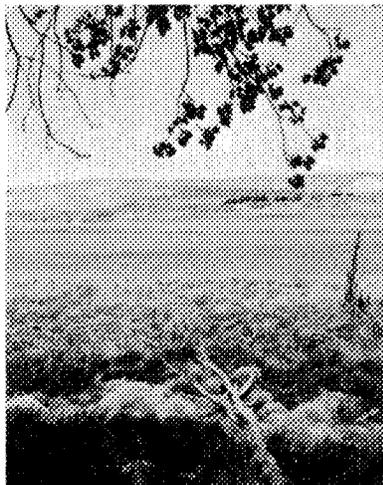
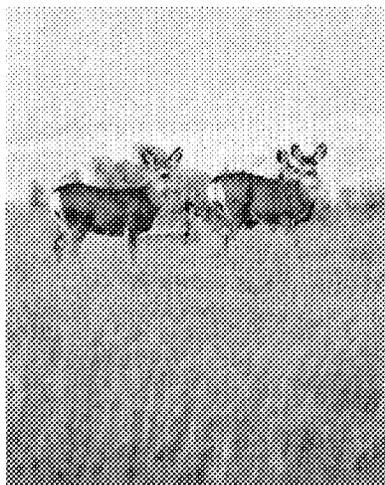
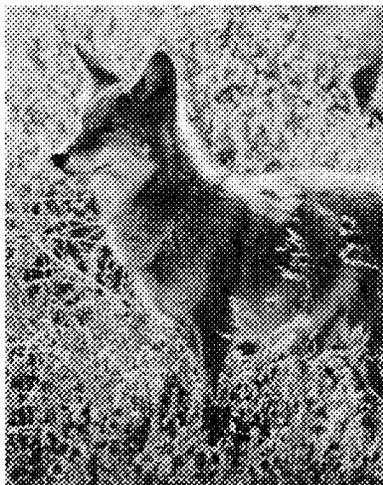
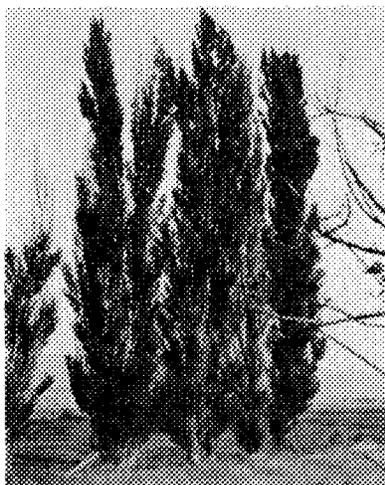


Environmental Surveillance at Hanford for CY-1979



**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**



NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The views, opinions and conclusions contained in this report are those of the contractor and do not necessarily represent those of the United States Government or the United States Department of Energy.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
Under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy \$ _____*; Microfiche \$3.00

*Pages	NTIS Selling Price
001-025	\$4.00
026-050	\$4.50
051-075	\$5.25
076-100	\$6.00
101-125	\$6.50
126-150	\$7.25
151-175	\$8.00
176-200	\$9.00
201-225	\$9.25
226-250	\$9.50
251-275	\$10.75
276-300	\$11.00

ENVIRONMENTAL SURVEILLANCE AT
HANFORD FOR CY-1979

J. R. Houston
P. J. Blumer

April 1980

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

6
4

24
11

PREFACE

The Environmental Surveillance Program at the Hanford Site in Washington State is conducted by the Pacific Northwest Laboratory (PNL) under contract to the Department of Energy (DOE). U.S. Government operations at Hanford have always included support for environmental surveillance, and the data collected provide a historical record of the levels of radionuclides and radiation attributable to natural causes, worldwide fallout, and Hanford operations. The findings of the present program demonstrate the negligible impact attributable to either current Hanford operations or cumulative environmental effects from past Hanford operations. Where appropriate, the data are compared with applicable standards for air and water quality set forth by the Department of Energy, the Environmental Protection Agency (EPA), and the state of Washington. Summaries and interpretations of the data are published annually; the present document is for calendar year 1979.

SUMMARY

Environmental data collected during 1979 show continued compliance by Hanford with all applicable state and federal regulations.

Data were collected for most environmental media including air, Columbia River water, external radiation, foodstuffs (milk, beef, eggs, poultry, and produce) and wildlife (deer, fish, and game birds), as well as soil and vegetation samples.

In general, offsite levels of radionuclides attributable to Hanford operations during 1979 were indistinguishable from background levels. The data are summarized in the following highlights.

- Hanford operations during 1979 caused no distinguishable impact on concentrations of airborne radionuclides or on external radiation dose measured near to and far from the Hanford Site. (See pages 5-18 and 23-26.)
- The only distinguishable impact to wildlife from Hanford operations was to ducks at the onsite waste water ponds (See pages 19-21).
- Radionuclides observed in foodstuffs, and soil samples were all attributed to either worldwide fallout or natural sources. (See pages 15-26.)
- External dosimeter measurements on the islands and shoreline along the Hanford reach of the Columbia River showed elevated doses attributed to the presence of a few long-lived radionuclides, principally ^{60}Co , ^{137}Cs and ^{154}Eu from past operation of once-through-cooled production reactors. An extensive radiation survey of the shoreline and islands conducted during 1979 revealed areas where dose rates were higher than was previously thought to be the case. The incremental increase in radiation exposure to recreational users of the river is still considered to be insignificant. (See pages 27-30.)
- Low-level concentrations of a few radionuclides released to the Columbia River from N Reactor during 1979 were observed at the downstream sampling location. All of the observed river concentrations were far less than 1% of the most restrictive Manual Chapter guides for unrestricted areas. (See pages 9-14.)

The estimated impact of Hanford operations in terms of radiological dose was computed for

both the maximum individual and the population around Hanford. (The maximum individual is a hypothetical person situated so as to receive the maximum radiation exposure possible.) These doses include the impact of measurable levels of radionuclides in the environment and those known to have been released but not detectable in the environment. Summarized in the following highlights are the estimated radiological impacts during 1979.

- The maximum "fence-post" exposure rate for 1979, 0.8 mR/hr, occurred on the shore of the Columbia River in the vicinity of N Reactor. Radiation from N-Reactor radioactive waste handling facilities was primarily responsible for this exposure rate.
- The maximum annual whole-body dose to an individual from 1979 effluents was estimated to be less than 0.1 mrem. This included contributions from airborne, drinking water, irrigated foodstuff, and aquatic recreation pathways. The annual dose to a single organ received from all pathways was less than 0.5 mrem to the thyroid. These doses can be compared with the standards of Manual Chapter 0524 of 500 mrem/yr for the whole body and 1500 mrem/yr for organs other than the gonads and the bone marrow. (See pages 31-34.)
- Airborne effluents from the Hanford Site's three operating areas resulted in an annual whole-body dose to the population within an 80-km (50-mile) radius of Hanford of about 1.3 person-rem. Liquid effluents during 1979 contributed very little (about 0.01 person-rem) to the total population dose. This dose estimate may be compared with the approximately 25,000 person-rem received annually from natural background radiation. (See pages 34-35.)

Air quality measurements of NO_2 in the vicinity of the Hanford Site and releases of SO_2 onsite were well within the applicable federal and state standards. Particulate air concentrations exceed the standards primarily because of agricultural activities in the area. (See pages 6-7.)

Discharges of waste water from Hanford facilities into the Columbia River under the National Pollution Discharge Elimination System (NPDES) permit were all within the parameter limits on the permit. (See page 13.)

CONTENTS

PREFACE	iii
SUMMARY	v
FIGURES	ix
TABLES	x
INTRODUCTION	1
ATMOSPHERIC MONITORING	5
AIR SAMPLING	5
RADIOLOGICAL ANALYSIS	5
NONRADIOLOGICAL ANALYSIS	6
COLUMBIA RIVER MONITORING	9
WATER SAMPLING	9
RADIONUCLIDE ANALYSES	9
DRINKING WATER	10
TEMPERATURE	11
BIOLOGICAL ANALYSES	12
CHEMICAL ANALYSES	13
WASTEWATER DISCHARGES TO THE COLUMBIA RIVER	13
FOODSTUFFS	15
MILK	15
BEEF, CHICKEN, AND EGGS	15
FRUIT AND LEAFY VEGETABLES	15
WILDLIFE	19
DEER	19
WATER FOWL	19
UPLAND GAME BIRDS	20
FISH	20
SOIL AND VEGETATION	23
COLLECTION AND ANALYSIS	23
SOIL	23
VEGETATION	23
EXTERNAL RADIATION	27

HANFORD ENVIRONS	27
COLUMBIA RIVER IMMERSION DOSE	27
COLUMBIA RIVER SHORELINE AND ISLANDS	28
RADIOLOGICAL IMPACT OF HANFORD OPERATIONS	31
RADIOLOGICAL IMPACT FROM 1979 EFFLUENTS	31
Maximum "Fence-Post" Exposure Rate	31
Maximum Individual Dose	31
Airborne Releases	33
Drinking Water	33
Irrigated Foodstuffs	33
Aquatic Recreation	34
Population Dose	34
RADIOLOGICAL IMPACT FROM PAST HANFORD OPERATIONS	34
IMPACT SUMMARY	36
REFERENCES	39
APPENDIX A - APPLICABLE STANDARDS	A.1
APPENDIX B - ANALYTICAL PROCEDURES	B.1
APPENDIX C - DATA ANALYSIS	C.1
APPENDIX D - QUALITY ASSURANCE	D.1
APPENDIX E - RADIATION DOSE CALCULATIONS	E.1

FIGURES

1	DOE's Hanford Site in Washington State	1
2	Air Sampling Locations	5
3	Average Monthly Gross Beta Activity in the Atmosphere	7
4	Upstream and Downstream Concentrations of Radionuclides in Columbia River Water	12
5	Average Monthly Water Temperatures at Richland and Vernita	12
6	Daily Variation in Mean Temperature and Flow Rate	13
7	Milk Sampling Locations	15
8	Log Normal Probability Plot of ⁹⁰ Sr in Milk Samples	17
9	Log Normal Probability Plot of ⁹⁰ Sr in Leafy Vegetables	18
10	Onsite Waste Water Ponds	21
11	Soil and Vegetation Sampling Locations	22
12	Log Normal Probability Plot for Soil Samples	25
13	Log Normal Probability Plot for Vegetation Samples	26
14	Log Normal Probability Plot of Monthly Dose Measurements at Perimeter and Distant Locations	28
15	Thermoluminescent Dosimeter Locations for Columbia River Immersion and Sediment Measurements	29
16	Comparative Doses Received from Various Radiation Sources	37
E.1	Estimated Geographic Distribution of the Population (236,000) Within a 50-Mile (80-km) Radius of the 100-N Area	E.2
E.2	Estimated Geographic Distribution of the Population (258,000) Within a 50-Mile (80-km) Radius of the Hanford Meteorological Station	E.3
E.3	Estimated Geographic Distribution of the Population (171,000) Within a 50-Mile (80-km) Radius of the 300 Areas	E.4

TABLES

1	Airborne Radioactivity in the Hanford Environs	6
2	Selected Airborne Radionuclide Concentrations in the Hanford Environs	8
3	Radionuclide Concentrations Upstream from Hanford Operations	10
4	Radionuclide Concentrations Downstream from Hanford Operations	11
5	Radiological Analyses of Richland Drinking Water	12
6	Columbia River Chemical and Biological Analyses	14
7	Radionuclides in Milk	16
8	Radionuclides in Meat, Chicken, and Eggs	16
9	Radionuclides in Fruit and Leafy Vegetables	18
10	Radionuclides in Muscle Tissue of Deer, Fish and Upland Gamebirds	20
11	Radionuclides in Muscle Tissue of Waterfowl	20
12	Radionuclides in Soil	24
13	Radionuclides in Vegetation	26
14	Environmental Radiation Dose Measurements in the Hanford Vicinity.	28
15	Columbia River Immersion Dose Rate	29
16	Environmental Radiation Dose Measurements Along the Columbia Islands River Shoreline and Islands	30
17	Radionuclide Composition of Hanford Effluents for Calendar Year 1979	32
18	Annual Dose to the Maximum Individual from Effluents Released During 1979	33
19	50-Year Dose Commitment for the Maximum Individual from Effluents Released During 1979	34
20	Dose to the Population from Liquid Effluents Released During 1979	35
21	Dose to the Population from Airborne Effluents Released During 1979	35
A.1	Washington State Water Quality Standards for the Hanford Reach of the Columbia River	A.1
A.2	Air Quality Standards	A.2
A.3	Radionuclide Concentration Guides	A.2
D.1	Summary of Laboratory Intercomparison Results for 1979	D.2
D.2	QA Data for 100 Area Airborne Release Dose Calculation	D.3
D.3	QA Data for 100 Area Liquid Release Dose Calculation	D.4
D.4	QA Data for 200 Areas Airborne Release Dose Calculation	D.5
D.5	QA Data for 300 Area Airborne Release Dose Calculations	D.6

E.1	Annual Average Atmospheric Dispersion Around the 100-N Area for an 82-m Release Height	E.2
E.2	Annual Average Atmospheric Dispersion Around the 200 Areas for an 89-m Release Height	E.3
E.3	Annual Average Atmospheric Dispersion Around the 300 Area for a Ground-Level Release	E.5
E.4	Foodstuff Holdup and Consumption	E.5
E.5	Consumption and Usage Factors for Calculation of Exposures from the Columbia River	E.6



ENVIRONMENTAL SURVEILLANCE AT
HANFORD FOR CY-1979

INTRODUCTION

The U.S. Department of Energy's Hanford Site is located in a rural region of south eastern 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.

Established in 1943, the Hanford plant was 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. 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.

Steam from N Reactor operation is used to drive turbine generators that produce up to 860 million watts of electrical power in the Washington Public Power Supply System's (WPPSS) Hanford Generating Plant. By the end of 1979, N Reactor had supplied enough steam to produce nearly 50 billion kilowatt hours of electrical energy, which was fed to the Bonneville Power Administration grid covering the Pacific Northwest.

Facilities on the Hanford Site include the historic reactor facilities for plutonium production along the Columbia River, in what are known as 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 the reactor fuel manufacturing facilities and research and development laboratories. The Fast Flux

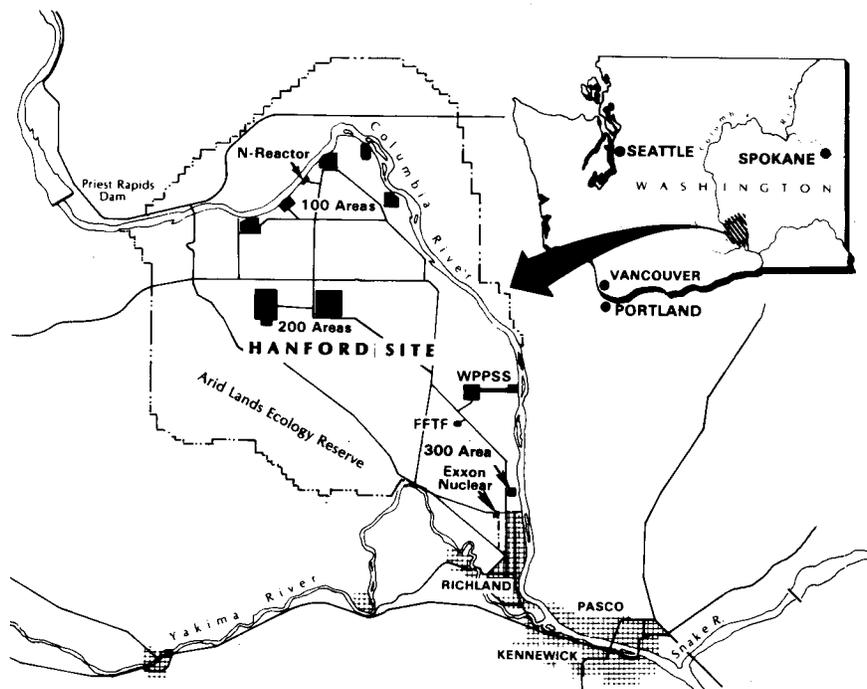


FIGURE 1. DOE's Hanford Site in Washington State

Test Facility (FFTF) is located in the 400 Area approximately 3.4 km (2.1 miles) northwest of the 300 Area.

Privately owned facilities located within the Hanford Site boundaries include the WPPSS generating station adjacent to N Reactor, the WPPSS power reactor site and office buildings, a hazardous waste disposal site, and a radioactive waste burial site. The Exxon fuel fabrication facility is located immediately 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 all site support services such as plant security, fire protection, central stores, electrical power distribution, etc.
- Battelle Memorial Institute-- responsible for operating the Department of Energy's Pacific Northwest Laboratory (PNL). This includes research in the physical, life, and environmental sciences, environmental surveillance, and advanced methods of nuclear waste management.
- UNC Nuclear Industries (UNI)-- responsible for operating and fabricating fuel for 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 the Fast Flux Test Facility.

During 1979, work at Hanford included N Reactor operation, nuclear fuel fabrication, liquid waste solidification, continued construction of the Fast Flux Test Facility, Hanford National Environmental Research Park (NERP) studies, and Arid Lands Ecology (ALE) studies, as well as continued use of a variety of research and laboratory facilities.

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 while the most abundant small game animal is the cottontail rabbit. The raccoon is the most abundant furbearing animal. 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 inversions that occur at night and break during the day, causing unstable and turbulent conditions.

With the exception of Hanford-related industries, the economy of the region is primarily agricultural. Crops include alfalfa, wheat, sugar beets, and potatoes. Several fruit orchards are located within a short distance of the Hanford Site. The Columbia River is used extensively for recreational purposes including fishing.

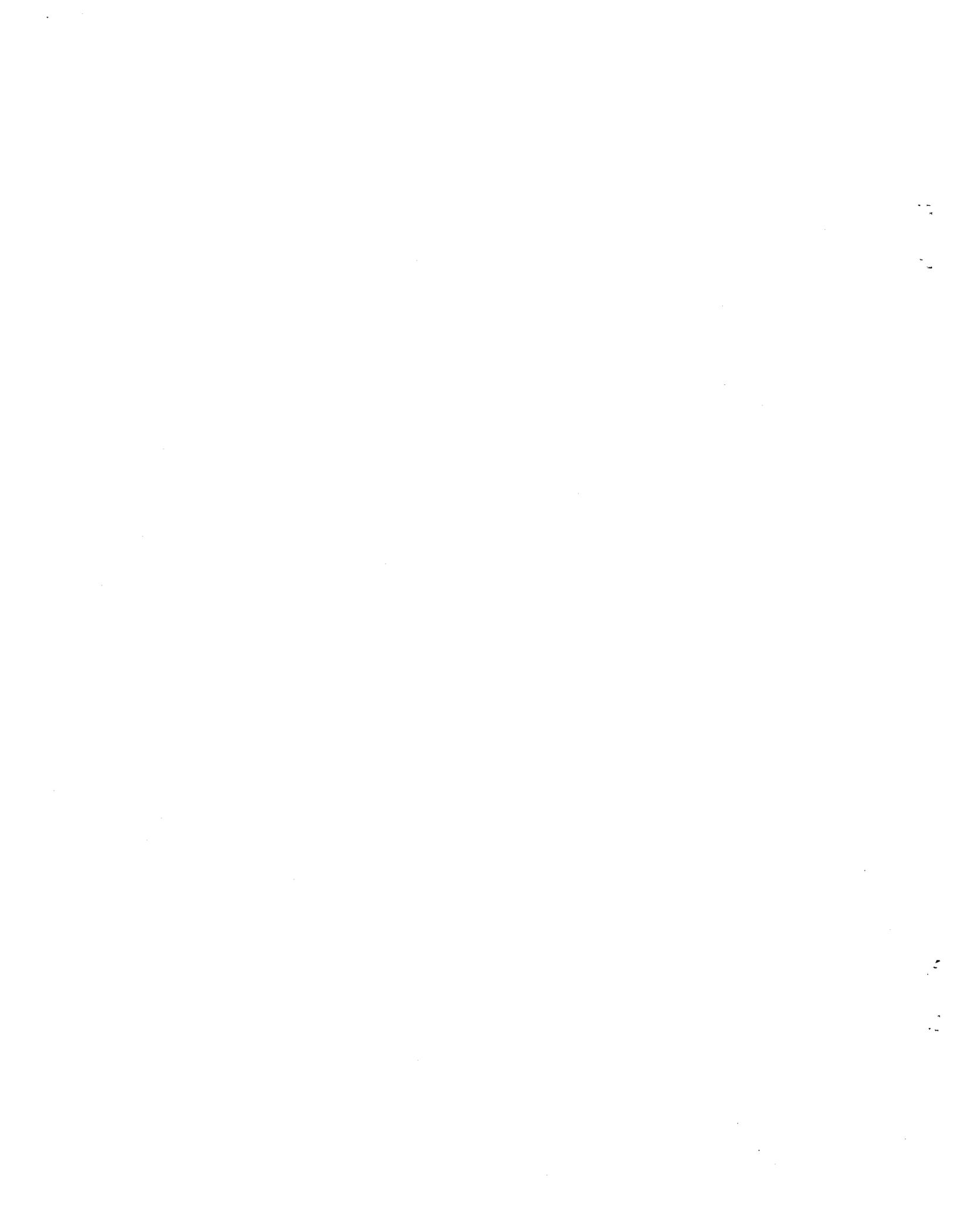
The population center nearest to the Hanford Site is the Tri-Cities area (Richland, Pasco, and Kennewick), situated on the Columbia River downstream from the site. The three communities, with a combined population of approximately 80,000, use the Columbia River as a source of drinking water. Approximately 250,000 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 for Waste Management Operations at Hanford.⁽¹⁾

The Hanford environmental surveillance program is conducted by PNL under contract to DOE. This program is designed to measure levels of radionuclides and radiation in the Hanford environs and to determine what portions are attributable to natural causes, worldwide fallout, and Hanford operations. The comprehensive ground-water monitoring program, also conducted by PNL for DOE, complements the surface portion of the total

program by determining the concentration, distribution, and impact of radionuclide and chemical constituents and is documented separately.⁽²⁾ Other environmental data collected deal with certain nonradioactive airborne pollutants and with the chemical and biological quality of the Columbia River and sanitary water.

All samples are collected according to a master surveillance schedule published each year.⁽³⁾ The analytical results of these

samples are presented and evaluated in a series of annual reports;⁽⁴⁾ included in this report are data collected during 1979. Any contribution to air or waterborne radionuclide concentrations that is attributable to Hanford operations is compared with the regulations in Manual Chapter 0524.⁽⁵⁾ Concentrations of nonradioactive pollutants are compared with applicable standards of the state of Washington⁽⁶⁾ or the Environmental Protection Agency.⁽⁷⁾



ATMOSPHERIC MONITORING

Many radionuclides from both natural sources and worldwide fallout are present in the atmosphere. Potential contributions to radionuclide levels from Hanford operations are smaller than those already present from worldwide fallout. Air is routinely sampled at numerous locations close to and distant from the Hanford Site to determine the existence and constituents of any Hanford contribution to the airborne radionuclide concentrations. During 1979, no statistically significant difference was observed between radionuclide concentrations at sampling locations near to and distant from the Hanford Site. Hanford contributions were thus indistinguishable from existing regional levels.

AIR SAMPLING

During 1979, radionuclides in the atmosphere were sampled by a network of 18 perimeter and 5 distant continuous air samplers at locations shown in Figure 2. Particulate airborne radionuclides are sampled by drawing air at a flow rate of 2.55 m³/hr (1.5 ft³/min) through 5-cm (2-in.)-diameter high-efficiency asbestos filter papers. Immediately downstream from the particulate filter is a cartridge of activated coconut charcoal impregnated with potassium iodide for the collection of gaseous radioiodine. Atmospheric moisture, for tritiated water analysis, is collected by passing a portion of the air flow through a cartridge of indicating silica gel at a rate of 28.4 l/hr (1 ft³/hr).

The particulate filters are collected biweekly and analyzed for gross beta and alpha activity after a wait of 7 days to allow the naturally-occurring short-lived

radon and thoron daughters to decay. Once a month the filters are grouped by geographical location and analyzed by gamma spectrometry. Each quarter the filters in each geographical group are dissolved and analyzed for ⁹⁰Sr and plutonium. Charcoal cartridges from six of the sampling locations are collected and analyzed biweekly for ¹³¹I. Charcoal cartridges from the remaining stations were changed monthly to assure that fresh collection media existed at each location. These samples were analyzed only if ¹³¹I was detected at one or more of the six stations where analyses were routinely performed. The silica gel cartridges, located at three of the perimeter sampling stations, are collected and analyzed biweekly.

RADIOLOGICAL ANALYSIS

Results for the particulate gross beta and gross alpha-emitter concentrations at perimeter and distant sampling stations are shown in Table 1. Gross beta-emitter concentrations were essentially the same at all stations, averaging 0.04×10^{-12} $\mu\text{Ci}/\text{ml}$ for both the perimeter and distant stations. This indicates that there was no measurable Hanford contribution to the airborne beta-emitter concentration. The decrease from the 1978 concentration of 0.11×10^{-12} $\mu\text{Ci}/\text{ml}$ for the perimeter stations is attributed to a reduction in world wide fallout levels.

Gross airborne beta-emitter concentrations for the years 1975 through 1979 are shown in Figure 3. Compared are the average monthly concentrations at perimeter and distant stations in the predominant downwind direction. The increase in airborne radionuclide concentrations observed in the spring is due to an increase in the rate at which natural and nuclear weapons test radioactivity is transferred from the lower stratosphere to the troposphere. This increase was not observed in 1976 or in 1978. The short-term increase in 1978 was due to the Chinese nuclear test in March.

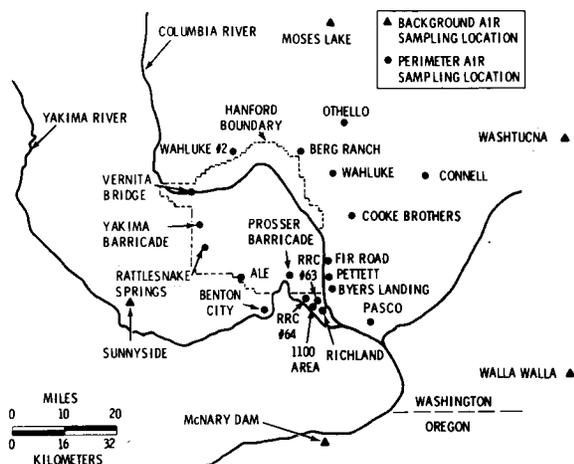


FIGURE 2. Air Sampling Locations

TABLE 1. Airborne Radioactivity in the Hanford Environs

Concentration Guide	Gross Beta Concentrations, pCi/m ³ (10 ⁻¹² uCi/ml)				Gross Alpha Concentrations, pCi/m ³ (10 ⁻¹² uCi/ml)			
	100				0.03			
	Average Detection Limit				0.0003			
Location	No. of Samples	Maximum	Minimum	Average ^(a)	No. of Samples	Maximum	Minimum	Average ^(a)
<u>Perimeter Stations</u>								
Benton City	26	0.09	0.005	0.04 ± 0.03	26	0.004	0.0006	0.001 ± 0.002
ALE	26	0.19	0.02	0.04 ± 0.07				
Rattlesnake Springs	26	0.15	0.02	0.05 ± 0.05				
Yakima Barricade	25	0.18	0.02	0.05 ± 0.06				
Vernita Bridge	27	0.13	0.01	0.04 ± 0.05				
Wahluke #2	27	0.10	0.02	0.04 ± 0.04				
Berg Ranch	26	0.10	0.02	0.04 ± 0.04	26	0.003	0.0006	0.001 ± 0.002
Othello	26	0.10	0.02	0.04 ± 0.04				
Wahluke Watermaster	26	0.08	0.01	0.04 ± 0.03				
Connell	26	0.12	0.01	0.04 ± 0.05				
Cooke Bros.	26	0.16	0.007	0.05 ± 0.06				
Fir Road	27	0.19	0.02	0.05 ± 0.07				
Pettett	27	0.15	0.02	0.04 ± 0.06				
Byers Landing	26	0.11	0.02	0.04 ± 0.04	25	0.004	0.0004	0.001 ± 0.002
Pasco	24	0.15	0.02	0.04 ± 0.06				
Richland	24	0.16	0.02	0.05 ± 0.06	24	0.004	0.0005	0.001 ± 0.002
1100 Area	25	0.18	0.01	0.04 ± 0.06				
RRC CP #64	26	0.17	0.03	0.05 ± 0.06	26	0.005	0.0005	0.002 ± 0.002
Overall Perimeter Station average ±2 standard deviations				0.04 ± 0.05				0.001 ± 0.002
<u>Distant Stations</u>								
McNary	26	0.17	0.02	0.04 ± 0.06				
Walla Walla	26	0.16	0.02	0.04 ± 0.05				
Washtucna	25	0.15	0.02	0.05 ± 0.06				
Moses Lake	26	0.12	0.02	0.04 ± 0.04				
Sunnyside	26	0.13	0.01	0.04 ± 0.05				
Overall Distant Station average ±2 standard deviations				0.04 ± 0.05				

(a) Average ±2 standard deviation is shown.

No entry indicates no analysis was made.

Shown in Table 2 are the results of specific radionuclide analyses. Beryllium-7 is a naturally-occurring radionuclide formed by the interaction of cosmic rays and nitrogen in the upper atmosphere. The other radionuclides, with the exception of plutonium, are fission products that result from atmospheric testing of nuclear weapons and, potentially, from Hanford operations.

All of the radionuclides shown were observed at similar concentrations at downwind, distant, and perimeter locations. All of the maximum observed concentrations occurred during the spring months.

NONRADIOLOGICAL ANALYSIS

Atmospheric emissions of total suspended particulates (TSP), SO₂, and NO₂ are within

applicable standards except for the TSP emission from two steam power plants. Projects have been defined to bring the TSP emissions within applicable standards.

The Hanford Site and surrounding area are not in compliance with the national and state primary ambient air standards for TSP. There are several reasons for this, none of which are related to Hanford operations. Primary contributors to the TSP concentrations in this area are agricultural and construction activities. Point source emissions of TSP on the Hanford Site total less than 5,000 tons/yr (4,545 metric tons/yr) compared to an estimated 2,500,000 tons (2,270,000 metric tons) in fugitive dust emissions from the surrounding three-county area.

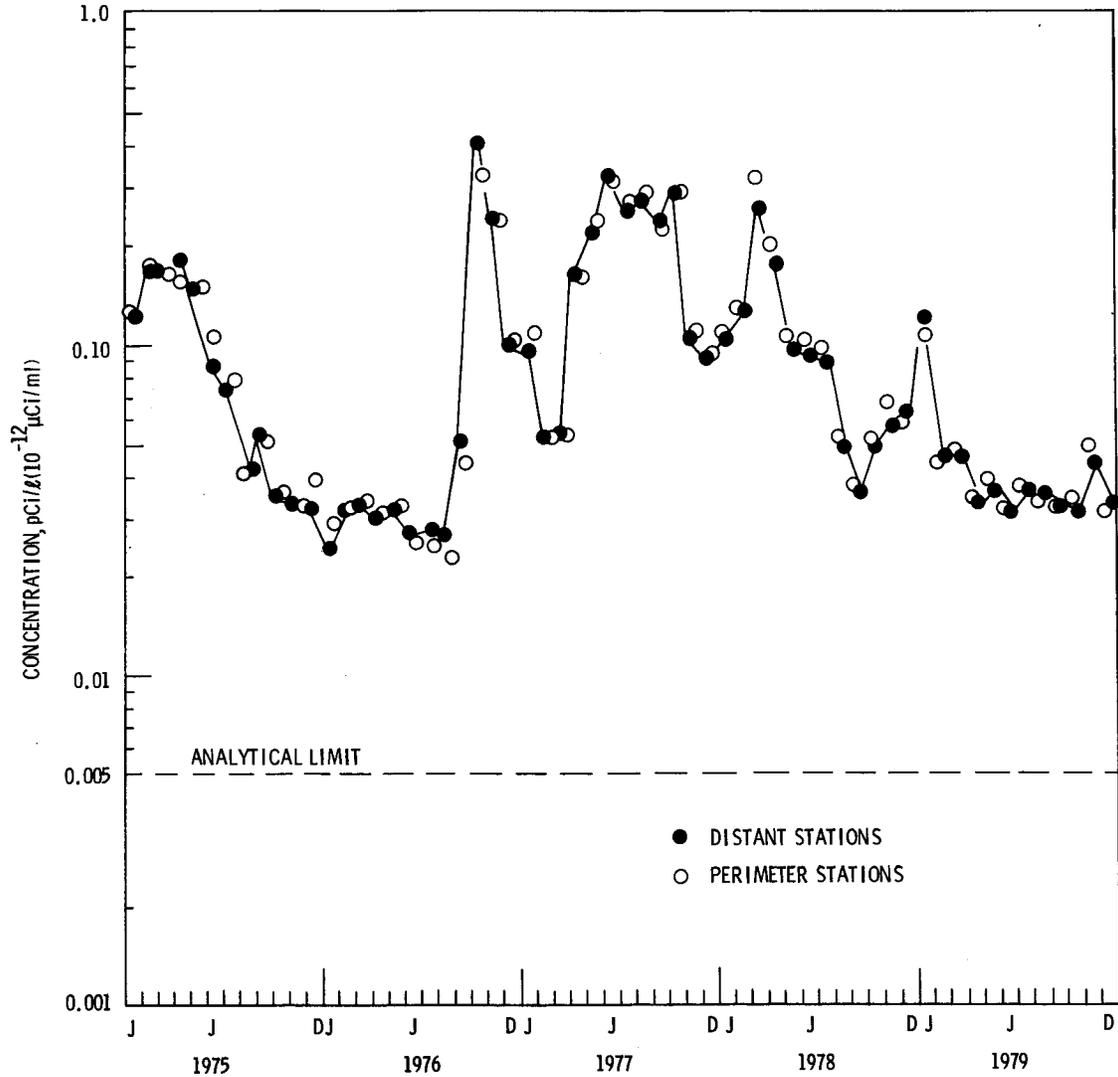


FIGURE 3. Average Monthly Gross Beta Activity in the Atmosphere

During 1979, measurements of NO₂ concentrations were made by the Hanford Environmental Health Foundation at several locations on the site boundary. An EPA-designated method was used.⁽⁸⁾ The maximum 24-hour concentration of 27 μg/m³ occurred across the Columbia River from the 300 Area near the Byers Landing sampling station. The maximum long-term average concentration of NO₂ occurred at the same location and was <6 μg/m³. These concentrations are well below the applicable national and state ambient air standards of 250 μg/m³ and 100 μg/m³ for daily average and annual mean, respectively.

None of the emissions of SO₂ from the four active steam power plants exceed the state emission standard of 1000 ppm.

TABLE 2. Selected Airborne Radionuclide Concentrations in the Hanford Environs

Radionuclide	Concentration Guide	Average Detection Limit	Composite Group ^(a)	Concentration, pCi/m ³ (10 ⁻¹² μ Ci/ml)		
				Maximum	Minimum	Mean
³ H	200,000	0.66	Distant	NS	NS	
			Perimeter	2.5	-0.01	0.63 \pm 1.1
			Downwind	2.5	-0.01	0.59 \pm 0.95
⁷ Be	40,000	0.02	Distant	0.23	-0.006	0.02 \pm 0.14
			Perimeter	0.11	-0.001	0.03 \pm 0.06
			Downwind	0.09	-0.003	0.03 \pm 0.05
⁹⁰ Sr	30	0.00007	Distant	0.0007	0	3.0 \times 10 ⁻⁴ \pm 4.5 \times 10 ⁻⁴
			Perimeter	0.0007	7.0 \times 10 ⁻⁶	3.5 \times 10 ⁻⁴ \pm 3.6 \times 10 ⁻⁴
			Downwind	0.0007	0.0002	4.0 \times 10 ⁻⁴ \pm 4.3 \times 10 ⁻⁴
⁹⁵ ZrNb	1,000	0.001	Distant	0.006	-0.0006	-0.001 \pm 0.006
			Perimeter	0.002	-0.0002	-0.001 \pm 0.002
			Downwind	-0.002	-0.0002	-0.001 \pm 0.001
¹³¹ I	100	0.01	Distant	0.007	0.0005	0.002 \pm 0.004
			Perimeter	0.01	0.0005	0.002 \pm 0.004
			Downwind	0.01	0.0005	0.002 \pm 0.004
¹³⁷ Cs	500	0.002	Distant	0.004	-8.0 \times 10 ⁻⁶	9.1 \times 10 ⁻⁵ \pm 0.003
			Perimeter	0.002	-7.0 \times 10 ⁻⁵	1.5 \times 10 ⁻⁴ \pm 0.001
			Downwind	0.001	-7.0 \times 10 ⁻⁵	9.9 \times 10 ⁻⁵ \pm 0.001
¹⁴⁴ CePr	200	0.02	Distant	0.05	-9 \times 10 ⁻⁴	-0.002 \pm 0.04
			Perimeter	0.02	-4 \times 10 ⁻⁴	-0.004 \pm 0.02
			Downwind	0.02	-4 \times 10 ⁻³	-0.003 \pm 0.01
Pu	0.06	0.00001	Distant	0.001	6.0 \times 10 ⁻⁶	9.7 \times 10 ⁻⁵ \pm 5.7 \times 10 ⁻⁴
			Perimeter	1.0 \times 10 ⁻⁴	3.0 \times 10 ⁻⁶	2.2 \times 10 ⁻⁵ \pm 5.3 \times 10 ⁻⁵
			Downwind	3.0 \times 10 ⁻⁵	4.0 \times 10 ⁻⁶	1.5 \times 10 ⁻⁵ \pm 2.5 \times 10 ⁻⁵

(a) Distant stations include Moses Lake, Washtucna, Walla Walla, McNary Dam, and Sunnyside. Perimeter stations are Wahluke #2, Berg Ranch, Othello, Vernita, Wahluke Watermaster, Connell, Cooke Bros., Yakima Barricade, Rattlesnake Springs, ALE, Benton City, Fir Road, Byers Landing, Pettett, Richland, Pasco, 1100 Area, and RRC CP #64. Downwind stations are Fir Road, Prosser Barricade, Byers Landing, Pasco, Richland, Pettett, 1100 Area, and RRC CP #64.

NS = Not sampled.

COLUMBIA RIVER MONITORING

The Columbia River from Grand Coulee Dam to the Washington-Oregon border, a stretch that includes the Hanford reach, has been designated Class A or excellent by the Washington State Department of Ecology.⁽⁶⁾ This designation requires that industrial uses of the river be compatible with substantially all water needs including sanitary water, recreation, and wildlife, as indicated in Appendix A. Many measurements of radionuclide concentration, temperature, nitrate ion, pH, turbidity, dissolved oxygen, fecal and total coliform, and biological oxygen demand are routinely conducted upstream and downstream from Hanford to monitor any effects that may be attributable to Hanford operations. The 1979 measurements show that Hanford operations had a minimal impact on the quality of Columbia River water. All parameters monitored were well within state or federal limits both upstream and downstream from the Hanford Site.

WATER SAMPLING

Samples of Columbia River water were routinely collected at upstream and downstream locations. Upstream sampling for radionuclide analysis consisted of placing a continuous filter-resin sampler at Priest Rapids Dam and a cumulative water sampler at the Hanford site 100-B Area water intake. Downstream sampling consisted of a continuous filter-resin sampler placed at the 300 Area forebay and a cumulative water sampler placed at the Richland sanitary water treatment plant.

The filter-resin sampler consists of a metering pump, a flow meter, a two stage particulate filter to remove particles 5 μm in diameter, and a mixed bed (anion-cation) ion exchange resin column. About 1000 liters of water were drawn through the sampler during each two week sampling period.

The cumulative water sampler consisted of a pump, a solenoid-operated valve, and a timer. Small aliquots of water were collected on a regular, timed basis (30 ml every 30 minutes). About 45 liters were collected during each monthly sampling period.

Other water samples collected included grab samples of Columbia River water collected at Vernita bridge (upstream from Hanford), and in Richland for biological and chemical analyses, and cumulative samples of drinking water collected at the Richland sanitary water treatment plant. The drinking water cumulative sampler operates on the same principle as the Columbia River cumulative sampler described previously.

RADIONUCLIDE ANALYSIS

Since shutdown of the last once-through-cooled production reactor in January 1971, radionuclide concentrations attributable to Hanford operations have been generally undetectable in the cumulative Columbia River water samples. Analysis of the filters and resin column from the filter-resin sampler makes possible the detection of radionuclides in Columbia River water at concentrations far below those obtainable from the analysis of conventional water samples. The filter-resin samples and cumulative water samples were all analyzed for gamma-emitting radionuclides. Monthly cumulative water samples were analyzed for total alpha- and beta-emitting radionuclides, for ^3H and for natural uranium. Quarterly composites of the cumulative water samples were analyzed for ^{89}Sr , ^{90}Sr , ^{226}Ra and ^{228}Ra . In addition, quarterly composites of the filter-resin samples were analyzed for plutonium and quarterly composites of the resin only were analyzed for ^{129}I . Shown in Tables 3 and 4 are the radionuclide concentrations measured in samples collected upstream and downstream of the Hanford Site. Only those radionuclides observed one or more times at concentrations significantly above the detection limit and those observed consistently at levels above the detection limit are shown in these tables. Very few of the 30-odd radionuclides routinely looked-for in these samples are observed at concentrations consistently above their detection limit. The data in Table 3 summarizes the 1979 concentrations of naturally occurring and worldwide fallout radionuclides measured in a stretch of the Columbia River before it is potentially effected by Hanford operations. Analogous data obtained downstream of the Hanford Site is presented in Table 4.

TABLE 3. Radionuclide Concentrations Upstream from Hanford Operations

Radionuclide	No. of Samples(a)	Concentration, pCi/l (10^{-9} μ Ci/ml)		
		Maximum	Minimum	Annual Average(b)
<u>Naturally Occurring</u>				
^{226}Ra	4	0.07	0.03	0.05 ± 0.04
^{228}Ra	4	0.29	0.02	0.18 ± 0.24
U-Nat	12	0.73	0.23	0.45 ± 0.31
<u>Worldwide Fallout</u>				
^3H	12	730	4	290 ± 450
^{51}Cr	24*	4.0	0.05	0.50 ± 3.8
^{54}Mn	24*	0.57	0.004	0.05 ± 1.1
^{59}Fe	24*	1.5	0.01	0.12 ± 2.6
^{60}Co	24*	14	0.006	0.79 ± 3.0
^{90}Sr	4	1.8	0.31	0.72 ± 1.4
^{95}Nb	24*	0.67	0.006	0.06 ± 0.81
^{95}Zr	24*	1.0	0.009	0.09 ± 1.7
^{125}Sb	24*	1.5	0.01	0.16 ± 4.9
^{129}I	4	4×10^{-4}	8×10^{-6}	$1 \times 10^{-4} \pm 4 \times 10^{-4}$
^{131}I	24*	1.1	0.01	0.11 ± 4.0
^{137}Cs	24*	1.4	0.009	0.10 ± 0.73
^{140}Ba (c)	24*	1.6	0.03	0.15 ± 1.6
^{140}La	24*	0.96	0.01	0.12 ± 0.99
^{238}Pu	4	8×10^{-5}	1×10^{-6}	$5 \times 10^{-5} \pm 8 \times 10^{-5}$
$^{239-240}\text{Pu}$	4	5×10^{-4}	-4×10^{-5}	$2 \times 10^{-4} \pm 4 \times 10^{-4}$

(a) Values marked with an * indicate the number of filter-resin sample sets analyzed.

(b) Annual average ± 2 standard deviations shown.

(c) Because of the large uncertainty on the analyses of two sample sets (3.7 ± 97 and 1.3 ± 176) these values were not included in the table or in the computation of the annual average.

Several radionuclides were observed downstream of the Hanford Site at slightly higher concentrations than were observed upstream; indicating a very small contribution from Hanford operations. The difference between the upstream and downstream average concentrations may be compared with the concentration guides from Manual Chapter 0524, Table II as shown in the last column of Table 4. In all cases, the increases in river concentrations as a result of Hanford Operations are a very small fraction of the concentration guides.

Data for several of the radionuclides of potential Hanford origin observed at concentrations consistently above the detection limit are shown in Figure 4.

DRINKING WATER

Many communities downstream from Hanford obtain their drinking water in whole or in part from the Columbia River. To determine the impact of Hanford operations on radionuclide concentrations in drinking water, cumulative water samples (30 ml every 30 minutes) were collected at the Richland sanitary water treatment plant. Richland is the first community downstream from Hanford to obtain its drinking water from the Columbia River. The detection limits for the analyses performed on the drinking water samples are much higher than those for the river samples but are consistent with the analytical procedures used and are within the

TABLE 4. Radionuclide Concentrations Downstream from Hanford Operations

Radionuclide	No. of Samples(a)	Concentration, pCi/l (10^{-9} μ Ci/ml)			Concentration Guide
		Maximum	Minimum	Annual Average(b)	
<u>Naturally Occurring</u>					
^{226}Ra	4	0.05	0.02	0.03 ± 0.03	30
^{228}Ra	4	0.43	0.11	0.22 ± 0.29	30
U-Nat	10	0.95	0.29	0.50 ± 0.44	20,000
<u>Artificially Produced</u>					
^3H	10	800	95	360 ± 430	3,000,000
^{51}Cr	26*	0.59	0.02	0.13 ± 1.0	2,000,000
^{54}Cr	26*	0.25	0.02	0.03 ± 0.09	100,000
^{59}Fe	26*	1.1	0.004	0.09 ± 0.32	50,000
^{60}Co	26*	0.75	0.006	0.09 ± 0.28	30,000
^{90}Sr	4	0.52	0.21	0.34 ± 0.27	300
^{95}Nb	26*	0.06	0.002	0.02 ± 0.06	100,000
^{95}Zr	26*	0.06	0.003	0.02 ± 0.19	60,000
^{125}Sb	26*	0.08	0.004	0.05 ± 0.30	100,000
^{129}I	4	1.5×10^{-4}	9.5×10^{-5}	$1.1 \times 10^{-4} \pm 5.0 \times 10^{-5}$	60
^{131}I	26*	0.26	0.003	0.07 ± 0.18	300
^{137}Cs	26*	0.07	0.002	0.03 ± 0.15	20,000
$^{140}\text{Ba}(c)$	26*	0.18	0.003	0.08 ± 0.94	20,000
^{140}La	26*	0.08	0.003	0.04 ± 0.26	200,000
^{238}Pu	4	8×10^{-5}	-9×10^{-5}	$-6.0 \times 10^{-5} \pm 3.5 \times 10^{-4}$	5,000
$^{239-240}\text{Pu}$	4	4×10^{-4}	2×10^{-5}	$3.1 \times 10^{-4} \pm 5.7 \times 10^{-4}$	5,000

(a) Values marked with an * indicate the number of filter-resin sample sets analyzed.

(b) Annual average ± 2 standard deviations shown.

(c) Because of the large uncertainty on the analysis of one sample set (0.05 ± 934) this value was not included in the table or in the computation of the annual average.

guidelines of the Washington State Water Quality Standards.

During 1979, the only radioactivity detected in the drinking water was gross alpha and gross beta activity, as shown in Table 5. Washington State Water Quality Standards require that radionuclide concentrations in drinking water not exceed 5 pCi/l of gross alpha activity and 50 pCi/l of gross beta activity with the further stipulation that certain individual radionuclides not exceed 1/100 of the values shown in Column 2, Table II, Appendix A of the Washington State Rules and Regulations for Radiation Protection.⁽⁶⁾ To determine compliance with the state standard, the average individual radionuclide concentrations shown in Table 4 can be compared with 1/100 of the Concentration Guide shown recognizing that, in many cases, the

water treatment facility will reduce the radionuclide concentrations below those observed in the river. All radionuclide concentrations are well within the state standard.

TEMPERATURE

One of the physical characteristics of the Columbia River most likely to be affected by Hanford operations is temperature. Figure 5 shows the average monthly water temperatures measured at Vernita Bridge and at Richland during 1979. Some of the difference between the two locations is due to natural causes while some is attributable to operations on the Hanford Site.⁽⁹⁾ Figure 6 illustrates the daily and seasonal variations in river temperature

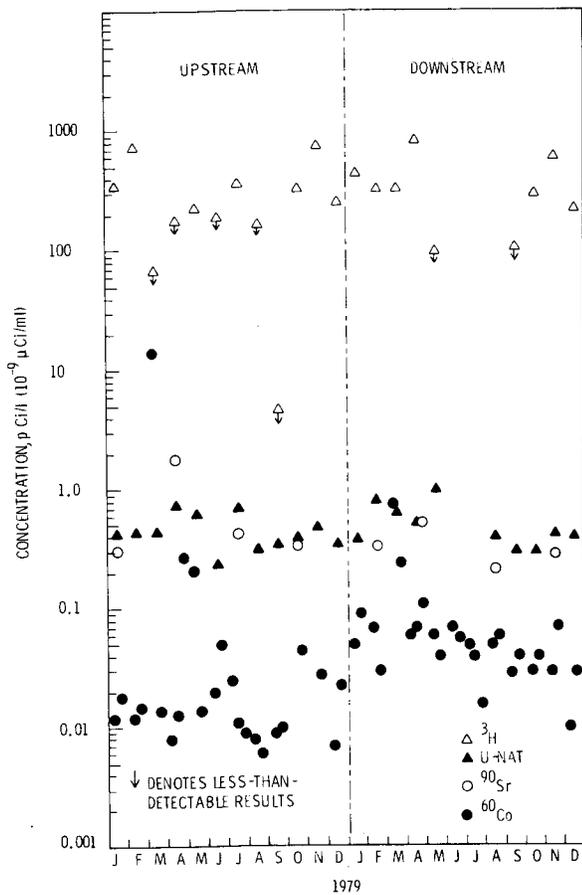


FIGURE 4. Upstream and Downstream Concentrations of Radionuclides in Columbia River Water

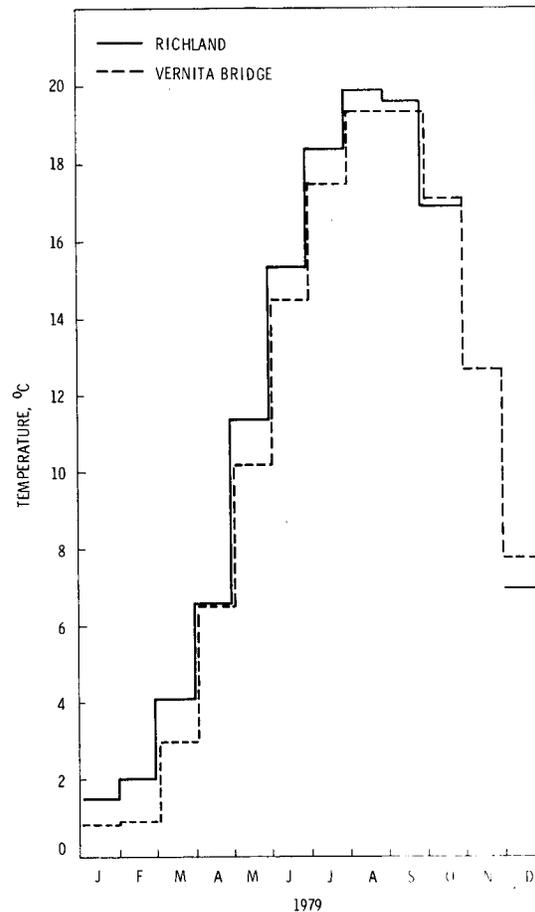


FIGURE 5. Average Monthly Water Temperatures at Richland and Vernita

TABLE 5. Radiological Analyses of Richland Drinking Water

Radionuclide	No. of Samples	Concentration, pCi/l (10^{-9} μ Ci/ml)				State Standard
		Detection Limit	Maximum	Minimum	Annual Average	
Gross Alpha	52	0.37	0.86	-0.05	0.33 ± 0.37	5
Gross Beta	52	5.0	9.3	0.14	3.3 ± 3.8	50

and flow rate during 1979. The gaps in the data in these figures results from equipment malfunctions during November. The greatest difference observed occurred during the late spring and early summer months when N Reactor was not in operation. Insolation appears to be the major source of heat for the river. Any heat contribution from N Reactor operations would be a small

fraction of the seasonal increases attributable to insolation.

BIOLOGICAL ANALYSES

Monthly measurements of total coliforms, fecal coliforms, and biological oxygen demand (BOD) were made on grab samples taken

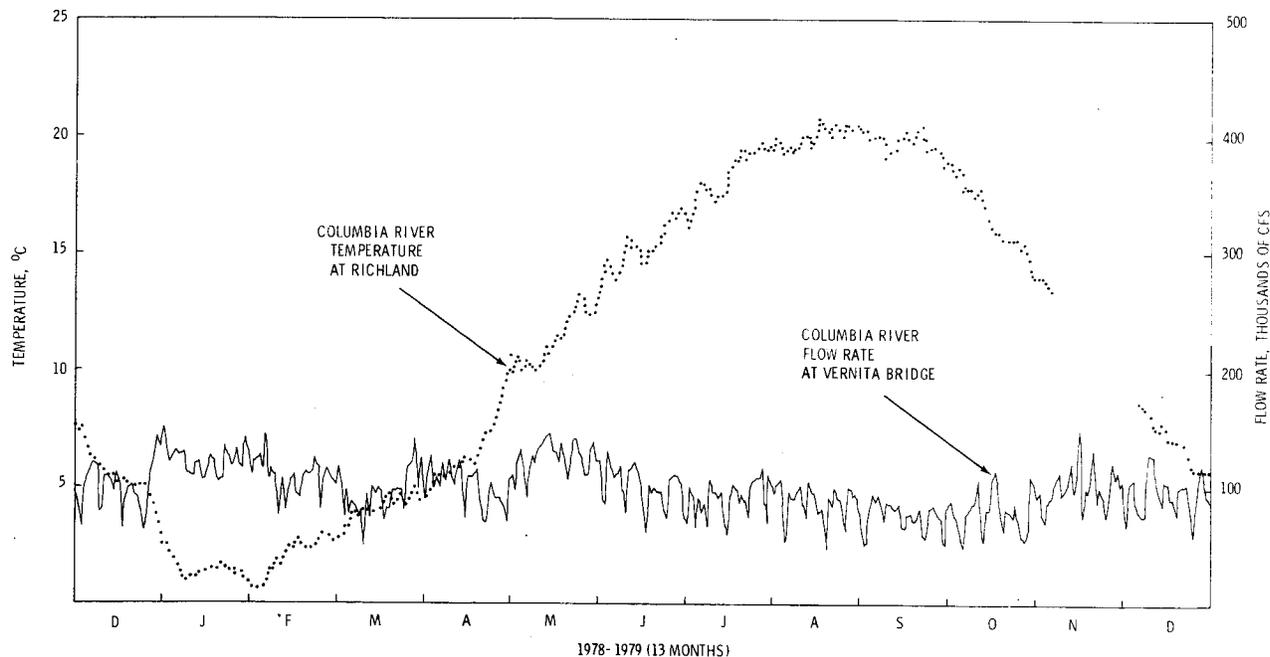


FIGURE 6. Daily Variation in Mean Temperature and Flow Rate

at Vernita Bridge (upstream from Hanford) and at Richland. The data, summarized in Table 6, indicate an increase in total and fecal coliform concentrations downstream from Hanford. These increases are attributed to drainage from farm activities and to wildlife. The Hanford stretch of the river serves as a refuge for large populations of waterfowl, especially in the autumn.

CHEMICAL ANALYSES

Grab samples taken at Vernita Bridge and Richland during 1979 were also subjected to chemical analyses. The nitrate concentration, pH, turbidity, and dissolved oxygen content were determined. The results were similar at the two locations and were well within applicable standards adopted by the state of Washington for Class A rivers. (See Appendix A.)

All of the pH measurements were well within the 6.5 to 8.5 standard except for one measurement of 8.6 upstream

The state of Washington's turbidity standard requires that any increase due to use of the river will be less than or equal to 5 NTU (Nephelometric Turbidity Units) above

the background levels. No significant differences were observed between Vernita Bridge and Richland, hence the values in Table 6 are assumed to represent normal background turbidity in the river.

The average values for dissolved oxygen in the river at both Vernita Bridge and Richland are well above the standard's minimum of 8 mg/l.

WASTEWATER DISCHARGES TO THE COLUMBIA RIVER

Wastewater is discharged at nine points along the Hanford reach of the Columbia River. These discharges consist of backwash water from water intake screens, cooling water, water storage tank overflow, and fish hatchery wastewater. Effluents from each of these outfalls are routinely monitored as required by the National Pollutant Discharge Elimination System (NPDES) permit. Among the effluent characteristics monitored are total flow, suspended solids, settleable solids, temperature, oils and grease, free available chlorine, and pH, depending on the nature of the effluent. During 1979, effluents were within the discharge limitations provided in the NPDES permit, with a few isolated exceptions.

TABLE 6. Columbia River Chemical and Biological Analyses

Analysis	Units	State Standard	No. of Samples	Vernita			Richland			
				Maximum	Minimum	Annual Average ^(a)	No. of Samples	Maximum	Minimum	Annual Average ^(b)
NO ₃	ppm	45	51	4.4	0.10	0.38 ± 1.2	49	0.80	0.10	0.35 ± 0.41
pH		6.5 to 8.5	39	8.6	7.2		33	8.4	7.2	
Turbidity	NTU ^(b)	5 + Bkgd.	41	4.5	0.35	1.4 ± 1.4	32	7.0	0.6	2.2 ± 3.4
Dissolved O ₂	mg/l	8	35	15.9	6.0	11 ± 5.4	24	16.8	3.0	11 ± 5.8
Total Coliforms	no./100 ml	-	11	350	2.0	79 ^(c)	11	920	2.0	130 ^(c)
Fecal Coliforms	no./100 ml	100	11	13	2.0	2 ^(c)	11	70	2.0	8 ^(c)
BOD ^(d)	mg/l	-	10	2.8	1.0	1.9 ± 1.3	10	2.4	0.6	1.6 ± 1.0

(a) Average ± two standard deviations.

(b) Nephelometric Turbidity Units.

(c) Annual median.

(d) Biological Oxygen Demand.

FOODSTUFFS

Foodstuffs, including milk, beef, chicken, eggs, fruit and leafy vegetables were collected from local and distant farms for analysis of gamma emitting radionuclides and ^{90}Sr . Since the Riverview farming area is irrigated with Columbia Riverwater that has passed the Hanford Site, samples of foodstuffs were obtained from this area. Analyses of these samples in 1979 indicated no observable impact from current or past Hanford operations.

MILK

Individual milk samples were collected every two weeks at farms in a generally downwind direction from the Hanford Site. A composite sample was collected on the same frequency from other farms in the same area to provide samples from most milk producers in the area. A biweekly sample was also obtained from a farm in Sunnyside, somewhat distant and upwind from the Hanford Site. The locations of these farms are shown in Figure 7. Each milk sample was analyzed by gamma spectrometry for gamma-emitting radionuclides and by specific analysis for ^{131}I . Samples from two farms were analyzed for ^{89}Sr and ^{90}Sr once a month. Samples from the other farms were analyzed only for ^{90}Sr on a quarterly basis.

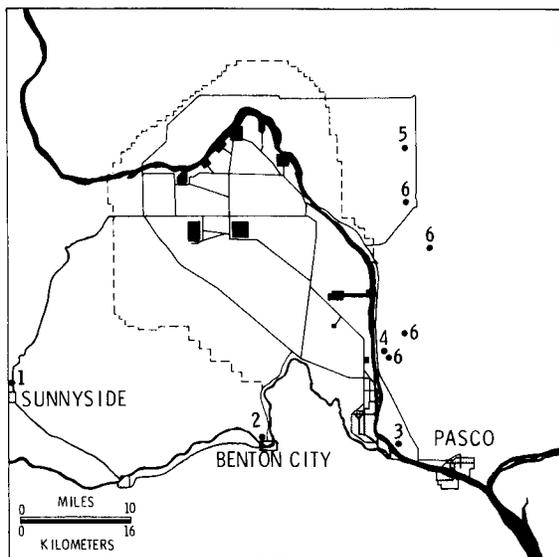


FIGURE 7. Milk Sampling Locations

The most abundant radionuclide measured in the milk samples was potassium-40, a naturally-occurring radionuclide. Strontium-90 was detected in many milk samples at concentrations typical of many areas around the United States. A log-normal probability plot of the ^{90}Sr data, shown in Figure 8, approximates a straight line indicating that the observed concentrations were the result of a single source (worldwide fallout). None of the ^{131}I concentrations in milk exceeded the detection limit during 1979. All of these results indicate that Hanford operations made no measurable contribution to radionuclide concentrations in milk during 1979 (Table 7).

BEEF, CHICKEN, AND EGGS

Samples of beef, chicken, and eggs were collected from the Riverview area and from a commercial source for analysis by gamma spectrometry and specific analysis for ^{90}Sr . The results of these analyses are shown in Table 8.

Strontium-90 and ^{137}Cs were measured in several of the samples at concentrations at or slightly above the detection limit. These low concentrations are similar to those observed previously, are typical of those observed elsewhere and are attributed to worldwide fallout. All other artificially-produced radionuclides were below detection limit. These results continue to indicate that any impact from Hanford releases on the radionuclide content of these foodstuffs is nil.

FRUIT AND LEAFY VEGETABLES

Samples of fruit and leafy vegetables (spinach, leaf lettuce, turnip greens, and mustard greens) were obtained during the growing season from a number of farms near to and distant from the Hanford Site. The sample locations at Riverview, Ringold, and in the Sagemoor vicinity are all near the site perimeter. The balance of the sample

TABLE 7. Radionuclides in Milk

Concentration Guide Average Detection Limit	Concentrations, pCi/l (10 ⁻⁹ µCi/ml)													
	40K			89Sr			90Sr			131I				
Location	Map Location	No. of Samples(a)	Maximum	Minimum	Average(b)	Maximum	Minimum	Average(b)	Maximum	Minimum	Average(b)	Maximum	Minimum	Average(b)
Riverview	3	26	1400	790	1000 ± 490	0.81	0.09	0.43 ± 0.66	1.4	0.99	1.2 ± 0.4	0.21	0.01	0.08 ± 0.12
Wahluke	5	19	1300	880	1000 ± 700				1.7	0.68	1.2 ± 0.8	0.27	0.008	0.10 ± 0.13
Sagemoor Vicinity	4	26	1500	820	1200 ± 420	0.86	0.0	0.47 ± 0.52	2.5	0.14	1.4 ± 1.4	0.39	0.01	0.11 ± 0.17
Benton City	2	25	1300	800	1100 ± 260				2.3	0.45	1.0 ± 1.7	0.17	0.003	0.07 ± 0.10
Sunnyside	1	26	1300	800	950 ± 500	1.9	0.0	0.66 ± 1.2	1.7	0.32	0.87 ± 0.79	0.21	0.01	0.08 ± 0.11
Composite	6	26	1300	900	1100 ± 180				1.9	0.46	1.1 ± 1.2	0.19	0.002	0.08 ± 0.12

(a) Total number of samples collected. All samples were analyzed for 131I and gamma-emitting radionuclides with a lesser number analyzed for 89Sr and 90Sr.

(b) Average ± standard deviations shown.

No entry indicates no analysis was made.

TABLE 8. Radionuclides in Meat, Chicken, and Eggs

Average Detection Limit	Concentrations, pCi/g (10 ⁻⁶ µCi/g, wet weight)												
	40K			90Sr			137Cs			90Y			
Location	No. of Samples	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)
Beef													
Commercial	4	2.8	2.3	2.6 ± 0.44	0.008	0	0.004 ± 0.006	0.04	0.006	0.02 ± 0.03			
Riverview	1			1.7						0.02			
Chicken													
Riverview	4	2.4	1.8	2.0 ± 0.50	0.02	0.002	0.007 ± 0.02	0.03	-0.02	0.006 ± 0.04			
Sunnyside	1			2.0			0.01			0.002			
Eggs													
Riverview	13	1.1	0.71	0.95 ± 0.23	0.01	0.003	0.007 ± 0.006(b)	0.02	-0.001	0.004 ± 0.018			
Sunnyside	2	1.1	0.87	0.99	0.003	0.002	0.003	-0.009	-0.00009	-0.005			

(a) ± standard deviations is shown if more than two sample results were available.

(b) Strontium-90 analysis was done on only four samples.

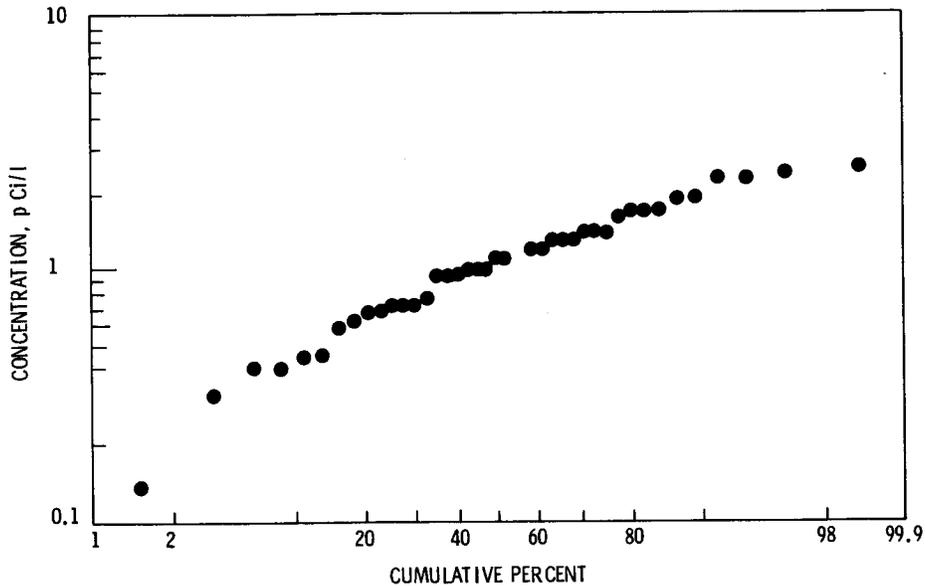


FIGURE 8. Log Normal Probability Plot of ^{90}Sr in Milk Samples

locations are at distances of 8 to 75 kilometers (5 to 47 miles) from the nearest site boundary.

All samples were analyzed by gamma spectrometry for gamma-emitting radionuclides. Radiochemical techniques were used for the ^{90}Sr analyses. Only the edible portions of the fruit and vegetables were analyzed. Results for 1979 are summarized in Table 9.

As in past years, some samples of leafy vegetables were found to contain low concentrations of ^{90}Sr and ^{137}Cs . The approximation of a straight line produced by the ^{90}Sr results on the log normal probability plot shown in Figure 9 indicates that a single source, worldwide fallout, is responsible for the observed concentrations. Cesium-137 was observed at the detection limit. In the fruit samples only naturally-occurring ^{40}K was detected. These data indicate that Hanford operations had no detectable impact on radionuclide concentrations in fruit or leafy vegetables.

TABLE 9. Radionuclides in Fruit and Leafy Vegetables

Average Detection Limit			Concentrations, pCi/g (10^{-6} μ Ci/g, wet weight)								
			^{40}K			^{90}Sr			^{137}Cs		
			0.35			0.01			0.03		
Location	Type	No. of Samples	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)
<u>Fruit</u>											
Sagemoor Vicinity	Cherries	1			1.5						0.003
Sagemoor Vicinity	Peaches	1			1.6						-0.004
Sagemoor Vicinity	Plums	1			1.8						0.003
Sagemoor Vicinity	Pears	1			0.73						0.02
Sagemoor Vicinity	Apples	1			1.1						0.01
Sagemoor Vicinity	Grapes	1			1.9						0.009
Sunnyside	Peaches	1			1.2						-0.002
Sunnyside	Plums	1			1.3						0.003
Sunnyside	Pears	1			0.87						0.01
Sunnyside	Apples	1			0.65						-0.003
Sunnyside	Cantaloupe	1			1.1						0.005
<u>Leafy Vegetables</u>											
Riverview		6	4.7	1.7	3.5 ± 2.5	0.17	0.002	0.05 ± 0.14	0.02	-0.002	0.01 ± 0.02
Sagemoor Vicinity		1			0.81						-0.005
Benton City		3	3.6	1.9	2.8 ± 1.7	0.01	0.004	0.007 ± 0.006	0.01	-0.008	-0.003 ± 0.02
Othello		2	3.9	2.2	3.1			0.004	0.004	0.003	0.002
Walla Walla		3	3.7	1.8	2.9 ± 2.0	0.04	0.02	0.03 ± 0.03	0.04	-0.01	0.01 ± 0.05
Sunnyside		1			2.6			0.01			-0.01

(a) ± 2 standard deviations is shown if more than two sample results were available.

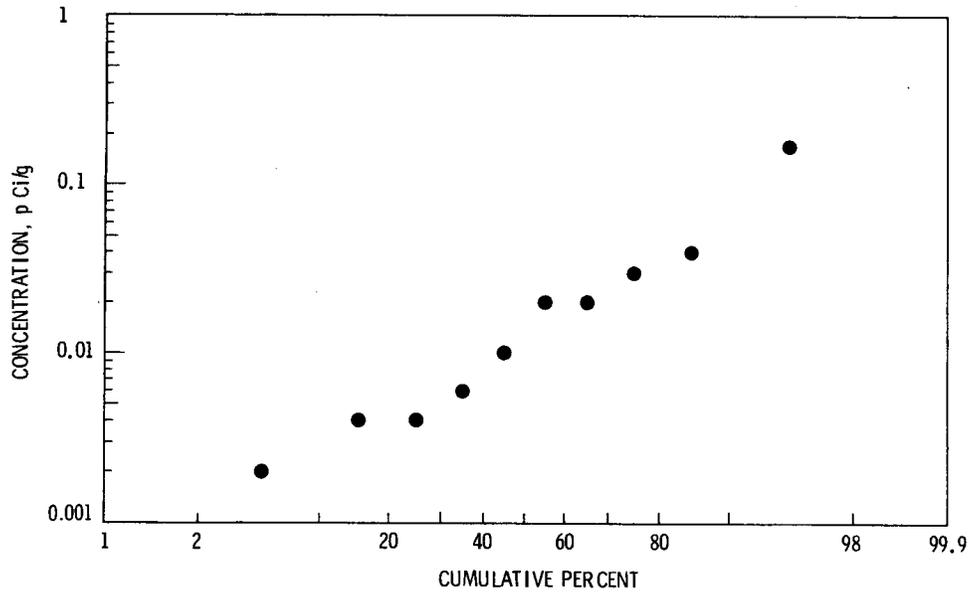


FIGURE 9. Log Normal Probability Plot of ^{90}Sr in Leafy Vegetables

WILDLIFE

A number of game animal species from the Hanford environs were collected and analyzed for gamma-emitting radionuclides. These wildlife constitute a potential pathway for the exposure of small groups of people who hunt or fish near the Hanford Site. Measurements during 1979 showed that the only distinguishable impact to wildlife from Hanford operations was to ducks at the onsite waste water ponds. A dose of about 5 mrem could potentially have resulted from the consumption of the duck with the highest observed ^{137}Cs concentration.

The Hanford Site serves as a refuge for migratory and resident waterfowl, dry-land gamebirds and a variety of mammals. Some of these animals have access to swamps, trenches and ponds on the site that receive slightly contaminated waste water or water that has a potential for being contaminated. Ingestion of the water or the vegetation growing in the water may result in measurable quantities of radionuclides being incorporated in the animals tissues.

Selected wildlife were collected on the Hanford Site to provide an indicator of radionuclide accessibility and the potential for transfer through the food chain to man. Although the Hanford Site south and west of the Columbia River is not open to public hunting, several wildlife species are game animals that could be taken by hunters during the time they spend offsite. These include pheasant, quail, ducks, geese, and deer. Fish from the Hanford reach of the Columbia River also constitute a potential pathway for radionuclides to man from Hanford operations. Samples are regularly obtained and analyzed to determine the magnitude of this potential exposure.

DEER

An attempt is made each year to sample deer in the vicinity of the operating areas on the Hanford Site. These areas present the greatest opportunity for deer to ingest radionuclides of Hanford origin. Samples of deer from these areas provide an indication of the availability of radionuclides and also indicate the magnitude of any potential exposure resulting from consumption of Hanford deer.

During 1979, three deer were obtained on the Hanford Site, all from "road kills". One sample was obtained on the west side of 200 East Area, another five miles southwest of 200 East Area and a third from the vicinity of 100 N Area. Samples of muscle tissue were analyzed to determine the concentration

of gamma-emitting radionuclides. The resulting data are shown in Table 10. Naturally-occurring ^{40}K and the fission product ^{137}Cs were the only radionuclides detected in the deer muscle samples. Concentrations of ^{137}Cs in the samples were all near or below the detection limit and were lower than levels observed in deer muscle samples obtained far from the Hanford Site.⁽¹⁰⁾ Observed levels of ^{137}Cs in Hanford deer are attributed to worldwide fallout, not to Hanford operations.

WATER FOWL

Duck and goose samples were collected in the vicinity of the 100 N Area and at White Bluffs along the Columbia River. Ducks were also collected from each of the 5 onsite waste water ponds shown in Figure 10. Analysis for gamma-emitting radionuclides was performed on a 454 gram (1 lb) sample of muscle tissue from each bird. Results of these analyses are shown in Table 11. Only ^{137}Cs and naturally-occurring ^{40}K were observed in the waterfowl samples. Samples of ducks and geese collected along the Columbia River showed low concentrations of ^{137}Cs attributable to worldwide fallout. Samples of pond ducks collected near the 200 Areas, however, showed the affect of their having resided on the ponds for a period of time, accumulating ^{137}Cs in their tissues. Contaminated waste water from past operations is responsible for the radioactivity in the ponds. The maximum concentration observed in a duck (175 pCi ^{137}Cs /g at Gable Pond) was similar to that observed in recent years. Consumption of 454 grams (1 lb) of meat from this duck would result in a whole body dose of about 5 mrem. The likelihood of such a duck being shot and consumed by an offsite hunter is considered to be very small because of the large number of migratory waterfowl passing through the area.

TABLE 10. Radionuclides in Muscle Tissue of Deer, Fish and Upland Gamebirds

		Concentrations, pCi/g (10^{-6} μ Ci/g, wet weight)					
		^{40}K			^{137}Cs		
Average Detection Limit		0.60			0.06		
Wildlife	No. of Samples	Maximum	Minimum	Average(a)	Maximum	Minimum	Average(a)
Deer	3	2.3	2.0	2.1 ± 0.3	0.09	0.02	0.05 ± 0.08
Pheasant	4	4.2	2.5	3.1 ± 1.5	0.06	-0.007	0.02 ± 0.04
Quail	2	3.2	2.1	2.7	0.13	0.03	0.08
Fish	7	14	3.1	4.6 ± 8.3	0.16	0.01	0.06 ± 0.10

(a) Average ± 2 standard deviations is shown if more than 2 samples were analyzed.

UPLAND GAME BIRDS

Upland game bird samples including pheasant and quail were collected near each of the old production reactor sites along the Columbia River. Attempts made at collecting upland game birds in the vicinity of the 200 areas were unsuccessful. Samples of muscle tissue from these birds were analyzed for gamma-emitting radionuclides. Results of these analyses are shown in Table 10. Cesium-137 and naturally occurring ^{40}K were the only radionuclides observed in the samples. None of the ^{137}Cs concentrations exceeded levels that would be expected in the birds from worldwide fallout, indicating that Hanford Operations had no impact on the radionuclides in these birds during 1979.

FISH

A total of 7 whitefish were collected from the vicinity of 100-D Area and Ringold during 1979. Both areas are downstream of N-Reactor. Boneless filets from these fish were analyzed for gamma-emitting radionuclides. Results of these analyses are shown in Table 10. The only radionuclides observed in the samples were ^{137}Cs and naturally-occurring ^{40}K . Concentrations of ^{137}Cs in the samples were all near or below the detection limit and are attributable to worldwide fallout.

TABLE 11. Radionuclides in Muscle Tissue of Waterfowl

			Concentration, pCi/g (10^{-6} μ Ci/g wet weight)					
			^{40}K			^{137}Cs		
Average Detection Limit			1.2			0.46		
Location	Species	No. of Samples	Maximum	Minimum	Average	Maximum	Minimum	Average
300 Pond	Duck	4	2.9	2.5	2.7 ± 0.33	0.07	0.03	0.04 ± 0.04
U Pond	Duck	1			2.1			0.26
Gable Pond	Duck	4	6.6	1.8	3.8 ± 4.3	175	0.45	67 ± 150
West Lake	Duck	2	5.8	2.6	4.2 ± 4.5	86	66	76 ± 14
B Pond	Duck	4	5.3	2.0	3.1 ± 3.0	40	6.6	21 ± 29
Columbia River	Duck	2	3.3	2.7	3.0 ± 0.85	0.03	-0.02	0.005 ± 0.07
Columbia River	Geese	3	2.6	2.4	2.5 ± 0.2	0.05	0.004	0.03 ± 0.05

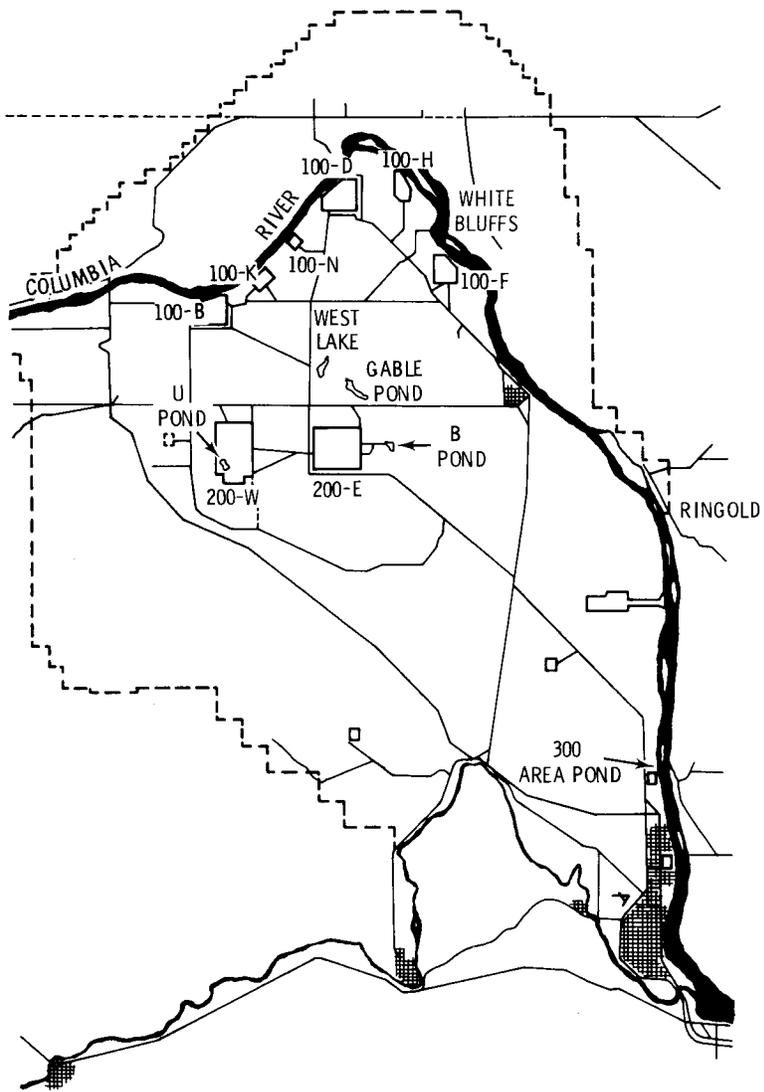


FIGURE 10. Onsite Waste Water Ponds

SOIL AND VEGETATION

Surface soil and vegetation samples are collected annually from a number of locations for the purpose of measuring the radionuclide concentrations from worldwide fallout, natural causes, and any cumulative buildup of radionuclides from Hanford operations. The data collected during 1979 indicate that any Hanford contribution to the radionuclide concentrations was indistinguishable from the variability observed in levels of worldwide fallout.

COLLECTION AND ANALYSIS

Soil and vegetation samples were collected once during 1979 in late summer at thirteen perimeter and distant locations. Each soil sample consisted of a composite of five "plugs" of soil collected at random from an area of approximately 100 m². These "plugs" were approximately 2.5 cm (1 in.) in depth and 10 cm (4 in.) in diameter. The composite samples were well mixed before aliquots were removed for analysis. Samples of perennial vegetation, rabbitbrush, sagebrush, and bitterbrush were collected in the immediate vicinity of each soil sample location. Since no one species exists at all sampling sites, the makeup of the sample varied from site to site and reflected the occurrence of each species, i.e., if the plant cover in the area consisted of 30% rabbitbrush and 70% sagebrush, the collected sample consisted of 30% rabbitbrush and 70% sagebrush. Aliquots from both sets of samples were analyzed for gamma-emitting radionuclides using a lithium drifted germanium detector; for plutonium isotopes using Alpha spectroscopy; and for ⁹⁰Sr and uranium by specific analysis.

The locations of the sample plots are shown in Figure 11. Hanford operations would be expected to contribute much more to the radionuclide concentrations at predominantly downwind locations (Riverview, Byers Landing, Sagemoor, Pettett, Baxter Substation, West End Fir Road, Ringold--locations 1 to 7) than to sampling locations lying in other directions (Yakima Barricade, Wahluke #2, etc.).

SOIL

Data from soil analyses for 1979 are summarized in Table 12. The naturally-occurring radionuclides ⁴⁰K, ²²⁴Ra, ²²⁶Ra, and uranium were observed at higher concentrations in the soil than any of the artificially produced radionuclides. The maximum ⁹⁰Sr concentration, 0.37×10^{-6} $\mu\text{Ci/g}$, was observed at Riverview and the Arid Lands Ecology Laboratory. Peak ²³⁹⁻²⁴⁰Pu concentrations (0.03×10^{-6} $\mu\text{Ci/g}$) were observed at

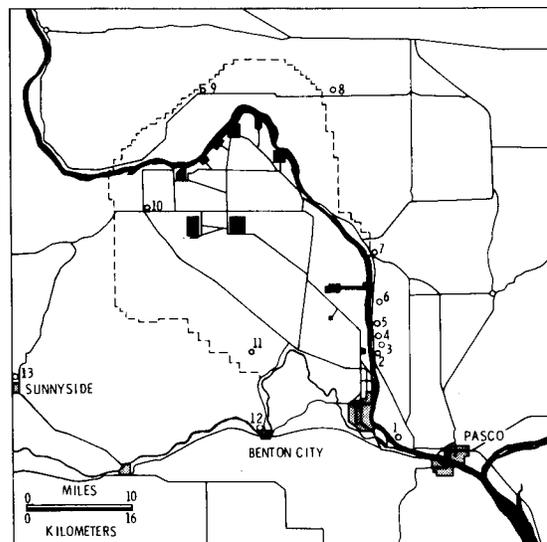


FIGURE 11. Soil and Vegetation Sampling Locations

Taylor Flats #2, the Arid Lands Ecology Laboratory and Sunnyside. All of these results, while much higher than those from other locations, are similar to maximum values measured in past years and indicate the highly variable nature of soil concentrations. (11) While there were considerable differences in radionuclide concentration between sample sites, no geographical pattern was detected. Log-normal probability plots of the data for ⁹⁰Sr, ¹³⁷Cs and ²³⁹Pu, shown in Figure 12 indicate by their approximating a straight line, that a single source, worldwide fallout, is responsible for the observed values. Hanford contributions, if present, were indistinguishable from worldwide fallout.

VEGETATION

Shown in Table 13 are the data obtained in 1979 for the vegetation samples. The maximum ⁹⁰Sr concentration, 0.46×10^{-6} $\mu\text{Ci/g}$ and the maximum ¹³⁷Cs concentration, 0.42×10^{-6} $\mu\text{Ci/g}$, both occurred at Benton City, a predominantly upwind location. No geographical pattern is evident in the

TABLE 12. Radionuclides in Soil

Part A: Naturally Occurring		Concentrations, pCi/g (10^{-6} μ Ci/g, dry weight)			
Location	Map Location	^{40}K	^{224}Ra	^{226}Ra	Total U
Average Detection Limit		1.4	0.09	0.10	0.18
Riverview	1	19	0.80	0.50	0.44
Byers Landing	2	15	1.1	0.63	0.05
Sagemoor	3	17	1.0	0.63	0.41
Taylor Flats #1	4	18	1.1	0.74	1.1
Taylor Flats #2	5	16	1.0	0.71	0.55
W. End Fir Road	6	16	1.1	0.64	0.57
Ringold	7	15	1.3	0.86	1.2
Berg Ranch	8	14	1.2	0.68	0.24
Wahluke #2	9	12	1.1	0.78	0.31
Yakima Barricade	10	13	1.2	0.69	0.39
ALE	11	14	1.3	0.93	0.33
Benton City	12	11	1.0	0.59	0.44
Sunnyside	13	10	0.96	0.75	0.22
Average ± 2 standard deviations		15 ± 5.3	1.1 ± 0.28	0.70 ± 0.23	0.48 ± 0.66

Part B: Artificially Produced		^{90}Sr	$^{95}\text{ZrNb}$	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239-240}\text{Pu}$
Location	Map Location							
Average Detection Limit		0.009	0.06	0.03	0.07	0.14	0.001	0.004
Riverview	1	0.37	0.03	0.04	0.35	0.29	0.00006	0.02
Byers Landing	2	0.18	-0.06	0.05	0.94	0.56	0.0003	0.02
Sagemoor	3	0.03	0.08	-0.0003	0.09	0.37	0.0006	0.001
Taylor Flats #1	4	0.06	0.08	0.06	0.13	0.45	0.0004	0.002
Taylor Flats #2	5	0.34	0.03	0.04	1.6	0.35	0.001	0.03
W. End Fir Road	6	0.12	0.09	0.04	0.57	0.44	-0.0002	0.01
Ringold	7	0.18	0.24	0.02	0.69	0.47	0.002	0.02
Berg Ranch	8	0.30	0.07	0.06	0.86	0.20	0.0001	0.01
Wahluke #2	9	0.10	0.07	0.06	0.46	0.46	0.0001	0.006
Yakima Barricade	10	0.23	-0.07	0.04	0.82	0.41	-0.0009	0.005
ALE	11	0.37	0.08	0.01	1.1	0.34	0.002	0.03
Benton City	12	0.34	0.03	0.02	0.75	0.25	0.0003	0.02
Sunnyside	13	0.25	-0.01	0.04	0.74	0.43	0.00009	0.03
Average ± 2 standard deviations		0.22 ± 0.24	0.05 ± 0.16	0.04 ± 0.04	0.70 ± 0.81	0.39 ± 0.20	0.0004 ± 0.002	0.02 ± 0.02

data. Log-normal probability plots of the data for ^{90}Sr and ^{137}Cs , shown in Figure 13, indicate that worldwide fallout is responsible for the observed values. Other

radionuclides were also present at about the same low concentrations as in previous years, again indicating no detectable Hanford contribution.

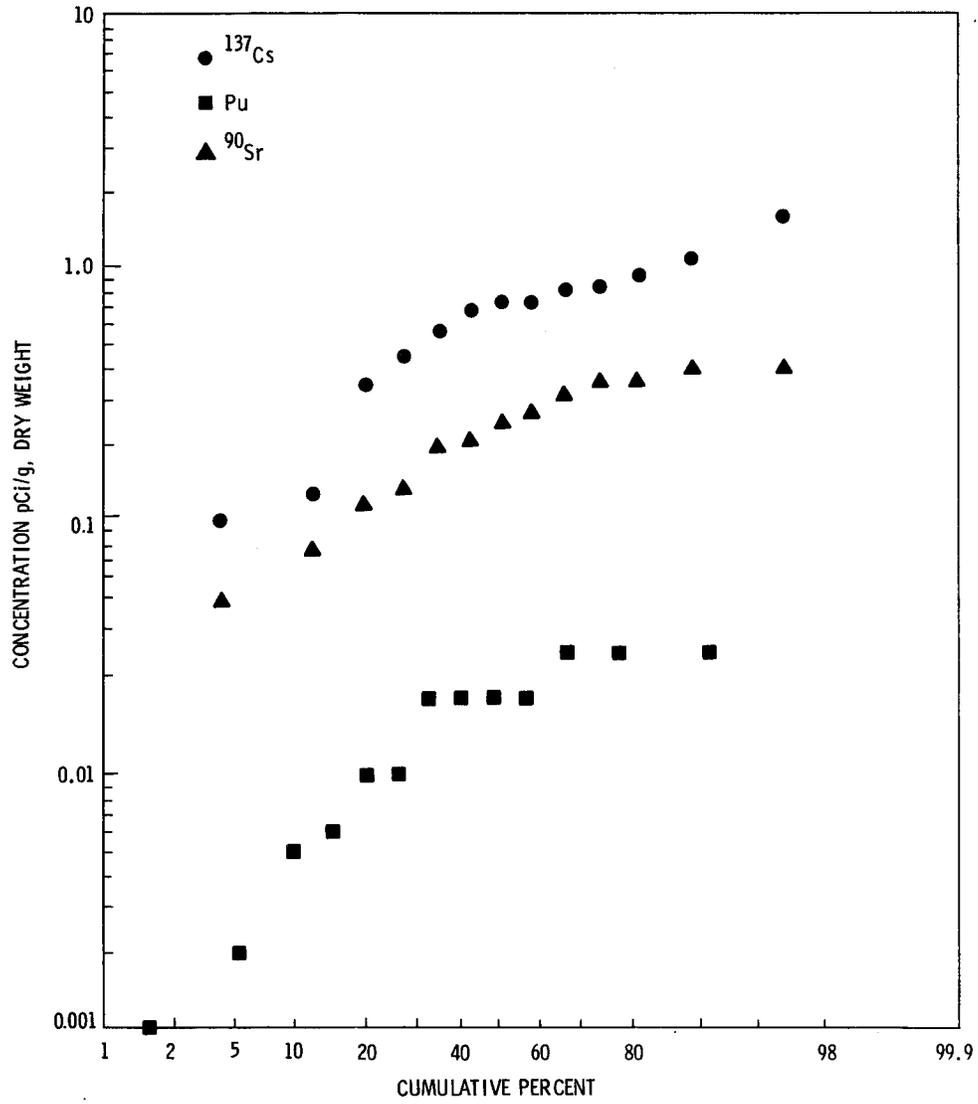


FIGURE 12. Log Normal Probability Plot for Soil Samples

TABLE 13. Radionuclides in Vegetation

Locations	Map Location	Concentrations, pCi/g (10 ⁻⁶ µCi/g, dry weight)							
		Naturally Occurring		Artificially Produced					
		⁴⁰ K	Total U	⁹⁰ Sr	⁹⁵ ZrNb	¹³⁷ Cs	¹⁴⁴ Ce	²³⁸ Pu	²⁴⁰⁻²³⁹ Pu
Average Detection Limit		3.8	0.02	0.03	0.34	0.16	0.76	0.006	0.006
Riverview	1	13	0.03	0.06	0.21	0.22	0.46	-0.002	0.004
Byers Landing	2	25	0.23	0.00	-0.23	-0.006	1.0	0.02	0.01
Sagemoor	3	16	0.05	0.03	-0.03	0.20	0.34	0.0003	0.003
Taylor Flats #1	4	13	0.03	0.07	0.14	0.14	0.33	-0.0002	0.001
Taylor Flats #2	5	15	0.05	0.03	0.23	0.09	0.59	0.02	0.001
W. End Fir Road	6	15	0.03	0.32	-0.10	0.09	0.30	0.001	0.002
Ringold	7	13	0.04	0.06	0.18	0.19	0.70	-0.001	0.002
Berg Ranch	8	15	0.06	0.03	0.16	0.01	0.26	0.002	0.002
Wahluke #2	9	7.0	0.01	0.03	0.03	0.09	0.98	0.0002	0.0002
Yakima Barricade	10	9.6	0.02	0.09	0.23	0.18	0.72	-0.001	0.002
ALE	11	12	0.02	0.20	0.23	0.35	0.51	0.004	0.008
Benton City	12	7.1	0.02	0.46	0.20	0.42	0.81	0.02	0.002
Sunnyside	13	3.8	0.008	0.11	0.06	0.16	1.2	0.008	0.002
Average +2 standard deviations		13 ± 11	0.05 ± 0.11	0.11 ± 0.27	0.10 ± 0.29	0.16 ± 0.24	0.63 ± 0.60	0.006 ± 0.02	0.003 ± 0.001

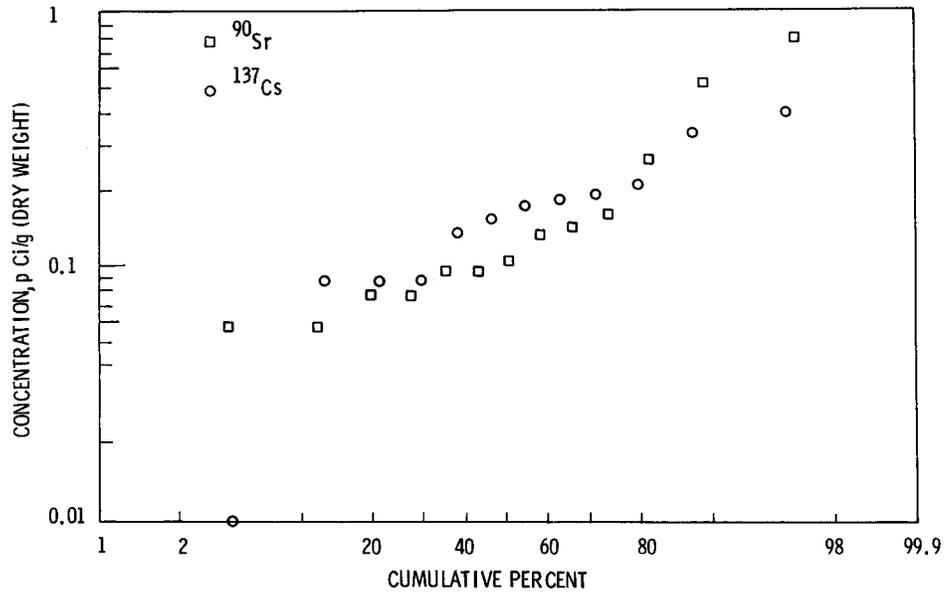


FIGURE 13. Log Normal Probability Plot for Vegetation Samples

EXTERNAL RADIATION

External radiation levels were measured using thermoluminescent dosimeters at all air sampling locations in the Hanford environs. The spatial pattern of recorded doses was used to determine any contribution attributable to Hanford operations, since releases from Hanford would contribute primarily to measurements made at downwind locations. Dosimeters were also used to measure the dose received along the Columbia River islands and shoreline near the Hanford Site, and the immersion dose in Columbia River water at two locations. Measurements during 1979 at the air sampling stations showed, with one possible exception, that there was no observable impact from current Hanford Operations. A radiological survey to evaluate the magnitude and distribution of radioactive contamination on the exposed shorelines of the Columbia River along and downstream of the Hanford Site was performed during 1979. Areas were found where dose rates were higher than was previously thought to be the case. The incremental increase in radiation exposure to recreational users of the river is still considered to be insignificant. The activity causing these dose rates is from past direct use of river water to cool production reactors.

HANFORD ENVIRONS

Thermoluminescent dosimeters (TLDs) were located at all of the perimeter and distant air sampling locations shown in Figure 2 (page 5). The dosimeters consisted of CaF₂: Mn chips (Harshaw TLD-400) encased in an opaque plastic capsule lined with 0.025 cm (0.01 in.) of tantalum and 0.005 cm (0.002 in.) of lead to flatten the low-energy response.⁽¹²⁾ The dosimeters were mounted 1 m above ground level and changed every 4 weeks.

The results for each four-week period at each location were converted to an annual dose rate for ease in comparing measurements and in calculating the annual average dose rate. These values summarized in Table 14 show that the average annual dose is essentially the same for perimeter and distant stations. Noteworthy, however, is a four-week period during August when the measured dose rate was apparently 50% higher than normal at the Waluke #2 station. Problems were encountered during the read-out of dosimeters for this station, making the result questionable. N-Reactor airborne effluents and meteorological conditions during August were reviewed for indications of a situation that could possibly have produced an increase in the dose rate. Nothing of an unusual nature was found to substantiate the validity of the high dose measurement. A log-normal probability plot of the individual data points for distant and perimeter locations (Figure 14) shows the similarity of the measurements except for the one Waluke #2

station value. In general, Hanford contributions to offsite radiation dose were indistinguishable from the background dose.

From information in Table 14, the external background dose received by the population in the Hanford environs can be estimated. The mean measured dose was about 70 mrem per year (here, 1 mrem equals 1 mrad). To this dose, 6 mrem per year must be added to account for the fast neutron component of cosmic radiation.⁽¹³⁾ Thus the population would have received a dose of about 76 mrem per year from external radiation. To estimate the total background dose (external plus internal), the 25 mrem received by the body from naturally-occurring radionuclides, primarily ⁴⁰K, must be included. Therefore, the total background dose received in the Hanford environs during 1979 was approximately 100 mrem per year, as it was during 1978.

COLUMBIA RIVER IMMERSION DOSE

Environmental dosimeters were submerged in the Columbia River at the two locations labeled in Figure 15: at Coyote Rapids, and at the Richland pumphouse. These dosimeters were collected monthly. The results (shown in Table 15) are similar to those obtained in previous years and show that a swimmer immersed in the Columbia River at Richland would receive a radiation dose rate of approximately 0.004 mrad/hr. By comparison, approximately 0.008 mrad/hr would be received on land.

COLUMBIA RIVER SHORELINE AND ISLANDS

TABLE 14. Environmental Radiation Dose Measurements in the Hanford Vicinity

Location	No. of Samples	Dose Rate (mrad/yr)		
		Maximum	Minimum	Average
<u>Perimeter Stations</u>				
Rattlesnake Springs	13	88	62	75 ± 14
ALE	12	91	73	78 ± 11
Benton City	13	73	51	58 ± 12
Yakima Barricade	13	95	69	77 ± 15
Vernita Bridge	13	80	69	74 ± 8
Wahluke #2	13	120	69	82 ± 25
Othello	13	84	55	64 ± 15
Connell	12	77	62	68 ± 9
Berg Ranch	13	88	69	80 ± 11
Wahluke Watermaster	13	80	55	72 ± 14
Cooke Bros.	13	73	58	66 ± 10
Richland	13	77	58	66 ± 9
Pasco	13	66	55	62 ± 7
Byers Landing	13	84	66	72 ± 11
Sagemoor	13	88	69	74 ± 10
Pettett Farm	13	84	47	64 ± 21
Fir Road	12	91	58	72 ± 16
RRC CP #64	13	80	58	68 ± 12
1100 Area	13	77	51	63 ± 14
Mean ±2 standard deviations				70 ± 19
<u>Distant Stations</u>				
Walla Walla	13	73	47	61 ± 14
McNary	13	88	58	72 ± 17
Moses Lake	13	88	58	68 ± 14
Wash Tucna	13	84	62	70 ± 12
Sunnyside	13	66	51	61 ± 9
Mean ±2 standard deviations				66 ± 16

Until late 1977, public access to the Hanford reach of the Columbia River between Ringold and Vernita was prohibited. The public now has free access to the river and its islands but is prohibited from landing on the shores of the Hanford reservation. Analyses of sediment samples collected along the Columbia River have shown the presence of a few long-lived radionuclides, primarily ⁶⁰Co, attributable to the past operation of production reactors cooled directly by river water. A 1974 aerial radiation monitoring survey showed low-level deposition of ⁶⁰Co over much of the Hanford reach of the river.⁽¹⁴⁾ Results of a 1978 aerial radiation monitoring survey showed ⁶⁰Co deposition patterns along the river similar to those of the previous survey but with reduced activity, accounted for by radioactive decay. At the time of this report, documentation of the 1978 aerial survey was in preparation.

As a followup to the recent aerial survey, a systematic, detailed, ground-level radiation survey of the Columbia River islands and shorelines for nearly 60 miles along and downstream of the Hanford Site was performed in 1979.⁽¹⁵⁾ Approximately 60% of the exposed shoreline was surveyed with emphasis on areas of higher ⁶⁰Co concentrations as observed in the 1978 aerial survey. The intent of the survey was to better

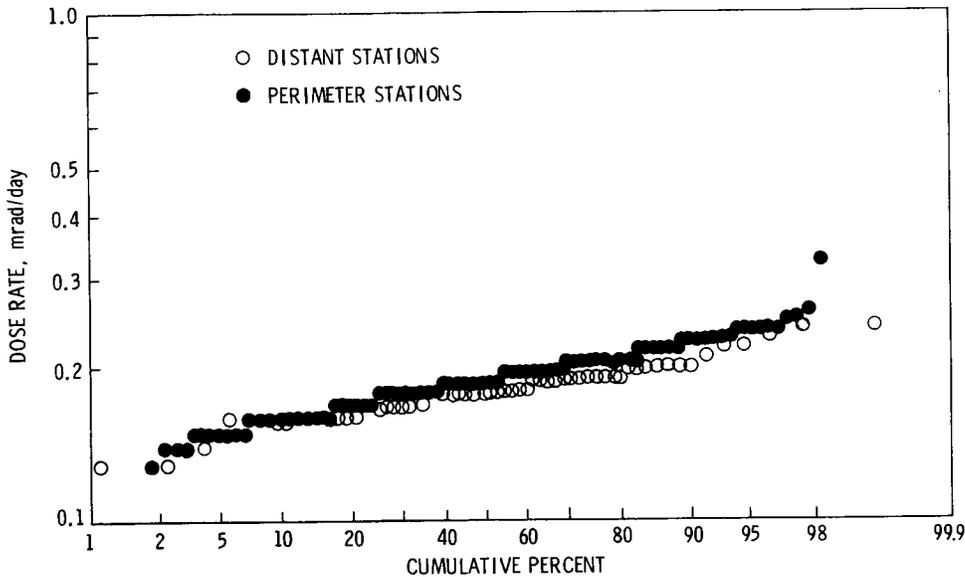


FIGURE 14. Log Normal Probability Plot of Monthly Dose Measurements at Perimeter and Distant Locations

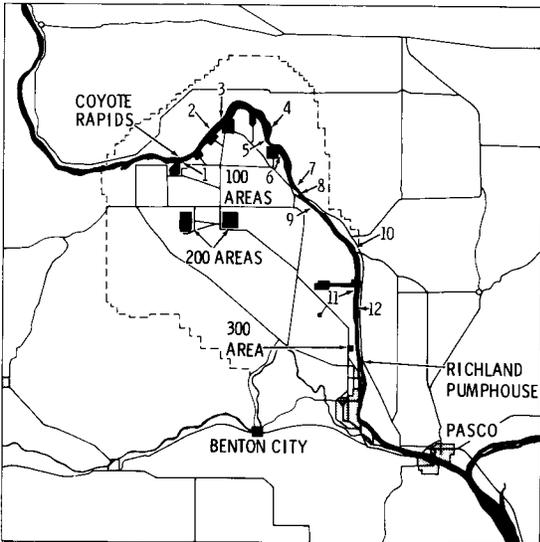


FIGURE 15. Thermoluminescent Dosimeter Locations for Columbia River immersion and Sediment Measurements

characterize the radiological status of the river shorelines and islands.

Contamination on the exposed island and shoreline areas was found to be present in three different distributions.

Low level contamination was observed over much of the study area producing an average exposure rate of 0.011 mR/hr; about 0.004 mR/hr above the background upstream of the Hanford Site.

Ninety-two areas were found in which exposure rates in the range of 0.025 to 0.045 mR/hr were observed. These areas ranged in size from a few square meters to several thousand square meters, and were usually found in areas of dense vegetation. Analyses of the soil in these areas showed a mixture of ^{60}Co , ^{137}Cs , and ^{152}Eu in approximately equal proportions.

Discrete particles of contamination containing ^{60}Co were also observed along the river, usually in flat, rocky areas with little or no vegetation. The particles were found to be minute metallic flakes, possibly fragments of stillite valve and pump components used in the production reactors. These particles were found at depths of 0 to 13 cm (5 in.) below the surface and contained from 2 to 25 μCi of ^{60}Co activity. The existence of the particles has been discussed in previous reports of this series.⁽⁴⁾ An assessment of the potential radiological impact of these particles is being performed and will be discussed in a future report.

During the course of the survey, several areas in the vicinity of the production reactor sites were found where elevated radiation levels were observed. These radiation levels were attributed primarily to onsite sources and, to a much smaller degree, to contaminated sediments on the shoreline. The maximum exposure rate (0.8 mR/hr) was found along the 100-N area shore, 30 meters (100 ft) from the water line.

Summarized in Table 16 are data from environmental dosimeters placed at 12 locations along the Columbia River shoreline, including three of the larger islands. Placement of these dosimeters is shown by numbered locations in Figure 15. These sites were selected on the basis of the 1974 aerial survey findings. Additional stations have been

TABLE 15. Columbia River Immersion Dose Rate

Location	No. of Measurements	Dose Rate (mrad/hr) ^(a)		
		Maximum	Minimum	Average ^(b)
Coyote Rapids	8	0.006	0.003	0.005 ± 0.002
Richland Pump House	13	0.005	0.003	0.004 ± 0.001

(a) Monthly measurements in mrad were converted to equivalent hourly dose rate.

(b) Average ± 2 standard deviations is shown for each location.

TABLE 16. Environmental Radiation Dose Measurements Along the Columbia River Shoreline and Islands

Location	Map Number	No. of Samples	Dose Rate (microrad/hr)(a)		
			Maximum	Minimum	Average
Above 100-K	1	9	9	7	8 ± 1
100-N Trench	2	9	85	32	56 ± 39
Opposite 100-D	3	9	8	7	8 ± 1
Locke Island	4	9	10	8	9 ± 1
White Bluffs	5	9	10	7	9 ± 1
Below 100-F	6	9	8	7	8 ± 1
Hanford Powerline Crossing	7	9	10	8	9 ± 2
Hanford Ferry	8	9	10	8	9 ± 1
Hanford Railroad	9	9	16	13	14 ± 5
Ringold Island	10	9	10	8	9 ± 1
Powerline Crossing	11	9	11	9	10 ± 1
Wooded Island	12	9	11	8	10 ± 2

(a) Monthly measurements in mrad were converted to average dose rate in microrad per hour.

(b) Average ±2 standard deviations is shown for each location.

added based on the 1979 survey findings and results will be documented in future reports of this series.

The maximum external dose rate as determined by the environmental shoreline dosimeters was measured at 100-N Trench Springs where it averaged about 0.085 mrad/hr over a 1-month period or about ten times the general background dose rate at Hanford. This represents a fairly long-term average of the dose rate at this location and is considerably lower than the maximum exposure rate (0.8 mR/hr) measured at a different location near 100-N Area during the shoreline survey. The elevated dose rate in these locations are believed to be due primarily to scattered radiation from N-Reactor operations as opposed to slightly contaminated soil at this location as was previously thought to be the case. Elevated dose rates at other sites are due primarily to ⁶⁰Co and other long-lived radionuclides in the sediment. Differences in the soil concentration are responsible for the variation in dose rate from site to site.

Surveys of recreational usage of the Columbia River in the vicinity of the Hanford Site have found that the maximum time spent on the river shoreline by any individual is less than 500 hours per year.⁽¹⁶⁾ The average individual recreating on the river spends about 17 hours per year on the shoreline. Five hundred hours spent in the area of the maximum offsite dose rate found during the 1979 survey (0.038 mR/hr on an island near the 300 area) would result in an incremental dose increase of about 20 mrad.⁽¹⁵⁾ It is highly unlikely, however, that an individual would spend more than a few hours in any of the areas where the higher offsite dose rates were observed. Dose rates along most of the shoreline are less than twice the natural background dose rate and the incremental increase in radiation exposure to the recreational user of the Hanford reach of the river is considered to be insignificant.

RADIOLOGICAL IMPACT OF HANFORD OPERATIONS

The preceding sections on environmental data collected during 1979 provide information for differentiating between those sources of environmental radiation arising from past or current Hanford operations and those due to worldwide fallout or natural radioactivity. Contributions from Hanford operations were distinguishable from other sources in only two areas. These include the residual levels of long-lived radionuclides, primarily ^{60}Co , associated with sediments along the Columbia River islands and shoreline near the Hanford Site, and the very low concentrations of radionuclides in Columbia River water as a result of current N Reactor operations. The radiological impact of Hanford operations is calculated from the quantity of radionuclides measured in effluents from operating facilities in 1979, and from the residual radionuclides in river sediments from the past operations. A comparison of the estimated impact from Hanford operations with the impacts from other sources of radiation exposure routinely encountered is included in the summary at the end of this section.

RADIOLOGICAL IMPACT FROM 1979 EFFLUENTS

The radionuclide composition of effluents reported for 1979 by all Hanford contractors is shown in Table 17. Since these quantities of radionuclides, when dispersed in large volumes of air and water, were generally undetectable in the off-site environment, empirical dose models^(17,18,19) were used to assess the resulting radiological dose impact. These models are considered to provide the best estimate of the dose impact from Hanford operations during 1979. Small differences in the calculated doses may appear from year to year, depending on the quantity and type of effluents and the flow rate of the Columbia River. During 1979, for instance, the river flow was less than in 1978, hence calculated doses for exposure via river pathways are higher than they were in 1978.

Manual Chapter 0513⁽²⁰⁾ states that a radiological impact assessment should provide realistic estimates of

- the exposure rate on the site boundary where the maximum exposure rates exist ("fence-post" exposure)
- the maximum dose to an individual member of the public
- the whole-body dose to the entire population within an 80-km (50-mile) radius of the site (person-rem).

The assessment of these impacts for 1979 follows.

Maximum "Fence-Post" Exposure Rate

Late in 1977 the full Hanford reach of the Columbia River was declared legally accessible to the public. As a result, the river shoreline effectively became the boundary for this portion of the site. In 1978, the "fence-post" was moved to a point on the Columbia River shoreline near N Reactor. Here the exposure to N Reactor airborne and liquid effluents and radiation from rad waste handling facilities is maximized. The whole body radiation exposure rate from 1979 effluents was calculated to be 2.6×10^{-4} mR/hr. Short-lived noble gases (^{41}Ar and ^{138}Xe) in the N Reactor airborne effluents were the major contributors to this exposure rate. Of greater magnitude is the contribution from the rad waste system and from accumulations of radionuclides along the shoreline near N Reactor. Measurements taken in the vicinity during 1979 indicated an exposure rate of 0.8 mR/hr.

Maximum Individual Dose

Computation of the maximum individual dose is complicated by several factors: the facilities on the Hanford Site are many miles apart, the effluents contain a variety of radionuclides in gaseous, particulate, and liquid forms, and assumptions must be made as to the living and dietary habits of the maximum individual. The radionuclides shown in Table 17 were used in computing the maximum dose to an individual member of the public for several exposure pathways.

The maximum individual dose calculation for 1979 includes estimates of the dose

TABLE 17. Radionuclide Composition of Hanford Effluents
for Calendar Year 1979

Radionuclide	Half Life	Effluent (Ci)			
		Liquid To River	Gaseous		
			100 Area	200 Areas	300 Area
³ H (HTO)	12.3 yr	200	15	--	8.4
¹⁴ C	5730 yr	--	9.7	--	--
²⁴ Na	15.0 hr	--	0.20	--	--
³² P	14.3 d	0.012	--	--	--
⁴¹ Ar	1.8 hr	--	86,000	--	--
⁵¹ Cr	27.8 d	--	0.080	--	--
⁵⁴ Mn	303.0 d	0.82	0.037	--	--
⁵⁶ Mn	2.6 hr	5.2	5.1	--	--
⁵⁹ Fe	46.0 d	2.1	0.045	--	--
⁵⁸ Co	71.0 d	0.13	0.012	--	--
⁶⁰ Co	5.3 yr	0.93	0.053	--	2.0 x 10 ⁻⁵ (a)
⁶⁵ Zn	245.0 d	--	0.009	--	--
⁷⁶ As	26.4 hr	--	0.45	--	--
^{85m} Kr	4.4 hr	--	420	--	--
⁸⁵ Kr	10.8 hr	--	--	--	1,500
⁸⁷ Kr	76.0 min	--	1,300	--	--
⁸⁸ KrRb	2.8 hr	--	970	--	--
⁸⁹ Sr	52.7 d	0.58	0.012	--	--
⁹⁰ Sr	27.7 yr	1.6	0.0004	0.19(b)	7.0 x 10 ⁻⁵ (b)
⁹¹ Sr	9.7 hr	--	2.4	--	--
⁹⁵ Zr	65.5 d	0.13	0.010	--	--
⁹⁵ Nb	35.0 d	0.17	0.009	--	--
⁹⁷ ZrNb	17.0 hr	--	0.055	--	--
^{99m} MoTc	66.7 hr	1.0	0.39	--	--
¹⁰³ Ru	39.5 hr	0.52	0.020	--	--
¹⁰⁶ Ru	368.0 d	0.45	0.083	--	--
¹²² Sb	2.8 d	--	0.016	--	--
¹²⁴ Sb	60.4 d	0.087	0.0043	--	--
¹²⁵ Sb	2.7 yr	0.19	0.0012	--	--
¹³² Te	77.7 hr	--	0.069	--	--
¹²⁹ I	1.7 x 10 ⁷ yr	2.7 x 10 ⁻¹⁰	2.3 x 10 ⁻⁸	--	--
¹³¹ I	8.1 d	5.1	0.54	--	4.1 x 10 ⁻⁴
¹³² I	2.3 hr	--	11	--	--
¹³³ I	20.3 hr	1.1	3.0	--	--
¹³⁵ I	6.7 hr	--	6.7	--	--
¹³³ Xe	5.3 d	6.9	4.1	--	--
¹³⁵ Xe	9.1 hr	--	1,400	--	--
¹³⁸ Xe	17.5 min	--	5,300	--	--
¹³⁴ Cs	2.1 yr	--	0.011	--	--
¹³⁷ Cs	30.0 yr	0.078	0.039	--	--
¹⁴⁰ Ba	12.8 d	0.45	0.16	--	--
¹⁴⁰ La	40.2 hr	2.7	0.36	--	--
¹⁴¹ Ce	32.5 d	0.053	0.030	--	--
¹⁴⁴ CePr	284.0 d	--	0.060	--	--
¹⁴⁷ Nd	11.1 d	--	0.073	--	--
¹⁵³ Sm	46.8 hr	0.28	0.12	--	--
¹⁵⁴ Eu	16.0 yr	--	0.0074	--	--
¹⁵⁵ Eu	1.8 yr	--	0.014	--	--
¹⁸⁷ W	23.9 hr	--	0.094	--	--
Th-Nat.	1.4 x 10 ¹⁰ yr	--	--	--	1.9 x 10 ⁻⁷
U-Nat.	4.4 x 10 ⁹ yr	--	--	--	2.7 x 10 ⁻⁵
²³⁹ Np	2.3 d	--	0.78	--	--
²³⁸ Pu	86.4 yr	6.8 x 10 ⁻⁵	3.4 x 10 ⁻⁷	--	9.6 x 10 ⁻⁴
²³⁹ Pu	2.44 x 10 ⁴ yr	5.0 x 10 ⁻⁵	2.0 x 10 ⁻⁶	0.0019	4.0 x 10 ⁻⁴ (c)
²⁴⁴ Cm	18.1 yr	--	--	--	5.1 x 10 ⁻⁸

- (a) Actually reported as mixed activation products. Cobalt-60 was assumed for simplicity and was used in dose calculations.
- (b) Actually reported as mixed fission products. Strontium-90 was assumed for simplicity and was used in dose calculations.
- (c) Actually reported as gross alpha. Plutonium-239 was assumed for simplicity and was used in dose calculations.
- Radionuclide not reported in effluent.

received from 1) exposure to airborne radionuclides at a location 1.6 km (1 mile) east of the 300 Area, 2) intake of drinking water obtained from the Columbia River at Richland, 3) consumption of foodstuff irrigated with Columbia River water at Riverview, and 4) aquatic recreation along the Hanford reach of the Columbia River. Shown in Tables 18 and 19 are the results of these calculations for the annual and the 50-yr dose commitment, respectively. The doses shown in these tables are not additive, since it is not possible for a single individual to be exposed to all sources at the same time. Further discussion of the dose from each of these pathways follows.

Airborne Releases

The maximum doses received offsite as a result of Hanford's airborne effluents in 1979 occurred at a location 1.6 km east of the 300 Area. Within this area are located the nearest dairy and farming operations in a downwind direction from the Hanford Site. Doses calculated include those received from inhalation of airborne radionuclides and from submersion in the plume for 8766 hr/yr (continuous occupancy); and that received from exposure to ground contamination for 4383 hr/yr (one-half of the total exposure time possible). In addition, the dose resulting from ingestion of a variety of foodstuffs (i.e., garden vegetables, milk, etc.) contaminated via dry deposition was calculated because of the foodstuffs grown in that area.

All of the annual doses resulting from exposure to the 1979 airborne effluents were far below Manual Chapter 0524 standards. The calculated annual whole-body dose (0.02 mrem represents 0.004% of the standard for the maximum individual in an uncontrolled area. Table 18 shows the 50-yr dose commitment from 1979 airborne effluents.

Drinking Water

Richland is the first city downstream from the Hanford Site to obtain some of its drinking water from the Columbia River. Tables 18 and 19 show the estimated annual dose and 50-yr dose commitment for an individual who drinks 730 liters (193 gal) of water obtained from the Columbia River. The calculated maximum annual dose (0.07 mrem to the thyroid) represents 1.8% of the Washington State drinking water standard of 4 mrem per year.

Irrigated Foodstuffs

The Riverview Area is the first area downstream from the Hanford Site that is extensively irrigated with Columbia River water. Shown in Tables 18 and 19 are the maximum annual dose and 50-yr dose commitments for an individual who consumes foodstuffs irrigated with Columbia River water, livestock raised on irrigated pasture, and a variety of other farm products whose culture involves Columbia River water. Many of the assumptions made about the maximum individual's diet, the crops irrigated, etc.,

TABLE 18. Annual Dose to the Maximum Individual from Effluents Released During 1979

Pathway	Dose (mrem) (a)					
	Skin	Body	GI ^(b)	Thyroid	Bone	Lung
Airborne(c)	0.23	0.02	0.02	0.06	0.02	0.14
Drinking Water	--	<0.01	<0.01	0.07	<0.01	<0.01
Irrigated Foodstuff	<0.01	<0.01	<0.01	0.20	0.01	<0.01
Aquatic Recreation(d)	<0.01	<0.01	<0.01	0.06	0.01	<0.01

- (a) The doses shown are not strictly additive. The dose received is dependent on the location and assumed living habits of the hypothetical maximum individual. The location of the maximum individual is different for each pathway shown; in some cases these locations are separated by many miles (see text).
- (b) Gastrointestinal tract (lower large intestine).
- (c) Includes dose contributions from inhalation, submersion, ingestion of foodstuffs contaminated by airborne deposition, and exposure to ground contamination.
- (d) Includes consumption of fish from the Columbia River.

TABLE 19. 50-year Dose Commitment for the Maximum Individual from Effluents Released During 1979.

Pathway	Dose (mrem) ^(a)					
	Skin	Body	GI ^(b)	Thyroid	Bone	Lung
Airborne ^(c)	0.23	0.05	0.02	0.07	0.60	0.56
Drinking Water	--	0.01	<0.01	0.08	0.05	<0.01
Irrigated Foodstuff	<0.01	0.05	<0.01	0.20	0.20	<0.01
Aquatic Recreation ^(d)	<0.01	0.03	<0.01	0.06	0.09	<0.01

- (a) The doses shown are not strictly additive. The dose received is dependent on the location and assumed living habits of the hypothetical maximum individual. The location of the maximum individual is different for each pathway shown; in some cases these locations are separated by many miles (see text).
- (b) Gastrointestinal tract (lower large intestine).
- (c) Includes dose contributions from inhalation, submersion, ingestion of foodstuffs contaminated by airborne deposition, and exposure to ground contamination.
- (d) Includes consumption of fish from the Columbia River.

are described in Appendix E. The calculated maximum annual dose (0.20 mrem to the thyroid) represents 0.01% of the Manual Chapter 0524 standard for the maximum individual in an uncontrolled area.

Aquatic Recreation

The Columbia River is used extensively for recreation. Estimates of the dose received from recreational activities, shown in Tables 18 and 19, are based on an individual who annually spends 500 hr along the shoreline, 100 hr swimming, and 100 hr boating, and who consumes 40 kg (88 lb) of fish from the Hanford reach of the Columbia River. All of the radionuclides released to the river were considered in the dose estimates. (Appendix D contains additional details on this calculation.) The calculated maximum annual dose (0.06 mrem to the thyroid) represents 0.004% of the Manual Chapter 0524 standard for the maximum individual in an uncontrolled area.

Population Dose

Doses to the population within an 80-km (50-mile) radius of the Hanford Site were computed for all of the radionuclides listed in Table 17. Since the affected population differs with each environmental pathway considered, a dose estimate is provided for each pathway-population combination. In addition, a population dose was calculated

for each major operating area since a different population distribution exists for each.

Summarized in Table 20 are the estimated population doses resulting from 1979 effluents to the Columbia River. Radionuclides in the drinking water obtained from the Columbia River downstream from Hanford produced most of the population dose from liquid effluents.

Shown in Table 21 are the computed doses to the population within an 80-km (50-mile) radius of the 100-N Area, 200 Areas, and 300 Area, from airborne effluents. Also shown are the estimated population groups affected by the effluents. Of the three operational areas, the releases from 100-N Area resulted in most of the population dose.

RADIOLOGICAL IMPACT FROM PAST HANFORD OPERATIONS

Previous sections of this report showed that, in general, any Hanford contributions to the levels of radiation observed in the environment were indistinguishable from pre-existing levels attributed to worldwide fallout or natural causes. Exceptions to these findings were the detection of a few radionuclides released from N Reactor to the Columbia River at concentrations less than 1% of the most restrictive guidelines of

TABLE 20. Dose to the Population from Liquid Effluents Released During 1979

Exposure Mode	Population Affected	Population Dose (person-rem)			
		Whole Body	GI(a)	Thyroid	Bone
		First-Year Dose			
Drinking water	50,000	0.01	0.03	1.80	0.03
Fish	(b)	<0.01	<0.01	0.02	<0.01
Aquatic Recreation	125,000	<0.01	<0.01	<0.01	<0.01
Irrigated Foodstuff	2,000	<0.01	<0.01	0.20	0.01
<u>50-Year Commitment</u>					
Drinking Water	50,000	0.09	0.03	1.80	0.32
Fish	(b)	0.01	<0.01	0.02	0.03
Aquatic Recreation	125,000	<0.01	<0.01	<0.01	<0.01
Irrigated Foodstuff	2,000	0.05	<0.01	0.20	0.20

(a) Gastrointestinal tract (lower large intestine).

(b) The population dose is based on consumption of 15,000 (33,000 lb) of fish during 1979. The population dose would be numerically the same regardless of the number of people eating the fish.

TABLE 21. Dose to the Population from Airborne Effluents Released During 1979

Effluent Release Point	80-Kilometer Population	Population Dose (person-rem)				
		Whole Body	GI(a)	Thyroid	Bone	Lung
		First-Year Dose				
100-N Area	236,000	1.3	1.3	3.2	1.4	1.3
200 Areas	258,000	<0.01	0.01	<0.01	0.01	0.02
300 Area	171,000	0.01	<0.01	0.03	<0.01	0.21
<u>50-Year Commitment</u>						
100-N Area	236,000	1.3	1.3	3.2	1.5	1.3
200 Areas	258,000	0.09	<0.01	<0.01	0.43	0.09
300 Area	171,000	0.06	<0.01	0.03	0.96	0.91

(a) Gastrointestinal tract (lower large intestine).

Manual Chapter 0524, and the continued presence of a few long-lived radionuclides, notably ^{60}Co , ^{137}Cs , and ^{154}Eu , along the Columbia River islands and shoreline near the Hanford Site. The radionuclides attributable to N Reactor were included in Table 17 and in the evaluation of the dose impact just discussed. The impact of the activity on the Columbia River islands and shoreline is evaluated here.

Shoreline sediments containing long-lived radionuclides would contribute to the maximum individual dose in proportion to the amount of time the individual spent in the area and exactly where it was spent, since the distribution is highly variable. An individual spending 500 hr/yr at the location of the highest observed offsite exposure rate as determined from the 1979 survey would receive an annual dose of about 20 mrem;⁽¹⁰⁾ this represents 5% of the 500 mrem standard from Manual Chapter 0524 for uncontrolled areas. It would be highly unlikely, however, for an individual to spend all 500 hours at one location, so the dose would probably be much smaller.

The contributions of the long-lived radionuclides in the shoreline sediments to the population dose computed for 1979 are insignificant because of the low levels of radioactivity, the remoteness of the shorelines, and the small number of people potentially affected.

IMPACT SUMMARY

The maximum "fence post" exposure rate for 1979, about 0.8 mR/hr occurred at a point on the Hanford shoreline of the Columbia River near N Reactor. Radiation from N Reactor rad waste facilities and accumulations of radionuclides in the soil at this location were responsible for most of this exposure rate.

The maximum annual whole-body dose to an individual member of the public from 1979 effluents is estimated to be less than 0.1 mrem, including contributions from airborne, drinking water, irrigated foodstuff,

and aquatic recreation pathways. The annual dose potentially received by any single organ (skin, GI, thyroid, bone, and lung) of the maximum individual from all pathways is estimated to be less than 0.5 mrem. These doses represent 0.02% of the maximum annual whole-body dose standard in Manual Chapter 0524.

Airborne effluents from the Hanford Site's three operating areas resulted in an annual whole-body dose to the population within an 80-km (50-mile) radius of Hanford of about 1.3 person-rem. Liquid effluents during 1979 contributed very little (about 0.01 person-rem) to the total whole body population dose because of the limited population affected. The total population dose is equivalent to an annual per capita whole-body dose of about 0.005 mrem (1.3 person-rem/250,000 people).

These dose estimates can be compared with doses from other routinely encountered sources of radiation such as natural background radiation,⁽²¹⁾ medical diagnostic procedures,⁽²¹⁾ and a 5-hr commercial jet flight.⁽¹³⁾ Compared graphically in Figure 16 are the average doses from these sources and the maximum individual and average per capita whole-body doses from Hanford operations for 1979. The estimated population dose of 1.3 person-rem may also be compared with the approximately 25,000 person-rem received annually by the same population from background radiation.

Hanford contributions to both individual and population radiation exposure clearly represent a very small fraction of the dose received from other sources. Moreover, the maximum dose potentially received from natural background radiation, diagnostic medical procedures, and commercial jet flights could be much greater than the values shown, depending on an individual's life-style.⁽²¹⁾ Thus, the dose contribution to the maximum individual from Hanford operations is much less than the variability in other doses received by people with different lifestyles.

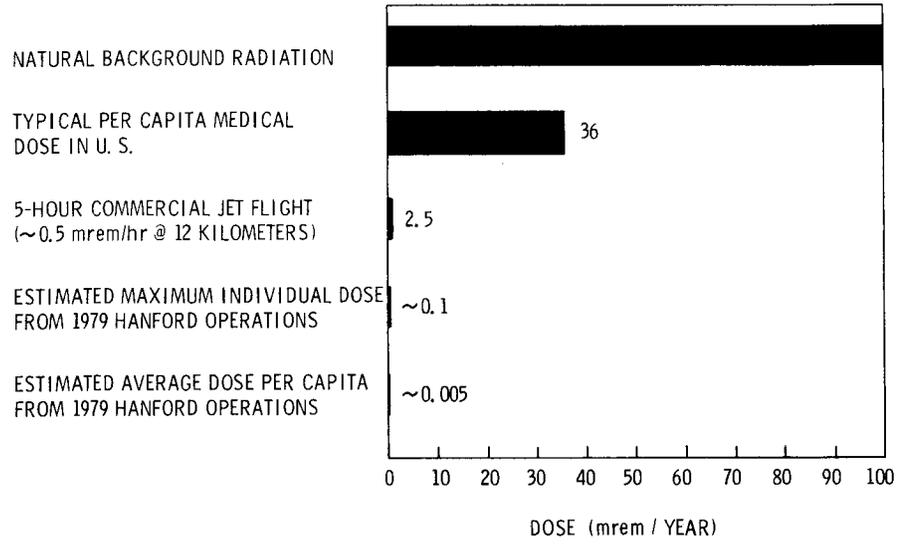
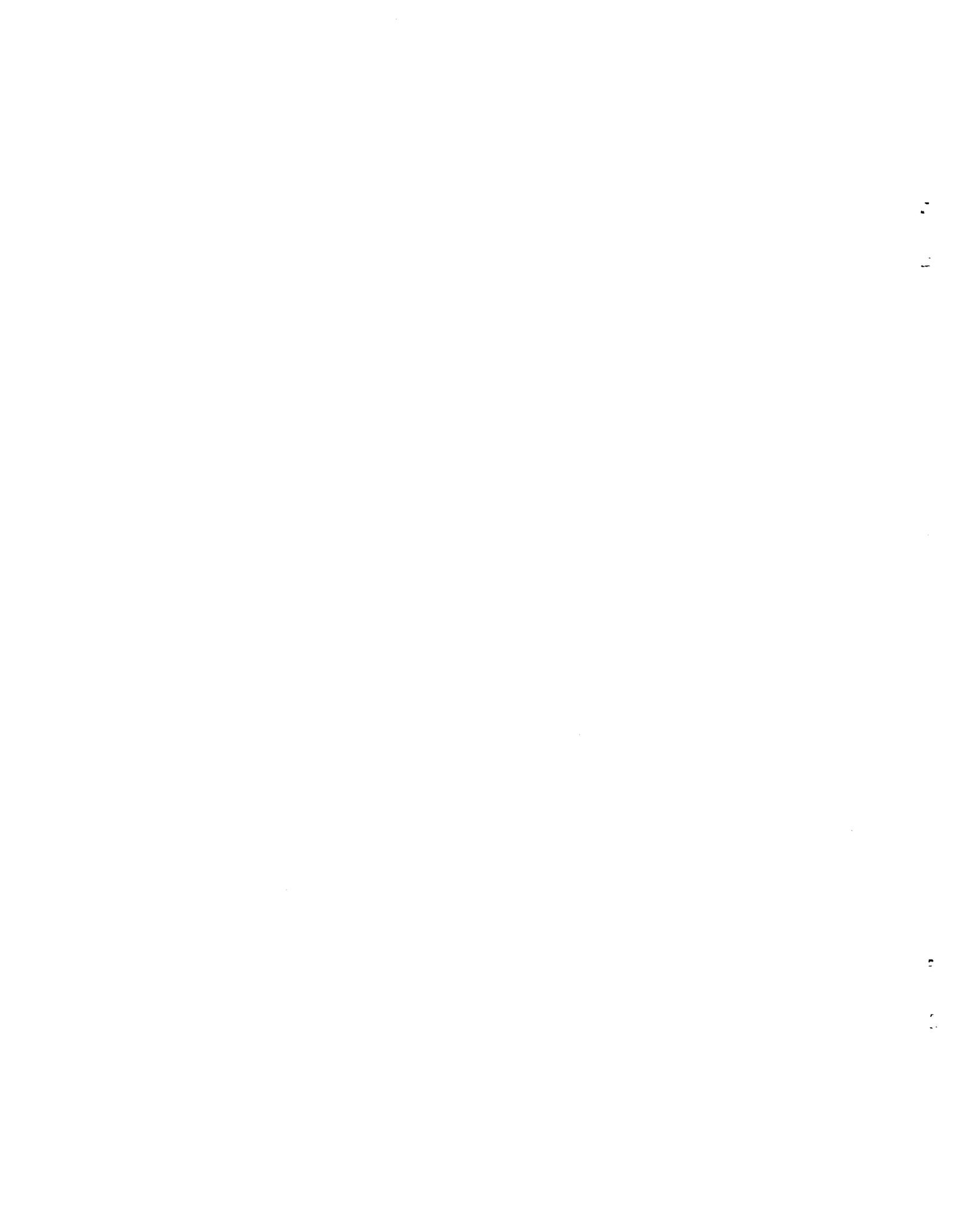


FIGURE 16. Comparative Doses Received from Various Radiation Sources



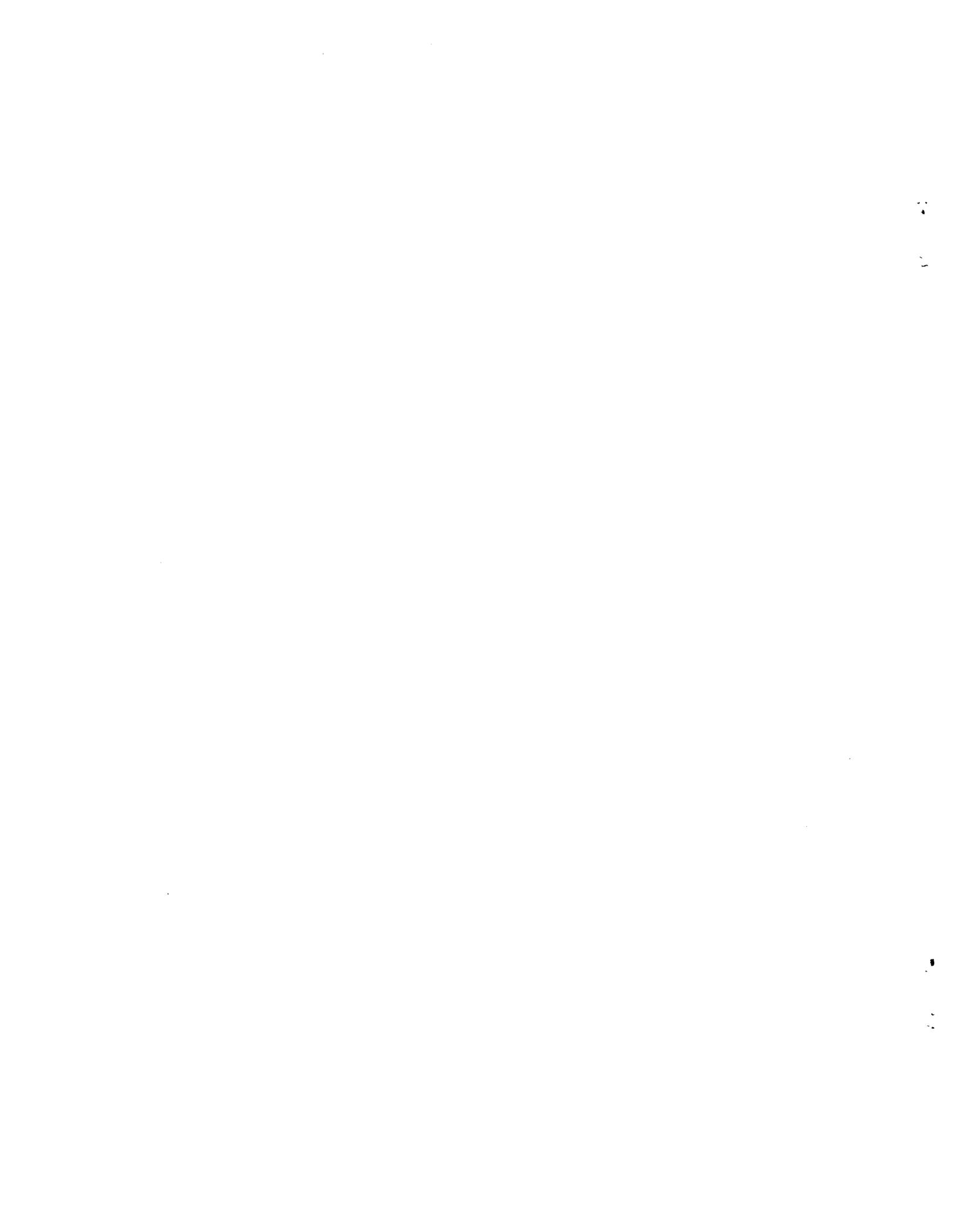
REFERENCES

1. U.S. Energy Research and Development Administration, Final Environmental Statement, Waste Management Operations, Hanford Reservation, ERDA-1538, U.S. Energy Research and Development Administration, Washington, DC, December 1975.
2. P. A. Eddy, Environmental Monitoring Report on the Status of Ground Water Beneath the Hanford Site January - December 1979. PNL-3346, Pacific Northwest Laboratory, Richland, WA 99352, (in preparation)
3. P. J. Blumer, J. R. Houston, and P. A. Eddy, Master Schedule for CY-1979 Hanford Environmental Surveillance Routine Program. PNL-2801, Pacific Northwest Laboratory, Richland, WA 99352, December 1978.
4. J. R. Houston and P. J. Blumer, Environmental Surveillance at Hanford for CY-1978. BNWL-2932, Pacific Northwest Laboratory, Richland, WA 99352, April 1979.
5. U.S. Energy Research and Development Administration, Manual Chapter 0524, "Standards for Radiation Protection," with Appendix. U.S. Energy Research and Development Administration, Washington, DC, October 1973.
6. Water Quality Standards. Washington State Department of Ecology, December 1977.
7. "Natural Primary and Secondary Ambient Air Quality Standards." Federal Regulations, 40 CFR 50, Environmental Protection Agency, January 1973.
8. "TGS-ANSA Method for the Determination of Nitrogen Dioxide in the Atmosphere." Method No. EQN-1277-028, U.S. Environmental Protection Agency, Environmental Monitoring Support Laboratory, Department E, Research Triangle Park, North Carolina.
9. R. T. Jaske and M. R. Synoground, Effect of Hanford Plant Operations on the Temperature of the Columbia River, 1964 to Present. BNWL-1345, Pacific Northwest Laboratory, Richland, WA 99352, November 1970.
10. K. R. Price, L. L. Cadwell, and R. G. Schreckhise, "Iodine-129 in Forage and Deer on the Hanford Site and Other Pacific Northwest Locations, PNL-3357, Pacific Northwest Laboratory, Richland, WA (in preparation).
11. M. L. Miller, J. J. Fix and P. E. Bramson, Radiochemical Analyses of Soil and Vegetation Samples Taken from the Hanford Environs, 1971-1976. BNWL-2249, Pacific Northwest Laboratory, Richland, WA 99352, June 1977.
12. J. J. Fix and M. L. Miller, The Hanford Environmental CaF₂:Mn Thermoluminescent Dosimeter. PNL-2489, Pacific Northwest Laboratory, Richland, WA 99352, March 1978.
13. National Council on Radiation Protection, Natural Background Radiation in the United States. NCRP Report No. 45, National Council on Radiation Protection, Washington, DC, 1975.
14. W. J. Tipton, An Aerial Radiological Survey of the U.S. Energy Research and Development Administration's Hanford Reservation. EGG-1183-1661, EG&G, Inc., Las Vegas, NV, April 1975.
15. M. J. Sula, Radiological Survey of Exposed Shorelines and Islands of the Columbia River Between Vernita and the Snake River Confluence, PNL-3127, Pacific Northwest Laboratory, Richland, WA 99352, April 1980.
16. T. W. Essig and J. P. Corley, Criteria Used to Estimate Radiation Doses Received by Persons Living in the Vicinity of Hanford: Interim Report No. 2, BNWL-1019, Pacific Northwest Laboratory, Richland, WA 99352, April 1969.
17. J. R. Houston, D. L. Strenge and E. C. Watson, DACRIN - A Computer Code for Calculating Organ Dose from Acute or Chronic Radionuclide Inhalation. BNWL-B-389, Pacific Northwest Laboratory, Richland, WA, 99352, August 1975.

18. D. A. Baker, G. R. Hoenes and J. K. Soldat, FOOD - An Interactive Code to Calculate Internal Radiation Doses from Contaminated Food Products. BNWL-SA-5523, Pacific Northwest Laboratory, Richland, WA 99352, February 1976.
19. J. K. Soldat, N. M. Robertson and D. A. Baker, Models and Computer Codes for Evaluating Environmental Radiation Doses, BNWL-1754, Pacific Northwest Laboratory, Richland, WA 99352, February 1974.
20. U.S. Energy Research and Development Administration, Manual Chapter 0513, "Effluents and Environmental Monitoring and Reporting." U.S. Energy Research and Development Administration, Washington, DC, February 1974.
21. U.S. Environmental Protection Agency, Estimates of Ionizing Radiation Doses in the United States, 1960-2000. ORP/CSD 72-1, Rockville, MD, August 1972.

APPENDIX A

APPLICABLE STANDARDS



APPENDIX A

APPLICABLE STANDARDS

Operations at the Hanford Site must conform to a variety of federal and state standards designed to ensure the radiological, chemical, biological, and physical quality of the environment for either aesthetic or public health considerations. The state of Washington has promulgated water quality standards for the Columbia River.⁽⁶⁾ Of interest to Hanford operations is the designation of the Hanford reach of the Columbia

River as Class A or excellent. This designation requires that the water be usable for substantially all needs including drinking water, recreation, and wildlife. Class A water standards are summarized in Table A.1. Air quality standards have been promulgated by the Environmental Protection Agency (EPA)⁽⁷⁾ and are summarized in Table A.2.

TABLE A.1. Washington State Water Quality Standards for the Hanford Reach of the Columbia River⁽⁶⁾

CLASS A WATER CHARACTERISTIC

Meets or exceeds requirements for all uses.

USES

Include but not limited to:
 Water supply--domestic, industrial, agricultural
 Wildlife habitat, stock watering
 General recreation and aesthetic enjoyment
 Commerce and navigation
 Fish and shellfish reproduction, rearing and harvesting

WATER QUALITY STANDARDS

<u>Parameter</u>	<u>Permissible Levels</u>
Fecal coliform organism	1) ≤ 100 organisms/100 ml (median) 2) $\leq 10\%$ of samples may exceed 200 organisms/100 ml
Dissolved oxygen	>8 mg/l
Temperature	1) $\leq 18^{\circ}\text{C}$ (64°F) due to human activities 2) Increases not to exceed $28/(T+27)$, where T = highest existing temperature in $^{\circ}\text{C}$ outside of mixing zone
pH	1) 6.5-8.5 range 2) <0.5 unit induced variation
Turbidity	≤ 5 NTU ^(a) over background turbidity
Toxic, radioactive, or deleterious materials	Concentrations shall be below those of public health significance, or which cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.
Aesthetic value	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

(a) NTU = Nephelometric Turbidity Units - Standard Candle

TABLE A.2. Air Quality Standards

Parameter	Maximum Permissible Level	Period
SO ₂ ^(a)	0.10 ppm 0.02 ppm	24-hr average Annual average
NO ₂ ^(b)	100 µg/m ³ 250 µg/m ³ ^(c)	Annual arithmetic mean 24-hr average
Suspended particulates ^(a)	60 µg/m ³ ^(d)	Annual mean

(a) Ref: Washington State Department of Ecology.

(b) Ref: U.S. EPA.

(c) Not to be exceeded more than once per year.

(d) Less background east of the Cascades.

Environmental radiation protection standards are published in Manual Chapter 0524, "Standards for Radiation Protection."⁽⁵⁾ These standards are based on guidelines originally recommended by the Federal Radiation Council (FRC) and other scientific groups such as the International Commission on Radiological Protection (ICRP) and the National Commission on Radiation Protection and Measurements (NCRP). The standards govern exposures to ionizing radiation for DOE and DOE contractor personnel and for members of the public who may be exposed to ionizing radiation resulting from DOE and DOE contractor operations. Several concentration guides for air and water are listed in Table A.3.

Copies of these regulations may be obtained from the following organizations:

- State of Washington
Department of Ecology
Olympia, WA 98504
- U.S. Environmental Protection Agency,
Region 10
1200 Sixth Avenue
Seattle, WA 98101
- U.S. Department of Energy
Richland Operations Office
Richland, WA 99352

TABLE A.3. Radionuclide Concentration Guides^(a)

Radionuclide	Water (10 ⁻⁹ µCi/ml)	Air (10 ⁻¹² µCi/ml)
Gross Alpha	30	0.02
Gross Beta	3,000	100
³ H	3,000,000	200,000
⁵⁴ Mn	100,000	1,000
⁵¹ Cr	2,000,000	80,000
⁶⁰ Co	30,000	300
⁶⁵ Zn	100,000	2,000
⁹⁰ Sr	300	30
⁹⁵ ZrNb	60,000	1,000
¹⁰⁶ Rn	10,000	200
¹³¹ I	300	100
¹³⁷ Cs	20,000	500
¹⁴⁰ BaLa	20,000	500
¹⁴⁴ Ce	10,000	200
²³⁹ Pu	5,000	0.06

(a) Obtained from Manual Chapter 0524, Table II. Most restrictive guide assumed.

APPENDIX B

ANALYTICAL PROCEDURES

APPENDIX B

ANALYTICAL PROCEDURES

AIR SAMPLES

Alpha-, Beta-, and Gamma-Emitting Radionuclides are measured by a direct count of the asbestos paper 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 collected on filter paper and determined by leaching the filters with nitric acid, precipitating with fuming nitric acid, scavenging with barium chromate, precipitating as a carbonate, transferring to a stainless steel planchet, and counting with a gas flow proportional counter.

Plutonium is leached from the filter paper with fuming nitric acid and passed through an anion exchange resin. The resin column is eluted with 0.4 N HNO₃ - 0.01 N HF and the plutonium in the eluate is 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 the well of a 23-cm x 23-cm (9-in. x 9-in.) NaI(Tl) well detector.

WATER SAMPLES

Beta-Emitting Radionuclides are measured by a direct count of dried residue.

Uranium and Plutonium (Total Alpha) are extracted into ether from strong nitric acid. The ether phase is evaporated off and the residue 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 the well of 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 a stainless steel planchet, and beta-counted with a low-level beta proportional counter. After a 15-day period the yttrium-90 daughter is separated and counted with a low-level beta proportional counter.

Tritium is measured in distilled water samples with a liquid scintillation spectrometer.

Filter-Resin Samples are analyzed for gamma-emitting radionuclides using a GeLi 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 spectrometric means for plutonium.

MILK

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

Iodine-131 is removed from milk with anion exchange resin, Cl⁻ form. The iodine is leached off the resin with sodium hypochlorite, precipitated as palladium chloride, and beta-counted with a low-background beta 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 beta counting.

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.

Plutonium analyses are made like those for air samples after drying, ashing in a furnace, and wet ashing with nitric acid.

Uranium analyses are made like those for water samples after drying, ashing in a furnace, and wet ashing with nitric acid.

Strontium-90 analyses are made like those for air samples after the pretreatment described for uranium and plutonium.

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 approximately 500 grams of sample into a marinelli beaker and counting on a lithium-drifted germanium detector, with a multichannel pulse height analyzer.

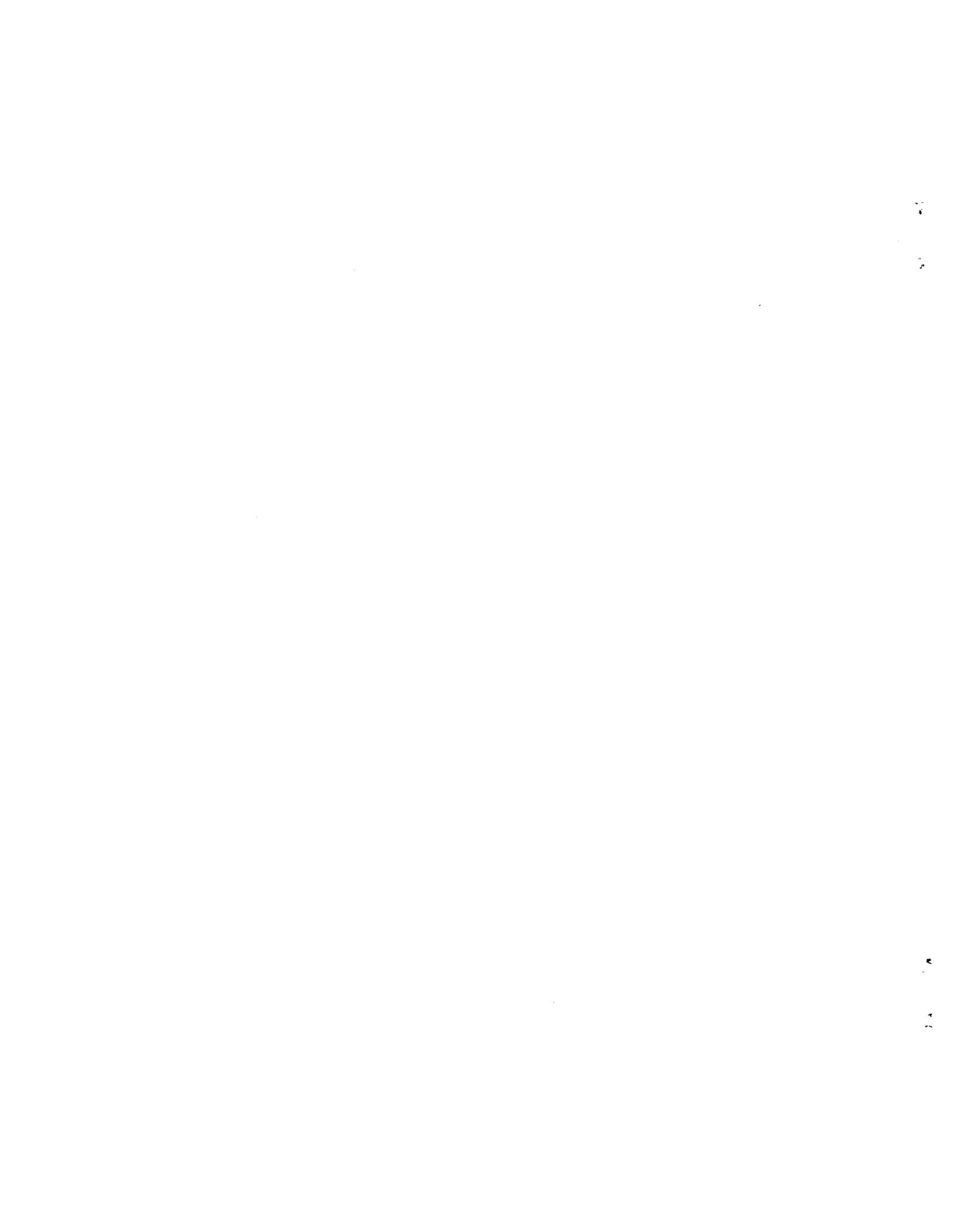
Plutonium and Strontium-90 are measured when the soil is dried, mixed thoroughly, leached with a mixture of nitric and hydrochloric acids, and then passed through an ion exchange resin in 8 N nitric acid.

The nitric acid retains strontium and other metal ions. This phase is precipitated with fuming nitric acid, scavenged with barium chromate, precipitated as a carbonate, and transferred to a stainless steel planchet. The ⁹⁰Sr sample is counted with a low-background beta proportional counter.

The plutonium is eluted from the resin column with 0.4 N HNO₃ - 0.01 N HF and electrodeposited on a stainless steel disk for alpha spectrometric analyses.

APPENDIX C

DATA ANALYSIS



APPENDIX C

DATA ANALYSIS

Most data summary tables in this report show maximum, minimum and average concentration values for various radionuclide-media-location combinations. Maximum and minimum refer to the largest and smallest concentrations found in a single sample during the year. Average values are usually accompanied by a plus or minus (+) value. This value is equivalent to twice the standard deviation of the distribution of the observed individual sample results and is a measure of the range in concentration or level encountered for those samples. When an average is shown for groups of locations, this value has been computed from the individual results and the plus or minus value accompanying the average is twice the standard deviation of the distribution of all the individual results.

The arithmetic averages and standard deviations shown in this report were calculated using the following equations:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$$

where: \bar{X} = arithmetic average
 n = numbers of samples analyzed
 X_i = individual sample results

$$s = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}}$$

where: s = standard deviation
 n = number of samples analyzed
 X_i = individual sample results
 \bar{X} = arithmetic average

For many sample analyses, it is possible to obtain net values that are lower than the detection limit of the system. This is particularly true when an instrument or chemical

background must be subtracted. It is not uncommon for individual measurements to result in negative numbers due to statistical fluctuations. In fact with many measurements of a true zero sample an approximately equal number of net positive and negative results would be expected. Although negative values do not represent a physical reality, they must be included along with the other values in order to compute the correct average for the population. For this reason the primary values given in this report are the actual values obtained from individual measurements.

A detection limit was computed for each sample analyzed during 1979 as an aid in determining the significance of each result. A sample result at the detection limit, as currently defined, means that there is a 95% chance that the material being measured is actually present. At the same time it means that there is a 5% chance that the result is due to a high statistical fluctuation in the background and the material being measured is not present. Since the detection limits vary considerably over the course of a year, an average detection limit is computed and presented in most tables to provide some perspective for the reader in evaluating the sample results.

Environmental data have been found to be better described by a Gaussian distribution function of the logarithms of the data than by the data itself (Speer and Waite 1975). This being the case, log-normal probability plots have been freely used throughout the report as analytical tools and to more graphically present the data. Log-normal probability plotting produces a straight line plot if the data are log-normally distributed and result from a single source such as worldwide fallout. If the data describe two connecting straight lines or if data points at high cumulative probability fall significantly above a single straight line, more than one source may be contributing to the observed values.



APPENDIX D

QUALITY ASSURANCE



APPENDIX D

QUALITY ASSURANCE

Several methods are used to assure that the data collected each year are representative of actual concentrations in the environment. First, extensive environmental data are collected to eliminate an unrealistic reliance on only a few results. Second, newly collected data are compared with historical data for each environmental medium to assure that current values are consistent with previous results. This allows for timely investigation of any unusual result. Third, measurements are collected using identical methods, near to and far from the Hanford Site, as well as upstream and downstream on the river, to provide for identification of any net difference that may be attributable to Hanford operations. These procedures, in conjunction with a program to demonstrate the accuracy of radiochemical analyses, assure that the data accurately represent environmental conditions.

ANALYTICAL LABORATORY QUALITY ASSURANCE

The majority of the routine radioanalyses for the Hanford environmental surveillance program are performed by the United States Testing Company in Richland, Washington. This laboratory maintains an internal quality assurance program that involves routine calibration of counting instruments, daily source and background counts, routine yield determinations of radiochemical procedures, replicate analyses to check precision, and analyses of reagents to assure purity of all chemicals. The accuracy of radionuclide determination is assured through the use of standards traceable to the National Bureau of Standards, when available. The laboratory also participates in laboratory

intercomparison programs conducted by the Environmental Measurements Laboratory (EML) and the Environmental Protection Agency (EPA). In these programs, a number of different environmental media (water, milk, air filters, soil and foodstuffs) containing one or more radionuclides in known amounts are prepared and distributed to participating laboratories. Replicate analyses are performed on each sample and the results forwarded to the sponsoring laboratory for comparison with known values and with the results from other laboratories. These programs enable a laboratory to demonstrate that it is capable of performing precise, accurate analyses.

Summarized in Table D.1 is a comparison of United States Testing Company, EPA and EML results. The EML and EPA results, while not the true values, are the mean of replicate analyses and are used as the reference values in the programs.

QUALITY ASSURANCE IN DOSE CALCULATIONS

Assurance of the dose calculation quality is provided in several ways. First, since doses are similar from year to year, a comparison is made against past calculated doses and any differences are validated. Second, all computed doses are double checked by the originator and by an independent third party who also checks all input data and assumptions used in the calculation. Third, information necessary to perform all of the calculations is fully documented. Synopses of the information for the 1979 calculations are shown in Tables D.2 - D.5.

TABLE D.1. Summary of Laboratory Intercomparison Results for 1979

Sample Medium	Radionuclide	EML		EPA	
		Number of Analyses	Average Ratio UST to EMS	Number of Samples	Average Ratio UST to EPA
Air	Alpha			3	0.83 ± 0.18
	Beta			3	1.01 ± 0.06
	⁷ Be	4	1.04 ± 0.03		
	²² Na	2	1.50 ± 0.01		
	⁵⁴ Mn	2	1.01 ± 0.01		
	⁵⁷ Co	2	0.95 ± 0.01		
	⁵⁸ Co	2	1.57 ± 0.01		
	⁶⁰ Co	2	0.82 ± 0.03		
	⁸⁹ Sr	4	1.15 ± 0.11		
	⁹⁰ Sr	6	1.26 ± 0.24	3	0.91 ± 0.10
	⁹⁵ Zr	4	2.68 ± 1.92		
	¹⁰⁶ Ru	4	1.72 ± 0.51		
	¹²⁹ Sb	4	0.94 ± 0.25		
	¹³⁴ Cs	4	4.99 ± 3.63		
	¹³⁷ Cs	6	1.35 ± 0.25	3	1.26 ± 0.25
	¹⁴⁴ Ce	2	1.15 ± 0.04		
	U	4	1.18 ± 0.17		
²³⁹ Pu	4	1.65 ± 0.67			
Water	Alpha			5	0.93 ± 0.12
	Beta			5	0.99 ± 0.16
	³ H	5	1.32 ± 0.19	4	1.23 ± 0.15
	²² Na	3	0.99 ± 0.10		
	⁵¹ Cr			1	1.46
	⁵⁴ Mn	2	1.14 ± 0.01		
	⁵⁷ Co	1	1.20 ±		
	⁶⁰ Co	4	0.86 ± 0.14	3	0.91 ± 0.05
	⁶⁹ Zn	1	1.00 ±	1	1.02 ±
	⁸⁹ Sr	2	5.09 ± 6.00	2	1.01 ± 0.24
	⁹⁰ Sr	3	0.98 ± 0.03	2	0.71 ± 0.25
	¹³¹ I			3	1.17 ± 0.13
	¹³⁴ Cs	2	0.97 ± 0.21	3	1.01 ± 0.18
	¹³⁷ Cs	5	1.03 ± 0.13	2	1.12 ± 0.03
	¹⁴⁴ Ce	1	1.02 ±		
	²²⁶ Ra			2	0.86 ± 0.11
	²²⁸ Ra			2	1.06 ± 0.28
	U	5	10.32 ± 12.40	2	0.91 ± 0.03
	²³⁸ Pu	3	0.99 ± 0.41		
²³⁹ Pu	4	1.01 ± 0.38	2	0.77 ± 0.09	
Soil	⁴⁰ K	4	0.60 ± 0.42		
	⁶⁰ Co	1	0.80 ±		
	⁹⁰ Sr	4	1.75 ± 1.70		
	¹³⁷ Cs	4	0.93 ± 0.08		
	²²⁶ Ra	4	0.75 ± 0.14		
	U	3	0.43 ± 0.28		
	²³⁸ Pu	4	10.44 ± 11.27	1	0.84
	²³⁹ Pu	4	0.85 ± 0.05		
	²⁴¹ Am	1	1.58 ±		
Vegetation	⁴⁰ K	3	1.23 ± 0.24		
	⁹⁰ Sr	3	0.79 ± 0.16		
	¹³⁷ Cs	3	0.93 ± 0.29		
	²²⁶ Ra	2	1.33 ± 0.88		
	U	1	0.45 ±		
	²³⁸ Pu	2	1.33 ± 0.88		
	²³⁹ Pu	3	4.24 ± 6.67		
Tissue	⁴⁰ K	3	3.84 ± 2.25		
	⁹⁰ Sr	3	3.08 ± 3.78		
	¹³⁷ Cs	2	1.07 ± 0.12		
	²²⁶ Ra	1	1.27 ±		
	U	1	1.74 ±		
	²³⁸ U	1	7.28 ±		
	²³⁹ Pu	1	0.58 ±		
Milk	⁴⁰ K			2	0.96 ± 0.12
	⁸⁹ Sr			4	1.17 ± 0.26
	⁹⁰ Sr			4	0.83 ± 0.05
	¹³⁷ Cs			4	1.18 ± 0.40
	¹³¹ I			4	1.22 ± 0.16
Food	⁴⁰ K			1	1.07 ±
	⁸⁹ Sr			2	1.21 ± 0.16
	⁹⁰ Sr			2	0.92 ± 0.02
	¹³¹ I			2	1.99 ± 1.34
	¹³⁷ Cs			2	1.91 ± 1.06

(a) Each sample is analyzed in triplicate.
 (b) Average ± standard deviation of the average.

TABLE D.2. QA Data for 100 Area Airborne Release Dose Calculation

Facility name:	100 Area
Releases:	See Table 17
Meteorological conditins:	100-N meteorological tower 1-year data (2-70 through 1-71), annual average, see Table E.1
Dispersion model:	Gaussian, Hanford parameters
X/Q:	Maximum individual 2.7×10^{-9} sec/m ³ @ 40 km SE-SSE 80-km population 4.1×10^{-4} person sec/m ³
Release height:	82.3 meters effective (60.96 meters actual stack height)
Populaton distribution:	236,000, see Figure E.1
Computer code:	DACRIN, Rev. 3-18-80
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Organ data library, Rev. 3-7-79 THERMA library, Rev. 10-29-75
Computer code:	FOOD, Rev. 3-13-80
Calculated dose:	Chronic ingestion and ground contamination exposure, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Radionuclide Library, Rev. 3-15-78 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 8-10-79 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	GRONK, Rev. 7-23-79
Calculated Dose:	Chronic air submersion, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	GIN, Rev. 4-24-79 TONIC, Rev. 4-24-79

TABLE D.3. QA Data for 100 Area Liquid Release Dose Calculation

Facility name:	100 Area
Releases:	See Table 17
River flow:	99,700 cfs
Mixing ratio:	1
Reconcentration formula:	3
Shore-width factor:	0.2
Population:	50,000--drinking water pathway 125,000--fish and direct exposure 2,000--irrigated foodstuff
Computer code:	ARRRG, Rev. 3-13-80
Calculated dose:	Chronic ingestion, direct exposure to water and shoreline, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Radionuclide Library, Rev. 3-15-78 Organ Data Library, Rev. 8-10-79 Hanford Specific Bio. Accum. Library External Dose Factor Library, Rev. 3-15-78
Computer code:	FOOD, Rev. 3-13-80
Calculated dose:	Chronic ingestion and ground contamination, maximum individual and 80 km population first-year dose and 50-year dose commitment
Files addresssed:	Radionuclide Library, Rev. 3-15-78 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 8-10-79 Ground Dose Factor Library, Rev. 3-15-78

TABLE D.4. QA Data for 200 Areas Airborne Release Dose Calculations

Facility name: 200 Areas

Releases: See Table 17

Meteorology conditions: HMS historical 15-year data (1955-1970), annual average, see Table E.2

Dispersion model: Gaussian, Hanford parameters

X/Q: Maximum individual 4.0×10^{-9} sec/m³ @ 37 km SE
80-km population 3.7×10^{-4} person sec/m³

Release height: 89.2 meters effective (60.96 meters actual stack height)

Population distribution: 258,000, See Figure E.2

Computer code: DACRIN, Rev. 3-18-80

 Calculated dose: Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-year dose commitment

 Files addressed: Organ Data Library, Rev. 3-7-79
 THERMA Library, Rev. 10-29-75

Computer code: FOOD, Rev. 3-13-80

 Calculated dose: Chronic ingestion and ground contamination exposure, maximum individual and 80-km population, first-year dose and 50-year dose commitment

 Files addressed: Radionuclide Library, Rev. 3-15-78
 Food Transfer Library, Rev. 2-27-78
 Organ Data Library, Rev. 8-10-79
 Ground Dose Factor Library, Rev. 3-15-78

Computer code: GRONK, Rev. 7-23-79

 Calculated dose: Chronic air submersion, maximum individual and 80-km population, first-year dose and 50-year dose commitment

 Files addressed: GIN, Rev. 4-24-79
 TONIC, Rev. 4-24-79

TABLE D.5. QA Data for 300 Area Airborne Release Dose Calculations

Facility name:	300 Area
Releases:	See Table 17
Meteorology conditions:	WPPSS 2-year data (4-74 through 3-76, annual average, see Table E.3)
Dispersion model:	Gaussian, Pasquill parameters
X/Q:	Maximum individual 3.4×10^{-6} sec/m ³ @ 1.6 km E 80-km population 5.7×10^{-3} person sec/m ³
Release height:	Ground level
Population distribution:	171,000, see Figure E.3
Computer code:	DACRIN, Rev. 3-18-80
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Organ Data Library, Rev. 3-7-79 THERMA Library, Rev. 10-29-75
Computer code:	FOOD, Rev. 3-13-80
Calculated dose:	Chronic ingestion and ground contamination exposure, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Radionuclide Library, Rev. 3-15-78 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 8-10-79 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	GRONK, Rev. 7-23-79
Calculated dose:	Chronic air submersion, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	GIN, Rev. 4-24-79 TONIC, Rev. 4-24-79

APPENDIX E

RADIATION DOSE CALCULATIONS

APPENDIX E

RADIATION DOSE CALCULATIONS

The methods used to compute environmental radiation doses from Hanford operations can be categorized as follows:

1. Whenever environmental monitoring data showed the presence of radionuclides due to Hanford operations in a pathway to man, the dose impact was calculated using the standard dose models referred to in the text. Assumptions as to the probable magnitude of the intake or exposure were stated in the text (i.e., the discussion on consumption of contaminated deer muscle on page 19 of this report).
2. The liquid and gaseous radionuclide effluent released during the year by all Hanford facilities is included in the report. Since the quantities shown are generally undetectable in the environment, the dose impact is calculated using the effluent quantities as source terms and using theoretical dispersion, uptake, and dose models to compute the radiation dose. All of the models have been used previously to calculate doses from Hanford facilities and are considered to provide the best estimates of the generally undetectable dose impact attributable to Hanford operations.

Because the calculation of doses resulting from situations in Category 1 is infrequent and sufficient detail is included in the text in such cases, no supporting information is considered necessary here.

Category 2 dose calculations, because of their complex nature, require considerable supporting information, to which the balance of this appendix is devoted. In computing the overall impact of Hanford operations, each major operating area (100-N Area, 200 Areas, 300 Area) is considered separately. The distances between these areas result in differences in the population distribution, the meteorological conditions, and the location of the maximum offsite impact. The assumptions used to calculate the dose impact during 1979 were as follows.

AIRBORNE EFFLUENTS

Separate impacts were calculated for releases from the 100-N Area, the 200 Areas, and the 300 Area (see Table 17). The source term used for each area was the 1979 release from that area. Specific information on the meteorology, demography, and release height for each area is given below.

100-N Area

Gaseous effluent was released at an effective height of 82 m (269 ft) above ground level. The population distribution shown in Figure E.1 for the area within an 80-km (50-mile) radius of the 100-N Area was used in the calculations. The annual average atmospheric dispersion data used are shown in Table E.1 for the 100-N Area and are based on a year's worth of meteorological data collected several years ago (the only data available). The Hanford maximum individual is located approximately 40 km (25 miles) southeast of 100-N area.

200 Areas

Gaseous effluent was assumed to be released at the center of the 200 Areas at an effective height of 89 m (292 ft) above ground level. Calculations used the population distribution shown in Figure E.2 for the area within an 80-km (50-mile) radius of the Hanford Meteorological Station (HMS) located on the east side of 200-West Area. Annual average atmospheric dispersion data used in the calculations are based on past meteorological data (the 15-yr average from 1955 to 1970) from HMS and are presented in Table E.2. The Hanford maximum individual is located approximately 37 km (23 miles) southeast of the 200 Areas.

300 Area

Gaseous effluent was assumed to be released at ground level since most stacks in the 300 Area are rather short compared to building height. Population distribution data shown in Figure E.3 for the area within an 80-km (50-mile) radius of the 300 Area were used in the calculations. Annual

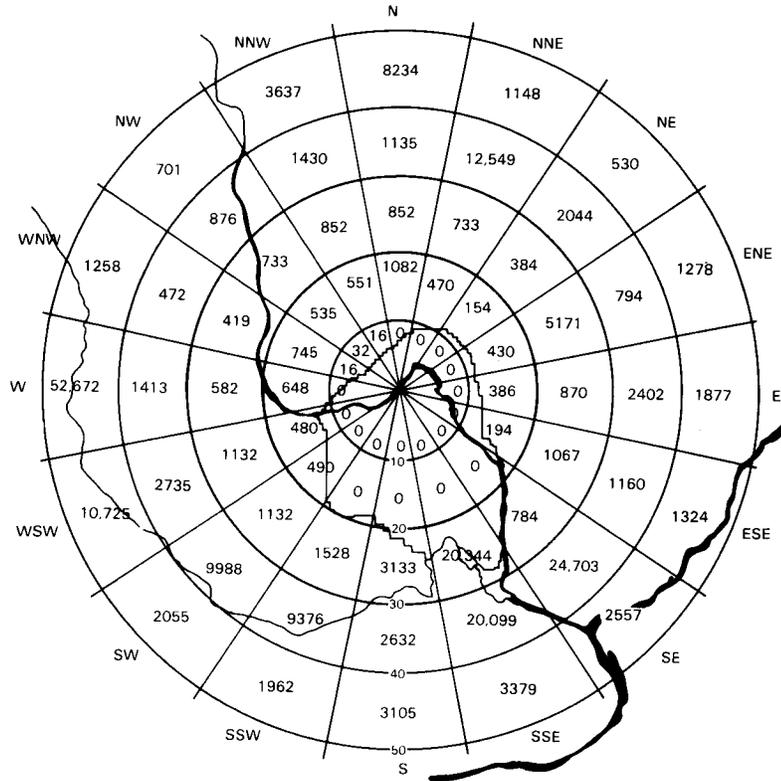


FIGURE E.1. Estimated Geographic Distribution of the Population (236,000) Within a 50-Mile (80-km) Radius of the 100-N Area

TABLE E.1. Annual Average Atmospheric Dispersion Around the 100-N Area for an 82-m Release Height (Units are sec/m^3) (a)

Direction	Range in Miles (km)									
	0.5 (0.8)	1.5 (2.4)	2.5 (4.0)	3.5 (5.6)	4.5 (7.2)	7.5 (12)	15 (24)	25 (40)	35 (56)	45 (72)
N	3.68E-08	1.60E-08	9.02E-09	5.69E-09	4.05E-09	2.49E-09	1.91E-09	1.44E-09	1.10E-09	8.69E-10
NNE	5.24E-08	2.05E-08	1.08E-08	6.64E-09	4.62E-09	1.94E-09	1.94E-09	1.46E-09	1.12E-09	8.90E-10
NE	1.44E-07	4.84E-08	2.35E-08	1.39E-08	9.39E-09	5.02E-09	3.30E-09	2.44E-09	1.87E-09	1.48E-09
ENE	1.21E-07	5.50E-08	2.81E-08	1.70E-08	1.17E-08	6.65E-09	4.72E-09	3.56E-09	2.73E-09	2.17E-09
E	1.14E-07	6.79E-08	3.60E-08	2.20E-08	1.54E-08	9.31E-09	7.43E-09	5.95E-09	4.70E-09	3.79E-09
ESE	1.20E-07	7.12E-08	3.76E-08	2.29E-08	1.59E-08	9.18E-09	6.87E-09	5.41E-09	4.27E-09	3.45E-09
SE	7.91E-08	4.84E-08	2.60E-08	1.60E-08	1.10E-08	5.95E-09	3.81E-09	2.74E-09	2.07E-09	1.63E-09
SSE	7.94E-08	4.40E-08	2.27E-08	1.37E-08	9.28E-09	4.73E-09	2.72E-09	1.85E-09	1.36E-09	1.05E-09
S	9.41E-08	4.26E-08	2.14E-08	1.27E-08	8.58E-09	4.25E-09	2.32E-09	1.55E-09	1.13E-09	8.70E-10
SSW	1.61E-07	5.84E-08	2.82E-08	1.65E-08	1.10E-08	5.38E-09	2.89E-09	1.93E-09	1.41E-09	1.09E-09
SW	7.78E-08	3.33E-08	1.77E-08	1.08E-08	7.49E-09	4.13E-09	2.67E-09	1.89E-09	1.41E-09	1.10E-09
WSW	5.39E-08	2.74E-08	1.62E-08	1.04E-08	7.39E-09	4.34E-09	2.99E-09	2.14E-09	1.59E-09	1.24E-09
W	7.20E-08	3.48E-08	1.97E-08	1.25E-08	8.81E-09	5.20E-09	3.64E-09	2.62E-09	1.95E-09	1.52E-09
WNW	8.53E-08	3.75E-08	2.07E-08	1.29E-08	9.02E-09	5.09E-09	3.39E-09	2.41E-09	1.80E-09	1.40E-09
NW	8.32E-08	3.48E-08	1.90E-08	1.18E-08	8.24E-09	4.62E-09	3.60E-09	2.19E-09	1.64E-09	1.28E-09
NNW	4.68E-08	2.07E-08	1.18E-08	7.43E-09	5.22E-09	2.99E-09	2.04E-09	1.48E-09	1.11E-09	8.69E-10

(a) Calculated from meteorological data collected for the period 2-70 through 1-71.

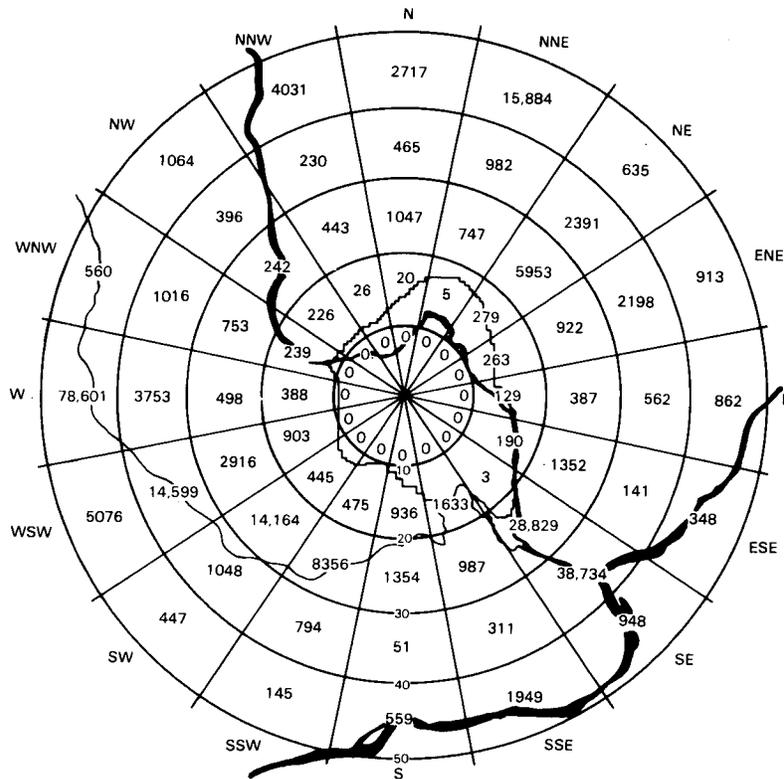


FIGURE E.2. Estimated Geographic Distribution of the Population (258,000) Within a 50-Mile (80-km) Radius of the Hanford Meteorological Station

TABLE E.2. Annual Average Atmospheric Dispersion Around the 200 Areas for an 89-m Release Height (Units are sec/m^3) (a)

Direction	Range in Miles (km)									
	0.5 (0.8)	1.5 (2.4)	2.5 (4.0)	3.5 (5.6)	4.5 (7.2)	7.5 (12)	15 (24)	25 (40)	35 (56)	45 (72)
N	3.29E-08	1.76E-08	1.04E-08	6.91E-09	4.87E-09	2.29E-09	1.08E-09	7.81E-10	6.23E-10	5.10E-10
NNE	4.70E-08	1.90E-08	1.05E-08	6.82E-09	4.76E-09	2.22E-09	1.08E-09	8.11E-10	6.60E-10	5.47E-10
NE	8.05E-08	3.02E-08	1.54E-08	9.44E-09	6.40E-09	2.92E-09	1.50E-09	1.19E-09	9.86E-10	8.26E-10
ENE	7.61E-87	2.84E-08	1.45E-08	3.94E-09	6.07E-09	2.85E-09	1.64E-09	1.37E-09	1.15E-09	9.64E-10
E	4.61E-08	2.28E-08	1.32E-08	8.72E-09	6.17E-09	3.18E-09	2.22E-09	1.95E-09	1.65E-09	1.39E-09
ESE	7.97E-08	4.00E-08	2.17E-08	1.36E-08	9.38E-09	4.77E-09	3.60E-09	3.37E-09	2.93E-09	2.50E-09
SE	1.67E-07	7.60E-08	4.02E-08	2.49E-08	1.70E-08	7.97E-09	4.54E-09	3.73E-09	3.12E-09	2.62E-09
SSE	8.34E-08	4.19E-08	2.47E-08	1.64E-08	1.16E-08	5.42E-09	2.40E-09	1.60E-09	1.22E-09	9.76E-10
S	8.65E-08	4.38E-08	2.55E-08	1.68E-08	1.18E-09	5.40E-09	2.14E-09	1.33E-09	9.81E-10	7.71E-10
SSW	7.93E-08	3.88E-08	2.19E-08	1.42E-08	9.89E-09	4.43E-09	1.65E-09	9.59E-10	6.90E-10	5.35E-10
SW	6.89E-08	4.06E-08	2.36E-08	1.54E-08	1.08E-08	4.82E-09	1.73E-09	9.64E-10	6.79E-10	5.19E-10
WSW	3.74E-08	2.39E-08	1.49E-08	1.01E-08	7.20E-09	3.30E-09	1.24E-09	7.20E-10	5.18E-10	4.02E-10
W	3.72E-08	2.57E-08	1.64E-08	1.13E-08	8.13E-09	3.76E-09	1.44E-09	8.57E-10	6.24E-10	4.87E-10
WNW	3.42E-08	2.37E-08	1.58E-08	1.12E-08	8.09E-09	3.84E-09	1.63E-09	1.07E-09	8.20E-10	6.56E-10
NW	4.17E-08	2.69E-08	1.82E-08	1.29E-08	9.41E-09	4.55E-09	2.08E-09	1.45E-09	1.13E-09	9.10E-10
NNW	2.68E-08	1.57E-08	1.03E-08	7.27E-09	5.27E-09	2.56E-09	1.22E-09	8.79E-10	6.94E-10	5.64E-10

(a) Calculated from meteorological data collected from 1955 through 1970.

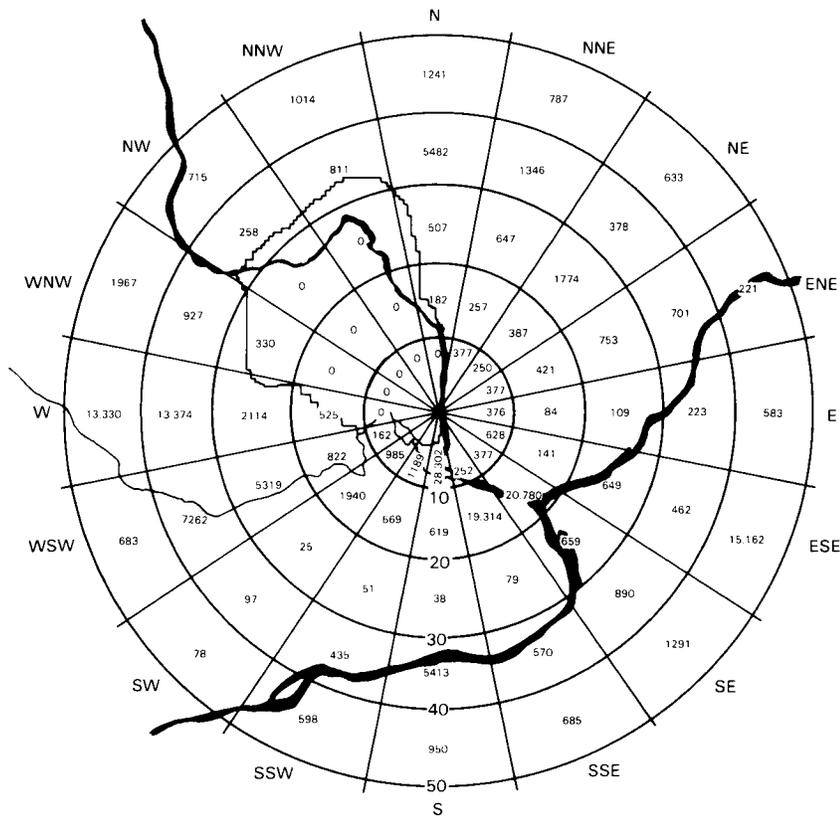


FIGURE E.3. Estimated Geographic Distribution of the Population (171,000) Within a 50-Mile (80-km) Radius of the 300 Areas

average atmospheric dispersion data developed from meteorological data collected by the Washington Public Power Supply System (WPPSS)(a) for the WNP-2 reactor were used. These data are shown in Table E.3. The Hanford maximum individual is located approximately 1.6 km (1 mile) east of the 300 Area.

Doses were then calculated for exposure via the following sources:

- inhalation
- submersion
- ground deposition
- eating vegetables, fruits, etc., grown in the vicinity of Hanford
- eating meat and poultry products from animals raised in the vicinity of Hanford.

LIQUID EFFLUENTS

The 1979 releases, shown in Table 17 in the text, were assumed to be mixed with the total annual flow of the Columbia River. For 1979, the United States Geological Survey reported that the mean annual flow rate was 99,700 cubic feet per second.

Doses were then calculated for intakes or exposure via the following sources:

- drinking sanitary water obtained from the river
- eating fish obtained from the river
- eating vegetables, fruits, etc., grown using river water for irrigation
- eating meat and poultry products from animals fed on irrigated pasture
- swimming, boating, and recreating on the shoreline.

(a) We wish to thank WPPSS for permission to use their meteorological data.

TABLE E.3. Annual Average Atmospheric Dispersion Around the 300 Area for a Ground-Level Release (Units are sec/m^3) (a)

Direction	Range in Miles (km)									
	0.5 (0.8)	1.5 (2.4)	2.5 (4.0)	3.5 (5.6)	4.5 (7.2)	7.5 (12)	15 (24)	25 (40)	35 (56)	45 (72)
N	5.7E-06	8.7E-07	3.9E-07	2.4E-07	1.6E-07	7.9E-08	3.1E-08	1.6E-08	1.0E-08	7.4E-09
NNE	5.0E-06	7.6E-07	3.4E-07	2.1E-07	1.4E-07	6.9E-08	2.7E-08	1.3E-08	8.7E-09	6.3E-09
NE	3.9E-06	5.9E-07	2.6E-07	1.6E-07	1.1E-07	5.3E-08	2.1E-08	1.0E-08	6.7E-09	4.9E-09
ENE	3.6E-06	5.5E-07	2.5E-07	1.5E-07	1.0E-07	5.0E-08	1.9E-08	9.8E-09	6.4E-09	4.6E-09
E	3.4E-06	5.1E-07	2.3E-07	1.4E-07	9.4E-08	4.6E-08	1.8E-08	9.0E-09	5.9E-09	4.3E-09
ESE	5.8E-06	8.8E-07	4.0E-07	2.4E-07	1.7E-07	8.0E-08	3.1E-08	1.6E-08	1.0E-08	7.5E-09
SE	7.2E-06	1.1E-06	4.9E-07	3.0E-07	2.1E-07	1.0E-07	3.9E-08	2.0E-08	1.3E-08	9.3E-09
SSE	7.2E-06	1.1E-06	4.7E-07	2.9E-07	2.0E-07	9.6E-08	3.8E-08	1.9E-08	1.2E-08	9.0E-09
S	5.5E-06	8.4E-07	3.8E-07	2.4E-07	1.6E-07	7.8E-08	3.0E-08	1.5E-08	1.0E-08	7.3E-09
SSW	4.4E-06	6.8E-07	3.1E-07	1.9E-07	1.3E-07	6.3E-08	2.5E-08	1.3E-08	8.2E-09	6.0E-09
SW	3.8E-06	5.9E-07	2.7E-07	1.7E-07	1.1E-07	5.5E-08	2.2E-08	1.1E-08	7.2E-09	5.2E-09
WSW	3.0E-06	4.6E-07	2.1E-07	1.3E-07	8.8E-08	4.3E-08	1.7E-08	8.5E-09	5.6E-09	4.0E-09
W	2.6E-06	4.1E-07	1.8E-07	1.2E-07	7.8E-08	3.8E-08	1.5E-08	7.5E-09	4.9E-09	3.6E-09
WNW	2.9E-06	4.4E-07	2.0E-07	1.2E-07	8.2E-08	4.0E-08	1.5E-08	7.8E-09	5.1E-09	3.7E-09
NW	3.6E-06	5.4E-07	2.4E-07	1.5E-07	1.0E-07	4.9E-08	1.9E-08	9.5E-09	6.2E-09	4.5E-09
NNW	5.4E-06	8.2E-07	3.7E-07	2.2E-07	1.5E-07	7.4E-08	2.9E-08	1.5E-08	9.5E-09	6.9E-09

(a) Calculated from meteorological data collected during the period 4-74 through 3-76.

DIETARY ASSUMPTIONS

All calculations were made using the models described in References 17, 18, and 19. The transfer and bioaccumulation factors are too numerous to be presented here but can be obtained from the references. Data on the consumption of the various foodstuffs considered in computing

both the hypothetical maximum individual and the population doses are summarized in Tables E.4 and E.5. The values shown in Table E.4 are also used to estimate the ingestion and external dose resulting from deposition of radionuclides released to the atmosphere.

TABLE E.4. Foodstuff Holdup and Consumption

Foodstuff	Maximum Individual Holdup (a) (Days)	Consumption (in kg/yr except as otherwise noted)		Population Holdup (a) (Days)
		Maximum Individual	Population	
Leafy vegetables	1	30	15	14
O.A.G. (b) vegetables	1	30	15	14
Potatoes	10	110	100	14
Other root vegetables	1	72	17	14
Berries	1	30	6	14
Melons	1	40	8	14
Orchard fruit	10	265	50	14
Wheat	10	80	72	14
Other grain	1	8.3	7.5	14
Eggs	1	30	20	18
Milk	1	274 ℓ /yr	230 ℓ /yr	4
Beef	15	40	40	34
Pork	15	40	30	34
Poultry	1	18	8.5	34
Ground contamination	0	4383 hr/yr	2920 hr/yr	0
Inhalation	0	7300 m^3 /yr	7300 m^3 /yr	0

(a) Holdup is the decay time between harvest and consumption

(b) Other above-ground.

TABLE E.5. Consumption and Usage Factors for Calculation of Exposures from the Columbia River

<u>Exposure Mode</u>	<u>Holdup(a)</u> <u>Hours</u>	<u>Usage</u>	
		<u>Maximum Individual</u>	<u>Population</u>
Fish	24	40 kg/yr	15,000 kg/yr ^(b)
Drinking Water	24	730 μ /yr	438 μ /yr
Shoreline	8 ^(c)	500 hr/yr	17 hr/yr
Swimming	8 ^(c)	100 hr/yr	10 hr/yr
Boating	8 ^(c)	100 hr/yr	5 hr/yr

- (a) Holdup is the decay time between harvest and consumption or between effluent release and exposure.
- (b) The population dose is based on the consumption of 15,000 kg of fish and would be numerically the same regardless of the number of people eating the fish.
- (c) A 13-hr holdup time was assumed for the population dose calculations.

DISTRIBUTION

<u>No. of Copies</u>	<u>No. of Copies</u>
<u>OFFSITE</u>	
A. A. Churm DOE Patent Division 9800 South Cass Avenue Argonne, IL 60439	M. W. Parrott Oregon State Health Division P.O. Box 231 Portland, OR 97207
W. W. Burr, Jr. DOE Office of Health and Environmental Research Washington, DC 20545	R. R. Mooney Washington State Department of Social and Health Services 1514 Smith Tower Seattle, WA 98104
R. H. Engleken NRC Directorate of Regional Operations, Region V 1990 N. California Blvd., Suite 202 Walnut Creek, CA 94596	W. F. Miller Washington State Department of Social and Health Services P.O. Box 1788, MS 56-1 Olympia, WA 98504
256 <u>DOE Technical Information Center</u>	S. I. Reed Washington State Department of Social and Health Services P.O. Box 1788, MS 56-1 Olympia, WA 98504
R. J. Beers DOE Idaho Operations Operational Safety Division Idaho Falls, ID 83401	T. Strong Washington State Department of Social and Health Services P.O. Box 1788, MS 56-1 Olympia, WA 98504
5 G. P. Dix DOE Operational and Environmental Safety Division Washington, DC 20545	W. G. Hallauer Washington State Department of Ecology Olympia, WA 98504
L. J. Deal DOE Operational and Environmental Safety Division Washington, DC 20545	G. Hansen Washington State Department of Ecology Olympia, WA 98450
S. R. Elliot DOE Nevada Operations Office Office of Safety and Health P.O. Box 14100 Las Vegas, NV 89114	E. Wallace Washington State Department of Ecology Olympia, WA 98504
E. Cowan Environmental Protection Agency Region X Seattle, WA 98101	Health Officer Yakima County Health District City Hall Yakima, WA 98901
L. B. Day, Director Oregon State Department of Environmental Quality 1234 S. W. Morrison Portland, OR 97205	H. Cahn Benton-Franklin Health Center Pasco, WA 99301

No. of
Copies

R. A. Chitwood
Washington Public Power
Supply System
3000 George Washington Way
Richland, WA 99352

R. F. Nowakowski
Washington Public Power
Supply System
3000 George Washington Way
Richland, WA 99352

K. R. Engstrom
City of Richland
Water and Sewer Department
505 Swift Boulevard
Richland, WA 99352

Exxon Nuclear
Horn Rapids Road
Richland, WA 99352

ONSITE

27 DOE RICHLAND OPERATIONS OFFICE

R. E. Austin
D. R. Elle (20)
O. J. Elgert
L. F. Perkins
H. E. Ransom
J. L. Rhoades
M. W. Tiernan
M. G. White

6 UNC Nuclear Industries, Inc.

T. E. Dabrowski
L. P. Diediker
J. J. Dorian
R. E. Dunn
J. W. Riches
UNI Files

7 Rockwell Hanford Operations

R. D. Fox
G. L. Hanson
W. F. Heine
P. G. Lorenzini
R. M. Mitchell
R. E. Wheeler
RHO Files

2 Hanford Environmental Health Foundation

B. D. Reinert
B. D. Breitenstein

No. of
Copies

1 J. A. Jones Construction Company

L. L. Crass

3 U. S. Testing Company, Inc.

W. V. Baumgartner
M. M. Lardy
H. E. Oens
E. L. Peterson

3 Westinghouse Hanford Company

H. Bicehouse
R. O. Budd
R. B. Hall

100 Pacific Northwest Laboratory

W. J. Bair
P. J. Blumer
F. J. Borst
P. E. Bramson (2)
F. P. Brauer
L. A. Carter
J. P. Corley
C. E. Cushing
R. L. Dirkes
P. A. Eddy
C. E. Elderkin
J. R. Eliason
R. O. Gilbert
D. L. Haggard
V. Q. Hale
J. R. Houston (43)
J. J. Fuquay
W. M. Harty, Jr.
W. T. Hinds
G. R. Hoenes
J. J. Jech
H. V. Larson
W. D. McCormack
J. M. Nielsen
D. E. Olesen
H. M. Parker
E. H. Phinney
R. W. Perkins
K. R. Price
M. R. Quarders (6)
L. L. Rader (2)
W. H. Rickard
D. B. Robertson
D. M. Robertson
J. M. Selby
C. L. Simpson
J. R. Sletager
J. K. Soldat
M. J. Sula
C. M. Unruh
B. E. Vaughan

Pacific Northwest Laboratory (cont.)

No. of
Copies

D. G. Watson
J. S. Wilbur
R. H. Williams
Technical Information (5)
Publishing Coordination SH (2)

