
Environmental Status of the Hanford Site for CY 1983

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FOREWORD

Environmental surveillance at the Hanford Site involves measuring a variety of environmental media for potential radioactive and nonradioactive contaminants. The results of these measurements are used to assess the environmental impact of site operations, to demonstrate compliance with applicable regulations, and to verify the adequacy of containment and effluent control systems applied to onsite facilities and operations.

The data generated by routine environmental surveillance measurements are reported annually in three separate reports. The first report, Environmental Surveillance at Hanford, summarizes offsite environmental sampling data and any onsite data that pertain to the assessment of offsite radiation doses. The report discusses the significance of observed results relative to background levels, previous measurements and regulatory limits. It also provides an assessment of the impacts of site operations on the environment in terms of radiation dose. The report containing 1983 results was issued in May 1984 as PNL-5038.

The second report, Ground-Water Surveillance at the Hanford Site, summarizes and evaluates the concentrations and distribution of radioactive and chemical constituents in the ground water beneath the Hanford Site and discusses their potential environmental impact. The report containing 1983 results was issued in July 1984 as PNL-5041.

The third report, Environmental Status of the Hanford Site, is provided here. This report specifically addresses surface environmental measurements made onsite. The primary purpose of this report is to present data concerning the radiological conditions in the immediate environs of the site's operating areas. The report also includes a summary of both radioactive and nonradioactive environmental discharges and related unusual occurrences for 1983 as reported by the operating contractors for the various operating areas.

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SUMMARY

Samples of air, surface water, soil, vegetation, and wildlife were collected and external penetrating radiation dose measurements were made in the vicinity of the major operating areas on the Hanford Site. Most samples were analyzed for radioactive constituents including ^3H , ^{14}C , ^{85}Kr , ^{90}Sr , ^{241}Am , plutonium isotopes, natural uranium, and gamma-emitting radionuclides. In addition, site roads, railroad tracks, and burial grounds were surveyed periodically to detect any abnormal conditions or unusual levels of radioactivity. Radioactive and nonradioactive waste discharges and environmentally-related unusual occurrences reported for the major operating areas were reviewed and summarized.

Highlights of the results for 1983 are:

- General airborne particulate radioactivity levels in the Hanford environs were lower in 1983 than in 1982 as airborne radionuclides associated with the worldwide fallout continued to decline.
- Airborne ^{90}Sr , ^{137}Cs , and plutonium concentrations were not significantly different from background measurements. Iodine-131 was not identified in any air sample.
- Tritium concentrations in atmospheric moisture were similar for all sample locations and reflected only worldwide fallout as in previous years.
- Cesium-137 concentrations in B Pond continued to decrease during 1983 from a peak observed in 1980. Strontium-90 concentrations in B Pond during 1983 were similar to 1982 levels. Radionuclide concentrations in other onsite ponds in 1983 were similar to those observed in 1982.
- Analyses of tissue samples from several types of wildlife collected onsite continue to indicate that Hanford-produced radionuclides are accessible in some areas to onsite wildlife.
- Several onsite soil and vegetation samples contained radionuclide concentrations above background levels. However, levels measured during 1983 were similar to those reported in recent years.

- External penetrating dose measurements during 1983 showed that dose rates at several onsite locations were above background levels but were similar to levels observed during 1982.
- No significant radioactive contamination was observed during routine road and railroad monitoring surveys during 1983.
- No significant changes were observed in the radiological status of radioactive waste burial grounds located outside of operating area perimeter fences.
- Reported discharges of radioactive and nonradioactive materials to the environment during 1983 were generally similar to those reported by site contractors for 1982. A small amount of ^{129}I was an additional gaseous effluent at the PUREX facility.
- Seven environmentally related unusual occurrences were reported at Hanford during 1983. No significant adverse environmental impacts resulted from these events.

CONTENTS

FOREWORD	iii
ACKNOWLEDGMENTS	iv
SUMMARY	v
INTRODUCTION	1
THE HANFORD SITE	3
AIR SAMPLING	7
PONDS.	20
WILDLIFE	24
DEER	24
UPLAND GAME BIRDS	25
WATERFOWL	26
RABBITS	28
SOIL AND VEGETATION	30
EXTERNAL RADIATION MEASUREMENTS	34
RADIATION SURVEYS	37
ROAD SURVEYS	37
RAILROAD SURVEYS	38
AERIAL SURVEY	38
WASTE DISPOSAL SITE SURVEYS	38
ENVIRONMENTAL RELEASES	39
ENVIRONMENTAL DISCHARGES	40
Airborne Effluents	40
Liquid Effluents	40
Solid Wastes	46

ENVIRONMENTALLY-RELATED UNUSUAL OCCURRENCES	.	.	.	.	.	.	.	.	.	46
REFERENCES	.	.	.	.	.	.	.	.	.	50
APPENDIX A--ANALYTICAL PROCEDURES	.	.	.	.	.	.	.	.	.	A.1
APPENDIX B--DATA ANALYSIS	.	.	.	.	.	.	.	.	.	B.1

FIGURES

1	DOE's Hanford Site in Washington State	3
2	Onsite and Background Environmental Air Sampling Locations	7
3	Monthly Average Gross-Beta-Emitter Activity in the Atmosphere	11
4	Average Annual Tritium Concentrations in Atmospheric Water Vapor at General Onsite Sampling Locations	19
5	Onsite Ponds	20
6	Strontium-90 and Cesium-137 Concentrations in B Pond	23
7	Onsite Wildlife Collection Sites	26
8	Onsite Soil and Vegetation Sampling Locations	30
9	Onsite External Penetrating Dose Rate Measurement Locations	34
10	Road and Railroad Survey Routes	37

TABLES

1	Onsite Air Sampling Schedule	8
2	Airborne Radionuclide Concentrations in the 100 Areas	12
3	Airborne Radionuclide Concentrations in the 200-E Area	13
4	Airborne Radionuclide Concentrations in the 200-W Area	14
5	Airborne Radionuclide Concentrations North of the 200 Areas	15
6	Airborne Radionuclide Concentrations in the 300 Area	16
7	Airborne Radionuclide Concentrations in the 400 Area	17
8	Airborne Radionuclide Concentrations in the 600 Area	18
9	Radionuclide Concentrations in Onsite Ponds	22
10	Radionuclide Concentrations in Deer	25
11	Radionuclide Concentrations in Game Bird Muscle Tissue	27

12	Cesium-137 Concentrations in Waterfowl Muscle Tissue	.	.	.	28
13	Radionuclide Concentrations in Rabbits	.	.	.	29
14	Radionuclide Concentrations in Onsite Soils	.	.	.	32
15	Radionuclide Concentrations in Onsite Vegetation	.	.	.	33
16	Onsite External Penetrating Dose Measurements	.	.	.	35
17	Radionuclide Discharges to the Atmosphere	.	.	.	41
18	Nonradioactive Discharges to the Atmosphere	.	.	.	42
19	Radionuclide Liquid Discharges to Ground Disposal Facilities	.	.	.	43
20	Nonradioactive Liquid Discharges to Ground Disposal Facilities	.	.	.	44
21	Radionuclide Liquid Discharges to the Columbia River	.	.	.	45
22	Composition of Solid Wastes Buried Onsite	.	.	.	47

ENVIRONMENTAL STATUS OF THE HANFORD SITE FOR CY 1983

INTRODUCTION

The U.S. Department of Energy (DOE) operations on the Hanford Site began in 1943 and have involved a wide variety of nuclear and non-nuclear activities, the most notable of which has been the large-scale production and processing of radioactive materials for the national defense program. During the performance of these activities, materials have been discharged to the environment both in a routine controlled manner and, occasionally, as a result of a process malfunction or other unplanned release. Environmental surveillance and effluent monitoring programs are conducted to aid onsite waste management activities and to assess the impact of radioactive and nonradioactive discharges to the environment.

The Hanford Environmental Surveillance Program is conducted by the Pacific Northwest Laboratory (PNL), which is operated by the Battelle Memorial Institute for DOE. The program provides for measuring, interpreting, and evaluating environmental samples and other measurements to assess environmental impact, determine compliance with pertinent regulations, and evaluate the adequacy of onsite waste management practices. The program also includes an evaluation of all significant pathways of potential environmental impact, with emphasis on those that are most significant. Summaries and evaluations of the data generated during the performance of environmental surveillance activities are published each year in three reports. These are:

- Environmental Surveillance at Hanford (offsite environmental surveillance report)
- Ground-Water Surveillance at the Hanford Site
- Environmental Status of the Hanford Site (onsite environmental surveillance report).

This report is the last of the three reports to be issued covering the calendar year 1983. The offsite report was issued as PNL-5038 (Price et al. 1984) and the ground water report was issued as PNL-5041 (Prater et al. 1984).

The data provided in this report concern the radiological status of the environment in the immediate vicinity of the major operating areas. In general, the data were compared both to background or control measurements taken at distant locations during 1983 and to data obtained during past years. Sample analysis procedures are described in Appendix A and data analysis methods are summarized in Appendix B.

THE HANFORD SITE

The Hanford Site is located in a rural region of southeastern Washington State and occupies an area of 1500 km². The site, shown in Figure 1, lies about 320 km east of Portland, Oregon, 270 km southeast of Seattle, Washington, and 200 km southwest of Spokane, Washington. The Columbia River flows through the northern edge of the Hanford Site and forms part of its eastern boundary.

The desert plain on which Hanford is located has a sparse covering of vegetation primarily suited for grazing. The most broadly distributed type of vegetation on the site is the sagebrush/cheatgrass/bluegrass community. The mule deer is the most abundant big-game animal on the site, and the most

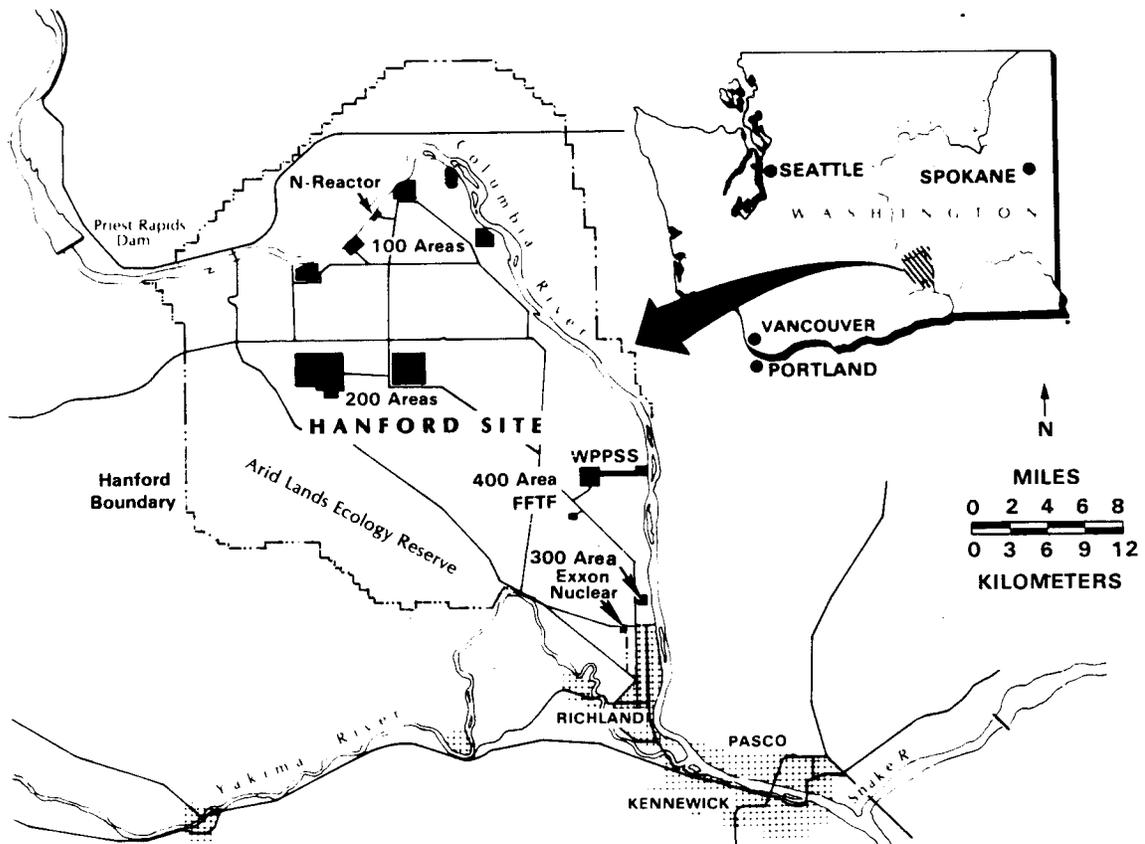


FIGURE 1. DOE's Hanford Site in Washington State

abundant small-game animal is the cottontail rabbit. The raccoon and coyote are the most abundant fur-bearing animals. The osprey, golden eagle, and bald eagle are occasional visitors to the relatively large areas of uninhabited land comprising the Hanford Site.

Hanford's climate is mild and dry; the area receives approximately 16 cm of precipitation annually. About 40% of the total precipitation occurs during November, December, and January, with only 10% falling in July, August, and September. The average maximum and minimum temperatures in July are 33°C and 16°C. For January, the respective averages are 3°C and -6°C. Approximately 45% of all precipitation from December through February is snow.

Mean monthly wind speeds range from about 14 km/h in the summer to 10 km/h in the winter. The prevailing regional winds are from the northwest with strong drainage and crosswinds causing complicated surface flow patterns. The region is a typical desert area with frequent strong atmospheric inversions that occur at night and break during the day, causing unstable and turbulent conditions.

With the exception of Hanford Site-related industries, the economy of the region is primarily agricultural. Major crops include alfalfa, wheat, corn, and potatoes. Several fruit orchards and vineyards are located within short distances of the Hanford Site. The Columbia River within and adjacent to the Hanford Site is used extensively for recreational purposes including fishing and waterfowl hunting.

The population center nearest to the Hanford Site is the Tri-Cities area (Richland, Pasco, and Kennewick), situated on the Columbia River downstream from the site with a combined population of approximately 90,000. Approximately 340,000 people live within an 80-km radius of the Hanford Site including the Yakima area, the Tri-Cities, several small communities, and the surrounding agricultural areas. Considerably more detail on site characteristics and activities is available in the Final Environmental Statement, Waste Management Operations at Hanford (USERDA 1975).

Established in 1943, facilities at the Hanford Site were originally designed, built, and operated to produce plutonium for nuclear weapons. At

one time, nine production reactors were in operation, including eight with once-through cooling by treated river water. Between December 1964 and January 1971, all eight reactors with once-through cooling were deactivated. N Reactor, the remaining production reactor in operation, has a closed primary cooling loop.

Four major operating areas exist at the Hanford Site. The "100 Areas" include facilities for the N-Production Reactor and the eight deactivated production reactors along the Columbia River. The reactor fuel processing and waste management facilities are on a plateau about 11.3 km from the river in the "200 Areas." The "300 Area," just north of the city of Richland, contains the reactor fuel manufacturing facilities and research and development laboratories. The Fast Flux Test Facility (FFTF) is located in the "400 Area" approximately 8.8 km northwest of the 300 Area. Remaining portions of the site not associated with these operating areas are known collectively as the "600 Area."

Privately owned facilities located within the Hanford Site boundaries include the Washington Public Power Supply System generating station adjacent to N Reactor, the Washington Public Power Supply System power reactor site and office buildings, and the radioactive waste burial site operated by U.S. Ecology. The Exxon fuel fabrication facility is located adjacent to the southern boundary of the Hanford Site.

Principal DOE contractors operating at Hanford are:

- Rockwell Hanford Operations (RHO)--responsible for fuel processing, waste management, and site support services such as plant security, fire protection, central stores, and electrical power distribution.
- Battelle Memorial Institute--responsible for operating the PNL for DOE. This operation includes research and development in the physical, life and environmental sciences, chemistry, and advanced methods of nuclear waste management. Environmental surveillance also is a part of PNL activities.
- UNC Nuclear Industries (UNC)--responsible for fabricating fuel and operating N Reactor.

- Westinghouse Hanford Company (WHC)--responsible for operating the Hanford Engineering Development Laboratory (HEDL), including advanced reactor developments, principally the Liquid Metal Fast Breeder Reactor Program and FFTF test reactor.
- Hanford Environmental Health Foundation (HEHF)--responsible for occupational medicine and environmental health support services.

Highlights of operational activities at Hanford during 1983 were:

- N Reactor operated for 201 days during which time it supplied steam used by the Washington Public Power Supply System to generate 870 MW of electrical power. Since its startup, N Reactor has supplied steam for the production of over 50 billion kilowatt-hours of electric power which was supplied to the Bonneville Power Administration grid covering the Pacific Northwest.
- The PUREX fuel reprocessing facility in 200-E Area began routine operations during the month of November following a 12-year shutdown period.
- The FFTF completed two 100-day full-power operating campaigns.

Work at Hanford during 1983 also included Hanford National Environmental Research Park studies, Arid Land Ecology studies, and Basalt Waste Isolation Program activities, as well as continued operation of a variety of national research and laboratory facilities.

AIR SAMPLING

Airborne particulate and radioiodine sampling stations have been established at 23 onsite locations, primarily in the immediate vicinity of the four major operating areas as shown in Figure 2. Samples were collected and analyzed according to the schedule presented in Table 1. Samples also were collected at five locations distant from the site (Figure 2), and the results provided radionuclide concentrations for comparison. Several air sampling locations contained an atmospheric moisture collection unit, and a few contained ^{14}C and ^{85}Kr sampler systems.

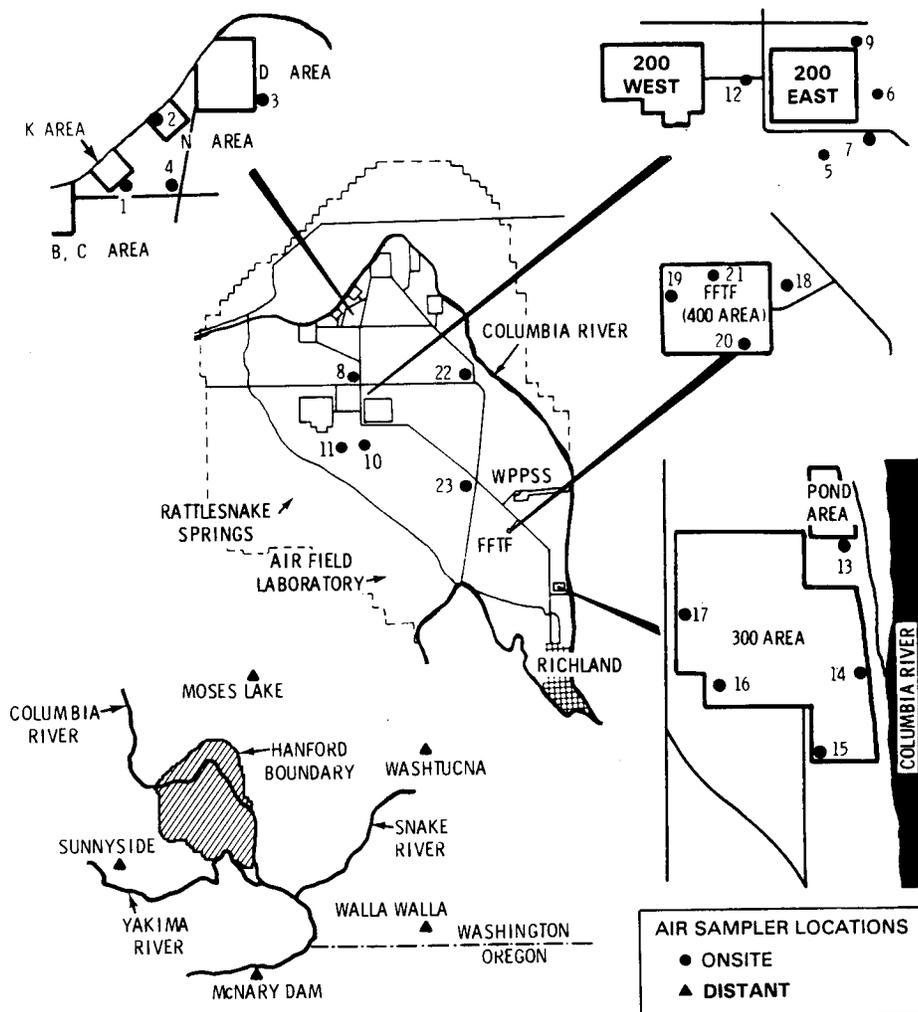


FIGURE 2. Onsite and Background Environmental Air Sampling Locations

TABLE 1. Onsite Air Sampling Schedule

Sample Location	Map Location (b)	Gross Beta	Gross Alpha	Gamma Scan	Analysis Frequency (a)					
					⁹⁰ Sr	Plutonium (c)	U (Natural)	¹³¹ I	³ H (HTO)	¹⁴ C	^{85}Kr
<u>100 Areas</u>										
100 K	1	BW						NRA		
100 N	2	BW						BW		
100 D	3	BW	BW					BW	M	BM
Fire Station	4	BW						NRA	M	
Composite					Q	Q	Q			
<u>200 East Area</u>										
S of 200 E	5	BW	BW					BW	M	M
E of 200 E	6	BW	BW					BW	M	M
200 ESE	7	BW	BW					BW	M	BM
Composite				M	Q	Q	Q			
<u>North of 200 Areas</u>										
Rt. 11A Mi 9	8	BW	BW					NRA		
N of 200 E	9	BW	BW					NRA	M	
Composite				M	Q	Q	Q			
<u>200 West Area</u>										
SW BC Cribs	10	BW	BW					NRA	M	
Army Loop Camp	11	BW	BW					NRA		
GTE Building	12	BW	BW					NRA	M	
Composite				M	Q	Q	Q			
<u>300 Area</u>										
300 Pond	13	BW	BW					NRA		M
3614-A Bldg.	14	BW						NRA		
300-S Gate	15	BW	BW					NRA		
300-SW Gate	16	BW						BW		
3705 Bldg.	17	BW						NRA		
Composite				M	Q	Q	Q			
<u>400 Area</u>										
400 E	18	BW	BW					BW	M	
400 W	19	BW	BW					BW		
400 S	20	BW	BW					BW		
400 N	21	BW	BW					BW		
Composite				M	Q	Q	Q			
<u>600 Area</u>										
Hanford	22	BW	BW					NRA	M	
Composite				M	Q	Q	Q			
Wye Barricade	23	BW	BW					NRA	M	BM
Composite				M	Q	Q	Q			

(a) The symbols for analysis frequency are described as follows: BW means biweekly, NRA means not routinely analyzed, BM means bimonthly, M means monthly and Q means quarterly. No entry indicates no analysis was made.

(b) Locations are identified in Figure 2.

(c) Both ²³⁹Pu and ²⁴⁰Pu were analyzed.

Particulate airborne radionuclides were sampled by drawing air at a flow rate of $2.6 \text{ m}^3/\text{h}$ through a 5-cm diameter high-efficiency particulate filter.^(a) Radioiodines were collected on a 4.4-cm diameter by 5.5-cm-deep bed of KI- and TEDA-impregnated charcoal located downstream of the particulate filter.^(b)

The particulate filters were collected biweekly and analyzed for gross beta and, in some cases, for gross alpha radioactivity after a seven-day holding period that allowed the short-lived naturally occurring radon and thoron daughters collected by the filter to decay. The filters were combined monthly according to geographical location and analyzed as a composite sample for gamma-emitting radionuclides, most importantly ^{137}Cs . On a quarterly basis, the filters for each geographical group were combined and analyzed as a composite for strontium and plutonium. All analyses were performed by U.S. Testing Company, Inc.

Charcoal cartridges from several of the sampling locations located close to operating facilities were exchanged on a biweekly frequency and analyzed for ^{131}I . The remaining cartridges were exchanged monthly to replenish the adsorption media, but were analyzed only if ^{131}I was identified in one of the routinely analyzed samples.

Tritium concentrations in atmospheric moisture were measured monthly in the vicinity of the 100, 200, 400 and 600 Areas. The tritium collection unit consisted of three cartridges containing silica gel through which a stream of air was passed at a flow rate of $0.01 \text{ m}^3/\text{h}$. The silica gel removed tritium in the form of water vapor (HTO). Moisture removed from the air stream by the silica gel was recovered in the laboratory and analyzed for tritium.

The ^{14}C (CO_2) collection unit consisted of a single cartridge containing sufficient soda lime to collect about 5 g of carbon over an eight-week sampling period at a flow rate of $0.03 \text{ m}^3/\text{h}$.

-
- (a) Measured efficiencies exceed 99% for DOP (dioctyl-phthalate) particles.
 - (b) Potassium iodide and triethylene diamine impregnated charcoal with retention efficiencies of 99% for both elemental and methyl iodine.

Samples of ambient air for ^{85}Kr analysis were collected by either one of two systems. The first utilized a compressor that cycled on and off every 50 minutes transferring 10-second duration samples into a pressure tank. Samples of about 0.5 m^3 were collected over a four-week sampling period. The second sampling unit consisted of a small laboratory pump that transferred a sample at a flow rate of $0.0004\text{ m}^3/\text{h}$ into a collection bag. The 0.3 m^3 of air in the bag collected over a four-week sampling period was then transferred by compressor into a pressure tank.

Results of the airborne particulate and radioiodine samples collected onsite during 1983 are summarized in Tables 2 through 8. General airborne particulate radioactivity levels in the Hanford environs were lower in 1983 than in 1982 as airborne radionuclides associated with worldwide fallout declined. The effect of atmospheric nuclear tests on ambient airborne radioactivity levels is demonstrated in Figure 3 which shows monthly averaged gross-beta particulate air concentrations near operating areas and at distant locations during the past five years. An increase in general background levels was observed almost immediately following the October 1980 atmospheric nuclear test, with maximum concentrations observed in samples collected during the spring and summer of 1981. By the beginning of 1982, airborne concentrations had returned to pretest levels. The figure also illustrates the similarity of airborne radioactivity levels at onsite and offsite locations during recent years.

In concert with gross radioactivity levels, individual radionuclides ($^{95}\text{ZrNb}$, ^{90}Sr , $^{144}\text{CePr}$, ^{137}Cs , ^{238}Pu , $^{239,240}\text{Pu}$) were detected only occasionally during 1983 compared to previous years. Radionuclide concentrations in air samples also were observed to be similar among locations as shown in Tables 2 through 8. As in recent years, ^{131}I was not observed in any of the air samples collected.

Analytical results for ^{85}Kr samples were similar for both onsite and distant locations with the exception of December samples collected in the 200 and 300 Areas which averaged 280 ± 22 and $210 \pm 28\text{ pCi/m}^3$, respectively. PUREX resumed operations late in 1983, and the samples collected in December reflected an expected increase in ^{85}Kr levels in ambient air. The average

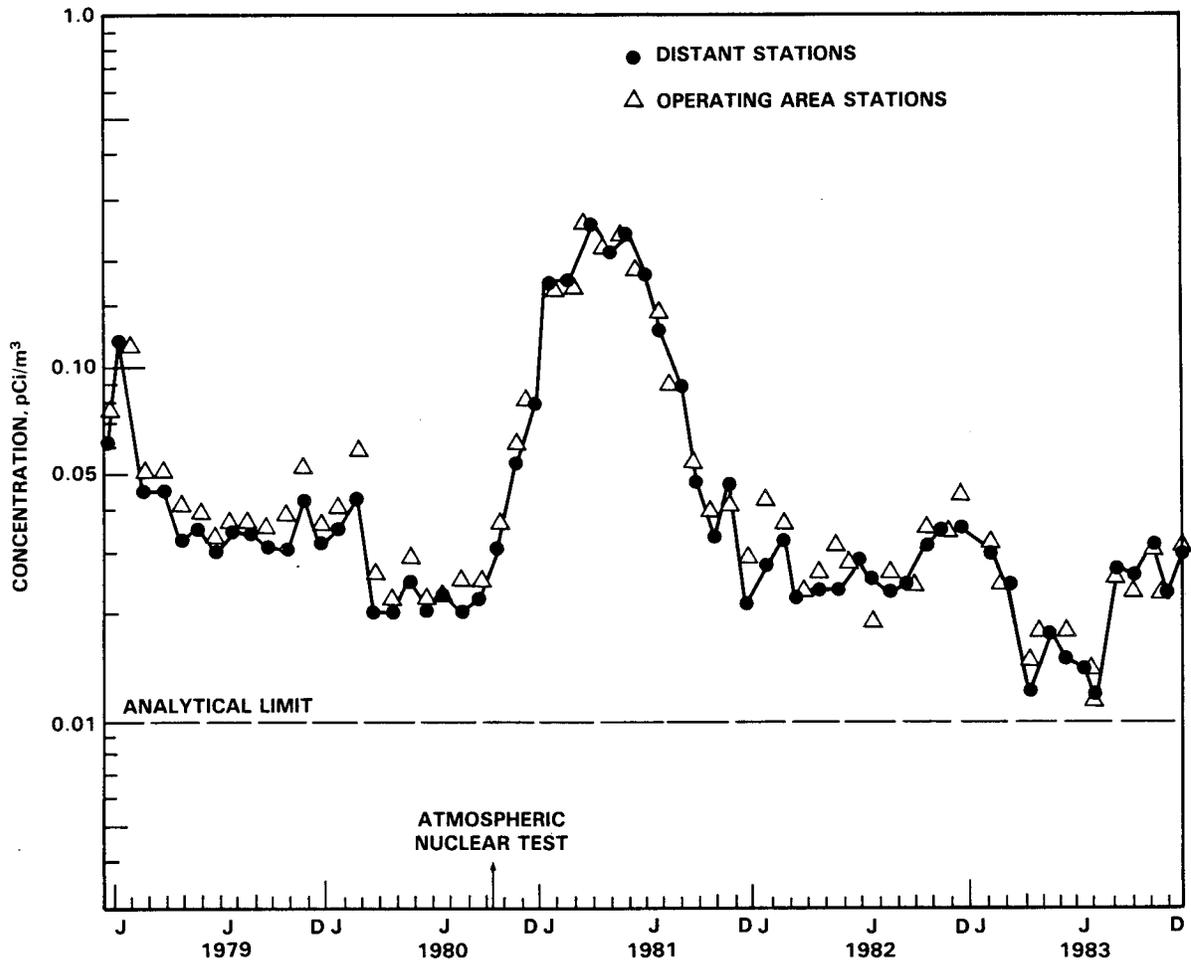


FIGURE 3. Monthly Average Gross-Beta-Emitter Activity in the Atmosphere

level of ^{85}Kr onsite as well as offsite prior to PUREX restart was about 17 pCi/m³. Elevated levels of ^{85}Kr in offsite ambient air due to PUREX operations were not detected in 1983.

The tritium collection unit in operation at Hanford since 1977 was redesigned in July 1983 to provide more quantitative and reliable information on the volume of air sampled (Sula et al. 1983). Therefore, the data presented in Tables 2 through 8 are expressed in pCi/m³ for the last five months of the year only. To enable comparison of the 1983 data with that obtained by the tritium samplers in previous years, historical data were converted from picocuries of tritium per cubic meter of air to picocuries of tritium per liter

TABLE 2. Airborne Radionuclide Concentrations in the 100 Areas

		Concentration, pCi/m ³ (a)				
Radionuclide	Sample Location	Fraction of Results >DL (b)	Maximum	Minimum	Annual Average (c)	Average 1983 Distant (d)
³ H (HTO)	K Area	2/6	5.5 ± 2.7 (e)	<DL (f)	(2.5 ± 0.9)	(2.9 ± 1.8)
	N Area	3/6	5.8 ± 2.9	<DL	(2.1 ± 1.4)	
	D Area	2/5	4.5 ± 2.2	<DL	(1.4 ± 0.8)	
	Fire Station	2/5	9.7 ± 2.9	<DL	(2.7 ± 0.8)	
¹⁴ C (CO ₂)	Fire Station	3/3	1.6 ± 0.1	1.4 ± 0.1	1.5 ± 0.2	1.4 ± 0.2
	Composite (g)	3/4	0.0002 ± 0.00006	<DL	0.0001 ± 0.00006	(0.0001 ± 0.0001)
⁹⁰ Sr	N Area	0/26	<DL	<DL	(0.0007 ± 0.002)	(0.001 ± 0.002)
	D Area	0/26	<DL	<DL	(0.0003 ± 0.002)	
¹³⁷ Cs	Composite	3/13	0.0008 ± 0.0005	<DL	(0.0002 ± 0.0002)	(0.0007 ± 0.0005)
	Composite	3/3	0.00002 ± 0.000006	0.000004 ± 0.000001	(0.00001 ± 0.00001)	0.00006 ± 0.00003
²³⁸ Pu	Composite	1/4	0.00002 ± 0.00001	<DL	(0.000005 ± 0.000008)	(0.000007 ± 0.000005)
	Composite	3/4	0.0002 ± 0.00005	<DL	(0.00006 ± 0.0001)	
Gross Beta	K Area	26/26	0.04 ± 0.005	0.009 ± 0.004	0.02 ± 0.004	0.02 ± 0.002
	N Area	26/26	0.05 ± 0.005	0.01 ± 0.004	0.03 ± 0.004	
	D Area	26/26	0.04 ± 0.005	0.01 ± 0.002	0.02 ± 0.004	
	Fire Station	26/26	0.04 ± 0.005	0.008 ± 0.004	0.02 ± 0.004	
Gross Alpha	D Area	26/26	0.002 ± 0.0006	0.0004 ± 0.0003	0.0009 ± 0.0002	0.0008 ± 0.0001

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
 (b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.
 (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
 (d) Distant sampling locations are identified in Figure 2.
 (e) Values for tritium are reported for August through December.
 (f) <DL means less than the detection level, i.e., radionuclide concentration was less than or equal to the associated ±2σ counting error.
 (g) Composites of biweekly samples from the individual sampling locations are identified in Table 1.

TABLE 3. Airborne Radionuclide Concentrations in the 200-E Area

		Concentration, pCi/m ³ (a)				
Radionuclide	Sample Location	Fraction of Results >DL (b)	Maximum	Minimum	Annual Average (c)	Average 1983 Distant(d)
³ H (HTO)	S of 200 E	5/5	11 ± 3.9 (e)	1.6 ± 1.4	4.9 ± 3.7	(2.9 ± 1.8)
	E of 200 E	3/5	10 ± 2.5	<DL	(4.3 ± 2.3)	
	200 ESE	1/6	2.8 ± 1.3	<DL	(1.0 ± 1.0)	
¹⁴ C (CO ₂)	200 ESE	5/5	1.6 ± 0.1	1.4 ± 0.2	1.5 ± 0.12	1.4 ± 0.2
	S of 200 E	5/5 (g)	280 ± 36	16 ± 5	71 ± 100	17 ± 2.7
E of 200 E	5/5	280 ± 36	19 ± 5	74 ± 99		
200 ESE	4/4	290 ± 37	18 ± 4.5	79 ± 59		
⁹⁰ Sr	Composite (h)	4/4	0.0002 ± 0.0002	0.0001 ± 0.00007	0.0002 ± 0.00008	(0.0001 ± 0.00001)
¹³¹ I	200 ESE	0/26	<DL	<DL	(0.0006 ± 0.002)	(0.001 ± 0.002)
¹³⁷ Cs	Composite	4/13	0.001 ± 0.0008	<DL	(0.0002 ± 0.0003)	(0.0007 ± 0.0005)
U (Natural)	Composite	3/3	0.00002 ± 0.000008	0.00001 ± 0.000004	0.00002 ± 0.000008	0.00006 ± 0.00003
²³⁸ Pu	Composite	2/4	0.00002 ± 0.00002	<DL	(0.000007 ± 0.000006)	(0.000007 ± 0.000005)
^{239,240} Pu	Composite	3/4	0.00004 ± 0.00001	<DL	(0.00002 ± 0.00002)	0.00002 ± 0.00001
Gross Beta	S of 200 E	14/14	0.03 ± 0.005	0.01 ± 0.004	0.02 ± 0.005	0.02 ± 0.002
	E of 200 E	16/16	0.04 ± 0.005	0.01 ± 0.005	0.02 ± 0.005	
	200 ESE	26/26	0.04 ± 0.005	0.007 ± 0.004	0.02 ± 0.002	
Gross Alpha	S of 200 E	14/14	0.001 ± 0.0006	0.0004 ± 0.0003	0.0009 ± 0.0002	0.0008 ± 0.0001
	E of 200 E	16/16	0.002 ± 0.0006	0.0005 ± 0.0004	0.001 ± 0.0002	
	200 ESE	24/26	0.002 ± 0.0006	0.0004 ± 0.0004	0.0008 ± 0.0001	

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
 (b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.
 (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
 (d) Distant sampling locations are identified in Figure 2.
 (e) Values for tritium are reported for August through December.
 (f) <DL means less than the detection level, i.e., radionuclide concentration was less than or equal to the associated ±2σ counting error.
 (g) Krypton-85 results are from August through December, 1983.
 (h) Composites of biweekly samples from the individual sampling locations are identified in Table 1.

TABLE 4. Airborne Radionuclide Concentrations in the 200-W Area

		Concentration, pCi/m ³ (a)			
Radionuclide	Sample Location	Fraction of Results >DL (b)	Maximum	Minimum	Average 1983 Distant(d)
³ H (HTO)	SW of BC Cribs GTE Building	2/5	5.4 ± 1.9 (e)	<DL (f)	(2.8 ± 1.3)
		4/5	9.3 ± 2.7	<DL	
⁹⁰ Sr	Composite (g)	0/4	<DL	<DL	(0.00007 ± 0.00006)
¹³¹ I	All Locations				NRA (h)
¹³⁷ Cs	Composite	3/13	0.0008 ± 0.0006	<DL	(0.0001 ± 0.0003)
U (Natural)	Composite	4/4	0.00002 ± 0.000006	0.000005 ± 0.000002	0.00006 ± 0.00003
²³⁸ Pu	Composite	0/4	<DL	<DL	(0.000006 ± 0.000006)
^{239,240} Pu	Composite	3/4	0.00005 ± 0.00002	<DL	0.00003 ± 0.00001
Gross Beta	SW BC Cribs Army Loop Camp GTE Building	25/25	0.04 ± 0.005	0.009 ± 0.004	0.02 ± 0.004
		25/25	0.03 ± 0.005	0.01 ± 0.004	0.02 ± 0.003
		26/26	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.004
					0.02 ± 0.002
Gross Alpha	SW BC Cribs Army Loop Camp GTE Building	25/25	0.002 ± 0.0006	0.0003 ± 0.0003	0.0008 ± 0.0002
		25/25	0.002 ± 0.0006	0.0004 ± 0.0003	0.0008 ± 0.0002
		26/26	0.002 ± 0.0006	0.0004 ± 0.0003	0.0008 ± 0.0002
					0.0008 ± 0.0009

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
 (b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.
 (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
 (d) Distant sampling locations are identified in Figure 2.
 (e) Values for tritium are reported for August through December.
 (f) <DL means less than the detection level, i.e. radionuclide concentration was less than or equal to the associated ±2σ counting error.
 (g) Composites of biweekly samples from the individual sampling locations are identified in Table 1.
 (h) Not routinely analyzed.

TABLE 5. Airborne Radionuclide Concentrations North of the 200 Areas

Radionuclide	Sample Location	Fraction of Results >DL(b)	Concentration, pCi/m ³ (a)		
			Maximum	Minimum	Average 1983 Distant(d)
³ H (HTO)	Rt. 11A, Mi. 9 N of 200 E	2/3	3.5 ± 2.3(e)	<DL (f)	2.3 ± 1.1
		2/3	7.2 ± 2.9	<DL	3.8 ± 1.4
					3.0 ± 1.7
⁹⁰ Sr	Composite(g)	4/4	0.0008 ± 0.0003	0.0003 ± 0.0002	0.0005 ± 0.0003 (0.0001 ± 0.0001)
¹³¹ I	All Locations				NRA(h)
¹³⁷ Cs	Composite	2/13	0.007 ± 0.006	<DL	(0.001 ± 0.001) (0.0007 ± 0.0005)
U (Natural)	Composite	4/4	0.00003 ± 0.00001	0.000005 ± 0.000002	0.00002 ± 0.00001 0.00006 ± 0.00003
²³⁸ Pu	Composite	0/4	<DL	<DL	(0.00002 ± 0.00002) (0.000007 ± 0.000005)
^{239,240} Pu	Composite	2/4	0.0001 ± 0.0001	<DL	(0.00004 ± 0.00007) 0.00002 ± 0.00001
Gross Beta	Rt. 11A, Mi. 9 N of 200 E	13/13	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.005
		24/24	0.05 ± 0.005	0.008 ± 0.004	0.02 ± 0.004
					0.02 ± 0.003
Gross Alpha	Rt. 11A, Mi. 9 N of 200 E	13/13	0.002 ± 0.0006	0.0005 ± 0.0004	0.0009 ± 0.0002
		24/24	0.002 ± 0.0006	0.0003 ± 0.0003	0.0009 ± 0.0002
					0.0009 ± 0.0001

- (a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
- (b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.
- (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
- (d) Distant sampling locations are identified in Figure 2.
- (e) Values for tritium are reported for August through December.
- (f) <DL means less than the detection level, i.e. radionuclide concentration was less than or equal to the associated ±2σ counting error.
- (g) Composites of biweekly samples from the individual sampling locations are identified in Table 1.
- (h) Not routinely analyzed.

TABLE 6. Airborne Radionuclide Concentrations in the 300 Area

		Concentration, pCi/m ³ (a)				
Radionuclide	Sample Location	Fraction of Results >DL(b)	Maximum	Minimum	Annual Average (c)	Average 1983 Distant(d)
⁸⁵ Kr	300 Pond	17/17(e)	210 ± 28	12 ± 5.5	47 ± 29	(17 ± 2.7)
⁹⁰ Sr	Composite (f)	2/4	0.0001 ± 0.00004	<DL (g)	(0.00007 ± 0.000005)	(0.0001 ± 0.0001)
¹³¹ I	300 SW Gate	0/25	<DL	<DL	(-0.0005 ± 0.002)	(0.001 ± 0.002)
¹³⁷ Cs	Composite	5/13	0.001 ± 0.0009	<DL	(0.0003 ± 0.0004)	(0.0007 ± 0.0005)
U (Natural)	Composite	3/3	0.0001 ± 0.00004	0.00004 ± 0.00002	0.00009 ± 0.00006	0.00006 ± 0.00003
²³⁸ Pu	Composite	1/4	0.00008 ± 0.00002	<DL	(0.00002 ± 0.000006)	(0.000007 ± 0.000005)
^{239,240} Pu	Composite	4/4	0.0001 ± 0.00003	0.000001 ± 0.0000008	(0.00003 ± 0.00005)	0.00002 ± 0.00001
Gross Beta	300 Pond	24/24	0.05 ± 0.005	0.008 ± 0.004	0.02 ± 0.005	
	3614-A Bldg.	26/26	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.004	
	300 S Gate	23/23	0.04 ± 0.006	0.008 ± 0.004	0.02 ± 0.004	
	300 SW Gate	25/25	0.06 ± 0.005	0.008 ± 0.004	0.02 ± 0.005	
	3705 Bldg.	24/24	0.04 ± 0.005	0.009 ± 0.004	0.02 ± 0.004	
Gross Alpha	300 Pond	24/24	0.002 ± 0.0007	0.0004 ± 0.0003	0.001 ± 0.0002	
	300 S Gate	23/23	0.002 ± 0.0007	0.0004 ± 0.0003	0.0009 ± 0.0002	
					0.001 ± 0.0002	0.0008 ± 0.0001

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
 (b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.
 (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
 (d) Distant sampling locations are identified in Figure 2.
 (e) Krypton-85 data includes duplicate samples for the months of September through December, 1983.
 (f) Composites of biweekly samples from the individual sampling locations are identified in Table 1.
 (g) <DL means less than the detection level, i.e., radionuclide concentration was less than or equal to the associated ±2σ counting error.

TABLE 7. Airborne Radionuclide Concentrations in the 400 Area

		Concentration, pCi/m ³ (a)			
Radionuclide	Sample Location	Fraction of Results >DL(b)	Maximum	Minimum	Average 1983 Distant(d)
³ H (HTO)	400 E	3/5	5.6 ± 3.0(e)	<DL (f)	(2.5 ± 1.8)
⁹⁰ Sr	Composite (g)	3/4	0.0003 ± 0.0001	<DL	(0.0001 ± 0.0001)
¹³¹ I	400 E	0/25	<DL	<DL	(0.0001 ± 0.002)
	400 W	0/23	<DL	<DL	(0.001 ± 0.002)
	400 S	0/24	<DL	<DL	(-0.0004 ± 0.002)
	400 N	0/21	<DL	<DL	(-0.0003 ± 0.002)
¹³⁷ Cs	Composite	3/13	0.003 ± 0.001	<DL	(0.0003 ± 0.0005)
U (Natural)	Composite	3/3	0.00002 ± 0.000007	0.00001 ± 0.000004	0.00002 ± 0.00001
²³⁸ Pu	Composite	1/4	0.000007 ± 0.000005	<DL	(0.000002 ± 0.000002)
^{239,240} Pu	Composite	3/4	0.00002 ± 0.000008	<DL	0.000009 ± 0.000005
	400 E	25/25	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.003
	400 W	24/24	0.04 ± 0.005	0.009 ± 0.004	0.02 ± 0.004
	400 S	24/24	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.004
Gross Beta	400 N	21/21	0.04 ± 0.005	0.007 ± 0.004	0.02 ± 0.002
Gross Alpha	400 E	25/25	0.002 ± 0.0007	0.0005 ± 0.0004	0.0009 ± 0.0002
	400 W	24/24	0.002 ± 0.0009	0.0004 ± 0.0004	0.001 ± 0.0002
	400 S	24/24	0.002 ± 0.0006	0.0005 ± 0.0004	0.001 ± 0.0002
	400 N	21/21	0.002 ± 0.0006	0.0003 ± 0.0003	0.001 ± 0.0001

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).
 (b) >DL means greater than detection level.
 (c) Parenthesis enclosing an average value indicates the radionuclide concentration was greater than the associated ±2σ counting error.
 (d) Distant sampling locations are identified in Figure 2.
 (e) Values for tritium are reported for August through December.
 (f) <DL means less than the detection level; i.e., radionuclide concentration was less than or equal to the associated ±2σ counting error.
 (g) Composites of biweekly samples from the individual sampling locations are identified in Table 1.

TABLE 8. Airborne Radionuclide Concentrations in the 600 Area

		Concentration, pCi/m ³ (a)				
Radionuclide	Sample Location	Fraction of Results >DL(b)	Maximum	Minimum	Annual Average(c)	Average 1983 Distant(d)
³ H (HTO)	Hanford	3/5	8.5 ± 2.7(e)	<DL (f)	(3.3 ± 2.7)	(2.9 ± 1.8)
	Wye Barricade	2/5	7.9 ± 2.6	<DL	(2.4 ± 0.8)	
¹⁴ C (CO ₂)	Wye Barricade	4/4	1.5 ± 1.1	1.3 ± 0.2	1.4 ± 0.1	1.4 ± 0.2
	Hanford	2/4	0.001 ± 0.0003	<DL	(0.0006 ± 0.0005)	(0.0001 ± 0.0001)
⁹⁰ Sr	Wye Barricade	0/4	<DL	<DL	(0.0002 ± 0.0001)	
	Hanford				NRA (g)	
¹³¹ I	Wye Barricade					
	Hanford					
¹³⁷ Cs	Hanford	2/13	0.001 ± 0.001	<DL	(-0.00004 ± 0.0009)	(0.0007 ± 0.0005)
	Wye Barricade	3/13	0.008 ± 0.005	<DL	(0.0009 ± 0.001)	
U (Natural)	Hanford	4/4	0.00003 ± 0.00001	0.000005 ± 0.000002	(0.00002 ± 0.00002)	0.00006 ± 0.00003
	Wye Barricade	4/4	0.00008 ± 0.00003	0.000002 ± 0.0000006	(0.00003 ± 0.00004)	
²³⁸ Pu	Hanford	2/4	0.00004 ± 0.00003	<DL	(0.00002 ± 0.00001)	(0.000007 ± 0.000005)
	Wye Barricade	2/4	0.00002 ± 0.00002	<DL	(0.00003 ± 0.00002)	
^{239,240} Pu	Hanford	4/4	0.00009 ± 0.00003	0.00002 ± 0.000008	0.00006 ± 0.00004	0.00002 ± 0.00001
	Wye Barricade	3/4	0.0001 ± 0.00009	<DL	(0.00004 ± 0.00004)	
Gross Beta	Hanford	25/25	0.05 ± 0.005	0.01 ± 0.004	0.02 ± 0.004	0.02 ± 0.002
	Wye Barricade	25/25	0.04 ± 0.005	0.01 ± 0.004	0.02 ± 0.005	
Gross Alpha	Hanford	24/25	0.002 ± 0.0006	<DL	0.0009 ± 0.0002	0.0008 ± 0.0001
	Wye Barricade	25/25	0.002 ± 0.0006	0.0004 ± 0.0003		

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include ± two standard error of the calculated mean (95% confidence level).

(b) >DL means greater than detection level, i.e. radionuclide concentration was greater than the associated ±2σ counting error.

(c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).

(d) Distant sampling locations are identified in Figure 2.

(e) Values for tritium are reported for August through December.

(f) <DL means less than the detection level; i.e., radionuclide concentration was less than or equal to the associated ±2σ counting error.

(g) Not routinely analyzed.

of atmospheric moisture. Figure 4 shows that tritium levels in atmospheric moisture have been relatively constant for the last several years and that concentrations did not differ appreciably between sampling locations.

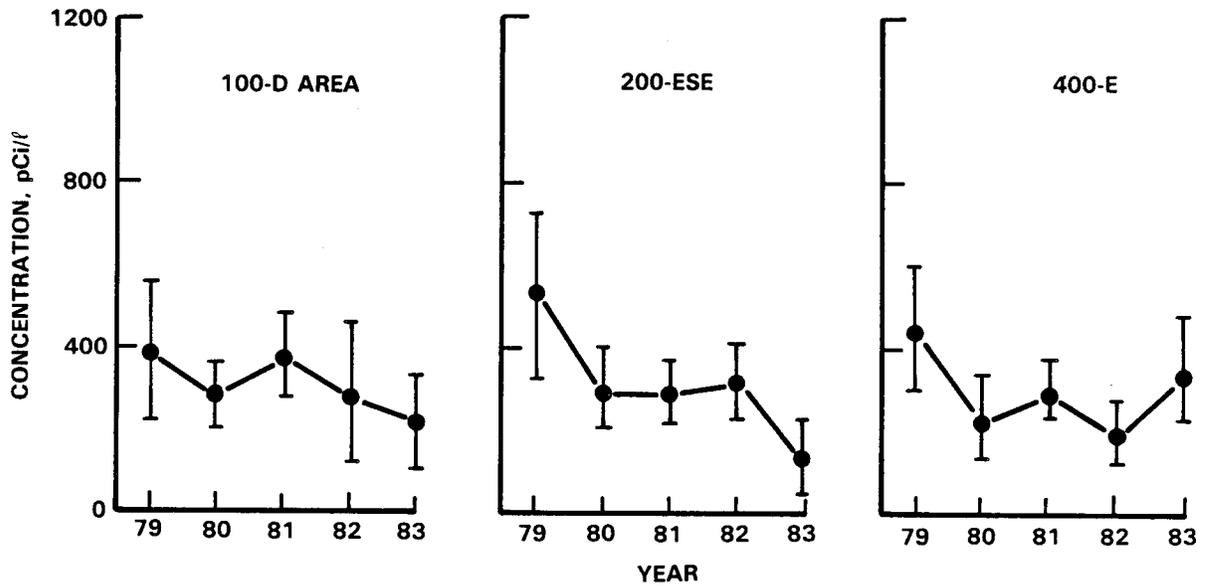


FIGURE 4. Average Annual Tritium Concentrations in Atmospheric Water Vapor at General Onsite Sampling Locations

PONDS

Four ponds located outside of operating area exclusion fences (Figure 5) were sampled periodically during 1983 for radioactivity. Two of the ponds, Gable Pond and B Pond near the 200-East Area, were excavated in the mid-1950's for disposal of chemical process cooling water and wastes occasionally containing low levels of radioactive contamination. The FFTF Pond, excavated in 1978, is a sewage disposal and treatment lagoon and does not receive any radio-

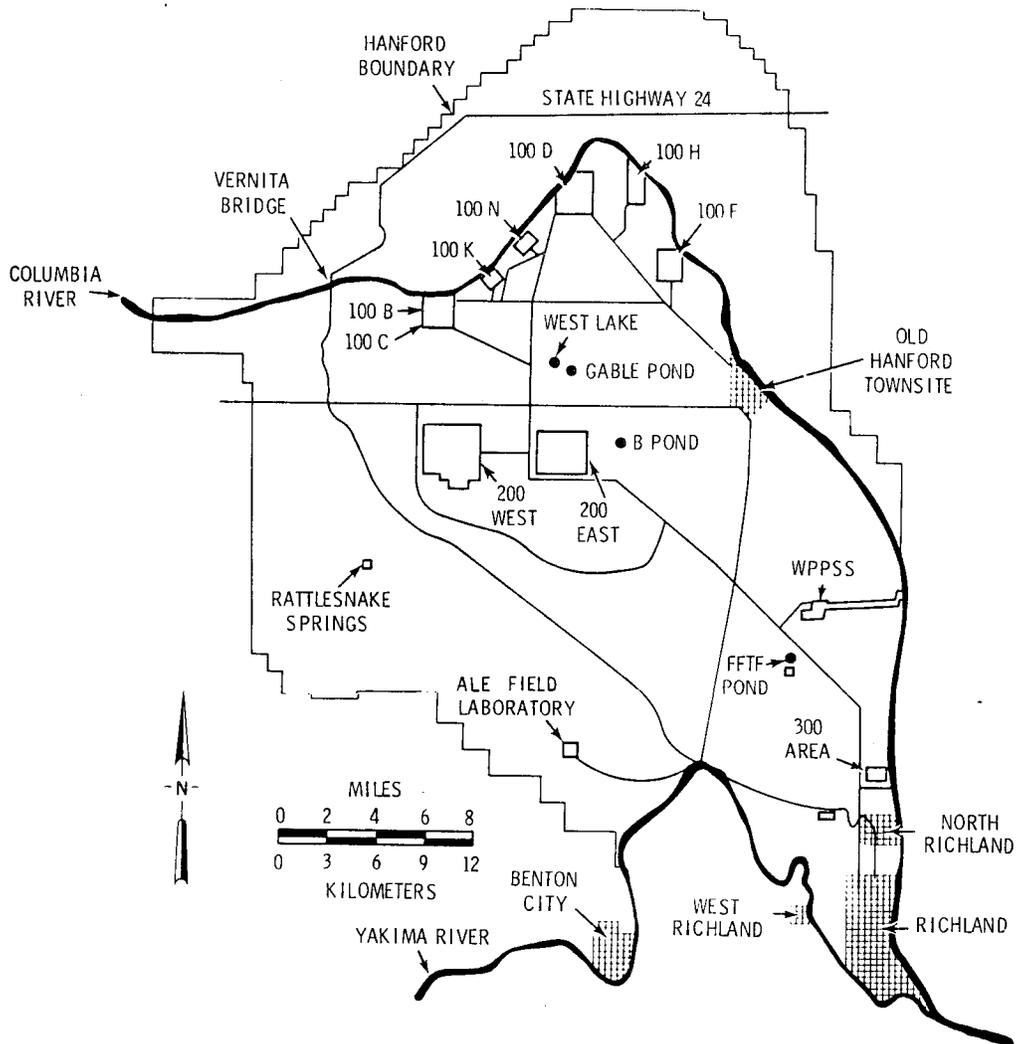


FIGURE 5. Onsite Ponds

active wastes. The fourth pond, West Lake, is a natural lake interconnected with the ground water and does not receive direct discharges from site facilities. Because the ponds are accessible to migrating waterfowl as well as other animals, a potential pathway exists for removal and dispersal of contaminants that may be present in the pond water and sediments or in biota associated with the ponds.

Grab samples of 10% of water from each pond were collected quarterly. Unfiltered sample aliquots were analyzed for gross alpha, gross beta, gamma emitters, ^3H , and ^{90}Sr except that the FFTF Pond samples were not analyzed for ^{90}Sr . Results for 1983 samples are shown in Table 9.

The highest gross alpha and gross beta concentrations were once again observed at West Lake, which is constantly recharged from a deep aquifer with only minor exchange of water between the pond and the shallow aquifer (Gephart et al. 1976). Special water samples collected and analyzed in 1975 indicated the radioactivity in the pond to be primarily from naturally occurring uranium (Fix, Speer and Blumer 1976). Therefore, the observed radioactivity was the result of naturally occurring radionuclides in the pond recharge that have been concentrated by evaporation over the years.

Tritium analysis of all pond water samples was initiated in 1983. The concentrations of tritium in West Lake samples reflected the concentrations known to occur in nearby ground water (Prater et al. 1984). A similar situation occurred at FFTF where the source of pond water was from the pumping and subsequent discharge of local ground water. Tritium levels in the FFTF Pond were noted to be about the same as concentrations in the local ground water. Ground water at the FFTF site is known to contain tritium from past effluent discharges in the 200 Areas (Prater et al. 1984).

Cesium-137 concentrations in B Pond continued to decrease during 1983 compared to prior years while ^{90}Sr concentrations remained about the same. Concentrations of these two radionuclides in B Pond increased during 1980 as shown in Figure 6. Monthly sampling was initiated during 1980 to enable trends to be observed more closely; however, radionuclide concentrations stabilized and the sampling frequency was reduced to quarterly to be consistent with the other onsite ponds.

TABLE 9. Radionuclide Concentrations in Onsite Ponds

Location	Date	Concentration, pCi/ℓ (a)				
		Gross Alpha Activity	Gross Beta Activity	³ H	⁹⁰ Sr	¹³⁷ Cs
West Lake	02/22	110 ± 10	280 ± 32	3,000 ± 250	0.12 ± 0.077	(0.97 ± 3.0)
	05/17	210 ± 14	330 ± 60	810 ± 220	1.1 ± 0.17	1.6 ± 0.75
	08/09	13 ± 3.6	410 ± 51	440 ± 210	3.8 ± 0.23	3.5 ± 3.1
	11/01	505 ± 23	690 ± 80	870 ± 220	3.2 ± 0.20	(1.0 ± 2.8)
Gable Pond	02/22	2.0 ± 0.65	51 ± 6.4	340 ± 210	7.3 ± 0.65	7.8 ± 1.7
	05/17	3.7 ± 2.2	200 ± 31	240 ± 210	6.9 ± 0.22	31 ± 2.4
	08/09	3.4 ± 2.1	210 ± 30	(-7.0 ± 210)	4.7 ± 0.15	65 ± 4.1
	11/01	0.37 ± 0.35	22 ± 5.7	320 ± 210	1.2 ± 0.09	30 ± 3.1
B Pond	02/22	1.6 ± 0.57	12 ± 5.4	470 ± 210	4.4 ± 1.4	2.0 ± 0.55
	05/17	8.9 ± 3.1	58 ± 27	(67 ± 210)	2.9 ± 0.26	4.0 ± 2.3
	08/09	3.4 ± 2.1	54 ± 43	(180 ± 210)	4.1 ± 0.21	1.4 ± 1.0
	11/01	2.5 ± 1.9	31 ± 23	(190 ± 210)	0.67 ± 0.11	2.4 ± 1.6
FFTF Pond	02/22	0.38 ± 0.33	20 ± 6.8	19,000 ± 420	NA ^(b)	(-0.92 ± 2.0)
	05/17	(-0.36 ± 0.92)	77 ± 28	22,000 ± 440	NA	1.0 ± 0.64
	08/09	(1.2 ± 1.5)	42 ± 27	18,000 ± 420	NA	(-0.22 ± 1.3)
	11/01	(1.6 ± 1.7)	40 ± 26	29,000 ± 500	NA	(0.15 ± 1.9)

(a) Individual results include the ±2σ counting error and are enclosed within parenthesis if the value is less than the associated ±2σ counting error.

(b) NA means not analyzed.

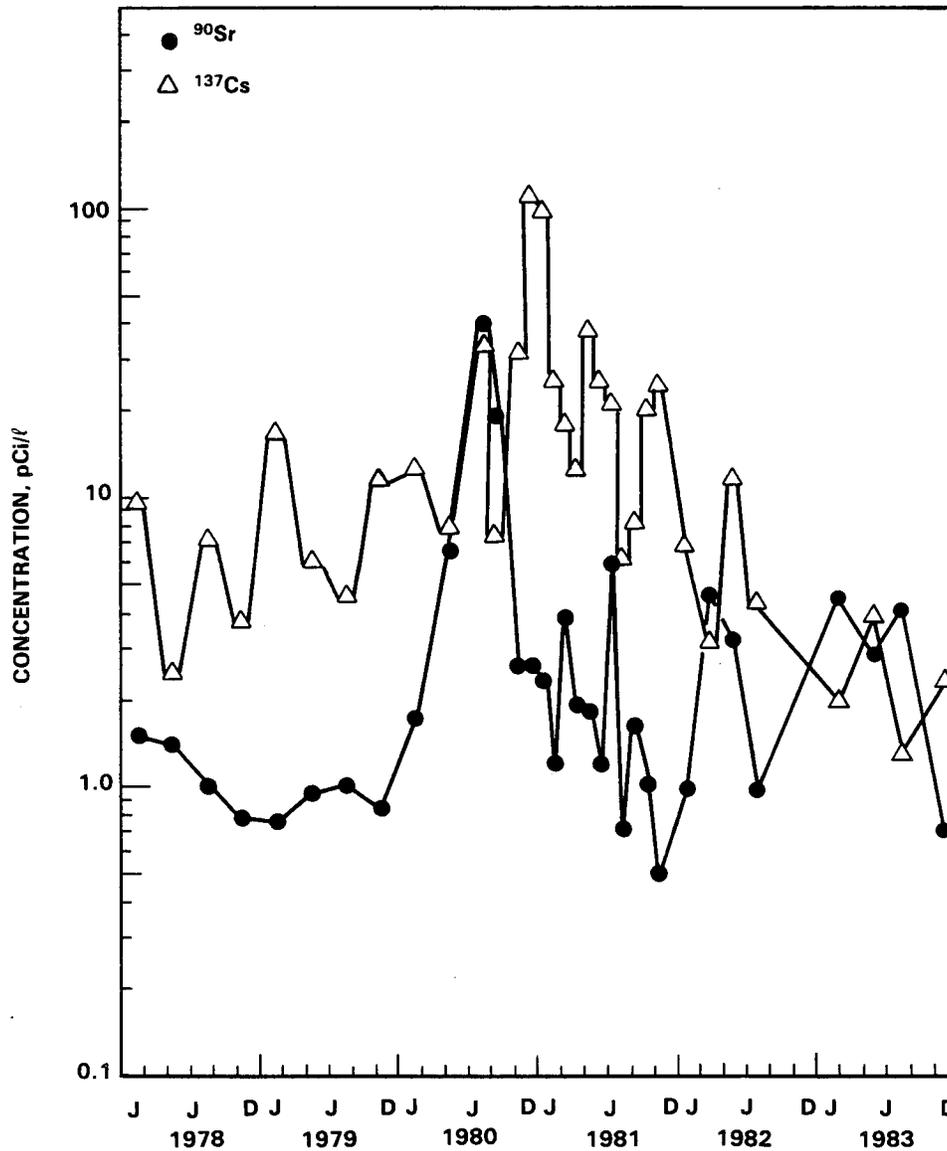


FIGURE 6. Strontium-90 and Cesium-137 Concentrations in B Pond

A comparison of radionuclide concentrations in the other onsite ponds (West Lake, Gable Pond, and FFTF Pond) to data obtained from the previous year's samples (Sula et al. 1983) showed no significant changes. Pond samples from the FFTF facility were analyzed for ^{22}Na , and results were below detection levels.

WILDLIFE

The Hanford Site provides refuge for migratory and resident waterfowl, upland game birds, and a variety of other animals. These animals have access to contaminated onsite ponds (see previous section) and vegetation growing in and near the ponds. The ingestion of contaminated water or vegetation from the pond areas, or from any other contaminated area, provides a mechanism for transfer of radionuclides away from the designated waste management areas. Additionally, for game animals, the ingestion of radioactive contamination and subsequent accumulation in edible meat represents a potential public exposure pathway.

Wildlife sampling provides an indication of the availability of contamination in the vicinity of the operating areas. Sampling was performed in and near operating areas to maximize the probability of collecting wildlife with detectable levels of Hanford-produced radionuclides.

Onsite wildlife sampling during 1983 included waterfowl (ducks, geese), upland game birds (quail, pheasant), deer, and rabbits. Results of 1983 wildlife samples, with the exception of rabbits, and the associated potential for offsite radiological impact were discussed in Environmental Surveillance at Hanford for CY 1983 (Price et al. 1984).

DEER

Samples from deer accidentally killed by vehicles on site roads were used to provide an indication of general levels of radionuclides in the herd residing on the site. Five road-killed deer were sampled and analyzed for ^{137}Cs and $^{239,240}\text{Pu}$ in muscle and liver tissue, respectively. Results (Table 10) indicated the presence of identifiable levels of ^{137}Cs in only one deer at 0.02 pCi/g of muscle tissue. The liver of the same animal contained 0.003 pCi/g of $^{239,240}\text{Pu}$. The concentrations were in the range generally associated with worldwide fallout.

A specially selected deer was collected in the vicinity of B Pond near the 200 Areas (Figure 7). This animal was part of a group studied during

TABLE 10. Radionuclide Concentrations in Deer

Location	Type	Concentration, pCi/g wet weight ^(a)		
		Fraction of Results >DL ^(b)	Maximum	Average ^(c)
¹³⁷ Cs				
Random (road kills)	Muscle	4/5	0.02 ± 0.007	(0.01 ± 0.01)
	Liver	--- ^(d)	---	---
Specially Selected	Muscle	1/1	---	0.20 ± 0.01 ^(e)
	Liver	---	---	---
^{239,240} Pu				
Random (road kills)	Muscle	---	---	---
	Liver	4/5	0.003 ± 0.0008	(0.001 ± 0.001)
Specially Selected	Muscle	---	---	---
	Liver	1/1	---	0.002 ± 0.0004 ^(e)

- (a) Maximum values include $\pm 2\sigma$ counting error. Averages include \pm two standard error of the calculated mean (95% confidence interval).
 (b) >DL means greater than detection level, i.e., radionuclide concentration was greater than the associated $\pm 2\sigma$ counting error.
 (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
 (d) Dashed lines indicate no analysis or no calculation.
 (e) Single sample.

1981 and 1982 to determine the probable maximum ¹³⁷Cs concentration in muscle tissue of deer residing on the Hanford Site (Eberhardt, Hanson, and Cadwell 1982). As part of the study, deer were captured and fitted with radio transmitting collars to track their movements. Data from radio tracking indicated the sampled deer tended to reside in the B-Pond Area during 1983. Results (Table 10) showed a slightly higher concentration of ¹³⁷Cs (0.20 pCi/g) in muscle compared to the road-killed deer. The ^{239,240}Pu concentration (0.002 pCi/g) in liver was similar to that in the road killed deer.

UPLAND GAME BIRDS

Samples of upland game birds including pheasant and chukar were collected in the 100, 200 and 300 Areas (Figure 7) during 1983. Samples of

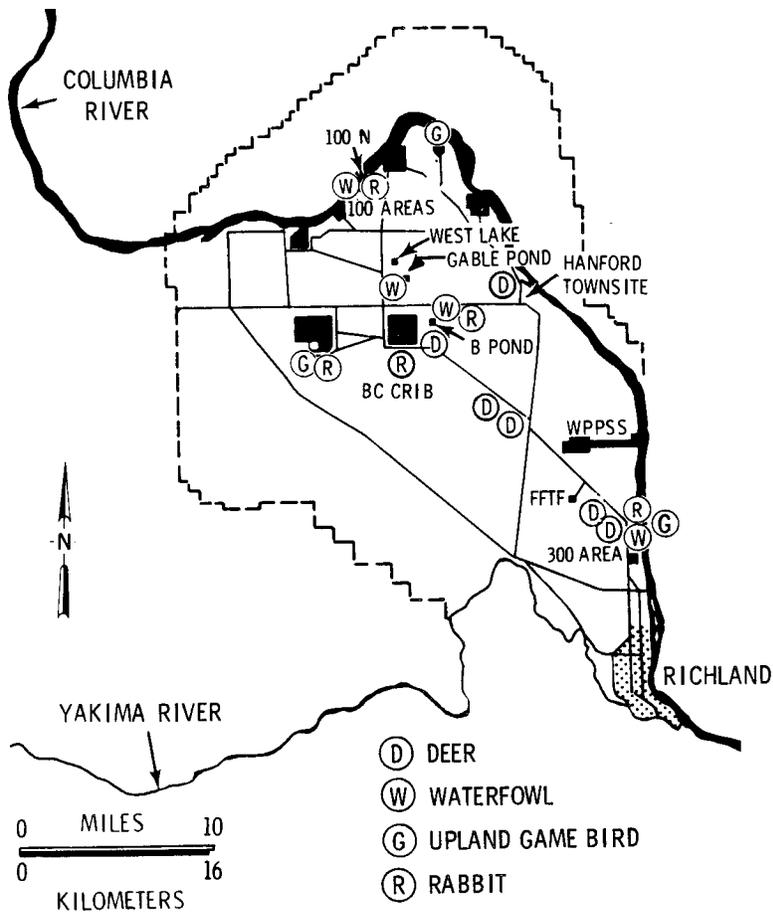


FIGURE 7. Onsite Wildlife Collection Sites

breast meat from each bird were analyzed for ^{60}Co and ^{137}Cs . Results are provided in Table 11. Cobalt-60 and ^{137}Cs concentrations were low for all samples, i.e., near the minimum detectable concentration.

WATERFOWL

Waterfowl samples (ducks and geese) were collected from three onsite ponds in the 200 and 300 Areas and from the 1301-N Trench in the vicinity of 100-N Area as shown in Figure 7. Approximately 0.5-kg of muscle tissue from each bird was analyzed for ^{137}Cs . Results of the analyses are shown in Table 12.

TABLE 11. Radionuclide Concentrations in Game Bird Muscle Tissue

Location	Concentration, pCi/g wet weight ^(a)		
	Fraction of Results >DL ^(b)	Maximum	Average ^(c)
⁶⁰ Co			
100 Areas			
Pheasant	1/6	0.013 ± 0.010	(0.0015 ± 0.011)
200 Areas			
Chukar	0/3	<DL ^(d)	(-0.0070 ± 0.0086)
300 Area			
Pheasant	0/1	--- ^(e)	(-0.017 ± 0.016) ^(f)
¹³⁷ Cs			
100 Areas			
Pheasant	5/6	0.021 ± 0.009	0.015 ± 0.0065
200 Areas			
Chukar	3/3	0.023 ± 0.010	0.021 ± 0.0069
300 Area			
Pheasant	0/1	---	(0.011 ± 0.015) ^(f)

- (a) Maximum values include the $\pm 2\sigma$ counting error. Averages include the \pm two standard error of the mean (95% confidence level).
- (b) >DL means greater than the detection level, i.e., radionuclide concentration was greater than the associated $\pm 2\sigma$ counting error.
- (c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).
- (d) <DL means less than detection level, i.e., radionuclide concentration was less than the associated $\pm 2\sigma$ counting error.
- (e) Dashed line indicates no value because only one sample was obtained.
- (f) Single sample.

TABLE 12. Cesium-137 Concentrations in Waterfowl Muscle Tissue

Location	Type	Fraction of Samples >DL	Concentration, pCi/g wet weight ^(a)		
			Maximum	Minimum	Average ^(c)
100-N Area					
1301-N Trench	Ducks	1/2	0.020 ± 0.0067	<DL ^(d)	(0.0084 ± 0.029)
200 Areas					
B Pond	Geese	2/2	0.96 ± 0.031	0.83 ± 0.028	0.90 ± 0.16
B Pond	Ducks	6/6	20 ± 0.14	4.3 ± 0.069	11 ± 5.0
Gable Pond	Ducks	20/20	77 ± 0.33	0.15 ± 0.017	21 ± 8.5
300 Area					
Pond	Ducks	4/4	0.76 ± 0.011	0.015 ± 0.014	0.034 ± 0.030

(a) Individual results include the $\pm 2\sigma$ counting error. Averages include the \pm two-standard error of the mean (95% confidence interval).

(b) >DL means greater than the detection level, i.e., radionuclide concentration was greater than the associated $\pm 2\sigma$ counting error.

(c) Parenthesis enclosing an average value indicates the radionuclide was not detectable (see Appendix B).

(d) <DL means less than the detection level, i.e., radionuclide concentration was less than the associated $\pm 2\sigma$ counting error.

Waterfowl samples were collected prior to the normal migration period in order to obtain birds from the local population and thus provide the best indication of the availability of radioactive materials to waterfowl. Gable Mountain Pond is both a favorite onsite refuge for waterfowl and a potential source of contamination. As such, 20 mallard ducks were specially collected from Gable Mountain Pond during September 1983 to provide an estimate of the ^{137}Cs concentration in resident ducks. Fewer samples were collected from the other locations as part of the normal sampling program. Results of the analyses are given in Table 12. Levels of ^{137}Cs in waterfowl were similar to those observed in recent years. The maximum ^{137}Cs concentration was 77 pCi/g, observed in a duck collected from Gable Mountain Pond.

RABBITS

Cottontail rabbits and black-tailed jack rabbits were collected in the vicinity of several onsite operating areas as indicated in Figure 7. The samples were analyzed for gamma-emitting radionuclides in muscle, ^{90}Sr in

bone, and plutonium in liver. Results for ^{90}Sr in bone and ^{137}Cs in muscle are provided in Table 13.

Strontium-90 was detectable in all but one bone sample. One cottontail collected near 100 N and one jack rabbit collected near 200-E Area showed higher levels of ^{90}Sr in bone than the other samples. Neither of these animals showed elevated levels of ^{137}Cs (0.032 ± 0.01 and 0.33 ± 0.031 pCi/g, respectively) in muscle tissue compared to the other samples. The cottontail from 100 N with the highest ^{137}Cs level also contained a moderate level of ^{90}Sr in bone tissue (12 ± 2.8 pCi/g) as well as detectable levels of ^{60}Co ($0.56 \pm .05$ pCi/g) and ^{65}Zn (0.15 ± 0.07 pCi/g) and ^{134}Cs (1.1 ± 0.06 pCi/g). No other gamma-emitting radionuclides of possible Hanford origin were detected in any samples at levels greater than expected from worldwide fallout. Concentrations of $^{239,240}\text{Pu}$ in liver samples ranged from less-than-detectable to a value near the detection limit (0.017 ± 0.0035 pCi/g).

TABLE 13. Radionuclide Concentrations in Rabbits

Location	Type	Concentration, pCi/g wet weight ^(a)			
		Fraction of Results >DL ^(b)	Maximum	Minimum	Average
^{90}Sr (Bone)					
100-N Area	Cottontail	8/8	450 ± 6	0.17 ± 0.05	$(61 \pm 110)^{(c)}$
200-E Area	Jack Rabbit	2/2	120 ± 2	0.97 ± 0.10	(59 ± 150)
200-E Area	Cottontail	1/1	---	---	$1.4 \pm 0.12^{(f)}$
200-W Area	Jack Rabbit	1/2	1.0 ± 0.14	0.81 ± 0.20	(0.93 ± 0.33)
300 Area	Cottontail	2/2	1.0 ± 0.13	0.37 ± 0.12	0.69 ± 0.82
^{137}Cs (Muscle)					
100-N Area	Cottontail	7/8	22 ± 0.24	<DL ^(e)	(2.8 ± 5.5)
200-E Area	Jack Rabbit	2/2	0.33 ± 0.031	0.03 ± 0.02	(0.18 ± 0.38)
200-E Area	Cottontail	1/1	---	---	$0.024 \pm 0.010^{(f)}$
200-W Area	Jack Rabbit	2/2	0.017 ± 0.0088	<DL	0.012 ± 0.0071
300 Area	Cottontail	1/2	0.024 ± 0.011	<DL	(0.026 ± 0.015)

(a) Individual results include the ± 2 counting error. Averages include the \pm two-standard error of the mean (95% confidence interval).

(b) >DL means greater than the detection level, i.e., radionuclide concentrations was greater than the associated $\pm 2\sigma$ counting error.

(c) <DL means less than the detection level, i.e., radionuclide concentration was less than the associated $\pm 2\sigma$ counting error.

(d) Parenthesis enclosing an average indicates the radionuclide was not detected (see Appendix B).

(e) Dashed line indicates no value because only one sample was obtained.

(f) Single sample.

SOIL AND VEGETATION

Soil and vegetation samples were collected to establish the concentrations of naturally occurring and fallout radionuclides and to assess any radionuclide build-up that might be attributable to site operations. Samples were collected from 16 onsite locations during 1983 as shown in Figure 8. Each sample consisted of a composite of five "plugs" of soil collected within a 100-m² area at designated sampling locations. Each plug of soil was 2.5 cm deep and 10 cm in diameter.

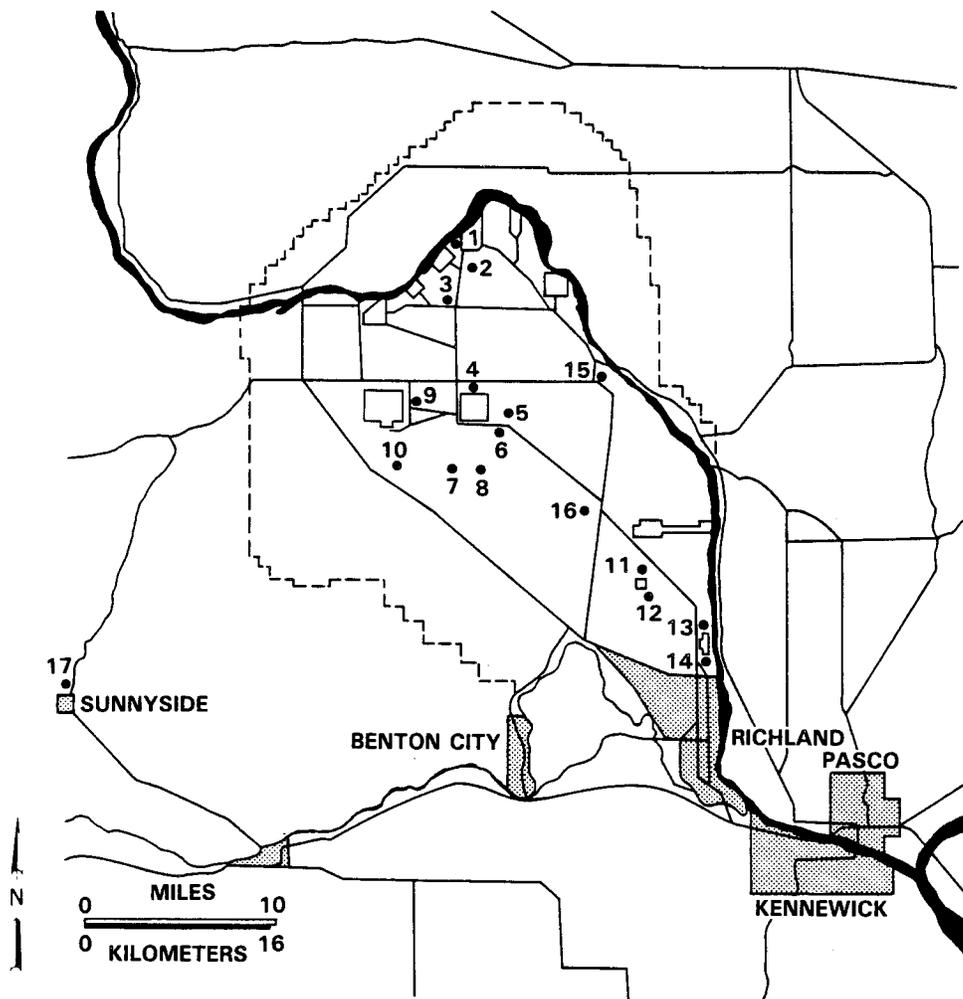


FIGURE 8. Onsite Soil and Vegetation Sampling Locations

Samples of perennial shrubs (rabbitbrush, sagebrush, and bitterbrush) were collected in the immediate vicinity of each soil sample location. Because no one type of perennial vegetation was available at every sampling location, each sample consisted of a mixture of the shrubs present at the sampling location in proportion to their relative abundance. Both the soil and vegetation samples were analyzed for gamma-emitting radionuclides, ^{90}Sr , plutonium, and uranium. Soil samples also were analyzed for ^{241}Am .

Tables 14 and 15 show the radionuclide concentrations observed in onsite soil and vegetation samples collected during 1983. Included for comparison is the result for the offsite location at Sunnyside. Soil and vegetation data at additional offsite locations during 1983 were provided in the offsite environmental report (Price et al. 1984).

Radionuclide concentrations in soil were similar to those reported in previous annual reports with ^{90}Sr , ^{137}Cs , and plutonium continuing to be observed at slightly elevated concentrations in several samples collected near the 200 Areas. Specifically, the 200-ENC sample showed elevated levels of ^{90}Sr and ^{137}Cs concentrations. The E of 200 W sample exhibited elevated levels of ^{90}Sr , ^{137}Cs , and $^{239,240}\text{Pu}$. There were no obvious increasing or decreasing trends in soil radionuclide concentrations as indicated by data collected during the last several years at these two locations.

Concentrations of long-lived radionuclides in vegetation samples (Table 15) were similar to those observed at the respective locations in previous years, and concentrations at onsite locations in 1983 were not significantly different from concentrations observed at offsite locations (Price et al. 1984). Radionuclides reported previously, such as ^{58}Co , ^{60}Co , $^{95}\text{ZrNb}$, ^{134}Cs , ^{144}Ce , ^{154}Eu , ^{238}Pu , and ^{241}Am , were either near detection limits or not detected in all soil and vegetation samples analyzed in 1983.

TABLE 14. Radionuclide Concentrations in Onsite Soils (a)

Sample Location	Map Location (c)	Concentration, pCi/g dry weight (b)				
		⁹⁰ Sr	¹³⁷ Cs	^{239,240} Pu	U-Total	
1 Mile NE of N Area	1	0.70 ± 0.02	0.48 ± 0.04	0.012 ± 0.003	0.39 ± 0.11	
1 Mile E of N Area 82	2	0.85 ± 0.03	0.77 ± 0.05	0.007 ± 0.001	0.28 ± 0.08	
100-Area Fire Station 82	3	1.7 ± 0.03	1.4 ± 0.07	0.002 ± 0.002	0.22 ± 0.06	
200 ENC	4	2.7 ± 0.05	28 ± 0.33	0.051 ± 0.007	0.25 ± 0.07	
E of 200 E 82	5	0.78 ± 0.03	1.3 ± 0.07	0.011 ± 0.002	0.26 ± 0.07	
200 ESE	6	1.3 ± 0.03	0.16 ± 0.03	0.028 ± 0.005	0.20 ± 0.06	
SW of 200-BC Cribs	7	0.38 ± 0.02	0.15 ± 0.03	0.009 ± 0.002	0.18 ± 0.05	
S of 200 E	8	0.79 ± 0.03	0.31 ± 0.04	0.008 ± 0.001	0.28 ± 0.08	
E of 200 W	9	2.6 ± 0.05	5.7 ± 0.15	0.83 ± 0.03	0.53 ± 0.15	
Army Loop Camp	10	0.28 ± 0.02	0.07 ± 0.02	0.001 ± 0.001	0.26 ± 0.08	
NE of FFTF	11	0.52 ± 0.02	0.18 ± 0.03	0.003 ± 0.001	0.25 ± 0.07	
SE of FFTF	12	0.54 ± 0.02	0.20 ± 0.04	0.004 ± 0.002	0.16 ± 0.5	
N of 300 Area	13	0.73 ± 0.02	0.53 ± 0.04	0.013 ± 0.002	0.50 ± 0.15	
S of 300 Area 82	14	1.4 ± 0.04	1.1 ± 0.06	0.022 ± 0.001	0.31 ± 0.08	
Hanford Townsite	15	1.9 ± 0.05	1.0 ± 0.07	0.021 ± 0.004	0.24 ± 0.07	
Wye Barricade	16	0.81 ± 0.03	0.84 ± 0.05	0.017 ± 0.002	0.19 ± 0.05	
Offsite location (Sunnyside)	17	1.6 ± 0.04	1.1 ± 0.06	0.026 ± 0.005	0.20 ± 0.05	

(a) Single samples were obtained at each location.
 (b) Individual results include the $\pm 2\sigma$ counting error.
 (c) Locations are identified in Figure 8.

TABLE 15. Radionuclide Concentrations in Onsite Vegetation (a)

Sample Location	Map Location (c)	Concentration, pCi/g dry weight (b)			U-Total
		⁹⁰ Sr	¹³⁷ Cs	^{239,240} Pu	
1 Mile NE of N Area	1	0.11 ± 0.02	(0.003 ± 0.012)	(0.0 ± 0.0)	0.006 ± 0.003
1 Mile E of N Area	2	0.29 ± 0.02	0.03 ± 0.01	(0.0002 ± 0.0005)	0.007 ± 0.003
100-Area Fire Station	3	0.37 ± 0.02	0.02 ± 0.01	0.032 ± 0.002	0.007 ± 0.003
200 ENC	4	0.63 ± 0.02	0.18 ± 0.01	(0.0003 ± 0.0004)	0.007 ± 0.004
E of 200 E	5	0.91 ± 0.03	0.07 ± 0.01	0.0007 ± 0.0004	0.008 ± 0.003
200 ESE	6	0.91 ± 0.03	0.05 ± 0.01	(0.0005 ± 0.0006)	0.007 ± 0.003
SW of 200-BC Cribs	7	0.53 ± 0.02	0.02 ± 0.01	(0.0002 ± 0.0003)	0.009 ± 0.004
S of 200 E	8	0.34 ± 0.02	0.01 ± 0.01	(0.0002 ± 0.0002)	0.005 ± 0.003
E of 200 W	9	0.47 ± 0.02	0.03 ± 0.01	0.004 ± 0.001	0.011 ± 0.004
Army Loop Camp	10	0.34 ± 0.02	0.03 ± 0.01	0.002 ± 0.001	0.007 ± 0.003
NE of FFTF	11	1.2 ± 0.04	0.02 ± 0.01	(0.0002 ± 0.0003)	0.005 ± 0.003
SE of FFTF	12	1.7 ± 0.04	0.03 ± 0.01	(0.0007 ± 0.0007)	0.010 ± 0.004
N of 300 Area	13	0.93 ± 0.03	(0.010 ± 0.006)	0.0005 ± 0.0004	0.018 ± 0.006
S of 300 Area	14	0.05 ± 0.01	(0.005 ± 0.012)	(0.0001 ± 0.0002)	0.012 ± 0.006
Hanford Townsite	15	0.29 ± 0.02	(0.0111 ± 0.0114)	(0.0007 ± 0.001)	(0.011 ± 0.048)
Wye Barricade	16	0.16 ± 0.01	0.02 ± 0.01	0.003 ± 0.0002	0.008 ± 0.004
Offsite Location (Sunnyside)	17	0.18 ± 0.02	(0.006 ± 0.009)	(0.0003 ± 0.0003)	0.009 ± 0.004

- (a) Single samples were obtained at each location.
 (b) Individual results include the ±2σ counting error.
 (c) Locations are identified in Figure 8.

EXTERNAL RADIATION MEASUREMENTS

Onsite external penetrating radiation was measured at the locations shown in Figure 9. The measurements were made with thermoluminescent dosimeters (TLDs) that consisted of $\text{CaF}_2:\text{Mn}$ chips encased in an opaque plastic capsule with appropriate filtration to flatten their response to low-energy radiations (Fix and Miller 1978). The dosimeters integrated the dose received during the four-week field exposure cycle. The results of measurements taken onsite during 1983 are given in Table 16.

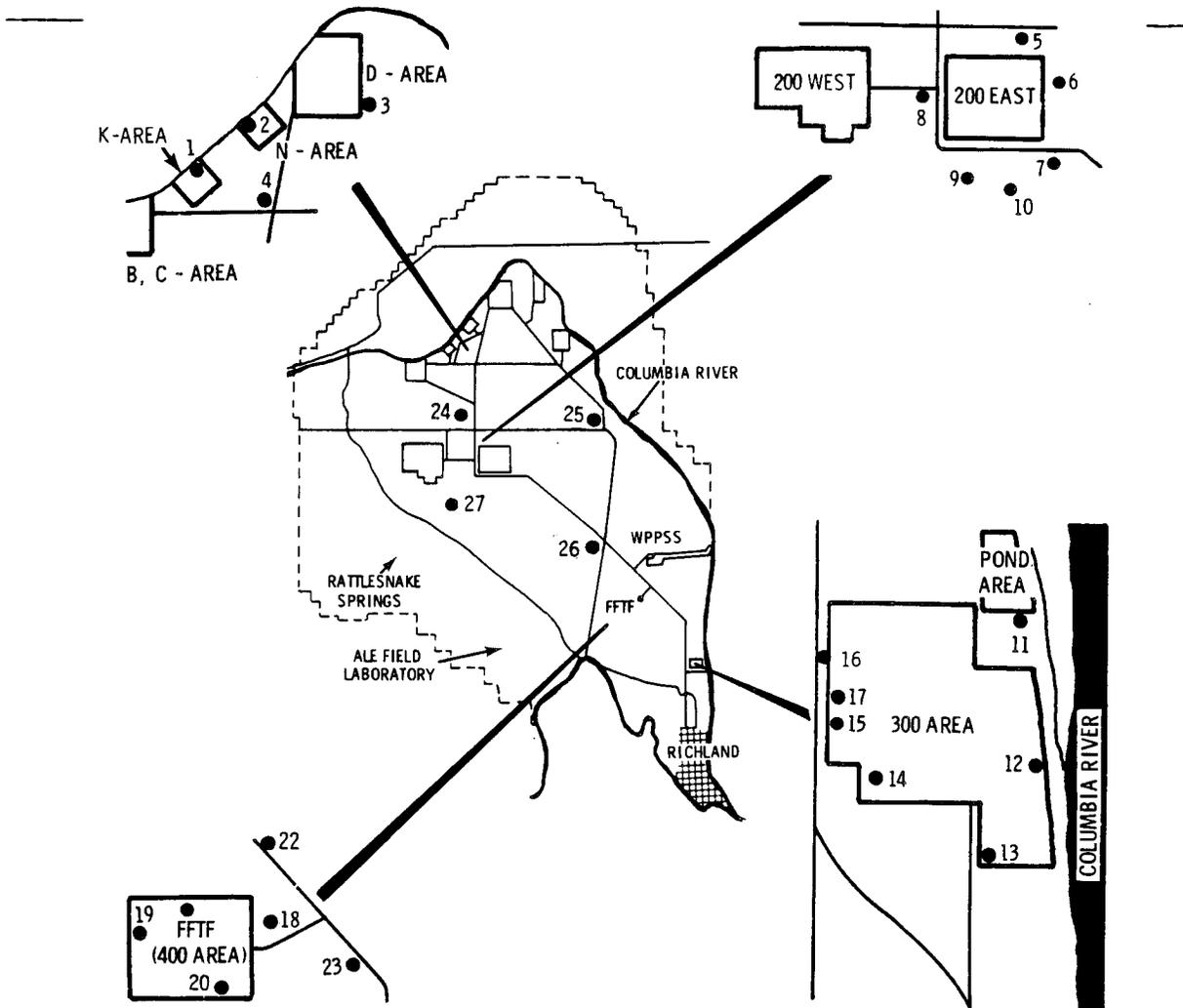


FIGURE 9. Onsite External Penetrating Dose Rate Measurement Locations

TABLE 16. Onsite External Penetrating Dose Measurements

Location	Map Location (b)	No. of Measurements	Dose Rate, mrem/h (a)		
			Maximum	Minimum	Average (c)
<u>100 Area</u>					
100 K	1	13	0.013	0.008	0.008 ± 0.0008
100 N	2	13	0.014	0.008	0.011 ± 0.001
100 N Shoreline (d)					
100-N Trench Springs	2	12	0.046	0.014	0.020 ± 0.005
Below 100-N Main Stack	2	13	0.033	0.015	0.024 ± 0.003
Upstream Tip 100-N Berm	2	13	0.035	0.016	0.025 ± 0.003
Downstream 100-N Outfall	2	13	0.038	0.020	0.025 ± 0.003
100 D	3	13	0.013	0.008	0.009 ± 0.0008
100 Area Fire Station	4	13	0.014	0.008	0.009 ± 0.0008
<u>200 Area</u>					
N of 200 E	5	14	0.010	0.008	0.009 ± 0.0003
E of 200 E	6	9	0.010	0.008	0.009 ± 0.0005
200 ESE	7	14	0.010	0.008	0.009 ± 0.0004
GTE Building	8	14	0.010	0.007	0.008 ± 0.0004
SW of 200-BC Cribs	9	14	0.013	0.008	0.009 ± 0.0007
S of 200 E	10	9	0.010	0.008	0.009 ± 0.0006
<u>300 Area</u>					
300 Pond	11	14	0.010	0.008	0.009 ± 0.0003
3614 A Building	12	14	0.012	0.008	0.008 ± 0.0006
300 S Gate	13	14	0.009	0.008	0.008 ± 0.0003
300 SW Gate	14	14	0.010	0.008	0.008 ± 0.0004
3705 West Fence (d)	15	14	0.016	0.014	0.015 ± 0.0004
377 Building (d)	16	9	0.290	0.250	0.280 ± 0.011
377 Building South Fence (d)	17	4	0.020	0.017	0.019 ± 0.002
<u>400 Area</u>					
400 E (d)	18	13	0.010	0.008	0.008 ± 0.0004
400 W	19	12	0.008	0.007	0.007 ± 0.0003
400 S	20	13	0.011	0.006	0.008 ± 0.0006
400 N	21	13	0.028	0.007	0.013 ± 0.004
FFTF North	22	14	0.011	0.008	0.009 ± 0.0005
FFTF Southeast	23	14	0.009	0.008	0.008 ± 0.0002
<u>600 Area</u>					
Rt. 11A Mi 9	24	10	0.010	0.008	0.008 ± 0.0005
Hanford	25	13	0.013	0.007	0.008 ± 0.0008
Wye Barricade	26	13	0.012	0.008	0.009 ± 0.0006
Army Loop Camp	27	14	0.011	0.008	0.009 ± 0.0005

(a) Monthly integrated readings in mR were converted to hourly rates.

(b) Locations are identified in Figure 9.

(c) Averages include ± two standard error of the mean (95% confidence level).

(d) Also reported in Price et al. 1984 (PNL-5038).

External penetrating radiation measurements above background were observed at several locations near onsite operating areas during 1983. Slightly elevated readings observed at the 100-N location were attributed to short-lived noble gases in airborne effluents and direct radiations during periods of N Reactor operation. Dose rates in the 300 Area were within the range of normal background levels at three locations routinely monitored, but were slightly elevated at three other locations. The highest rates were observed at the 300 Area perimeter fence just west of the steam generator examination facility (Location 17 in Figure 9) where measured dose equivalent rates for 1983 averaged 0.28 mrem/h. Access to this location was permanently restricted in September 1983 and the TLD location moved to the new fence line (Location 16 in Figure 9). Dose rates near the 400 Areas were at normal ambient levels except at 400 N where a temporarily parked railroad tank car increased levels slightly. Dose rates near the 200 Areas were at normal ambient levels during 1983.

RADIATION SURVEYS

Onsite roads, railroads and radioactive waste disposal sites located outside of operating areas were routinely surveyed during 1983 to detect abnormal levels of radioactivity. The frequency of the surveys for specific routes on the roads and railroads was established based on their use and the potential for contamination. The majority of the waste sites were surveyed on a semi-annual basis during 1983. In addition to the above, an aerial survey of the site perimeter was conducted during 1983. Specific routes and frequencies for surveys conducted during 1983 were defined in the surveillance program's master schedule (Blumer et al. 1982)

ROAD SURVEYS

Roads, shown in Figure 10, were surveyed routinely using four scintillation detectors positioned approximately 0.3 m above the ground across the

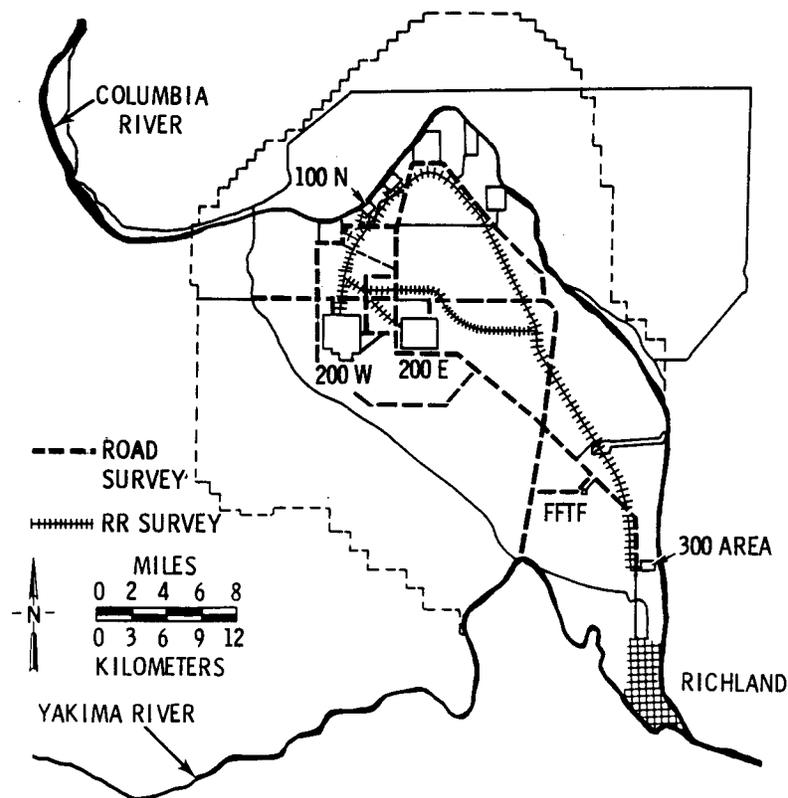


FIGURE 10. Road and Railroad Survey Routes

rear bumper of a vehicle. During 1983, an isolated spot of low-level contamination was identified on the roadway between the 200-East and 200-West Areas. Appropriate personnel were notified and the area was subsequently cleaned up. No other abnormal conditions were observed on the roads during 1983.

RAILROAD SURVEYS

Railroad tracks, also shown in Figure 10, were surveyed using two scintillation detectors mounted approximately 0.3 m directly above the tracks on a small rail car. Three spots of minor contamination near the gate at 100-N Area were detected during a routine survey on August 28, 1983. Appropriate notifications were made concerning the contamination. No other abnormal conditions were observed during railroad surveys conducted in 1983.

AERIAL SURVEY

The perimeter of the site was surveyed using a scintillation detector mounted in an aircraft. The plane was flown approximately 500 ft above the ground at an air speed of 70 to 80 mph. There was no indication of unusual contamination levels observed during the 1983 survey.

WASTE DISPOSAL SITE SURVEYS

Waste disposal sites (active, inactive and retired) outside of operating area perimeter fences were surveyed for changes in levels of radioactivity and visually inspected with respect to general physical conditions. In general, radiation surveys conducted during 1983 showed levels similar to those observed in the past. Two locations where surveys indicated levels higher than those observed in recent years were brought to the attention of the responsible contractor. Subsequent surveys revealed a return to normal levels.

ENVIRONMENTAL RELEASES

The operating contractors at Hanford are responsible for controlling, monitoring, sampling and reporting effluents discharged from their facilities. This section summarizes the planned and unplanned release of effluents at Hanford during 1983 as reported by the appropriate operating contractor. The section is divided into two parts: "Environmental Discharges" and "Environmentally Related Unusual Occurrences."

Information included within the "Environmental Discharges" section was obtained from the following sources:

PNL--Radioactive discharges to the environment during 1983 are contained in the DOE Effluent Information System. Nonradioactive discharges are monitored through the National Pollutant Discharge Elimination System (NPDES).

WHC--Radioactive discharges to the environment during 1983 are contained in the DOE Effluent Information System.

UNC--Radioactive and nonradioactive discharges during 1983 are reported in an annual Effluent Release Report (Rokkan 1984) and in the DOE Effluent Information System.

RHO--Radioactive and nonradioactive discharges during 1983 are reported in several reports which are issued annually (Aldrich 1984a; Aldrich 1984b; Anderson, Poremba and McCann 1984; and Tanner et al. 1984).

The "Environmentally Related Unusual Occurrences" portion of this section includes a compilation of those unusual occurrences during 1983 that involved the unplanned release of radioactive materials to the environment. Formal reporting of the occurrence by the contractor involved is required by DOE. The completed unusual occurrence reports, of which brief summaries are provided here, are maintained in the public reading room of the Hanford Science Center, located in the Federal Building, Richland, Washington.

ENVIRONMENTAL DISCHARGES

The planned release of radioactive and nonradioactive materials to the environment may occur as airborne or liquid effluents or as solid waste.

Airborne Effluents

Radioactive and nonradioactive pollutants discharged to the atmosphere during 1983 are summarized in Tables 17 and 18. The tables are subdivided according to the major operating areas and include all releases reported by contractors in each of the areas. The quantity of each radionuclide as well as the kinds of radionuclides reported in effluent streams are subject to revision by the operating contractor as additional information becomes available. The quantities of ^3H and ^{14}C released from the 200 Areas were revised (lowered) after the offsite annual report (Price et al. 1984) was distributed. Moreover, ^{129}I was reported as an additional radionuclide released from the 200 Areas. These revised and new values (as of July 1, 1984) are included in Table 17. Subsequent to the receipt of revised data, the offsite dose was recalculated with the new data and indicated no substantive change to the hypothetically exposed maximum individual, however, a new population thyroid dose of 17 person-rem (seven person-rem reported in Price et al. 1984) was estimated.

Radioactive materials discharged to the atmosphere consisted of fission and activation products normally associated with Hanford operations as well as releases from PUREX activities following restart in November. Nonradioactive airborne releases consisted primarily of emissions from fossil-fueled steam plants; oxides of nitrogen from fuel fabrication, waste handling facilities, and PUREX activities; and organic liquids evaporated from laboratory facilities.

Liquid Effluents

Liquid wastes generated at Hanford are placed in storage facilities, converted to solids, or discharged either to ground disposal facilities (cribs, trenches, ponds, etc.) or to the Columbia River.

TABLE 17. Radionuclide Discharges to the Atmosphere

Radionuclide	Half-Life	Release, Ci ^(a)			
		Airborne			
		100 Area	200 Area	300 Area	400 Area
³ H (HTO)	12.3 yr	9.9	46 ^(b)		
¹⁴ C	5730 yr		0.6 ^(b)		
²⁴ Na	15.0 h	0.017			
⁴¹ Ar	1.8 h	1.2 X 10 ⁵			
⁵⁴ Mn	303 d	0.0031			
⁵⁶ Mn	2.6 h	0.15			
⁵⁹ Fe	46.0 d	0.0033			
⁵⁸ Co	71.0 d	0.0013			
⁶⁰ Co	5.3 yr	0.0063		3.2 X 10 ^{-6(c)}	
⁷⁶ As	26.4 h	1.0			
^{85m} Kr	4.4 h	170			
⁸⁵ Kr	10.7 yr		17,600		220
⁸⁷ Kr	76.0 min	430			
⁸⁸ KrRb	2.8 h	670			
⁸⁹ Sr	52.7 d	0.0010			
⁹⁰ Sr	27.7 yr	0.0007	0.003	4.0 X 10 ^{-5(d)}	1.7 X 10 ⁻⁵
⁹¹ Sr	9.7 h	0.024			
⁹⁵ Nb	35.0 d	8.0 X 10 ⁻⁴			
^{99m} MoTc	66.7 h	0.059			
¹⁰³ Ru	39.5 d	0.0017			
¹⁰⁶ Ru	368 d	3.0 X 10 ⁻⁴			
¹²⁹ I	1.6 X 10 ⁷ yr		0.02 ^(b)		
¹³¹ I	8.1 d	0.34		3.4 X 10 ⁻⁴	7.0 X 10 ⁻⁶
¹³² I	2.3 h	0.54			
¹³³ I	20.3 h	0.72			
¹³⁵ I	6.7 h	0.88			
¹³³ Xe	5.3 d	11			
¹³⁴ Cs	2.1 y	1.4 X 10 ⁻⁵			
¹³⁵ Xe	9.1 h	820			
¹³⁷ Cs	30.0 yr	9.6 X 10 ⁻⁴	0.029		
¹³⁸ Cs	32.2 min	540			
¹⁴⁰ BaLa	12.8 d	0.028			
¹⁴⁴ CePr	284 d	0.0055			
¹⁵⁵ Eu	1.8 yr	4.2 X 10 ⁻⁵			
U-nat	4.4 X 10 ⁹ yr		1.5 X 10 ⁻⁶	2.1 X 10 ⁻⁴	
²³⁸ Pu	86.4 yr	2.9 X 10 ⁻⁶			
^{239,240} Pu	2.4 X 10 ⁴ yr	2.2 X 10 ⁻⁵	6.2 X 10 ^{-4(e)}	1.8 X 10 ⁻⁵	3.5 X 10 ⁻⁶
²⁴⁴ Cm	18.1 yr			9.9 X 10 ⁻⁸	

(a) Values are those reported by operating contractors.

(b) Reported in PNL-5038 as: 180 Ci³H; 1.2 Ci ¹⁴C; ¹²⁹I not reported.

(c) Reported as mixed activation products.

(d) 3.3 X 10⁻⁵ Ci reported as ⁹⁰Sr. 1.3 X 10⁻⁵ Ci reported as mixed-fission products.

(e) Composed of Pu and unidentified alpha considered to be ^{239,240}Pu for reporting purposes.

TABLE 18. Nonradioactive Discharges to the Atmosphere

Constituent	Release, kg ^(a)			
	100 Area	200 Area ^(b)	300 Area	1100 Area
Particulates	5.2×10^4	$2.4 \times 10^{5(c)}$	1.8×10^4	3.0×10^3
Nitrogen oxides	1.9×10^5	7.1×10^5	2.1×10^5	6.9×10^3
Sulfur oxides	6.0×10^5	8.8×10^5	3.1×10^5	4.2×10^3
Carbon monoxide	9.3×10^3	6.7×10^4		1.0×10^1
Hydrocarbons	7.0×10^3	3.3×10^4		3.0×10^2
Aldehydes	2.5×10^3			
Perchloroethylene			$2.0 \times 10^{4(d)}$	
1,1,1,-Trichloroethane			$1.4 \times 10^{3(d)}$	

(a) Values are those reported by operating contractors.

(b) Assume emission control is 95% efficient during time of operation based on compliance testing.

(c) Fly ash.

(d) Reported as quantity placed in an evaporation lugger.

Radioactive and nonradioactive liquid wastes discharged to the ground during 1983 are shown in Tables 19 and 20, respectively. The quantities listed are totals for all ground disposal facilities within operating areas.

Radioactive liquids discharged to the Columbia River from operating facilities during 1983 are listed in Table 21. The reported discharges are for liquid effluent systems in the 100 Areas, including seepage into the Columbia River from the 1301-N crib and trench system at 100-N Area. Not included in Table 21 are the quantities of ^3H and ^{129}I that entered the Columbia River via the unconfined Hanford aquifer (Prater et al. 1984). Comparison of radionuclide concentrations in the river upstream and downstream of the site did not show a statistically significant increase in tritium levels attributable to this source. The tritium contribution from the aquifer during 1983 was too small to be accurately measured in the presence of relatively high background concentrations in the Columbia River (Price et al. 1984).

TABLE 19. Radionuclide Liquid Discharges to Ground Disposal Facilities

Radionuclide	Half-Life	Release, Ci ^(a)		
		100 Areas	200 Areas	300 Area
³ H	12.3 yr	180	60	
²⁴ Na	15.0 h	0.13		
³² P	14.3 d	93		
⁵¹ Cr	17.8 d	110		
⁵⁴ Mn	303 d	650		
⁵⁹ Fe	46.0 d	580		
⁵⁸ Co	71.0 d	48		
⁶⁰ Co	5.3 yr	770	0.7	
⁶⁵ Zn	245 d	12		
⁸⁹ Sr	52.7 d	230		
⁹⁰ Sr	27.7 yr	110	19	
⁹⁵ ZrNb	65.5 d	410		
⁹⁹ Tc	2.1 X 10 ⁵ yr			0.71
^{99m} MoTc	66.7 h	420		
¹⁰³ Ru	39.5 d	60		
¹⁰⁶ Ru	368 d	65	<0.005	
¹²⁴ Sb	60 d	7.9		
¹³¹ I	8.1 d	140		
¹³³ I	20.3 h	0.14		
¹³³ Xe	5.3 d	210		
¹³⁴ Cs	2.1 yr	14		
¹³⁷ Cs	30.0 yr	200	19	
¹⁴⁰ BaLa	12.8 d	2600		
¹⁴¹ Ce	33 d	97		
¹⁴⁴ CePr	284 d	240		
¹⁵³ Sm	47 h	25		
¹⁸⁷ W	23.9 h	180		
Unidentified beta			62	0.30
Short-lived radionuclides ^(b)		12,000		
²³⁴ U	2.5 X 10 ⁵ yr			0.27
²³⁵ U	7.1 X 10 ⁸ yr			0.014
²³⁶ U	2.4 X 10 ⁷ yr			0.024
²³⁸ U	4.5 X 10 ⁹ yr			0.21
²⁴¹ Am	458 yr		<0.29	
²³⁸ Pu	86.4 yr	0.30		
^{239,240} Pu	2.4 X 10 ⁴ yr	2.0		
Pu (Total)			0.31	

(a) Values are those reported by operating contractors.

(b) Short-lived radionuclides T_{1/2} < 48h.

TABLE 20. Nonradioactive Liquid Discharges to Ground Disposal Facilities

Constituent	Release, kg (except as noted) ^(a)		
	100 Area ^(b)	200 Area	300 Area
Aluminum sulfate	2.0×10^5		
Chlorine	1.5×10^4		
Polyacrylamide	6.4×10^2		
Sulfuric acid	4.9×10^5		
Ammonium hydroxide	1.6×10^5 &		
Hydrazine	5.0×10^3		
Morpholine	1.4×10^3		
Sodium hydroxide	1.9×10^5		
Nonradioactive effluents		1.8×10^6 m ^{3(c)}	
Zn			910
Hg			0.45
NO ₃ ⁻			1.3×10^5
Pb			16
Cd			5.4
Cu			860
F ⁻			3.5×10^3
Cr			41

(a) Values are those reported by operating contractors.

(b) Reported as quantity consumed.

(c) Includes water treatment backwash, powerhouse cooling water, ash sluicing water, steam condensates, sewage, septic sludge.

TABLE 21. Radionuclide Liquid Discharges to the Columbia River

Radionuclide	Half-Life	Release, Ci ^(a)
³ H (HTO)	12.3 yr	180
²⁴ Na	15.0 h	0.13
³² P	14.3 d	0.023
⁵¹ Cr	27.8 d	0.17
⁵⁴ Mn	303 d	0.58
⁵⁹ Fe	46.0 d	0.61
⁵⁸ Co	71.0 d	0.11
⁶⁰ Co	5.3 yr	1.8
⁸⁹ Sr	52.7 d	1.0
⁹⁰ Sr	27.7 yr	4.0
⁹⁵ ZrNb	65.5 d	0.42
^{99m} MoTc	66.7 h	0.26
¹⁰³ Ru	39.5 d	0.21
¹⁰⁶ Ru	368 d	0.22
¹²⁴ Sb	60 d	0.063
¹²⁵ Sb	2.7 yr	0.19
¹³¹ I	8.1 d	1.3
¹³³ I	20.3 h	0.14
¹³³ Xe	5.3 d	0.91
¹³⁷ Cs	30.0 yr	0.13
¹⁴⁰ BaLa	12.8 d	1.1
¹⁴¹ Ce	33 d	0.020
¹⁴⁴ CePr	284 d	0.084
²³⁸ Pu	86.4 yr	1.3 X 10 ⁻⁴
^{239,240} Pu	2.4 X 10 ⁴ yr	1.8 X 10 ⁻⁴

(a) Values are those reported by operating contractors.

Nonradioactive liquid effluents discharged to the Columbia River are monitored in compliance with limits given in the NPDES permits. Monitoring required by the permits includes flow, temperature, pH, suspended and settleable solids, chlorine, ammonia, chromium, iron, heat discharge, and oil and grease as appropriate for each specific discharge point. Chemical pollutants reported discharged in small quantities to the river during 1983 included aluminum sulfate, hydrazine, and morpholine (Rokkan 1984).

Solid Wastes

Radioactive solid wastes are buried in trenches or special facilities within the 200 Areas. Radioactive materials in solid wastes include fission and activation products, uranium, and solid transuranics. Solid wastes containing ^{233}U or transuranics are packaged and buried separately from the non-transuranic wastes for possible retrieval at a future date. Table 22 lists the quantities of radionuclides contained in solid waste burials during 1983 (Anderson, Poremba and McCann 1984).

Nonradioactive solid wastes include general refuse, asbestos and waste chemicals that are buried in a sanitary landfill near the 200 Areas. The quantities buried during 1983 are listed in Table 22.

ENVIRONMENTALLY-RELATED UNUSUAL OCCURRENCES

Several unusual occurrences were reported by onsite operating contractors during 1983. Some of these involved the release of radioactive or nonradioactive pollutants to the environment. There were no permanent adverse environmental impacts reported as a result of the releases. The brief summaries of the occurrences provided here are based on information contained in the formal unusual occurrence reports. The formal reports, including the event description and corrective actions taken, were issued by the responsible contractor and are available for review in the public reading room located at the Hanford Science Center.

TABLE 22. Composition of Solid Wastes Buried Onsite

<u>Constituent</u>	<u>Quantities</u> ^(a)
<u>Radioactive</u>	
Uranium	1.8 X 10 ⁷ g
Plutonium	1.5 X 10 ⁴ g
Other transuranics and thorium	7.6 X 10 ⁴ g
Strontium-90	1.2 X 10 ⁵ Ci
Ruthenium-106	1.6 X 10 ³ Ci
Cesium-137	2.9 X 10 ⁵ Ci
Other fission and activation products	2.7 X 10 ⁴ Ci
<u>Nonradioactive</u>	
General wastes	2.7 X 10 ⁴ m ³
Asbestos	3.1 X 10 ² m ³
Waste chemicals	1.5 X 10 ² m ³

(a) Values are those reported by the operating contractors.

January 18, 1983; UNC Occurrence Report No. 83-15

The smoke opacity standard was exceeded on the 184-N boiler stack on January 18, 1983. Ignitor firing testing, which requires 30 to 40 minutes to complete, resulted in the time limit allowed for greater than 20 percent opacity to be exceeded. No adverse environmental impact was observed as a result of this event.

January 22, 1983; Rockwell Occurrence Report No. 83-01

A leak was discovered in the PUREX chemical sewer line during construction activities on the 241-AP Tank Farm. Subsequent investigation revealed the corrosive leakage had created a hole in the nearby PUREX cooling water line causing additional water leakage. The leakage in the chemical sewer was assumed to have been long term and caused by the failure of old vitrified clay pipe (VCP) joints. New designs for VCP installation minimize

the chance of a recurrence of this type of problem. The plans for the 241-AP Tank Farm called for the rerouting of the chemical sewer line and the relocation of the cooling water line out of this area. Both portions of the project have been completed and the failed areas were taken out of service. No adverse environmental impacts were observed due to this incident.

February 22, 1983; Rockwell Occurrence Report No. 83-07

Flooding in C-Cell at the 224-U Building was discovered on February 22, 1983. The water backed up outside the building into an area between the 272-U shop buildings and 224-U. The affected area extended beyond the existing radiation area. The area was immediately roped off and subsequently decontaminated. A new procedure was established for routine monitoring at the UO₃ Plant to provide for the timely detection of off-normal conditions and assure that proper notifications are made. No adverse environmental impact was caused by this event.

June 13, 1983; Rockwell Occurrence Report No. 83-13

Recovered nitric acid inadvertently contaminated a process tank and overflowed into the chemical sewer effluent line at the PUREX plant. A valve was inadvertently left open allowing the cross contamination and the overflow to occur. An estimated 2,600 gallons were discharged to the chemical sewer. Subsequent sampling and analysis revealed that the effluent never exceeded appropriate discharge limits. Proper lock and tag control procedures were implemented to preclude a recurrence of this incident. No adverse environmental impact resulted from this event.

June 15, 1983; Rockwell Occurrence Report No. 83-14

The required volume for the chemical sewer effluent sample was not collected during the period June 11 through June 15, 1983. This violated internal operating procedures and constituted an unusual event. A leak in the system was discovered and repaired. A backup system was also installed to preclude similar occurrences. No adverse environmental impact was observed due to this occurrence.

August 8, 1983; UNC Occurrence Report No. 83-11

Personnel working on spent fuel shipping casks at 100-K Area which were believed to be uncontaminated, but were in fact contaminated, unknowingly spread contamination during the period of August 5 through August 8, 1983. All areas affected were secured, cleaned up and released. Several work practice deficiencies were identified and corrective actions were taken. No permanent adverse environmental impact was observed due to this occurrence.

August 24, 1983; UNC Occurrence Report No. 83-12

An estimated 100 gallons of diluted nitric and sulfuric acid and 54 pounds of 0.95% ²³⁵U overflowed to the process sewer in the 300 Area on August 3, 1983. On August 4, 1983 nitric acid again was inadvertently spilled into the process sewer while an acid supply tank was filled for normal operations. On August 18, 1983, nitric acid again overflowed spilling a small amount into the process sewer. Several modifications, both physical and administrative, were made to prevent a recurrence. All spills entered the controlled process sewer and all discharges from the sewer were found to be in compliance with applicable limits. A special investigation determined there was no detrimental environmental effect from the spills.

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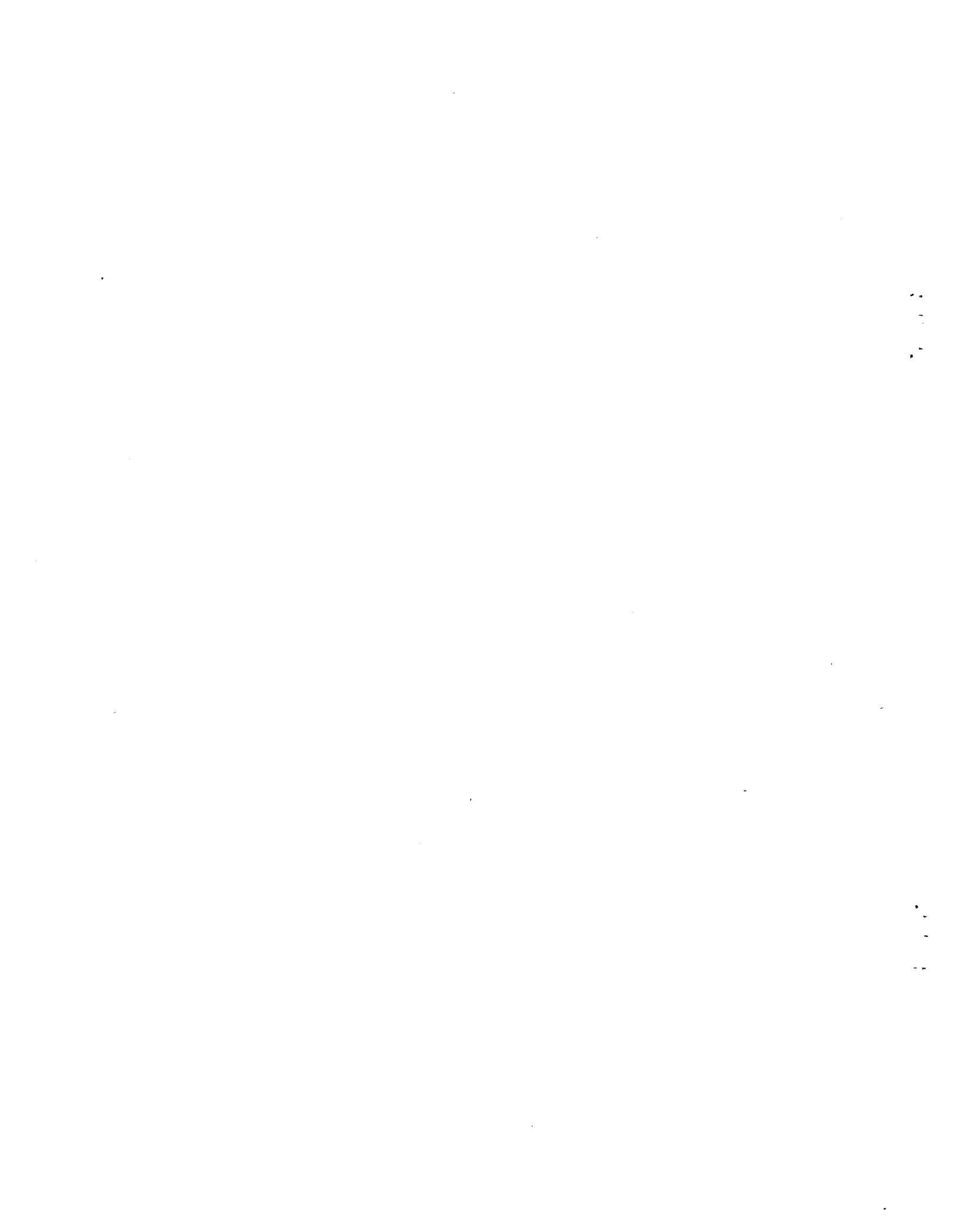
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APPENDIX A

ANALYTICAL PROCEDURES



APPENDIX A

ANALYTICAL PROCEDURES

RADIOLOGICAL SAMPLES

All routine environmental surveillance samples are analyzed according to detailed, written analytical procedures that are described in general terms below. Minimum detectable concentrations for the various medium/analysis combinations are shown in Table A.1.

Air Samples

Alpha-, Beta-, and Gamma-Emitting Radionuclides are measured by a direct count of the glass fiber filter; alpha on a low-background gas flow proportional counter, beta on a gas flow proportional counter, and gamma on a Ge(Li) detector with a multichannel pulse height analyzer.

Strontium-90 is determined by leaching the glass fiber filters with nitric acid, scavenging with

barium chromate, precipitating as a carbonate, transferring to a stainless steel planchet, and counting with a low-background gas flow proportional counter.

Uranium is leached from the glass fiber filters with nitric acid and extracted as tetrapropyl ammonium uranyl trinitrate followed by back extraction into water. A portion of the water extract is fused with sodium and lithium fluoride and analyzed with a fluorometer.

Plutonium is leached from the glass fiber filters with fuming nitric acid and passed through an anion exchange resin. The plutonium on the resin column is eluted with nitric and hydrofluoric acids electrodeposited on a stainless steel disk, and then counted with an alpha spectrometer.

Tritium in air as HTO is determined by collecting the water vapor with silica gel. The water vapor is

TABLE A.1. Minimum Detectable Concentrations (MDC)^(a)

Radionuclide	Air		Water		Water (Resin Sampler)		Foodstuff & Wildlife		Soil & Vegetation	
	Minimum Sample Size, m ³	MDC, pCi/m ³	Minimum Sample Size, l	MDC, pCi/l	Minimum Sample Size, l	MDC, pCi/l	Minimum Sample Size, kg	MDC, pCi/kg	Minimum Sample Size, kg	MDC, pCi/kg
³ H (river)	--- ^(b)	---	1	50	---	---	---	---	---	---
³ H (other)	5(ml)	300 (pCi/l)	0.1	300	---	---	0.01 ^(c)	300	---	---
⁸⁹ Sr	---	---	10	0.6	---	---	4	2	---	---
⁹⁰ Sr	1500	0.001	10	0.06	---	---	4	2	0.5	5
¹²⁹ I	---	---	---	---	1000	0.000001	4	0.0001	---	---
¹³¹ I	1500	0.01	2	1	1000	0.1	4	0.5	---	---
U-nat	1500	0.005	0.1	0.5	---	---	---	---	0.5	10
²³⁸ Pu	---	---	---	---	1000	0.01	---	---	---	---
^{239,240} Pu	1500	0.0001	---	---	1000	0.01	---	---	0.5	0.6
Gamma-Emitters ^(d)	1500	0.01	5	8	1000	0.1	4	10	0.5	20 soil, 30 vegeta- tion
Gross Alpha	800	0.001	1	4	---	---	---	---	---	---
Gross Beta	800	0.003	1	8	---	---	---	---	---	---

(a) Contractually established MDC based on the minimum sample size shown. Lower MDCs are usually obtained.

(b) Dashed line indicates no value.

(c) Measurement on 10 ml water from sample.

(d) Based on ¹³⁷Cs minimum detectable concentration. When present individually, other gamma emitting radionuclides will have a MDC commensurate with their photon yield and energy as related to ¹³⁷Cs.

removed by heat and vacuum and collected in a freeze trap. The tritium content of the water vapor is determined with a liquid scintillation spectrometer.

Iodine-131 is collected on activated charcoal which is then counted on a Ge(Li) detector with a multichannel pulse height analyzer.

Carbon-14 is collected as carbon dioxide gas trapped in soda lime. The carbon dioxide is released from the soda lime sample with acid and injected into a "Benzene Synthesizer" instrument. The carbon dioxide is quantitatively converted to benzene through a series of catalyzed reactions. The benzene product is mixed with scintillator fluid and counted on a low temperature liquid scintillation counter.

Krypton-85 is removed from the air sample and purified using a specially constructed cryogenic chromatography instrument. The sample is passed through a series of cold traps. The purified krypton is mixed with scintillation fluid and counted on a low temperature liquid scintillation counter.

Water Samples

Beta-Emitting Radionuclides are measured by a direct count of dried residue with a gas flow proportional counter.

Alpha-Emitting Radionuclides (Uranium and Plutonium) are extracted into ether from strong nitric acid. The ether phase is evaporated. The residue is plated on a stainless steel planchet and counted with a low-background gas flow proportional counter.

Gamma-Emitting Radionuclides are determined by a direct count of 500 ml of sample concentrate using a Ge(Li) detector with a multichannel pulse height analyzer.

Strontium-90 in large-volume water samples is precipitated with fuming nitric acid, scavenged with barium chromate, precipitated as a carbonate, transferred to a stainless steel planchet, and counted with a low-background gas flow proportional counter. After a 15-day period the yttrium-90 daughter is separated and then counted with a proportional counter.

Tritium samples are either counted directly with a liquid scintillation spectrometer or the sample

is enriched by alkaline electrolysis and then counted with a liquid scintillation spectrometer.

Filter-Resin Samples are analyzed for gamma-emitting radionuclides using a Ge(Li) detector with a multichannel gamma-ray spectrometer. Aliquots of the samples are analyzed by neutron activation analysis for ¹²⁹I and by chemical separation and alpha spectrometry for plutonium.

Milk

Gamma-Emitting Radionuclides are measured by a direct count of the sample on a Ge(Li) detector with a multichannel pulse height analyzer.

Tritium in water distilled from milk is counted directly with a liquid scintillation spectrometer.

Iodine-129 is separated from milk with an anion exchange resin, purified, and analyzed by the neutron activation method.

Iodine-131 is removed from milk with an anion exchange resin. The iodine is eluted with sodium hypochlorite, precipitated as palladium iodide and beta-counted with a low-background gas flow proportional counter.

Strontium-89,90 is removed from milk with a cation resin, eluted with sodium chloride, precipitated as a carbonate, and transferred to a stainless steel planchet for counting with a low-background gas flow proportional counter.

Foodstuffs

Gamma-Emitting Radionuclides are determined by a direct count of the sample on a Ge(Li) detector with a multichannel pulse height analyzer.

Tritium in water distilled from farm produce is counted directly with a liquid scintillation spectrometer.

Plutonium is determined as in air filter samples after drying, ashing in a furnace, and treating with nitric acid prior to the anion exchange step.

Uranium is determined as in water samples after drying, ashing in a furnace, and treating with nitric acid prior to the ether extraction step.

Strontium-90 is determined as in air samples after drying, ashing in a furnace, and treating with nitric acid prior to the fuming nitric acid step.

Vegetation and Wildlife

Uranium, Plutonium, Strontium, and Gamma-Emitting Radionuclides are determined using the procedures described for farm produce.

Soil

Gamma-Emitting Radionuclides are analyzed by placing the sample into a marinelli beaker and counting on a Ge(Li) detector with a multi-channel pulse height analyzer.

Plutonium and Strontium-89,90 are determined after the soil is dried, mixed thoroughly, leached with nitric acids, and then precipitated as strontium oxalate. The sample is then precipitated as a carbonate, transferred to a planchet and counted as with water samples.

After removal of strontium from the sample, plutonium is co-precipitated with calcium oxalate, dissolved and loaded onto an ion exchange resin column.

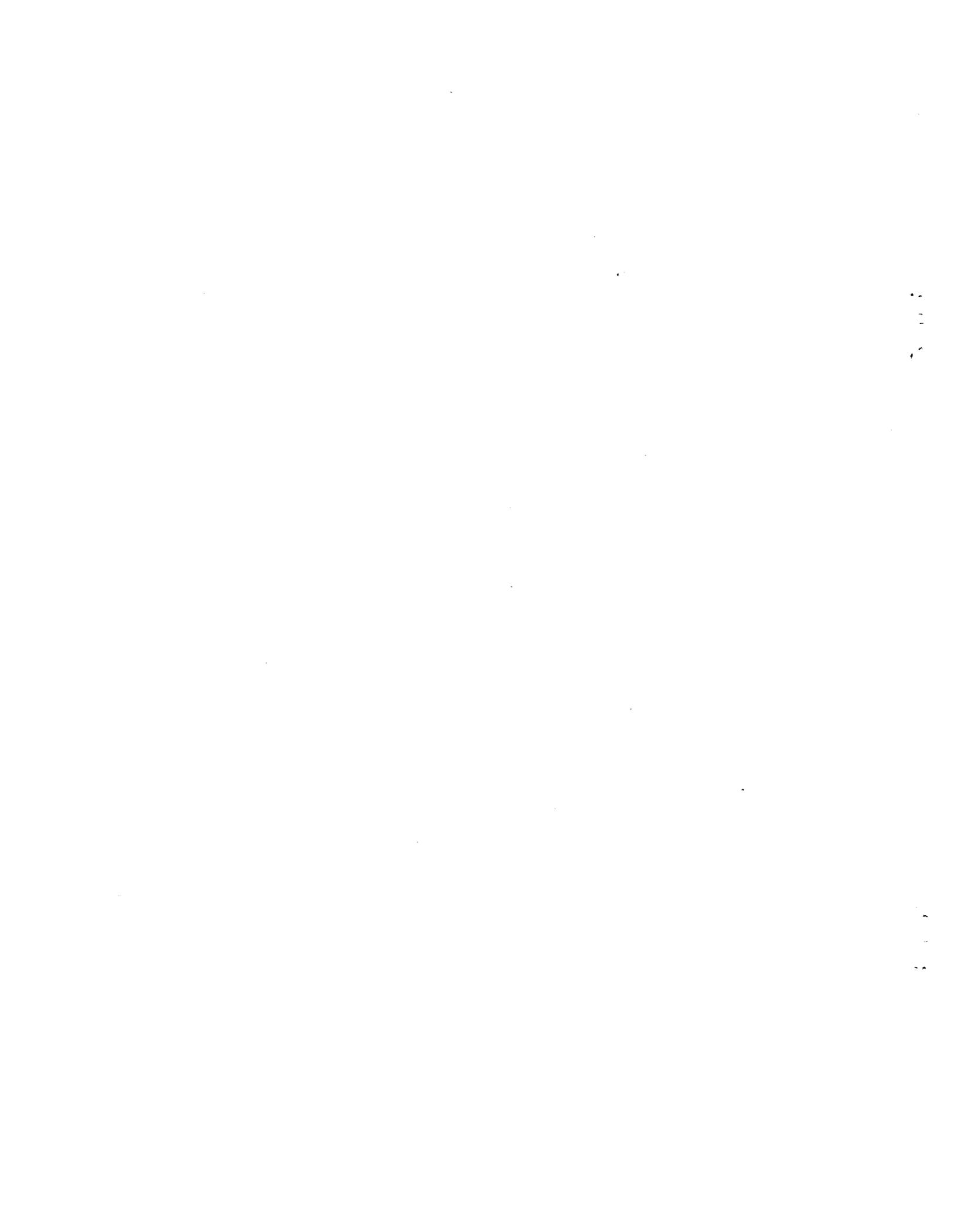
The plutonium is eluted from the resin column with nitric and hydrofluoric acids and analyzed

by a method similar to the procedure described for air filter samples.

Uranium analysis is conducted after the sample is dried, ashed in a furnace, and leached with hot nitric acid. Uranium is extracted from the acid leachate as tetrapropyl ammonium uranyl trinitrate and then extracted back into water. A portion of the water extract is fused with sodium and lithium fluoride and analyzed with a fluorometer.

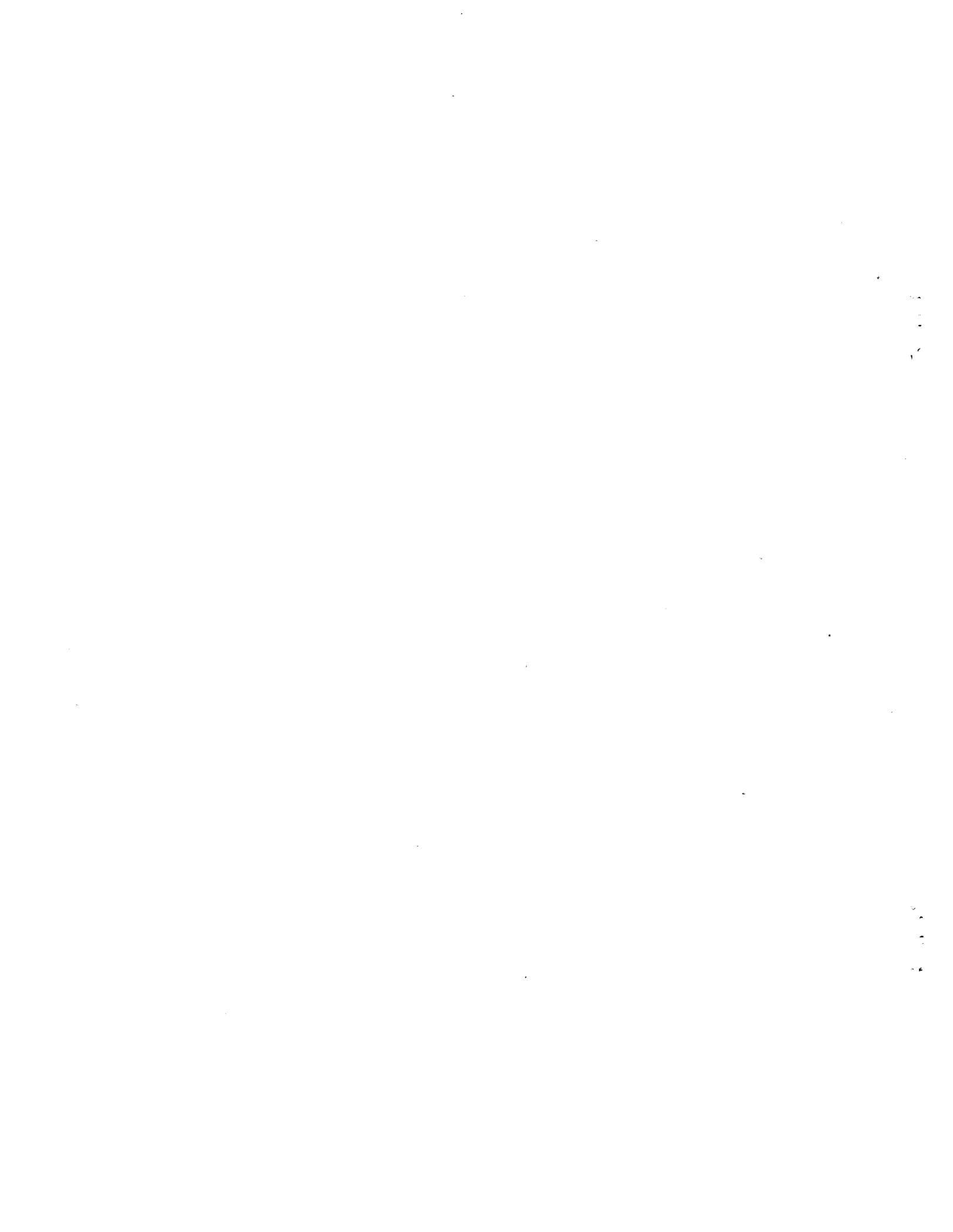
NONRADIOLOGICAL SAMPLES

Water samples collected to monitor water quality of the Columbia River are analyzed according to standard methods. The most applicable methods recommended by the American Public Health Association in their publication *Standard Methods for the Examination of Water and Wastewater (APHA 1975)* are used for most onsite analyses. Supplemental USGS samples are analyzed according to approved USGS standard methods.



APPENDIX B

DATA ANALYSIS



APPENDIX B

DATA ANALYSIS

The measurement of any physical quantity, be it temperature, distance, time, or radioactivity has some degree of inherent uncertainty associated with the final result. The uncertainty results from the combination of all possible inaccuracies in the measurement process including, for example, the reading of the result, the calibration of the measurement device, numerical rounding errors, etc. In this report, individual radioactivity measurements are accompanied by a plus or minus (\pm) analytical uncertainty term. This term represents the statistical counting error (two-standard deviations) associated with the measurement of the radioactivity in the sample. Reported means also include an uncertainty term. The term used to express the uncertainty associated with the mean is the two-standard error of the mean (95% confidence interval) and includes consideration of the uncertainty of the individual results as well as their variability with respect to each other.

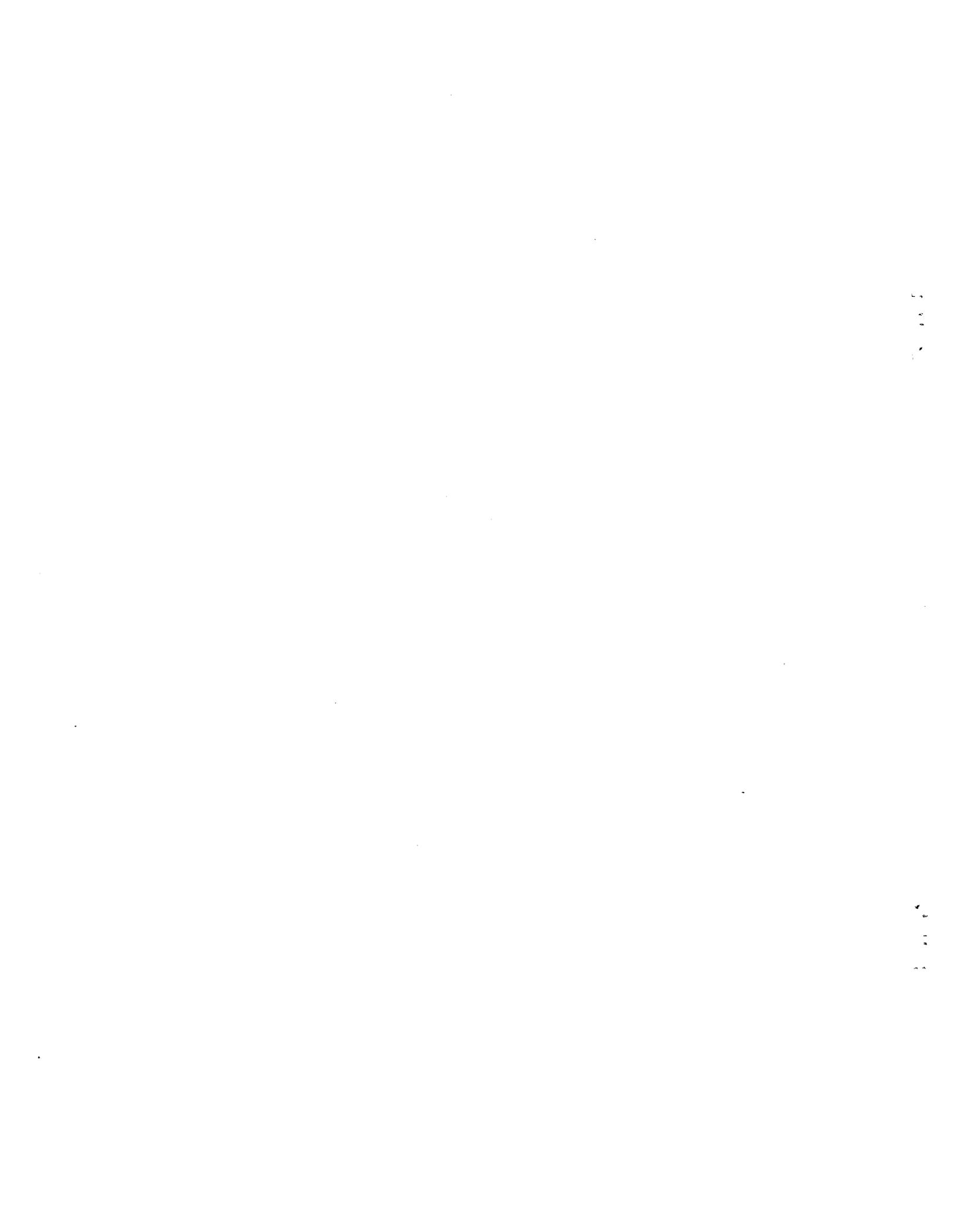
Maximum and minimum values are also included in most data tables. These are shown numerically only if the result was greater than the associated uncertainty level. To report maximum or minimum results in which the radionuclide was not identified in the sample would not be appropriate.

Radionuclide concentrations in many environmental type samples are very low, near zero, such that the uncertainty associated with the measurement is large relative to the result of the measurement. Concentrations may, in fact, be so low that the associated analytical uncertainty

is equal to or greater than the reported result. In such cases, the radionuclide concentration was too low to be measured given the analytical technique used, and individual results are reported as being "less than detectable" (<DL). Although results which are less than their associated analytical uncertainty do not represent a physically real quantity in themselves, it is nevertheless appropriate to use the values when calculating the mean (i.e., average) of a set of similarly analyzed samples. Mean concentrations reported in this document therefore are calculated using all reported analytical results including those less than their associated analytical uncertainty.

As an aid to the reader in understanding the quality of such calculated means, the mean value and its two-standard error term are enclosed within parenthesis if a) fewer than three-fourths of the individual results used in the calculation were greater than their analytical uncertainty term (i.e., positively identified), b) the calculated mean was less than its calculated two-standard error term, or c) the mean was calculated to be a negative value. Generally, the use of parenthesis indicates that the concentrations measured in the sample were essentially indistinguishable from zero considering the analytical technique used. The term following the \pm sign provides an indication of the minimum concentration the analytical technique used is capable of achieving under the given circumstances.

Footnotes to the tables further explain the data presented.



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