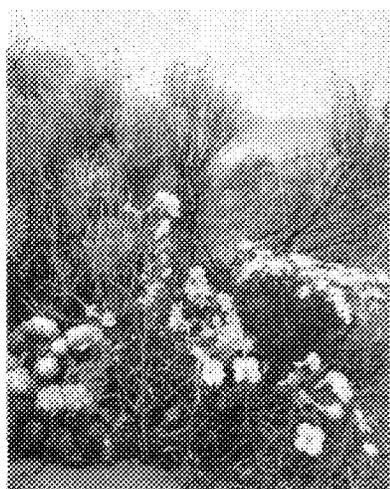
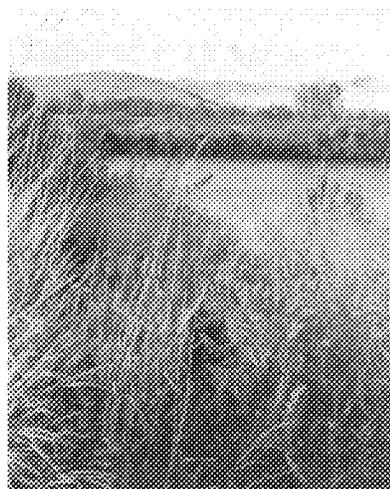
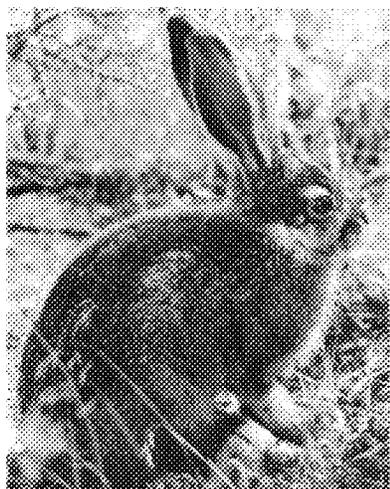


*Cushing*

## Environmental Surveillance at Hanford for CY-1980



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



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ENVIRONMENTAL SURVEILLANCE AT  
HANFORD FOR CY-1980

M. J. Sula  
P. J. Blumer

April 1981

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Pacific Northwest Laboratory  
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## 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 an 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 relatively small impact attributable to either current or 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; this document is for calendar year 1980.



## SUMMARY

Data were collected for most environmental media including air, Columbia River water, foodstuffs, wildlife, soil and vegetation, as well as for direct radiation.

Offsite levels of radionuclides attributable to 1980 Hanford operations were indistinguishable from background levels. Low-level concentrations of a few radionuclides attributed to past operations at Hanford were identified in a few of the environmental samples. The data are summarized in the following highlights:

- All observed radionuclide concentrations and radiation dose measurements were far below all applicable concentration guides or dose standards.
- No distinguishable difference was detected between airborne radionuclide concentrations in samples taken near to and far from the Hanford Site (see pages 5-9).
- An apparent increase in  $^{129}\text{I}$  concentrations in Columbia River water downstream of the Hanford Site was observed. However, the observed concentrations were negligible in comparison to radionuclide concentrations guides and drinking water standards (see pages 11-17).
- Low levels of radionuclides attributed to past operations at Hanford were observed in several samples of whitefish collected from the Columbia River and in duck samples collected from onsite wastewater ponds. In addition, Hanford deer thyroids contained small amounts of  $^{129}\text{I}$  attributable to onsite operations. Calculated doses resulting from assumed consumption of the samples were very small and far below dose standards (see pages 25-28).
- External dose measurements on the islands and shoreline along the Hanford reach of the Columbia River showed elevated dose rates attributed to the presence of a few long-lived radionuclides, principally  $^{60}\text{Co}$  and  $^{154}\text{Eu}$ , from past operations of the Hanford production reactors. The incremental increase in radiation dose to recreational users of the river due to these radionuclides is very low and well below the applicable dose standards. External dose measurements at other locations both near to and far

from the Hanford site showed no discernable difference from each other (see pages 33-37).

- The location of the highest dose rate on the site boundary (the "fence-post" dose) is considered to be the 100-N Area shoreline. Measurements taken during a special radiological survey in 1979 indicated a maximum dose rate on the shoreline of 0.2 mrem/hr. (A dose rate of 0.8 mrem/hr, measured approximately 30 meters inland from the shoreline, was inadvertently reported as the fence-post dose rate in the 1979 Annual Environmental Surveillance Report.) The maximum dose rate (based on monthly integrated readings) by a dosimeter located in this area during 1980 was 0.063 mrem/hr.

An estimate of the radiological impact of Hanford operations during 1980 was calculated for both a maximum-exposed individual and for the population around the Hanford site. (The maximum-exposed individual is the hypothetical person who received the highest dose from 1980 Hanford operations.)

- The maximum first-year whole-body dose to an individual from 1980 effluents was calculated to be 0.01 mrem. This included contributions from airborne effluents, drinking water, irrigated foodstuffs, and aquatic recreation pathways. The maximum first-year dose to a single organ considering all pathways was approximately 0.7 mrem to the thyroid of a similarly hypothetical infant. These doses can be compared with the standards of DOE Manual Chapter 0524 of 500 mrem/yr for the whole body and 1,500 mrem/yr for the thyroid (see pages 41-42).
- Effluents from the Hanford Site resulted in a 50-year whole-body dose commitment to the population within an 80-km (50-mile) radius of Hanford of about 0.6 man-rem. (A dose expressed in "man-rem" is the product of the average individual dose and the number of people in the surrounding population.) This dose was primarily due to effluents released from N-Reactor. This dose may be compared to the approximately 25,000 man-rem whole-body dose received each year by the same population from natural background radiation (see page 42).

Air quality measurements of nonradiological parameters in facility effluents and in the environment showed all pollutants to be within state and national standards with the following exceptions:

- Particulate emissions from two coal-fired power plants exceeded standards during 1980. Modifications to bring the plants into compliance are underway. The Columbia basin area frequently exceeded ambient air total suspended particulate (TSP) concentra-

tions; however, construction and agricultural activities were considered to be the primary cause (see page 7).

- NPDES permit thermal limitations were exceeded on several occasions during the year at one of the eight liquid discharge locations. The effect of these technical violations on the temperature of the Columbia River was imperceptible. Efforts are underway to eliminate future violations (see page 14).

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# ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1980

## 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 km<sup>2</sup> (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 by treated river water. Between December 1964 and January 1971, all eight reactors with once-through cooling were deactivated. N Reactor, the remaining production reactor in operation, has a closed primary cooling loop.

Facilities on the Hanford Site include the N-Production Reactor and the eight deactivated production reactors along the Columbia River in the section 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 Test Facility (FFTF) is located in the "400 Area" approximately 8.8 km (5.5 miles) northwest of the 300 Area.

Privately owned facilities located within the Hanford Site boundaries include the Washington Public Power Supply System generating station adjacent to N Reactor, the Washington Public Power Supply System power reactor site and office buildings (under construction), a hazardous waste disposal site, and a radioactive waste burial site. The Exxon fuel fabrication facility is

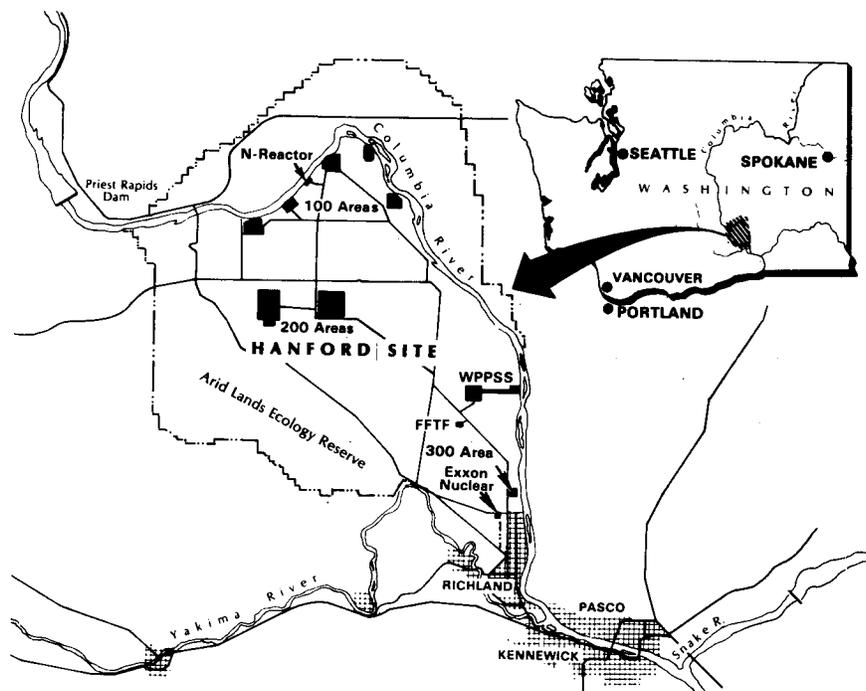


FIGURE 1. DOE's Hanford Site in Washington State

located immediately adjacent to the southern boundary of the Hanford Site.

Principal DOE contractors operating at Hanford are:

- Rockwell Hanford Operations-- 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 (UNC)-- 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.

Highlights of operational activities at Hanford during 1980 are:

- N Reactor operation was limited to the period January through May due to a Hanford-wide labor dispute.
- Steam from N Reactor operation was used to drive turbine generators that produce up to 860 million watts of electrical power in the Washington Public Power Supply System's Hanford Generating Plant. Since its startup, N Reactor has supplied enough steam to produce nearly 50 billion kilowatt hours of electrical energy which was provided to the Bonneville Power Administration grid covering the Pacific Northwest.
- The Fast Flux Test Facility achieved initial criticality for a brief period on February 9, and achieved full power operation on December 21.

- A steam generator, removed from the Surry Nuclear Generating Station, was transported onto the site where it will undergo testing.
- Construction of double-walled underground storage tanks for high-level liquid wastes was completed.

Work at Hanford during 1980 also included Hanford National Environmental Research Park (NERP) studies, and Arid Land Ecology (ALE) studies, as well as continued operation of a variety of research and laboratory facilities.

The desert plain on which Hanford is located has a sparse covering of vegetation primarily suited for grazing. The most broadly distributed type of vegetation on the site is the sagebrush/cheatgrass/bluegrass community. The mule deer is the most abundant big game mammal on the site and the most 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 site-related industries, the economy of the region is primarily agricultural. Major crops include alfalfa, wheat, corn, and potatoes. Several fruit orchards are located within a short distance of the Hanford Site. The

Columbia River is used extensively for recreational purposes including fishing and waterfowl hunting.

The population center nearest to the Hanford Site is the Tri-Cities area (Richland, Pasco, and Kennewick), situated on the Columbia River downstream from the site with a combined population of approximately 90,000. Approximately 277,000 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 (ERDA 1975).

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. A 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 in the ground water underlying the site and is documented sepa-

ately (Eddy 1981). Other environmental data deal with certain nonradioactive airborne pollutants and with the chemical and biological quality of the Columbia River and sanitary water.

All environmental samples are collected according to a master surveillance schedule published each year (Blumer, Houston and Eddy 1979). The analytical results of these samples are summarized and evaluated in annual reports. Included in this report are data collected during 1980. Sampling data from previous years are contained in a series of similar reports (Houston and Blumer 1980). Any contribution to air or waterborne radionuclide concentrations attributable to Hanford operations is compared with the regulations in DOE Manual Chapter 0524 published in 1973. Concentrations of nonradioactive pollutants are compared with applicable standards of the Washington State Department of Ecology (1977) or the Environmental Protection Agency.

For uniformity of presentation and to aid understanding, radiation dose impacts in this report are given in terms of the dose equivalent or dose equivalent rate, expressed in terms of mrem or in mrem per unit time. The qualifier "equivalent" will be implicit in the use of the single term "dose."



## ATMOSPHERIC MONITORING

Many radionuclides from both natural sources and worldwide fallout are present in the atmosphere. 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 1980, 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 airborne radioactivity levels.

### AIR SAMPLING

During 1980, radionuclides in the atmosphere were sampled by a network of 19 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 m<sup>3</sup>/hr (1.5 ft<sup>3</sup>/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 ft<sup>3</sup>/hr).

The particulate filters are collected bi-weekly 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 <sup>90</sup>Sr and plutonium. Charcoal cartridges from six of the sampling locations are collected and analyzed biweekly for <sup>131</sup>I. Charcoal cartridges from the remaining stations were changed monthly to ensure that fresh collection media existed at each location. These samples were analyzed only when <sup>131</sup>I 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  $0.04 \times 10^{-12}$  pCi/m<sup>3</sup> for both the perimeter and distant stations. This indicates that there was no measurable Hanford contribution to the airborne beta-emitter concentrations. Maximum observed airborne concentrations occurred during November and December following an atmospheric nuclear test by the People's Republic of China on October 16.

Gross airborne beta-emitter concentrations for the years 1976 through 1980 are shown in Figure 3. Compared are the average monthly concentrations at perimeter and distant stations. Increases in airborne concentration occurred following atmospheric nuclear tests.

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 result from atmospheric testing of nuclear weapons and, potentially, from Hanford operations.

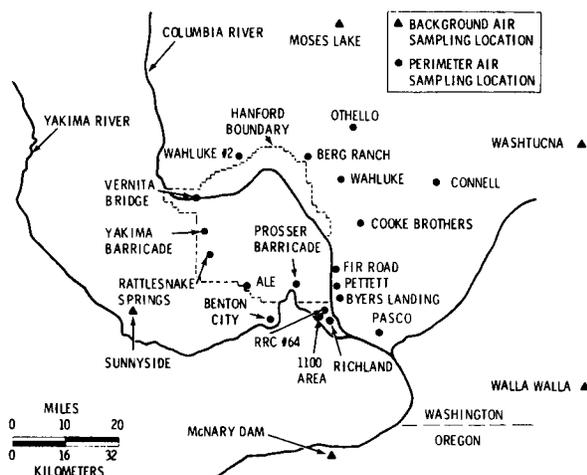


FIGURE 2. Air Sampling Locations

**TABLE 1. Airborne Radioactivity in the Hanford Environs**

Concentration Guide (b)	Gross Beta Concentrations, (a) pCi/m <sup>3</sup> (10 <sup>-12</sup> µCi/m)			Gross Alpha Concentrations, (a) pCi/m <sup>3</sup> (10 <sup>-12</sup> µCi/m)				
	No. of Samples	Maximum	Minimum	Average	No. of Samples	Maximum	Minimum	Average
		100				0.03		
<b>Perimeter Stations</b>								
Prosser Barricade	25	0.11 ± 0.009	0.01 ± 0.004	0.04 ± 0.05	25	0.004 ± 0.001	0.0005 ± 0.0004	0.001 ± 0.002
Benton City	26	0.12 ± 0.006	0.008 ± 0.005	0.04 ± 0.06	24	0.003 ± 0.0007	0.0003 ± 0.0003	0.001 ± 0.002
ALE	26	0.13 ± 0.006	0.01 ± 0.004	0.04 ± 0.05				
Rattlesnake Springs	26	0.12 ± 0.006	0.01 ± 0.004	0.04 ± 0.05				
Yakima Barricade	26	0.09 ± 0.006	0.01 ± 0.004	0.03 ± 0.04				
Vernita Bridge	24	0.13 ± 0.006	0.01 ± 0.005	0.04 ± 0.06				
Wahluke #2	26	0.16 ± 0.007	0.01 ± 0.008	0.04 ± 0.07				
Berg Ranch	24	0.15 ± 0.007	0.02 ± 0.004	0.04 ± 0.06	24	0.002 ± 0.0007	0.0005 ± 0.0004	0.001 ± 0.001
Othello	23	0.17 ± 0.007	0.02 ± 0.004	0.04 ± 0.07				
Wahluke Watermaster	24	0.12 ± 0.007	0.02 ± 0.004	0.04 ± 0.05				
Connell	24	0.18 ± 0.007	0.02 ± 0.004	0.04 ± 0.07				
Cooke Bros.	26	0.18 ± 0.007	0.01 ± 0.004	0.04 ± 0.08				
Fir Road	23	0.09 ± 0.006	0.005 ± 0.004	0.04 ± 0.06				
Pettett	24	0.14 ± 0.006	0.01 ± 0.004	0.04 ± 0.06	26	0.002 ± 0.0006	0.0007 ± 0.0004	0.001 ± 0.001
Byers Landing	26	0.08 ± 0.004	0.009 ± 0.004	0.03 ± 0.03	24	0.005 ± 0.002	0.0006 ± 0.0004	0.001 ± 0.002
Pasco	24	0.12 ± 0.005	0.01 ± 0.004	0.04 ± 0.05				
Richland	26	0.09 ± 0.12	0.009 ± 0.003	0.03 ± 0.05	26	0.002 ± 0.0007	0.0007 ± 0.0004	0.001 ± 0.001
1100 Area	26	0.13 ± 0.007	0.01 ± 0.004	0.04 ± 0.06				
RRC CP #64	26	0.14 ± 0.007	0.02 ± 0.004	0.04 ± 0.06				
Overall Perimeter Station average				0.04 ± 0.06				0.001 ± 0.002
<b>Distant Stations</b>								
McNary	23	0.11 ± 0.006	0.01 ± 0.004	0.04 ± 0.05				
Walla Walla	24	0.21 ± 0.008	0.01 ± 0.004	0.04 ± 0.09				
Washtucna	24	0.19 ± 0.007	0.01 ± 0.004	0.04 ± 0.07				
Moses Lake	23	0.16 ± 0.007	0.01 ± 0.004	0.04 ± 0.07				
Sunnyside	25	0.14 ± 0.006	0.009 ± 0.004	0.03 ± 0.06				
Overall Distant Station average				0.04 ± 0.07				

(a) Maximum and minimum concentrations shown include the 2σ counting error. Average concentrations include an estimate of the uncertainty of the average at the 95% confidence level.

(b) As stated in DOE MC 0524.

NOTE: No entry indicates no analysis was performed.

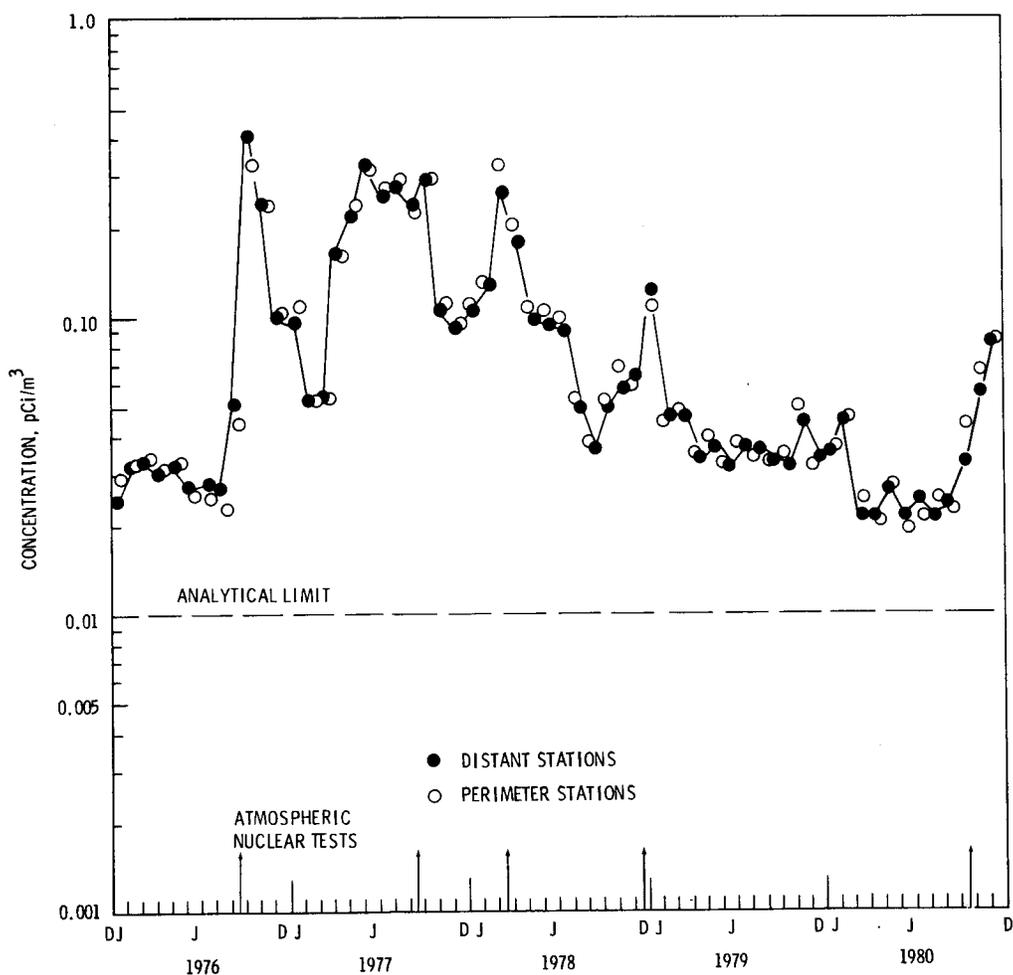


FIGURE 3. Average Monthly Gross Beta Activity in the Atmosphere

All of the radionuclides shown were observed at similar concentrations at downwind, distant, and perimeter locations. All of the maximum observed concentrations occurred during late summer with the exception of  $^{95}\text{ZrNb}$  and  $^{144}\text{CePr}$  which reached maximums following the October 16 nuclear test.

#### NONRADIOLOGICAL ANALYSIS

Nonradiological pollutants in routine gaseous emissions from chemical processes and fossil-fueled power plants at Hanford consist primarily of particulates, sulfur dioxide ( $\text{SO}_2$ ) and oxides of nitrogen ( $\text{NO}_x$ ). With the exception of particulates at two of the coal-fired power plants, the above pollutants were within applicable national and state standards. Baghouses, which will bring the particulate emissions within stan-

dards, are presently being installed at the two power plants which are not in compliance with the particulate emissions standard. Completion of the baghouse installations is expected by the end of 1981.

The Hanford Site and surrounding areas are also monitored for compliance with national and state ambient air standards. Ambient nitrogen dioxide ( $\text{NO}_2$ ) measurements were made at several locations around the site during 1980 by the Hanford Environmental Health Foundation (HEHF) in support of PUREX preoperational surveillance programs. During 1980, the maximum observed annual average  $\text{NO}_2$  concentration was less than 0.007 parts per million (ppm) as compared to the 0.05 ppm national ambient air standard (40 CFR 50 1973).

TABLE 2. Selected Airborne Radionuclide Concentrations in the Hanford Environs

Radionuclide	Concentration Guide	Composite Group (b)	Concentration, pCi/m <sup>3</sup> (10 <sup>-12</sup> μCi/ml) (a)		
			Maximum	Minimum	Mean
<sup>3</sup> H	200,000	Distant Perimeter	3.7 ± 0.30	-0.13 ± 0.09	NS
		Downwind Perimeter	3.7 ± 0.30	0.05 ± 0.02	0.70 ± 1.5 0.77 ± 1.6
<sup>7</sup> Be	40,000	Distant Perimeter	0.13 ± 0.05	-5 × 10 <sup>-5</sup> ± 0.03	0.009 ± 0.12
		Downwind Perimeter	0.08 ± 0.01 0.05 ± 0.008	-0.003 ± 0.01 0.01 ± 0.008	0.03 ± 0.05 0.02 ± 0.03
<sup>90</sup> Sr	30	Distant Perimeter	4 × 10 <sup>-4</sup> ± 1 × 10 <sup>-4</sup>	9 × 10 <sup>-5</sup> ± 2 × 10 <sup>-4</sup>	2.5 × 10 <sup>-4</sup> ± 4.4 × 10 <sup>-4</sup>
		Downwind Perimeter	4 × 10 <sup>-4</sup> ± 5 × 10 <sup>-5</sup> 3 × 10 <sup>-4</sup> ± 3 × 10 <sup>-5</sup>	6 × 10 <sup>-5</sup> ± 6 × 10 <sup>-5</sup> 9 × 10 <sup>-5</sup> ± 3 × 10 <sup>-5</sup>	1.9 × 10 <sup>-4</sup> ± 2.5 × 10 <sup>-4</sup> 2.0 × 10 <sup>-4</sup> ± 2.4 × 10 <sup>-4</sup>
<sup>95</sup> Zr/Nb	1,000	Distant Perimeter	0.07 ± 0.003	-8 × 10 <sup>-5</sup> ± 0.003	0.001 ± 0.02
		Downwind Perimeter	0.02 ± 0.001 0.02 ± 9 × 10 <sup>-4</sup>	-3 × 10 <sup>-4</sup> ± 6 × 10 <sup>-4</sup> -3 × 10 <sup>-4</sup> ± 6 × 10 <sup>-4</sup>	3.3 × 10 <sup>-4</sup> ± 0.01 0.001 ± 0.01
<sup>131</sup> I	100	Distant Perimeter	0.007 ± 0.012	5 × 10 <sup>-4</sup> ± 0.007	0.002 ± 0.01
		Downwind Perimeter	0.01 ± 0.18 0.01 ± 0.18	0.0 ± 0.01 0.0 ± 0.01	0.002 ± 0.02 0.002 ± 0.02
<sup>137</sup> Cs	500	Distant Perimeter	0.006 ± 0.007	-5 × 10 <sup>-5</sup> ± 0.002	2.4 × 10 <sup>-4</sup> ± 5.4 × 10 <sup>-3</sup>
		Downwind Perimeter	0.001 ± 0.001 2 × 10 <sup>-4</sup> ± 5 × 10 <sup>-4</sup>	-4 × 10 <sup>-5</sup> ± 9 × 10 <sup>-4</sup> -9 × 10 <sup>-5</sup> ± 5 × 10 <sup>-4</sup>	-1.0 × 10 <sup>-4</sup> ± 0.002 -1.3 × 10 <sup>-4</sup> ± 0.001
<sup>144</sup> CePr	200	Distant Perimeter	0.03 ± 0.05	-9 × 10 <sup>-5</sup> ± 0.03	-0.005 ± 0.05
		Downwind Perimeter	0.03 ± 0.007 0.03 ± 0.007	-1 × 10 <sup>-4</sup> ± 0.01 -0.002 ± 0.006	-0.003 ± 0.02 -0.002 ± 0.02
Pu	0.06	Distant Perimeter	2 × 10 <sup>-4</sup> ± 7 × 10 <sup>-5</sup>	-3 × 10 <sup>-6</sup> ± 8 × 10 <sup>-6</sup>	3.1 × 10 <sup>-5</sup> ± 1.2 × 10 <sup>-4</sup>
		Downwind Perimeter	3 × 10 <sup>-5</sup> ± 1 × 10 <sup>-5</sup> 2 × 10 <sup>-5</sup> ± 6 × 10 <sup>-6</sup>	-5 × 10 <sup>-7</sup> ± 4 × 10 <sup>-6</sup> 8 × 10 <sup>-7</sup> ± 2 × 10 <sup>-6</sup>	7.2 × 10 <sup>-6</sup> ± 1.7 × 10 <sup>-5</sup> 7.2 × 10 <sup>-6</sup> ± 1.8 × 10 <sup>-5</sup>

(a) Maximum and minimum concentrations shown include the 2σ counting error. Average concentrations include an estimate of the uncertainty of the average at the 95% confidence level. In cases where only one analysis was performed during the year, the result is shown in the average column along with the associated 2σ counting error.

(b) 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, Prosser Barricade, Fir Road, Byers Landing, Pettett, Richland, Pasco, 1100 Area, and RRC CP #64. The Downwind Perimeter stations are a subset of the Perimeter group and include: Fir Road, Prosser Barricade, Byers Landing, Pasco, Richland, Pettett, 1100 Area, and RRC CP #64.

NOTE: NS = Not Sampled.

The Columbia Basin area is not in compliance with the total suspended particulate (TSP) standard for ambient air. Heavy construction and agricultural activities are identified as the primary contributors to the ambient TSP concentrations. Fugitive

dust concentrations in the area have been estimated to be 2,500,000 tons per year (2,270,000 metric tons) as compared to less than 5,000 tons per year (4,545 metric tons) which are attributable to Hanford operations.



## 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 (1977). 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 1980 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 involved 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 larger than 5  $\mu\text{m}$  in diameter, and a mixed bed (anion-cation) ion exchange resin column. About 1000 liters of water are drawn through the sampler during each two-week sampling period.

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

Other water samples included grab samples of Columbia River water collected at Vernita bridge (upstream from Hanford) and at Richland for biological and chemical analyses. Cumulative samples of drinking water were also 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 analysis by conventional water sampling methods. All filter-resin samples and cumulative water samples were analyzed for gamma-emitting radionuclides. Monthly cumulative water samples were analyzed for total alpha and beta-emitting radionuclides, for  $^3\text{H}$ , and for natural uranium. Quarterly composites of the cumulative water samples were analyzed for  $^{89}\text{Sr}$ ,  $^{90}\text{Sr}$ ,  $^{226}\text{Ra}$  and  $^{228}\text{Ra}$ . In addition, quarterly composites of the filter-resin samples were analyzed for plutonium, and quarterly composites of the resin only were analyzed for  $^{129}\text{I}$ . 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 are shown in these tables. Very few of the approximately 30 radionuclides routinely analyzed in these samples are observed at concentrations above their detection limit. The data in Table 3 summarizes the 1980 concentrations of

TABLE 3. Radionuclide Concentrations Upstream from Hanford Operations (a)

Radionuclide	No. of Samples (b)	Concentration, pCi/ℓ (10 <sup>-9</sup> pCi/ml)		
		Maximum	Minimum	Annual Average
<sup>226</sup> Ra	4	0.28 ± 0.09	0.02 ± 0.01	0.10 ± 0.25
<sup>228</sup> Ra	4	0.17 ± 0.06	0.09 ± 0.07	0.13 ± 0.10
U-Nat	12	0.59 ± 0.21	0.30 ± 0.10	0.40 ± 0.25
<u>Artificially Produced (Worldwide Fallout)</u>				
<sup>3</sup> H	12	420 ± 150	27 ± 120	230 ± 310
<sup>51</sup> Cr	17*	0.29 ± 0.69	0.02 ± 1.0	0.08 ± 0.61
<sup>54</sup> Mn	24*	0.03 ± 0.09	0.004 ± 0.06	0.007 ± 0.06
<sup>59</sup> Fe	22*	0.09 ± 0.20	0.01 ± 0.27	0.02 ± 0.27
<sup>60</sup> Co	24*	0.05 ± 0.01	0.004 ± 0.007	0.01 ± 0.05
<sup>90</sup> Sr	4	0.32 ± 0.14	0.14 ± 0.26	0.24 ± 0.23
<sup>95</sup> Nb	19*	0.07 ± 0.13	0.004 ± 0.06	0.01 ± 0.08
<sup>95</sup> Zr	23*	0.05 ± 0.14	0.006 ± 0.09	0.02 ± 0.22
<sup>125</sup> Sb	24*	0.08 ± 0.08	0.009 ± 0.51	0.02 ± 0.32
<sup>129</sup> I	4*	7.4 × 10 <sup>-6</sup> ± 2.1 × 10 <sup>-6</sup>	4.2 × 10 <sup>-6</sup> ± 1.3 × 10 <sup>-6</sup>	5.9 × 10 <sup>-6</sup> ± 3.2 × 10 <sup>-6</sup>
<sup>131</sup> I	11*	0.04 ± 0.78	0.008 ± 0.08	0.02 ± 0.31
<sup>137</sup> Cs	24*	0.09 ± 0.01	0.004 ± 0.006	0.01 ± 0.05
<sup>140</sup> Ba	13*	0.12 ± 1.1	0.02 ± 0.32	0.05 ± 0.63
<sup>140</sup> La	13*	0.07 ± 0.04	0.01 ± 0.23	0.02 ± 0.11
<sup>238</sup> Pu	4*	(c)	(c)	<2.7 × 10 <sup>-5</sup> (c)
<sup>239-240</sup> Pu	4*	5.4 × 10 <sup>-4</sup> ± 1.0 × 10 <sup>-4</sup>	9.8 × 10 <sup>-5</sup> ± 2.6 × 10 <sup>-5</sup>	3.3 × 10 <sup>-4</sup> ± 3.7 × 10 <sup>-4</sup>

(a) Maximum and minimum concentrations include the 2σ counting error. Average concentrations include an estimate of uncertainty at the 95% confidence level.

(b) Numbers marked with an \* were filter-resin samples of which 24 were taken during 1980. Results of analyses were not included in tabulations if the interval between sampling and analysis exceeded two half-lives. The filter resin samples were composited quarterly for <sup>129</sup>I and plutonium analysis.

(c) All results reported as "less than" values.

TABLE 4. Radionuclide Concentrations Downstream from Hanford Operations(a)

Radionuclide	No. of Samples	Concentration, pCi/ℓ (10 <sup>-9</sup> μCi/ml)			Concentration Guide
		Maximum	Minimum	Annual Average	
226Ra	4	0.05 ± 0.02	0.03 ± 0.02	0.04 ± 0.03	30
228Ra	4	0.15 ± 0.07	0.05 ± 0.06	0.10 ± 0.11	30
U-Nat	12	0.80 ± 0.28	0.38 ± 0.13	0.54 ± 0.34	20,000
3H(c)	12	490 ± 290	160 ± 76	265 ± 274	3,000,000
51Cr	18*	0.28 ± 0.42	0.03 ± 0.53	0.09 ± 0.86	2,000,000
54Mn	24*	0.03 ± 0.04	0.004 ± 0.10	0.008 ± 0.07	100,000
59Fe	21*	0.07 ± 0.10	0.01 ± 0.22	0.03 ± 0.19	50,000
60Co	25*	0.12 ± 0.02	0.007 ± 0.009	0.03 ± 0.06	30,000
90Sr(c)	4	0.22 ± 0.14	0.18 ± 0.14	0.20 ± 0.16	300
95Nb	20*	0.03 ± 0.01	0.004 ± 0.07	0.01 ± 0.08	100,000
95Zr	22*	0.04 ± 0.05	0.007 ± 0.04	0.02 ± 0.19	60,000
125Sb	25*	0.07 ± 0.15	0.01 ± 0.15	0.03 ± 0.22	100,000
129I	4*	9.4 × 10 <sup>-5</sup> ± 3.2 × 10 <sup>-5</sup>	2.9 × 10 <sup>-5</sup> ± 6.9 × 10 <sup>-6</sup>	5.4 × 10 <sup>-5</sup> ± 5.8 × 10 <sup>-5</sup>	60
131I	12*	0.13 ± 0.14	0.01 ± 0.01	0.05 ± 0.13	300
137Cs	25*	0.19 ± 0.04	0.005 ± 0.007	0.02 ± 0.10	20,000
140Ba	14*	0.16 ± 1.2	0.03 ± 0.51	0.07 ± 0.95	20,000
140La	14*	0.07 ± 0.07	0.01 ± 0.13	0.03 ± 0.13	200,000
238Pu	4*	(d)	(d)	<3.4 × 10 <sup>-5</sup> (d)	5,000
239-240Pu	4*	4.8 × 10 <sup>-4</sup> ± 6.2 × 10 <sup>-5</sup>	1.7 × 10 <sup>-4</sup> ± 3.6 × 10 <sup>-5</sup>	3.2 × 10 <sup>-4</sup> ± 3.2 × 10 <sup>-4</sup>	5,000

(a) Maximum and minimum concentrations include the 2σ counting error. Average concentrations include an estimate of uncertainty at the 95% confidence level.

(b) Numbers marked with an \* were filter-resin samples of which 25 samples were taken during 1980. Results of analyses were not included in tabulations if the interval between sampling and analysis exceeded two half-lives. Filter-resin samples were composited quarterly for I29I and plutonium analysis.

(c) Samples taken at intake to Richland water plant. State drinking water standard for 3H and are 20,000 pCi/ℓ and 8 pCi/ℓ, respectively.

(d) All results reported as "less than" values.

naturally occurring and worldwide fallout radionuclides measured in the Columbia River before it is potentially affected by Hanford operations. Analogous data obtained downstream of the Hanford Site is presented in Table 4.

Only  $^{129}\text{I}$  appeared to be at a higher concentration downstream of the Hanford Site than was observed upstream; indicating a very small possible contribution from Hanford operations. The difference between the upstream and downstream average concentration may be compared with the concentration guides from DOE Manual Chapter 0524 as shown in the last column of Table 4. The possible increases in river concentrations as a result of Hanford Operations is a very small fraction of the concentration guides.

Data for several of the other radionuclides of potential Hanford origin observed at concentrations consistently above the detection limit are graphed 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 guidelines of the Washington State Public Water Supply Standards (1977).

Washington State Water Quality Standards require that radionuclide concentrations in drinking water not exceed 15 pCi/l of gross alpha activity and that the average annual concentration of beta particle and photon radioactivity from man-made radionuclides not produce an annual dose equivalent to the total body or to any internal organ greater than 4 mrem/yr. Compliance with the 4 mrem/yr dose limitation may be assumed if the average annual concentration for gross beta activity, tritium, and Strontium-90 is less than 50 pCi/l, 20,000 pCi/l and 8 pCi/l, respectively. Compliance with the state standard is demonstrated by comparing the above concentration limits with the applicable 1980 sampling data in Tables 4 and 5.

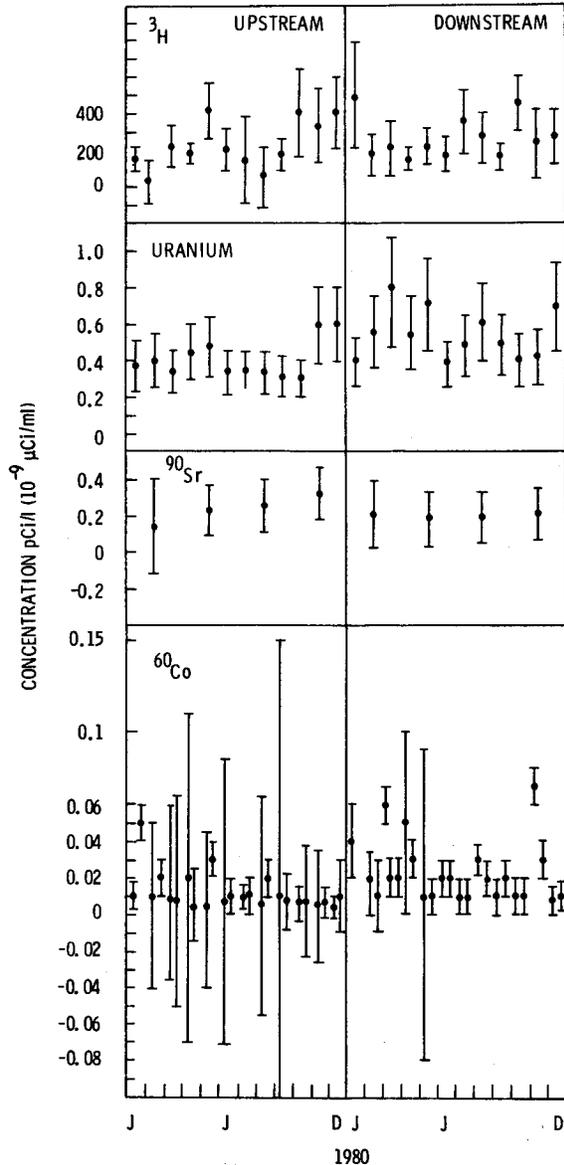


FIGURE 4. Upstream and Downstream Concentrations of Radionuclides in Columbia River Water (including 2 $\sigma$  error bars)

#### 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 1980. Figure 6 illustrates the daily and seasonal fluctuations in river temperature and flow rate during

TABLE 5. Radiological Analyses of Richland Drinking Water

Radionuclide	No. of Samples	Concentration, pCi/l ( $10^{-9}$ $\mu$ Ci/ml)			State Standard
		Maximum	Minimum	Annual Average	
Gross Alpha	50	1.1 $\pm$ 0.43	-0.12 $\pm$ 0.33	0.43 $\pm$ 0.72	15
Gross Beta	50	11 $\pm$ 5.3	-1.3 $\pm$ 5.3	2.7 $\pm$ 6.6	50

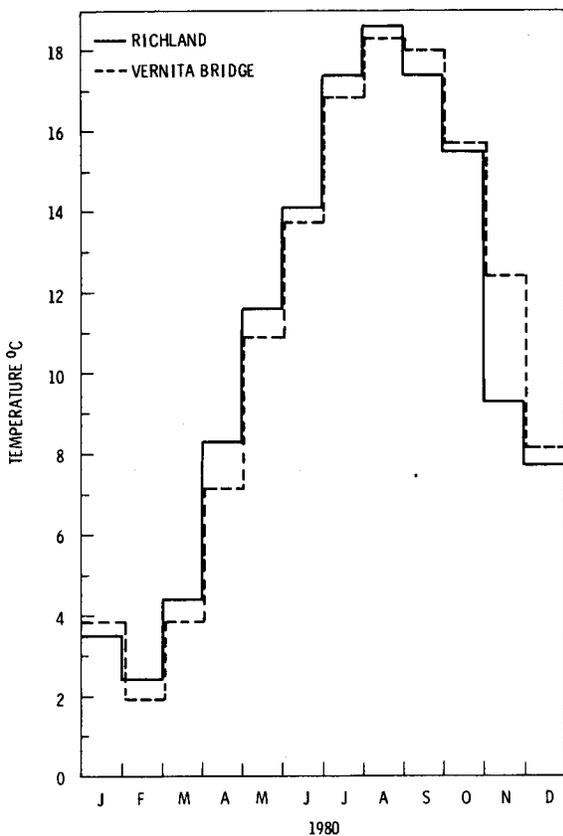


FIGURE 5. Average Monthly Water Temperatures at Richland and Vernita

1980. N Reactor, the only Hanford facility potentially capable of noticeably affecting the river temperature, operated only through mid-May 1980. However, heating of the river between Vernita and Richland occurred from February through August. Insolation; therefore, appears to be a major cause of temperature increase for the river.

#### BIOLOGICAL ANALYSES

Monthly measurements of total coliforms, fecal coliforms, and biological oxygen de-

mand (BOD) were made on grab samples taken 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 fall.

#### CHEMICAL ANALYSES

Grab samples taken at Vernita Bridge and Richland during 1980 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).

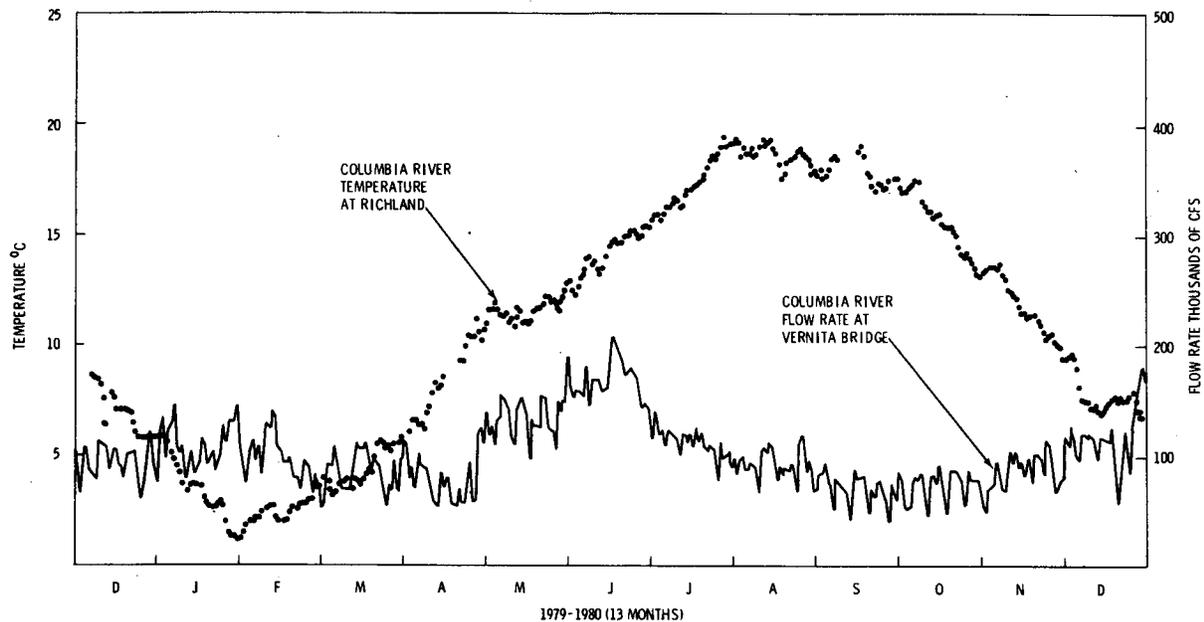
All of the pH measurements were within the 6.5 to 8.5 standard.

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 eight 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 laboratory wastewater. Effluents from each of these outfalls are routinely monitored as required by the National Pollutant



**FIGURE 6.** Daily Variation in Mean Temperature and Flow Rate

Discharge Elimination system (NPDES) permit. Among the effluent characteristics monitored are total flow, suspended solids, solids, temperature, oils and grease, free available chlorine, and pH, depending on the nature of the effluent. During 1980, effluents were within the discharge limitations provided in

the NPDES permit, with the exception of a single discharge point which experienced random thermal permit limitation excursions on several occasions. An engineering study is currently underway to determine the cause(s) for the violations and to develop corrective measures.

TABLE 6. Columbia River Chemical and Biological Analyses

Analysis	Units	State Standard	Vernita				Richland			
			No. of Samples	Maximum	Minimum	Annual Average <sup>(a)</sup>	No. of Samples	Maximum	Minimum	Annual Average <sup>(a)</sup>
NO <sub>3</sub> <sup>-</sup>	ppm	45	52	0.71	<0.10	0.26 ± 0.15	52	0.64	<0.1	0.25 ± 0.14
pH		6.5 to 8.5	45	8.2	6.5	N/A	47	8.2	6.9	N/A
Turbidity	NTU <sup>(b)</sup>	5 + Bkgd.	48	12	0.85	2.2 ± 1.7	45	18	0.67	2.4 ± 2.6
Dissolved O <sub>2</sub>	mg/l	8	44	13.4	4.5	10 ± 1.8	43	13.7	5.5	10 ± 1.7
Total Coliforms	no./100 ml	None	13	350	11	70 <sup>(c)</sup>	13	920	33	130 <sup>(c)</sup>
Fecal Coliforms	no./100 ml	100	12	11	<2.0	2.0 <sup>(c)</sup>	12	49	<2.0	13 <sup>(c)</sup>
BOD <sup>(d)</sup>	mg/l	None	14	5.5	0.6	2.3 ± 1.4	14	4.8	<0.5	1.9 ± 1.2

(a) Average ± two standard deviations.

(b) Nephelometric Turbidity Units.

(c) Annual median.

(d) Biological Oxygen Demand.

N/A Not Applicable.



## FOODSTUFFS

Foodstuffs, including milk, beef, fruit and leafy vegetables were collected from local and distant farms for analysis of gamma-emitting radionuclides and  $^{90}\text{Sr}$ . Because the River-view farming area is irrigated with Columbia Riverwater that has passed the Hanford Site, samples of foodstuffs were also obtained from this area. Analyses of these samples in 1980 indicated no observable impact from current or past Hanford operations. Elevated levels of  $^{131}\text{I}$  were observed in some local milk samples following an atmospheric nuclear detonation on October 16 by the People's Republic of China.

### MILK

Milk samples were collected every two weeks at farms in a generally downwind direction from the Hanford Site. 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  $^{131}\text{I}$ . Samples from two farms were analyzed for  $^{89}\text{Sr}$  and  $^{90}\text{Sr}$  once a month. Samples from the other farms were analyzed only for  $^{90}\text{Sr}$  on a quarterly basis.

As noted in Table 7, the most abundant radionuclide measured in the milk samples

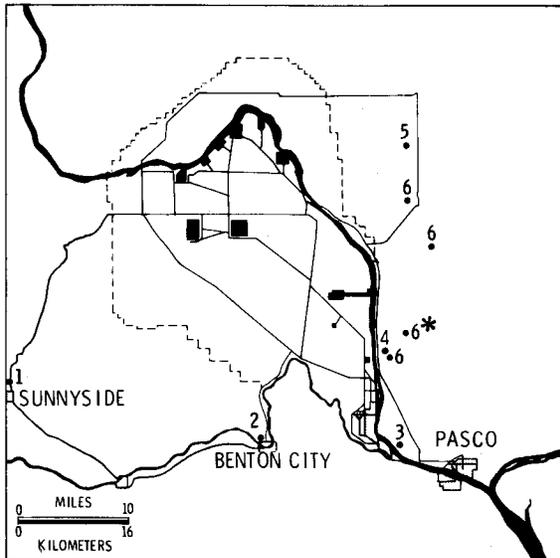


FIGURE 7. Milk Sampling Locations.(a)

- (a) Refer to Table 7 for descriptions of sample locations. Samples from locations numbered 6 and 6\* were combined to form a composite sample.

was potassium-40, a naturally occurring radionuclide. Strontium-90 was, in a few instances, detected in milk samples at concentrations typical of many areas around the United States. A log-normal probability plot of the  $^{90}\text{Sr}$  data, shown in Figure 8, approximates a straight line suggesting that the observed concentrations were the result of a single source--worldwide fallout. The maximum  $^{131}\text{I}$  concentrations in milk were observed following the October 16 atmospheric nuclear tests by the People's Republic of China.

Special milk sampling was performed at the Riverview, Benton City, and Eltopia sampling locations (2, 3, and 6\* in Figure 7) following the atmospheric nuclear test. Positive  $^{131}\text{I}$  in milk concentrations was consistently observed only at the Eltopia location, for which concentrations observed following the test are shown in Figure 9. The thyroid dose which could potentially be received by an infant consuming one liter per day of milk at the concentrations shown in Figure 9 would be approximately 0.3 mrem, using dose calculation methods described in Appendix E.

### BEEF

Samples of beef are routinely collected from two private and one commercial source near the site perimeter in a downwind direction. However, because of the unavailability of samples from the private sources and the closure of the commercial supplier during the early 1980, only one sample was obtained during the year. The sample from the commercial source was analyzed for gamma-emitters and  $^{90}\text{Sr}$ . The results of these analyses are shown in Table 8.

Cesium-137 was the only artificially produced radionuclide identified in the sample. The low concentration observed is typical of that expected due to worldwide fallout and is similar to levels observed in previous years.

**TABLE 7. Radionuclides in Milk(a)**

Concentration Guide	Concentrations, pCi/ (10 <sup>-9</sup> μCi/ml)															
	40K			89Sr			90Sr			131I						
	Location	Map Location	No. of Samples (b)	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average				
Riverview	3	27	1900 ± 420	820 ± 86	1100 ± 580	3.6 ± 2.3	0.54 ± 1.8	1.8 ± 3.4	3.1 ± 1.4	0.86 ± 1.4	1.5 ± 2.6	0.32 ± 0.29	-0.02 ± 0.21	0.06 ± 0.42		
Wahluke	5	18	1700 ± 390	940 ± 100	1200 ± 620	---	---	---	---	---	0.90 ± 1.4	0.23 ± 0.36	-0.07 ± 0.057	0.07 ± 0.34		
Sage Moor Vicinity	4	23	2000 ± 230	750 ± 220	1200 ± 620	1.5 ± 2.3	0.0 ± 2.3	0.77 ± 2.5	1.4 ± 1.4	0.14 ± 1.5	0.67 ± 1.6	0.30 ± 0.49	-0.08 ± 0.50	0.04 ± 0.38		
Benton City	2	27	2000 ± 400	710 ± 220	1200 ± 760	---	---	---	---	---	1.4 ± 1.4	0.68 ± 1.4	1.1 ± 1.6	0.48 ± 0.52	-0.006 ± 0.26	0.08 ± 0.53
Sunnyside	1	26	2400 ± 440	380 ± 88	1100 ± 900	1.8 ± 2.3	0.0 ± 2.3	0.78 ± 2.6	2.0 ± 1.4	0.45 ± 1.4	0.98 ± 1.7	0.30 ± 0.31	-0.01 ± 0.48	0.06 ± 1.1		
Composite	6	27	2200 ± 410	890 ± 87	1200 ± 780	---	---	---	---	---	1.7 ± 1.4	0.18 ± 1.4	0.90 ± 2.1	0.60 ± 2.2	-0.02 ± 0.21	0.07 ± 0.64

(a) Maximum and minimum concentrations shown include the 2σ counting error. Average concentrations include an estimate of the uncertainty of the average at the 95% confidence level. In cases where only one analysis was performed during the year, the result is shown in the average column along with the associated 2σ counting error.  
 (b) Total number of samples collected. All samples were analyzed for 131I and gamma-emitting radionuclides with a lesser number analyzed for 89Sr and 90Sr.

No entry indicates no analysis was performed.

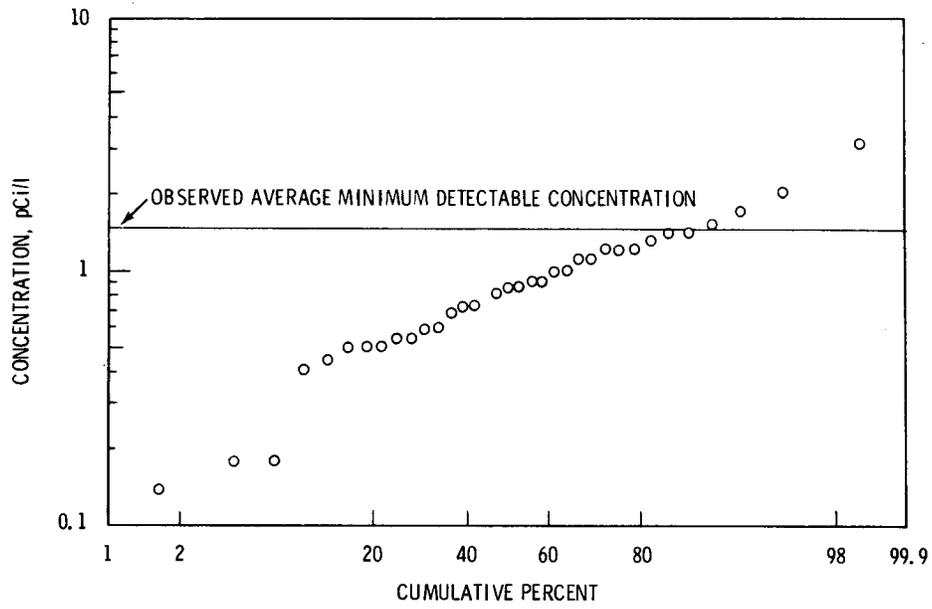


FIGURE 8. Log Normal Probability Plot of  $^{90}\text{Sr}$  in Milk Samples

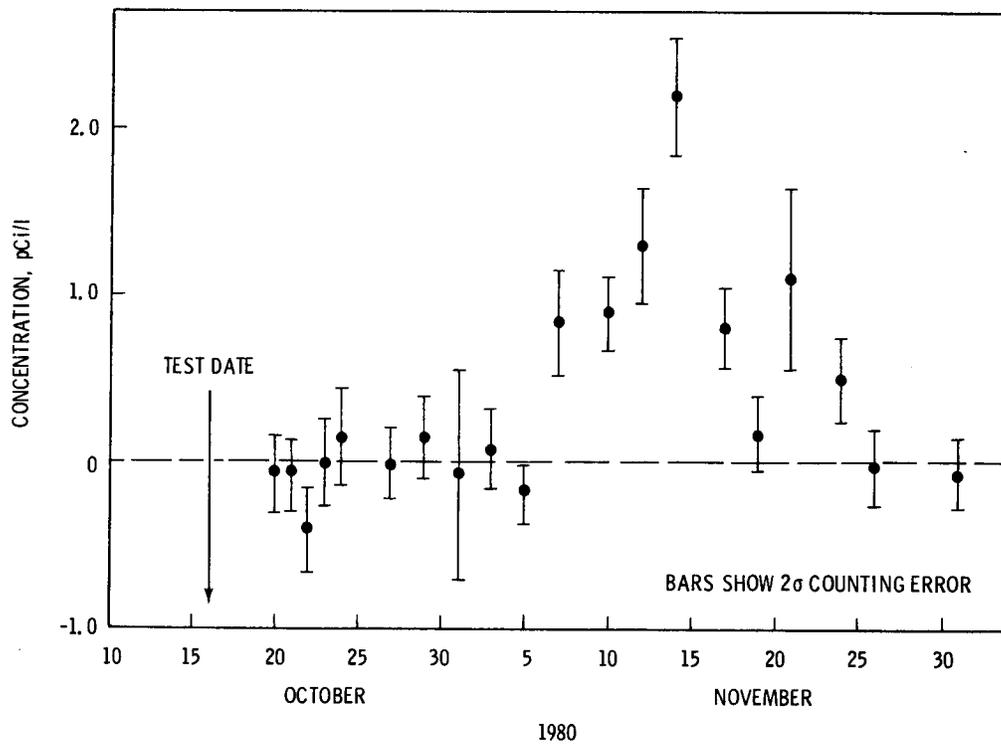


FIGURE 9. Iodine-131 Concentrations in Milk Samples Collected Near Eltopia Following the October Nuclear Test

### 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 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  $^{90}\text{Sr}$  analyses. Only the edible portions of the fruit and vegetables were analyzed. Results for 1980 are summarized in Table 8.

As in past years, low concentrations of  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$  were identified in some samples. A log-normal probability plot of the sampling data, shown in Figure 10, approximates a straight line, suggesting that the observed concentrations were the result of world-wide fallout.

TABLE 8. Radionuclides in Beef, Fruit, and Leafy Vegetables(a)

Location	Type	No. of Samples	<sup>40</sup> K			<sup>90</sup> Sr			<sup>137</sup> Cs		
			Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
<b>Beef</b>											
Commercial		1			2.2 ± 0.21			0.007 ± 0.04			0.03 ± 0.02
<b>Fruit</b>											
Sagemoor Vicinity	Cherries	1			2.2 ± 0.09						0.01 ± 0.007
Sagemoor Vicinity	Plums	1			0.77 ± 0.09						-0.004 ± 0.007
Sagemoor Vicinity	Pears	1			0.77 ± 0.11						-0.005 ± 0.009
Sagemoor Vicinity	Grapes	1			1.4 ± 0.07						0.001 ± 0.006
Sagemoor Vicinity	Apples	1			5.0 ± 0.31						0.01 ± 0.02
Sunnyside	Cherries	1			1.4 ± 0.24						0.006 ± 0.02
Sunnyside	Pears	1			0.62 ± 0.12						0.01 ± 0.01
Sunnyside	Plums	1			1.2 ± 0.10						0.005 ± 0.009
Sunnyside	Peaches	1			1.1 ± 0.11						-0.004 ± 0.01
Sunnyside	Apples	1			0.89 ± 0.12						0.008 ± 0.01
Sunnyside	Grapes	1			1.5 ± 0.08						0.02 ± 0.007
<b>Leafy Vegetables</b>											
Riverview		4	3.9 ± 0.57	3.0 ± 0.17	3.4 ± 0.91	0.09 ± 0.04	0.05 ± 0.03	0.07 ± 0.05	0.02 ± 0.01	-0.02 ± 0.05	0.007 ± 0.05
Sagemoor Vicinity		1			1.1 ± 0.15						0.001 ± 0.01
Ringold		1			25 ± 0.93			0.08 ± 0.03			0.14 ± 0.08
Benton City		2	1.5 ± 0.14	0.53 ± 0.13	1.0 ± 1.4	0.01 ± 0.03	0.001 ± 0.04	0.006 ± 0.04	0.004 ± 0.01	-0.004 ± 0.01	0.0 ± 0.02
Othello		2	3.7 ± 0.22	3.5 ± 0.17	3.6 ± 0.34	0.06 ± 0.04	0.03 ± 0.03	0.04 ± 0.06	0.0005 ± 0.02	-0.009 ± 0.01	-0.004 ± 0.02
Moses Lake		1			1.7 ± 0.20			0.14 ± 0.007			0.02 ± 0.02
Walla Walla		1			1.3 ± 0.13			0.0 ± 0.03			0.007 ± 0.01
Sunnyside		1			1.3 ± 0.18			0.04 ± 0.05			0.004 ± 0.02

(a) Maximum and minimum concentrations shown include the 2σ counting error. Average concentrations include an estimate of the uncertainty of the average at the 95% confidence level. In cases where only one analysis was performed during the year, the result is shown in the average column along with the associated 2σ counting error.

No entry indicates no analysis was performed.

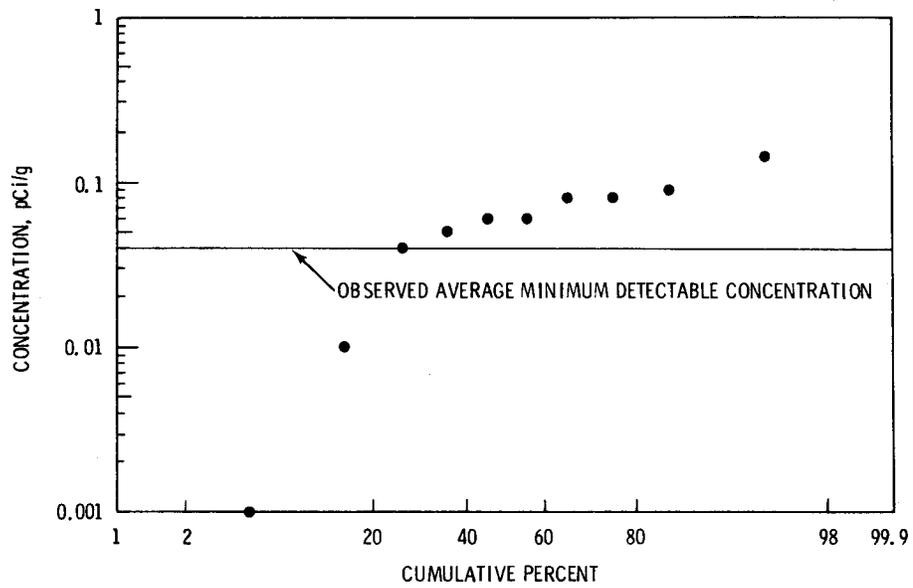


FIGURE 10. Log Normal Probability Plot of <sup>90</sup>Sr in Leafy Vegetables

## WILDLIFE

Animals from the Hanford environs were collected and analyzed for gamma-emitting radionuclides. Wildlife is a potential pathway for the exposure of people who hunt or fish near the Hanford Site. Low levels of radionuclides attributed to past operations at Hanford were observed in several samples of whitefish collected from the Columbia River and in ducks collected from onsite wastewater ponds. In addition, a special study conducted during 1980 determined that Hanford deer contained small amounts of  $^{129}\text{I}$  attributable to onsite operations. Calculated doses resulting from assumed consumption of the samples were very small and far below dose standards.

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 onsite ditches and ponds that receive waste water with a potential for being contaminated. Measurable quantities of radionuclides may be incorporated into the animals that ingest the water or the vegetation growing in the water.

Samples of 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 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 could also be 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

Deer sampling at Hanford consists of retrieving "road kills" for radionuclide analysis. Therefore, deer samples vary in number and location from year to year. During 1980, ten deer were obtained on the Hanford Site. One was taken from near 100-D Area, three from about 10 km (6 miles) southeast of the 200 Areas, two from near the Washington Public Power Supply System No. 1 Site, three just north of the 300 Area, and one from near the Prosser Barricade. Samples of muscle tissue were analyzed to determine the concentration of gamma-emitting radionuclides. The resulting data are shown in Table 9. Naturally occurring  $^{40}\text{K}$  and the fission product  $^{137}\text{Cs}$  were the only radionuclides detected in the deer muscle samples. Concentrations of  $^{137}\text{Cs}$  in the samples were all near or below minimum detectable concentration levels and were similar to levels observed in samples collected at locations far from the Hanford Site (Price, Cadwell and Schreckhise 1981). Concentrations of  $^{137}\text{Cs}$  in Hanford deer for 1980 were thus at levels attributable to worldwide fallout.

TABLE 9. Radionuclides in Muscle Tissue of Deer and Upland Gamebirds

Concentrations, pCi/g ( $10^{-6}$   $\mu\text{Ci/g}$ ), wet weight

Wildlife	No. of Samples	$^{40}\text{K}$			$^{137}\text{Cs}$		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Deer	10	$3.6 \pm 0.41$	$2.0 \pm 0.20$	$2.6 \pm 1.3$	$0.02 \pm 0.01$	$-0.003 \pm 0.01$	$0.007 \pm 0.02$
Pheasant	2	$5.3 \pm 2.2$	$3.2 \pm 2.0$	$4.3 \pm 3.6$	$0.02 \pm 0.08$	$-0.003 \pm 0.07$	$0.009 \pm 0.08$
Quail	3	$5.8 \pm 2.6$	$2.4 \pm 0.23$	$3.8 \pm 3.9$	$0.13 \pm 0.02$	$-0.007 \pm 0.09$	$0.04 \pm 0.16$

NOTE: Individual results include the  $2\sigma$  counting error. Averages show the  $2\sigma$  uncertainty level based on the variance of the mean as well as counting errors.

In a special study (Price, Cadwell and Schreckhise 1981), samples of deer were collected from the Hanford Site as well as from several offsite locations up to 370 km (230 miles) distant for the purpose of measuring  $^{129}\text{I}$  concentrations. All samples were found to contain very low concentrations of  $^{129}\text{I}$ , but samples taken within 160 km (100 miles) showed higher levels than those taken from the more distant sampling locations. The increased  $^{129}\text{I}$  concentrations above the background concentrations (due to natural production and fallout) were attributed to past Hanford operations. The maximum net  $^{129}\text{I}$  concentrations were in deer taken from the Hanford site. The average concentration of  $^{129}\text{I}$  observed in Hanford

deer muscle was  $7.3 \times 10^{-6}$  pCi/gram, wet weight. The 50-yr dose commitment to an adult thyroid resulting from the consumption of 45 kg of meat (equivalent to the meat obtainable from a Hanford deer) would be 0.0024 mrem,<sup>(a)</sup> negligible in comparison to the applicable DOE dose standard in Appendix A.

#### WATERFOWL

Duck and goose samples were collected in the vicinity of the 100-N Area and at White

(a) Dose calculation methods described in Appendix E were used.

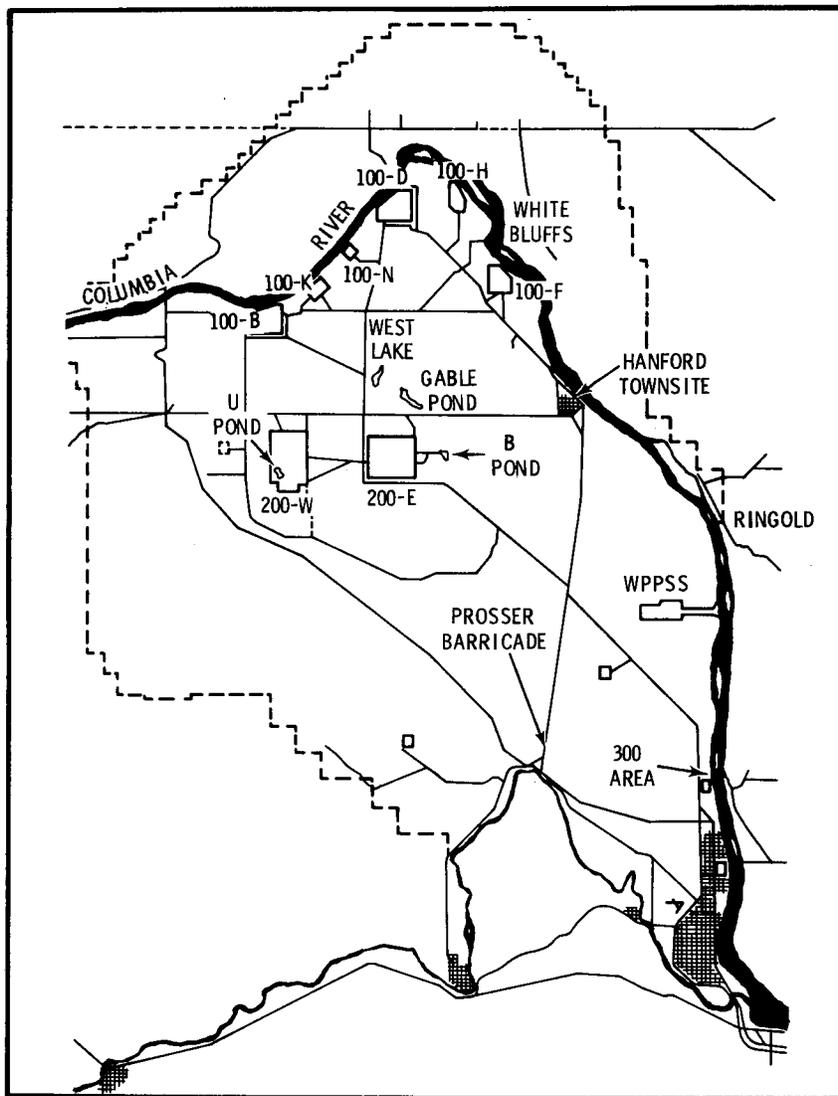


FIGURE 11. Onsite Waste Water Ponds and Production Areas

Bluffs along the Columbia River. Ducks were also collected from each of the four onsite ponds shown in Figure 11. 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 10. Only  $^{137}\text{Cs}$  and naturally occurring  $^{40}\text{K}$  were observed in the waterfowl samples. Samples of ducks and geese collected along the Columbia River showed low concentrations of  $^{137}\text{Cs}$  attributable to worldwide fallout. Samples of ducks collected from waste water ponds near the 200 Areas; however, showed the effect of residence on the ponds by an accumulation of  $^{137}\text{Cs}$  in their tissues. The maximum concentration observed in a duck (210 pCi- $^{137}\text{Cs}$ /g, wet weight, at Gable Pond) was similar to that observed in ducks collected from the waste water ponds in recent years. Consumption of 454 grams (1 lb) of meat from this duck would result in a whole body dose of about 3 mrem or less than 1% of the applicable DOE dose standard in Appendix A.<sup>(a)</sup> 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.

#### UPLAND GAME BIRDS

Upland game bird samples including pheasant and quail were collected on the Hanford Site during 1980. Two pheasants were collected near the old production reactor sites and three quail were collected, one each from the 100, 200, and 300 areas (see Figure 11). Samples of muscle tissue from these birds were analyzed for gamma-emitting radionuclides. Results of these analyses are shown in Table 9. Cesium-137 and naturally occurring  $^{40}\text{K}$  were the only radionuclides observed in the samples. None of the  $^{137}\text{Cs}$  concentrations exceeded levels that would be expected from worldwide fallout.

#### FISH

A total of 13 whitefish were collected from the vicinity of 100-D Area and Ringold

during 1980. Two bass were collected from near the old Hanford Townsite. All sample locations were downstream of N Reactor. Boneless fillets from these fish were analyzed for gamma-emitting radionuclides. Results of these analyses are shown in Table 11.

In addition to the naturally occurring  $^{40}\text{K}$  which was observed in all fish samples, the artificially produced radionuclides,  $^{60}\text{Co}$ ,  $^{65}\text{Zn}$ , and  $^{137}\text{Cs}$ , were also identified in several of the samples. Concentrations of the artificially produced radionuclides were in every case very low and well below the observed  $^{40}\text{K}$  natural radioactivity levels in the tissues. The detection of  $^{60}\text{Co}$  and  $^{65}\text{Zn}$  in the samples was made possible by improvements in radionanalytical techniques enabling the radionuclides to be measured at lower concentrations in 1980 than in previous years.

Cesium-137 concentrations were in the range expected from world-wide fallout. Cobalt-60 was observed at very low concentrations in several of the whitefish samples. Residual  $^{60}\text{Co}$  in river sediments from past operations and current releases from N Reactor (0.76 Ci during 1980) were the most likely sources. An individual consuming 454 grams (1 lb) of fish at the maximum observed concentration (0.10 pCi/gram) would receive a GI-tract (critical organ) dose of 0.18 mrem.<sup>(a)</sup>

Zinc-65, a radionuclide primarily associated with pre-1971 Hanford operations was also reported at very low concentrations in several of the whitefish samples. An adult consuming 454 grams of fish at the maximum observed concentration (0.15 pCi/gram) would receive a dose to the liver (critical organ) of 0.001 mrem.<sup>(a)</sup> The calculated doses represent less than 0.01% of the applicable DOE dose standard (Appendix A).

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(a) Dose calculation methods described in Appendix E were used.

TABLE 10. Radionuclides in Muscle Tissue of Waterfowl

Location	Type	Number Sampled	<sup>40</sup> K			<sup>137</sup> Cs		
			Maximum	Minimum	Average	Maximum	Minimum	Average
U Pond	Duck	1			3.6 ± 1.7			52 ± 1.1
B Pond	Duck	2	5.0 ± 2.8	2.3 ± 0.35	3.7 ± 4.3	110 ± 2.0	0.03 ± 0.03	57 ± 150
West Lake	Duck	2	4.7 ± 2.8	2.9 ± 1.3	3.8 ± 3.4	47 ± 0.37	0.007 ± 0.11	24 ± 66
Gable Pond	Duck	1			20 ± 10			210 ± 5.3
Columbia River	Duck	7	4.6 ± 0.83	2.5 ± 0.70	3.6 ± 1.8	0.10 ± 0.09	0.003 ± 0.02	0.06 ± 0.17
Columbia River	Geese	2	4.3 ± 1.6	3.4 ± 1.8	3.9 ± 2.1	0.01 ± 0.07	0.005 ± 0.06	0.008 ± 0.07

NOTE: Individual results show the 2σ counting error. Averages show the 2σ uncertainty level based on the variance of the mean as well as the counting errors.

TABLE 11. Radionuclides in Fish Muscle from the Columbia River

Radionuclide	No. of Samples	Whitefish			Bass		
		Maximum	Minimum	Average	Maximum	Minimum	Average
<sup>40</sup> K	13	8.4 ± 3.6	2.5 ± 0.18	3.6 ± 3.6	3.1 ± 0.67	2.8 ± 0.47	3.0 ± 0.72
<sup>60</sup> Co	13	0.10 ± 0.05	0.00009 ± 0.04	0.03 ± 0.09	0.0009 ± 0.09	0.0006 ± 0.06	0.0008 ± 0.08
<sup>65</sup> Zn	13	0.15 ± 0.07	-0.02 ± 0.07	0.05 ± 0.17	-0.02 ± 0.11	-0.01 ± 0.08	-0.02 ± 0.10
<sup>137</sup> Cs	13	0.12 ± 0.03	-0.02 ± 0.03	0.04 ± 0.10	0.06 ± 0.06	0.03 ± 0.04	0.05 ± 0.07

NOTE: Individual results show the 2σ counting error. Averages show the 2σ uncertainty level based on the variance of the mean as well as the counting errors.

## 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. Radionuclide concentrations in samples taken during 1980 were similar to previous years. No obvious geographical radionuclide distribution pattern was observed in the 1980 samples.

### COLLECTION AND ANALYSIS

Soil and vegetation samples were collected once during 1980 in late summer at fourteen 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 m<sup>2</sup>. 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, plutonium, <sup>90</sup>Sr, and uranium.

The locations of the sample plots are shown in Figure 12. Hanford operations would be expected to contribute 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, 11, 12, 14) than to sampling locations lying in other directions.

### SOIL

Data from soil analyses for 1980 are summarized in Table 12. The naturally occurring radionuclides <sup>40</sup>K, <sup>224</sup>Ra, <sup>226</sup>Ra, and uranium were observed at higher concentrations in the soil than any of the artificially produced radionuclides.

Both maximum and average observed radionuclide concentrations were similar to results obtained in previous years and no obvious geographical distribution pattern was

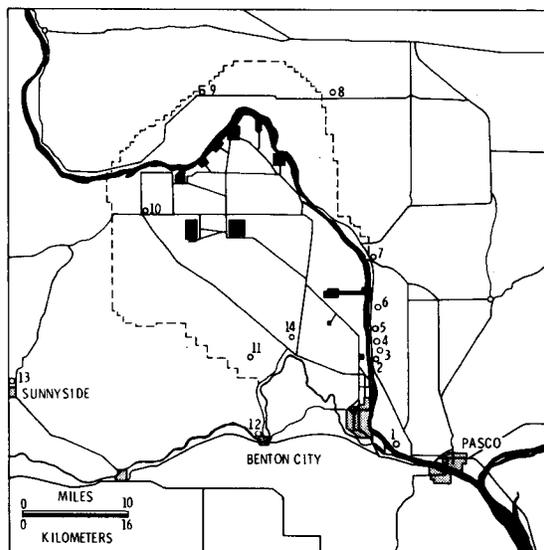


FIGURE 12. Soil and Vegetation Sampling Locations

observed. The differences in radionuclide concentration between sample sites is normal and can be attributed to the highly variable nature of soil concentrations (Miller, Fix and Bramson 1979).

### VEGETATION

Shown in Table 13 are the data obtained in 1980 for the vegetation samples. Concentrations were similar to those observed during previous years and no obvious geographical distribution pattern was observed.

Radionuclides potentially associated with Hanford operations which were consistently observed in samples were uranium, <sup>90</sup>Sr, and plutonium. Concentrations of these radionuclides were within the range normally attributed to either natural variability or world-wide fallout.

**TABLE 12. Radionuclides in Soil**

Part A: Naturally Occurring

Location	Map Location	Concentrations, pCi/g ( $10^{-6}$ $\mu$ Ci/g), dry weight			
		$^{40}\text{K}$	$^{224}\text{Ra}$	$^{226}\text{Ra}$	Total U
Riverview	1	10 $\pm$ 1.4	0.92 $\pm$ 0.07	0.57 $\pm$ 0.08	0.33 $\pm$ 0.11
Byers Landing	2	14 $\pm$ 1.3	1.2 $\pm$ 0.08	0.69 $\pm$ 0.09	0.34 $\pm$ 0.12
Sagemoor	3	17 $\pm$ 1.4	1.2 $\pm$ 0.09	0.75 $\pm$ 0.10	0.37 $\pm$ 0.13
Taylor Flats #1	4	20 $\pm$ 1.8	1.3 $\pm$ 0.10	1.0 $\pm$ 0.13	1.4 $\pm$ 0.50
Taylor Flats #2	5	18 $\pm$ 1.7	0.91 $\pm$ 0.09	0.83 $\pm$ 0.12	0.61 $\pm$ 0.21
W. End Fir Road	6	14 $\pm$ 1.3	0.96 $\pm$ 0.08	0.64 $\pm$ 0.09	0.46 $\pm$ 0.16
Ringold	7	11 $\pm$ 1.2	0.79 $\pm$ 0.07	0.45 $\pm$ 0.08	0.34 $\pm$ 0.12
Berg Ranch	8	13 $\pm$ 1.3	1.1 $\pm$ 0.08	0.73 $\pm$ 0.10	0.23 $\pm$ 0.08
Wahluke #2	9	13 $\pm$ 1.2	0.97 $\pm$ 0.08	0.68 $\pm$ 0.09	0.34 $\pm$ 0.12
Yakima Barricade	10	14 $\pm$ 1.3	1.1 $\pm$ 0.08	0.65 $\pm$ 0.09	0.29 $\pm$ 0.10
ALE	11	14 $\pm$ 1.5	1.2 $\pm$ 0.10	0.86 $\pm$ 0.12	0.36 $\pm$ 0.13
Benton City	12	13 $\pm$ 1.3	1.3 $\pm$ 0.09	0.90 $\pm$ 0.11	0.70 $\pm$ 0.24
Sunnyside	13	10 $\pm$ 1.4	0.78 $\pm$ 0.09	0.50 $\pm$ 0.10	0.41 $\pm$ 0.14
Prosser Barricade	14	15 $\pm$ 1.3	0.80 $\pm$ 0.07	0.58 $\pm$ 0.09	0.16 $\pm$ 0.06
Average $\pm 2\sigma$ Uncertainty		14 $\pm$ 5.8	1.0 $\pm$ 0.38	0.70 $\pm$ 0.33	0.45 $\pm$ 0.64

Part B: Artificially Produced

Location	Map Location	Concentration, pCi/g ( $10^{-6}$ $\mu$ Ci/g), Dry Weight						
		$^{90}\text{Sr}$	$^{95}\text{ZrNb}$	$^{134}\text{Cs}$	$^{137}\text{Cs}$	$^{144}\text{Ce}$	$^{238}\text{Pu}$	$^{239-240}\text{Pu}$
Riverview	1	0.001 $\pm$ 0.007	0.05 $\pm$ 0.04	0.03 $\pm$ 0.02	1.1 $\pm$ 0.09	0.37 $\pm$ 0.11	0.0005 $\pm$ 0.0006	0.02 $\pm$ 0.002
Byers Landing	2	0.003 $\pm$ 0.007	0.07 $\pm$ 0.04	0.01 $\pm$ 0.02	0.34 $\pm$ 0.05	0.33 $\pm$ 0.11		
Sagemoor	3	0.02 $\pm$ 0.007	0.05 $\pm$ 0.04	0.004 $\pm$ 0.02	0.55 $\pm$ 0.06	0.36 $\pm$ 0.12	0.007 $\pm$ 0.002	0.008 $\pm$ 0.002
Taylor Flats #1	4	0.007 $\pm$ 0.007	-0.03 $\pm$ 0.05	0.04 $\pm$ 0.03	0.09 $\pm$ 0.04	0.22 $\pm$ 0.15	0.007 $\pm$ 0.002	0.003 $\pm$ 0.001
Taylor Flats #2	5	0.25 $\pm$ 0.01	0.05 $\pm$ 0.05	-0.02 $\pm$ 0.02	1.4 $\pm$ 0.11	0.39 $\pm$ 0.15	0.005 $\pm$ 0.002	0.03 $\pm$ 0.004
W. End Fir Road	6	0.17 $\pm$ 0.007	0.005 $\pm$ 0.04	0.02 $\pm$ 0.02	0.19 $\pm$ 0.04	0.28 $\pm$ 0.12	0.0001 $\pm$ 0.0007	0.008 $\pm$ 0.002
Ringold	7	0.07 $\pm$ 0.007	-0.007 $\pm$ 0.04	0.03 $\pm$ 0.03	0.68 $\pm$ 0.07	0.13 $\pm$ 0.10	0.002 $\pm$ 0.001	0.02 $\pm$ 0.003
Berg Ranch	8	0.14 $\pm$ 0.007	0.02 $\pm$ 0.04	0.02 $\pm$ 0.02	0.58 $\pm$ 0.06	0.47 $\pm$ 0.12	0.001 $\pm$ 0.0009	0.009 $\pm$ 0.002
Wahluke #2	9	0.31 $\pm$ 0.01	0.03 $\pm$ 0.04	0.05 $\pm$ 0.02	0.35 $\pm$ 0.05	0.39 $\pm$ 0.12	0.0007 $\pm$ 0.0008	0.006 $\pm$ 0.002
Yakima Barricade	10	0.02 $\pm$ 0.007	0.03 $\pm$ 0.04	0.06 $\pm$ 0.03	0.77 $\pm$ 0.07	0.39 $\pm$ 0.12	0.004 $\pm$ 0.001	0.02 $\pm$ 0.003
ALE	11	0.0 $\pm$ 0.007	-0.02 $\pm$ 0.05	0.03 $\pm$ 0.03	1.2 $\pm$ 0.10	0.53 $\pm$ 0.17	0.003 $\pm$ 0.001	0.02 $\pm$ 0.003
Benton City	12	0.29 $\pm$ 0.005	0.04 $\pm$ 0.04	0.02 $\pm$ 0.02	1.0 $\pm$ 0.09	0.38 $\pm$ 0.12	0.002 $\pm$ 0.001	0.02 $\pm$ 0.003
Sunnyside	13	0.19 $\pm$ 0.02	0.02 $\pm$ 0.06	0.03 $\pm$ 0.03	0.65 $\pm$ 0.08	0.44 $\pm$ 0.17	0.002 $\pm$ 0.001	0.01 $\pm$ 0.003
Prosser Barricade	14	0.003 $\pm$ 0.007	0.05 $\pm$ 0.04	0.01 $\pm$ 0.02	0.95 $\pm$ 0.08	0.36 $\pm$ 0.11		
Average $\pm 2\sigma$ Uncertainty		0.11 $\pm$ 0.23	0.03 $\pm$ 0.07	0.02 $\pm$ 0.05	0.70 $\pm$ 0.78	0.36 $\pm$ 0.24	0.003 $\pm$ 0.005	0.02 $\pm$ 0.02

NOTE: Individual results include the  $2\sigma$  counting error. Average shows the  $2\sigma$  uncertainty level based on variance of mean as well as counting errors. No entry indicates that analysis was not successfully analyzed for the particular constituent.

TABLE 13. Radionuclides in Vegetation

Locations	Map Location	Concentrations, pCi/g ( $10^{-6}$ $\mu$ Ci/g), dry weight							
		Naturally Occurring		Artificially Produced					
		<sup>40</sup> K	Total U	<sup>90</sup> Sr	<sup>95</sup> ZrNb	<sup>137</sup> Cs	<sup>144</sup> Ce	<sup>238</sup> Pu	<sup>239-240</sup> Pu
Riverview	1	8.0 ± 3.4	0.008 ± 0.01	0.04 ± 0.01	-0.06 ± 0.20	0.02 ± 0.17	-0.02 ± 0.63		
Ryers Landing	2	30 ± 6.6	0.03 ± 0.02	0.06 ± 0.04	0.08 ± 0.31	0.18 ± 0.20	-0.14 ± 0.88		
Sage Moor	3	17 ± 3.4	0.003 ± 0.01	0.05 ± 0.01	0.09 ± 0.16	-0.03 ± 0.09	-0.16 ± 0.47		
Taylor Flats #1	4	20 ± 5.2	0.07 ± 0.03	0.04 ± 0.01	0.02 ± 0.26	0.01 ± 0.15	-0.30 ± 0.81	0.001 ± 0.001	0.04 ± 0.004
Taylor Flats #2	5	14 ± 4.3	0.11 ± 0.04	0.08 ± 0.05	-0.03 ± 0.23	0.27 ± 0.17	0.80 ± 0.73		
W. End Fir Road	6	17 ± 5.3	0.003 ± 0.01		0.04 ± 0.28	-0.02 ± 0.16	-0.36 ± 0.89	0.02 ± 0.004	0.09 ± 0.009
Ringold	7	14 ± 4.6	0.02 ± 0.01	0.04 ± 0.01	0.04 ± 0.25	0.21 ± 0.17	0.02 ± 0.77		
Berg Ranch	8	15 ± 4.6	0.008 ± 0.01	0.05 ± 0.01	0.14 ± 0.26	0.01 ± 0.14	0.49 ± 0.80		
Wahluke #2	9	14 ± 3.9	0.002 ± 0.01	0.02 ± 0.01	0.003 ± 0.41	-0.05 ± 0.12	-0.22 ± 0.59	0.001 ± 0.004	0.03 ± 0.008
Yakima Barricade	10	19 ± 4.9	0.01 ± 0.01	0.07 ± 0.01	-0.08 ± 0.26	0.18 ± 0.17	0.15 ± 0.74		
ALE	11	11 ± 3.4	0.07 ± 0.03	0.09 ± 0.01	-0.02 ± 0.18	0.03 ± 0.11	0.16 ± 0.54	0.02 ± 0.004	0.15 ± 0.01
Benton City	12	17 ± 5.8	0.03 ± 0.02	0.08 ± 0.01	-0.12 ± 0.32	-0.01 ± 0.18	-0.003 ± 1.0	0.01 ± 0.004	0.10 ± 0.01
Sunnyside	13	15 ± 4.5	0.02 ± 0.01	0.05 ± 0.01	0.05 ± 0.25	0.05 ± 0.14	-0.33 ± 0.71		
Prosser Barricade	14	19 ± 4.2	0.01 ± 0.01	0.03 ± 0.01	0.12 ± 0.21	0.04 ± 0.11	-0.14 ± 0.56		
Average ±2 $\sigma$ Uncertainty		16 ± 11	0.03 ± 0.07	0.05 ± 0.05	0.02 ± 0.30	0.06 ± 0.25	-0.004 ± 0.98	0.01 ± 0.02	0.08 ± 0.10

NOTE: Individual results include the 2 $\sigma$  counting error. Averages show the 2 $\sigma$  uncertainty level based on variance of the mean as well as counting errors. No entry indicates the sample was not successfully analyzed for the particular constituent.



## EXTERNAL RADIATION

*External radiation levels were measured using thermoluminescent dosimeters at all air sampling locations in the Hanford environs. Dosimeters were also used to measure the dose rates along the Columbia River islands and shoreline near the Hanford Site and the immersion dose in Columbia River water upstream and downstream of Hanford liquid effluent discharge points. Measurements during 1980 at the air sampling stations could not distinguish any difference in external dose rates between the perimeter and distant stations. The number of Columbia River Island and Shoreline dose measurement locations was increased during 1980 to include areas with the highest dose rates measured during an extensive radiological survey of the river in 1979. Based on measurements at these locations, the maximum potential increase in radiation dose to recreational users of the river was 3 mrem/yr. The radioactivity causing these dose rates is from pre-1971 operation of production reactors at Hanford.*

### HANFORD ENVIRONS

Thermoluminescent dosimeters (TLDs) were located at all of the perimeter and distant air sampling locations shown in Figure 2. The dosimeters consisted of  $\text{CaF}_2\text{:Mn}$  chips 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 (Fix and Miller 1978). The dosimeters were mounted 1-m above ground level and exchanged 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. A log-normal probability plot of the individual dosimeter readings for distant and perimeter locations (Figure 13) shows the similarity of the measurements. Based on the external radiation dose measurements made in 1980, Hanford contributions to the offsite radiation dose were imperceptible.

From information in Table 14, the external background dose received by the general public in the Hanford environs can be estimated. The mean measured dose was about 69 mrem per year. To this dose, 6 mrem per year must be added to account for the fast neutron component of cosmic radiation (NCRP 1975). Thus the population would have received a dose of about 75 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 (NCRP 1975). Therefore, the total background dose received in the Hanford environs during 1980 was approximately 100 mrem per year, as it was during 1979.

### COLUMBIA RIVER IMMERSION DOSE

Environmental dosimeters were submerged in the Columbia River at Coyote Rapids and at the Richland pumphouse as shown in Figure 14. 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 mrem/hr. By comparison, approximately 0.008 mrem/hr would be received on land.

### COLUMBIA RIVER SHORELINE AND ISLANDS

Until late 1977, public access to the Hanford reach of the Columbia River between Ringold and Vernita was prohibited. The river is now open to the public; however, the shorelines along the river within the Hanford boundary (see Figure 1) are posted to public access upstream of the Hanford Townsite powerline crossing. Downstream of the powerline crossing, access to the river bank up to the high water mark is allowed.

Summarized in Table 16 are data from environmental dosimeters placed at 20 locations along the Columbia River shoreline, including six of the islands. Placement of locations are shown in Figure 14. The dosimeters were located in areas with higher dose rates observed during special aerial and ground surveys of the river (Tipton 1975, Sula 1980).

TABLE 14. Environmental Radiation Dose Measurements in the Hanford Vicinity

Location	No. of Samples	Dose Rate (mrem/yr) <sup>(a)</sup>		
		Maximum	Minimum	Average
<u>Perimeter Stations</u>				
Rattlesnake Springs	10	84	55	73 ± 17
ALE	10	84	69	77 ± 11
Benton City	10	73	55	62 ± 14
Yakima Barricade	10	88	69	78 ± 10
Vernita Bridge	10	77	69	73 ± 6
Wahluke #2	10	84	73	77 ± 7
Othello	9	69	58	60 ± 7
Connell	11	88	58	70 ± 18
Berg Ranch	10	84	73	76 ± 6
Wahluke Watermaster	10	80	69	74 ± 6
Cooke Bros.	10	77	62	68 ± 8
Richland	12	77	58	65 ± 10
Pasco	10	80	58	64 ± 14
Byers Landing	11	80	66	71 ± 10
Sagemoor	10	77	66	73 ± 6
Pettett Farm	10	66	47	58 ± 10
Fir Road	10	73	66	68 ± 5
RRC CP 64	11	73	62	67 ± 9
1100 Area	11	91	55	61 ± 21
Prosser Barricade	10	84	69	<u>74 ± 10</u> 69 ± 16
<u>Distant Stations</u>				
Walla Walla	11	102	58	65 ± 25
McNary	11	91	66	73 ± 14
Moses Lake	10	77	58	67 ± 13
Washtucna	7	80	66	74 ± 11
Sunnyside	10	73	62	<u>66 ± 7</u> 69 ± 17

(a) Monthly measurements in mR were converted to yearly dose equivalent rates.

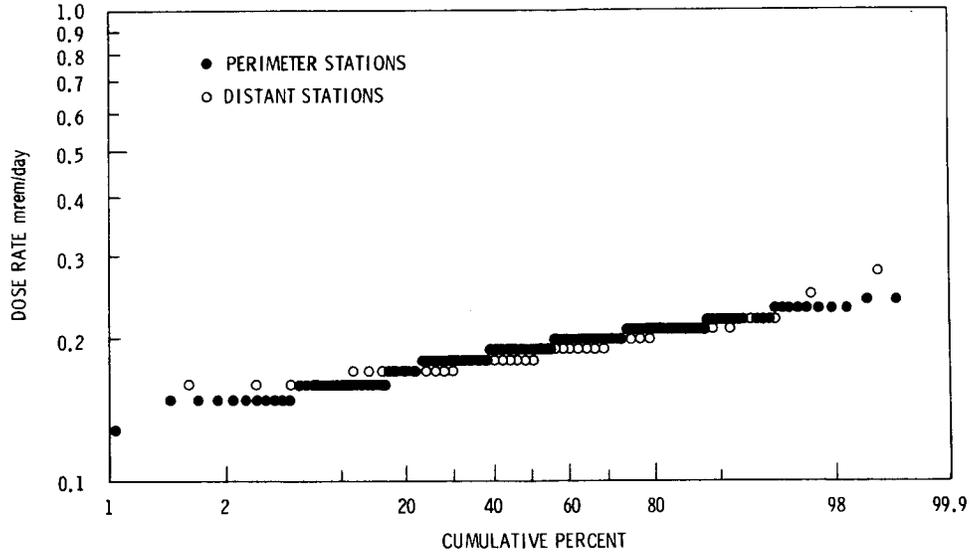


FIGURE 13. Log Normal Probability Plot of Monthly TLD Dose Measurements at Perimeter and Distant Locations

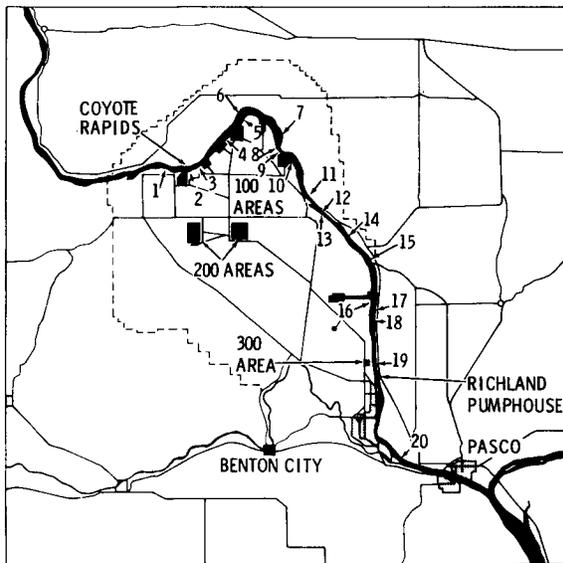


FIGURE 14. Dosimeter Locations Along Columbia River Shoreline

The maximum monthly external dose rate, as measured by the shoreline dosimeters, was 0.063 mrem/hr (including 0.008 mrem/hr background) at 100-N Area (location #4, Figure 14.(a)). The maximum monthly shoreline dose rate measured downstream of the Hanford Powerline crossing was 0.016 mrem/hr (including background) on an island near the 300 Area (location #19).

Dose rates at the 100-Area shoreline are primarily caused by operational activities at N Reactor. The nature of these

(a) A comprehensive radiological survey of the Columbia River shorelines and islands was performed in 1979 (Sula 1980) and is summarized in the 1979 annual environmental report (Houston and Blumer 1980). The highest dose rates were observed at 100-N Area where a shoreline dose rate of 0.2 mrem/hr (increasing to 0.8 mrem/hr 30-meters inland) was measured.

TABLE 15. Columbia River Immersion Dose Rate

Location	No. of Measurements	Radiation Dose Rate (mrem/hr) (a)		
		Maximum	Minimum	Average (b)
Coyote Rapids	9	0.011	0.004	0.006 ± 0.004
Richland Pump House	12	0.005	0.002	0.004 ± 0.002

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

(b) Average  $\pm 2\sigma$  uncertainty is shown for each location.

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

Location	Map No.	No. of Samples (a)	Dose Rate (mrem/hr) (b)		
			Maximum	Minimum	Average (c)
Upriver 100-B Area	1	9*	0.009	0.006	0.008 ± 0.002
Below 100-B Retention Basin	2	9*	0.025	0.016	0.022 ± 0.005
Above 100-K Boat Ramp	3	11	0.008	0.007	0.008 ± 0.001
100-N Trench Springs	4	11	0.063	0.019	0.030 ± 0.024
Downriver 100-D	5	9*	0.015	0.012	0.013 ± 0.002
Downriver Opposite 100-D	6	11	0.010	0.006	0.008 ± 0.002
Lower End Locke Island	7	9	0.010	0.008	0.009 ± 0.001
White Bluffs Slough	8	9*	0.019	0.014	0.017 ± 0.003
White Bluffs Ferry Landing	9	10	0.009	0.008	0.008 ± 0.0008
Below 100-F	10	11	0.010	0.006	0.008 ± 0.002
Hanford Powerline Crossing	11	11	0.010	0.008	0.009 ± 0.001
Hanford Ferry Landing	12	9	0.009	0.007	0.008 ± 0.001
Hanford Railroad Track	13	11	0.015	0.011	0.013 ± 0.002
Savage Island Slough	14	10*	0.013	0.010	0.012 ± 0.002
Ringold Island	15	11	0.010	0.007	0.008 ± 0.002
Powerline Crossing	16	10	0.012	0.009	0.010 ± 0.002
North End Wooded Island	17	9*	0.009	0.005	0.007 ± 0.003
South End Wooded Island	18	11	0.011	0.008	0.009 ± 0.002
Island River Mile 344	19	8*	0.016	0.007	0.014 ± 0.007
Island River Mile 333	20	8*	0.011	0.003	0.009 ± 0.005

(a) Dose measurements at locations with \* were initiated in March 1980.

(b) Monthly measurements in mR were converted to average dose equivalent rate in mrem/hr.

(c) Average  $\pm 2\sigma$  uncertainty shown for each location.

activities accounts for the relatively large observed variability in the dose rate at this location compared to the other dosimeter locations for which dose rates above background are due to the presence of Hanford produced radionuclides in the sediments.

Analysis of sediments along the Columbia River have shown the presence of a few radionuclides, primarily  $^{60}\text{Co}$  and  $^{154}\text{Eu}$ , from past operations of the Hanford Production Reactors (Robertson and Fix 1977). Differences in concentrations of these radionuclides are responsible for the variation in the measured dose rate from site to site. In addition, discrete particles containing  $^{60}\text{Co}$  have also been observed in shoreline sediments primarily on islands near the production reactor sites (Sula 1980). The particles, observed at an average areal density of  $3 \times 10^{-3}$  particles/m<sup>2</sup>, contained up to 25  $\mu\text{Ci}$  of activity per particle and were usually located several centimeters below the ground surface. Because of their relative remoteness and inaccessibility, the particles are not believed to contribute significantly to the doses received by recreational users of the river.

Surveys of the recreational use of the Columbia River in the vicinity of the Hanford Site downstream of Ringold have shown

that the maximum time spent on the river shoreline by an individual during recreational activities (boating, fishing, hunting, etc.) is less than 500 hours per year. The average recreational user spends only about 17 hours per year on this stretch of the river. Estimates are not yet available on the amount of time spent by individuals recreating on the upper part of the river; however, river access limitations, shoreline restrictions, and remoteness are factors which limit the use and hence dose received on this stretch of the river to well below that downstream of Ringold. An estimate of the potential maximum dose received during recreation on the lower part of the river during 1980 can be made assuming that the maximum usage time (500 hours) is spent in the area of the highest observed annual average dose rate (0.006 mrem/hr above background on an island near the 300 Area. Such recreation could potentially result in a dose of about 3 mrem above background. It is highly unlikely that an individual would spend more than a few hours in any of the locations where the higher off-site dose rates were observed. The dose rates along most of the shoreline (especially accross from the Hanford Site are close to the background levels, and the incremental increase in dose to a recreational user of the river would actually be much smaller than the above estimate.



## RADIOLOGICAL IMPACT OF HANFORD OPERATIONS

The radiological impact of Hanford operations during 1980 was calculated based upon the quantity of radionuclides measured in effluents from operating facilities. The first-year dose to the hypothetical maximum-exposed individual was calculated to be 0.72 mrem to the thyroid, 0.5% of the applicable DOE Radiation Protection Standard. The 50-yr whole-body dose commitment to the population within an 80-km (50-mile) radius of the Hanford Site was calculated to be 0.60 man-rem. A comparison of the estimated potential impact from 1980 Hanford operations with the impact from other sources of radiation exposure routinely encountered (Figure 15) demonstrates the comparatively small impact of current operations.

### RADIOLOGICAL IMPACT FROM 1980 OPERATIONS

The radiological impact of Hanford operations during 1980 was assessed in terms of:

- the maximum dose rate on the site boundary (the "fence-post" dose)
- the maximum dose to an individual in an offsite location
- the whole-body dose to the population within an 80-km (50-mile) radius of the site.

Radioactive effluents discharged from Hanford facilities during 1980 were so small that when dispersed in the environment they could not be discerned from radionuclides already present as a result of natural processes, world-wide fallout, and previous (primarily pre-1971) Hanford operations. Therefore, except for "fence-post" dose measurements, the assessment of the radiological impact of Hanford operations during 1980 could not be made based on the direct analysis of environmental media.

In order to assess the radiological impact from 1980 operations, indirect methods in the form of empirical dose models (described in Appendix E) were used. The radionuclide release quantities used as source terms for the dose calculations are shown in Table 17. The table includes all radionuclides reported discharged to the environment during 1980 from Hanford facilities.

### 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 radioactive waste handling facilities is maximized. The whole body radiation dose rate from 1980 effluents was calculated to be  $7.6 \times 10^{-5}$  mrem/hr. Short-lived noble gases in the N-Reactor airborne effluents

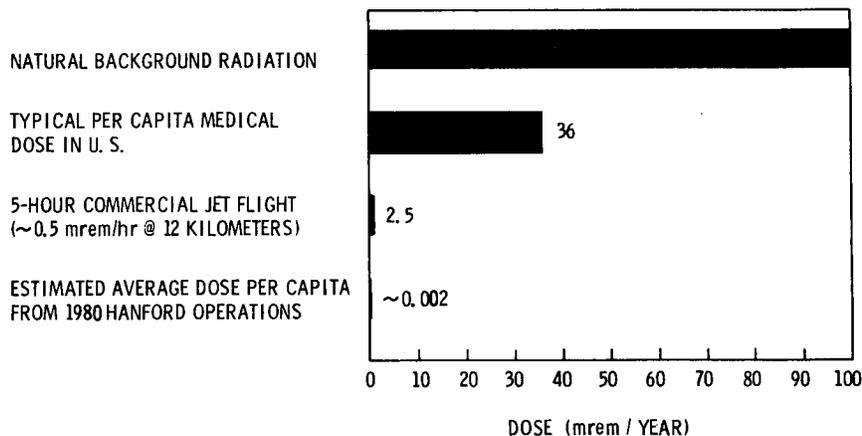


FIGURE 15. Comparative Whole Body Doses Received from Various Radiation Sources

TABLE 17. Radionuclide Composition of Hanford Effluents for Calendar Year 1980

Radionuclide	Half-Life	Effluent (Ci)			
		Liquid To River	100 Area	Airborne 200 Area      300 Area	
<sup>3</sup> H (HTO)	12.3 yr	88	14	---	---
<sup>24</sup> Na	15.0 hr	---	0.36	---	---
<sup>32</sup> P	14.3 d	0.27	---	---	---
<sup>41</sup> Ar	1.8 hr	---	23,000	---	---
<sup>51</sup> Cr	27.8 d	0.20	0.081	---	---
<sup>54</sup> Mn	303 d	0.13	0.020	---	---
<sup>56</sup> Mn	2.6 hr	4.2	3.4	---	---
<sup>59</sup> Fe	46.0 d	0.18	0.037	---	---
<sup>58</sup> Co	71.0 d	0.033	0.011	---	---
<sup>60</sup> Co	5.3 yr	0.76	0.030	---	1.7 x 10 <sup>-5</sup> (a)
<sup>65</sup> Zn	245 d	---	0.012	---	---
<sup>76</sup> As	26.4 hr	---	0.38	---	---
<sup>85m</sup> Kr	4.4 hr	---	150	---	---
<sup>87</sup> Kr	76.0 min	---	500	---	---
<sup>88</sup> Kr	2.8 hr	---	370	---	---
<sup>89</sup> Sr	52.7 d	0.94	0.033	---	---
<sup>90</sup> Sr	27.7 yr	1.8	0.0023	0.23 <sup>(b)</sup>	4.5 x 10 <sup>-5</sup> (c)
<sup>91</sup> Sr	9.7 hr	---	1.7	---	---
<sup>95</sup> Zr	65.5 d	0.071	0.0054	---	---
<sup>95</sup> Nb	35.0 d	0.11	0.0057	---	---
<sup>97</sup> ZrNb	17.0 hr	---	0.041	---	---
<sup>99m</sup> MoTc	66.7 hr	0.39	0.53	---	---
<sup>103</sup> Ru	39.5 d	0.59	0.012	---	---
<sup>106</sup> Ru	368 d	0.65	0.025	---	---
<sup>122</sup> Sb	2.8 d	---	0.022	---	---
<sup>124</sup> Sb	60.4 d	0.10	0.0067	---	---
<sup>125</sup> Sb	2.7 yr	0.16	---	---	---
<sup>132</sup> Te	77.7 hr	---	0.013	---	---
<sup>129</sup> I	1.7 x 10 <sup>7</sup> yr	6.2 x 10 <sup>-6</sup>	5.1 x 10 <sup>-9</sup>	---	---
<sup>131</sup> I	8.1 d	2.1	0.21	---	6.7 x 10 <sup>-4</sup>
<sup>132</sup> I	2.3 hr	---	9.5	---	---
<sup>133</sup> I	20.3 hr	0.36	1.4	---	---
<sup>135</sup> I	6.7 hr	---	7.1	---	---
<sup>133</sup> Xe	5.3 d	3.2	---	---	---
<sup>135</sup> Xe	9.1 hr	---	480	---	---
<sup>134</sup> Cs	2.1 yr	---	0.0033	---	---
<sup>137</sup> Cs	30.0 yr	0.040	0.0055	---	---
<sup>138</sup> Cs	32.2 min	---	1900	---	---
<sup>140</sup> Ba	12.8 d	0.33	0.17	---	---
<sup>140</sup> La	40.2 hr	0.55	0.31	---	---
<sup>141</sup> Ce	32.5 d	0.036	0.0094	---	---
<sup>144</sup> CePr	284 d	---	0.046	---	---
<sup>147</sup> Nd	11.1 d	0.028	0.077	---	---
<sup>153</sup> Sm	46.8 hr	---	0.023	---	---
<sup>154</sup> Eu	16.0 yr	---	0.0021	---	---
<sup>155</sup> Eu	1.8 yr	---	0.013	---	---
<sup>187</sup> W	23.9 hr <sup>10</sup>	---	0.13	---	---
Th-nat	1.4 x 10 <sup>10</sup>	---	---	---	2.3 x 10 <sup>-7</sup>
U-nat	4.4 x 10 <sup>9</sup>	---	---	---	4.9 x 10 <sup>-5</sup>
<sup>239</sup> Np	2.3 d	---	0.16	---	---
<sup>238</sup> Pu	86.4 yr	3.5 x 10 <sup>-4</sup>	2.5 x 10 <sup>-6</sup>	---	---
<sup>239</sup> Pu	2.44 x 10 <sup>4</sup> yr	2.0 x 10 <sup>-4</sup>	1.5 x 10 <sup>-5</sup>	0.0012 <sup>(d)</sup>	2.7 x 10 <sup>-5</sup> (e)

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

(b) Reported as total beta activity composed principally of <sup>90</sup>Sr.

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

(d) Reported as total alpha activity composed principally of <sup>239</sup>Pu.

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

NOTE: --- Radionuclide not reported in effluent.

were the major contributors to this exposure rate. Of greater magnitude is the contribution from direct exposure to the radiation emitted by radioactive material contained in onsite facilities. Measurements taken during a special radiological survey along the river during 1979 indicated a maximum dose rate on the shoreline just below N Reactor of 0.2 mrem/hr<sup>(a)</sup> at the waters' edge increasing to 0.8 mrem/hr 30 meters inland towards the facility (Sula 1980). (The 0.8 mrem/hr measurement was inadvertently reported as the shoreline dose in the 1979 Environmental Surveillance Report.) These readings were made during a period of transfer of radioactive waste from N Reactor to the 200 Area waste storage facilities and represents a short-term (few hours) maximum expected dose rate. The highest dose rate measured along the N-Area shoreline during 1980 based on monthly integrated TLD measurements at the N-Springs measurement location was 0.063 mrem/hr (Note: public access to the shore in this area is restricted).

#### Maximum Individual Dose

The maximum individual dose is that dose received by a hypothetical individual whose living and dietary habits are assumed so as to allow the combined dose from all exposure pathways to produce the highest dose realistically achievable by a person offsite. The characteristics of the maximum-exposed individual are determined annually based on consideration of the magnitude, composition, and source location of radioactive effluents from Hanford; atmospheric dispersion characteristics of the release point; river flow rate data; and assumptions concerning the living, dietary, and recreational habits of individuals in the population surrounding the site.

The following exposure pathways were considered in evaluating the maximum individual dose: inhalation and submersion in the airborne release plumes, consumption of foodstuffs contaminated via dry deposition from airborne releases, use of drinking water obtained from the Columbia River, ingestion of foodstuffs for which Columbia River water was used for irrigation, consumption of fish taken from the Columbia River, and direct exposure to radionuclides in the river water during recreational activities on the river. Thyroid doses were calculated for both an adult and an infant (one-year-old). Other organ doses were calculated for adults only.

(a) Actually reported in units of mR/hr which, in this case, can be expressed in terms of mrem/hr.

The evaluation of the dose received from each of the pathways using the source terms given in Table 17 and assumptions discussed in Appendix E, indicated that the hypothetical maximum-exposed individual during 1980 was a person who:

- 1) resided in the southeastern part of the Riverview district in Pasco, approximately 13 km (8 miles) south-southeast of the 300 Area,
- 2) consumed foodstuffs grown in the northwestern part of the Riverview district using Columbia River water for irrigation,
- 3) consumed Pasco city drinking water obtained from the Columbia River, and
- 4) used the Columbia River extensively for recreational activities including boating, swimming, and fishing (including consumption of caught fish).

The first-year dose (i.e., the dose received during 1980) and the 50-year dose commitment for the maximum-exposed individual are summarized in Table 18. Where there is a difference between the first-year and 50-year commitments, the dose is predominantly due to radionuclides with short physical and/or biological half-lives.

All the doses resulting from effluents discharged to the environment during operations at Hanford in 1980 were well below the applicable Radiation Protection Standards in Manual Chapter 0524, Appendix A. The organ dose representing the largest fraction of the standard was the infant thyroid. The infant thyroid dose was calculated to be 0.72 mrem which represents 0.05% of the standard. All other organ doses were less than 0.05% of their respective standard. The infant thyroid dose was primarily the result of <sup>131</sup>I in milk and drinking water. The <sup>131</sup>I in milk results from the irrigation of dairy pasture with Columbia River water and the deposition of airborne <sup>131</sup>I onto the pasture grass.

For comparison, the maximum dose received by a hypothetical offsite individual in the northwest part of the Riverview district 1.6 km east of the 300 Area as a result of the direct airborne pathway was calculated to be less than 0.01 mrem to the thyroid of an infant. The whole body dose due to the airborne pathway at this location was also calculated to be less than 0.01 mrem. The total dose received at this location was less than that calculated for the maximum-exposed individual described above because

TABLE 18. Dose to the Maximum-Exposed Individual from Effluents Released During 1980

Pathway	First-Year Dose (mrem)					
	Whole Body	GI (a)	Bone	Lung	Thyroid	
					Adult	Infant
Direct Airborne <sup>(b)</sup>	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Foodstuffs <sup>(c)</sup>	<0.01	<0.01	0.03	<0.01	0.11	0.62
Drinking Water	<0.01	<0.01	<0.01	<0.01	0.13	0.10
River Recreation <sup>(d)</sup>	<0.01	<0.01	0.01	<0.01	0.02	---
Total	0.01	0.02	0.04	<0.01	0.16	0.72

Pathway	50-Year Dose Commitment (mrem)					
	Whole Body	GI (a)	Bone	Lung	Thyroid	
					Adult	Infant
Direct Airborne <sup>(b)</sup>	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Foodstuffs <sup>(c)</sup>	0.06	<0.01	0.23	<0.01	0.11	0.65
Drinking Water	0.01	<0.01	0.06	<0.01	0.03	0.10
River Recreation <sup>(d)</sup>	0.03	<0.01	0.10	<0.01	0.03	---
Total	0.10	0.02	0.39	<0.01	0.17	0.75

- (a) Gastrointestinal tract (lower large intestine).
- (b) Includes inhalation, submersion, and direct exposure to ground deposition.
- (c) Includes consumption of all foodstuffs contaminated via irrigated water and dry deposition as well as direct exposure to soils contaminated via irrigated water.
- (d) Includes consumption of fish taken from the Columbia River.

the drinking water at this location is not obtained from the Columbia River.

Richland and Pasco are the first cities downstream of the Hanford Site to obtain drinking water from the Columbia River. Drinking water doses shown in Table 18 for the hypothetical maximum-exposed individual infant thyroid (0.10 mrem) represents 2.5% of the Washington State drinking water standard of 4 mrem per year.

Population Dose

The 50-year dose commitment to the population within an 80-km (50-mile) radius of the Hanford Site because of 1980 operations was calculated using the radionuclide releases (Table 17) and pathways discussed previously in the maximum individual dose calculation, except that assumptions of living and dietary habits were based on an average individual (Appendix E). In general, the population dose was calculated by computing the dose to the average individual

within each pathway and then multiplying this dose by the number of individuals in the pathway. Airborne pathway doses included adjustments for the variation in airborne concentration at different locations due to atmospheric dispersion.

Summarized in Table 19 are the calculated 50-year population dose commitments. The consumption of drinking water obtained from the Columbia River downstream of Hanford was the principal dose pathway for liquid effluents. The airborne dose was primarily attributed to short-lived noble gases and <sup>131</sup>I in effluents from 100-N Area. Individual members of the population could receive doses ranging from zero to the maximum individual dose. For an 80-km (50-mile) radius population of 250,000 persons, the average per capita dose commitment would be 0.0024 mrem (0.6 man-rem/250,000 persons).

These dose estimates can be compared with doses from other routinely encountered sources of radiation such as natural

TABLE 19. 50-Year Population Dose Commitment from Effluents Released During 1980

Pathway	First-Year Dose (man-rem)				
	Whole Body	GI (a)	Bone	Lung	Thyroid
Direct Airborne <sup>(b)</sup>	0.36	0.36	0.36	0.36	0.36
Foodstuffs <sup>(c)</sup>	0.14	0.07	0.51	<0.01	0.77
Drinking Water	0.09	0.03	0.35	<0.01	0.74
River Recreation <sup>(d)</sup>	0.01	<0.01	0.04	<0.01	0.01
Total	0.60	0.46	1.3	0.37	1.9

(a) Gastrointestinal tract (lower large intestine).

(b) Includes inhalation, submersion, and direct exposure to ground deposition.

(c) Includes consumption of all foodstuffs contaminated via irrigated water and dry deposition as well as direct exposure to soils contaminated via irrigated water.

(d) Includes consumption of fish taken from the Columbia River.

background radiation (USEPA 1972), medical diagnostic procedures (USEPA 1972), and a 5-hr commercial jet flight (NCRP 1975). Compared graphically in Figure 15 are the average doses from these sources and the average per capita whole-body doses from Hanford operations for 1980. The estimated population dose of 0.6 man-rem may also be compared with the approximately 25,000 man-rem received annually by the same population from background radiation.

#### RADIOLOGICAL IMPACT FROM PAST HANFORD OPERATIONS

In previous sections of this report the presence of small amounts of radioactivity was occasionally detected in samples of environmental media. In these cases, the assessment of the potential radiological impact was conservatively based on consumption of the media at the maximum observed concentration. In all cases the calculated dose was well below the dose guidelines.



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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 (Washington State Department of Ecology 1977). 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 1973) and are summarized in Table A.2.

Environmental radiation protection standards are published in DOE Manual Chapter 0524, "Standards for Radiation Protection". These standards (shown in Table A.3) 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 from DOE operations. DOE Manual Chapter 0524 also lists radionuclide concentration guides for air and water. Several of the concentration guides for air and water are listed in Table A.4.

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.1. Washington State Water Quality Standards for the Hanford Reach of the Columbia River, 1977

Parameter	Permissible Levels
Fecal Coliform Organism	1) $\leq 100$ organisms/100 ml (median) 2) $\leq 10$ of samples may exceed 200 organisms/100 ml
Dissolved Oxygen	$> 8$ mg/l
Temperature	1) $\leq 18^\circ\text{C}$ ( $64^\circ\text{F}$ ) 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 to 8.5 range 2) $< 0.5$ unit induced variation
Turbidity	$\leq 5$ NTU <sup>(a)</sup> 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 <sub>2</sub> <sup>(a)</sup>	0.10 ppm	24-hr Average
	0.02 ppm	Annual Average
NO <sub>2</sub> <sup>(b)</sup>	100 $\mu\text{g}/\text{m}^3$ <sup>(c)</sup>	Annual Arithmetic Mean
	250 $\mu\text{g}/\text{m}^3$ <sup>(c)</sup>	24-hr Average
Suspended Particulates <sup>(a)</sup>	60 $\mu\text{g}/\text{m}^3$ <sup>(d)</sup>	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.

TABLE A.3. Radiation Protection Standards for External and Internal Exposure

<u>Type of Exposure</u>	<u>Annual Dose Equivalent or Dose Commitment (rem)<sup>(a)</sup></u>	
	Based on Dose to Individuals at Points of Maximum Probable Exposure	Based on an Average Dose to a Suitable Sample of the Exposed Population
Whole Body, Gonads, or Bone Marrow	0.5	0.17
Other Organs	1.5	0.5

(a) In keeping with DOE policy on lowest practicable exposure, exposures to the public shall be limited to as small a fraction of the respective annual dose limits as is practicable.

TABLE A.4. Radionuclide Concentration Guides<sup>(a)</sup>

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

(a) Obtained from DOE Manual Chapter 0524.  
Most restrictive guide assumed.



APPENDIX B

ANALYTICAL PROCEDURES



## APPENDIX B

### ANALYTICAL PROCEDURES

#### AIR SAMPLES

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

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 HNO<sub>3</sub> - 0.01 N HF and the plutonium in the eluate is electro-deposited 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 <sup>129</sup>I 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<sup>-</sup> 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.

TABLE B.1. Minimum Detectable Concentrations (MDC)(a)

Radionuclide	Air		Water		Water (Resin Sampler)		Foodstuff & Wildlife		Soil & Vegetation	
	Minimum Sample Size (m <sup>3</sup> )	MDC (pCi/m <sup>3</sup> )	Minimum Sample Size (liters)	MDC (pCi/l)	Minimum Sample Size (liters)	MDC (pCi/l)	Minimum Sample Size (kg)	MDC (pCi/kg)	Minimum Sample Size (kg)	MDC (pCi/kg)
<sup>3</sup> H	5 m (condensate)	300 pCi/ (condensate)	1	500			0.02	3500		
<sup>89</sup> Sr	1500	0.06	10	0.6			0.5	5		
<sup>90</sup> Sr	1500	0.006	10	0.06			0.5	2	0.5	5
<sup>99</sup> Tc			1	20						
<sup>106</sup> Ru			1	5						
<sup>129</sup> I										
<sup>131</sup> I	1500	0.01	1	4	1000	0.1	4l (milk)	0.5 (pCi/l)		
<sup>226</sup> Ra			10	0.06						
<sup>228</sup> Ra			10	0.06						
U-nat			0.01	0.5					0.5	10
<sup>238</sup> Pu			10	0.01					0.5	0.6
<sup>239,240</sup> Pu			10	0.01					0.5	0.6
Pu-total	1500	0.0001								
Gamma-Emitters	1500	0.1(b)	5	8(b)	1000	0.1(b)	0.5	5(b)	0.5	20 Soil, 30 Veg.
Gross Alpha	800	0.001	1	5						
Gross Beta	800	0.01	1	10						

(a) Contractually established MDCs based on the minimum sample size shown. Lower MDCs are usually obtained in actual practice. <sup>137</sup>Cs minimum detectable concentration. When present individually, other gamma emitting radionuclides will have a MDC commensurate with its photon yield and energy as related to <sup>137</sup>Cs.

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 <sup>90</sup>Sr sample is counted with a low-background beta proportional counter.

The plutonium is eluted from the resin column with 0.4 N HNO<sub>3</sub> - 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. The words 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 ( $\pm$ ) value. This value indicates the 95% confidence range for the primary value (i.e., two times the total standard deviation of the sample distribution), and is derived by taking the square root of the mean square error (MSE). The MSE is calculated by adding the variability between the observed individual sample results (Eq. 2) to the mean sample variability contributed by measurement or counting errors as shown in Equation 4. The relative magnitude of the MSE is indicative of the precision of the combined sample mean. When an average is shown for groups of locations, this value has also been computed from the individual results; and the plus or minus value accompanying it is also twice the square root of its MSE. Where individual samples are reported (e.g., maximum and minimum concentrations) no estimates of sample variability can be made, so only the individual  $2\sigma$  counting error estimates are provided.

The means, variances, standard deviations and error mean square estimates shown in this report were calculated using the following equations.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (1)$$

where  $x$  = arithmetic average, or mean  
 $n$  = number of samples analyzed  
 $x_i$  = individual sample results

$$\sigma^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1} \quad (2)$$

where:  $\sigma^2$  = variance  
 $n$  = number of samples analyzed  
 $x_i$  = individual sample results  
 $x$  = arithmetic mean

$$\sigma = \sqrt{\sigma^2} \quad (3)$$

where:  $\sigma$  = standard deviation  
 $\sigma^2$  = variance

$$MSE = \frac{\sum_{i=1}^n \sigma_i^2(CE) + \sigma^2(\text{samples})}{n} \quad (4)$$

where:

MSE = mean square error

$\sigma_i^2(CE)$  = variance of individual counting error estimates

$\sigma^2(\text{samples})$  = variance between individual results

$n$  = number of samples taken

$$TSD_x = \text{MSE} \quad (5)$$

where

$TSD_x$  = Total standard deviation of a mean ( $x$ )

MSE = Mean square error.

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 because of statistical fluctuations. In fact, an approximately equal number of net positive and negative results is expected when many measurements of a true zero sample are taken. Although negative values do not represent a physical reality, they must be included along with the other values when computing the correct average for the population. For this reason the primary values given in this report are the actual values obtained from individual measurements.

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). Therefore, log-normal probability plots have been freely used throughout the report as analytical tools and graphic presentation

of 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

A number of steps are taken to ensure that the data collected each year are representative of actual concentrations in the environment. First, extensive environmental data are obtained to eliminate an unrealistic reliance on only a few results. Second, newly collected data are continually compared with both recent results and historical data for each location and each environmental medium to ensure that current values are consistent with previous results. Third, samples are collected using well established and documented procedures to ensure consistency in the actual sample collection. Fourth, any effects of Hanford on the surrounding environment are identified by using identical methods both near to and far from the site. These procedures, in conjunction with a program to demonstrate the accuracy of radiochemical analyses, ensure 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 ensure purity of all chemicals. The accuracy of radionuclide determination is ensured 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 food-stuffs) 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 are 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 by the participating laboratories and are used as the reference values in the programs.

In addition to these programs, the laboratory is also subject to receiving unexpected spiked samples according to the present contractual agreements. This provides yet another check on the accuracy and precision of their methods.

#### 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 1980 calculations are shown in Tables D.2 through D.5.

**TABLE D.1. Summary of Laboratory Intercomparison Results for 1980**

Sample Medium	Radionuclide	EML		EPA	
		No. of Analyses	Ave. Ratio UST to EML	No. of Samples	Ave. Ratio UST to EPA
Air	Alpha			3	0.99 ± 0.02
	Beta			3	1.77 ± 0.92
	<sup>7</sup> Be	6	1.03 ± 0.12		
	<sup>54</sup> Mn	4	0.94 ± 0.16		
	<sup>60</sup> Co	6	0.97 ± 0.10		
	<sup>90</sup> Sr	4	1.12 ± 0.11	2	0.96 ± 0.01
	<sup>95</sup> Zr	4	1.09 ± 0.17		
	<sup>125</sup> Sb	4	0.90 ± 0.06		
	<sup>134</sup> Cs	2	1.59 ± 0.07		
	<sup>137</sup> Cs	4	0.97 ± 0.17	3	1.02 ± 0.48
	<sup>144</sup> Ce	6	1.19 ± 0.06		
	U	2	1.12 ± 0.40		
<sup>239</sup> Pu	4	0.87 ± 0.23			
Soil	<sup>40</sup> K	3	0.87 ± 0.09		
	<sup>60</sup> Co	1	0.78 ± 0.26		
	<sup>90</sup> Sr	2	2.53 ± 0.65		
	<sup>137</sup> Cs	3	3.53 ± 1.01		
	<sup>226</sup> Ra	3	0.74 ± 0.12		
	<sup>238</sup> Pu	3	13.24 ± 11.31		
	<sup>239</sup> Pu	3	4.69 ± 1.09		
	<sup>241</sup> Am	1	2.67 ± 1.31		
Vegetation	<sup>40</sup> K	3	1.06 ± 0.09		
	<sup>60</sup> Co	2	1.07 ± 0.07		
	<sup>90</sup> Sr	3	0.85 ± 0.05		
	<sup>226</sup> Ra	1	1.95 ± 0.45		
	<sup>238</sup> Pu	1	2.25 ± 2.46		
	<sup>239</sup> Pu	3	0.65 ± 0.24		
	<sup>241</sup> Am	1	4.00 ± 2.19		
	<sup>137</sup> Cs	3	0.96 ± 0.11		
Tissue	<sup>40</sup> K	2	1.62 ± 0.58		
	<sup>60</sup> Co	2	1.16 ± 0.09		
	<sup>90</sup> Sr	1	0.74 ± 0.01		
	<sup>137</sup> Cs	2	1.19 ± 0.04		
	<sup>239</sup> Pu	2	0.91 ± 0.28		
	<sup>241</sup> Am	1	3.41 ± 2.99		
Milk	<sup>89</sup> Sr			4	0.91 ± 0.21
	<sup>90</sup> Sr			3	0.69 ± 0.34
	<sup>131</sup> I			3	1.28 ± 0.40
	<sup>137</sup> Cs			4	0.98 ± 0.13
Food	<sup>89</sup> Sr			4	1.44 ± 0.45
	<sup>90</sup> Sr			3	1.32 ± 0.28
	<sup>131</sup> I			4	5.66 ± 3.26
	<sup>137</sup> Cs			4	1.06 ± 0.22
Water	Alpha			6	0.89 ± 0.21
	Beta			6	0.90 ± 0.18
	<sup>3</sup> H	4	1.21 ± 0.05	7	1.01 ± 0.16
	<sup>22</sup> Na	2	0.87 ± 0.23		
	<sup>51</sup> Cr	1	1.00 ± 0.13	3	1.20 ± 0.21
	<sup>57</sup> Co	2	1.15 ± 0.21		
	<sup>60</sup> Co	3	0.94 ± 0.19	3	0.94 ± 0.08
	<sup>89</sup> Sr	3	0.88 ± 0.13	3	1.41 ± 0.27
	<sup>90</sup> Sr	1	0.89 ± 0.24	3	0.89 ± 0.11
	<sup>134</sup> Cs	1	1.22 ± 0.05	3	0.93 ± 0.14
	<sup>137</sup> Cs	3	1.03 ± 0.16	3	0.96 ± 0.13
	<sup>131</sup> I			3	0.98 ± 0.09
	<sup>226</sup> Ra			3	0.88 ± 0.65
	<sup>228</sup> Ra			3	1.13 ± 0.42
	U			2	0.96 ± 0.06
<sup>238</sup> Pu	2	1.04 ± 0.36			
<sup>239</sup> Pu	1	0.57 ± 0.09	3	0.73 ± 0.09	

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

Facility name:	100 Area
Releases:	See Table 17
Meteorological conditions:	100-N meteorological tower 1-year data (2-70 through 1-71), annual average, see Table E.1
Dispersion model:	Gaussian, Hanford parameters (ERDA 1975)
X/Q:	Maximum individual $2.7 \times 10^{-9}$ sec/m <sup>3</sup> at 40 km SE-SSE 80-km population $4.1 \times 10^{-4}$ person-sec/m <sup>3</sup>
Release height:	82.3 meters effective (60.96 meters actual stack height)
Population distribution:	236,000, see Figure E.1
Computer code:	DACRIN, Rev. 1.2, 1980
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-yr dose commitment
Files addressed:	Organ data library, Rev. 2-5-81 Radionuclide library, Rev. 1-15-81
Computer code:	FOOD, Rev. 1.0, 1978
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. 1-15-81 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 2-5-81 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	GRONK, Rev. 10-19-79
Calculated dose:	Chronic air submersion, maximum individual and 80-km population, first-year dose.
Files addressed:	GIN, Rev. 8-7-79

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**TABLE D.3. Quality Assurance Data for 100 Area Liquid Release Dose Calculation**

Facility name:	100 Area
Releases:	See Table 17
River flow:	102,000 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. 1.0, 1978
Calculated dose:	Chronic ingestion, direct exposure to water and shoreline, maximum individual and 80-km population, first-year dose and 50-yr dose commitment
Files addressed:	Radionuclide Library, Rev. 1-15-81 Organ Data Library, Rev. 2-5-81 Hanford Specific Bio. Accum. Library External Dose Factor Library, Rev. 3-15-78
Computer code:	FOOD, Rev. 1.0, 1978
Calculated dose:	Chronic ingestion and ground contamination, maximum individual and 80 km population first-year dose and 50-year dose commitment
Files addressed:	Radionuclide Library, Rev. 1-15-81 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 2-5-81 Ground Dose Factor Library, Rev. 3-15-78

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TABLE D.4. Quality Assurance 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 (ERDA 1975)
X/Q:	Maximum individual $4.0 \times 10^{-9}$ sec/m <sup>3</sup> at 37 km SE 80-km population $3.7 \times 10^{-4}$ person sec/m <sup>3</sup>
Release height:	89.2 meters effective (60.96 meters actual stack height)
Population distribution:	258,000, See Figure E.2
Computer code:	DACRIN, Rev. 1.2, 1980
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Organ Data Library, Rev. 2-581 Radionuclide Library, Rev. 1-15-81
Computer code:	FOOD, Rev. 1.0, 1978
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. 1-15-81 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 2-5-81 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	GRONK, Rev. 10-19-79
Calculated dose:	Chronic air submersion, maximum individual and 80-km population, first-year dose
Files addressed:	GIN, Rev. 8-7-79

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

Facility name:	300 Area
Releases:	See Table 17
Meteorology conditions:	Washington Public Power Supply System 2-year data (4-74 through 3-76, annual average, see Table E.3)
Dispersion model:	Gaussian, Pasquill parameters
X/Q:	Maximum individual $2.0 \times 10^{-6}$ sec/m <sup>3</sup> at 1.6 km E 80-km population $5.7 \times 10^{-3}$ person-sec/m <sup>3</sup>
Release height:	Ground level
Population distribution:	171,000, see Figure E.3
Computer code:	DACRIN, Rev. 1.2, 1980
Calculated dose:	Chronic inhalation, maximum individual and 80-km population, first-year dose and 50-year dose commitment
Files addressed:	Organ Data Library, Rev. 2-5-81 Radionuclide Library, Rev. 1-8-81
Computer code:	FOOD, Rev. 1.0, 1978
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. 1-15-81 Food Transfer Library, Rev. 2-27-78 Organ Data Library, Rev. 2-5-81 Ground Dose Factor Library, Rev. 3-15-78
Computer code:	GRONK, Rev. 10-19-79
Calculated dose:	Chronic air submersion, maximum individual and 80-km population, first-year dose
Files addressed:	GIN, Rev. 8-7-79

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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 surveillance data indicated the presence of a radionuclide in a pathway to man, and the radionuclide was not attributed to either naturally occurring radioactivity or world-wide fallout, an estimate of the potential dose was calculated using dose factors in the standard Hanford computer code, ARRRG (Napier, et al 1980). Assumptions of the intake or exposure period were stated in the text.
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 was 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.

#### AIRBORNE EFFLUENTS

Impacts were calculated separately 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 1980 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).

#### 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.

#### 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 average atmospheric dispersion data developed from meteorological data collected by the Washington Public Power Supply System<sup>(a)</sup> for the WNP-2 reactor were used. These data are shown in Table E.3.

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(a) We wish to thank Washington Public Power Supply System for permission to use their meteorological data.

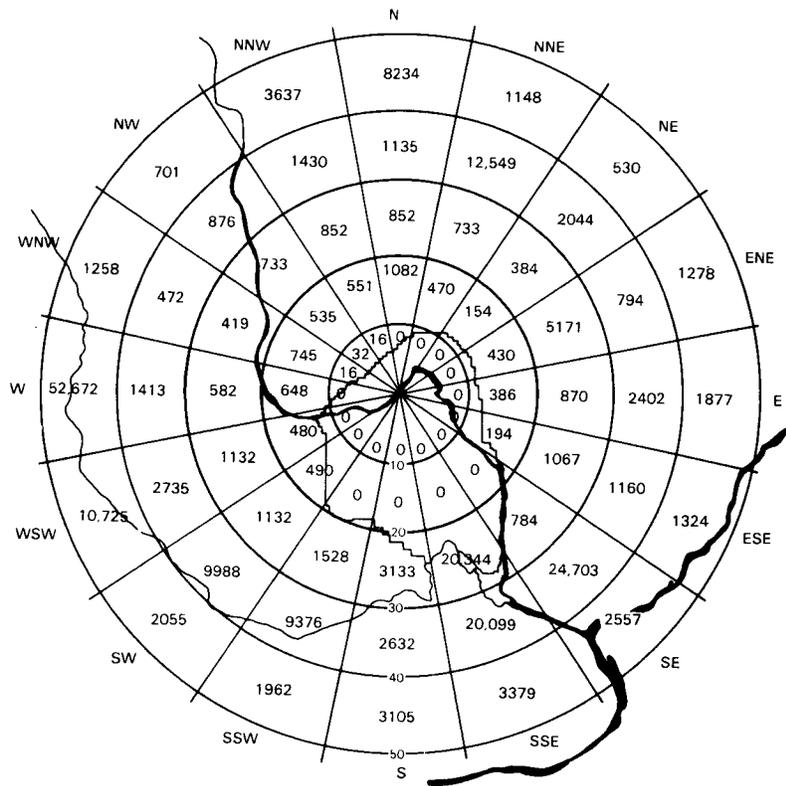


FIGURE E.1. Estimated Geographic Distribution of the Population (236,000) Within a 50-Mile (80-km) Radius of the 100-N Area

TABLE E.1. Annual Average Atmospheric Dispersion Around the 100-N Area For an 82-m Release Height (units are  $\text{sec}/\text{m}^3$ ) (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.

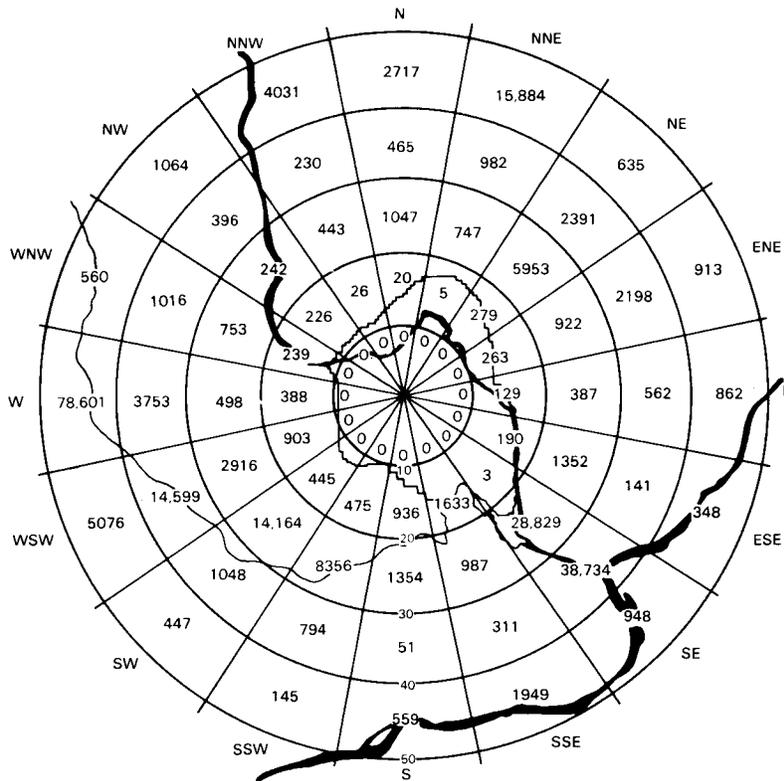


FIGURE E.2. Estimated Geographic Distribution of the Population (258,000) Within a 50-Mile (80-km) Radius of the Hanford Meteorological Station

TABLE E.2. Annual Average Atmospheric Dispersion Around the 200 Areas for an 89-m Release Height (Units are  $\text{sec}/\text{m}^3$ ) (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-08	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-08	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.

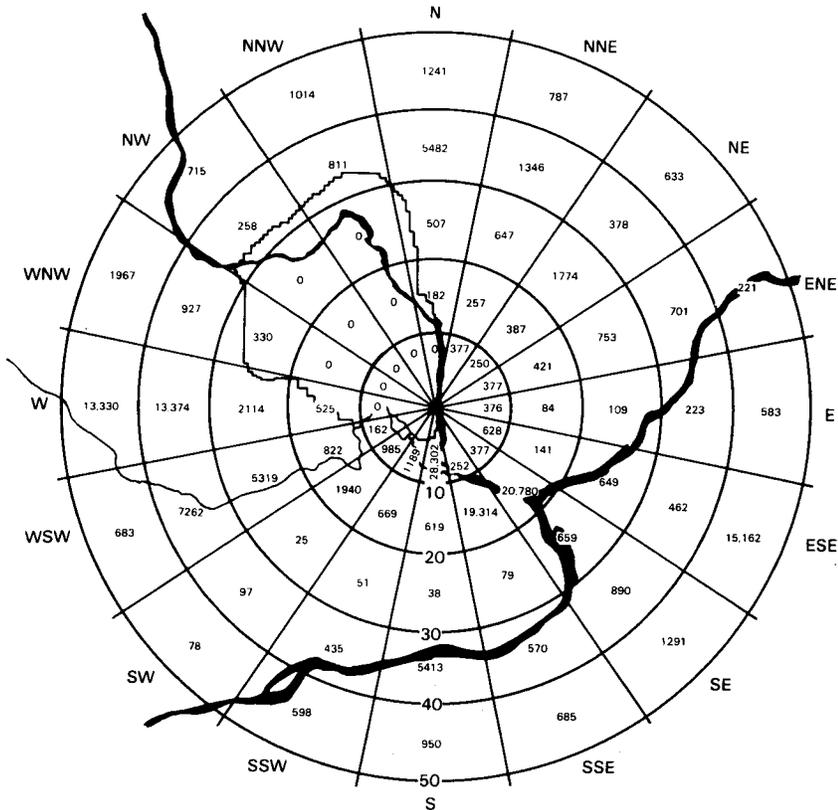


FIGURE E.3. Estimated Geographic Distribution of the Population (171,000) Within a 50-Mile (80-km) Radius of the 300 Areas

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

Doses were then calculated for exposure via the following sources:

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

#### LIQUID EFFLUENTS

The 1980 releases, shown in Table 17 in the text, were assumed to be mixed with the total annual flow of the Columbia River. For 1980, the United States Geological Survey reported that the mean annual flow rate was 102,000 ft<sup>3</sup> per second.

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

- drinking potable water obtained from the river

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

#### DIETARY ASSUMPTIONS

All calculations were made according to models described in PNL-3180 and BNWL-389. 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. Holdup and Consumption

<u>Pathway</u>	<u>(a)</u>		<u>(b)</u>	
	<u>Holdup (days)</u>		<u>Consumption (kg/yr)</u>	
	<u>Maximum Individual</u>	<u>Population</u>	<u>Maximum Individual</u>	<u>Population</u>
Foodstuffs				
Leafy Vegetables	1	30	15	14
Above Ground 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 $\ell$ /yr	230 $\ell$ /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 <sup>3</sup> /yr <sup>(c)</sup>	7300 m <sup>3</sup> /yr	0

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

(b) Consumption in (kg/yr except as otherwise noted).

(c) Breathing rate for infant assumed to be 1400 m<sup>3</sup>/yr (based on NRC Regulatory Guide 1.109).

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

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

- (a) Holdup is the decay time between harvest and consumption or between effluent release and exposure.
- (b) Drinking water pathway population assumed to be 50,000. River recreation involves 125,000 members of the 80-km population.
- (c) 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.
- (d) For calculation of dose to an infant, a consumption rate of 330  $\mu$ /hr was used (based on NRC Regulatory Guide 1.109).
- (e) A 13-hr holdup time was assumed for the population dose calculations.

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