
Environmental Status of the Hanford Site for CY 1981

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August 1982

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FOREWORD

Environmental surveillance at the Hanford Site involves measuring a variety of environmental media for potential radioactive contaminants. The results of these measurements are used for assessing the environmental impact of site operations, for demonstrating compliance with applicable regulations, and for verifying 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, regulatory limits and provides an assessment of the impact of site operations on the environment in terms of radiation dose. The 1981 report was issued in May 1982.

The second report, Radiological Status of the Ground Water Beneath the Hanford Site, summarizes and evaluates the concentrations and distribution of radioactive and other chemical constituents in the ground water beneath the Hanford Site and discusses their potential environmental impact. The 1981 report was issued in April 1982.

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 1981 as reported for the various operating areas.

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. The samples were analyzed for radioactive constituents including tritium, strontium-90, plutonium, and gamma-emitting radionuclides. In addition, site roads, railroad tracks, and burial grounds were surveyed periodically to detect any abnormal 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 1981 are:

- General levels of airborne particulate radioactivity in the Hanford environs were greater in 1981 than in recent years as a result of fallout from a foreign atmospheric nuclear test conducted in late 1980. Levels of radioactivity in airborne particulates began decreasing during the summer and by the end of the year had returned to levels observed prior to the test.
- Airborne strontium-90, plutonium, and tritium concentrations at the onsite sampling stations were not significantly different from background measurements. Radioiodine was not identified in any air sample during 1981.
- Strontium-90 and cesium-137 concentrations in B-Pond water were lower compared to levels observed during 1980.
- Analyses of tissue samples from several types of wildlife collected onsite continue to indicate that Hanford-produced radionuclides in some areas are accessible to wildlife.
- Several onsite soil and vegetation samples contained radionuclide concentrations above background levels. However, observed levels were similar to those reported in recent years.
- External penetrating dose measurements during 1981 showed that dose rates at several onsite locations were above background levels. The

most significant change with respect to measured external penetrating radiation levels occurred as a result of the movement of a radioactive steam generator from one location to another within the 300 Area.

- No instances of observable contamination on roads or railroads were observed during routine surveys although the road monitor did, on one occasion, detect slightly contaminated soil near the process ponds in the 300 Area.
- There were no significant changes in the radiological status of radioactive-waste burial grounds located outside of operating area perimeter fences observed during routine surveys.
- Discharges of radioactive and nonradioactive materials to the environment during 1981 were generally greater than those during 1980 as a result of increased operational activities compared to 1980, especially at the FFTF and N-Reactor facilities.
- A total of 11 environment-related unusual occurrences were reported at Hanford during 1981.

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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 nonnuclear 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 and controlled manner and, occasionally, as a result of a process upset or other unplanned occurrence. Effluent and environmental 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 Pacific Northwest Laboratory (PNL), which is operated by the Battelle Memorial Institute for DOE. The program provides for the measurement, interpretation, and evaluation of environmental samples and other measurements for the purposes of assessing environmental impact, determining compliance with pertinent regulations, and evaluating the adequacy of onsite waste management practices. The program is designed to evaluate all significant pathways of potential environmental impact, with emphasis on those which are most significant. Summaries and evaluations of the data generated during the performance of environmental surveillance activities are published annually in three reports. These are:

- Environmental Surveillance at Hanford (offsite environmental surveillance report)
- Radiological Status of the Ground Water Beneath 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 for the year 1981. The Environmental Surveillance at Hanford for CY-1981 was issued as PNL-4211 (Sula et al. 1982) and the Radiological Status of the Ground Water Beneath the Hanford Site was issued as PNL-4237 (Eddy, Cline and Prater 1982).

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 measurements made during 1981

and to previous years' data. Sample analysis procedures are described in Appendix A and data analysis methods are provided in Appendix B.

THE HANFORD SITE

The U.S. Department of Energy's Hanford Site is located in a rural region of southeastern Washington State and occupies an area of 1500 km² (560 square miles). The site, shown in Figure 1, lies about 320 km (200 miles) east of Portland, Oregon, 270 km (170 miles) southeast of Seattle, Washington, and 200 km (125 miles) 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 mammal on the site and the most

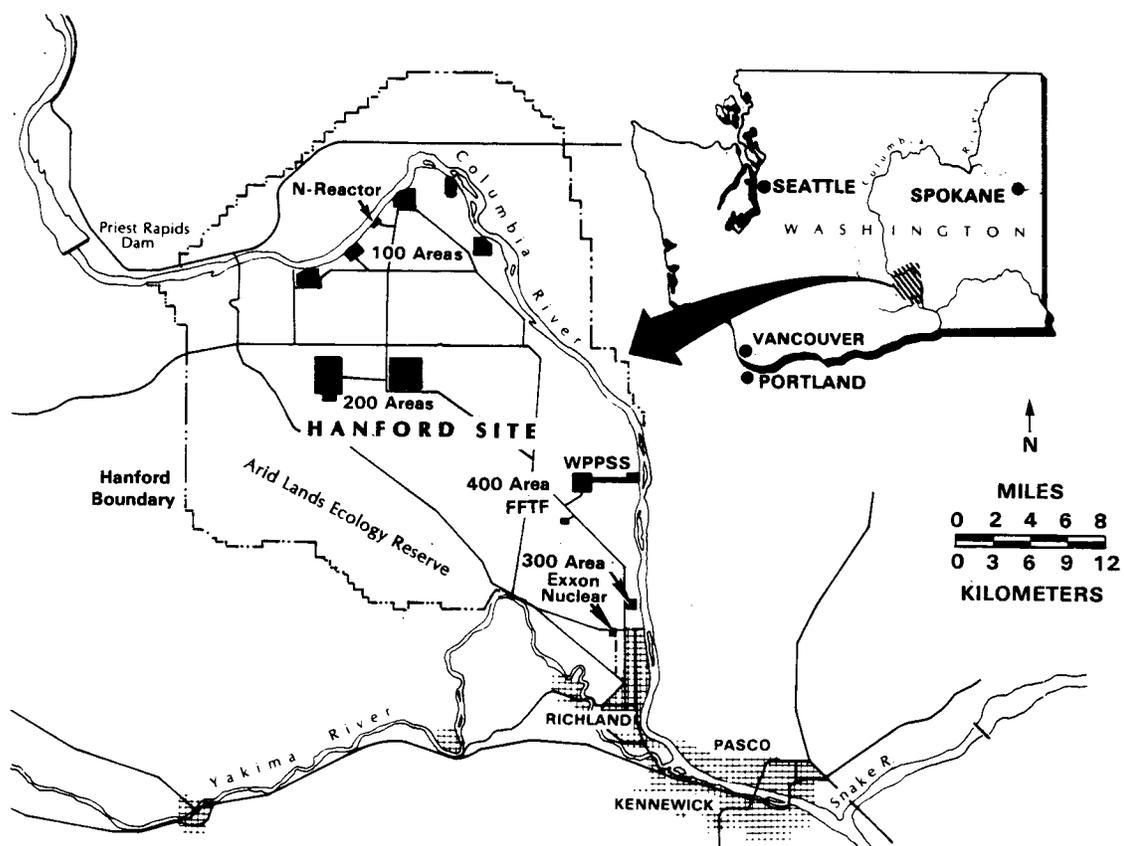


FIGURE 1. DOE's Hanford Site in Washington State

abundant small-game animal is the cottontail rabbit. The raccoon and coyote are the most abundant furbearing animals. The osprey, golden eagle, and bald eagle are all 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 (6.3 in.) 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 (92°F) and 16°C (61°F). For January, the respective averages are 3°C (37°F) and -6°C (22°F). Approximately 45% of all precipitation from December through February is snow.

Mean monthly wind speeds range from about 14 km/hr (9 mph) in the summer to 10 km/hr (6 mph) 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 are located within a short distance 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 (50-mile) radius of the Hanford Site in 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).

The Hanford plant was 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.

Facilities on the Hanford Site include the N-Production Reactor and the eight deactivated production reactors along the Columbia River in the 100 Areas. The reactor fuel-processing and waste-management facilities are on a plateau about 11.3 km (7 miles) from the river in the 200 Areas. The 300 Area, just north of the city of Richland, contains facilities for manufacturing reactor fuel and laboratories for research and development. The Fast Flux Test Facility (FFTF) is located in the 400 Area approximately 8.8 km (5.5 miles) northwest of the 300 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 (under construction), a hazardous-waste disposal site near the 200 Area, and a radioactive-waste burial site. 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, etc.
- Battelle Memorial Institute--responsible for operating PNL, including research in the physical, life, and environmental sciences; environmental surveillance; and development of advanced methods of nuclear waste management.
- UNC Nuclear Industries (UNC)--responsible for fabricating fuel for and operating N-Reactor.

- Westinghouse Hanford Company--responsible for operating the Hanford Engineering Development Laboratory (HEDL), including advanced reactor developments, principally the Liquid Metal Fast Breeder Reactor Program and the Fast Flux Test Facility.

Highlights of operational activities of interest, environmentally, during 1981 were:

- N-Reactor operated for 103 days during which time it supplied steam used by the Washington Public Power System to generate 870 MW of electrical power. Since its startup, N Reactor has supplied steam for the production of nearly 50 billion kWh of electric power, which has been supplied to the Bonneville Power Administration grid covering the Pacific Northwest.
- The FFTF underwent an eight-day full-power run in late November during which a series of radiation tests were successfully performed in preparation for regular operation to begin in April 1982.
- A steam generator, removed from the Surry Nuclear Generating Station and transported onsite during 1980, was moved to a permanent housing facility in the 300 Area in late December. The generator is the subject of a five-year research effort.
- Baghouses were installed on the coal-fired steam plants in the 200 Areas and initial performance testing was begun.
- A solid cover was installed over the N Reactor trench to deter wildlife entry.

Work at Hanford during 1981 also included Hanford National Environmental Research Park (NERP) studies, and Arid Land Ecology (ALE) studies, as well as continued operation of a variety of research and laboratory facilities.

AIR SAMPLING

Air 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 as described in Table 1. Samples are also collected at five locations distant from the Site (Figure 2). These locations provide background concentrations for comparison.

Particulate airborne radionuclides are sampled by drawing air at a flow rate of $2.6 \text{ m}^3/\text{hr}$ through a 5-cm diameter high-efficiency particulate filter.^(a) Radioiodines are 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) Samplers located at 100-D, 200-ESE and 400-E (see Table 1) also contain a tritium collection unit.

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 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 for gamma-emitting radionuclides, primarily ^{137}Cs . On a quarterly basis, the filters for each geographical group were combined and analyzed as a composite for ^{90}Sr and plutonium. All analyses were performed by U.S. Testing Company, Inc. (UST).

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

The tritium collection unit consists of two 5-cm diameter by 20-cm deep cartridges containing silica gel through which a stream of air is passed at a flow rate of $0.03 \text{ m}^3/\text{hr}$. The first silica gel cartridge removes tritium in the

(a) Model LB 5211, manufactured by Hollingsworth and Vose, Measured efficiencies exceed 99% for DOP (dioctyl-phthalate) particles.

(b) Manufactured by Nuclear Consulting Services, Inc. Retention efficiencies are 99% for both elemental and methyl-iodide.

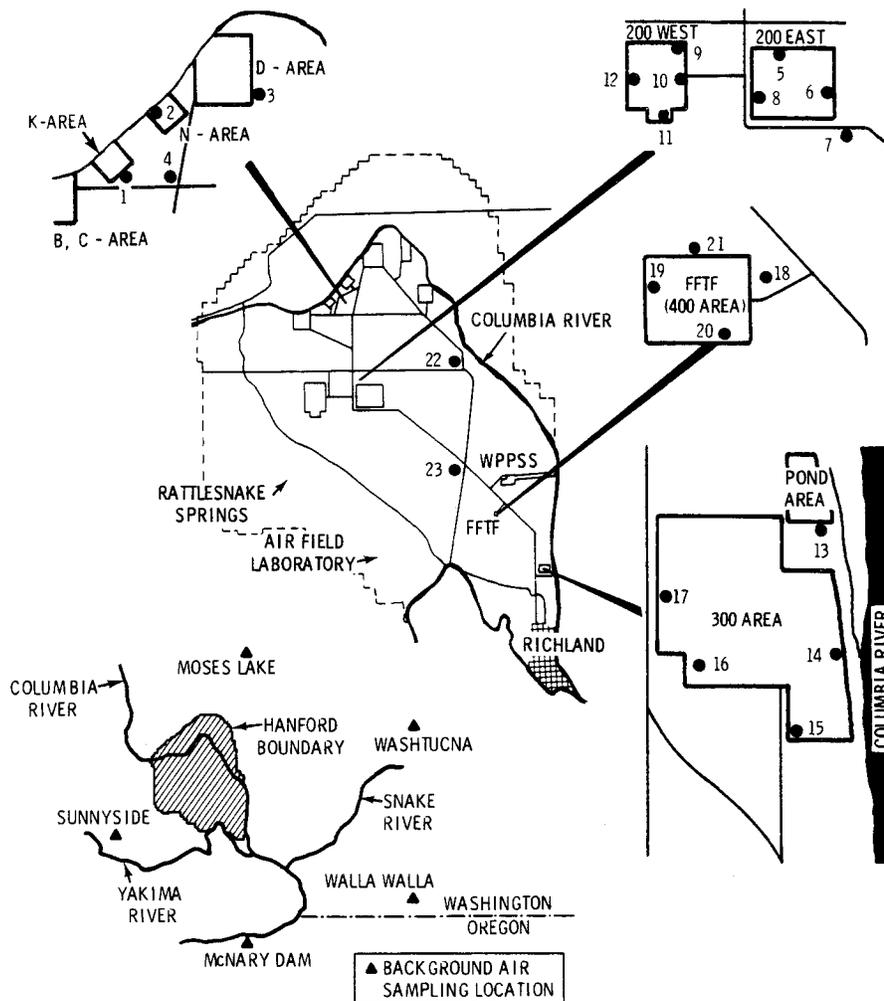


FIGURE 2. Onsite and Background Environmental Air Sampling Locations

form of water vapor (HTO). A catalytic oxidizer located downstream of the first silica gel cartridge then converts gaseous hydrogen and hydrocarbons in the air to water vapor that is collected by the second silica gel cartridge. Airborne tritium results are thus reported as tritiated water (HTO) and gaseous tritium (HT).

The silica gel cartridges were replaced every two weeks. Moisture was removed from the silica gel by heating and then condensing the trapped water. The water was analyzed for tritium by UST, using liquid-scintillation counting methods.

TABLE 1. Onsite Air Sampling Schedule

Sample Location	Map Number	Particulate Filter					Charcoal Cartridge		Silica Gel Cartridge	
		Filter Exchange Period	Analysis Frequency			Cartridge Exchange Period	Analysis Frequency	Cartridge Exchange Period	Analysis Frequency	
			Gross Beta	Gross Alpha	Gamma Scan				90 ^{Sr}	Pu
<u>100 Areas</u>										
100-K	1	BW					M			
100-N	2	BW					M			
100-D	3	BW					BW			BW
Fire Station Composite	4	BW		M			M			
<u>200 East Area</u>										
200 ENC	5	BW	BW				M			
200 EEC	6	BW	BW				M			
200 ESE	7	BW	BW				BW			BW
200 EMC Composite	8	BW	BW	M			M			
<u>200 West Area</u>										
200 MNE	9	BW	BW				M			
200 MEC	10	BW	BW				M			
Redox	11	BW	BW				M			
200 VMC Composite	12	BW	BW	M			M			
<u>300 Area</u>										
300 Pond	13	BW	BW				M			
3614-A Bldg.	14	BW	BW				M			
300 S Gate	15	BW	BW				M			
300 SW Gate	16	BW	BW				BW			
3705 Bldg. Composite	17	BW	BW	M			M			
<u>400 Area</u>										
400-E	18	BW	BW				BW			
400-W	19	BW	BW				BW			
400-S	20	BW	BW				BW			
400-N Composite	21	BW	BW	M			M			
<u>Inner East Sector</u>										
Hanford	22	BW	BW				M			
Wye Barricade Composite	23	BW	BW	M			M			

BW - Biweekly
M - Monthly
Q - Quarterly
NRA - Not Routinely Analyzed
No entry indicates no analysis

Results of air samples collected onsite during 1981 are summarized in Tables 2 through 7. General airborne particulate radioactivity levels in the Hanford environs were greater in 1981 than in recent years as the result of a foreign atmospheric nuclear test conducted during the latter part of 1980 (Sula and Blumer 1981). However, radionuclide concentrations near all operating areas were comparable to levels observed at the background (offsite) sampling locations.

Figure 3 shows a comparison of the 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 end of 1981, airborne concentrations had returned to pretest levels.

Maximum radionuclide concentrations during 1981 were observed in the spring months. By the end of the year, the shorter-lived radionuclides ($^{95}\text{ZrNb}$, $^{144}\text{CePr}$) could no longer be detected in air samples and concentrations of the long-lived radionuclides had returned to levels observed just before the atmospheric nuclear test. Iodine-131 was not observed in any of the air samples collected and analyzed during 1981.

TABLE 2. Airborne Radioactivity Concentrations During 1981--100 Areas

Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Concentration, pCi/m ³ (a)		Annual Average (c)	Average 1981/Background (b)
				Maximum	Minimum		
³ H (HTO)	D-Area	24	22	1.8 ± 1.0	<DL	0.71 ± 0.19	NS
³ H (HT)	D-Area	24	22	1.9 ± 0.99	<DL	0.88 ± 0.19	NS
⁹⁰ Sr	Composite (d)	4	4	0.002 ± 0.0003	0.0004 ± 0.00007	0.001 ± 0.0008	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴
⁹⁵ Zr/Nb	Composite (d)	12	9	0.12 ± 0.002	<DL	0.05 ± 0.03	0.06 ± 0.02
¹³¹ I	K-Area	12				NRA	
	N-Area	12				NRA	
	D-Area	24	0	<DL	<DL	(<0.01)	(<0.002)
	Fire Station	12				NRA	
¹³⁷ Cs	Composite (d)	12	9	0.009 ± 0.001	<DL	0.003 ± 0.002	0.004 ± 0.002
¹⁴⁴ CePr	Composite (d)	12	8	0.09 ± 0.01	<DL	(0.04 ± 0.02)	(0.05 ± 0.03)
²³⁸ Pu	Composite (d)	4	1	1.0X10 ⁻⁴ ± 2.0X10 ⁻⁵	<DL	(1.6X10 ⁻⁵ ± 5.7X10 ⁻⁵)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)
²³⁹⁻²⁴⁰ Pu	Composite (d)	4	3	6.0X10 ⁻⁵ ± 1.0X10 ⁻⁵	<DL	2.9X10 ⁻⁵ ± 2.4X10 ⁻⁵	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)
Gross Beta	K-Area	26	26	0.43 ± 0.01	0.02 ± 0.004	0.14 ± 0.04	
	N-Area	26	26	0.31 ± 0.009	0.02 ± 0.005	0.13 ± 0.03	
	D-Area	23	23	0.30 ± 0.009	0.02 ± 0.004	0.12 ± 0.04	
	Fire Station	25	25	0.32 ± 0.009	0.02 ± 0.004	0.14 ± 0.04	
						0.13 ± 0.02	0.13 ± 0.02

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NRA Not routinely analyzed.

NS Tritium was not sampled at "distant" locations. The average HTO and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include the two-standard error term (95% confidence interval).

(b) Except as noted, based on annual average of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washtucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the four individual sampling locations identified in Table 1.

TABLE 3. Airborne Radioactivity Concentrations During 1981--200-E Area

Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Concentration, pCi/m ³ (a)		Annual Average (c)	Average 1981 Background (b)
				Maximum	Minimum		
³ H (HTO)	200 ESE	24	20	2.5 ± 1.1	<DL	0.66 ± 0.23	NS
³ H (HT)	200 ESE	26	22	1.2 ± 0.42	<DL	0.55 ± 0.14	NS
⁹⁰ Sr	Composite (d)	4	4	2.0X10 ⁻³ ± 3.0X10 ⁻⁴	3.0X10 ⁻⁴ ± 2.0X10 ⁻⁴	9.3X10 ⁻⁴ ± 7.8X10 ⁻⁴	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴
⁹⁵ ZrNb	Composite (d)	12	9	0.13 ± 0.002	<DL	0.05 ± 0.03	0.06 ± 0.02
¹³¹ I	200 ENC	12				NRA	
	200 EEC	12				NRA	
	200 ESE	26	0	<DL	<DL	(<0.002)	(<0.002)
	200 EWC	12				NRA	
¹³⁷ Cs	Composite (d)	12	10	0.008 ± 0.001	<DL	0.004 ± 0.002	0.004 ± 0.002
¹⁴⁴ CePr	Composite (d)	12	8	0.08 ± 0.01	<DL	(0.04 ± 0.02)	(0.05 ± 0.03)
²³⁸ Pu	Composite (d)	4	0	<DL	<DL	(<6.2X10 ⁻⁶)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)
²³⁹⁻²⁴⁰ Pu	Composite (d)	4	4	3.0X10 ⁻⁵ ± 2.0X10 ⁻⁵	<DL	1.5X10 ⁻⁵ ± 1.5X10 ⁻⁵	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)
Gross Beta	200 ENC	25	25	0.36 ± 0.01	0.03 ± 0.004	0.13 ± 0.04	
	200 EEC	25	25	0.38 ± 0.01	0.02 ± 0.004	0.14 ± 0.04	
	200 ESE	25	25	0.36 ± 0.01	0.02 ± 0.004	0.14 ± 0.04	
	200 EWC	23	23	0.30 ± 0.009	0.02 ± 0.004	0.14 ± 0.04	
						0.14 ± 0.02	0.13 ± 0.02
Gross Alpha	200 ENC	25	25	0.003 ± 0.0008	0.0006	3.0X10 ⁻³ ± 2.8X10 ⁻⁴	
	200 EEC	25	25	0.004 ± 0.0009	0.0006	1.5X10 ⁻³ ± 3.9X10 ⁻⁴	
	200 ESE	25	25	0.003 ± 0.0007	0.0005	1.3X10 ⁻³ ± 3.3X10 ⁻⁴	
	200 EWC	23				NRA	
						1.4X10 ⁻³ ± 1.9X10 ⁻⁴	NS

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NRA Not routinely analyzed.

NS Tritium was not sampled at "distant" locations. The average HTO and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include the two-standard error term (95% confidence interval).

(b) Except as noted, based on annual average of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washtucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the four individual sampling locations identified in Table 1.

TABLE 4. Airborne Radioactivity Concentrations During 1981--200-W Area

Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Concentration, pCi/m ³ (a)		Annual Average (c)	Average 1981 Background (b)
				Maximum	Minimum		
⁹⁰ Sr	Composite (d)	4	4	2.0X10 ⁻³ ± 3.0X10 ⁻⁴	3.0X10 ⁻⁴ ± 2.0X10 ⁻⁴	9.3X10 ⁻⁴ ± 7.8X10 ⁻⁴	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴
⁹⁵ Zr-Nb	Composite (d)	12	9	0.12 ± 0.002	<DL	0.05 ± 0.03	0.06 ± 0.02
¹³¹ I	200 WNE 200 WEC 200 WWC 200 WMC Redox	12 12 12 12 12				NRA NRA NRA NRA NRA	
¹³⁷ Cs	Composite (d)	12	10	0.008 ± 0.001	<DL	0.003 ± 0.002	0.004 ± 0.002
¹⁴⁴ CePr	Composite (d)	12	8	0.09 ± 0.02	<DL	(0.04 ± 0.02)	(0.05 ± 0.03)
²³⁸ Pu	Composite (d)	4	0	<DL	<DL	(<4.8X10 ⁻⁶)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)
²³⁹⁻²⁴⁰ Pu	Composite (d)	4	4	5.0X10 ⁻⁵ ± 2.0X10 ⁻⁵	9.0X10 ⁻⁶ ± 4.0X10 ⁻⁶	3.2X10 ⁻⁵ ± 2.2X10 ⁻⁵	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)
Gross Beta	200 WNE 200 WEC 200 WWC 200 WMC Redox	25 27 24 24 24	25 27 24 24 24	0.30 ± 0.009 0.31 ± 0.009 0.29 ± 0.009 0.29 ± 0.009	0.02 ± 0.004 0.02 ± 0.004 0.02 ± 0.004 0.03 ± 0.005	0.12 ± 0.04 0.14 ± 0.03 0.13 ± 0.04 0.14 ± 0.04 0.13 ± 0.02	0.13 ± 0.02
Gross Alpha	200 WNE 200 WEC 200 WWC 200 WMC Redox	25 27 24 24 24	26 24 24 24 24	0.003 ± 0.001 0.003 ± 0.0007	<DL 0.0007 ± 0.0004	NRA 0.001 ± 0.0006 NRA 0.001 ± 0.0003 0.001 ± 0.0003	NS

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NRA Not routinely analyzed

NS Tritium was not sampled at "distant" locations. The average HT0 and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include the two-standard error term (95% confidence interval).

(b) Except as noted, based on annual average of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washitucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the four individual sampling locations identified in Table 1.

TABLE 5. Airborne Radioactivity Concentrations During 1981--300 Area

Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Concentration, pCi/m ³ (a)		Annual Average (c)	Average 1981 Background (b)
				Maximum	Minimum		
⁹⁰ Sr	Composite (d)	4	4	2.0X10 ⁻³ ± 2.0X10 ⁻⁴	2.0X10 ⁻⁴ ± 2.0X10 ⁻⁴	8.0X10 ⁻⁴ ± 9.0X10 ⁻⁴	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴
⁹⁵ Zr-Nb	Composite (d)	12	9	0.13 ± 0.002	<DL	0.05 ± 0.03	0.06 ± 0.02
¹³¹ I	300 Pond	12				NRA	
	3614-A-Bldg.	12				NRA	
	300 S Gate	12				NRA	
	300 SW Gate	25	0	<DL	<DL	(<0.002)	(<0.002)
	3705 Bldg.	12				NRA	
¹³⁷ Cs	Composite (d)	12	9	0.008 ± 0.001	<DL	0.004 ± 0.002	0.004 ± 0.002
¹⁴⁴ CePr	Composite (d)	12	8	0.09 ± 0.01	<DL	(0.04 ± 0.02)	(0.05 ± 0.03)
²³⁸ Pu	Composite (d)	4	0	<DL	<DL	(<2.2X10 ⁻⁶)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)
²³⁹⁻²⁴⁰ Pu	Composite (d)	4	2	2.0X10 ⁻⁵ ± 8.0X10 ⁻⁶	<DL	(1.3X10 ⁻⁵ ± 1.5X10 ⁻⁵)	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)
Gross Beta	300 Pond	24	24	0.36 ± 0.01	0.03 ± 0.004	0.14 ± 0.04	
	3614-A-Bldg.	26	26	0.35 ± 0.009	0.02 ± 0.004	0.14 ± 0.04	
	300 S Gate	25	25	0.33 ± 0.009	0.03 ± 0.004	0.14 ± 0.04	
	300 SW Gate	25	25	0.36 ± 0.01	0.02 ± 0.004	0.13 ± 0.04	
	3705 Bldg.	25	25	0.31 ± 0.009	0.03 ± 0.004	0.14 ± 0.02	0.13 ± 0.02
Gross Alpha	300 Pond					NRA	
	3614-A-Bldg.					NRA	
	300 S Gate	25	25	4.0X10 ⁻³ ± 9.0X10 ⁻⁴	4.0X10 ⁻⁴ ± 3.0X10 ⁻⁴	2.0X10 ⁻³ ± 3.0X10 ⁻⁴	NS
	3705 Bldg.					NRA	

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NS Tritium was not analyzed.

NRA Not routinely analyzed.

(a) Maximum and minimum concentrations include the ±2σ counting error. The average HT0 and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(b) Except as noted, based on annual average of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washitucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the five individual sampling locations identified in Table 1.

TABLE 6. Airborne Radioactivity Concentrations During 1981--400 Area (FFTF)

		Concentration, pCi/m ³ (a)					
Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Maximum	Minimum	Annual Average (c)	Average 1981 Background (b)
³ H (HTO)	400 E	26	22	2.6 ± 1.5	0.11 ± 0.07	0.85 ± 0.24	NS
⁹⁰ Sr	Composite (d)	4	4	2.0X10 ⁻³ ± 3.0X10 ⁻⁴	2.0X10 ⁻⁴ ± 7.0X10 ⁻⁵	8.0X10 ⁻⁴ ± 8.5X10 ⁻⁴	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴
⁹⁵ ZrNb	Composite (d)	12	9	0.15 ± 0.002	<DL	0.05 ± 0.03	0.06 ± 0.02
¹³¹ I	400 E	27	0	<DL	<DL	<0.002	<0.002
	400 W	25	0	<DL	<DL	<0.002	<0.002
	400 S	27	0	<DL	<DL	<0.002	<0.002
	400 N	26	0	<DL	<DL	<0.002	<0.002
¹³⁷ Cs	Composite (d)	12	8	0.007 ± 0.001	<DL	(0.003 ± 0.002)	0.004 ± 0.002
¹⁴⁴ CePr	Composite (d)	12	8	0.09 ± 0.02	<DL	(0.04 ± 0.02)	(0.05 ± 0.03)
²³⁸ Pu	Composite (d)	4	0	<DL	<DL	(<1.3X10 ⁻⁵)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)
²³⁹⁻²⁴⁰ Pu	Composite (d)	4	3	5.0X10 ⁻⁵ ± 1.0X10 ⁻⁵	<DL	2.4X10 ⁻⁵ ± 2.1X10 ⁻⁵	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)
Gross Beta	400 E	25	25	0.32 ± 0.008	0.02 ± 0.004	0.13 ± 0.04	
	400 W	24	24	0.30 ± 0.009	0.02 ± 0.004	0.13 ± 0.04	
	400 S	26	26	0.33 ± 0.009	0.01 ± 0.006	0.12 ± 0.03	
	400 N	25	25	0.34 ± 0.009	0.02 ± 0.004	0.12 ± 0.04	0.13 ± 0.02
Gross Alpha	400 E	25	25	3.0X10 ⁻³ ± 8.0X10 ⁻⁴	5.0X10 ⁻⁴ ± 3.0X10 ⁻⁴	1.0X10 ⁻³ ± 3.0X10 ⁻⁴	
	400 W	24	24	4.0X10 ⁻³ ± 9.0X10 ⁻⁴	5.0X10 ⁻⁴ ± 4.0X10 ⁻⁴	2.0X10 ⁻³ ± 3.8X10 ⁻⁴	
	400 S	26	26	4.0X10 ⁻³ ± 9.0X10 ⁻⁴	5.0X10 ⁻⁴ ± 4.0X10 ⁻⁴	1.0X10 ⁻³ ± 3.4X10 ⁻⁴	
	400 N	25	25	4.0X10 ⁻³ ± 9.0X10 ⁻⁴	4.0X10 ⁻⁴ ± 3.0X10 ⁻⁴	2.0X10 ⁻³ ± 4.1X10 ⁻⁴	
						1.5X10 ⁻³ ± 1.8X10 ⁻⁴	NS

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NS Not routinely analyzed.

Tr Tritium was not sampled at "distant" locations. The average HTO and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include the two-standard error term (95% confidence interval).

(b) Except as noted, based on annual average of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the four individual sampling locations identified in Table 1.

TABLE 7. Airborne Radioactivity Concentrations During 1981--Inner East Sector

Radionuclide	Sample Location	No. of Samples	No. of Results >DL	Concentration, pCi/m ³ (a)			Annual Average (c)	Average 1981 Background (b)
				Maximum	Minimum	Annual Average (c)		
90Sr	Composite (d)	4	4	2.0X10 ⁻³ ± 5.0X10 ⁻⁴	3.0X10 ⁻⁴ ± 1.0X10 ⁻⁴	9.3X10 ⁻⁴ ± 8.0X10 ⁻⁴	9.0X10 ⁻⁴ ± 5.0X10 ⁻⁴	
95Zr/Nb	Composite (d)	12	9	0.13 ± 0.003	<DL	0.05 ± 0.03	0.06 ± 0.02	
131I	Hanford Wye Barricade	12				NRA		
		12				NRA		
137Cs	Composite (d)	12	5	0.01 ± 0.002	<DL	(0.003 ± 0.002)	0.004 ± 0.002	
144Ce/Pr	Composite (d)	12	6	0.10 ± 0.02	<DL	(0.04 ± 0.03)	(0.05 ± 0.03)	
238Pu	Composite (d)	4	0	<DL	<DL	(<1.5X10 ⁻⁵)	(7.5X10 ⁻⁵ ± 1.8X10 ⁻⁴)	
239-240Pu	Composite (d)	4	0	<DL	<DL	(<2.4X10 ⁻⁵)	(5.0X10 ⁻⁵ ± 3.0X10 ⁻⁵)	
Gross Beta	Hanford Wye Barricade	26	26	0.36 ± 0.01	0.03 ± 0.005	0.13 ± 0.04		
		25	25	0.38 ± 0.01	0.03 ± 0.005	0.15 ± 0.04		
						0.15 ± 0.03	0.13 ± 0.02	
Gross Alpha	Hanford Wye Barricade	26	26	3.0X10 ⁻³ ± 7.0X10 ⁻⁴	6.0X10 ⁻⁴ ± 4.0X10 ⁻⁴	1.0X10 ⁻³ NRA	NS	

>DL Greater than the detection level, i.e., analysis of the sample yielded a positive identification.

<DL Less than the detection level; radionuclide not identified in sample.

NRA Not routinely analyzed.

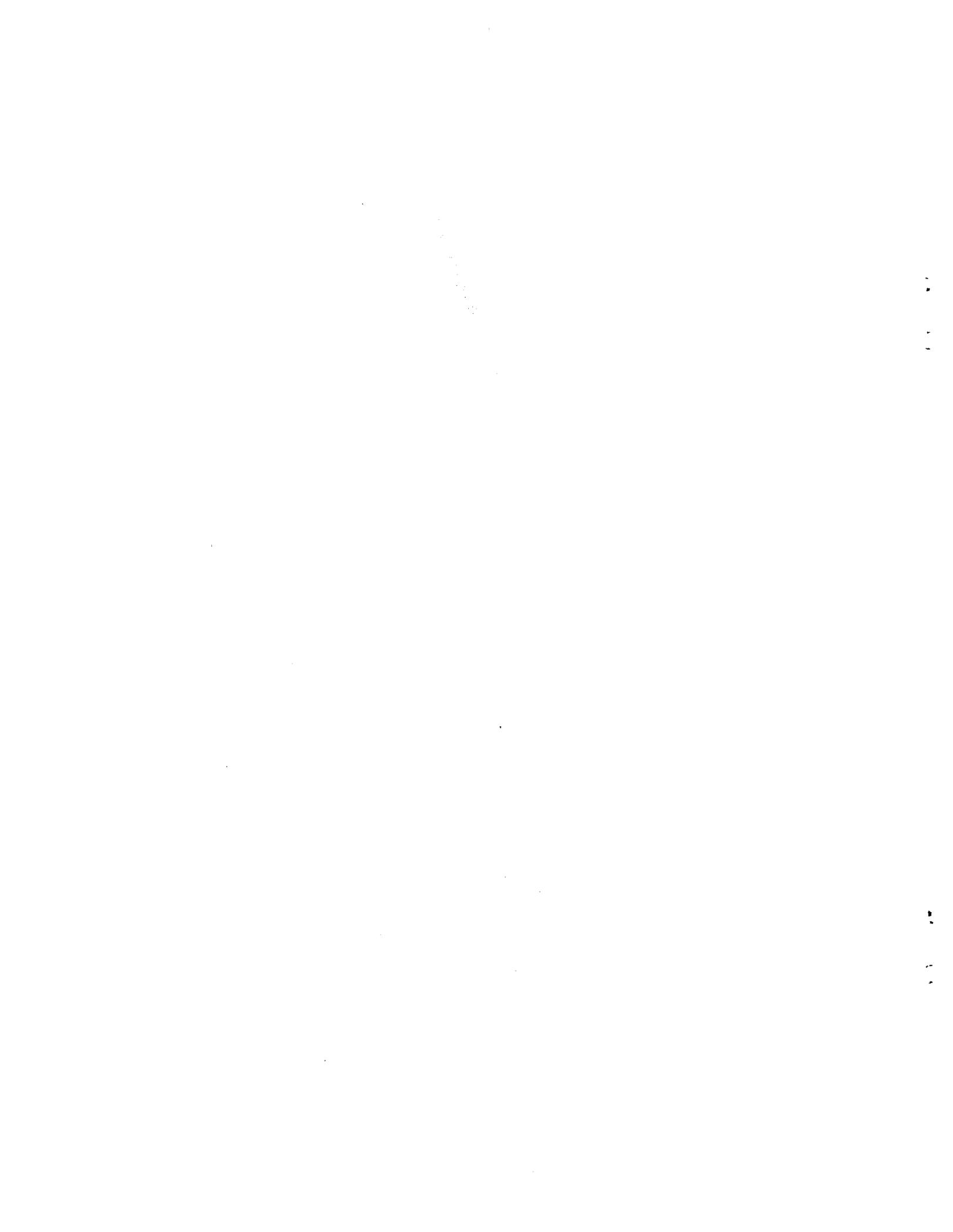
NS Tritium was not sampled at "distant" locations. The average HTO and HT concentration in samples collected at two site perimeter locations was 0.74 ± 0.13 and 0.70 ± 0.15 pCi/m³ respectively.

(a) Maximum and minimum concentrations include the ±2σ counting error. Averages include the two-standard error term (95% confidence interval).

(b) Except as noted, based on annual averages of samples collected at "distant" stations during 1981. The distant stations were located at Moses Lake, Washtucna, Walla Walla, McNary Dam, and Sunnyside as shown in Figure 1.

(c) If fewer than 75% of the results were >DL, the average is enclosed within parenthesis, except that if fewer than 25% of the results were >DL, no average was calculated and the approximate minimum detectable concentration is shown within parenthesis.

(d) Composites of biweekly samples from the two individual sampling locations identified in Table 1.



PONDS

Four ponds located outside of operating area exclusion fences (Figure 4) were sampled routinely for radioactivity. Two of the ponds, Gable Pond and B-Pond near the 200 East Area, were built in the mid-1950's for disposal of chemical process cooling water and wastes occasionally containing low levels of radioactive contamination. The FFTF Pond, built in 1978, is a sewage disposal and treatment lagoon and does not receive any radioactive wastes. The fourth

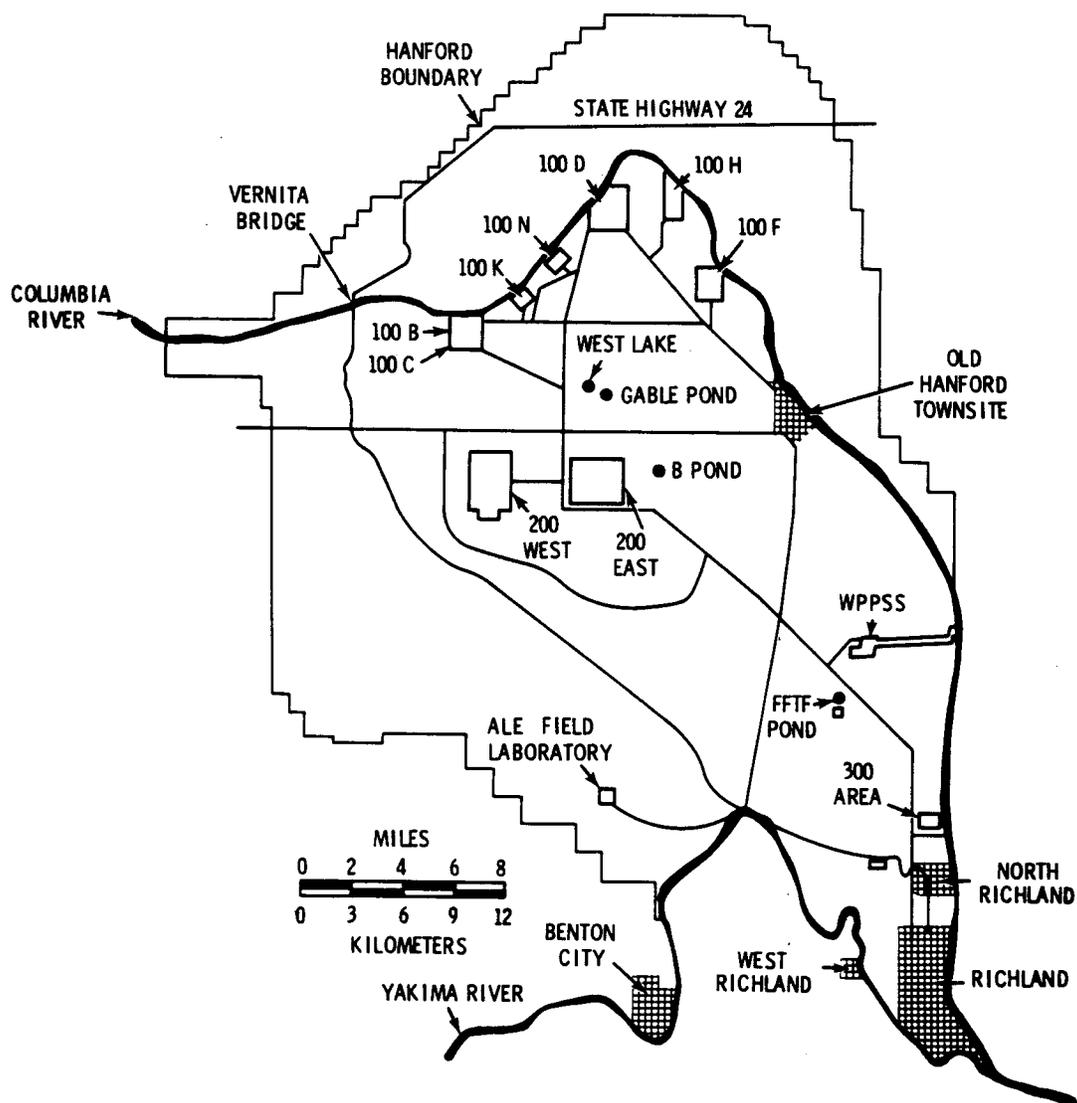


FIGURE 4. Onsite Ponds Sampled During 1981

pond, West Lake, is a natural lake and does not receive any discharges from site facilities. The ponds are accessible to migrating waterfowl as well as other animals. Thus, 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.

Three-gallon grab samples of water from each pond are routinely collected and analyzed for gross alpha, gross beta, gamma emitters, and ^{90}Sr , with the exception that FFTF Pond water is analyzed for ^{22}Na instead of ^{90}Sr . Samples were collected on a quarterly frequency during 1981 for all ponds except B-Pond for which samples were collected monthly as a result of an apparent increase in B-Pond radionuclide concentrations during 1980. Results of 1981 samples are shown in Table 8.

Strontium-90 and cesium-137 concentrations in B-Pond were lower during 1981 compared to 1980. Concentrations of these two radionuclides in B-Pond increased during 1980 as shown in Figure 5. Monthly sampling was initiated during 1980 to enable trends to be observed more closely; however, with stabilization of radionuclide concentrations during 1981 the sampling was subsequently reduced to a quarterly frequency consistent with the other onsite ponds. The increased radionuclide concentrations observed during 1980 were well below applicable Concentration Guides and did not pose any special environmental problems.

A comparison of radionuclide concentrations in the other onsite ponds (West Lake, Gable Pond, and FFTF Pond) to data obtained from previous years' samples (Sula, Blumer and Dirkes 1981) showed no significant changes.

The highest gross alpha and gross beta concentrations were observed in West Lake. 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). West Lake is recharged from a deep aquifer with only minor exchange of water between the pond and the shallow aquifer (Gephart et al. 1976). Therefore, the observed radioactivity is the result of naturally occurring radionuclides in the pond recharge that have been concentrated by evaporation over the years.

TABLE 8. Radionuclide Concentrations in Onsite Ponds During 1981

Location	Date	Concentration pCi/g (a)				Total Alpha Activity	Total Beta Activity
		⁵¹ Cr (b)	⁹⁰ Sr (c)	¹³⁷ Cs (b,d)	²² Na		
West Lake	2/10	37 ± 14	3.6 ± 0.97	6.4 ± 1.7	NA	241 ± 15	365 ± 41
	5/5	3.0 ± 35	3.0 ± 0.11	4.6 ± 5.1		187 ± 13	643 ± 58
	11/17	59 ± 53	2.0 ± 0.14	-0.04 ± 2.6		278 ± 20	15 ± 2.7
Gable Pond	2/10	13 ± 5.9	0.57 ± 0.14	40 ± 1.1		0.56 ± 0.46	64 ± 6.6
	5/5	1.4 ± 11	0.41 ± 0.06	41 ± 4.7		0.93 ± 0.60	183 ± 8.7
	8/11	2.1 ± 7.2	0.35 ± 0.56	1.9 ± 0.92		0.13 ± 0.32	8.8 ± 5.2
	11/17	3.9 ± 15	0.21 ± 0.05	6.4 ± 1.1		0.38 ± 0.37	18 ± 5.6
B Pond	1/13	0.85 ± 19	2.3 ± 0.27	94 ± 8.8		0.69 ± 0.40	51 ± 6.2
	2/10	13 ± 11	1.2 ± 0.17	24 ± 3.4		1.1 ± 0.54	43 ± 6.1
	3/10	6.4 ± 12	3.8 ± 0.42	17 ± 3.2		0.30 ± 0.45	22 ± 5.6
	4/6	-0.32 ± 8.6	1.9 ± 0.21	12 ± 1.2		0.72 ± 0.46	18 ± 5.3
	5/5	6.3 ± 9.8	1.8 ± 0.06	36 ± 4.1		0.44 ± 0.37	41 ± 5.8
	6/16	4.2 ± 8.1	1.2 ± 0.08	24 ± 1.1		1.0 ± 0.50	29 ± 5.8
	7/16	8.1 ± 14	5.8 ± 0.06	20 ± 3.7		1.6 ± 0.63	8.6 ± 5.2
	8/11	3.6 ± 12	0.07 ± 0.02	5.8 ± 2.3		1.0 ± 0.49	12 ± 5.2
	9/8	-5.2 ± 8.5	1.6 ± 0.13	7.8 ± 1.1		3.9 ± 0.92	16 ± 5.2
	10/20	25 ± 59	1.0 ± 0.13	19 ± 7.4		0.82 ± 0.39	25 ± 5.8
	11/17	21 ± 26	0.50 ± 0.05	23 ± 3.9		0.70 ± 0.44	24 ± 5.6
FFTF Pond	2/10	8.8 ± 11	NA	2.0 ± 1.5	3.5 ± 4.6	0.47 ± 0.43	23 ± 6.9
	5/5	7.7 ± 11		-0.15 ± 1.4	1.2 ± 4.6	0.23 ± 0.48	27 ± 6.6
	8/11	2.6 ± 11		-0.12 ± 1.4	-0.18 ± 4.6	0.16 ± 0.29	57 ± 6.1
	11/17	-46 ± 350		19 ± 20	8.2 ± 49	0.07 ± 0.36	22 ± 7.1

NA Radionuclide not analyzed.
 (a) Individual results show the 2σ counting error.
 (b) Based on analysis by gamma-spectrometry. Except for ^{137}Cs and ^{51}Cr , no artificially produced radionuclides were detected.
 (c) Concentration Guide for uncontrolled areas is 300 pCi/g (DOE 5480.1, Chapter XI).
 (d) Concentration Guide for uncontrolled areas is 20,000 pCi/g (DOE 5480.1, Chapter XI).

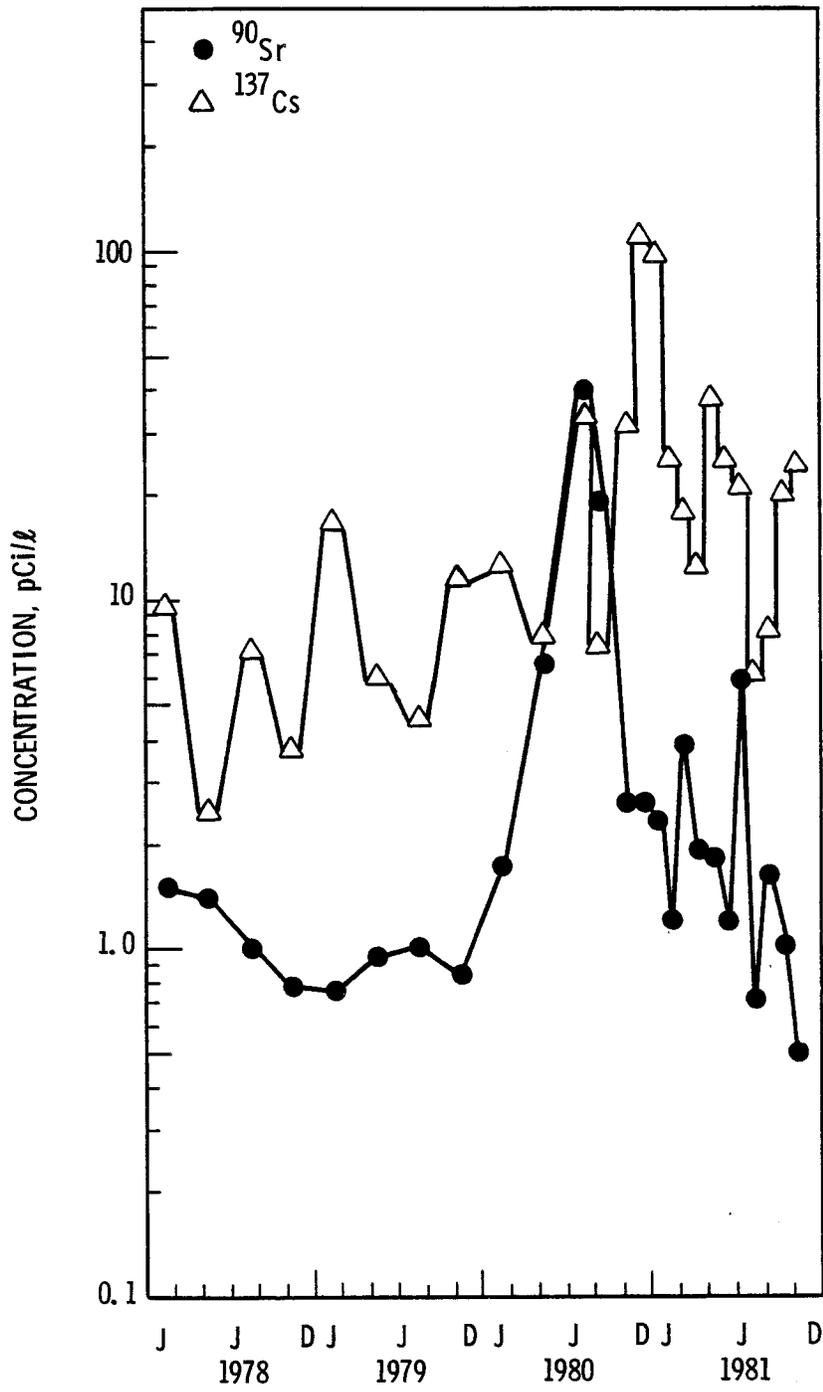


FIGURE 5. Strontium-90 and Cesium-137 Concentrations in B-Pond

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 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 sampled during 1981 included waterfowl (ducks, geese), upland game birds (quail, pheasant), deer, and rabbits. Results of 1981 wildlife samples and the associated potential for offsite radiological impact has been previously discussed in the Environmental Surveillance at Hanford for CY-1981 report (Sula et al. 1982).

DEER

The routine method for sampling deer at Hanford consists of analyzing tissue samples from deer that have been accidentally killed by vehicles on site roads. Results of analyses of deer samples collected as part of the routine sampling program are shown in Table 9. Collection locations are shown in Figure 6. Although deer tend to have definable home-ranges, distant movements within or off the site are common; therefore, the location of uptake of radionuclides observed in road-kill deer samples is unknown.

In addition to the routine sampling conducted during 1981, several deer were also sampled as part of a special study to estimate maximum ¹³⁷Cs concentrations in onsite deer. For this study, deer were captured, radio-collared and tracked to determine their foraging locations. Deer that remained within

TABLE 9. Radionuclide Concentrations in Hanford (Road-Killed) Deer

Sample Location	Map Location	Date	Concentration, pCi/g wet weight (a)			
			Muscle 137Cs	Bone 90Sr	Liver 238Pu	239-240Pu
Rt 4S Mi 9	D-1	5/15	(0.009 ± 0.02)	1.7 ± 0.63	(-0.00002 ± 0.0009)	(0.0002 ± 0.0009)
Rt 4N Mi 6	D-2	5/21	0.44 ± 0.03	0.52 ± 0.01	(0.0002 ± 0.0005)	0.003 ± 0.0008
Rt 2N Mi 8	D-3	5/28	(-0.0002 ± 0.02)	0.55 ± 0.01	--	--
Rt 4S Mi 19	D-4	10/29 12/2	(0.001 ± 0.008) (0.009 ± 0.01)	0.46 ± 0.01 0.27 ± 0.04	(-0.0005 ± 0.0004) (-0.0007 ± 0.0004)	0.0005 ± 0.0005 0.001 ± 0.0005
300 Area	D-5	11/11	(-0.007 ± 0.01)	0.34 ± 0.02	(-0.0007 ± 0.0004)	(0.0003 ± 0.0004)

(a) Results include the two-sigma counting error. Results are shown within parentheses if less than the counting error.

No entry indicates the analysis was not performed.

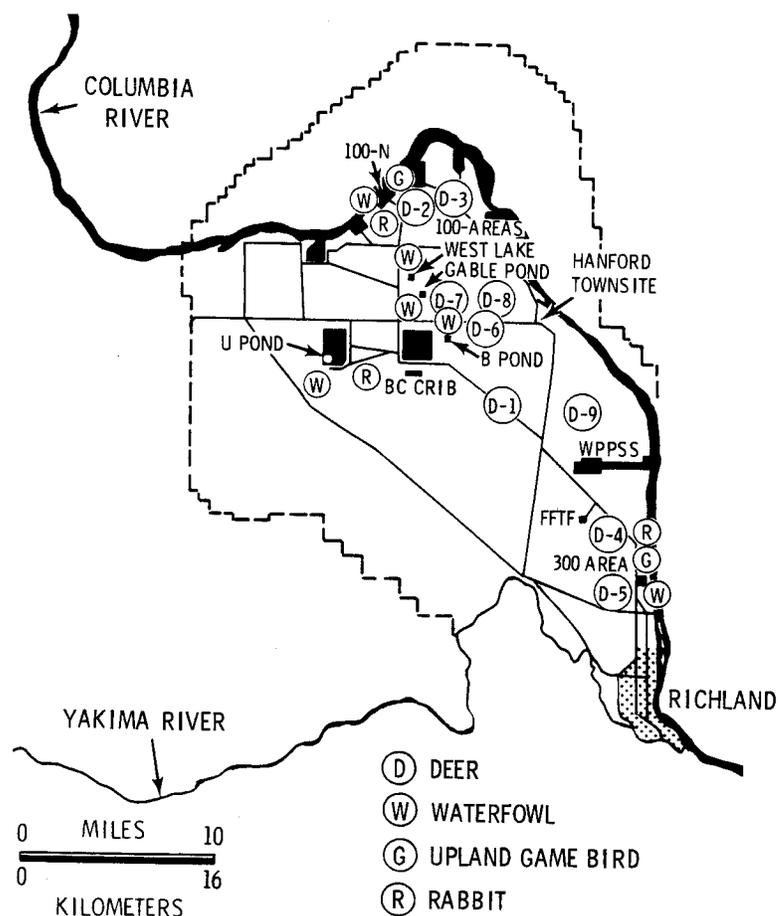


FIGURE 6. Onsite Wildlife Collection Locations

specific areas of interest were sacrificed and sampled. Results of the special samples collected in 1981 are shown in Table 10.

Comparison of Tables 9 and 10 shows that road-killed deer generally had lower radionuclide concentrations than the deer known to have foraged near waste management areas. The study has continued into 1982 and a special report will be prepared upon completion.

WATERFOWL

Waterfowl samples (ducks and geese) were collected along the Columbia River in the vicinity of the 100-N and 300 Areas as well as from each of the

TABLE 10. Radionuclide Concentrations in Specially Sampled Hanford Deer

Sample (b) Location	Map Location	Date	Concentration pCi/g wet weight (a)			
			Muscle ¹³⁷ Cs	Bone ⁹⁰ Sr	²³⁸ Pu	Liver ²³⁹⁻²⁴⁰ Pu
B Pond	D-6	5/8	(1.4 ± 1.6)	20 ± 1.0	0.05 ± 0.002	0.01 ± 0.001
Gable Pond	D-7	5/8	0.50 ± 0.01	21 ± 0.43	(0.0001 ± 0.0006)	0.002 ± 0.0009
		5/8	0.88 ± 0.13	39 ± 0.68	(0.0005 ± 0.0006)	0.003 ± 0.0007
Gable Mt.	D-8	12/29	(-0.007 ± 0.01)	5.3 ± 0.44	0.001 ± 0.0008	(0.0003 ± 0.0005)
		12/29	(0.01 ± 0.02)	65 ± 0.85	(-0.0004 ± 0.0005)	0.00062 ± 0.00057
		12/31	0.01 ± 0.008	5.3 ± 0.61	(0.0005 ± 0.0007)	0.002 ± 0.0007
N 3 Mi WPPSS 2	D-9	12/31	0.01 ± 0.009	0.59 ± 0.04	(0.0002 ± 0.0004)	0.0009 ± 0.0004

(a) Results include the two-sigma counting error. Results are shown within parentheses if less than the counting error.

(b) Animals were collected at the specified location following at least a three month residence.

six onsite ponds shown in Figure 6. Approximately 0.5-kg samples of breast meat from each bird were analyzed for ^{137}Cs using methods described in Appendix A. Results are shown in Table 11.

With the exception of one duck collected near the 100-N Area, samples taken from the Columbia River did not contain detectable levels of ^{137}Cs . The duck sample collected near 100-N Area contained ^{137}Cs at a concentration similar to birds collected from waste-water ponds in or near the 200 Areas.

Samples collected from 200 Areas waste-water ponds showed an accumulation of ^{137}Cs in tissues at levels similar to that observed in recent years. The maximum concentration of ^{137}Cs (280 pCi/g) was observed in a duck collected from U-Pond, located within the 200-West area.

UPLAND GAME BIRDS

Upland game birds including chukar, dove, pheasant, and quail were collected on the Hanford Site during 1981. Samples were collected in the vicinity of the 100, 200 and 300 Areas as well as in the White Bluffs area across the river from 100-F (see Figure 6). A minimum of three samples was scheduled for collection at each location (the 100 Areas were subdivided into six locations for a total of 18 birds and the 200 Areas were subdivided into west and east areas for a total of 6 birds). In several cases, fewer than the scheduled numbers of samples were obtained because the birds were not available.

Samples of breast meat from each bird were analyzed for ^{137}Cs and ^{60}Co and results are shown in Table 11.

All results, except for two quail and one dove collected from the 100-N Area, were either below the detection level or were in the range attributable to worldwide fallout. The highest radionuclide concentrations (120 pCi $^{137}\text{Cs}/\text{g}$ and 4.3 pCi $^{60}\text{Co}/\text{g}$) were observed in a quail collected near the 100-N trench. Subsequent to the collection of the samples, a permanent solid cover has been installed over the 100-N trench. The cover is expected to restrict the future access of wildlife to radionuclides contained in the trench.

TABLE 11. Radionuclide Concentrations in Game Birds and Waterfowl

Location	Species	No. of Samples	⁶⁰ Co					¹³⁷ Cs				
			No. of Results >DL	Maximum	Minimum	Average (b)	No. of Results >DL	Maximum	Minimum	Average (b)		
100 Areas	Quail	6	2	4.3 ± 0.6	<DL	[1.5 ± 1.5]	4	120 ± 8	<DL	[22 ± 39]		
	Dove	1	1	--	--	4.0 ± 0.2	1	--	--	0.30 ± 0.09		
	Pheasants	12	0	<DL	<DL	(0.003 ± 0.009)	4	0.05 ± 0.04	<DL	0.02 ± 0.01		
	Geese	2	0	<DL	<DL	(-0.006 ± 0.03)	0	<DL	<DL	(0.006 ± 0.037)		
200 Areas	Ducks	3	0	<DL	<DL	(0.004 ± 0.026)	1	45 ± 1	<DL	[15 ± 30]		
	Chukar Pheasant	3	0	<DL	<DL	(0.0001 ± 0.04)	1	0.14 ± 0.06	0.008 ± 0.05	(0.07 ± 0.17)		
	Pheasant	1	0	--	--	(0.01 ± 0.03)	0	--	--	(0.01 ± 0.02)		
	Ducks	5	0	<DL	<DL	(-0.001 ± 0.23)	1	130 ± 2	<DL	[29 ± 48]		
U Pond	Ducks	7	1	0.77 ± 0.26	<DL	(0.096 ± 0.03)	6	280 ± 3	<DL	110 ± 80		
	Ducks	5	2	1.4 ± 0.18	<DL	(0.31 ± 0.57)	3	71 ± 1	<DL	29 ± 27		
Gable Pond	Ducks	4	0	<DL	<DL	(0.013 ± 0.062)	3	50 ± 1	<DL	23 ± 26		
	Ducks	3	0	<DL	<DL	(-0.003 ± 0.05)	0	<DL	<DL	(0.016 ± 0.056)		
300 Pond	Quail	1	0	--	--	(0.04 ± 0.04)	0	--	--	(0.01 ± 0.03)		
	Ducks	6	0	<DL	<DL	(0.007 ± 0.014)	1	0.03 ± 0.02	<DL	(0.011 ± 0.015)		
300 Area	Quail	1	0	--	--	(0.0002 ± 0.03)	0	--	--	(0.01 ± 0.02)		
	Ducks	6	0	<DL	<DL	--	0	--	--	--		
White Bluffs	Pheasant	1	0	--	--	--	0	--	--	--		

[] = Average significantly biased by single high result.
 >DL = Greater than the detection level; i.e., analysis of the sample yielded a positive identification.
 <DL = Less than the detection level; radionuclide not identified in sample.
 (a) Individual results shown with the ± two sigma counting error. Averages include the ± two standard error term (95% confidence interval).
 (b) Average enclosed in parenthesis if the ± two standard error term was greater than the indicated concentration.

RABBITS

Cottontail rabbits and Jackrabbit hares were collected in the vicinity of the onsite operating areas shown in Figure 6. Samples were analyzed for ^{90}Sr in bone and ^{60}Co and ^{137}Cs in muscle. Results of samples collected during 1981 are summarized in Table 12.

The highest radionuclide concentrations for the 1981 rabbit samples were observed in samples collected near the 100-N Area outside of the perimeter fence. Because of the few number of rabbit samples collected annually, comparison of concentrations between locations or for different times should be made with caution. Nevertheless, samples collected around the site during the past few years appear to indicate that the availability of uptake of radionuclides by rabbits is greater at 100-N Area than at the other sampling locations. The primary source of radionuclides at 100-N Area is the 1301-N crib/trench facility. As previously discussed, a solid cover was installed over the 1301-N trench during late 1981 to restrict access by wildlife.

TABLE 12. Radionuclide Concentrations in Rabbits and Hares

Location ^(b)	Date	Concentration pCi/g, wet weight ^(a)		
		Muscle		Bone
		⁶⁰ Co	¹³⁷ Cs	⁹⁰ Sr
300 Area	1/16	(0.15 ± 0.16)	(0.07 ± 0.13)	0.30 ± 0.28
	4/7	(0.0004 ± 0.03)	(0.62 ± 0.03)	0.97 ± 0.49
	4/7	(0.00005 ± 0.03)	(0.01 ± 0.02)	(0.21 ± 1.0)
	7/10	(0.03 ± 0.05)	(0.004 ± 0.03)	0.35 ± 0.05
	9/22	(-0.007 ± 0.03)	(-0.01 ± 0.03)	0.29 ± 0.10
200 E Area	1/30	(0.05 ± 0.14)	0.45 ± 0.11	1.6 ± 0.75
	8/4	124 ± 2.0	4.8 ± 0.33	1.7 ± 0.26
100 N Area	2/6	(-0.01 ± 0.05)	0.07 ± 0.05	19 ± 1.4
	4/2	(-.0002 ± 0.08)	(0.02 ± 0.07)	14 ± 0.86
	5/15	0.36 ± 0.06	0.07 ± 0.04	11 ± 0.75
	5/15	0.06 ± 0.03	(0.02 ± 0.03)	1.4 ± 0.11
	5/15	0.07 ± 0.03	(-0.01 ± 0.02)	49 ± 0.98
	5/15	230 ± 3.6	0.5 ± 0.61	1.5 ± 0.12
	8/6	0.53 ± 0.09	(-0.006 ± 0.05)	1.7 ± 0.07
	8/6	4.4 ± 0.80	(-0.24 ± 0.41)	1.4 ± 0.14
	10/15	0.11 ± 0.06	0.11 ± 0.06	140 ± 2.1
200 BC Crib	4/29	(0.00004 ± 0.02)	0.03 ± 0.02	3.2 ± 0.57
200 W Area	8/4	100 ± 2.5	6.7 ± 0.54	1.1 ± 0.37
	8/4	5.9 ± 0.66	0.36 ± 0.18	3.3 ± 0.66
	12/4	(0.002 ± 0.02)	0.03 ± 0.02	0.57 ± 0.06

(a) Results include the two-sigma counting error. Results are shown within parentheses if less than the counting error.

(b) Cottontail rabbits were collected from the 100 and 300 Areas. Jack rabbit hares were collected from all other locations.

SOIL AND VEGETATION

Soil and vegetation samples are collected annually to establish background 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 seven onsite locations during 1981 as shown by map locations 1 to 7 in Figure 7. Each sample consisted of a composite of five "plugs" of soil collected within a 100-m² area designated as the sampling location. Each "plug" of soil was 2.5 cm deep and 10 cm in diameter.

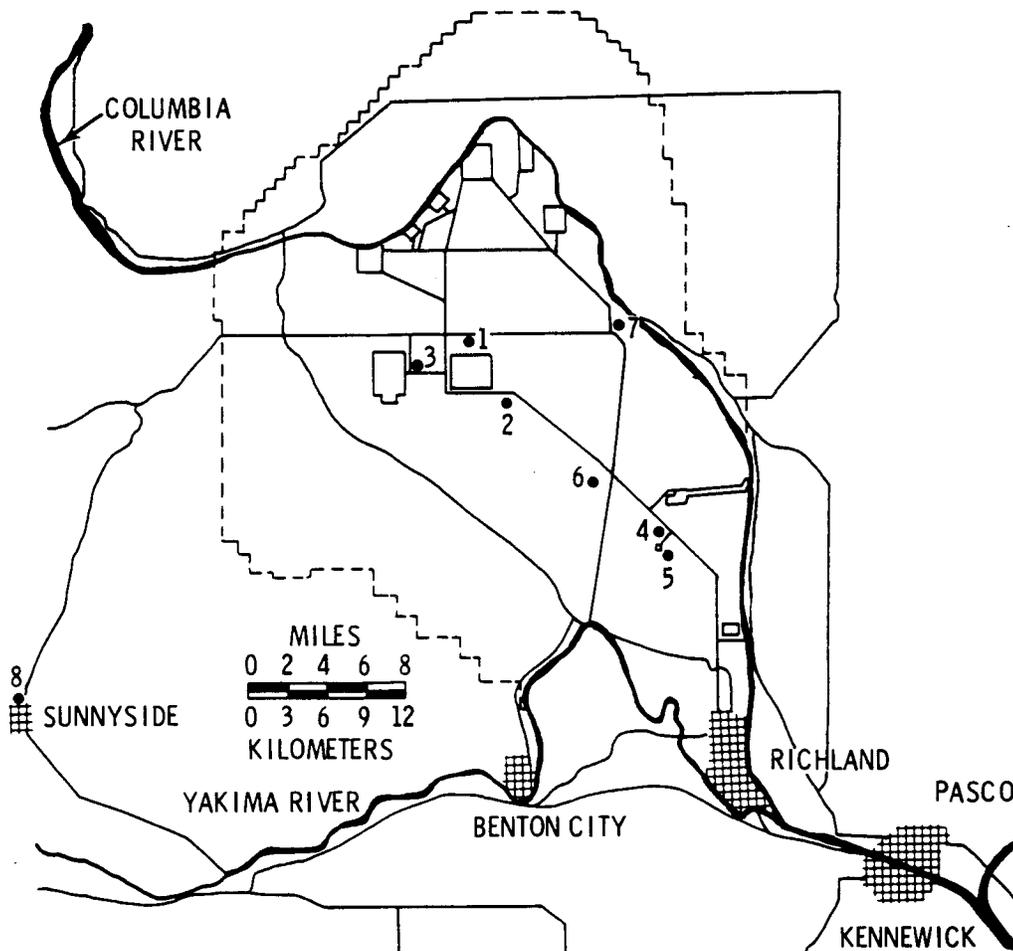


FIGURE 7. Onsite Soil and Vegetation Sampling Locations

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 abundant at every one of the sampling locations, each sample consisted of a mixture of the species present at the sample location in proportion to its relative abundance. Both the soil and vegetation samples were analyzed for gamma-emitting radionuclides, ^{90}Sr , plutonium, and uranium.

Tables 13 and 14 show the radionuclide concentrations observed in onsite soil and vegetation samples collected during 1981. Included for comparison is the result of analysis of a sample collected at Sunnyside (Location 8 in Figure 7) representative of general background levels of radionuclides. Additional soil and vegetation data at offsite locations during 1981 is provided in the report on environmental surveillance at Hanford for CY-1981 (Sula et al. 1982).

Soil radionuclide concentrations were, in general, similar to concentrations that have been reported in the previous several annual reports with ^{90}Sr , ^{137}Cs , and plutonium continuing to be observed at concentrations above background in several of the samples collected near the 200 Areas. Specifically, the "200-ENC" sample (Location 1) showed higher than background ^{90}Sr and ^{137}Cs concentrations consistent with previous samples collected at this location. The "East of 200-West Area" sample (Location 3, Figure 7) exhibited higher than background $^{239,240}\text{Pu}$ concentrations, as it has during previous years. There are no obvious trends in soil radionuclide concentrations as indicated by data collected during the last several years.

Radionuclide concentrations in soil near the FFTF facility continue to be somewhat below worldwide fallout levels. This may possibly be attributed to a range fire in 1970 that destroyed the cover vegetation in the FFTF area and exposed the surface soil to wind erosion.

Concentrations of long-lived radionuclides in vegetation samples (Table 14) were similar to those observed at the respective locations in previous years and were not significantly different from concentrations observed during 1981 at offsite locations (Sula et al. 1982).

TABLE 13. Radionuclide Concentrations in Onsite Soil Samples

Sample Location	Map Location	60Co	90Sr	95ZrNb	137Cs	144Ce	238Pu	239-240Pu	U-Total
		Concentration pCi/g, dry weight							
200 ENC	1	(-0.01 ± 0.02)	0.14 ± 0.003	0.87 ± 0.08	0.11 ± 0.03	0.80 ± 0.12	(-0.0007 ± 0.0003)	0.001 ± 0.0004	0.01 ± 0.004
200 East Hill	2	(-0.004 ± 0.02)	0.07 ± 0.005	0.52 ± 0.07	0.05 ± 0.02	0.62 ± 0.13	0.002 ± 0.001	0.004 ± 0.001	0.008 ± 0.003
East of 200 West	3	(-0.002 ± 0.02)	0.09 ± 0.005	0.90 ± 0.07	0.05 ± 0.02	1.1 ± 0.12	(-0.0007 ± 0.0006)	0.003 ± 0.001	0.01 ± 0.004
NE of FFTF	4	(0.003 ± 0.01)	0.04 ± 0.004	0.89 ± 0.04	0.04 ± 0.01	0.85 ± 0.07	(-0.0005 ± 0.0005)	0.001 ± 0.0007	0.02 ± 0.006
SE of FFTF	5	(0.01 ± 0.02)	0.04 ± 0.005	1.1 ± 0.08	0.05 ± 0.02	1.1 ± 0.11	(-0.0007 ± 0.0003)	0.001 ± 0.0006	0.008 ± 0.003
Wye Barricade	6	(-0.02 ± 0.01)	0.05 ± 0.006	0.90 ± 0.05	0.05 ± 0.02	1.0 ± 0.09	(-0.0006 ± 0.0003)	0.003 ± 0.0007	0.01 ± 0.004
Hanford Townsite	7	(-0.004 ± 0.02)	0.06 ± 0.003	0.70 ± 0.07	0.03 ± 0.02	0.62 ± 0.12	(-0.0005 ± 0.0003)	0.002 ± 0.0006	0.005 ± 0.003
Offsite Location (Sunnyside)	8	(0.0003 ± 0.02)	0.19 ± 0.02	0.37 ± 0.06	0.03 ± 0.02	0.47 ± 0.11	(-0.0007 ± 0.0004)	0.003 ± 0.0008	0.01 ± 0.005

Results include the ±2σ counting error. Results are shown within parenthesis if less than its counting error.

TABLE 14. Radionuclide Concentrations in Onsite Vegetation Samples

Sample Location	Map Location	58Co	60Co	90Sr	95ZrNb	134Cs	137Cs	144Ce	238Pu	239-240Pu	U-Total	
		Concentration pCi/g, dry weight										
200 ENC (a)	1	(-0.008 ± 0.008)	(-0.001 ± 0.009)	0.63 ± 0.006	0.05 ± 0.02	0.02 ± 0.01	18 ± 0.16	0.52 ± 0.06	(-0.0003 ± 0.0006)	0.02 ± 0.002	0.40 ± 0.14	
		0.02 ± 0.01	(-0.008 ± 0.01)	0.45 ± 0.02	0.07 ± 0.02	(0.009 ± 0.01)	12 ± 0.16	0.52 ± 0.07	0.03 ± 0.002	0.04 ± 0.002	0.66 ± 0.23	
200 East Hill	2	(0.0008 ± 0.01)	(-0.01 ± 0.01)	0.18 ± 0.007	0.04 ± 0.02	0.01 ± 0.01	1.2 ± 0.05	0.24 ± 0.06	(0.001 ± 0.001)	0.03 ± 0.004	0.42 ± 0.15	
East of 200 West Area	3	(0.0006 ± 0.01)	(0.003 ± 0.01)	0.48 ± 0.03	0.04 ± 0.02	0.02 ± 0.01	2.5 ± 0.08	0.20 ± 0.06	0.005 ± 0.0009	0.42 ± 0.008	0.72 ± 0.25	
NE of FFTF	4	0.01 ± 0.01	0.02 ± 0.01	0.04 ± 0.007	0.10 ± 0.02	0.03 ± 0.01	0.11 ± 0.02	0.45 ± 0.07	(-0.001 ± 0.0003)	0.003 ± 0.0008	0.49 ± 0.17	
SE of FFTF	5	(0.001 ± 0.01)	(-0.0007 ± 0.01)	0.05 ± 0.002	0.12 ± 0.02	0.02 ± 0.01	0.08 ± 0.02	0.53 ± 0.07	0.001 ± 0.0007	0.003 ± 0.0008	0.47 ± 0.16	
Wye Barricade	6	0.02 ± 0.01	0.02 ± 0.01	0.20 ± 0.02	0.09 ± 0.03	0.02 ± 0.01	0.69 ± 0.04	0.33 ± 0.06	(-0.0004 ± 0.0004)	0.012 ± 0.001	0.37 ± 0.13	
Hanford Townsite	7	0.01 ± 0.01	(-0.004 ± 0.01)	0.40 ± 0.004	0.11 ± 0.03	0.03 ± 0.01	1.6 ± 0.06	0.47 ± 0.07	(-0.0003 ± 0.0003)	0.02 ± 0.002	0.40 ± 0.14	
Offsite Location (Sunnyside)	8	(0.03 ± 0.01)	(-0.007 ± 0.01)	0.16 ± 0.02	0.08 ± 0.02	0.03 ± 0.01	0.63 ± 0.04	0.44 ± 0.07	(-0.001 ± 0.0004)	0.01 ± 0.001	0.34 ± 0.12	

Results include the ±2σ counting error. Results are shown within parenthesis if less than its counting error.
 (a) Two samples were collected at this location during 1981.

Short-lived radionuclides associated with worldwide fallout from atmospheric nuclear weapons tests ($^{95}\text{ZrNb}$, ^{144}Ce) were identified in onsite soil and vegetation samples at concentrations similar to that observed at offsite locations. A recent (October 1980) foreign atmospheric nuclear test is considered to be the source of most of the fallout radionuclides.

EXTERNAL RADIATION MEASUREMENTS

Onsite external penetrating radiation measurements were made at the locations shown in Figure 8. The measurements were made using thermoluminescent dosimeters (TLDs) that consist 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 integrate the dose received during their four-week field cycle.

The results of measurements taken onsite during 1981 are given in Table 15. All readings are expressed in units of mrem/yr to be comparable with offsite external dose measurements reported in the Environmental Surveillance

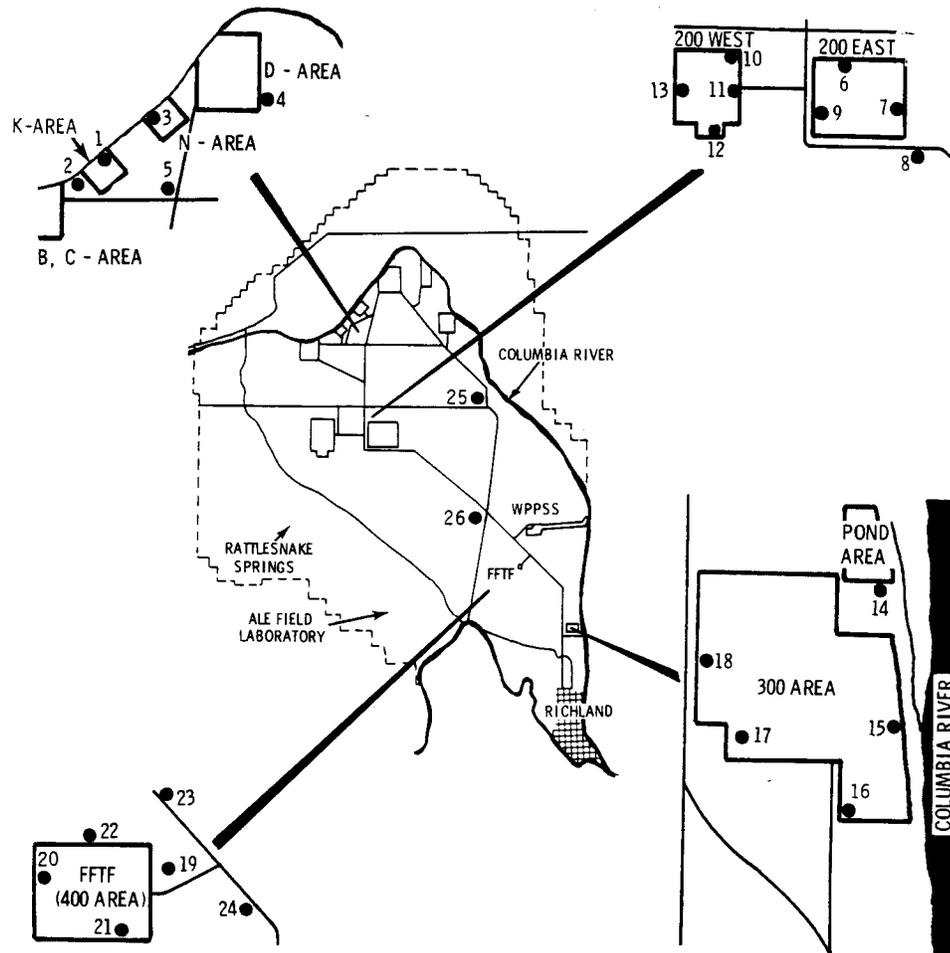


FIGURE 8. Onsite External Penetrating Dose Rate Measurement Locations--1981

TABLE 15. Onsite External Penetrating Dose Measurements

Location	Map Location	No. of Measurements	Dose Rate, mrem/yr ^(a)		
			Maximum	Minimum	Average ^(b)
Operating Areas					
100 Area	100 K	1	135	58	73 ± 11
	Below 100 K Retention Basin	2	402	325	368 ± 13
	100 N	3	124	47	85 ± 10
	100 D	4	88	69	76 ± 2.8
	100 Area Fire Station	5	13	77	66
200 East Area	200 ENC	6	172	120	146 ± 6.7
	200 EEC	7	88	77	81 ± 1.7
	200 ESE	8	84	69	77 ± 2.0
	200 EWC	9	13	77	62
200 West Area	200 WNE	10	84	66	72 ± 2.7
	200 WEC	11	77	62	68 ± 2.0
	Redox	12	88	66	74 ± 3.1
	200 WWC	13	13	106	88
300 Area	300 Pond	14	730	175	376 ± 132
	3614-A Bldg.	15	73	66	70 ± 1.5
	300 S Gate	16	80	66	71 ± 2.3
	300 SW Gate	17	73	62	70 ± 1.9
	3705 Bldg.	18	13	88	66
400 Area	400 E	19	77	66	72 ± 1.6
	400 W	20	73	62	65 ± 2.1
	400 S	21	73	62	69 ± 1.5
	400 N	22	77	62	68 ± 2.1
	FFTF North	23	80	69	73 ± 1.9
	FFTF Southeast	24	13	77	66
Inner East Sector	Hanford	25	73	58	69 ± 2.4
	Wye Barricade	26	84	69	74 ± 2.4

(a) Monthly integrated readings in mR were converted to annual dose equivalent rates.
 (b) Average shown includes ± two-standard error term (95% confidence level).

at Hanford for Cy-1981 (Sula et al. 1982, Table 14). For comparison, the 1981 average background dose rate, based on measurements recorded at five dosimeter locations some distance from the site boundary was $66 \pm 3^{(a)}$ mrem/yr.

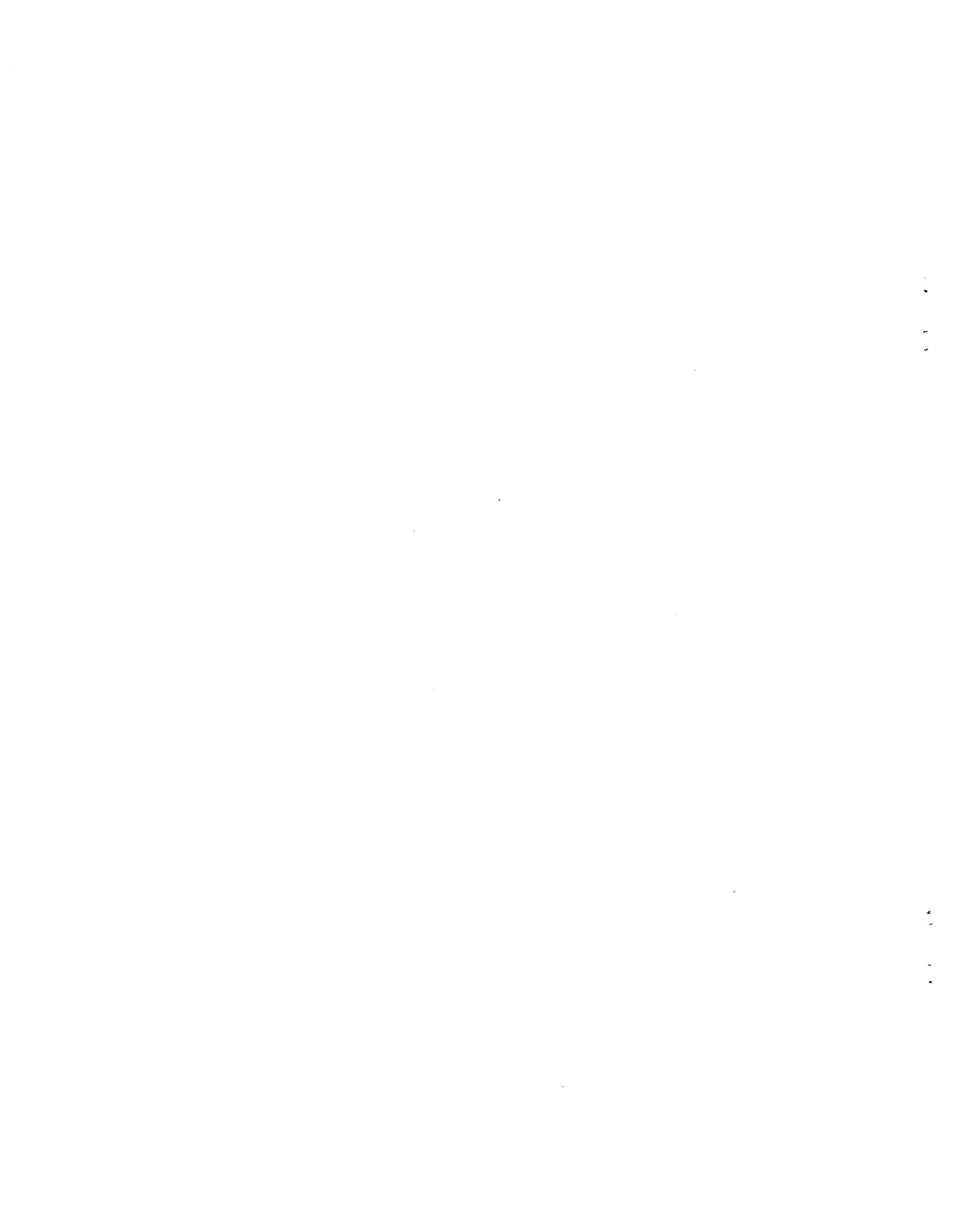
External penetrating radiation above background levels was observed in several locations near onsite operating areas during 1981. The existence of a subsurface contamination deposit at the "Below 100-K Retention Basin" dosimeter location was responsible for the consistently elevated dose rates observed at this location during the year. Slightly elevated readings were also observed at the 100-N and 100-D locations and are attributed to direct radiations and short-lived noble gases associated with N-Reactor operations.

Several dosimeters located on the perimeter of the 200 Areas also showed dose rates above background. The highest dose rates were observed at the 200-ENC location and at the 200-WWC location. Stored radioactive wastes within the 200 Areas are considered to be the cause for the slightly elevated dose rates. Dose rates in the 200 Areas were similar to those observed in previous years.

Dose rates in the 300 Area were near expected background levels except for the 300-Pond locations where monthly readings averaged five times background during 1981. Dose rates at this location increased sharply from background during 1980 because of the temporary storage of a radioactive steam generator nearby. An additional increase in dose rate was observed in August of 1981 during preparations for the relocation of the steam generator to a permanent facility. The increased dose rate is attributed to the movement of shielding and equipment at the temporary storage site. The steam generator was removed to a permanent storage location near the end of 1981 and, although not reflected in the data presented here, dose rates at the 300-Pond location have since returned to their original levels. The new steam generator examination facility is located in the northwest part of the 300 Area.

Dose rates near the 400 Areas were at expected background levels during 1981.

(a) The error term represents the two-standard error of the mean (95% confidence interval) compared to the two-standard deviation of the distribution of measurement data reported in previous years.



RADIATION SURVEYS

Onsite environmental surveillance activities include periodic radiation surveys of site roads, railroads and radioactive waste disposal sites outside of operating areas. An aerial survey of the site perimeter also is conducted. Any observation of degradation of radiological conditions is resolved and appropriate facility personnel are notified. Followup surveys or reviews are performed as needed. Routes and frequencies for 1981 surveys were defined in the surveillance program's Master Schedule (Blumer, Sula and Eddy 1980).

ROAD SURVEYS

Roads, shown in Figure 9, were surveyed using scintillation detectors mounted on the rear bumper of a vehicle and positioned approximately 0.3 m

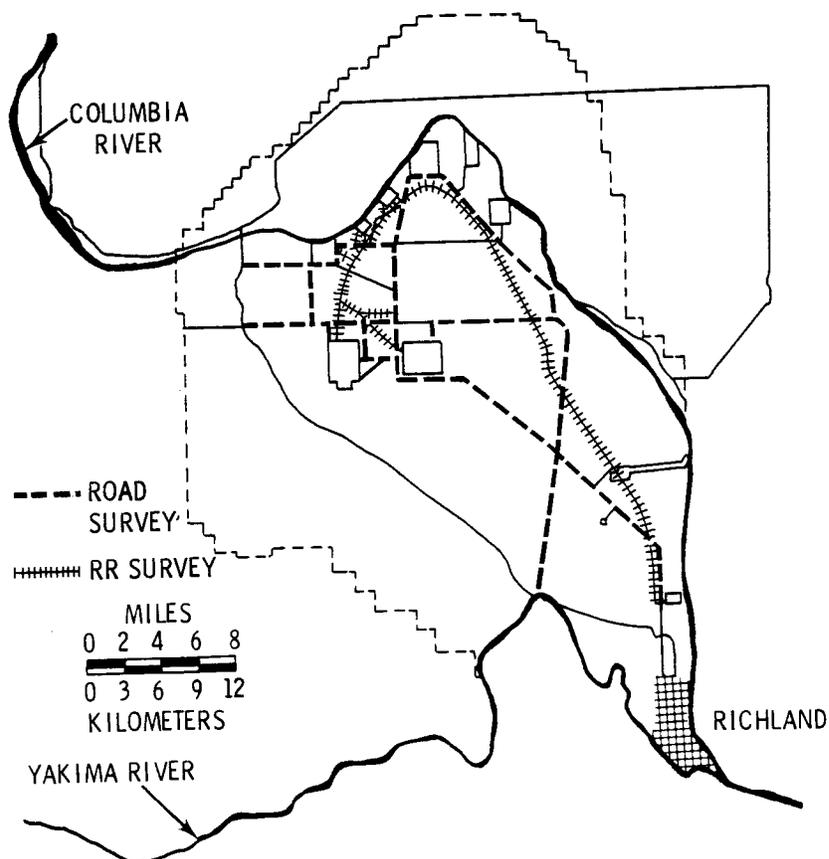


FIGURE 9. Road and Railroad Survey Routes

above the surface of the road. During 1981, two systems were used intermittently as a new and improved road monitoring system was being developed. The first, described by Phillip and Sheen (1965), used a single detector mounted on the right side of the front bumper. The second system uses four detectors mounted across the rear bumper and provides for more complete road coverage. During 1981, slightly elevated contamination levels were observed inside the 300-Area gate near the process ponds. These levels resulted from the transfer of slightly contaminated soil from another area to the present location inside the 300 Area.

RAILROAD SURVEYS

Site railroad tracks, shown in Figure 9, were surveyed using a single scintillation detector mounted approximately 0.3 m above the ground in the center of a small rail car. The frequency of surveys was determined by the use of the track and the potential for contamination. No instances of railroad track contamination were detected during 1981.

AERIAL SURVEY

The perimeter of the site is surveyed on an annual basis using a scintillation detector mounted in an aircraft that is flown 500 ft above the ground at an air speed of 120 to 130 mph. No indication of any abnormal contamination levels were observed during the 1981 survey.

WASTE DISPOSAL SITE SURVEYS

Waste disposal sites (active, inactive, and retired) outside of operating area perimeter fences are routinely surveyed for changes in levels of radioactivity and visually inspected for general physical conditions. During 1981, no significant increases in the radioactivity levels from these waste disposal sites were observed. Decreases were noted in several cases due to recent decontamination efforts.

ENVIRONMENTAL RELEASES

Each operating contractor at Hanford is responsible for controlling, monitoring and reporting effluents discharged from their facilities. This section summarizes the planned and unplanned release of effluents at Hanford during 1981 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:

Battelle-Pacific Northwest Laboratories--Radioactive discharges to the environment during 1981 are contained in the DOE Effluent Information System. Nonradioactive discharges are monitored through the National Pollutant Discharge Elimination System (NPDES).

Westinghouse Hanford Company--Radioactive discharges to the environment during 1981 are contained in the DOE Effluent Information System.

UNC Nuclear Industries--Radioactive and nonradioactive discharges during 1981 are reported in an annual Effluent Release Report (Fogel 1982).

Rockwell Hanford Operations--Radioactive and nonradioactive discharges during 1981 are reported in several reports which are issued annually (Aldrich 1982; Sliger 1982; Anderson, Poremba and McCann 1982; and Speer et al. 1982).

The "Environmentally Related Unusual Occurrences" portion of this section includes a compilation of those unusual occurrences during 1981 which involved the unplanned release of radioactive materials to the environment. Formal reporting of the occurrence by the contractor involved is required by DOE. The complete 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 wastes.

- Airborne Effluents--Radioactive and nonradioactive pollutants discharged to the atmosphere during 1981 are summarized in Tables 16 and 17. The tables are subdivided according to the major operation areas and include all releases reported by contractors in each of the areas. Radioactive materials discharged to the atmosphere consisted of fission and activation products normally associated with the uranium fuel cycle. Nonradioactive airborne releases consisted primarily of emissions from fossil-fueled steam plants, oxides of nitrogen from fuel fabrication and waste handling facilities, and evaporated organic liquids 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.

Radioactive and nonradioactive liquid wastes, discharged to the ground during 1981, are shown in Tables 18 and 19, 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 1981 are listed in Table 20. The reported discharges are for liquid effluent systems in the 100 Areas, including seepage from the 1301-N crib and trench system at 100-N Area. Not included in Table 20 are the quantities of ^3H (tritium) and ^{129}I that entered the Columbia River via the unconfined Hanford aquifer (Eddy, Cline and Prater 1982). 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, but did indicate that approximately 0.005 Ci of ^{129}I entered the river via ground water during 1981 (Sula et al. 1982).

TABLE 16. Radioactive Airborne Discharges from DOE Facilities at Hanford During 1981

Radionuclide	Half-Life	Effluent (Ci)			
		100 Area	200 Area	300 Area	400 Area
³ H (HTO)	12.3 yr	18			
¹⁴ C	5700 yr	3.2		4.5 x 10 ⁻⁷	
²⁴ Na	15.0 hr	0.12			
³² P	14.3 d				
⁴¹ Ar	1.8 h	65,000			
⁵⁴ Mn	303 d	0.003			
⁵⁶ Mn	2.6 hr	0.46			
⁵⁹ Fe	46.0 d	0.003			
⁵⁸ Co	71.0 d	0.008			
⁶⁰ Co	5.3 yr	0.018		3.3 x 10 ^{-7(a)}	
⁶⁵ Zn	245 d	0.001			
⁷⁶ As	26.4 hr	0.68			
^{85m} Kr	4.4 hr	250			
⁸⁷ Kr	76.0 min	280			
⁸⁸ KrRb	2.8 hr	530			450
⁸⁹ Sr	52.7 d	0.002			
⁹⁰ Sr	27.7 yr	0.006	0.02 ^(b)	4.6 x 10 ^{-5(c)}	4.1 x 10 ^{-5(c)}
⁹¹ Sr	9.7 hr	0.18			
⁹⁵ Nb	35.0 d	0.001			
^{99m} MoTc	66.7 hr	0.26			
¹⁰³ Ru	39.5 d	0.003			
¹⁰⁶ Ru	368 d	0.004			
¹²⁴ Sb	60.4 d	0.037			
¹³² Te	77.7 hr	0.006			
¹²⁹ I	1.7 x 10 ⁷ yr	1.9 x 10 ⁻⁸			
¹³¹ I	8.1 d	0.097		2.9 x 10 ⁻⁴	1.3 x 10 ⁻⁵
¹³² I	2.3 hr	4.7			
¹³³ I	20.3 hr	0.82			
¹³⁵ I	6.7 hr	3.0			
¹³⁵ Xe	9.1 hr	490			
¹³⁴ Cs	2.1 yr	7.5 x 10 ⁻⁵			
¹³⁷ Cs	30.0 yr	0.01	0.06		
¹³⁸ Cs	32.2 min	11,000			
¹⁴⁰ BaLa	12.8 d	0.11			
¹⁴⁴ CePr	284 d	0.11			
¹⁴⁷ Nd	11.1 d	0.011			
¹⁵⁴ Eu	16.0 yr	0.15			
¹⁵⁵ Eu	1.8 yr	0.026			
¹⁸⁷ W	23.9 hr	0.10			
U-nat	4.4 x 10 ⁹			7.5 x 10 ⁻⁵	
²³⁸ Pu	86.4 yr	1.0 x 10 ⁻⁵			
²³⁹ Pu	2.4 x 10 ⁴ yr	6.4 x 10 ⁻⁵	7.3 x 10 ^{-4(d)}	4.2 x 10 ^{-5(e)}	6.3 x 10 ^{-6(e)}

(a) Reported as mixed activation products. Cobalt-60 was assumed for dose calculations.

(b) Reported as total beta activity composed principally of ⁹⁰Sr.

(c) Reported as mixed fission products and unidentified beta-gamma activity. Strontium-90 was assumed for dose calculations.

(d) Reported as total alpha activity composed principally of ²³⁹Pu.

(e) Reported as ²³⁹Pu and unidentified alpha activity. Plutonium-239 was assumed for dose calculations.

NOTE: As reported by the operating contractor.

TABLE 17. Nonradioactive Airborne Discharges from DOE Facilities at Hanford During 1981

Constituent	Effluent, kg		
	100 Area	200 Area	300 Area
Particulates	5.9×10^4	3.7×10^6	1.3×10^4
Nitrogen Oxides	2.1×10^5	3.9×10^5	$1.7 \times 10^{5(a)}$
Sulfur Oxides	7.0×10^5	5.9×10^5	2.2×10^5
Carbon Monoxide	1.0×10^4	5.1×10^4	
Hydrocarbons	7.9×10^3	2.6×10^4	
Aldehydes	2.7×10^3	2.6×10^4	
Perchloroethylene			$1.5 \times 10^{4(b)}$
1,1,1-Trichloroethylene			$1.1 \times 10^{3(b)}$

(a) Includes discharges by HEDL and UNC.

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

NOTE: As reported by the operating contractor.

Nonradioactive liquid effluents discharged to the Columbia River are monitored in compliance with discharge permits issued under the National Pollution Discharge Elimination System (NPDES). Monitoring required by the permits includes flow, temperature, pH, suspended and settleable solids, and oil and grease as appropriate for each specific discharge point. Chemical pollutants reported discharged to the river during 1981 included aluminum sulfate, hydrazine, and morpholine (Fogel 1982).

- 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 (primarily plutonium). Solid wastes containing ^{233}U or transuranics are packaged and buried separately from the nontransuranic wastes for possible retrieval at a future date. Table 21 lists the quantities of radionuclides contained in solid waste burials during 1981 (Anderson, Poremba and McCann 1982). Nonradioactive solid wastes include general refuse, asbestos and waste

TABLE 18. Radioactivity in Liquids Discharged to Ground Disposal Facilities at Hanford During 1981

Radionuclide	Quantity, Ci (except as noted)		
	100 Areas	200 Areas	300 Area
³ H	82	1.9	
³² P	140		
⁵¹ Cr	110		
⁵⁴ Mn	240		
⁵⁹ Fe	160		
⁵⁸ Co	180		
⁶⁰ Co	370		
⁸⁹ Sr	66		
⁹⁰ Sr	84	10	
⁹⁵ ZrNb	66		
^{99m} MoTc	760		
¹⁰³ Ru	260		
¹⁰⁶ Ru	100	3.1	
¹²⁴ Sb	6.4		
¹²⁵ Sb	2.7		
¹³¹ I	120		
¹³³ Xe	180		
¹³⁴ Cs	21	.01	
¹³⁷ Cs	240	19.4	
¹⁴⁰ BaLa	3000		
¹⁴¹ Ce	13		
¹⁴⁴ CePr	120		
¹⁵⁴ Eu		.013	
¹⁵⁵ Eu	15	.010	
Unidentified Beta		110	.180
Short-Lived Radionuclides	26,000 ^(a)		
²³⁴ U			.098
²³⁵ U			.004
²³⁸ U		<309 Kgm	.089
²⁴¹ Am		.074	
²³⁸ Pu	.11		
²³⁹⁻²⁴⁰ Pu	.56	.13	
Pu Total		2.13 grams	

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

NOTE: As reported by the operating contractor.

TABLE 19. Nonradioactive Liquid Discharges to the Ground at Hanford During 1981

Constituent	Quantity Discharged, kg (except as noted)		
	100 Area ^(a)	200 Area	300 Area
Aluminum Sulfate	2.2 x 10 ⁵		
Chlorine	2.0 x 10 ⁴		
Polyacrylamide	5.4 x 10 ²		
Sulfuric Acid	4.4 x 10 ⁵		
Ammonium Hydroxide	1.8 x 10 ⁴		
Hydrazine	1.3 x 10 ⁵ l		
Morpholine	8.7 x 10 ³ l		
Sodium Hydroxide	2.3 x 10 ⁶ l		
Nonradioactive Effluents		2.5 x 10 ⁵ m ³ (b)	
Zn			159
Hg			0.45
NO ₃			2.6 x 10 ⁴
Pb			1.36
Cd			5.90
Cu			277
F			1.1 x 10 ³

(a) Reported as quantity consumed.

(b) Includes water treatment backwash, powerhouse cooling water, ash sluicing water, steam condensates, etc.

NOTE: As reported by the operating contractor.

chemicals that are buried in a sanitary landfill near the 200 Areas.

The quantities buried during 1981 are listed in Table 21.

ENVIRONMENTAL-RELATED UNUSUAL OCCURRENCES

Several unplanned releases of radioactive or nonradioactive materials occurred during 1981 as a result of accidents or other unusual occurrences (equipment or instrumentation malfunctions, operator errors, or design inadequacies). The impact of the releases on the environment was negligible and, for the most part, confined to the immediate vicinity of the release point.

TABLE 20. Radioactive Liquid Discharges to the Columbia River from DOE Facilities at Hanford During 1981

<u>Radionuclide</u>	<u>Half-Life</u>	<u>Discharge, Ci</u>
³ H (HTO)	12.3 yr	82
³² P	14.3 d	0.68
⁵⁴ Mn	303 d	0.036
⁵⁶ Mn	2.6 hr	3.8
⁵⁸ Co	71.0 d	0.023
⁶⁰ Co	5.3 yr	0.60
⁸⁹ Sr	52.7 d	1.2
⁹⁰ Sr	27.7 yr	1.8
⁹⁵ ZrNb	65.5 d	0.1
^{99m} MoTc	66.7 hr	0.83
¹⁰³ Ru	39.5 d	0.038
¹⁰⁶ Ru	368 d	0.38
¹²⁴ Sb	60.4 d	0.77
¹²⁵ Sb	2.7 yr	0.12
¹²⁹ I	1.7 x 10 ⁷ yr	8.0 x 10 ⁻⁶
¹³¹ I	8.1 d	2.4
¹³³ I	20.3 hr	0.62
¹³³ Xe	5.3 d	1.5
¹³⁷ Cs	30.0 yr	0.053
¹⁴⁰ BaLa	12.8 d	0.5
¹⁴⁴ CePr	284 d	0.02
²³⁸ Pu	86.4 yr	2.9 x 10 ⁻⁴
²³⁹ Pu	2.4 x 10 ⁴ yr	7.3 x 10 ⁻⁵

NOTE: As reported by the operating contractor.

Formal occurrence reports were issued by the responsible contractor for each occurrence. A brief discussion of each occurrence is provided in the following summaries. The complete report may be found in the public reading room of the Hanford Science Center.

TABLE 21. Solid Wastes Buried at Hanford During 1981

Waste	Quantity
Radioactive	
Uranium	5.6 x 10 ⁶ g
Plutonium	2.9 x 10 ⁴ g
Other Transuranics	2.2 x 10 ⁴ g
Strontium-90	1.8 x 10 ⁴ Ci
Ruthenium-106	1.7 x 10 ⁴ Ci
Other Fission and Activation Products	8.9 x 10 ⁴ Ci
General Wastes	16,000 m ³
Asbestos	310 m ³
Waste Chemicals	54 m ³
Fly Ash and Boiler Clinker Wastes	1.8 x 10 ⁴ m ³

NOTE: As reported by the operating contractor.

- Airborne Effluents--No unusual occurrences relating to airborne effluents were reported during 1981.
- Liquid Effluents--Five unusual occurrences involving liquid wastes were reported during 1981.

- UNC Occurrence Report No. 81-01, 01/05/81

Perchloroethylene (371 gal) was spilled into the 333 Building chemical sewer when a hose connection broke. A total of 255 gal of solvent was recovered with no indication of significant environmental impact.

- UNC Occurrence Report No. 81-08, 01/12/81

The NPDES temperature limit for Discharge 005 at the 100-N Area was exceeded. The violation occurred when the Emergency Raw Water Silo was drained without the adequate addition of cool water. The procedure for draining the silo was modified to preclude future violations. No indication of significant environmental impact was observed.

- UNC Occurrence Report No. 81-15, 03/20/81

Sulfuric acid, resulting from a transfer line leak, was observed outside of the 108-N Building, in the 100-N Area. The material was neutralized with soda ash and the area cleaned up with no indication of adverse environmental impact.
- RHO Occurrence Report No. 81-43, 06/25/81

The Chemical Sewer line from 231-Z was crushed by a water truck. No contaminated effluent was present or expected in the line and no contamination was detected at the site. The pipe was repaired with no indication of adverse environmental impact.
- RHO Occurrence Report No. 81-47, 07/07/81

Cooling water from B-Plant was inadvertently released without being sampled. This effluent is routinely discharged to B-Pond following proper sampling and volume determinations. Continuous monitors on the effluent line indicated the released water was within discharge limits. Training procedures were improved for personnel responsible for sampling. No indication of adverse environmental impact was observed.
- Solid Wastes--Six occurrences during 1981 involved contaminated solid materials.
 - RHO Occurrence Report No. 81-10, 02/03/81

Uranium oxide was inadvertently spread outside of the 224-UA and 224-U Buildings in the 200-W Area. The area was immediately cleaned up with no adverse effect on the environment.
 - RHO Occurrence Report No. 81-33, 04/30/81

A few very small specks of contamination were discovered in the vicinity of the 241-S Tank farm while operators were relocating materials within the site. The low-level contamination was promptly cleaned up with no indication of adverse environmental effects.

- RHO Occurrence No. 81-38, 06/04/81

Radioactively contaminated tumbleweeds were found in the vicinity of the BC Cribs Controlled Area. The contaminated vegetation was cleaned up and tumbleweeds growing over the trenches were removed and the area sprayed with an herbicide to prevent future vegetation growth over the trenches. No indication of adverse environmental impact was noted.

- RHO Occurrence Report No. 81-68, 10/13/81

Radioactive contamination was found on and around several railroad cars during a transfer of solid wastes to the 200-E burial grounds. The contamination was fixed immediately with soil and plastic and the affected areas subsequently cleaned up with no indication of adverse environmental impact.

- RHO Occurrence Report No. 81-22, 10/27/81

Radioactively contaminated pigeon feces (primarily ^{90}Sr) were discovered on and near several buildings in and around the 200 Areas. Due to the nature of the contamination, clean up efforts are continuing through 1982. No adverse environmental impact is expected due to the locations of the materials and relatively low levels of contamination observed. Efforts to preclude the entry of birds to areas where the radioactive materials are available in the 200 Areas are ongoing.

- RHO Occurrence Report No. 81-80, 11/23/81

A contamination spread occurred near the 204-S railroad car unloading facility in the 200-W Area. The affected area was immediately secured, stabilized and decontaminated with no indication of adverse environmental impact.

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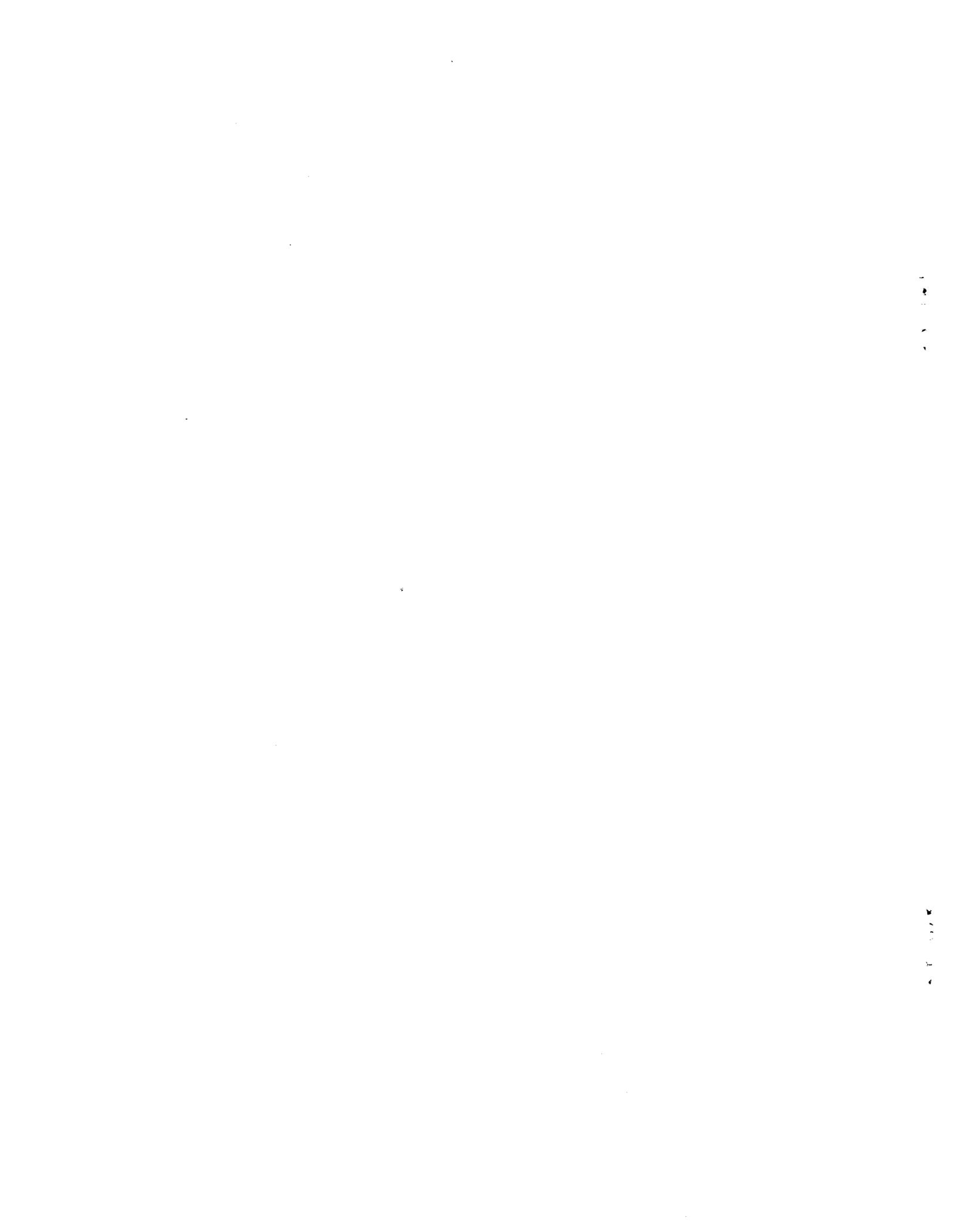
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APPENDIX A

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 23-cm x 23-cm (9-in. x 9-in.) NaI (Tl) well detector with a multichannel gamma-ray spectrometer.

Strontium-89, 90 are 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.

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 and electrodeposited on a stainless steel disk, exposed to nuclear track film, and then counted.

Tritium in air as HTO is determined by collecting the water vapor with silica gel. The water vapor is 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 in a 23-cm x 23-cm (9-in. x 9-in.) NaI (Tl) well detector with a multichannel gamma-ray spectrometer.

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 (liters)	MDC (pCi/l)	Minimum Sample Size (liters)	MDC (pCi/l)	Minimum Sample Size (kg)	MDC (pCi/kg)	Minimum Sample Size (kg)	MDC (pCi/kg)
³ H	5 m ³	300 pCi/l	1	50						
⁸⁹ Sr	1500	0.06	10	0.6			0.5	5		
⁹⁰ Sr	1500	0.006	10	0.06			0.5	2	0.5	5
¹²⁹ I					1000	0.00001				
¹³¹ I	1500	0.01	1	4	1000	0.1	4l (milk)	0.5 (pCi/l)		
U-nat			0.01	0.5					0.5	10
²³⁸ Pu					1000	0.01			0.5	0.6
^{239/240} Pu	1500	0.0001			1000	0.01			0.5	0.6
Gamma-Emitters	1500	0.1 ^(b)	5	8 ^(b)	1000	0.1 ^(b)	0.5	15 ^(b)	0.5	20 soil, 30 vegetation
Gross Alpha	800	0.001	1	5						
Gross Beta	800	0.01	1	10						

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

(b)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.

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 in a 23-cm x 23-cm (9-in. x 9-in.) NaI (Tl) well detector with a multichannel gamma-ray spectrometer.

Strontium-90 in large-volume water samples is precipitated with fuming nitric acid, scavenged with barium chromate, precipitated as a carbonate, transferred to 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 electrolysis and then counted with a 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 ^{129}I and by chemical separation and alpha spectrometry for plutonium.

Milk

Gamma-Emitting Radionuclides are measured by a direct count of the sample in a 23-cm x 23-cm (9-in. x 9-in.) NaI (Tl) well detector with a multichannel gamma-ray spectrometer.

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-90 is removed by drying, wet ashing, precipitating with fuming nitric acid, scavenging with barium chromate, precipitating as a carbonate, and transferring to a stainless steel planchet for counting with a low-background gas flow proportional counter.

Farm Produce

Gamma-Emitting Radionuclides are determined by a direct count of the sample in the well of a 23-cm x 23-cm (9-in. x 9-in.) NaI (Tl) well detector with a multichannel gamma-ray spectrometer.

Plutonium analyses are made like those for air filter samples after drying, ashing in a furnace, and treating with nitric acid prior to the anion exchange step.

Uranium analyses are made like those for water samples after drying, ashing in a furnace, and treating with nitric acid prior to the ether extraction step.

Strontium-90 analyses are made like those for air samples after drying, ashing in a furnace, and treating with nitric acid prior to the fuming nitric acid step.

Vegetation

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 multichannel pulse height analyzer.

Plutonium and Strontium-90 are determined after the soil is dried, mixed thoroughly, leached with a mixture of nitric and hydrochloric acids, and then passed through an ion exchange resin in nitric acid.

The nitric acid retains strontium and other metal ions. Strontium-90 is separated and counted in a manner similar to the fuming nitric acid procedure described for air filter samples.

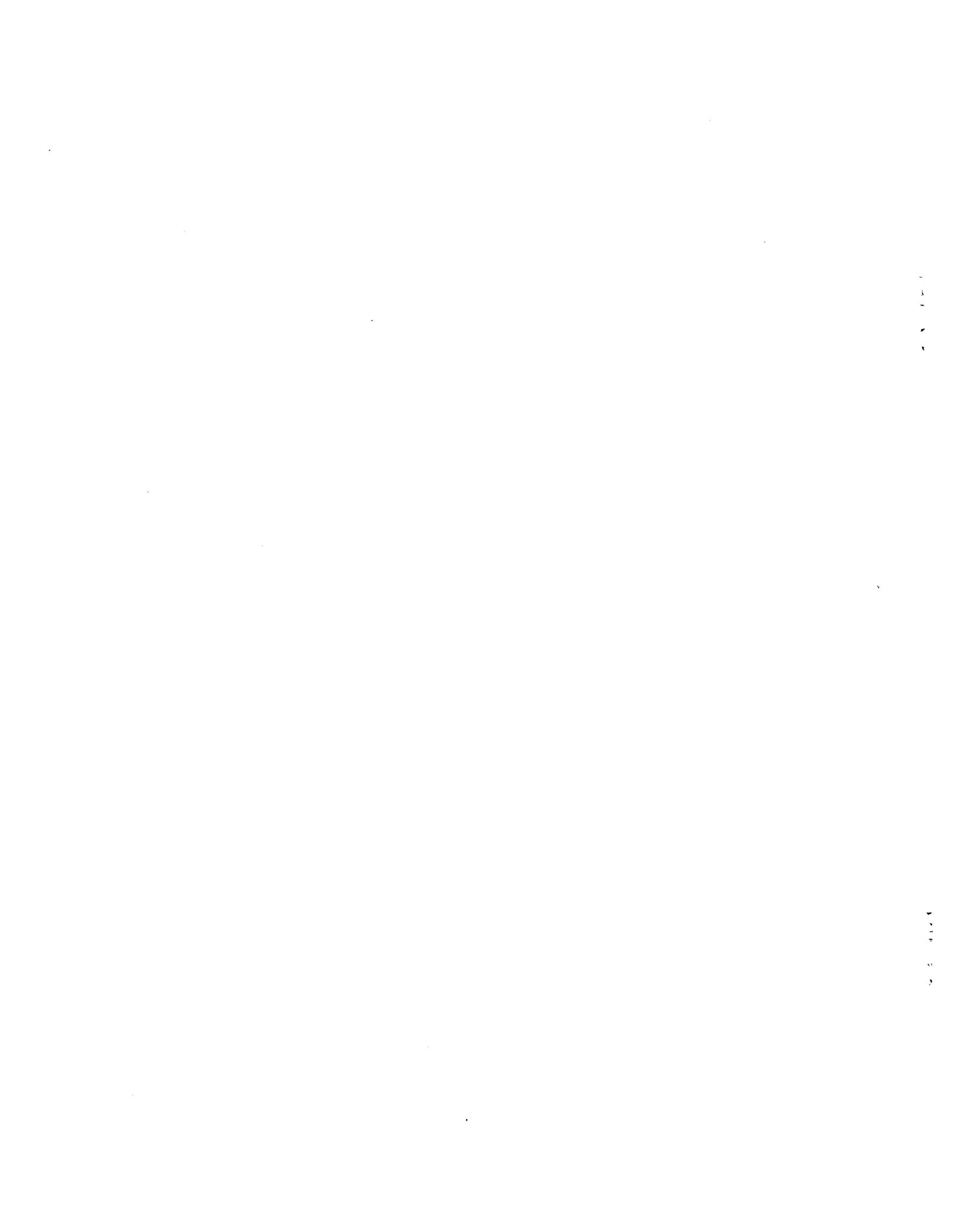
The plutonium is eluted from the resin column with nitric and hydrofluoric acids and analyzed by a method similar to the procedure described for air filter samples.

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* are used for a wide range of analyses.



APPENDIX B

DATA ANALYSIS

APPENDIX B

DATA ANALYSIS

The measurement of any physical quantity, whether it be 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, most 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. Many of the concentrations of radioactivity in samples of environmental media are very low, near zero, such that the counting error associated with the measurement may be larger than the indicated concentration. In these situations, the radioactivity in the sample was too low to be detected using the particular measurement technique. As an aid to the reader, individual measurements in this report, if less than their associated analytical uncertainty, are enclosed within parenthesis. If the number within the parenthesis includes a " \pm " term, the actual observed result is given along with its statistical counting error. This result will always be smaller than its counting error and may even be zero or a negative number. If the number within the parenthesis is preceded by a "<" sign, the number signifies the

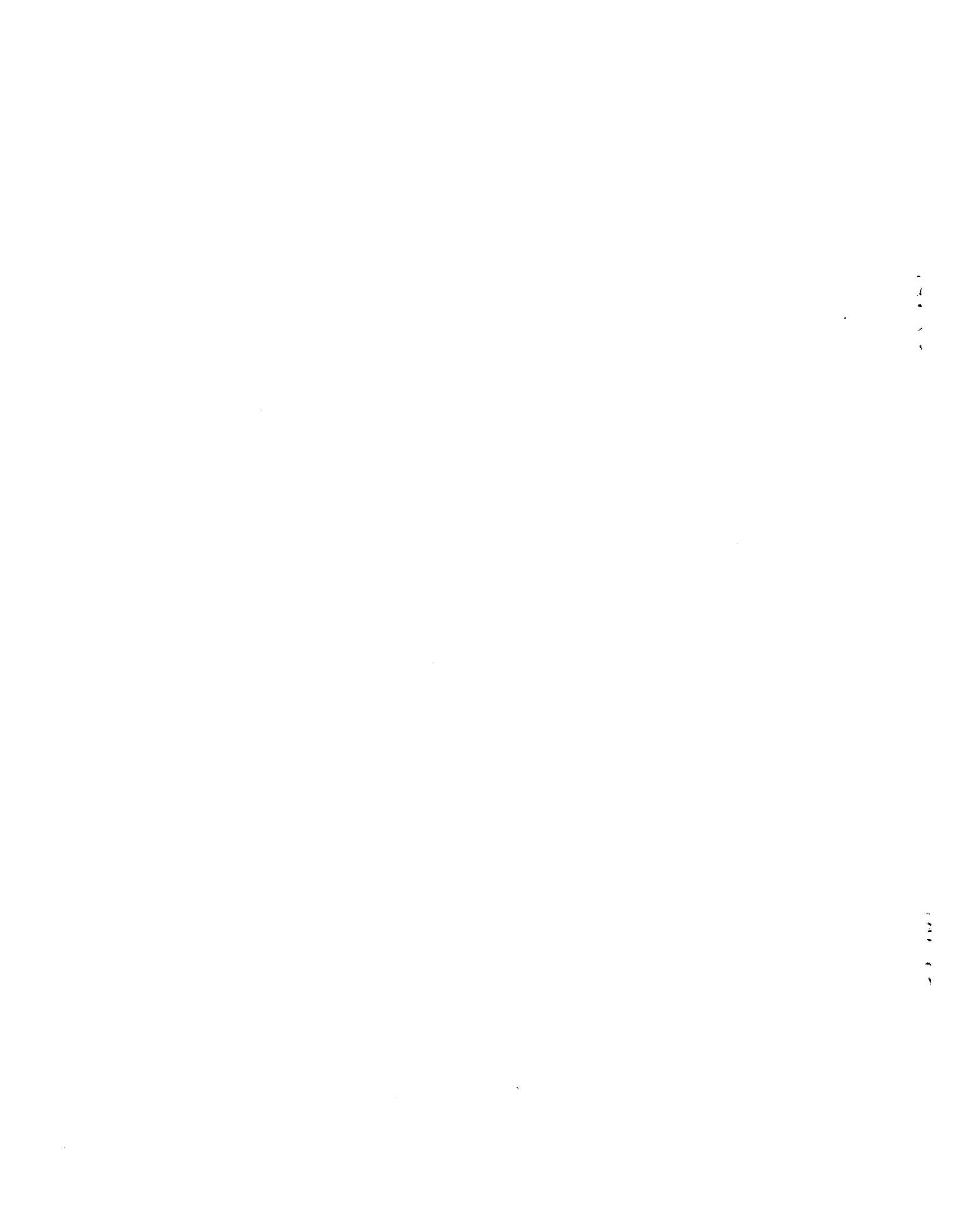
statistical counting error with the implied assumption that the observed result was lower.

Although values that are less than their associated uncertainty term do not represent a physically real quantity in themselves, it is appropriate to include them when computing the overall averages of a group of samples. For samples whose results were reported as less than (<) the statistical counting error, the concentration in the sample was assumed to be equal to the reported counting error when calculating group averages. This procedure results in a high biased average, which is reported with an accompanying less than (<) sign.

In this report, averages also include an uncertainty term that represents the distribution of the calculated mean. The term used to express the uncertainty associated with the mean is the two-standard error of the mean 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.

Footnotes to the tables further explain the data presented.



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