring radioactivity as measured at the distant locations. The average monthly concentrations of particulate beta activity for 1976 through 1980 are shown in Figure 5. Activity in the charcoal filters, assumed to be I-131, was not above the detection limit of approximately 7×10^{-14} μCi/mL at any location.

Because the quantity and identity of radionuclides released from Site facilities are known, specific radionuclide analysis is a more sensitive indicator than beta analysis of the impact of Site operations on the environment. The results of specific nuclide analyses of the quarterly composites are shown in Table III, excluding Be-7 (natural) and several nuclides attributed to fallout which were detected but were not released in appreciable quantities by Site operations. A foreign nuclear weapons test was conducted in October 1980, and worldwide fallout radionuclides were detected during the weeks following the test. These included Ru-103, Ce-141, Ce-144, and Zr-95 which were detected at nearly all boundary and distant locations. Barium-140 was detected at two locations, and I-131 was detected at one location.

It is always risky to draw firm conclusions from analytical results which are near the detection limit. There are many factors which can influence

Figure 4. Technician changing the filter on a low-volume air sampler used at the INEL Site.

the result to some degree, and we try to account for these in the methods used for determining the uncertainty of the measurement. Small factors are not particularly important when the size of the measurement is many times larger than the uncertainty (e.g., 40 ± 2), but may become quite important when working near the detection limit where the uncertainty in the measurement is nearly equal to the measurement itself and the lower limit of the range of the measurement approaches zero (e.g., 0.8 ± 0.7, which means the measurement lies between 0.1 and 1.5 at the 95% confidence level). It would be an error to attach great significance to such a number by itself; because if there is a small factor which has not been included in the uncertainty, then the true value of the measurement may be zero, meaning the material being measured was not, in fact, present. Therefore, when analytical results show a measurement very near the detection limit, statistical tools and all additional information available must be used to reach a conclusion.

In the case of the Sb-125 measurements reported at the boundary stations, meteorological and Site operations information was correlated with the times and locations of the measurements to conclude that the measurements are non-zero measurements and that the material probably resulted from releases at the INEL. The concentrations of Sb-125 in air at six of the seven boundary stations for the fourth quarter of 1980

TABLE II

PARTICULATE BETA ACTIVITY IN AIR (1980)

Locations	Number of Samples	Concentration (10^{-15} µCi/mL) Minimum	Maximum	Annual[a] Average
Distant Stations				
Idaho Falls	53	9	270	61 ± 16
Blackfoot	53	14	329	72 ± 21
Pocatello	53	15	251	62 ± 14
Grand Mean				65 ± 10
Boundary Stations				
Arco	53	16	289	64 ± 18
Atomic City	53	16	369	81 ± 24
Craters of the Moon	52	18	332	82 ± 24
Howe	53	14	285	68 ± 19
Monteview	53	16	373	64 ± 20
Mud Lake	53	18	277	70 ± 20
Reno Ranch	53	20	346	81 ± 24
Grand Mean				73 ± 8

[a] Average ± the estimate of the 95% confidence interval around the mean. See Appendix C.

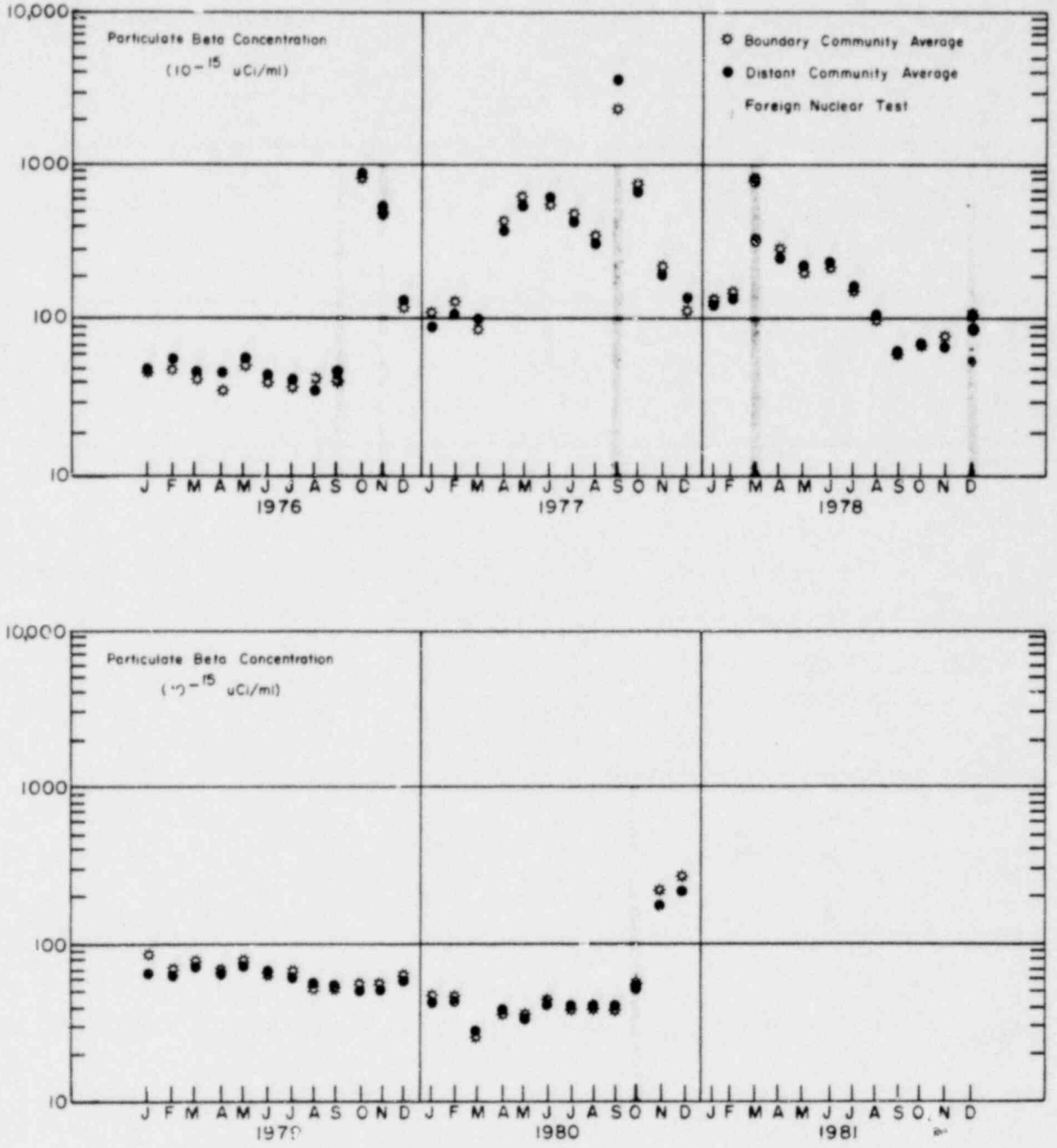


Figure 5. Particulate beta concentrations in air.

TABLE III

SPECIFIC RADIONUCLIDE ACTIVITY IN AIR (1980)

	Concentration (10^{-15} µCi/mL)					
	Sb-125		Cs-134		Cs-137	
Detection limit[a]	6		2		1	
Concentration guide[b]	900,000		400,000		500,000	
Location	Maximum[c]	Average[d]	Maximum	Average	Maximum	Average
Distant Stations						
Idaho Falls	BDL[e]	NSS[f]	BDL	NSS	1.5 ± 1.0	NSS
Blackfoot	BDL	NSS	BDL	NSS	2.9 ± 1.4	NSS
Pocatello	BDL	NSS	BDL	NSS	2.4 ± 1.4	NSS
Average[h]		-0.6 ± 1.5		0.13 ± 0.11		1.2 ± 1.2
Boundary Stations						
Arco	5.9 ± 3.3	NSS	1.4 ± 1.0	NSS	1.1 ± 0.5	1.1 ± 0.7
Atomic City	5.7 ± 3.1	NSS	BDL	NSS	1.6 ± 1.0	NSS
Craters of the Moon	4.2 ± 3.5	NSS	BDL	NSS	0.8 ± 0.2	0.9 ± 0..
Howe	5.2 ± 2.7	NSS	BDL	NSS	0.8 ± 0.6	NSS
Monteview	BDL	NSS	BDL	NSS	1.6 ± 0.8	0.7 ± 0.3
Mud Lake	5.3 ± 3.1	NSS	BDL	0.21 ± 0.19	1.7 ± 0.8	0.7 ± 0.4
Reno Ranch	4.2 ± 3.3	NSS	BDL	NSS	2.3 ± 0.8	1.2 ± 0.4
Average		1.2 ± 0.9		0.14 ± 0.13		0.9 ± 0.2

	Concentration (10^{-15} µCi/mL)				Concentration (10^{-18} µCi/mL)	
	Ru-106		Sr-90		Pu-239/240	
Detection limit[a]	10		0.6		6	
Concentration guide[b]	200,000		30,000		60,000	
Location	Maximum[c]	Average[d]	Maximum	Average	Maximum	Average
Distant Stations						
Idaho Falls	BDL[e]	NSS[f]	0.3 ± 0.2	NSS	9 ± 6	NSS
Blackfoot	BDL	NSS	0.3 ± 0.2	NSS	9 ± 6	NSS
Pocatello	BDL	NSS	NA[g]	NA	NA	NSS
Average[h]		1.8 ± 2.1		0.28 ± 0.08		4.5 ± 8.4
Boundary Stations						
Arco	BDL	NSS	0.4 ± 0.2	NSS	NA	NA
Atomic City	BDL	3.9 ± 2.2	0.5 ± 0.2	NSS	11 ± 6	NSS
Craters of the Moon	BDL	NSS	0.5 ± 0.4	NSS	12 ± 6	NSS
Howe	13 ± 9	NSS	NA	NA	NA	NA
Monteview	BDL	NSS	BDL	NSS	8 ± 4	NSS
Mud Lake	BDL	NSS	NA	NA	11 ± 6[i]	NSS
Reno Ranch	BDL	NSS	NA	NA	NA	NA
Average		2.0 ± 1.4		0.33 ± 0.13		7.4 ± 3.1

[a] Detection limits are approximate. Detection limits vary because of different airflow volumes, counting times, radionuclide composition, and time prior to analysis.

[b] Concentration guides are based on ERDAM 0524 standards for release to an uncontrolled area.

[c] Single sample maximum values of analytical results ± 2σ, decay corrected assuming a constant concentration during the sampling period. See Appendix C.

[d] Location average concentrations ± the 95% confidence interval around the mean. See Appendix C.

[e] Below detection limit.

[f] Not statistically significant. Zero is encompassed within the 95% confidence interval of the mean. See Appendix C.

[g] No analysis.

[h] Average for all stations in the group (distant or boundary) ± the uncertainty at the 95% confidence level. See Appendix C.

[i] The minimum concentration at this location was also detectable at 7 ± 6 x 10^{-18} µCi/mL. Otherwise, at all locations minimum concentrations for all nuclides were below detection limits.

were statistically greater than the concentrations at the distant locations. The annual average concentration at each boundary station for Sb-125 was less than 0.0002% of the uncontrolled area concentration guide. The annual average of all boundary stations grouped together was also statistically different from the background average, and was about 0.0001% of the uncontrolled area concentration guide.

Offsite atmospheric tritium in the form of tritiated water (HTO) is monitored at Idaho Falls (a background location). No concentration of HTO exceeded the approximate detection limit of 1×10^{-11} μCi/mL.

Nonradiological. Nonradioactive atmospheric particulates are routinely monitored at the same stations using the same filters as for radioactive particulates. The analysis involves determining the net particulate weight on the quarterly composite of weekly filters at each station. Results of atmospheric particulate measurements for 1980 are shown in Table IV. This method gives a detection limit of approximately 35 $\mu g/m^3$ compared to the most restrictive standard of 60 $\mu g/m^3$. The boundary average was 38 $\mu g/m^3$ which was statistically the same as the distant average. Most of the airborne particulates in the Site vicinity are probably windblown dust from the desert floor.

The maximum SO_2 and NO_2 concentrations at the Site boundary were calculated using the total 1980 discharges and a computer model of the dispersive characteristics of the air for 1980. See Figure 10 on page 23 and the general discussion of the mesoscale meteorological map on page 21. The calculated maximum offsite concentrations of NO_2 and SO_2 occurred near the southern Site boundary and were each 0.4 $\mu g/m^3$. These concentrations are well below the national primary ambient air quality standards of 100 and 80 $\mu g/m^3$, respectively.

Water Sampling

Water samples are collected from offsite drinking water production wells and from the Snake River. Offsite water sampling locations are shown in Figure 6. All offsite samples are collected semiannually. Gross alpha, gross beta, and tritium analyses are routinely performed on the water samples. For gross alpha analysis, a portion of the sample is evaporated on a stainless steel planchet and counted with a scintillation counter system. Another portion is evaporated and counted for gross beta activity in a low-background beta counter. Tritium concentrations are determined with a liquid scintillation counter. The detection limits for gross alpha, gross beta, and tritium are 3×10^{-9}, 5×10^{-9}, and 4×10^{-7} μCi/mL, or about 10, 20, and 0.01%, respectively, of concentration guides for an uncontrolled offsite area. These detection limits are also 20, 10, and 2%, respectively, of regulations listed by the Environmental Protection Agency (EPA) in 1980 for community drinking water.

One of the offsite water samples collected in late October 1980, from a private well at Reno Ranch (upgradient from the INEL Site) contained an average concentration of gross alpha activity of $2.9 \pm 2.3 \times 10^{-9}$ μCi/mL, a level which is considerably less than the community drinking water standards. No offsite water samples collected during 1980 contained gross beta or tritium levels above the detection limits.

Most of the onsite water sampling is conducted by the U.S. Geological Survey. Eight new monitoring wells were drilled in the southern part of the INEL Site in 1980 to further define the extent of tritium and other waste products in the aquifer. Five of these wells were near the INEL boundary. Analyses of water samples from the aquifer indicate that tritium is not detectable offsite nor at any point closer than 3 km (2 mi) to the nearest Site boundary. Strontium-90 and I-129 concentrations were above the detection limit only for those samples collected within 3 km (2 mi) of the release point at the Idaho Chemical Processing Plant disposal well, or approximately 10 km (6 mi) inside the nearest Site boundary. The detection limits for Sr-90 and I-129 are about 5×10^{-9} and 2×10^{-9} μCi/mL, or about 2 and 3%, respectively, of the concentration guides for an uncontrolled area. Cesium and actinides have been shown to be even less mobile in the aquifer than strontium and iodine.

Nonradiological wastes in the aquifer are determined by measuring the specific conductance and the chloride, sodium, and total chromium content of the water. All of these waste products were at background levels or below detection limits 3 km (2 mi) inside the nearest Site boundary.

TABLE IV

PARTICULATE CONCENTRATIONS IN AIR (1980)

	Concentration ($\mu g/m^3$)		
Approximate Detection Limit	35		
Concentration Guide [a]	60		
Location	Minimum	Maximum	Average
Distant Stations			
Idaho Falls	60	80	70 ± 14
Blackfoot	8	51	36 ± 32
Grand Mean [b]			53 ± 19
Boundary Stations			
Arco	31	116	82 ± 60
Atomic City	16	49	29 ± 25
Craters of the Moon	16	22	20 ± 4
Howe	14	60	39 ± 31
Monteview	14	83	49 ± 45
Mud Lake	17	39	27 ± 17
Reno Ranch	18	27	21 ± 7
Grand Mean [b]			38 ± 11

[a] Concentration guide is based on the Environmental Protection Agency's national secondary ambient air standards.

[b] Average ± the uncertainty at the 95% confidence level. See Appendix C.

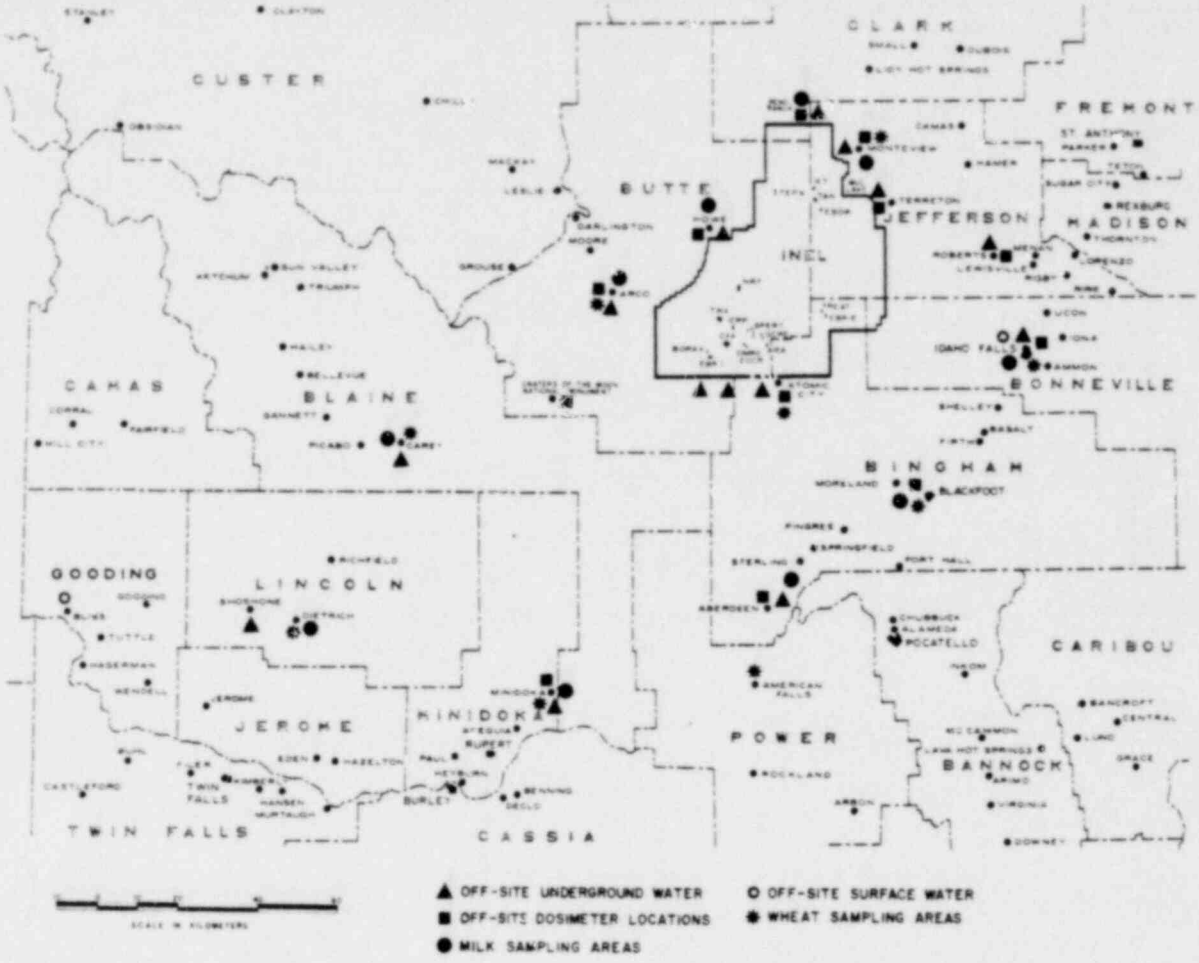


Figure 6. Offsite water, milk, and wheat sampling locations and penetrating radiation dosimetry locations.

Foodstuff Sampling

Milk, wheat, and lettuce are sampled routinely since they are part of the typical American daily diet. These three foodstuffs could be pathways to the public from nuclear weapons fallout or, potentially, from Site operations. Milk and wheat sampling locations are shown in Figure 6. Lettuce was collected at Atomic City, Idaho Falls, Arco, Howe, Mud Lake, Blackfoot, and Pocatello.

A total of 148 routine milk samples were collected from dairies around the Site. Samples are normally collected monthly, except in Idaho Falls where a sample is collected weekly. Exceptions were 11 samples from Carey, 13 samples from Mud Lake, and only one from Reno Ranch where the family cow which had died was not replaced until late in the year. All milk samples are passed through anion exchange resins which are analyzed for I-131 by gamma spectrometry. Milk from each location is analyzed for Sr-90 and tritium once during each year. In addition, four November milk samples, two from Idaho Falls, and one each from Mud Lake and Carey, were analyzed for I-129.

In 1980 nine milk samples contained I-131 in concentrations above the detection limit, and five of these samples were taken in the period during which fallout from the October 1980 weapons test was detected. These data are given in Table V. The highest annual average concentration of any station is 2.9×10^{-10} μCi/mL, a level which is 0.29% of the concentration guide. As previously discussed, it is difficult to draw conclusions from measurements at the detection level. If the meteorological and operations information is considered, it is concluded that the positive I-131 results reported, because of their variation in time and location, did not result from Site operations. Those measurements footnoted in Table V, because of their timing, probably resulted from

TABLE V

CONCENTRATIONS OF I-131 IN MILK (1980)

Sample Location and Frequency	Number of Analyses	Number Above Detection Limit	Concentration (10^{-9} µCi/mL) Value of Samples Above Detection Limit[b]	Average[c]
Approximate Detection Limit			1	
Concentration Guide[a]			100	
Idaho Falls (weekly)	52	2	0.54 ± 0.52[d] 0.65 ± 0.56[d]	0.14 ± 0.10
Minidoka (monthly)	12	2	0.68 ± 0.64 0.9 ± 0.6[d]	NSS[e]
Dietrich (monthly)	12	1	0.56 ± 0.52	0.26 ± 0.16
Carey (monthly)	11	1	1.5 ± 0.8	NSS
Firth Route (monthly)	12	0	BDL	NSS
Riverside Route (monthly)	12	0	BDL	NSS
Mud Lake (monthly)	13	2	0.9 ± 0.6 0.63 ± 0.52[d]	NSS
Reno Ranch (monthly)	1	0	BDL	NSS
Howe (monthly)	12	0	BDL	0.21 ± 0.14
Arco (monthly)	12	1	0.81 ± 0.78[d]	0.29 ± 0.15

[a] Concentration guide for milk established by the Federal Radiation Council (Report No. 2). The guide value given corresponds to the upper limit of Range II.

[b] Analytical results ± 2σ decay corrected to time of collection. All the minimum concentrations were below the detection limit. See Appendix C.

[c] Average ± uncertainty of the mean at the 95% confidence level. See Appendix C.

[d] Sample collected after fallout from October, 1980 foreign nuclear weapons test was detected at INEL.

[e] Not statistically significant. See Appendix C.

the nuclear explosion by the People's Republic of China in October 1980. The concentrations measured were well below the health protection guides.

One milk sample from a distant area was found to contain Sr-90 at a detectable concentration of $2.0 \pm 1.6 \times 10^{-9}$ μCi/mL. This concentration is consistent with the trend of Sr-90 levels in Idaho Falls milk samples reported by the EPA for previous years.

Wheat and lettuce sampling results are shown in Table VI. The lettuce was washed lightly with water to remove the obvious dirt, then dried and weighed. Lettuce samples were analyzed for Sr-90 and gamma-emitting radionuclides. There was no statistical difference between the average concentrations of Sr-90 found at boundary and distant locations. No other manmade radionuclides were detected in lettuce.

The wheat was weighed prior to analysis but not washed. All wheat samples were analyzed for Sr-90 but only two samples, one from Monteview and one from Carey, were analyzed by gamma spectrometry. No manmade radionuclides other than Cs-137 and Sr-90 were detected in wheat, and concentrations for both of these were statistically the same for boundary and distant samples.

Muscle and liver samples were taken from four sheep which had been grazing onsite and from two sheep which had never grazed near the Site. Analysis for Cs-137 gave an average concentration for all six animals of 2.9×10^{-8} μCi/g for muscle tissue and an average of 1.9×10^{-8} μCi/g for liver tissue. There was no statistical difference between the averages for onsite and offsite sheep for either tissue.

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

Penetrating Radiation Measurements

Thermoluminescent dosimeters (TLDs) are used to measure penetrating radiation (gamma plus beta greater than about 200 keV) exposures at seven boundary community locations and five distant community locations. At each location, a dosimeter containing five individual Harshaw TLD-700 chips (3.18 x 3.18 x 0.89 mm) is placed 1 m above ground level. The dosimeter at each location is changed semiannually. The measured cumulative exposure for the 1-year period from November 1979 to November 1980 is shown in Table VII. Minidoka, one of the distant stations, has not been included because data were available for only 6 months of the year (the dosimeter was missing from the post during one 6-month period). The TLDs measure penetrating radiation exposures from natural radioactivity in the air and soil, cosmic radiation from outer space, fallout from nuclear weapons tests, radioactivity from fossil fuel burning, and radioactive effluents from Site operations and other industrial processes.

The measured average annual exposures for boundary and distant community locations were 118 and 119 mR (113 and 114 mrem), respectively, which shows there are no statistically significant contributions to doses at boundary locations from INEL operations.

Table VIII summarizes the calculated dose rate an individual receives on the Snake River Plain from various background radiation sources. This dose rate varies from year to year depending on the amount of snow cover. For 1980, the average ground cover due to snow during fall and winter months was negligible, so no correction was made to the terrestrial dose rate.

Soil Sampling

To establish background levels of natural and fallout radioactivity in surface soil and to assess any potential buildup of radioactivity from Site operations, soil samples have been collected from undisturbed distant and boundary locations most years since 1970, except 1972, 1977, and 1979. (The biennial soil sampling program was established in 1978, and Figure 7 shows routine sampling locations.) Soil samples collected in 1970, 1971, and 1973, represented a composite of five cores of soil from a 1-m^2 area. Each core was a cylinder 10 cm in diameter and 5 cm in depth. In all other years, a 100-m^2 area was sampled for each composite. A number of samples from the 5- to 10-cm depth were also collected. All soil samples were analyzed for gamma-emitting radionuclides. Most were also analyzed for Sr-90 and alpha-emitting nuclides. The soils were dried at

TABLE VI

RADIONUCLIDE CONCENTRATIONS IN WHEAT AND LETTUCE (1980)

	Wheat[a]		Garden Lettuce[a]
	Concentration (10^{-9} µCi/g dry wt)		Concentration (10^{-9} µCi/g dry wt)
	Sr-90	Cs-137	Sr-90
Approximate Detection Limit	4	4	80
Sample Location			
Distant Stations			
Pocatello	NA[c]	NA	300 ± 100
American Falls	10 ± 4	NA	NA
Blackfoot	11 ± 4	NA	80 ± 60
Carey	5 ± 4	10 ± 6	NA
Dietrich	11 ± 4	NA	NA
Idaho Falls	16 ± 6	NA	140 ± 100
Minidoka	BDL[d]	NA	NA
Average[b]	10 ± 5	10 ± 6	200 ± 300
Boundary Stations			
Arco	9 ± 4	NA	BDL
Atomic City	11 ± 4	NA	90 ± 60
Howe	NA	NA	BDL
Monteview	BDL	13 ± 6	NA
Mud Lake	NA	NA	220 ± 80
Average[b]	8 ± 9	13 ± 6	110 ± 120

[a] Analytical result ±2σ. See Appendix C.
[b] Average ± the uncertainty at the 95% confidence level. See Appendix C.
[c] No analysis.
[d] Below detection limit.

TABLE VII

PENETRATING RADIATION EXPOSURE
(November 1979 to November 1980)

Location	Exposure (mR)[a]
Distant Stations	
Aberdeen	121 ± 3
Blackfoot	118 ± 4
Idaho Falls	102 ± 3
Roberts	135 ± 5
Average	119 ± 22[b]
Boundary Stations	
Arco	120 ± 3
Atomic City	121 ± 4
Craters of the Moon	116 ± 3
Howe	109 ± 3
Monteview	112 ± 3
Mud Lake	126 ± 4
Reno Ranch	119 ± 3
Average	118 ± 5[b]

[a] Analytical results ± 2 σ. See Appendix C.

[b] Average ± the uncertainty at the 95% confidence level. See Appendix C.

TABLE VIII

BACKGROUND RADIATION DOSE RATE (1980)
(mrem/year)

Source of Background Dose	Estimated[a]	Measured (TLD)[b]
External		
Terrestrial	76	
Cosmic (ionizing)	43	
Subtotal	119	114
Cosmic (neutron)	6	
Internal		
K-40 and others	27	
Total	152	

[a] Doses are estimated from charts and tables in NCRP Report No. 45[1]. Doses are not strictly additive since some doses are for air and others are for tissue.

[b] For conversion from mR in air to mrem in tissue, f factor was 0.96, estimated from Johns and Cunningham[2].

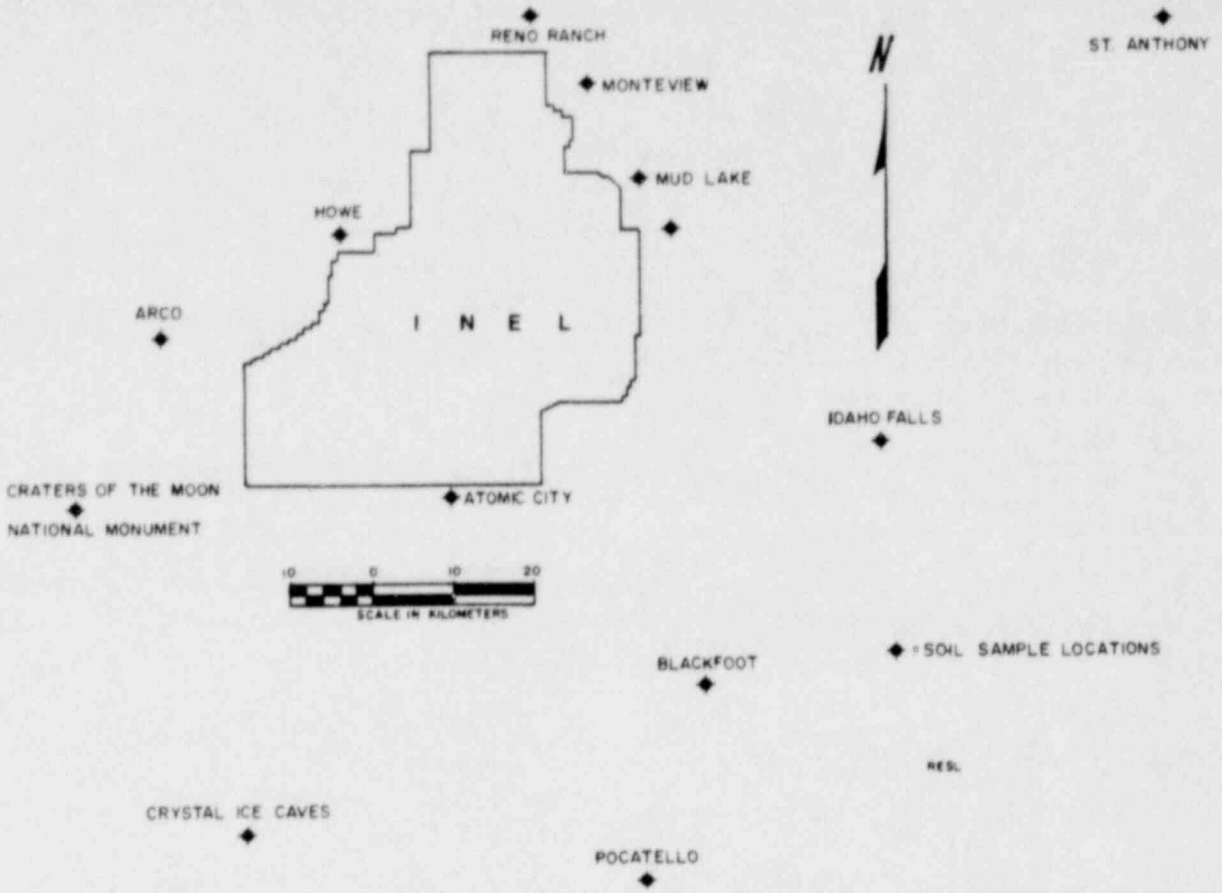


Figure 7. Soil sampling locations for INEL Site vicinity.

least 3 hours at 120°C or, if much organic debris was present, at 400°C. Only soil particles less than 200 microns in diameter (35 mesh) were analyzed. The data are reported in units of activity per gram of soil (pCi/g dry wt) and also in units of areal activity (nCi/m^2), which is the total activity in each soil sample divided by the surface area (0.033 m^2) of the sample.

Concentrations of natural radioactivity in the surface soil were reported in 1977.[3] The Th-232 and U-238 activities were determined from those of the progeny radionuclides, Ac-228 and Pb-214. Oakley[4] indicated that the average concentrations of uranium, thorium, and K-40 in the earth's upper crust, when translated from ppm to pCi/g, are 0.9, 1.1, and 17 pCi/g, respectively. The local soils averaged about 1.5, 1.3, and 19 pCi/g, respectively; values which are higher in natural radioactivity than earth crustal averages. Although much of the surface rock on the plain is basalt, the local soil is largely derived from silicic volcanics which have higher uranium and thorium concentrations than basalt.

Estimates of the average yearly gamma ray dose received from U-238 plus daughters, Th-232 plus daughters, and K-40 in average Site area soil have been calculated to be 21, 28, and 27 mrem, respectively; for a total of 76 mrem. These calculations are based on conversion factors obtained from Reference 1. This reference shows the decrease in gamma radiation with depth of snow cover. Because the average amount of snow cover on the Site and its vicinity during the fall and winter months was less than 1 cm, the soil gamma dose remained at approximately 76 mrem for 1980.

Concentrations of Cs-137, Sr-90, Pu-238, Pu-239/240, and Am-241 in surface soil as found in 1970 through 1975, compared to 1978 and 1980 are shown in Table IX. The 1976 data are not included because the sampling locations used that year are not considered representative of the area. The average concentrations of radionuclides were less than in previous years. No explanation for the decrease has been found. Distant and boundary location average concentrations are not statistically different for any nuclide. It is concluded,

TABLE IX

RADIONUCLIDES IN OFFSITE SURFACE SOILS [a]
(in the vicinity of the INEL)

Radionuclide	Year	Geometric Average[b] (pCi/g)	Geometric Average[b] (nCi/m^2)	Number of Samples	Detection Limit (pCi/g)	Detection Limit (nCi/m^2)
Cs-137	1970-1975[c]	0.94x/÷1.2	54x/÷1.1	60	0.04	3
	1978	0.94x/÷1.3	58x/÷1.3	10	0.04	3
	1980	0.64x/÷1.4	41x/÷1.4	10	0.04	3
Sr-90	1970-1975	0.54x/÷1.1	34x/÷1.1	55	0.09	10
	1978	0.52x/÷1.3	32x/÷1.4	10	0.09	10
	1980	0.35x/÷1.4	22x/÷1.5	10	0.09	10
Pu-238	1970-1975	0.0028x/÷1.2	0.15x/÷1.2	55	0.002	0.2
	1978	0.0010x/÷2.0	0.06x/÷1.9	10	0.002	0.2
	1980	0.0007x/÷1.3	0.05x/÷1.3	10	0.002	0.2
Pu-239	1970-1975	0.020x/÷1.2	1.06x/÷1.1	54	0.004	0.3
	1978	0.018x/÷1.4	1.09x/÷1.4	10	0.004	0.3
	1980	0.010x/÷1.7	0.63x/÷1.7	10	0.004	0.3
Am-241	1970-1975	0.0041x/÷1.2	0.24x/÷1.2	37	0.004	0.3
	1978	0.0062x/÷1.4	0.38x/÷1.3	10	0.004	0.3
	1980	0.003 x/÷1.3	0.20x/÷1.4	10	0.004	0.3

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

[b] Geometric average x/÷2 standard geometric deviations of the mean.

[c] Excluding 1972. No samples taken.

therefore, that any of the radionuclides detected are present as a result of worldwide fallout.

Game Species

Neither hunting nor fishing are allowed on the Site. However, game animals migrate on and off the Site and, therefore, represent a potential, but very low exposure pathway. Only antelope which had been killed on Site roads were sampled during 1980. Data were obtained as part of DOE research programs rather than as part of the routine environmental monitoring program.

Muscle and liver tissues from four antelope which were killed onsite were analyzed for gamma-emitting radionuclides. Only Cs-137 was detected and the average concentrations for the group were 3.0×10^{-8} μCi/g and 2.5×10^{-8} μCi/g in muscle and liver tissues, respectively. Studies from earlier years included antelope collected far from the Site and found Cs-137 average concentrations for these background animals at 3.8×10^{-8} μCi/g and 4.7×10^{-8} μCi/g for muscle and liver tissues, respectively. The 1980 averages were not statistically different from these offsite averages.

No fish were taken from the Big Lost River during 1980 because the river on the Site was again dry most of the year.

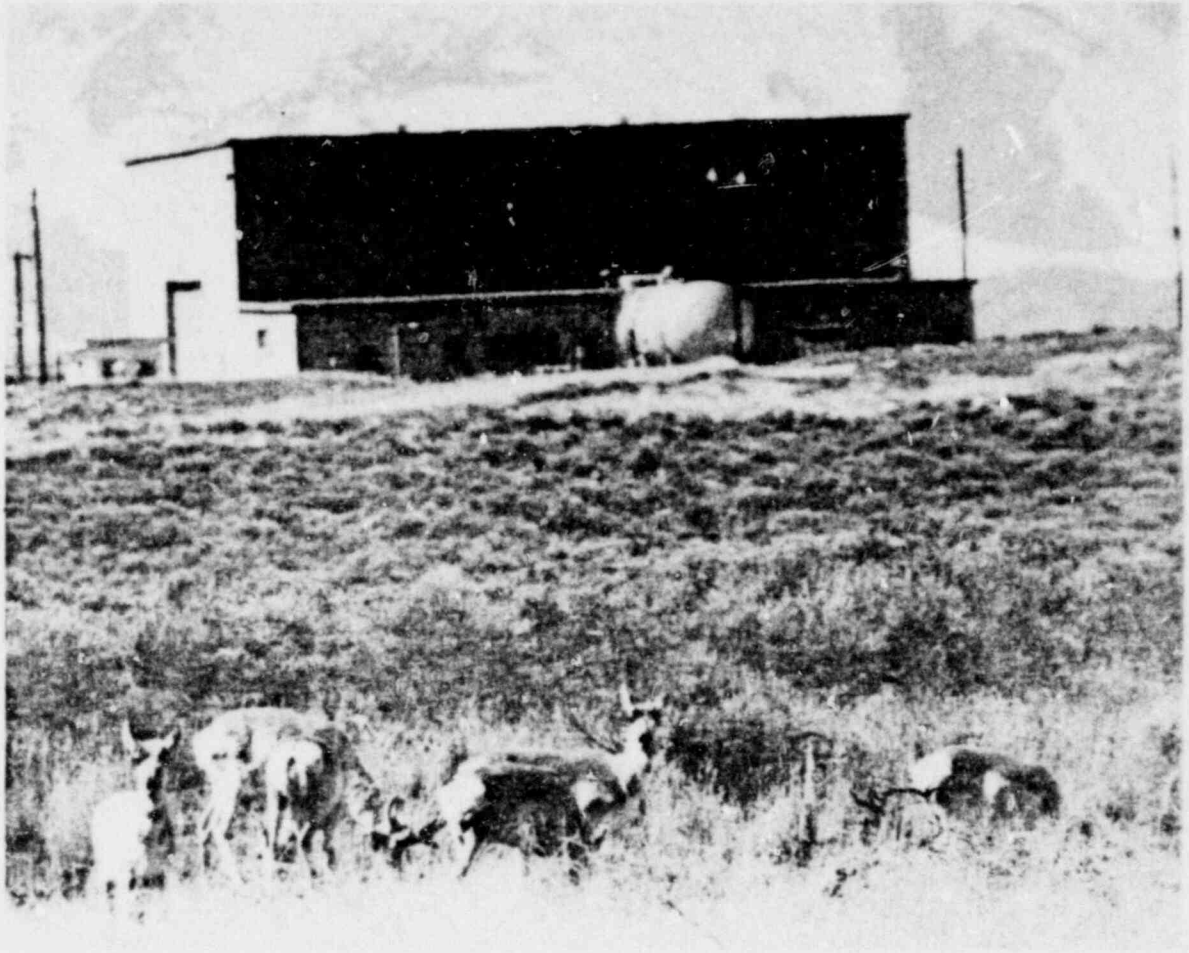


Figure 8. Antelope grazing near the Power Burst Facility on the INEL Site.

RADIOLOGICAL IMPACT OF INEL SITE OPERATIONS

General

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

- The maximum *fencepost* or Site boundary dose
- The maximum potential dose to a member of a population group
- The potential population dose which could have been received by the public within an 80-km (50-mi) radius of the operations center of the Site [Test Reactor Area (TRA) and Idaho Chemical Processing Plant (ICPP)].

The possible exposure pathways by which radioactive materials from Site operations could be transported to offsite environs are shown diagrammatically in Figure 9. Atmospheric transport is the principal potential exposure pathway from the Site. There are no surface streams from onsite to offsite locations, and the low-level radioactive waste released to the aquifer has never been observed within 3 km (2 mi) of the southern boundary of the Site.

Several indirect exposure pathways have been and are continuing to be studied at the Site to determine their effect, if any, upon the highest possible dose that could have been received by a member of the public. The principal indirect exposure pathway involves the hunting or fishing for game species that have spent some time on the Site. The data on foodstuff sampling indicate that no measurable dose results from these indirect exposure pathways, but a calculated potential dose is described in the section "Maximum Individual Whole-Body Dose."

The monitoring data presented in the previous sections indicated that at offsite sampling locations, with one possible exception, no particulate radioactivity in the air from Site operations was discernible from the preexisting levels due to natural and fallout radioactivity. As mentioned in the section on air sampling, noble gas radionuclides in air are not sampled by the air monitoring system. Because of these limitations, an estimate of the radiological impact of Site operations on the surrounding region has been made by using the known amounts of various radionuclides released during 1980 from Site facilities and by using a meteorological model for estimating the concentrations at selected locations in the vicinity. A summary of the radionuclides released to the atmosphere from Site facilities is shown in Table X. Due to radioactive decay of the short-lived radionuclides, the activity that would reach offsite areas is less than the 103,400 Ci indicated in Table X. The ICPP and TRA facilities together were the source of more than 99% of the total radioactivity released to the atmosphere. Noble gases comprised about 98% of the total radioactive airborne effluent.

The mesoscale meteorological map (Figure 10) shows the calculated 1980 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) group at the INEL from data gathered continuously at 25 meteorological stations on and around the Site. To facilitate the display, the concentration isopleth values have been 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 isopleth in Figure 10, the value of the 1980 average air concentration (e.g., 30 x 10^{-9} hr^2/m^3) was multiplied by the number of curies of radionuclide released during 1980 and was divided by the number of hours in a year squared (7.67 x 10^7). Logarithmic interpolation between isopleths was used to obtain concentrations at other points.

Maximum Individual Whole-Body Dose

The maximum hypothetical whole-body dose to an adult from inhalation and submersion in air was calculated assuming that an individual resided continuously for a year at the point of maximum radionuclide concentration outside the Site boundary (fencepost dose). The calculated dose represents the 50-year dose commitment for

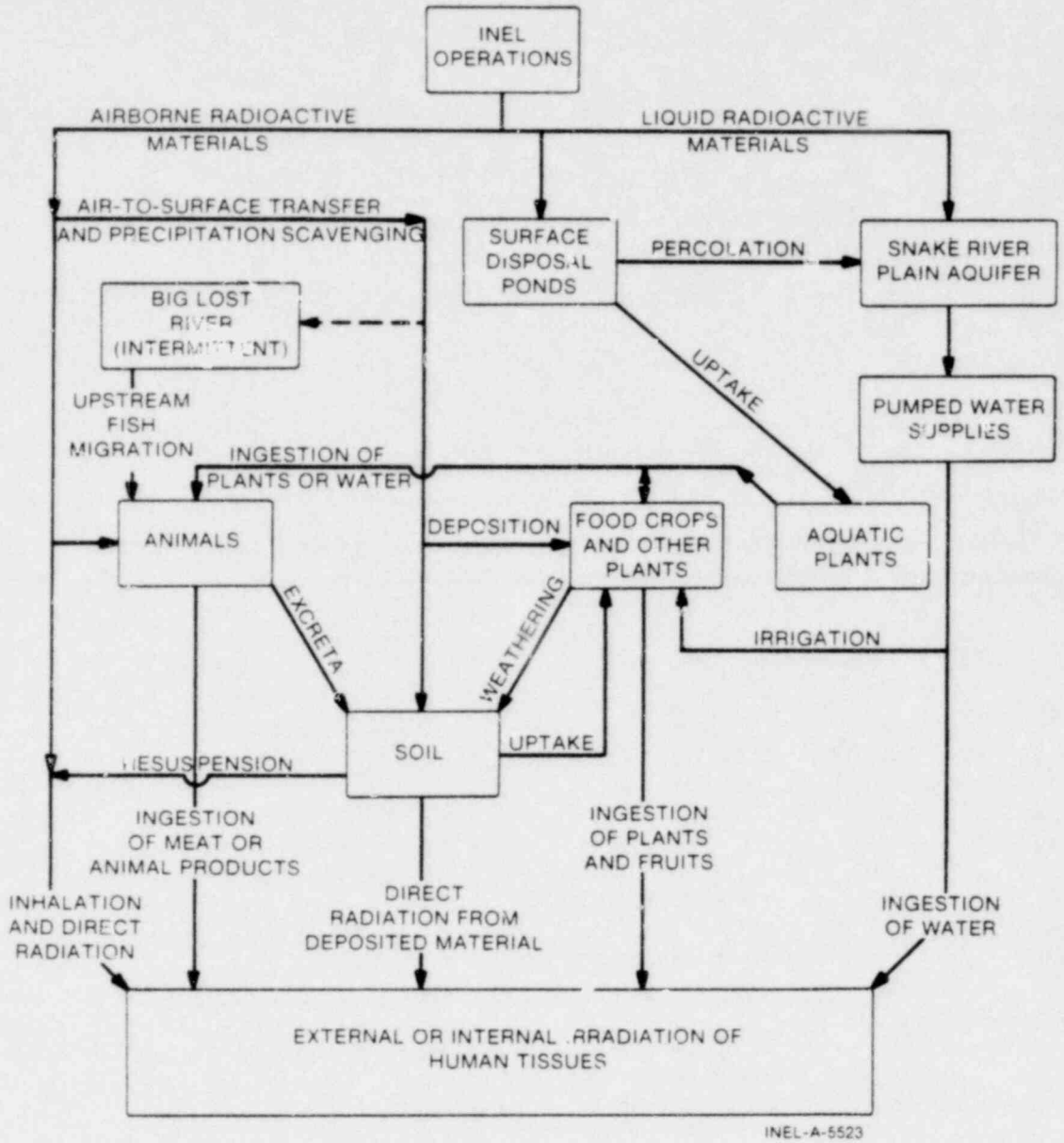


Figure 9. Possible exposure pathways of INEL Site radioactive materials to humans within 80 km (50 mi) of ICPP and TRA.

chronic exposure occurring during 1980. The calculation was based on data presented in Table X and Figure 10. The maximum offsite concentration occurred along the southern Site boundary just inside the isopleth labeled "100" in Figure 10. This concentration was found to be 110×10^{-9} hr^2/m^3. The whole-body dose from each radionuclide in Table XI was computed using the appropriate dose conversion factor given in References 6 and 7. The maximum hypothetical whole-body dose estimated for an adult from Site airborne effluent is 0.05 mrem for 1980 (less for a younger person). About 94% of that computed dose was due to noble gases and particulates having half-lives of less than 10 hours. This dose is 0.01% of the radiation protection standard for exposure to an individual in an uncontrolled area (DOE Order 5480.1, ERDAM 0524). Calculations were also made of doses to several critical organs (bone, thyroid, lung, and skin) for several age categories (adult, teen, child, and infant). All calculated doses were less than the whole-body dose except for the dose to the skin which was 0.27 mrem.

Potential dose to an individual from ingestion of game meat continues to be investigated. In the 1979 issue of this report, it was stated that in the

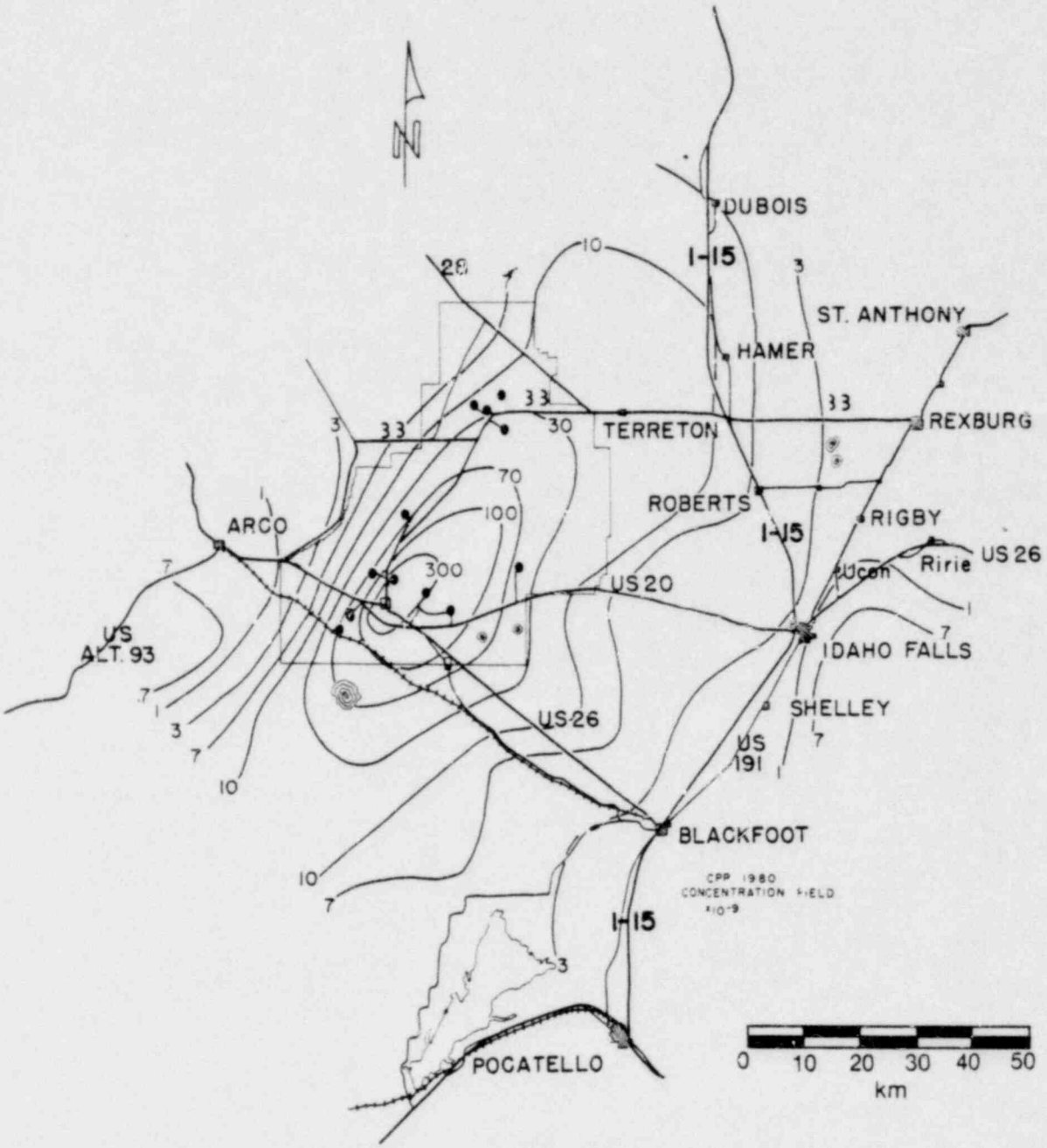


Figure 10. 1980 average of mesoscale dispersion isopleths of air concentrations at ground level, normalized to unit release rate. Units are 10^{-9} hr^2/m^3.

unlikely event that an individual had eaten all the flesh of a duck within 24 hours after the duck had left a liquid waste pond used for the disposal of low-level reactor effluents (Figure 11), the average potential dose would have been about 10 mrem and the maximum about 50 mrem, depending upon how long the duck had been on the pond. This dose is about 10% of the radiation protection standard. Normally, the duck would not be killed and eaten immediately after leaving the pond; therefore, a more realistic dose is 1 to 5 mrem. Furthermore, only about one duck in 4000 passing through this area has a chance of becoming contaminated. A conservative estimate of the dose which could have been received by a single individual eating an entire antelope with the highest levels of radionuclides was less than 4 mrem. (This is based on 1974 data; more recent

TABLE X

RADIONUCLIDE COMPOSITION OF AIRBORNE EFFLUENTS (1980)

Radionuclide	Half-Life	Airborne Effluent (Ci)[a] ANL	ICPP	TRA	Total[b]
Noble Gases					
Kr-85	10.7 yr	6.19	89900	---	89910
Xe-138	14.2 min	0.55	---	3696	3700
Ar-41	1.83 hr	79.5	---	2120	2200
Kr-87	1.27 hr	2.19	---	1302	1304
Xe-135	9.09 hr	36.7	---	1220	1256
Kr-83	2.84 hr	4.42	---	1210	1215
Xe-135m	15.3 min	0.43	---	628	628
Xe-133	5.25 da	125	---	468	593
Kr-85m	4.48 hr	2.81	---	355	358
Tritium					
H-3	12.3 yr	1.48	1887	---	1889
Particulates					
Ba-139	1.39 hr	---	---	258	258
Cs-138	32.2 min	---	---	25.5	25.5
Rb-88	17.7 min	---	---	15.1	15.1
Sb-125	2.73 yr	---	1.34	---	1.34
Sr-90/Y-90[c]	29 yr	---	5.26×10^{-3}	4.99×10^{-6}	5.28×10^{-3}
Pu-238	87.7 yr	---	2.53×10^{-4}	---	2.53×10^{-4}
Pu-239/240		---	3.76×10^{-5}	---	3.76×10^{-5}
Others					
C-14	5730 yr	---	4.09	---	4.29
All Others Total		6.39×10^{-2}	2.76×10^{-2}	4.60×10^{-4}	9.77×10^{-2}
TOTAL		260	91,790	11,300	103,400

[a] Radioactivity listed in 1980 Waste Management Information System Report[3]. Values are not corrected for decay after release.

[b] Totals include small amounts from facilities not listed.

[c] Parent-daughter equilibrium assumed.

TABLE XI

MAXIMUM WHOLE-BODY DOSE (1980)

Radionuclide[a]	Maximum Offsite Concentration[b] (μCi/mL)	Maximum Whole-Body Dose[c] (mrem)
Kr-88	1.1×10^{-12}	0.023
Ar-41	1.5×10^{-12}	0.014
Kr-87	6.1×10^{-13}	0.007
H-3	2.7×10^{-12}	0.003
Xe-135	1.5×10^{-12}	0.003
Kr-85	1.3×10^{-10}	0.003
Kr-85m	3.7×10^{-13}	0.0004
Xe-138	1.4×10^{-14}	0.0003
Xe-133	8.4×10^{-13}	0.0002
Pu-238	3.6×10^{-19}	0.0002
Total		0.054 mrem

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

[b] Estimate of radioactive decay obtained by using the 1980 average wind-speed from 345-350° of 7100 m/hr and a distance of 14,490 m from TRA-ICPP to point of maximum offsite concentration.

[c] Whole-body dose estimated using parameters given in "A Guide for Environmental Radiological Surveillance at ERDA Installations"[4] and given in "Age-Specific Radiation Dose Commitment Factor for a One-Year Chronic Intake"[5]. Doses are 50-year dose commitments.

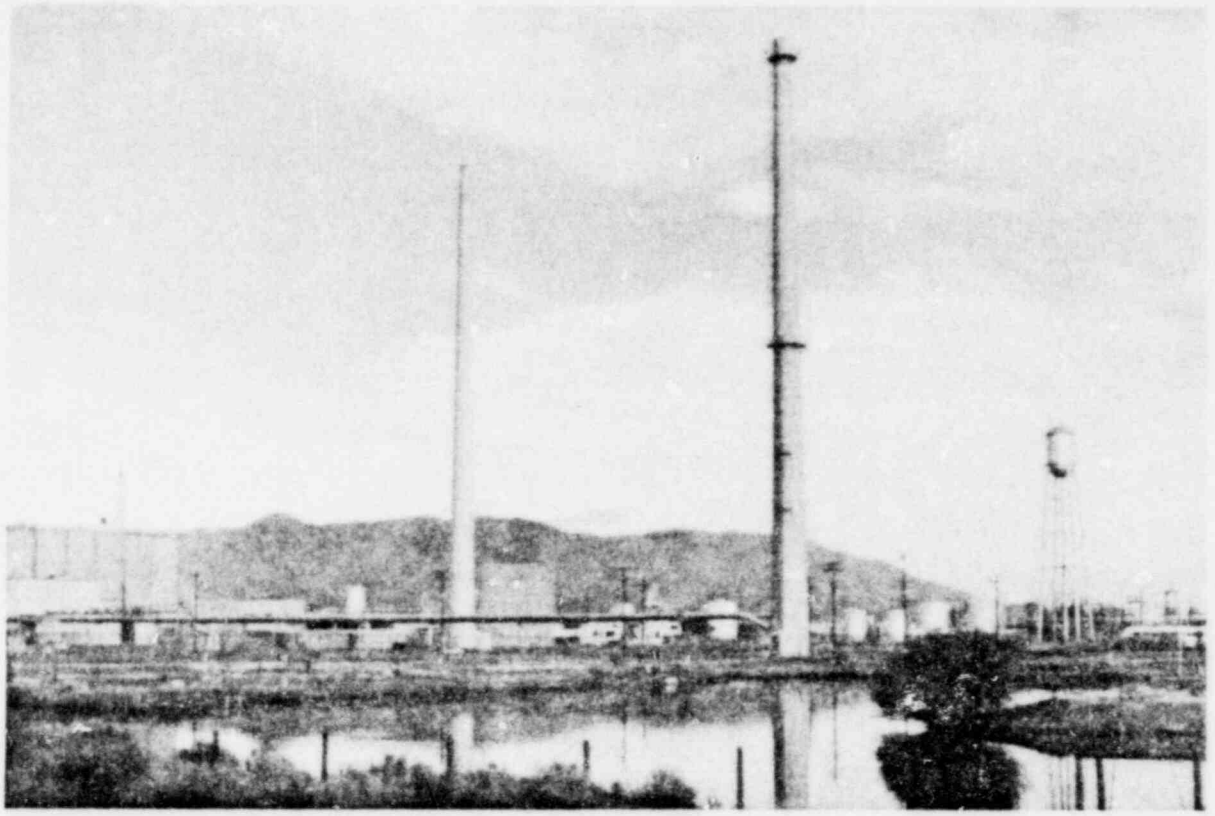


Figure 11. TRA low-level waste disposal pond on INEL Site.

data indicate a lower dose.) An even lower dose would have been received from eating doves and grouse.

The hypothetical whole-body dose (0.05 mrem) resulting from Site operations may be compared to the 150 mrem received from cosmic and terrestrial radiation each year, to the approximately 36 mrem from medical and radiological diagnostic procedures, to the estimated 25 mrem received each year from natural radionuclides in the body, to about 3.5 mrem received during a 5-hour transcontinental jet flight, or to the 0.05 to 0.1 mrem received annually by the average television viewer.[8]

Individual Dose to a Member of a Population Group

As indicated in Figure 10, Atomic City was the population group with the greatest potential dose from Site operations. Using 80 x 10^{-9} hr^2/m^3 as the normalized air concentration isopleth for Atomic City and allowing for radioactive decay during the transit of the radionuclides to Atomic City, the potential individual dose from inhalation and submersion was calculated to be 0.04 mrem. This dose is less than 0.03% of the radiation protection standard for exposure to a member of a population group (DOE Order 5480.1, ERDAM 0524).

80-Kilometer Population Dose

An estimate of the maximum whole-body dose from submersion or inhalation which could have been received by all members of the public within an 80-km (50-mi) radius of the TRA-ICPP complex was made by summing the potential individual doses to the people of each census division within the 80-km (50-mi) radius. The dose to an individual of a particular census division is a fraction of the maximum individual dose (fencepost dose) calculated in a previous section. The fraction is obtained by taking the ratio of the air concentration isopleth at each census division from Figure 10 to the air concentration value of 110 x 10^{-9} hr^2/m^3 used to calculate the maximum individual dose. The potential dose to the population of the census division is the product of the

potential dose to each resident multiplied by the census division population. The calculation is conservative since radioactive decay of the isotopes was not calculated during transport over distances greater than the 14 km (9 mi) from the TRA-ICPP to the southern Site boundary. Idaho Falls, for instance, is about 66 km (41 mi) from TRA-ICPP.

The 80-km (50-mi) population dose was the sum of population doses for the various census divisions. The results are summarized in Table XII. The estimated potential population dose was 0.14 man-rem to a population of 102,306. This can be compared with an approximate population dose of 15,500 man-rem from natural background, or an increase of only about 0.0009%. The dose of 0.14 man-rem can also be compared to the following estimated whole-body population doses for the Site vicinity population: 3,672 man-rem for medical and radiological diagnostic procedures and 113 man-rem for two common sources of miscellaneous radiation—air transport and television viewing.

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

TABLE XII

80-KILOMETER POPULATION DOSE (1980)

Census Division	Dispersion Coefficient[a]	Population[b] 1980	Population Dose[c] (man-rem)
Aberdeen	5×10^{-9}	2,849	0.0070
Arco	0.8×10^{-9}	2,904	0.0011
Atomic City	80×10^{-9}	358	0.014
Blackfoot	2.5×10^{-9}	12,172	0.015
Carey (part)	0.7×10^{-9}	100	0.00003
Clark, West (part)	9×10^{-9}	125	0.0006
Firth (part)	2×10^{-9}	2,000	0.0020
Fort Hall (part)	2×10^{-9}	960	0.0009
Hamer	20×10^{-9}	2,333	0.023
Howe	5×10^{-9}	447	0.0004
Idaho Falls	1.5×10^{-9}	57,510	0.042
Idaho Falls, West	3×10^{-9}	1,658	0.0024
Lewisville-Menan	3×10^{-9}	3,175	0.0047
Moreland	5×10^{-9}	7,760	0.019
Roberts	7×10^{-9}	1,329	0.0046
Shelley	2×10^{-9}	5,793	0.0057
Ucon (part)	2×10^{-9}	833	0.0008
TOTALS		102,306	0.143

[a] Coefficient, obtained from Figure 10, is the 1980 average concentration normalized to unit release rate (hr^2/m^3). The value selected represents an estimated average based on the location of population center in the census division.

[b] Population for each division based upon 1980 Preliminary Census Report for Idaho. Estimates were made when only part of a division is located within the 80-km radius.

[c] This population dose does not include radioactive decay beyond 14.5 km.

ENVIRONMENTAL STANDARDS AND REGULATIONS

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

U.S. Energy Research and Development Administration, *Standards for Radiation Protection, ERDA Manual*, Chapter 0524, 1977.

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

U.S. Environmental Protection Agency, *National Primary and Secondary Ambient Air Quality Standards*, 40 CFR 50, 1980.

U.S. Environmental Protection Agency, *Drinking Water Regulations*, 40 CFR 141, 1980.

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

Idaho State Board of Environmental and Community Services, *Water Quality Standards and Wastewater Treatment Requirements*, 1973.

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

The principal standards and guides for releases of radionuclides at the INEL are those of ERDA Manual Chapter 0524. This manual chapter is further authorized for use as guidance by DOE Order 5480.1, dated May 5, 1980, entitled Environmental Protection, Safety, and Health Programs for DOE Operations. Radiation protection standards and selected radioactivity concentration guides from ERDA Manual Chapter 0524 are listed in Table XIII. The most restrictive guide is listed when there is a difference between soluble and insoluble chemical forms. These listed guides are identical to those in the *Idaho Radiation Control Regulations*, Radiation Control Section, State of Idaho, 1973.

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

TABLE XIII

ERDAM 0524 STANDARDS AND CONCENTRATION GUIDES

Radiation Protection Standards Annual Whole-Body Dose Equivalent (mrem/yr)	
Individuals at points of maximum probable exposure	500
Suitable sample of the exposed population	170

Concentration Guides for Effluent Releases to Uncontrolled Areas (μCi/mL)

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

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

TABLE XIV

AMBIENT AIR QUALITY STANDARDS ($\mu g/m^3$)

Pollutant	Sampling Period	U.S. EPA	State of Idaho
SO_2	24-hour Average	365	365
	Annual Average	80	80
NO_2	Annual Average	100	100
Total Particulates (Secondary Standard)	24-hour Average	150	150
	Annual Average	60	60

TABLE XV

MAXIMUM CONTAMINANT LEVELS FOR PUBLIC COMMUNITY DRINKING WATER SYSTEMS

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

[a]Based on a 2-liter per day drinking water intake.

[b]Applies to non-community water systems also.

REFERENCES

1. National Council on Radiation Protection and Measurements, *Natural Background Radiation in the United States*, NCRP Report No. 45, 1975, pp. 61, 63, 108.

2. H. E. Johns and J. R. Cunningham, *The Physics of Radiology*, Springfield, Illinois: Charles C. Thomas Publisher, 1974, p. 276.

3. U.S. Energy Research and Development Administration, Idaho Operations Office, *1976 Environmental Monitoring Program Report*, IDO-12082(76), May 1977, p. 27.

4. D. T. Oakley, *Natural Radiation Exposures in the United States*, U.S. Environmental Protection Agency, ORP/STD 72-1, 1972, p. 16.

5. H. M. Batchelder, *Idaho National Engineering Laboratory Radioactive Waste Management Information for 1980*, IDO-10055(80), 1981.

6. J. P. Corley et al., *A Guide for Environmental Radiological Surveillance at ERDA Installations*, Appendix B.1 to B.18, ERDA 77-24, March 1977.

7. G. R. Hoenes and J. K. Soldat, *Age Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake*, NUREG 0172, November 1977.

8. U.S. Environmental Protection Agency, *Estimates of Ionizing Radiation Doses in the United States, 1960-2000*, ORP/CSD 72-1, August 1972.

APPENDIX A

MAJOR PROGRAMS, LOCATION, GEOLOGY, AND CLIMATOLOGY

The Idaho National Engineering Laboratory Site (INEL) 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. The number of reactors built has reached 52, of which 17 are operating or operable. The INEL's broad mission is to develop economic energy sources by applying its engineering and scientific expertise to the Department of Energy's (DOE) research and development programs. Major DOE programs currently underway at the INEL Site fall into six categories:

1. Providing test irradiation services from the two operating high-flux test reactors—the Engineering Test Reactor (ETR) and the Advance Test Reactor (ATR)

2. 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)

3. Conducting light-water-cooled reactor safety testing and research at the Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF)

4. Operating the Experimental Breeder Reactor No. 2 (EBR-II)

5. Operating the Naval Reactors Facility (NRF)

6. Storage and surveillance of solid transuranic wastes.

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

The Site is situated on the Upper Snake River Plain in southeastern Idaho at an average elevation of 1500 m (4900 ft). The Site encompasses 2300 km^2 (890 mi^2); it extends 63 airline km (39 mi) from north to south and is about 58 km (36 mi) wide at its broader southern part. 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 2 in the main text). With a population of about 1300, Arco is the largest nearby community in the area surrounding the Site. Land immediately beyond the boundaries of the Site is either desert or agricultural land. Most of this nearby farming is concentrated northeast of the Site. Large areas of agricultural land are farmed in the Snake River Valley regions which are more distant from the Site.

The desert plain on which the INEL Site is located, is part of the cool desert shrub biome. Average annual temperature at the Site is 5.6°C (42°F) with extremes of 39°C (103°F) and -42°C (-43°F). Vegetation is typical of a cool desert with sagebrush conspicuous over 80% of the Site. Frequenting the Site are the pronghorn antelope and a few deer, but various kinds of birds, reptiles, and large populations of small mammals are also present. To take full advantage of the Site's ecosystem, the area has been made a National Environmental Research Park (NERP), where scientists from DOE, other federal and state agencies, universities, and private research foundations can study changes caused by man's activities and obtain data for use in making decisions on land use. At present, about 25 different environmental studies are being conducted.

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

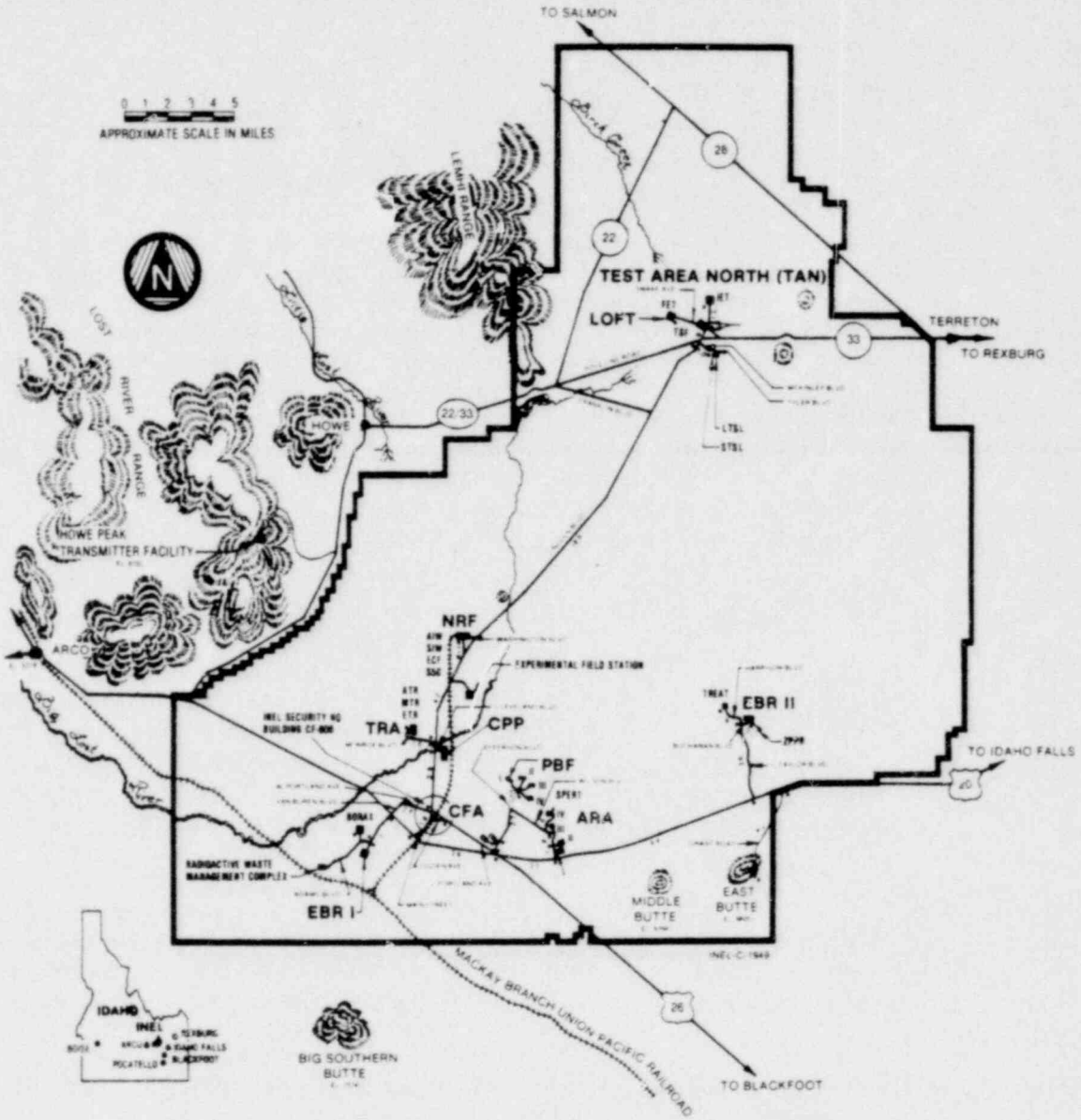


Figure A-1. Idaho National Engineering Laboratory Site facility locations.

TABLE A-1

TABULATION OF FACILITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY

Name	Abbreviation	Operating[a] Contractor
Reactors Operating or Operable as of December 1979		
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
Engineering Test Reactor	ETR	EG&G
Engineering Test Reactor Critical	ETRC	EG&G
Experimental Breeder Reactor No. 2	EBR-II	ANL
Large Ship Reactor "A"	A1W-(A)	WEC
Large Ship Reactor "B"	A1W-(B)	WEC
Loss-of-Fluid Test Facility	LOFT	EG&G
Natural Circulation Reactor	S5G	WEC
Power Burst Facility	PBF	EG&G
Submarine Thermal Reactor	S1W (STR)	WEC
Transient Reactor Test Facility	TREAT	ANL
Neutron Radiography Facility[b]	NRAD	ANL
Zero Power Plutonium Reactor[b]	ZPPR	ANL
Reactors Dismantled, Transferred, or in Standby Status		
Boiling Water Reactor No. 1	BORAX-I	ANL
Boiling Water Reactor No. 2	BORAX-II	ANL
Boiling Water Reactor No. 3	BORAX-III	ANL
Boiling Water Reactor No. 4	BORAX-IV	ANL
Boiling Water Reactor No. 5	BORAX-V	ANL
Experimental Breeder Reactor No. 1	EBR-I	ANL
Experimental Organic Cooled Reactor (Mothballed before startup)	EOCR	PPCo
Materials Test Reactor	MTR	PPCo & INC
Organic Moderated Reactor Experiment	OMRE	AI
Special Power Excursion Reactor Test No. 1	SPERT-I	PPCo
Special Power Excursion Reactor Test No. 2	SPERT-II	PPCo & INC
Special Power Excursion Reactor Test No. 3	SPERT-III	PPCo & INC
Special Power Excursion Reactor Test No. 4	SPERT-IV	PPCo & INC
Spherical Cavity Reactor Critical Experiment	SCRCE	ANC
Zero Power Reactor No. 3[b]	ZPR-III	ANL
Other Facilities in Use		
Argone National Laboratory - West	ANL-W	ANL
Auxiliary Reactor Area	ARA	EG&G
Central Facilities Area	CFA	EG&G
Chemical Engineering Laboratory	CEL	EG&G
Computer Science Center (Idaho Falls)	CSC	EG&G
Expended Core Facility	ECF	WEC
Experimental Field Station	EFS	DOE-ID
Field Engineering Test Facility	FET	EG&G
Fuel Element Storage Facility	FESF	ENICO
Hot Fuel Examination Facilities	HFEF	ANL
Hot Pilot Plant	HPP	ENICO
Idaho Chemical Processing Plant	ICPP	ENICO
Irradiated Fuel Storage Facility	IFSF	ENICO
LOFT Test Support Laboratory	LTSL	EG&G
Naval Reactors Facility	NRF	WEC
Radioactive Waste Management Complex	RWMC	EG&G
Radiological and Environmental Sciences Laboratory	RESL/ID	DOE-ID
Raft River Geothermal Project	--	EG&G
Reactor Training Facility	RTF	EG&G
Semiscale Test Support Laboratory	STSL	EG&G
Standards Calibration Laboratory (CF-698)	--	EG&G
Technical Services Center (CF-688, 689)	TSC	EG&G
Technical Service Facility	TSF	EG&G
Test Area North	TAN	EG&G
Test Reactor Area	TRA	EG&G
Waste Calcining Facility	WCF	ENICO
Facilities Not Presently in Use		
Initial Engineering Test Facility	IET	EG&G
Fluorinel and Fuel Storage Facility	FAST	ENICO
New Waste Calcining Facility	NWCF	ENICO
Major Programs at INEL		
Chemical Processing Program		ENICO
Geothermal Program		EG&G
Liquid Metal Fast Breeder Reactor Program		ANL
Naval Propulsion Reactors Program		WEC
Reactor Materials Testing Program		EG&G
Transuranic Waste Management Program		EG&G
Water Reactor Safety Program		EG&G

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

[b] Zero or low power reactor.

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

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

APPENDIX B

QUALITY ASSURANCE

A quality control and assurance program is maintained by the Radiological and Environmental Sciences Laboratory (RESL/ID) to assure consistent and reliable monitoring results. An internal quality control program is maintained by:

1. Adherence to written procedures for sample collection and analytical methods
2. Documentation of program changes
3. Routine calibration of field instrumentation
4. Daily analytical equipment performance checks for background and counting rates for standards
5. Routine yield determinations of radiochemical procedures
6. Duplicate analyses to determine precision
7. Analysis of quality control standards in an appropriate matrix
8. Analysis of reagent blanks to verify chemical purity.

The calibration of analytical 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/ID for analysis by gamma spectrometry. Comparisons are also made for beta emitters, including Sr-90 and tritium, and for alpha emitters such as Pu-238, Pu-239, and Am-241. The results are reported directly to the NBS. Results during the last year have agreed with those of the NBS within the limits of statistical uncertainty. Results have repeatedly demonstrated traceability to the NBS to within 2.5%.

RESL/ID also participates in the Division of Operational and Environmental Safety Quality Assurance Program administered by the Environmental Measurements Laboratory of the Department of Energy. In past years RESL/ID has also participated in the American Society for Testing Materials round-robin testing of standard methods and in intercomparison with the Environmental Protection Agency in Las Vegas, Nevada.

To verify the quality of the environmental dosimetry program, in addition to the internal quality control program, RESL/ID has participated in the three International Environmental Intercomparison Studies, sponsored by Environmental Measurements Laboratory and the University of Texas School of Public Health. The RESL/ID results were within 10% of the measured or test exposure values.

APPENDIX C

STATISTICAL METHODS

Individual analytical results are given in the report with plus or minus (±) two analytical standard deviations (2) where all analytical uncertainties have been properly propagated. Many of the results were less than or equal to 2 (and, in fact, some were negative) which is considered as meaning that they were below the detection limit. Arithmetic averages were calculated using actual assay results, regardless of their being above or below the detection limit. The 95% confidence interval around the average was determined by multiplying the standard error of the mean by the t statistic. Confidence intervals which include zero were assumed to indicate no discernible average activity in the group of samples. In situations where a group of samples contain radioactivity in amounts near the detection limit, the average may indicate the presence of activity (the 95% confidence interval does not include zero), even though no individual sample contained detectable radioactivity. An unpaired t-test was used to determine whether the annual averages for the boundary stations were different from the annual averages for the distant stations. All tests were made at the 95% confidence level.[C-1]

REFERENCE

C-1. G. W. Snedecor and W. G. Cochran, *Statistical Methods*, Ames, Iowa: Iowa State University Press, 1967.

DISTRIBUTION RECORD FOR IDO-12082(80)

INTERNAL DISTRIBUTION

DOE-ID

N. C. Aquilina
J. H. Barry (3)
R. J. Beers
R. L. Blackledge (12)
J. X. Combo
J. P. Hamric
S. B. Milam
C. R. Nichols
I. Resendez
C. R. Robertson (2)
R. E. Tiller
C. E. Williams
R. E. Wood
RESL/ID (200)

EG&G Idaho, Inc.

J. R. Fielding, Manager, Safety Div.
E. N. Fray, Manager, WM
W. G. Hathaway, Branch Mgr., CFA Safety
L. J. Johnson, Manager, SH&S
R. W. Kiehn, General Manager
D. W. Marshall, Branch Mgr., TAN Safety
L. G. Johnson, Information Mgmt.
N. G. Reece, Branch Mgr., TRA Safety
J. H. Spickard, Manager, Medical Div.
G. B. Wiersma, Manager E&LS
INEL Technical Library (10)

ENICO

D. R. Alexander, R&ES
P. W. Smith, President
C. R. Tracey, Mgr. QAS&S

Argonne-West

C. S. Abrams, Rad. Engr.
R. J. Teunis, Manager
L. C. Whitbeck, E&SE

Westinghouse Electric Corp.

P. R. Bengel, Rad. Con. Mgr.
C. E. Davies, Manager

PNRO-IBO

R. C. Cullison, Radiation Control

Chicago Patent Group - DOE

Total Copies Printed - 300

DISTRIBUTION LIST

EXTERNAL DISTRIBUTION

W. Bruce Arnell, District Seven Health Dept., Idaho Falls, ID
J. T. Barraclough, U.S. Geological Survey, Idaho Falls, ID
Bruce W. Church, Health Physics Division, DOE, Las Vegas, NV
Darrel W. Clapp, Idaho Dept. of Water Resources, Boise, ID
Charles Costa, Envrnl. Monitoring & Support Lab, EPA, Las Vegas, NV
Ed Cowan, EPA, Seattle, WA
Todd Crawford, Transport Div., Envrnl. Sciences Section, SRL, Aiken, SC
R. C. DeYoung, Office of Inspection and Enforcement, NRC, Washington, DC
C. Ray Dickson ARL-FRO, NOAA, Idaho Falls, ID
Director, Idaho Dept. of Health & Welfare, Boise, ID
Director, Idaho Dept. of Water Resources, Boise, ID
Director, Operational & Envrnl. Safety Div., DOE, Washington, DC (8)
Donald P. Dubois, Region 10, EPA, Seattle, WA
Kenneth Dunn, Idaho Dept. of Water Resources, Boise, ID
D. R. Elle, Environmental Protection Branch, DOE, Richland, WA
J. J. Fix, Radiological Sciences Battelle Pacific NW Lab., Richland, WA
Robert Funderberg, Rad. Control, ID Dept. of Health & Welfare, Boise, ID
Wayne C. Hansen, Environmental Studies Group, LASL, Los Alamos, NM
Tom Humphrey, Environmental Branch, DOE, Las Vegas, NV
Gerald V. Hurst, Public Health District 5, Twin Falls, ID
James Jelke, Southeastern District Health Dept., Pocatello, ID
Harold V. Larson, Safety Dept., Battelle Pacific NW Lab., Richland, WA
Darrus Martin, Bingham County Office, Blackfoot, ID
Helen McCammon, Ecological Research, OHER, DOE, Washington, DC
O'Dell Merritt, Western General Dairies, Inc., Idaho Falls, ID
Henry Moran, Idaho Dept. of Health & Welfare, Pocatello, ID
Edward M. Morimoto, Envrnl. Sciences Division, LLL, Livermore, CA
William S. Osburn, Jr., Ecological Research, OHER, DOE, Washington, DC
J. Vincent Panesko, Envrnl. Anal. and Monitoring, Rockwell, Richland, WA
H. Wade Patterson, Hazards Control Dept., LLL, Livermore, CA
Gerald Ramsey, Idaho Dept. of Water Resources, Idaho Falls, ID
Billy D. Shipp, Operational and Envrnl. Safety Division, DOE, Argonne, IL
Victor Stello Jr., Office of Inspection & Enforcement, NRC, Washington, DC
Lee Stokes, Div. of Environment, ID Dept. of Health & Welfare, Boise, ID
Robert Watters, Ecological Research, OHER, DOE, Washington, DC
Jerry F. Wing, Environmental Protection Branch, OR, DOE, Oak Ridge, TN
Stephen R. Wright, Environmental Activities, SR, DOE, Aiken, SC