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**Environmental Surveillance  
at Hanford for CY-1975**

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**June 1976**

**Prepared for the Energy Research  
and Development Administration  
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From Dwayne R. Speer 

Subject Environmental Surveillance at Hanford  
For CY-1975, BNWL-1979 Revision

It has come to our attention that some errors were made in the subject publication. Tables 24 and 25 are affected by these errors and the corrected versions of both are attached. Please insert them as pages 46 and 47 in your copy. These changes do not affect the text or any conclusions drawn as to the environmental acceptability of Hanford operations.

DRS:mg  
Attachments

ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1975

Dwayne R. Speer  
Jack J. Fix  
Peggy J. Blumer  
Occupational and Environmental Safety Department

June 1976

BATTELLE  
PACIFIC NORTHWEST LABORATORIES  
RICHLAND, WASHINGTON 99352

## FOREWORD

The Environmental Surveillance Program at Hanford is conducted by Battelle, Pacific Northwest Laboratory (also referred to as Battelle-Northwest or BNW) and Hanford Environmental Health Foundation (HEHF) under contract to the Energy Research and Development Administration (ERDA). Efforts by BNW are designed, primarily, to measure the levels of radiation in the environs of Hanford and to determine the respective components of these levels whether of natural causes, nuclear testing fallout, or Hanford operations. Other environmental data are collected on the chemical and biological quality of river water. HEHF collects data on air quality in the Hanford environs and on the chemical and biological quality of sanitary water. When appropriate, the data are compared with applicable standards for air and water quality set forth by the Energy Research and Development Administration, Environmental Protection Agency (EPA), U. S. Public Health Service and Washington State. Interpretation and summaries of the data are presented annually; the present document is for calendar year 1975.

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## ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY1975

Dwayne R. Speer  
Jack J. Fix  
Peggy J. Blumer

The Hanford plant was originally designed, built, and operated to produce plutonium for nuclear weapons. At one time, nine production reactors, eight with once-through cooling, were in operation. Between December 1964 and January 1971, all eight reactors with once-through cooling were deactivated. N Reactor, the remaining production reactor in operation, has a closed primary cooling loop. Steam from N Reactor operation is used to drive turbine generators generating up to 860 million watts of electrical power in the Washington Public Power Supply System's Hanford Generating Plant. By the end of 1975, N Reactor had supplied steam to produce 32 billion kilowatt hours of electrical energy which was fed to the Bonneville Power Administration grid covering the Pacific Northwest.

During 1975, the work at Hanford included N Reactor operation, nuclear fuel fabrication, liquid waste solidification, continued construction of the Fast Flux Test Facility, continued construction of Washington Public Power Supply System (WPPSS) No. 2 power reactor, Arid Lands Ecology studies, as well as continued use of a variety of research and laboratory facilities. Privately owned facilities are located within the Hanford site boundaries including the WPPSS generating station adjacent to N Reactor, WPPSS power reactor site and office buildings, and a radioactive waste burial site. The Exxon fuel fabrication facility is located immediately adjacent to the southern boundary of the Hanford site.

The Hanford site is located in a semi-arid region of southeastern Washington State (Figure 1), occupying an area of about 1500 square kilometers (560 square miles). The site lies about 320 kilometers (200 miles) east of Portland, Oregon, 270 kilometers (170 miles) southeast of Seattle, Washington, and 200 kilometers (125 miles) southwest of Spokane, Washington. The Columbia River flows through the northern edge of the Hanford site and forms part of the eastern boundary. Figure 2 shows the location of

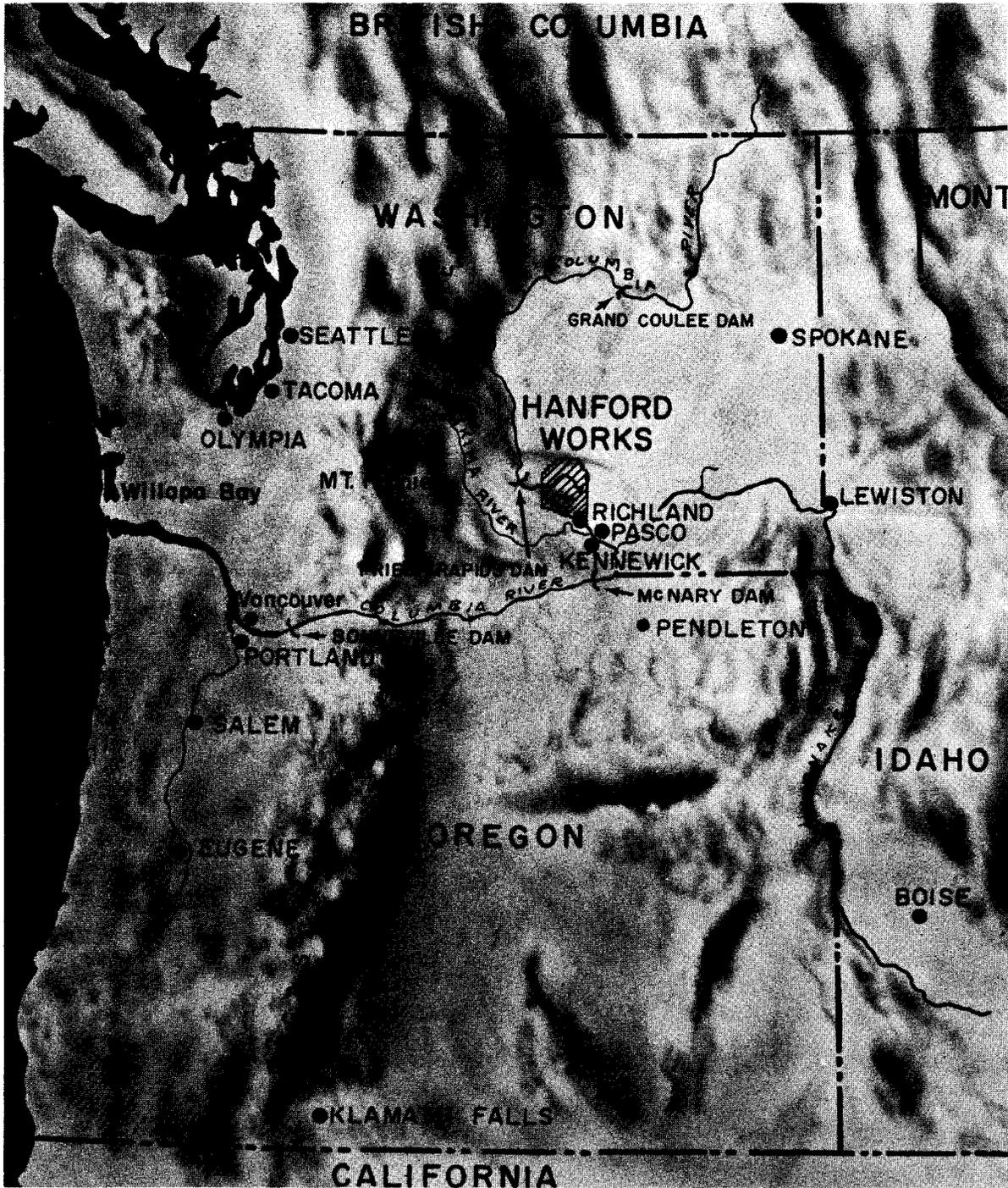


FIGURE 1. Geographical Location of Hanford and Surrounding Areas

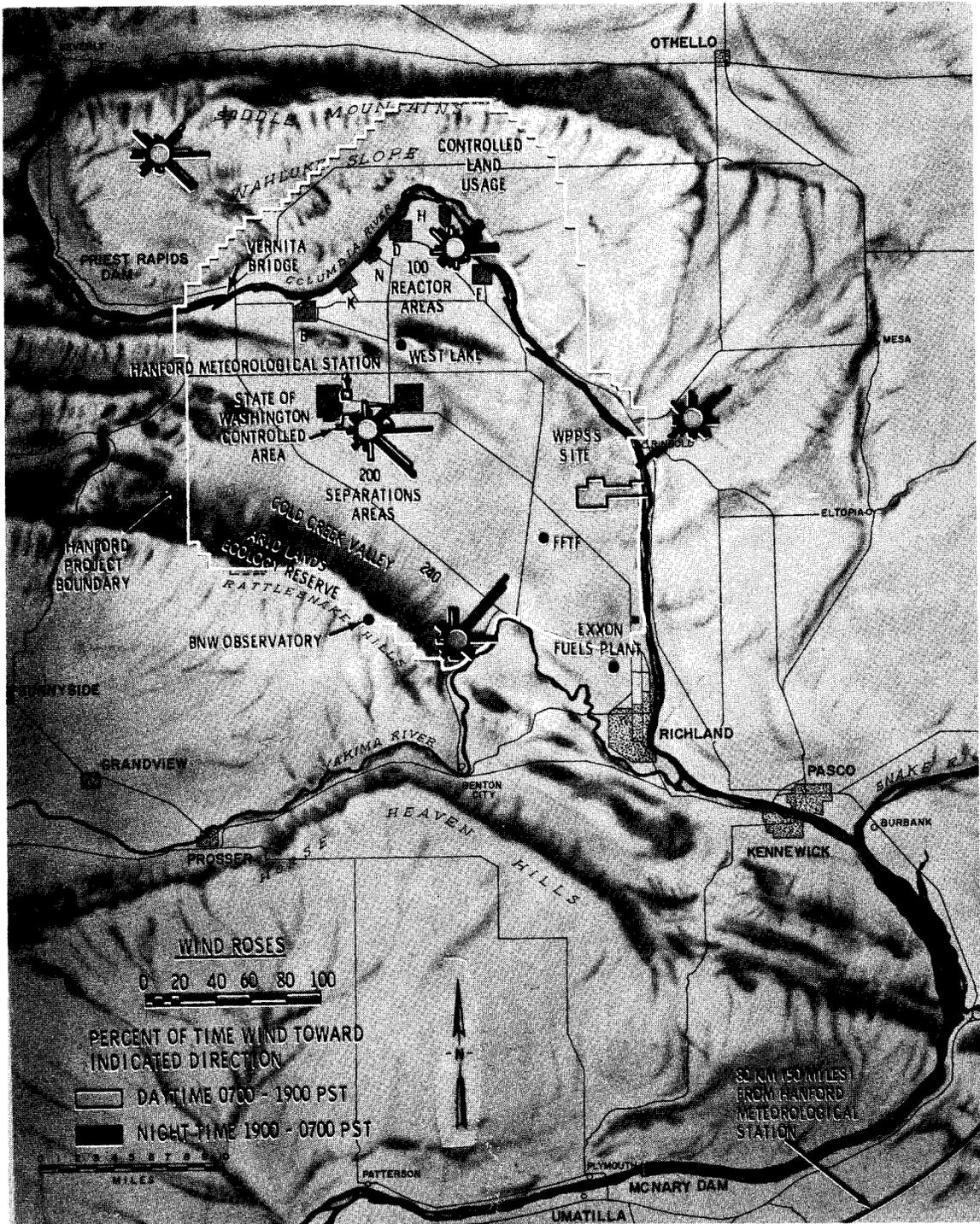


FIGURE 2. Features of Hanford Site and Vicinity

reactor facilities along the Columbia River in what are known as the 100 Areas. The reactor fuel processing and waste management facilities are on a plateau about 7 miles from the river in the 200 Areas. The 300 Area, just north of Richland, contains the reactor fuel manufacturing facilities and research and development laboratories.

The desert plain on which Hanford is located has a sparse covering of vegetation primarily suited for grazing, although extensive areas near the site have gradually been put under irrigation during the past several years. The most broadly distributed vegetation type on the site is the sagebrush/cheatgrass/bluegrass community. Mule deer is the only big game mammal found; the cottontail rabbit is the most abundant small game animal. The raccoon is probably 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.

The Hanford climate is mild and dry, receiving approximately 16 cm (6.3 in.) of precipitation annually. The months of November, December, and January contribute about 40% of the total precipitation, whereas July, August, and September contribute only 10%. 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 during the months of December through February is in the form of 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. As indicated by the wind roses shown in Figure 2, 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 occurring at night but breaking during the day causing unstable and turbulent conditions.

The nearest population center to the Hanford site is the Tri-Cities area (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream of the site. These communities with a combined population of approximately 80,000 utilize the Columbia River as a source of drinking water. Approximately 250,000 people reside within a 80 kilometer (50-mile) radius of the Hanford Meteorological Station (HMS) located in the 200 Area

of the Hanford site (Figure 1). This population is composed of the Yakima area, Tri-Cities, several small communities, and the surrounding agricultural community. The economy of the area, with the exception of Hanford related industries, is primarily agricultural. Primary crops include alfalfa, hay, wheat, sugar beets, and potatoes. Several fruit orchards are located within a short distance of the Hanford site. The Columbia River is extensively used for recreational purposes including fishing.

The principal operating contractors at Hanford are:

- Atlantic Richfield Hanford Company (ARHCO)--Responsible for fuel processing, waste management, and all site general support services such as plant security, fire protection, central stores, electrical power distribution, etc.
- Battelle-Northwest (BNW)--Responsible for the operation of the Pacific Northwest Laboratories of Battelle Memorial Institute which includes research in general areas of life sciences, environmental science, environmental surveillance, advanced methods of nuclear waste management, and a wide variety of other physical and biological sciences.
- United Nuclear Industries (UNI)--Responsible for operation of N Reactor and for N Reactor fuel fabrication.
- Westinghouse Hanford Company (WHC)--Responsible for the operation of the Hanford Engineering Development Laboratory (HEDL) which includes advanced reactor developments, principally the Liquid Metal Fast Breeder Program and the Fast Flux Test Reactor (FFTF).

The Hanford Environmental Surveillance Program is conducted by BNW and Hanford Environmental Health Foundation (HEHF) under contract to the Energy Research and Development Administration (ERDA). The program is designed, primarily, to measure the levels of radiation in the Hanford environs and to determine the respective components of the levels whether of natural causes, worldwide fallout, or Hanford operations. Other environmental data are collected on nonradioactive pollutants in air in the Hanford area and on chemical and biological quality of Columbia River and sanitary

water. The data are reported and evaluated in a series of annual reports; the present report evaluates data collected during 1975. Detailed analytical data are published in a separate report (BNWL-1980).

For each set of data where each individual analysis yielded a positive value, an annual average plus or minus two sample standard deviations (95% confidence interval) was calculated. Many sets of data contain individual analyses which were less than the detection limit. In such cases, a less-than annual average was calculated from the data assuming that each less-than value was equal to the detection limit. This method maximizes the annual average. Any identifiable contribution to the observed concentrations of radioactivity in air or water attributable to Hanford operations was compared to ERDA Manual Chapter 0524 regulations.<sup>1</sup> Observed concentrations of nonradioactive pollutants were compared to applicable standards promulgated by the State of Washington<sup>2</sup> or the Environmental Protection Agency.<sup>3</sup>

## SUMMARY

Environmental data collected during 1975 showed continued compliance of Hanford operations with all applicable State and Federal regulations. Levels of radioactivity in the atmosphere from Hanford operations at all offsite sampling locations were indistinguishable from levels due to natural causes and worldwide fallout from the atmosphere. Air quality measurements of NO<sub>2</sub> in the Hanford environs recorded a maximum yearly average concentration of 0.004 ppm or 8% of the ambient air standard. There was no indication that Hanford operations contributed significantly to these levels. All SO<sub>2</sub> results were less than the detection limit of 0.005 ppm or 25% of the ambient air quality standard.

Routine radiological, chemical, biological, and physical analyses of Columbia River water upstream and downstream of the Hanford Reservation did not show any identifiable effect due to Hanford operations with the possible exception of water temperature. Levels of radioactivity were similar at both locations and were indistinguishable from natural and fallout radioactivity. The data indicate an increase of coliform organisms, enterococci, and BOD for the downstream location. These increases are believed to be the result of drainage from farm activities and wildlife. The Hanford stretch of the river serves as a refuge for large populations of waterfowl. Nitrates, pH, turbidity and dissolved oxygen measurements were similar at both locations. The temperature of the Columbia River between the upstream measurement station and the downstream station increases as a result of solar insolation and operations at Hanford. This part of the Columbia River is the last remaining stretch of free flowing Columbia River water in the United States and the amount of solar insolation can raise or lower the temperature of the river water significantly. The maximum temperature of the river water reached 20°C (67°F) during a few days during September. The annual average temperature and 95% confidence interval for Priest Rapids Dam and Richland during 1975 were 10.7±11.7°C and 11.1±11.7°C, respectively, based on 365 daily measurements.

Beginning in October, 1975, water samples were collected at Priest Rapids, upstream of the Hanford site, and analyzed using a filter-resin system.<sup>5</sup>

This upstream sampler is used to provide background information for comparison to data obtained from a similar unit located at the 300 Area. The filter-resin system, described in Appendix A, has a much lower analytical detection limit than previously used methods and is used to determine the portion of radioactivity which is particulate in nature (suspended sediments) and that which is in solution. This information is especially useful in that most particulate matter is removed by sanitary water systems. The data collected in 1975 showed measurable levels of radioactivity in the river due to past operations of once-through cooling reactors and the continued operation of N reactor. The levels measured were all less than 0.2% of ERDAM 0524 drinking water standards for all radionuclides due to Hanford operations.

The majority of radioactivity measured in foodstuffs during 1975 was the result of naturally occurring  $^{40}\text{K}$  and the fallout related radionuclides  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ . Other radionuclides detected occasionally are also attributed to worldwide fallout. Cobalt-60 was measured in four of nine whitefish collected and is attributed to past once-through cooling production reactor operation. Soil samples collected in the Hanford environs did not show any identifiable contribution from Hanford operations with the exception of samples collected on the Columbia River islands, shoreline and slough areas. A few of these samples showed elevated levels of several radionuclides due to deposition on the islands of suspended sediment during periods of high water while the once-through cooling production reactors were in operation. Radioactivity from past once-through cooling production reactor operations was associated with the sediment.

External radiation levels in the Hanford environs were measured during 1975 by thermoluminescent dosimeters (TLDs) deployed at 17 different locations, TLDs immersed in the Columbia River at 4 locations, and several portable instrument surveys. The data collected during 1975 indicate that the average dose and 95% confidence interval received from background radiation in the Hanford environs is approximately  $72 \pm 18$  mrem/year. Adding the approximate 25 mrem received annually due primarily to internal dose from  $^{40}\text{K}$  yields an estimate of approximately  $103 \pm 18$  mrem/year due to all background sources. For convenience, the total background dose is assumed to be approximately 100 mrem/year.

The radiological impact of Hanford operations during 1975 has been estimated for three parameters: 1) the maximum "fence-post" exposure rate, 2) the maximum dose to an individual received during 1975 and the 50-year dose commitment due to 1975 effluent, and 3) the population dose received during 1975 and the 50-year dose commitment by the approximate 250,000 people residing within an 80-kilometer radius of the Hanford Reservation. The contribution of observed radioactivity in wildlife, oysters, suspended sediment in the Columbia River, and on the islands from past once-through cooling production reactor operations to these parameters was also evaluated. The estimated values for these parameters are:

- The maximum "fence-post" exposure rate during 1975 occurred on the Columbia River islands. The maximum observed exposure rate was 0.014 mR/hr in addition to the approximate 0.010 mR/hr due to external background radiation. The source of the radiation was previous deposition of radioactivity attached to sediments on the islands during periods of high water flow. The radioactivity is due to past once-through cooling production reactor operation.
- The maximum total-body dose to an individual during 1975 and the 50-year dose commitment to this individual from effluent released during 1975 were 0.023 mrem and 0.033 mrem, respectively. The contribution to this individual from external exposure on the islands would depend on the length of time spent on the islands and where the time was spent. Assuming the individual was at the point of maximum observed exposure, an additional dose of approximately 0.014 mrem would have been received for each hour spent at this point. It is unlikely that anyone would spend more than a few hours each year on the islands.
- The total body dose to the population received during 1975 and the 50-year dose commitment received from effluents released during 1975 were estimated to be 0.9 and 1.5 man-rem, respectively. The contribution to the population dose from the observed radioactivity is numerically insignificant.

For comparison, all members of the population receive approximately 100 mrem/year from natural background radiation. The resulting total body population dose to the 250,000 people is approximately 25,000 man-rem.

## ENVIRONMENTAL SAMPLE COLLECTION, ANALYSIS, AND EVALUATION

### GENERAL

Environmental surveillance at Hanford has been conducted throughout the nearly three decades of Hanford operations. Extensive radiological data collected during this time provide a historical record of environmental radioactivity due to Hanford operations, worldwide nuclear fallout, and natural causes. Levels of radioactivity in Columbia River water, sediments, and biota have been studied extensively to estimate the effect of past once-through cooling production reactor operations. Nonradioactive pollutants in air and water have been measured during the past several years.

Monitoring activities during 1975 continued to measure the levels of pollutants, primarily radiological, in all significant environmental media. Environmental air sampling stations were operated at several locations in the vicinity of Hanford for the purpose of measuring radioactive and non-radioactive pollutants. Routine measurements were made of the chemical, biological, physical, and radiological quality of Columbia River water. Levels of radioactivity in Columbia River fish, local wildlife, and locally grown foodstuffs were routinely measured. Oysters from Willapa Bay were analyzed for  $^{65}\text{Zn}$ . External radiation levels were measured with environmental dosimeters, portable survey instruments, and an aerial survey.

In evaluating radiological data collected during 1975, the general philosophy was to compare radiation levels measured at locations potentially affected by Hanford operations with radiation levels measured at locations expected to reflect only radioactivity due to natural causes or worldwide nuclear fallout. Extensive data were collected for most environmental media to provide reliable estimates of the observed radioactivity which, in many cases, were near the detection limit of the analyses rather than unrealistic reliance on a few measurements.

A discussion of each major routine environmental sampling program follows. The location of each sampling station, the number of samples collected in 1975, and a summary and interpretation of the data are presented, for each program.

## AIR

Air sampling responsibilities for the Hanford environs are divided between BNW and HEHF. BNW is responsible for measuring the radiological parameters while HEHF is responsible for nonradiological parameters.

### Radiological Evaluation

Radioactivity in the atmosphere was sampled by a network of 17 perimeter and 5 distant continuous air samplers during 1975 (Figure 3). Each air sampler maintains a flow of 2.5 m<sup>3</sup>/hr through a particle filter (Hollingsworth & Vose Company, HV-70) and a 15-cm long, 5-cm diameter charcoal cartridge. The system is expected to collect approximately 85% of the radioactivity associated with airborne dust and both organic and elemental forms of radioiodine. The system does not collect noble gases. The filters were collected biweekly and analyzed for gross beta and alpha activity after

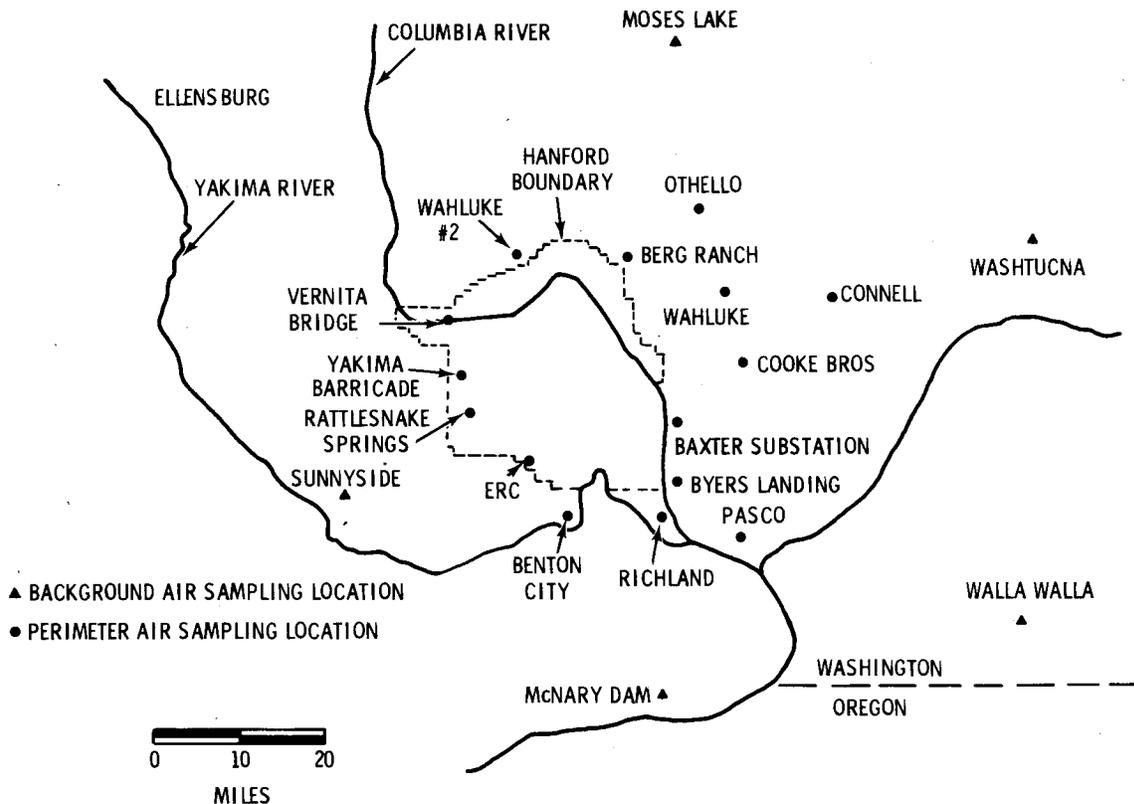


FIGURE 3. Hanford Environmental Air Sampling Locations During 1975

waiting 7 days to allow the short-lived radon and thoron daughters to decay. The filters were composited into groups according to geographical location and analyzed monthly by gamma spectrometry and quarterly for  $^{90}\text{Sr}$  and plutonium.

Tritiated water vapor was collected at three sampling stations (Berg Ranch, Baxter Substation, and Richland) by drawing air through a 25-cm long by 5-cm diameter cartridge of silica gel at the rate of  $0.68 \text{ m}^3/24 \text{ hrs}$ . The activity collected in this fashion was used to evaluate trends in air quality. There was no significant observable differences in values observed at the different stations due primarily to the variability of water vapor collection and measured tritium levels. The results of this sampling program are presented in Table 1.

The results of gross beta, gross alpha, and  $^{131}\text{I}$  analyses for perimeter and distant sampling locations are shown in Table 2. The distant stations are sufficiently remote from Hanford operations to insure that observed levels of radiation were due to natural causes or fallout. During 1975, airborne beta concentrations followed an atypical pattern, with the maximum concentrations occurring in the late winter and early spring

TABLE 1. Tritiated Water Vapor in the Air in 1975

Location	No. of Samples	Tritium Concentration <sup>(a)</sup> ( $\mu\text{Ci/ml}$ )			Volume of Water Collected <sup>(b)</sup> (ml)		
		Max.	Min.	Average <sup>(c)</sup>	Max.	Min.	Average <sup>(c)</sup>
Berg Ranch	25	$3.0 \times 10^5$	*	$<1.6 \times 10^3$	32	5	$16.8 \pm 13.3$
Baxter Substation	23	$5.1 \times 10^4$	*	$<1.1 \times 10^3$	22	2	$13.5 \pm 10.8$
Richland	24	$4.1 \times 10^4$	*	$<6.5 \times 10^2$	38	4	$13.0 \pm 16.4$
		Average <sup>(c)</sup>		$<1.1 \times 10^3$			$14.4 \pm 4.1$

\* Less than detectable. The minimum detectable activity is  $370 \mu\text{Ci/ml}$ .

(a) The tritium concentration in water vapor collected is used as a trend indicator only.

(b) The volume of water vapor collected is a function of the volume of air sampled, the relative humidity, and the air temperature.

(c) Average plus or minus two standard deviations when all analyses were positive; otherwise a less than number is reported using all results including less than values.

TABLE 2. Radioactivity in Air - 1975

		Concentration ( $10^{-12}$ $\mu\text{Ci/ml}$ ) <sup>a</sup>										
		Gross Beta			Gross Alpha <sup>(b)</sup>			Iodine-131				
Analytical Limit		0.02			0.0004			0.07				
Concentration Guide <sup>(c)</sup>		100.			0.03			100.				
Location	No. of Samples	Max.	Min.	Average	No. of Samples	Max.	Min.	Average	No. of Samples	Max.	Min.	Avg.
<b>Perimeter Stations</b>												
Baxter Substation	22	0.16	*	<0.09					26	*	*	*
Benton City	26	0.20	0.02	0.10±0.12	26	0.002	*	<0.001	26	*	*	*
Berg Ranch	26	0.28	0.02	0.10±0.15	26	0.002	*	<0.001				
Byers Landing	25	0.22	0.03	0.10±0.12	25	0.003	*	<0.001	26	*	*	*
Connell	26	0.21	0.02	0.10±0.12								
Cooke Bros.	29	0.21	*	<0.09								
ERC	25	0.23	0.02	0.09±0.12								
Othello	28	0.22	0.03	0.10±0.13								
Pasco	25	0.21	0.02	0.10±0.13								
Rattlesnake Springs	24	0.21	0.02	0.09±0.11								
Richland	25	0.25	0.03	0.09±0.12	25	0.002	*	<0.001	26	*	*	*
Vernita Bridge	26	0.21	0.02	0.10±0.12								
Wahluke	28	0.23	0.02	0.09±0.11								
Wahluke #2	25	0.26	0.02	0.10±0.12								
Yakima Barricade	24	0.22	0.03	0.11±0.13								
RRC CP#63	14	0.08	0.03	0.05±0.04								
RRC CP#64	14	0.09	0.02	0.04±0.04								
				<0.09				<0.001				
<b>Distant Stations</b>												
McNary Dam	26	0.20	0.02	0.09±0.13	25	0.002	0.0005	0.001±0.001				
Moses Lake	26	0.23	0.02	0.10±0.14								
Sunnyside	23	0.20	0.03	0.10±0.12								
Walla Walla	23	0.22	0.03	0.10±0.13	22	0.002	0.0005	0.001±0.001				
Washtucna	19	0.20	0.03	0.08±0.12								
				0.094±0.018 <sup>(d)</sup>				0.001±0.001				

No entry indicates no analysis.

\* Less than detectable.

(a)  $1 \text{ pCi/m}^3 = 10^{-12} \text{ } \mu\text{Ci/ml}$ . Average  $\pm 2$  sample standard deviations shown if all analyses had positive results. Otherwise, a less than number is calculated from all results, including less than values.

(b) Gross alpha activity does not include any significant contribution due to naturally occurring radon and short-lived daughters in the air. The filters are held 7 days before analysis to allow radioactive decay of these radionuclides.

(c) ERDA 0524 standards only apply to concentrations of radioactivity in excess of that due to naturally occurring or fallout radioactivity.

(d) Average  $\pm 2$  Sample Standard Deviations.

and decreasing during the remainder of the year. Figure 4 illustrates the annual cyclic pattern observed from 1971 through 1975. The eastern quadrant stations called out in Figure 4 are in a predominately downwind direction from Hanford. The average beta concentration during 1975 observed at all perimeter stations was not significantly different than that observed at all distant stations. The average beta concentration for 1975 was  $9 \times 10^{-14} \text{ } \mu\text{Ci/ml}$  as compared to the 1974 average of  $17 \times 10^{-14} \text{ } \mu\text{Ci/ml}$ . The highest observed 1975 gross beta concentration,  $2.8 \times 10^{-13} \text{ } \mu\text{Ci/ml}$ , occurred at Berg Ranch on February 12.

The highest observed gross alpha concentration during 1975 occurred at Byers Landing ( $3 \times 10^{-15} \text{ } \mu\text{Ci/ml}$ ) on February 26, 1975. Analyses for gross alpha concentrations in the atmosphere lack the sensitivity required to

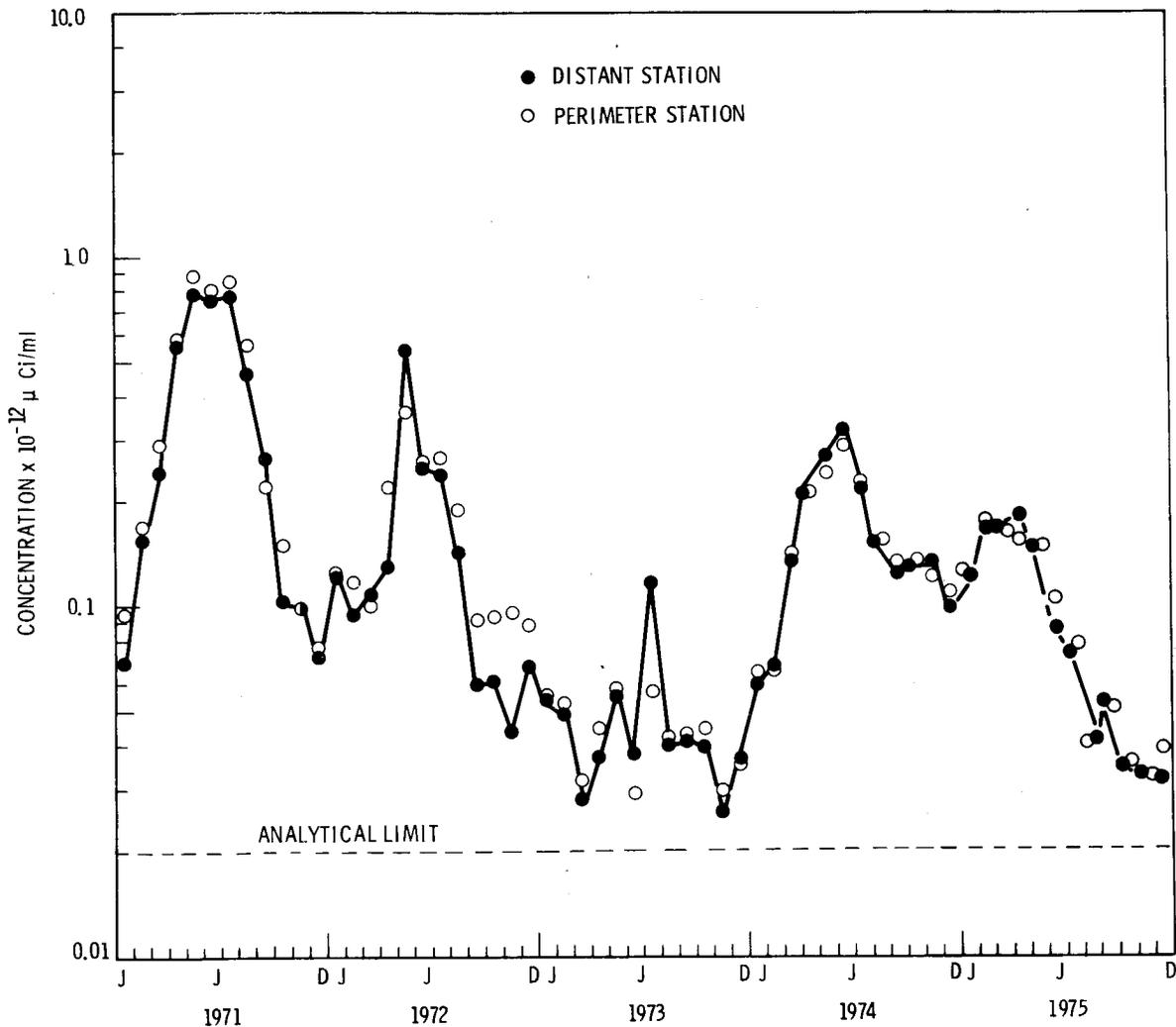


FIGURE 4. Monthly Average Gross Beta Activity in the Atmosphere

detect potential contributions from routine Hanford operations and, as such, were obtained at only a few locations in order to detect any unusual increases due to natural or fallout radioactivity. The annual average concentration of gross alpha radioactivity was about  $1 \times 10^{-15}$   $\mu\text{Ci}/\text{m}^3$  at all locations as compared to  $2 \times 10^{-15}$   $\mu\text{Ci}/\text{m}^3$  in 1974.

Analysis for  $^{131}\text{I}$  concentrations in the atmosphere were performed on a bi-weekly interval for 4 of the 17 perimeter sampling stations during 1975. Charcoal cartridges were located at all perimeter and distant sampling stations, thus providing available samples for analysis if the presence of

iodine in the atmosphere had been indicated. The charcoal for these stations was changed monthly. All  $^{131}\text{I}$  analyses during 1975 were less than the detection limit of  $0.07 \times 10^{-12}$   $\mu\text{Ci/ml}$ , or less than 0.07% of the ERDA Manual Chapter 0524 standard of  $1 \times 10^{-10}$   $\mu\text{Ci/ml}$  for uncontrolled areas.<sup>1</sup>

Results of specific radionuclide analyses are shown in Table 3. Beryllium-7 is a naturally occurring radionuclide formed by the interaction of cosmic rays with nitrogen in the upper atmosphere. The other radionuclides are fission or activation products and result from either fallout, Hanford operations, or other nuclear facilities. The data show that all radionuclides, except for  $^{65}\text{Zn}$ , were observed in both perimeter and distant composite groups at approximately the same concentration. Zinc-65 was detected only once during the year and then at a concentration very near the analytical detection limit. Sunnyside, the point of detection, is quite distant from and lies in a predominately upwind direction of the Hanford plant. The reported value of  $2.3 \times 10^{-14}$   $\mu\text{Ci/ml}$  is attributed to the expected analytical variability associated with environmental samples.

In summary, radioactivity observed at the perimeter environmental air sampling stations was indistinguishable from radioactivity observed at distant or background environmental air sampling stations. The radioactivity was attributed either to natural causes or to fallout from past nuclear device testing in the atmosphere.

#### Nonradiological Evaluation

HEHF, under contract to ERDA, is responsible for monitoring the non-radiological quality of the atmosphere in the Hanford environs. Monitoring activities during 1975 included 24-hour sequential sampling for  $\text{NO}_2$  and  $\text{SO}_2$  at three locations across the Columbia River from Richland, North Richland, and Hanford 300 Area operations. The three stations along the river were located in the southeasterly or downwind direction from Hanford operations. Table 4 summarizes the  $\text{NO}_2$  data collected during 1975. The highest yearly average concentration of  $\text{NO}_2$  measured was 0.004 ppm, or 8% of the ambient air standard of 0.05 ppm. All  $\text{SO}_2$  results were less than the detection limit of 0.005 ppm, or 25% of the ambient air standard of 0.02 ppm.

TABLE 3. Concentration of Specific Radionuclides in Air - 1975

Radionuclide	Concentration ( $10^{-12}$ $\mu\text{Ci}/\text{ml}$ ) <sup>a</sup>		Annual Average	Radionuclide	Concentration ( $10^{-12}$ $\mu\text{Ci}/\text{ml}$ ) <sup>a</sup>		Annual Average	Radionuclide	Concentration ( $10^{-12}$ $\mu\text{Ci}/\text{ml}$ ) <sup>a</sup>		Annual Average	ERDA 0524 Standard	Detection Limit	
	Maximum Observed	Minimum Observed			Maximum Observed	Minimum Observed			Maximum Observed	Minimum Observed				
Inner Southeast Quadrant														
Be-7	0.09	*	<0.03	Be-7	0.089	*	<0.03	Be-7	0.089	*	<0.03	40,000	0.03	
Mn-54	0.004	*	<0.003	Sr-90	0.002	0.0008	( $1.5 \pm 1.3$ ) $\times 10^{-3}$	Mn-54	0.002	0.0008	( $1.5 \pm 1.3$ ) $\times 10^{-3}$	1,000	0.002	
Co-60	0.086	*	<0.007	Zr-Nb-95	0.032	*	<0.012	Sr-90	0.032	*	<0.012	300	0.003	
Sr-90	0.002	*	<0.0007	Ru-106	0.22	*	<0.13	Zr-Nb-95	0.22	*	<0.13	2,000	0.006	
Zr-Nb-95	0.043	*	<0.013	Ce-Pr-144	0.03	*	<0.005	Ru-106	0.03	*	<0.005	30	0.0002	
Ru-106	0.18	*	<0.1	Total Pu	$4 \times 10^{-5}$	$6 \times 10^{-6}$	( $2 \pm 3$ ) $\times 10^{-5}$	Ce-Pr-144	$4 \times 10^{-5}$	$6 \times 10^{-6}$	( $2 \pm 3$ ) $\times 10^{-5}$	3,000	0.002	
Cs-137	0.007	*	<0.001					Cs-137	0.007	*	<0.001	200	0.04	
Ce-Pr-144	0.072	*	<0.02	Outer Northeast Quadrant									500	0.003
Total Pu	$9 \times 10^{-5}$	$6 \times 10^{-6}$	( $3 \pm 8$ ) $\times 10^{-5}$	Be-7	0.136	*	<0.03	Be-7	0.136	*	<0.03	1,000	0.15	
Inner Northeast Quadrant														
Be-7	0.125	*	0.051 $\pm$ 0.057	Mn-54	0.01	*	<0.001	Mn-54	0.01	*	<0.001	300	0.003	
Mn-54	0.005	*	<0.002	Sr-90	0.003	0.001	( $2 \pm 2$ ) $\times 10^{-3}$	Sr-90	0.003	0.001	( $2 \pm 2$ ) $\times 10^{-3}$	2,000	0.006	
Zr-Nb-95	0.040	*	0.001 $\pm$ 0.0027	Ru-106	0.2	*	<0.11	Ru-106	0.2	*	<0.11	30	0.0002	
Ru-106	0.199	*	<0.014	Cs-137	0.006	*	<0.001	Cs-137	0.006	*	<0.001	3,000	0.002	
Cs-137	0.006	*	<0.09	Ce-Pr-144	0.064	*	<0.01	Ce-Pr-144	0.064	*	<0.01	500	0.04	
Ce-Pr-144	0.05	*	<0.02	Total Pu	$1 \times 10^{-4}$	*	< $4 \times 10^{-5}$	Total Pu	$1 \times 10^{-4}$	*	< $4 \times 10^{-5}$	1,000	0.03	
Total Pu	$4 \times 10^{-5}$	*	< $2 \times 10^{-5}$	Inner Northwest Quadrant									200	0.03
Inner Southwest Quadrant														
Be-7	0.119	*	<0.04	Be-7	0.154	*	<0.06	Be-7	0.154	*	<0.06	0.06	$2 \times 10^{-6}$	
Mn-54	0.007	*	<0.001	Mn-54	0.013	*	<0.001	Mn-54	0.013	*	<0.001	0.06	0.03	
Sr-90	0.003	0.0008	( $2 \pm 1.8$ ) $\times 10^{-3}$	Sr-90	0.002	0.0004	( $1 \pm 1.4$ ) $\times 10^{-3}$	Sr-90	0.002	0.0004	( $1 \pm 1.4$ ) $\times 10^{-3}$	0.06	0.002	
Zr-Nb-95	0.034	*	<0.012	Zr-Nb-95	0.04	*	<0.012	Zr-Nb-95	0.04	*	<0.012	0.06	0.002	
Ru-106	0.198	*	<0.11	Ru-106	0.13	*	<0.08	Ru-106	0.13	*	<0.08	0.06	0.002	
Cs-137	0.005	*	<0.0006	Cs-137	0.007	*	<0.001	Cs-137	0.007	*	<0.001	0.06	0.002	
Ce-Pr-144	0.072	*	<0.017	Ce-Pr-144	0.062	*	<0.021	Ce-Pr-144	0.062	*	<0.021	0.06	0.002	
Total Pu	$1 \times 10^{-5}$	$3 \times 10^{-6}$	( $8 \pm 7$ ) $\times 10^{-6}$	Total Pu	$4 \times 10^{-5}$	*	< $2 \times 10^{-5}$	Total Pu	$4 \times 10^{-5}$	*	< $2 \times 10^{-5}$	0.06	$2 \times 10^{-6}$	
Outer Western Quadrant														
Be-7	0.18	*	<0.03	Be-7	0.18	*	<0.03	Be-7	0.18	*	<0.03	0.06	0.03	
Mn-54	0.014	*	<0.002	Mn-54	0.014	*	<0.002	Mn-54	0.014	*	<0.002	0.06	0.03	
Zn-65	0.023	*	<0.001	Zn-65	0.023	*	<0.001	Zn-65	0.023	*	<0.001	0.06	0.03	
Sr-90	0.01	0.0005	( $3.6 \pm 1.8$ ) $\times 10^{-3}$	Sr-90	0.01	0.0005	( $3.6 \pm 1.8$ ) $\times 10^{-3}$	Sr-90	0.01	0.0005	( $3.6 \pm 1.8$ ) $\times 10^{-3}$	0.06	0.03	
Zr-Nb-95	0.04	*	<0.012	Zr-Nb-95	0.04	*	<0.012	Zr-Nb-95	0.04	*	<0.012	0.06	0.03	
Ru-106	0.27	*	<0.09	Ru-106	0.27	*	<0.09	Ru-106	0.27	*	<0.09	0.06	0.03	
Cs-137	0.01	*	<0.002	Cs-137	0.01	*	<0.002	Cs-137	0.01	*	<0.002	0.06	0.03	
Total Pu	$6 \times 10^{-5}$	$5 \times 10^{-6}$	( $3 \pm 5$ ) $\times 10^{-5}$	Total Pu	$6 \times 10^{-5}$	$5 \times 10^{-6}$	( $3 \pm 5$ ) $\times 10^{-5}$	Total Pu	$6 \times 10^{-5}$	$5 \times 10^{-6}$	( $3 \pm 5$ ) $\times 10^{-5}$	0.06	$2 \times 10^{-6}$	

NOTES

- \* Less than detection limit.
- (a)  $1 \mu\text{Ci}/\text{m}^3 = 10^{-12} \mu\text{Ci}/\text{ml}$
- (b) Weekly air filters are composited into groups for monthly analysis by gamma spectroscopy or quarterly analysis for Sr-90 and total Pu. Specific stations included in each quadrant are: Inner Northeast; Othello, Connell, Berg Ranch, Wahluke Wm, and Cooke Bros. Inner Southeast; Richland, Baxter Substation, Byers Landing, and Pasco. Inner Southwest; Rattlesnake Springs, ERC and Benton City. Inner Northwest; Yakima Barricade, Vernia, and Wahluke #2. Outer Northeast; Moses Lake and Wash-tucna. Outer Southeast; Walla Walla and McNary. Outer Western; Sunnyside.
- (c) ERDA 0524 standards apply to radionuclide concentrations in excess of that occurring naturally or due to fallout.

TABLE 4. Hanford Environs Air Quality Measurements - 1975

Annual Air Quality Standard	NO <sub>2</sub> (ppm)				
	0.05				
Location	No. of Samples	Daily Max	Daily Min	Annual Average	Percent of Standard
Opposite Richland (Hol Kirk Ranch)	145	0.0130	0.0003	0.0039	7.8
Opposite N. Richland (Gillum Ranch)	121	0.0138	0.0009	0.0040	8.0
Opposite 300 Area (Sullivan Ranch)	100	0.0110	0.0008	0.0034	6.8

WATER

Columbia River

The Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford reach, has been designated as Class A or excellent by the Washington State Department of Ecology. This designation requires that industrial uses of the river be compatible with substantially all water needs including sanitary water, recreation, and wildlife. Numerous routine samples were collected from the river to measure the effect of Hanford operations on the existing radiological, chemical, biological, and physical status of the river water. The Columbia River is a source of potable water for Hanford personnel and for the Tri-City populace directly downstream of the Hanford site. Also the river below Hanford is extensively used for recreation as well as a source of irrigation water for the Ringold and Riverview farming areas.

Radiological Evaluation

Samples of Columbia River water were obtained from Vernita Bridge, 100-B, Hanford powerline, 300 Area, and Richland. Since the shutdown of the last once-through cooling production reactor in January 1971, levels of specific radionuclides in river water have generally become undetectable with routine analytical methods. Table 5 is a summary of the routine water data obtained

TABLE 5. Routine Analysis of Columbia River Water

Analysis	Analytical Limit	Concentration ( $10^{-9}$ $\mu\text{Ci/ml}$ ) <sup>(a)</sup>								
		Upstream of Hanford <sup>(b)</sup>				Downstream of Hanford <sup>(c)</sup>				ERDA 0524 <sup>(e)</sup> Standards
		No. of Samples	Maximum Observed	Minimum Observed	Annual Average <sup>(d)</sup>	No. of Samples	Maximum Observed	Minimum Observed	Annual Average <sup>(d)</sup>	
Alpha	0.23	12	0.59	*	<0.27	12	0.83	*	<0.34	30
H-3	360	12	860	*	<370	11	940	*	<454	3,000,000
Sc-46	30	12	*	*	*	51	*	*	*	40,000
Cr-51	360	12	*	*	*	51	*	*	*	2,000,000
Co-60	24	12	*	*	*	51	*	*	*	30,000
Zn-65	50	12	*	*	*	51	62	*	<3.6	100,000
Sr-90	0.04	12	0.76	0.14	0.35 $\pm$ 0.40	12	1.0	0.09	0.46 $\pm$ 0.59	300
Cs-137	26	12	*	*	*	51	*	*	*	20,000
Pu-239	0.02	2	0.04	*	<0.03	2	0.02	*	<0.02	5,000

\* Less than analytical limit.

(a)  $10^{-9}$   $\mu\text{Ci/ml}$  = 1 pCi/l

(b) Upstream samples were obtained at Vernita Bridge (weekly grab samples) and at 100-B (cumulative sample).

(c) Downstream samples were obtained from the Richland sanitary water pumping dock (cumulative sample).

(d) Annual average  $\pm$ 2 sample standard deviations shown if all analyses were positive. Otherwise, a less-than number was calculated from the results, including less-than values.

(e) ERDA 0524 standards only apply to concentrations in the environment in excess of naturally occurring or fallout radioactivity.

during 1975. The alpha measurements are an approximation of the naturally occurring uranium in the river. The observed values of  $^{90}\text{Sr}$  and  $^{239}\text{Pu}$  are attributed to fallout since concentrations measured upstream of Hanford operations did not significantly differ from concentrations measured downstream. The tritium concentrations are due to fallout with approximately 10 pCi/l due to naturally occurring tritium. A positive  $^{65}\text{Zn}$  concentration was reported and is attributed to expected analytical variability in counting low-level environmental samples, not to Hanford operations. No other radionuclides were detected.

During 1975 an up-river filter-resin sampler<sup>5</sup> was installed at Priest Rapids to ascertain the types and amounts of radionuclides that exist in the Columbia River before it reaches the Hanford site. The data obtained from this sampler are presented in Table 6 and reflect existing quantities of naturally occurring or fallout related radionuclides. The data obtained from the down-river sampler (Table 7), located at the 300 Area, are compared to the upstream data to determine the impact of past or present Hanford operations on the Columbia River water quality. During 1975, radioactivity due to

TABLE 6. Concentration of Radionuclides in the Columbia River at Priest Rapids (a,b)

Radionuclide	Detection Limit	No. of Samples <sup>(b)</sup>	Concentration ( $10^{-9}$ $\mu$ Ci/ml)									ERDA 0524 <sup>(d)</sup> Standard	Percent of Standard <sup>(e)</sup>
			Soluble			Particulate			Total				
			Maximum Observed	Minimum Observed	Annual <sup>(c)</sup> Average	Maximum Observed	Minimum Observed	Annual <sup>(c)</sup> Average	Annual <sup>(c)</sup> Average				
K-40	0.009	6	0.69	0.32	0.49 $\pm$ 0.28	0.02	*	<0.02	<0.51	-	-		
Mn-54	0.014	6	*	*	*	*	*	*	*	100,000	-		
Co-60	0.0005	6	0.0032	*	<0.0009	*	*	*	<0.007	30,000	<3 $\times$ 10 <sup>-5</sup>		
Zn-65	0.005	6	*	*	*	*	*	*	*	100,000	-		
ZrNb-95	0.005	6	*	*	*	*	*	*	*	60,000	-		
Ru-106	0.005	6	0.06	0.04	0.05 $\pm$ 0.008	0.007	*	<0.005	<0.06	10,000	<6 $\times$ 10 <sup>-4</sup>		
Cs-137	0.005	6	*	*	*	*	*	*	*	20,000	-		
Eu-152	0.02	6	*	*	*	*	*	*	*	60,000	-		
Ra-226	0.002	6	0.04	0.01	0.02 $\pm$ 0.03	0.004	0.002	0.002 $\pm$ 0.002	0.024 $\pm$ 0.023	30	8 $\times$ 10 <sup>-2</sup>		
Th-228	0.0005	6	0.004	0.001	0.003 $\pm$ 0.002	0.002	*	<0.001	<0.004	1,000	<4 $\times$ 10 <sup>-4</sup>		

\* Less than detection limit.

(a) Samples collected with a filter-ion exchange sampler developed by the radiological chemistry group at Battelle. Filters and resin counted directly after collection with a high sensitivity multi-dimensional gamma ray spectrometer.

(b) Sample collection began in October and ran through December.

(c) Annual average  $\pm$ 2 sample standard deviation shown if all analyses were positive. Otherwise, a less-than number was calculated from the results, including less-than values.

(d) ERDA 0524 standards only apply to concentrations in excess of naturally occurring or fallout radioactivity.

(e) K-40, Ra-226, Th-228, occur naturally. Co-60 and Ru-106 are due to fallout.

TABLE 7. Concentration of Radionuclides in the Columbia River at the 300 Area (a)

Radionuclide	Detection Limit	No. of Samples	Concentration ( $10^{-9}$ $\mu$ Ci/ml)									ERDA 0524 <sup>(c)</sup> Standard	Percent of Standard
			Soluble			Particulate			Total				
			Maximum Observed	Minimum Observed	Annual <sup>(b)</sup> Average	Maximum Observed	Minimum Observed	Annual <sup>(b)</sup> Average	Annual <sup>(b)</sup> Average				
K-40	0.009	19	0.70	0.22	0.50 $\pm$ 0.28	0.11	*	<0.02	<0.51	-	-		
Mn-54	0.014	19	0.05	*	<0.014	0.54	*	<0.07	<0.054	100,000	<5.4 $\times$ 10 <sup>-5</sup>		
Co-60	0.0005	19	0.02	0.004	0.009 $\pm$ 0.007	0.11	0.002	0.02 $\pm$ 0.05	0.02 $\pm$ 0.05	30,000	<2.3 $\times$ 10 <sup>-4</sup>		
Zn-65	0.005	19	*	*	*	0.09	*	<0.01	<0.01	100,000	<1.0 $\times$ 10 <sup>-5</sup>		
ZrNb-95	0.005	19	0.07	*	<0.004	0.38	*	<0.037	<0.06	60,000	<1.0 $\times$ 10 <sup>-4</sup>		
Ru-106	0.005	19	0.16	0.06	0.08 $\pm$ 0.05	0.07	0.002	0.01 $\pm$ 0.03	0.10 $\pm$ 0.08	10,000	<1.8 $\times$ 10 <sup>-3</sup>		
I-131	0.01	12	*	*	*	*	*	*	*	300	-		
Cs-134	0.0005	19	0.06	*	<0.006	0.03	*	<0.003	<0.009	9,000	<1.0 $\times$ 10 <sup>-2</sup>		
Cs-137	0.005	19	0.29	*	<0.04	0.13	*	<0.014	<0.06	20,000	<3.0 $\times$ 10 <sup>-4</sup>		
BaLa-140	0.005	19	0.24	*	<0.02	0.04	*	<0.006	<0.01	20,000	<5.0 $\times$ 10 <sup>-5</sup>		
Eu-152	0.02	19	*	*	*	*	*	*	*	60,000	-		
Ra-226	0.002	19	0.06	*	<0.03	0.06	*	<0.006	<0.04	30	<1.3 $\times$ 10 <sup>-1</sup>		
Th-228	0.0005	19	0.04	*	<0.005	0.001	*	<0.002	<0.007	1,000	<7.0 $\times$ 10 <sup>-4</sup>		

\* Less than detection limit.

(a) Samples collected with a filter-ion exchange sampler developed by the radiological chemistry group at Battelle. Filters and resin counted directly after collection with a high sensitivity multi-dimensional gamma ray spectrometer.

(b) Annual average  $\pm$ 2 sample standard deviation shown if all analyses were positive. Otherwise, a less-than number was calculated from the results, including less-than values.

(c) ERDA 0524 standards only apply to concentrations in excess of naturally occurring or fallout radioactivity.

Hanford operations, was observed at the downstream sampler and is attributed to resuspension of sediments into which radioactivity from past once-through cooling production reactor operation is sorbed and to the annual maintenance outage at N Reactor in late May and early June. Quantities of radionuclides observed during this time were all less than 1% of the ERDAM 0524 concentration guides. Ba-La-140 was detected only during the outage. A large majority of the particulate  $^{54}\text{Mn}$ ,  $^{60}\text{Co}$ ,  $^{65}\text{Zn}$ , and  $^{95}\text{ZrNb}$  concentrations are attributable to resuspension of river sediment. The other radionuclides listed are primarily dissolved in the river water and are probably due to both fallout and current Hanford operations. All of the annual measured concentrations were less than 0.2% of the ERDAM 0524 concentration guides. A synopsis of the filter-resin sampling system is given in Appendix A.

#### Nonradiological Evaluation

Measurements of water quality parameters other than radioactivity are routinely made on Columbia River water in order to:

- Detect any impact of the Hanford waste disposal practices on river water quality.
- Demonstrate continued compliance with Washington State Water Quality<sup>2</sup> Standards for the Columbia River and Public Health Service<sup>6</sup> recommendations for sources of drinking water.

Physical and chemical parameters measured during 1975 included pH, turbidity, dissolved oxygen, nitrate ion and temperature. Biological measurements included coliform organisms and BOD. Enterococci measurements were made to clarify the types of coliforms present. The parameters most likely to be affected by Hanford operations are temperature and nitrate ion. Figure 5 shows the average monthly temperature measured at Vernita Bridge and at Richland during 1975. Some of the temperature difference is due to natural causes<sup>7</sup> and some is attributable to operations on the Hanford site. The greatest observed difference occurs during the summer months when N reactor was not in operation. The annual average temperature and 95% confidence interval for Priest Rapids Dam and Richland during 1975 were  $10.7 \pm 11.7$  and  $11.1 \pm 11.7^\circ\text{C}$ , respectively, based on 365 daily measurements. Figure 6 illustrates the daily variation of river temperature with season and flowrate during 1975.

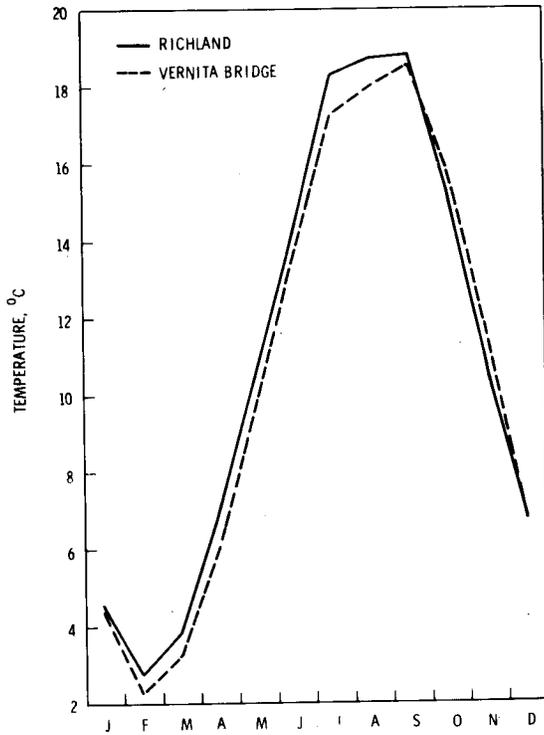


FIGURE 5. Columbia River Monthly Temperature at Richland and Priest Rapids Dam for 1975

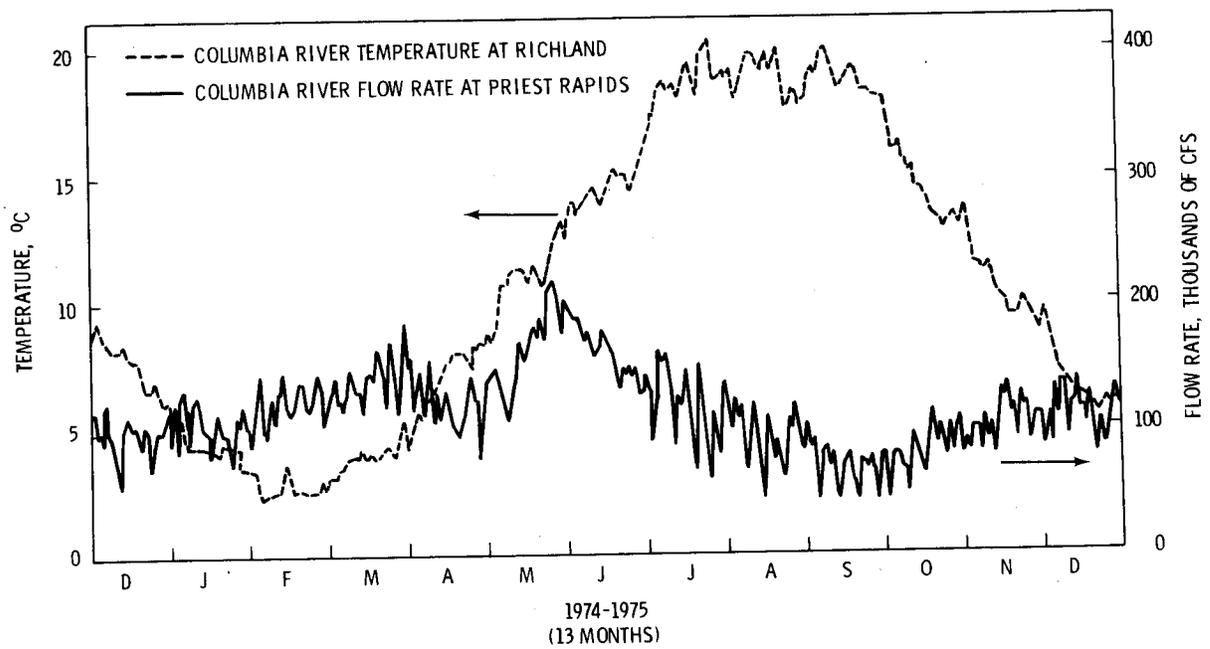


FIGURE 6. Columbia River Daily Flow and Temperature During 1975

Results of biological analyses of Columbia River water during 1975 are shown in Table 8. The data indicate an increase of coliform organisms, enterococci, and BOD between Vernita Bridge and Richland. These apparent increases are believed to be the result of drainage from farm activities and wildlife, for the Hanford stretch of the river serves as a refuge for large populations of waterfowl.

Results of chemical analyses are shown in Table 9. Nitrates, pH, turbidity, and dissolved oxygen were measured at both Vernita Bridge and Richland. The measurements observed were similar at both locations and well within applicable standards adopted by the State of Washington for Class A rivers.<sup>2</sup> Average nitrate concentrations were less than 0.6% of the 45 ppm standard, a 40% decrease from 1974 values. Average pH for 1975 was 8.0 at Vernita

**TABLE 8. Columbia River Biological Analyses - 1975**

Analysis	Units	Standard	Vernita			Richland				
			No. of Samples	Max	Min	Average	No. of Samples	Max	Min	Average
Coliform	No./100ml	240	8	64	12	30±33	9	56	8	36±35
Enterococci	No./100ml	-	8	26	4	14±17	9	51	3	27±29
BOD	mg/l	-	8	4.5	3.0	3.9±1.0	9	5.8	2.4	4.0±1.8

**TABLE 9. Columbia River Chemical Analyses - 1975**

Analysis	Units	Standard	Vernita			Richland <sup>(a)</sup>				
			No. of Samples	Maximum	Minimum	Annual <sup>(b)</sup> Average	No. of Samples	Maximum	Minimum	Annual <sup>(b)</sup> Average
NO <sub>3</sub>	ppm	45	51	0.63	*	<0.25	51	0.54	*	<0.26
pH		6.5 to 8.5	48	8.5	7.6	8.0±0.78	247	8.8	7.4	8.0±0.7
Turbidity	JTU <sup>(c)</sup>	5+Bkg	41	6.5	0.4	1.7±2.3	210	6.0	0.4	1.7±1.8
Dissolved O <sub>2</sub>	mg/l	8.0 min	38	13.9	9.5	11.7±2.4	218	14.1	8.6	11.8±2.5

\* Less than detection limit. Detection limit would be a tabled value of 0.1 for NO<sub>3</sub> analysis.

(a) pH, turbidity and dissolved O<sub>2</sub> samples obtained from 300 Area sanitary water pumping dock.

(b) Average ±2 sample standard deviations shown if all analyses were positive. Otherwise a less-than number was calculated from all results, including less-than detectable values.

(c) Jackson turbidity units.

Bridge and Richland, equivalent to 1974 values and well within the 6.5 to 8.5 standard. The turbidity standard is based on an increase of 5 JTU (Jackson turbidity units) above background. Since no observed differences were apparent between Vernita Bridge and Richland, the tabled values were assumed to represent background. Average values for dissolved oxygen in the river were well above the minimum standard of 8 mg/l. The averages observed at Vernita Bridge and Richland during 1975 were 11.7 mg/l and 11.8 mg/l, respectively an increase of approximately 10% over 1974 values.

In summary, the Hanford site has had no measurable chemical impact on the Columbia River in 1975 and the river water quality is well within Washington State standards.

#### Sanitary Water

The city of Richland is the first community below the Hanford Reservation that uses the Columbia River as a source of drinking water. BNW collects a cumulative (30 ml every 30 minutes) sanitary water sample at the Richland treatment plant for radiological analyses, and HEHF routinely collects grab samples for analyses of bacteriological and chemical purity.

#### Radiological Evaluation

In addition to the samples of river water collected at Vernita Bridge, 100-B, Hanford powerline, 300 Area, and Richland, cumulative sanitary water sampling was conducted at the Richland treatment plant. The samples collected were analyzed on a weekly basis by gross beta and gross alpha analyses and by gamma spectrometry of a monthly composite of weekly samples. The results of these analyses for 1975 are shown in Table 10. The gross alpha measurement is an approximation of the naturally occurring uranium in the river. Strontium-90 was observed on several occasions and was attributed to fallout. No other radionuclides were observed. Specific analyses for tritium in drinking water was not done because the levels would be the same as observed in the river water (Table 5), since tritium cannot be removed by sanitary water treatment facilities. The source of tritium is primarily fallout with a small amount occurring naturally.

TABLE 10. Radiological and Chemical Analyses of Drinking Water - 1975(a)

Analysis	Analytical Limit	Units	Standards (b)	Richland			
				No. of Samples	Maximum Observed	Minimum Observed	Annual Average
<u>Radiological</u>							
Alpha	0.40	pCi/l	30	52	1.2	*	<0.42
Beta	0.5	cpm/ml	30	52	*	*	*
H-3	250	pCi/l	3,000,000				N.A.
Sc-46	10	pCi/l	40,000	12	*	*	*
Cr-51	140	pCi/l	2,000,000	12	*	*	*
Co-60	5.6	pCi/l	30,000	12	*	*	*
Zn-65	17	pCi/l	100,000	12	*	*	*
Sr-90	0.08	pCi/l	300	10	0.83	*	<0.37
Cs-137	8.8	pCi/l	20,000	13	*	*	*
<u>Chemical</u>							
NO <sub>3</sub>	0.1	ppm	45	52	2.8	*	<0.46

\* Less than analytical limit.

N.A. Not analyzed.

(a) Average plus or minus two sample standard deviations shown if all analyses were positive. Otherwise, a less-than number was calculated from all results, including less-than numbers.

(b) Radiological standards obtained from ERDA 0524 and apply only to concentrations in excess of natural or fallout activity. Nitrate standard was promulgated by the Environmental Protection Agency.

Nonradiological Evaluation

Grab samples were collected from the Richland sanitary water system during 1975 for analyses of chemical and bacteriological purity. All bacteriological tests were negative and thus in compliance with the standard of no detectable coliform bacteria in potable water. Chemical analysis for nitrate was done on a weekly basis during 1975 (Table 10). The annual average nitrate concentration was about 1% of the EPA drinking water standard of 45 ppm.<sup>3</sup>

Groundwater

An extensive groundwater monitoring program continued to demonstrate no measurable effect on Columbia River quality from low-level wastes released to ground disposal sites within the Hanford plant boundaries. The data from this program is documented separately, the most recent report in this series being BNWL-1970.<sup>8</sup> A remote possibility exists that radioactive or process materials could penetrate to confined aquifers underlying the Pasco Basin. Several farm wells penetrating these confined aquifers on the east side of the Columbia River (Figure 8) are routinely sampled for tritium and nitrate ion. The data are not definitive, since contamination from the surface by nitrate from fertilizers and tritium from recent precipitation can also occur. Table 11 shows data from these wells for 1975.

TABLE 11. Groundwater Analyses from Wells in the Vicinity of Hanford - 1975

Concentration Guide Analytical Limit	Guide <sup>(b)</sup> Limit <sup>(c)</sup>	<sup>3</sup> H (10 <sup>-9</sup> μCi/ml) <sup>(a)</sup>			NO <sub>3</sub> (ppm)		
		3,000,000 ~800			45 0.5		
<u>Location</u>	<u>Samples</u>	<u>Max</u>	<u>Min</u>	<u>Ave</u>	<u>Max</u>	<u>Min</u>	<u>Ave</u>
Webber	2	1200	<500	<850	*	*	*
W-15	2	< 930	<700	<815	*	*	*
Vail	2	< 900	700	<800	*	*	*
Allison Manor	2	<1300	<500	<900	*	*	*
White Bluffs Association	2	< 870	<500	<685	*	*	*

\* Less than the analytical limit.

(a) 10<sup>-9</sup> μCi/ml = 1 pCi/l.

(b) ERDA 0524 Concentrations Guides only apply to concentrations in excess of naturally occurring or fallout levels.

(c) Average analytical limit shown for tritium was calculated from the detection limit of each analysis.

## FOODSTUFF

Foodstuffs, including milk, meat, chicken, eggs and leafy vegetables were collected from local farms and commercial outlets, and analyzed for gamma emitting radionuclides and <sup>90</sup>Sr (Tables 12 through 14). Since Riverview farming area is irrigated with Columbia River water after it has passed through the Hanford site, samples of each foodstuff were obtained from this area. The data were used to evaluate the approximate dose received from eating these particular foods which comprise a significant fraction of the typical diet.

Potassium-40, a naturally occurring radionuclide, contributed the majority of the radioactivity measured in all samples. Strontium-90 was measured in most foodstuff samples and the observed levels are attributed to fallout,

TABLE 12. Concentrations of Radionuclides in Milk - 1975

Concentration Guide <sup>(b)</sup> Analytical Limit	Concentration (10 <sup>-9</sup> μCi/ml) <sup>(a)</sup>									
	K-40			Sr-90			I-131			
	560			200.0			100.0			
				0.73			0.40			
Sample Results <sup>(c)</sup> <sup>(d)</sup>										
Location	No. of Samples	Max	Min	Average	Max	Min	Average	Max	Min	Average
Riverview	26	1200	720	880±250	3.2	*	<1.8	0.41	*	<0.40
Wahluke	26	1200	780	970±220	3.7	1.0	2.4±3.0	0.42	*	<0.40
Benton City #3	27	1200	630	980±250	5.0	*	<3.6	*	*	*
Benton City #4 <sup>(e)</sup>	20	990	*	<820	1.2	1.1	1.2±0.08	*	*	*
Benton City #5 <sup>(e)</sup>	6	1100	*	<880			1.4 <sup>(f)</sup>	0.57	*	<0.43
Commercial Brand H	14	1300	820	1000±270	5.0	*	<2.4	*	*	*
Commercial Composite	14	1200	730	960±270	5.4	*	<2.6	0.76	*	<0.43

\* Less than detectable

(a) 10<sup>-9</sup> μCi/ml = 1 pCi/ℓ

(b) Strontium-90 and Iodine-131 concentration guides in milk were established by the Federal Radiation Council. Potassium-40 is a naturally occurring radionuclide.

(c) The arithmetic mean ±2 sample standard deviations are tabled under the Average column if positive results were observed for each analyses. Otherwise, a less-than value is calculated from all the results, including less-than detectable values.

(d) Sr-90 analysis is performed quarterly.

(e) Benton City #4 source was discontinued 10-1-75, Benton City #5 source was begun on 10-23-75.

(f) Only one analysis.

**TABLE 13. Concentrations of Radionuclides in Meat, Chicken, and Eggs - 1975**

Concentration ( $10^{-6}$   $\mu\text{Ci/gm}$ ) wet weight<sup>(a)</sup>

Sample Location	No. of Samples	K-40			Zn-65			Sr-90			Cs-137		
		Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
<u>Meat</u>													
Commercial	13	2.4	1.6	2.0±0.7	0.08	*	<0.02	0.007	*	<0.002	*	*	*
Riverview	1			1.9			*			0.002			0.03
<u>Chicken</u>													
Commercial	2	1.5	1.3	1.4±0.3	*	*	*	0.006	*	<0.004	*	*	*
Riverview	4	2.0	1.1	1.6±0.8	*	*	*	0.01	*	<0.005	*	*	*
<u>Eggs</u>													
Commercial	2	0.8	0.78	0.79±0.03	*	*	*	0.003 <sup>(b)</sup>	0.001	0.002±0.0014	*	*	*
Riverview	13	1.1	0.64	0.92±0.23	*	*	*	0.003 <sup>(b)</sup>	*	<0.001	*	*	*

- \* Less than detectable. Approximate detection limits would be: K-40, 0.6; Zn-65, 0.07; Sr-90, 0.002; Cs-137, 0.04.  
 (a)  $10^{-6}$   $\mu\text{Ci/gm}$  = 1 pCi/gm. The arithmetic mean plus or minus two sample standard deviations, are tabled under the average column if positive results were observed for each analysis. Otherwise, a less-than value is calculated from all results, including the less-than values.  
 (b) Sr-90 analysis done on only 3 samples.

**TABLE 14. Concentrations of Radionuclides in Leafy Vegetables- Spinach, Leaf Lettuce, Turnip Greens, Mustard Greens - 1975**

Concentration ( $10^{-6}$   $\mu\text{Ci/gm}$ ) Wet Weight<sup>(a)</sup>

Sample Location	No. of Samples	K-40 <sup>(b)</sup>			Sr-90 <sup>(b)</sup>			
		Max	Min	Average <sup>(c)</sup>	Max	Min	Average	
Riverview	4	3.3	2.1	2.6±1.0	2	0.06	0.02	0.04
Benton City	1			1.4	1			0.02
Commercial	6	5.1	2.1	3.3±2.7	2	0.03	0.004	0.02

- (a)  $10^{-6}$   $\mu\text{Ci/gm}$  = 1 pCi/gm.  
 (b) Detection limits are: K-40, 1.5; Sr-90, 0.003. There were no other radionuclides detected.  
 (c) Average  $\pm 2$  sample standard deviations.

not to Hanford operations. In 10 (~8%) of 133 milk samples analyzed  $^{131}\text{I}$  was reported and then at levels very near the environmental detection limit. No  $^{131}\text{I}$  was detected in air or river water samples, the only pathways of transport. Other isotopes were detected only occasionally and the levels only slightly above the detection limit of the analyses. To obtain absolute measurements with such low levels of radioactivity is extremely difficult; several of the tabled values may represent nothing more than the statistical variability of background.

In summary, most of the radioactivity measured in foodstuffs during 1975 was the result of naturally occurring  $^{40}\text{K}$  and  $^{90}\text{Sr}$  due to fallout. Other radionuclides occasionally detected are believed to be due to worldwide fallout or the statistical variability of background.

#### WILDLIFE

Samples of wildlife, including gamebirds and fish were routinely collected from the Hanford environs and analyzed for levels of radioactivity. Table 15 lists the results obtained during 1975. Fish, usually whitefish, were collected monthly from the Columbia River and the composite analyzed. Gamebirds were collected along the Columbia River, primarily during hunting season. The radionuclide present in the greatest quantity was  $^{40}\text{K}$ , a naturally occurring radionuclide. Cobalt-60,  $^{90}\text{Sr}$ , and  $^{137}\text{Cs}$  were observed in several samples of fish. Strontium-90 was detected in 10 ducks and  $^{137}\text{Cs}$  was detected in 2 ducks out of the 27 collected. Cesium-137 was observed in 4 out of 17 geese sampled and  $^{90}\text{Sr}$  was observed in 4 out of 16 pheasants collected. All of the artificially produced radionuclides detected in the wildlife samples were detected at levels at or very near the respective environmental detection limits. The origin of the  $^{60}\text{Co}$  activity is attributed to previous operation of the once-through cooling production reactors, as discussed under the Columbia River Section. Strontium-90 and  $^{137}\text{Cs}$  activity are attributed to fallout.

**TABLE 15. Concentrations of Radionuclides in Muscle Tissue of Selected Wildlife Obtained from the Hanford Environs - 1975**

Concentration ( $10^{-6}$   $\mu\text{Ci/gm}$ ) wet weight<sup>(a,b)</sup>

Wildlife	No. of Samples	K-40			Co-60			Sr-90			Cs-137		
		Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
Whitefish	9	4.2	2.8	4.0±4.8	0.24	*	<0.1	0.18	*	<0.03	0.43	*	<0.13
Ducks	27	4.1	*	<3.12	*	*	*	0.05	*	<0.01	0.15	*	<0.05
Geese	17	3.5	2.0	3.12±3.4	*	*	*	-	-	-	0.17	*	<0.12
Pheasants	16	3.8	*	<2.8	*	*	*	0.08	*	<0.02	0.1	*	<0.08

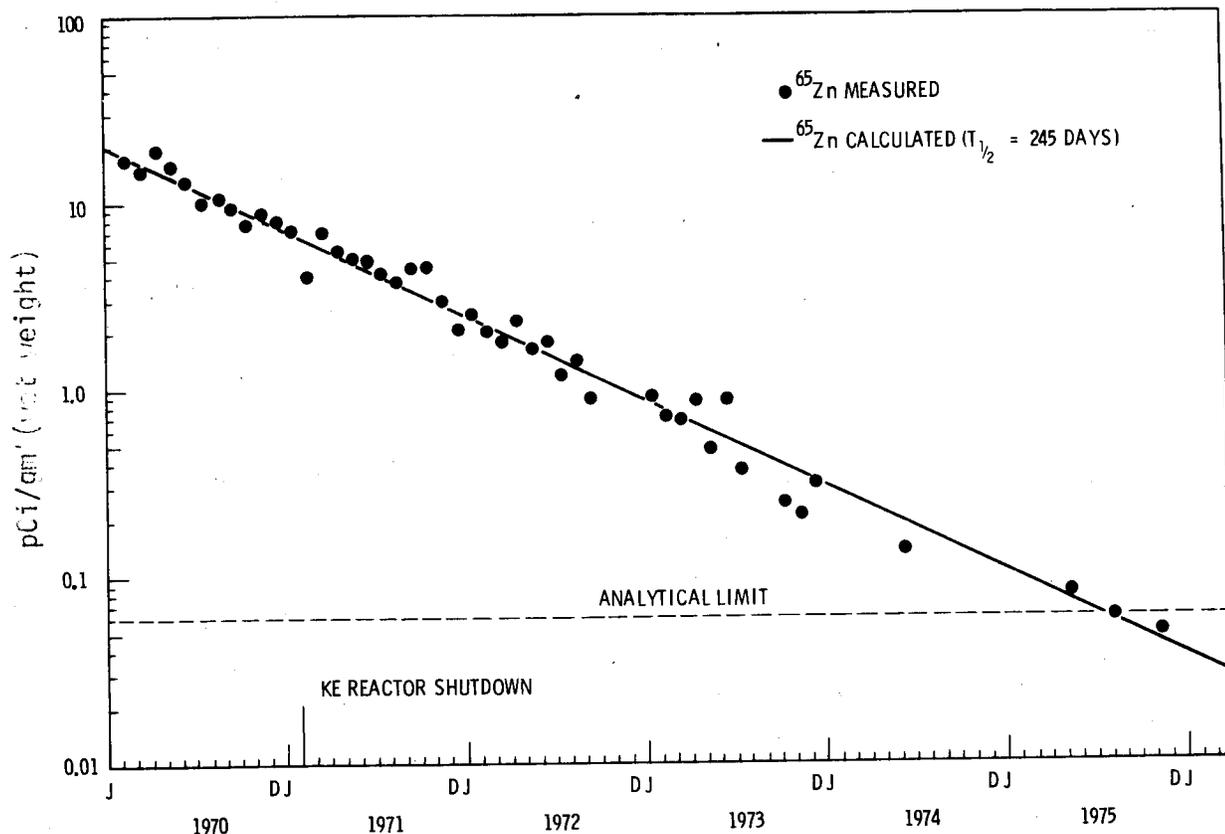
\* Less than detectable. Tabled detection limits would be approximately: K-40, 2.0; Co-60, 0.12; Sr-90, 0.005; Cs-137, 0.1.

- No specific analysis made.

(a)  $10^{-6}$   $\mu\text{Ci/gm}$  = 1 pCi/gm.

(b) Average plus or minus two sample standard deviations reported if all analyses were positive. Otherwise a less than value was calculated from all results, including less-than values.

Willapa Bay oysters were collected in 1975 and analyzed for  $^{65}\text{Zn}$  activity. Zinc-65 has a 245-day half-life and the observed decline of activity in oysters, as shown in Figure 7, closely approximates the radioactive decay rate. The radioactive decay rate will result in a yearly loss of approximately 64% of the previous year's activity. Since early 1970, an approximate five-hundred-fold decrease in activity has occurred.



**FIGURE 7.** Zinc-65 Concentration in Willapa Bay Oysters During 1970 Through 1975

### SOIL AND VEGETATION

Surface soil and perennial vegetation samples were collected from 8 different locations during the summer of 1975 for the purpose of measuring the levels of radioactivity due to fallout and natural causes as well as to assess any potential buildup of radioactivity from Hanford operations. These locations are shown in Figure 8 and the results listed in Tables 16 and 17. Each soil sample represents the composite of five "plugs" of soil from an approximate 10 m<sup>2</sup> area. Each plug was approximately 2.5 centimeters (1 inch) in depth and 10 centimeters (4 inches) in diameter. The vegetation samples were collected in the immediate vicinity of each soil sampling location and consisted of perennial vegetation, primarily the new growth from rabbit-brush plants. Both sets of samples were analyzed for

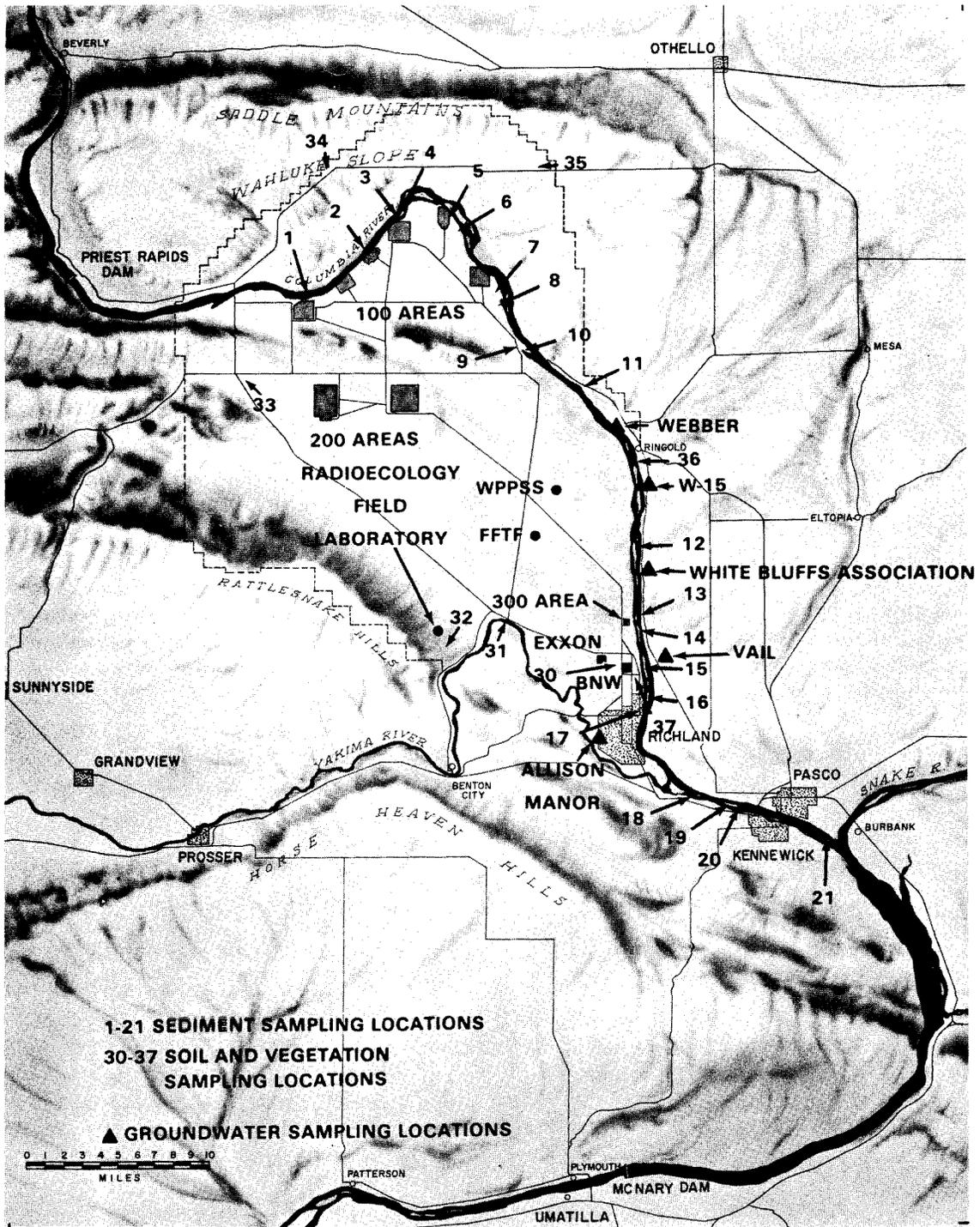


FIGURE 8. Soil, Sediment, and Groundwater Sampling Locations in the Vicinity of the Hanford Site.

**TABLE 16. Concentrations of Radionuclides in Perimeter Soil Samples - 1975**  
**Units of 10<sup>-6</sup> μCi/g of Soil (Dry Weight)**

Sample Location	Map Location	Naturally Occurring Radionuclides				Artificially Produced Radionuclides												
		<sup>40</sup> K	<sup>226</sup> Ra	<sup>226</sup> Ra U-total		<sup>54</sup> Mn	<sup>59</sup> Co	<sup>60</sup> Co	<sup>65</sup> Zn	<sup>90</sup> Sr	<sup>95</sup> ZrNb	<sup>106</sup> Ru-Rh	<sup>134</sup> Cs	<sup>137</sup> Cs	<sup>144</sup> Ce	<sup>154</sup> Eu	<sup>238</sup> Pu	<sup>239-244</sup> Pu
Analytical Limit		1.8	0.08	0.12	0.03													
Exxon Site	30	13	0.59	0.38	0.14													
Prosser Barricade	31	14	0.56	0.46	0.21													
ALE Field Lab	32	13	1.3	0.80	0.15													
Yakima Barricade	33	12	0.83	0.58	0.25													
Wahluke #2	34	11	0.83	0.51	0.19													
Berg Ranch	35	12	0.83	0.66	0.26													
Ringold	36	12	0.83	0.62	0.21													
300 Area 331 Bldg.	37	13	0.68	0.65	0.17													
Maximum		14	1.3	0.80	0.26													
Minimum		11	0.56	0.38	0.14													
Avr. ±2 Sample Deviations (a)		13±1.5	0.80±0.43	0.58±0.26	0.20±0.08													
Sample Location	Map Location	<sup>54</sup> Mn	<sup>59</sup> Co	<sup>60</sup> Co	<sup>65</sup> Zn	<sup>90</sup> Sr	<sup>95</sup> ZrNb	<sup>106</sup> Ru-Rh	<sup>134</sup> Cs	<sup>137</sup> Cs	<sup>144</sup> Ce	<sup>154</sup> Eu	<sup>238</sup> Pu	<sup>239-244</sup> Pu				
Analytical Limit		0.02	0.02	0.03	0.04	0.01	0.39	0.16	0.02	0.07	0.12	0.16	0.003	0.001				
Exxon Site	30	*	*	*	0.14	0.56	*	0.29	*	0.67	0.20	*	*	0.02				
Prosser Barricade	31	*	*	*	*	0.18	*	0.30	0.05	0.20	*	*	*	*				
ALE Field Lab	32	*	*	*	*	0.47	0.20	*	*	1.6	0.27	*	*	0.01				
Yakima Barricade	33	*	*	0.10	0.09	0.12	*	0.18	*	0.10	0.16	0.25	*	0.005				
Wahluke #2	34	0.03	*	*	0.10	0.10	*	*	*	0.31	0.16	*	*	*				
Berg Ranch	35	0.03	*	*	*	0.18	*	0.40	0.03	0.32	*	*	*	*				
Ringold	36	*	0.03	*	*	0.07	*	0.30	*	0.17	0.11	*	*	0.004				
300 Area 331 Bldg.	37	*	*	*	0.09	0.05	0.40	*	*	0.06	0.24	*	*	*				
Maximum		0.03	0.03	0.10	0.14	0.56	0.40	0.40	0.05	1.6	0.27	0.25	*	0.02				
Minimum		*	*	*	*	*	*	*	*	0.06	*	*	*	*				
Avr. ±2 Sample Deviations (a)		<0.01	<0.009	<0.01	<0.06	0.22±0.38	*	<0.17	<0.01	0.42±0.99	<0.16	<0.04	<0.0004	<0.007				

\* Indicates result was less than the analytical limit shown.  
(a) Average and two sample standard deviations shown if radionuclide detected at all locations. Otherwise, a less-than number is calculated from the other results, including less-than values.

**TABLE 17. Concentrations of Radionuclides in Perimeter Vegetation Samples - 1975**  
**Units of 10<sup>-6</sup> μCi/g of Vegetation (Dry Weight)**

Sample Location	Map Location	Naturally Occurring Radionuclides		Artificially Produced Radionuclides									
		<sup>40</sup> K	U-total	<sup>54</sup> Mn	<sup>59</sup> Co	<sup>60</sup> Co	<sup>65</sup> Zn	<sup>90</sup> SR					
Analytical Limit		3	0.03	0.09	0.10	0.10	0.2	0.01					
Exxon Site	30	11	0.04	*	*	0.10	*	0.03					
Prosser Barricade	31	12	*	*	*	*	*	0.14					
ALE Field Lab	32	4.3	*	*	*	*	*	0.24					
Yakima Barricade	33	6.8	*	*	*	*	*	0.06					
Wahluke #2	34	12	*	*	*	*	*	0.02					
Berg Ranch	35	16	*	*	*	*	*	0.01					
Ringold	36	16	*	*	*	*	*	0.02					
300 Area 331 Bldg.	37	40	*	*	*	*	*	0.48					
Maximum		40	0.04	*	*	0.11	*	0.48					
Minimum		4.3	*	*	*	*	*	0.01					
Average Sample Deviations (a)		15.22	0.02	*	*	0.04	*	0.13	0.33				

Sample Location	Map Location	Artificially Produced Radionuclides									
		<sup>95</sup> ZrNb	<sup>105</sup> RuRh	<sup>131</sup> I	<sup>134</sup> Cs	<sup>137</sup> Cs	<sup>141</sup> Ce	<sup>144</sup> CePr	<sup>238</sup> Pu	<sup>239-240</sup> Pu	
Analytical Limit		0.4	0.6	2.4	0.08	0.09	0.21	0.47	0.003	0.001	
Exxon Site	30	*	*	*	*	*	0.25	0.56	*	.002	
Prosser Barricade	31	*	*	*	*	0.10	*	0.34	*	.002	
ALE Field Lab	32	*	*	*	*	*	*	0.58	*	.002	
Yakima Barricade	33	*	*	*	*	0.17	*	0.92	*	.002	
Wahluke #2	34	*	*	*	*	*	*	0.34	*	*	
Berg Ranch	35	*	*	*	*	0.12	*	*	*	.001	
Ringold	36	*	*	*	*	*	*	*	*	.001	
300 Area 331 Bldg.	37	*	*	*	*	*	*	1.3	*	*	
Maximum		*	*	*	*	0.17	0.25	1.3	*	0.002	
Minimum		*	*	*	*	*	*	*	*	*	
Average Sample Deviations (a)		*	*	*	*	-0.10	*	0.54	*	-0.002	

\* Indicates result was less than the analytical limit shown.  
(a) Average and two sample standard deviations shown if radionuclide detected at all locations. Otherwise, a less-than number is calculated from the other results, including less-than values.

gamma emitting radionuclides using a lithium drifted germanium detector, for plutonium isotopes using alpha spectroscopy, and for  $^{90}\text{Sr}$  and uranium by specific chemical analysis.

Potassium-40,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{224}\text{Ra}$ ,  $^{226}\text{Ra}$ , and uranium were observed in soil samples from all locations. All of these radionuclides occur naturally except for  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ . Strontium-90 and  $^{137}\text{Cs}$ , as well as the other artificially produced radionuclides shown in Tables 16 and 17, are produced by fission and must be due to either Hanford operations or to fallout of radioactive debris from the atmosphere from past nuclear device testing. Hanford operations would be expected to contribute to radionuclide concentrations measured at predominately downwind sampling locations (Baxter Substation, Byers Landing, 300 Area south gate, etc.) than to those at sampling locations lying in an improbable wind direction from Hanford facilities (Prosser Barricade, Wahluke #2, etc.). No distinct pattern is apparent because of the variability of results measured at all locations. Hence, contributions to radioactivity by Hanford operations were indistinguishable from the variability in concentrations due to fallout.

During the spring of 1975, sediment samples were collected at 21 locations along the Columbia River and islands and analyzed (Figure 8). The results of these are presented in Table 18 and 19. The radionuclides observed in the sediment samples at all locations included  $^{40}\text{K}$ ,  $^{224}\text{Ra}$ , and  $^{226}\text{Ra}$  (naturally occurring) and  $^{60}\text{Co}$ , and  $^{137}\text{Cs}$  (artificially produced). Those radionuclides occurring in most of the samples included  $^{144}\text{Ce}$ ,  $^{152}\text{Eu}$ , and  $^{154}\text{Eu}$ . An aerial survey of the river by EG&G of Las Vegas<sup>9</sup> in 1974 noted elevated levels of  $^{60}\text{Co}$  at many of the islands and shoreline locations. This previously noted radioactivity and the radionuclides detected in the sediment samples taken in 1975 are assumed to be due to past Hanford operations. The observed radionuclides remain in the river sediments because of the past operation of once-through-cooling production reactors. The periodic flooding of islands and low-lying areas during high water,

**TABLE 18. Concentrations of Radionuclides in Sediment Sampled at Columbia River Island and Shoreline Locations - 1975**  
Units of pCi/g (dry weight)

River Mile	Map Location	Detection Limit(a)	Naturally Occurring Radionuclides				Artificially Produced Radionuclides								
			<sup>40</sup> K	<sup>226</sup> Ra	<sup>226</sup> Ra	<sup>54</sup> Mn	<sup>60</sup> Co	<sup>65</sup> Zn	<sup>106</sup> Ru	<sup>134</sup> Cs	<sup>137</sup> Cs	<sup>144</sup> Ce	<sup>152</sup> Eu	<sup>154</sup> Eu	<sup>155</sup> Eu
			1.8	0.08	0.12	0.02	0.03	0.04	0.16	0.02	0.07	0.12	0.06	0.16	0.04
384.3	1		11	1.3	0.4	*	0.2	*	*	*	0.4	0.1	0.2	0.1	*
379.8	2		11	1.8	0.7	0.05	0.6	0.4	0.15	0.02	0.7	0.4	0.3	0.8	0.3
377.3	3		9	2.9	0.6	*	2.4	*	*	*	0.6	0.6	1.5	0.5	*
376.6	4		11	2.8	0.9	0.2	9.6	0.2	*	0.1	0.8	0.9	0.4	0.6	*
370.6	6		12	1.3	0.4	*	0.06	*	*	0.02	0.07	0.2	*	0.2	*
368.0	7		12	2.1	0.7	*	1.1	*	*	0.04	1.7	0.2	1.6	0.4	*
363.1	9		13	2.2	0.7	*	1.0	*	*	0.04	1.0	*	0.7	0.1	*
362.6	10		14	1.8	0.6	*	*	0.1	*	0.03	0.2	0.3	*	*	*
359.0	11		14	3.2	0.7	0.04	0.7	0.1	*	0.05	0.4	*	0.3	0.8	0.1
346.0	13		14	1.5	0.6	0.2	6.2	0.1	0.2	0.02	1.8	*	2.2	0.2	*
344.6	14		11	2.2	0.8	0.07	2.4	0.1	0.3	0.03	0.5	0.4	0.7	0.2	*
342.7	15		12	1.7	0.8	0.02	2.1	*	*	*	0.7	*	0.3	0.4	*
340.3	16		14	1.0	0.4	*	0.6	*	0.7	*	1.0	0.08	0.6	*	*
333.3	18		13	1.1	0.4	0.1	2.5	*	*	*	0.5	0.1	0.6	*	*
332.2	19		13	1.6	0.8	0.06	2.1	*	*	0.05	1.0	0.1	0.9	0.2	*
332.0	20		12	2.8	1.1	0.04	3.2	*	*	*	1.6	0.4	1.9	1.2	*
324.5	Replicates														
	21-1		11	1.9	0.6	0.04	0.6	*	0.1	*	1.2	*	0.6	0.1	*
	21-2		12	1.5	0.5	*	0.2	0.1	*	0.03	0.5	0.08	0.1	*	*
	21-3		14	2.2	0.6	*	0.6	*	*	*	1.2	0.15	0.8	0.2	*
	21-4		11	1.6	0.6	*	0.2	0.1	*	0.02	0.6	0.14	*	0.2	*
	21-5		13	1.3	0.4	*	*	0.1	*	*	0.3	*	0.1	*	*
	Averages (b)		12±3	1.9±1.2	0.6±0.4	<0.05	<1.73	<0.09	<0.12	<0.02	0.8±1.0	<0.23	<0.67	<0.31	<0.05

\* Less than the analytical detection limit.

(a) The analytical detection limit listed is the average of individual analytical detection limit for each analyses.

(b) Average and two sample standard deviations shown if radionuclide detected at all locations. Otherwise, a less-than number is calculated from the other results, including less-than values.

**TABLE 19. Depth Profile of Radionuclide Concentrations in Sediment Sampled at Selected Columbia River Island and Shoreline Locations - 1975**  
Units of pCi/g (dry weight)

River Mile	Map Location	Naturally Occurring Radionuclides				Artificially Produced Radionuclides										
		<sup>40</sup> K	<sup>226</sup> Ra	<sup>54</sup> Mn	<sup>60</sup> Co	<sup>65</sup> Zn	<sup>106</sup> Ru	<sup>134</sup> Cs	<sup>137</sup> Cs	<sup>144</sup> Ce	<sup>152</sup> Eu	<sup>154</sup> Eu	<sup>155</sup> Eu	<sup>90</sup> Sr	<sup>238</sup> Pu	<sup>239-240</sup> Pu
	Analytical Limit(a)	1.8	0.08	0.12	0.03	0.04	0.16	0.02	0.07	0.12	0.06	0.16	0.04	0.01	0.003	0.001
371.4	5 - 0-1"	14	7.5	1.1	1.0	0.06	*	0.06	1.6	0.5	0.7	0.2	0.05	0.05	*	0.004
	1-2"	14	2.0	0.8	0.4	*	*	0.5	0.9	*	0.9	0.2	*	*	*	
	2-4"	12	1.4	0.5	0.6	*	0.2	*	1.9	0.1	1.2	*	*	0.07	*	
	4-6"	12	2.5	1.0	0.2	*	0.2	*	3.3	0.1	1.0	*	*	*	*	
	6-8"	12	5.7	1.1	0.1	*	*	*	0.6	0.2	0.6	*	*	*	*	
367.3	8 - 0-1"	12	2.5	0.9	3.3	0.05	0.3	0.06	1.7	*	2.8	1.0	*	0.03	*	0.013
	1-2"	12	1.9	0.7	7.3	0.05	0.2	*	1.5	0.2	2.8	0.6	*	*	*	
	2-4"	13	1.8	0.6	1.6	*	*	0.08	1.2	*	2.7	0.7	*	*	*	
	4-6"	13	2.2	0.9	0.6	0.05	*	*	0.6	*	1.1	0.5	0.07	*	*	
	6-8"	14	1.9	0.6	0.08	0.08	*	*	0.05	0.2	0.07	0.3	*	*	*	
349.8	12 - 0-1"	12	2.0	0.7	1.7	*	*	0.07	1.8	0.1	1.8	0.3	*	0.3	*	<0.1
	1-2"	12	1.5	0.9	1.5	*	0.2	0.06	0.5	1.0	2.6	6.0	1.6	*	*	
	2-4"	12	1.6	0.6	1.1	*	*	0.02	1.1	0.1	0.5	0.1	0.06	*	*	
	4-6"	13	2.0	0.5	0.2	*	*	0.02	0.5	0.2	0.1	*	*	*	*	
	6-8"	13	1.1	0.5	0.03	0.04	*	*	0.3	*	*	0.1	*	*	*	
340.0	17 - 0-1"	16	1.1	0.5	1.4	*	*	*	0.6	0.2	0.6	*	*	0.1	*	<0.1
	1-2"	14	2.0	1.0	2.3	*	*	*	1.5	*	1.3	1.0	*	*	*	
	2-4"	12	2.8	1.1	2.8	0.07	*	*	2.6	0.2	3.1	0.7	*	*	*	
	4-6"	14	1.0	0.6	0.8	0.05	*	0.02	1.2	0.2	1.1	0.4	*	*	*	
	6-8"	12	1.3	0.6	0.2	0.05	*	0.04	0.9	0.2	0.3	*	*	*	*	
Averages	0-1"	13.5±3.8	3.3±5.6	0.8±0.5	1.9±2	<0.04	<0.2	<0.05	1.4±1.1	<0.2	1.5±2.1	<0.4	<0.05	0.12	0.25	<0.05
	1-2"	13.0±2.3	1.9±0.5	0.9±0.3	2.9±6.1	<0.04	<0.2	<0.15	1.1±1.0	0.3	1.9±1.9	2.0±5.4	<0.43	*	*	*
	2-4"	12.3±1.0	1.9±1.2	0.7±0.5	1.5±1.9	<0.04	<0.1	<0.03	1.7±1.4	<0.1	1.9±2.5	<0.4	*	*	*	
	4-6"	13.0±1.6	1.9±1.3	0.8±0.5	0.5±0.6	<0.04	<0.1	<0.03	1.4±2.6	<0.1	0.8±1.0	<0.3	<0.06	*	*	
	6-8"	12.8±1.9	4.0±4.3	0.7±0.5	0.1±0.1	<0.05	*	<0.02	0.5±0.7	0.2±0.0	<0.3	<0.1	*	*	*	

\* Less than the analytical detection limit.

(a) The analytical detection limit listed is the average of individual analytical detection limit for each analyses.

(b) Average and two sample standard deviations shown if radionuclide detected at all locations. Otherwise, a less-than number is calculated from the other results, including less-than values.

resulting in the deposition of these sediments, is the probable reason for the observed concentrations. This phenomenon is explored in detail in a separate publication.<sup>10</sup>

Results of depth profile samples indicated a slight increase in the levels of radioactivity in the one to two-inch layer for  $^{60}\text{Co}$ ,  $^{154}\text{Eu}$ , and  $^{155}\text{Eu}$ , although this may be due to the natural variability of environmental sampling as demonstrated by the replicate samples taken at location 21.

#### EXTERNAL RADIATION MEASUREMENT

External radiation levels in the Hanford environs were measured during 1975 by several methods. Thermoluminescent dosimeters (TLDs) were deployed at 12 perimeter and 5 distant locations to measure the ambient radiation dose received from natural and fallout radioactivity as well as to detect any contribution from Hanford operations. TLDs were submerged in the Columbia River at four locations. State highways through the site, control plots, and Columbia River shoreline were routinely surveyed with portable instruments to detect any trend in ambient radiation levels.

#### Ambient Radiation Dose

TLDs were used to measure the external background dose at several perimeter and distant communities. Table 20 shows the results of these measurements. The dosimeter consisted of 3 chips of  $\text{CaF}_2:\text{Dy}$  (Harshaw TLD-200) encased in an opaque plastic capsule lined with 0.010 inch of tantalum and 0.002 inch of lead to flatten the lower energy response.<sup>11</sup> The dosimeters were mounted approximately one meter above ground level and changed either bi-weekly or monthly.

The external dose measured at any location is affected by several parameters, including the height of the dosimeter above ground, the elevation, and the amount of natural and fallout radioactivity in the underlying soil. The variability in measured dose from the different locations was expected primarily because of the spatial dependence of natural radioactivity in soil. Contributions from Hanford operations were indiscernible from the variability in background dose measured at the different communities.

TABLE 20. Ambient Radiation Dose - 1975(a)

Location	No. of Measurements <sup>(b)</sup>	Dose (mrem/yr) <sup>(c)</sup>		
		Maximum	Minimum	Average
<u>Perimeter Community Dose</u>				
Pasco	12	80	66	70±8
Richland	26	77	62	71±7
Vernita	25	102	77	88±12
Benton City	13	69	51	60±9
Othello	13	69	51	60±10
Connell	13	69	55	65±8
Berg Ranch	13	84	73	78±8
Wahluke Wm.	11	77	69	73±6
Cooke Bros.	13	73	62	68±7
Ringold	10	91	77	85±9
Baxter Sub.	13	73	58	67±9
Byers Landing	13	91	73	78±10
Average ±2 sample standard deviations				72±18
<u>Distant Community Dose</u>				
Walla Walla	13	77	66	73±7
Sunnyside	13	69	58	65±8
McNary	12	84	66	73±9
Moses Lake	13	73	58	67±7
Washtucna	13	73	58	68±8
Average ±2 sample standard deviations				69±7

- (a) Total background dose from external irradiation would include an additional dose from the neutron component of cosmic radiation. This is estimated to be equivalent to 4 mrem/year at the elevation of the Hanford region from EPA publication ORP/SID 72-1.
- (b) Dosimeters are generally deployed on a two-week or four-week interval. This practice results in approximately 26 or 13 separate measurements at each location. There is some variability because of scheduling and year-to-year overlap.
- (c) Monthly or biweekly measurements converted to equivalent annual dose. Average ±2 sample standard deviations calculated for each location.

The external background dose received by the population in the Hanford environs can be estimated from the data in Table 20. The average measured dose and 95% confidence interval at perimeter locations was about  $72 \pm 18$  mrem/year (1 mrem equals 1 mrad in this case). To this number, an additional 6 mrem/year must be added to account for the neutron component of cosmic radiation.<sup>12</sup> Thus an estimate of  $78 \pm 18$  mrem/yr from external radiation would be realistic. An estimate of the total (external plus internal) background dose must include the approximate 25 mrem/year received from radioactivity, primarily  $^{40}\text{K}$ , in our bodies.<sup>4</sup> Therefore, the average total background dose received in the Hanford environs is approximately  $103 \pm 18$  mrem/year.

#### Columbia River Immersion Dose

TLDs were submerged in the Columbia River at four locations: Coyote Rapids (above 100-K Area), below 100-N, Hanford powerline, and the Richland pumphouse. The TLDs were collected monthly and the results (shown in Table 21) are similar to 1974.<sup>13</sup> The information was used to evaluate the dose rate received while swimming in the river. At Richland, an immersed swimmer would receive approximately 0.004 mrad/hr, compared to approximately 0.008 mrad/hr received on land (Table 19).

TABLE 21. Columbia River Immersion Dose Rate - 1975

<u>Location</u>	<u>No. of Measurements</u>	<u>Radiation Dose (mrad/hr)<sup>(a)</sup></u>		
		<u>Maximum</u>	<u>Minimum</u>	<u>Annual<sup>(b)</sup> Average</u>
Coyote Rapids	12	0.006	0.004	$0.005 \pm 0.001$
Below 100-N	10	0.010	0.004	$0.007 \pm 0.003$
Hanford Powerline	9	0.006	0.003	$0.004 \pm 0.002$
Richland Pumphouse	13	0.005	0.003	$0.004 \pm 0.001$

- (a) Monthly measurements in mrad were converted to equivalent hourly dose.  
 (b) Average  $\pm 2$  sample standard deviations calculated for each location.

### Portable Instrument Surveys

Roads and land surfaces in the vicinity of Hanford were periodically surveyed to detect possible radionuclide deposition resulting from Hanford operations and related activities. Public Highways 24 and 240, which traverse the Hanford Reservation, were surveyed quarterly with a bioplastic scintillation detector<sup>14</sup> attached to the bumper of a truck and positioned about 0.6 meters (2 feet) above the edge of the road surface (described in BNWL-62). No radioactivity other than background was detected during 1975.

Eleven small areas, called control plots, were located around the Hanford boundaries. These plots, measuring 3m x 3m (10 ft x 10 ft) were surveyed monthly or semimonthly with a Geiger-Muller (GM) survey meter for deposited radioactive material. No surface radioactivity of Hanford origin was detected on these control plots during 1975.

The shoreline of the Columbia River was surveyed monthly with a low-level GM counter (Nuclear Enterprises Model 2601) at selected locations to detect any change in ambient radiation levels from previous measurements. The data obtained during 1975 for three of these locations, Vernita, Richland and Sacajawea, are summarized in Table 22. No statistical difference is apparent between the results for the three locations given the wide variability in observed values.

TABLE 22. Columbia River Shoreline Exposure Rate - 1975

Shoreline Location	No. of Measurements	Exposure Rate (mR/hr)		
		Maximum	Minimum	Average <sup>(a)</sup>
Vernita	6	0.015	0.006	0.009±0.007
Richland	12	0.016	0.008	0.012±0.005
Sacajawea	21	0.020	0.009	0.013±0.005

(a) Average ±2 sample standard deviations for each location.

## RADIOLOGICAL IMPACT OF HANFORD OPERATIONS

Potential environmental exposure pathways from Hanford operations to the population are shown pictorially in Figure 9. Many of these same pathways are responsible for transporting naturally occurring and fallout radioactivity from the environment to man. The evaluation of monitoring data from several environmental media discussed in the previous sections attempted to determine the contribution to ambient radiation levels due to Hanford operations from the contributions due to fallout and natural radioactivity. The contribution from Hanford operations during 1975 to the radiation levels measured in all environmental media (atmosphere, water, foodstuffs, wildlife, soil, and vegetation) were indistinguishable from pre-existing radiation levels. Some of the radioactivity that was measured in occasional samples of wildlife, suspended sediment in river water, soil samples from Columbia River islands, and oysters from Willapa Bay was due to past once-through cooling production reactor operation. The last of these reactors, KE, was deactivated during January 1971. The radioactivity in the river sediments and biota due to this cause is gradually becoming undetectable through dilution and radioactive decay.

Table 23 lists the radionuclide composition of effluent reported by all Hanford contractors during 1975. Because of the difficulty in measuring the contribution of these radionuclides to the existing radiation levels due to fallout and natural radioactivity, the radiological impact from Hanford operations during 1975 was estimated from theoretical models relating releases of radioactivity from Hanford operations with subsequent radiation dose to the population. The models<sup>15,16</sup> have been used previously to determine the radiological impact from Hanford facilities (Waste Management Operations - Hanford Reservation - ERDA-1538).<sup>17</sup> There will be small differences in calculated doses from year to year depending on the quantity of effluent, annual meteorology, river flow rate, and calculation methodology. The methods employed are expected to provide a best estimate of the calculated doses due to Hanford operations during 1975. The radiological impact from radioactivity measured in wildlife, island soil samples, river sediments, and oysters from past Hanford operations are addressed separately.

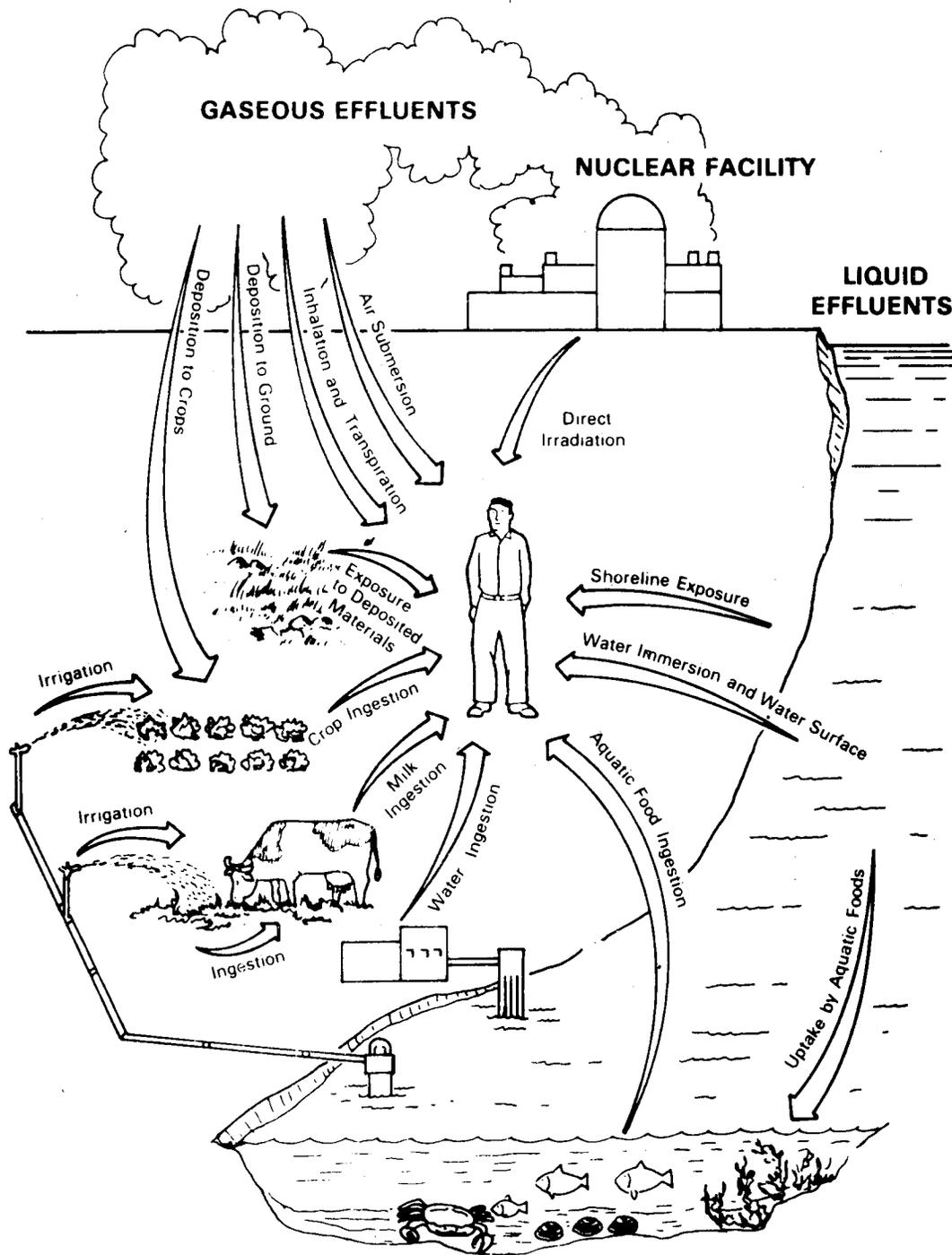


FIGURE 9. Exposure Pathways to Man<sup>15</sup>

TABLE 23. Radionuclide Composition of Effluent-1975<sup>(a)</sup>

Radionuclide	Half life	Liquid to River	Effluent (Curies)		
			100 Area	Gaseous	
			200 Areas	300 Areas	
H-3 (HTO)	12.3 yr	130	8		
Na-24	15 hr	1			
P-32	14.3 d	0.06			
Ar-41	1.8 hr		30,900		
Sc-46	84 d	0.02			
Cr-51	28 d	0.2			
Mn-54	303 d	0.4	0.02		
Mn-56	2.6 hr	5	0.06		
Co-58	71 d	0.02			
Fe-59	46 d	0.1	0.03		
Co-60	5.3 yr	1.3	0.09		1.7x10 <sup>-4</sup> (b)
Zn-65	245 d	0.2			
As-76	26.4 hr	0.03	0.4		
Sr-89	50.8 d	0.1	0.003		
Sr-90	28 yr	0.4	0.0001	0.42 <sup>(c)</sup>	3.3x10 <sup>-5</sup> (c)
Nb-95	35 d	0.1			
Zr-95	66 d	0.04			
Mo-99	67 hr	1.2	0.1		
Tc-99	2.1x10 <sup>5</sup> yr				
Ru-103	40 d	0.22			
Ru-106	368 d	0.5			
Sb-124	60 d	0.02			
Sb-125	2.7 yr	0.02			
I-131	8 d	2.53	0.46		0.005
I-132	2.3 hr	0.01	0.17		
I-133	20.3 hr		2.4		
Cs-134	2 yr	0.01			
I-135	6.7 hr		4.5		
Xe-135	9.1 hr		1590		
Cs-137	30 yr	0.07			
BaLa-140	12.8 d	0.4	0.1		
Ce-141	32.5 d	0.03			
Ce-144	284 d	0.1			
Pu-Alpha <sup>(d)</sup>	24,390 yr	0.0009		0.001	
U-Alpha <sup>(d)</sup>	4.5x10 <sup>9</sup> yr				0.0009

(a) Table includes all reported releases.

(b) Actually reported as mixed activation products. Cobalt-60 assumed for simplification and was used in dose calculations.

(c) Actually reported as mixed fission products. Strontium-90 assumed for simplification and was used in dose calculations.

(d) Gross alpha counts for different facilities interpreted as either reflecting Pu-239 or uranium activity depending on the nature of the operations inside the facilities.

## RADIOLOGICAL IMPACT FROM 1975 EFFLUENT

Three separate parameters are suggested by ERDA Manual Chapter 0513<sup>18</sup> to evaluate the radiological impact of Hanford operations on the surrounding region. These are:

- Maximum "fence-post" exposure rate at any point on the site boundary.
- Maximum dose to an individual member of the public.
- Total body dose (man-rem) to the entire population within an 80-kilometer (50-mile) radius of the site.

### Maximum "Fence-Post" Exposure Rate

The maximum "fence-post" exposure rate during 1975 was calculated to be  $6 \times 10^{-6}$  mR/hr along the northwest boundary of the Hanford Reservation. Although no one lives in this particular area, the dose potentially received by an individual continuously present on the boundary was estimated to be 0.06 mrem. The majority of the dose received would be from <sup>41</sup>Ar (half-life 1.8 hours) and <sup>135</sup>Xe (half-life 9.2 hours) released at N Reactor.

### Maximum Individual Dose

The maximum dose to an individual member of the public during 1975 and the 50-year dose commitment from 1975 effluent were calculated for all of the radionuclides listed in Table 23.

All significant environmental exposure pathways were evaluated including submersion in the plume, drinking water, foodstuffs irrigated with Columbia River water, atmospheric iodine-pasture-cow-milk pathway, etc. The methods employed are expected to provide a best estimate of the doses due to the different exposure pathways.

Past studies, combined with results of the environmental surveillance program, have facilitated the construction of a hypothetical person whose dietary and recreational habits maximize the dose he might receive from Hanford operations. Such a hypothetical person is called the maximum individual. The habits and diet of the maximum individual include the maximum reported for each exposure mode in spite of the fact that the maximum

values are not, in actuality, attributable to the same person. The maximum individual is a person assumed to have the following characteristics:

- Resides continuously directly across the river from the Hanford 300 Area.
- Obtains drinking water from the Columbia River.
- Drinks 275 liters of milk during a nine-month period from a cow eating pasture grass near his residence.
- Eats 710 kg of produce grown near his residence and irrigated with Columbia River water.
- Eats 40 kg of fish per year caught from the Columbia River.
- Spends as much as 500 hours per year on the shoreline of the Columbia River, 100 hours per year swimming in the river, and 100 hours per year boating.

The estimated total body dose received during 1975 for such an individual from effluent released during 1975 is  $7 \times 10^{-3}$  mrem as shown in Table 24. The dose received was primarily the result of radionuclides ingested with fish from the Columbia River ( $2.4 \times 10^{-3}$ ), foodstuffs irrigated with Columbia River water ( $1.7 \times 10^{-4}$  mrem), and external radiation from  $^{41}\text{Ar}$  and  $^{135}\text{Xe}$  releases from N Reactor ( $2.6 \times 10^{-3}$  mrem).

The dose potentially received by the thyroid of an infant (one year old) was estimated to be 0.9 mrem from effluent released during 1975, as shown in Table 24. The dose was primarily due to  $^{131}\text{I}$  in milk and drinking water. The iodine in milk results from irrigation of the pasture with Columbia River water and deposition on the pasture grass of airborne iodine. Essentially all of the dose would be received during 1975 since  $^{131}\text{I}$  has an eight-day half-life.

The 50-year total body dose commitment to the maximum individual from 1975 effluents is 0.02 mrem as shown in Table 25. The additional 0.01 mrem received after 1975 is due primarily to the consumption during 1975 of  $^{90}\text{Sr}$  in drinking water, fish, and irrigated foods. The bone dose received during 1975 was estimated to be  $9 \times 10^{-3}$  mrem due primarily to fish consumption.

**TABLE 24. Estimated Dose to the Maximum Individual During 1975 from Effluents Released from Hanford Facilities During 1975**

	Annual Exposure	Annual Dose (mrem) (a)				
		Skin	Body	GI-LLI	Bone	Thyroid
<u>Gaseous Effluents</u>						
Air Submersion	8766 hr	$3.8 \times 10^{-3}$	$2.6 \times 10^{-3}$			
Tritium - Inhalation and Transpiration	8766 hr	$1.3 \times 10^{-9}$	$1.3 \times 10^{-9}$	( $2.6 \times 10^{-3}$ ) (b)	( $2.6 \times 10^{-3}$ )	( $2.6 \times 10^{-3}$ ) $1.3 \times 10^{-9}$
Radioiodine - Inhalation	7300 m <sup>3</sup>	---	---	---	---	$4.2 \times 10^{-3}$
Milk	274 liters (c)	---	---	---	---	0.1
Vegetables (leafy)	30 kg (d)	---	---	---	---	$2.2 \times 10^{-2}$
Total Air Pathways		$3.8 \times 10^{-3}$	$2.6 \times 10^{-3}$	$2.6 \times 10^{-3}$	$2.6 \times 10^{-3}$	0.13
<u>Liquid Effluents</u>						
Drinking Water	730 liters	---	$2.4 \times 10^{-4}$	$1.3 \times 10^{-3}$	$2.6 \times 10^{-4}$	$2.5 \times 10^{-2}$
Fish Consumption	40 kg	---	$3.4 \times 10^{-3}$	$2.8 \times 10^{-2}$	$4.4 \times 10^{-3}$	$2.5 \times 10^{-2}$
Irrigated Foods	710 kg (e)	---	$1.7 \times 10^{-4}$	$1.4 \times 10^{-3}$	$5.9 \times 10^{-4}$	$7.6 \times 10^{-3}$
Shoreline	500 hr	$7.0 \times 10^{-4}$	$6.1 \times 10^{-4}$	( $6.1 \times 10^{-4}$ )	( $6.1 \times 10^{-4}$ )	( $6.1 \times 10^{-4}$ )
Swimming	100 hr	$4.3 \times 10^{-5}$	$3.2 \times 10^{-5}$	( $3.2 \times 10^{-5}$ )	( $3.2 \times 10^{-5}$ )	( $3.2 \times 10^{-5}$ )
Boating	100 hr	$2.2 \times 10^{-5}$	$1.6 \times 10^{-5}$	( $1.6 \times 10^{-5}$ )	( $1.6 \times 10^{-5}$ )	( $1.6 \times 10^{-5}$ )
Total Water Pathways		$7.7 \times 10^{-4}$	$4.5 \times 10^{-3}$	$3.1 \times 10^{-2}$	$5.9 \times 10^{-3}$	$5.8 \times 10^{-2}$
TOTAL ADULT		$5 \times 10^{-3}$	$7 \times 10^{-3}$	$3 \times 10^{-2}$	$9 \times 10^{-3}$	0.2
<u>Infant Thyroid Dose</u>						
Airborne Tritium	8766 hr					$7.6 \times 10^{-10}$
Air Submersion	8766 hr					( $2.6 \times 10^{-3}$ )
Inhalation	2045 m <sup>3</sup>					$8.5 \times 10^{-3}$
Milk	274 liters (c)					0.74
Drinking Water	292 liters					$9.5 \times 10^{-2}$
TOTAL INFANT						0.9

- (a) Dose received during 1975 due to effluent during 1975.  
 (b) Internal dose from external exposure indicated by parenthesis ( ).  
 (c) One liter per day for a 9-month grazing season.  
 (d) 200 g/d for a 5-month growing season.  
 (e) Only the potentially irrigated produce is included.

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**TABLE 25. Estimated 50-Year Dose Commitment to the Maximum Individual from Effluents Released from Hanford Facilities During 1975**

Pathway	Annual Exposure	Dose Commitment (mrem)(a)				
		Skin	Body	GI-LLI	Bone	Thyroid
<b>Gaseous Effluents</b>						
Air Submersion	8766 hr	3.8x10 <sup>-3</sup>	2.6x10 <sup>-3</sup>	(2.6x10 <sup>-3</sup> )(b)	(2.6x10 <sup>-3</sup> )	(2.6x10 <sup>-3</sup> )
Tritium - Inhalation and Transpiration	8766 hr	1.3x10 <sup>-9</sup>	1.3x10 <sup>-9</sup>	1.3x10 <sup>-9</sup>	---	1.3x10 <sup>-9</sup>
Radioiodine - Inhalation	7300m <sup>3</sup>	---	---	---	---	4.2x10 <sup>-3</sup>
Milk	274 liters(c)	---	---	---	---	0.1
Vegetables (leafy)	30 kg(d)	---	---	---	---	2.2x10 <sup>-2</sup>
Total Air Pathways		3.8x10 <sup>-3</sup>	2.6x10 <sup>-3</sup>	2.6x10 <sup>-3</sup>	2.6x10 <sup>-3</sup>	0.13
<b>Liquid Effluents</b>						
Drinking Water	730 liters	---	7.8x10 <sup>-4</sup>	2.3x10 <sup>-3</sup>	2.2x10 <sup>-3</sup>	2.5x10 <sup>-2</sup>
Fish Consumption	40 kg	---	7.8x10 <sup>-3</sup>	2.8x10 <sup>-2</sup>	2.2x10 <sup>-2</sup>	2.5x10 <sup>-2</sup>
Irrigated Foods	710 kg(e)	---	2.8x10 <sup>-3</sup>	1.0x10 <sup>-2</sup>	1.6x10 <sup>-2</sup>	6.3x10 <sup>-2</sup>
Shoreline	500 hrs	7.0x10 <sup>-4</sup>	6.1x10 <sup>-4</sup>	(6.1x10 <sup>-4</sup> )	(6.1x10 <sup>-4</sup> )	(6.1x10 <sup>-4</sup> )
Swimming	100 hrs	4.3x10 <sup>-5</sup>	3.2x10 <sup>-5</sup>	(3.2x10 <sup>-5</sup> )	(3.2x10 <sup>-5</sup> )	(3.2x10 <sup>-5</sup> )
Boating	100 hrs	2.2x10 <sup>-5</sup>	1.6x10 <sup>-5</sup>	(1.6x10 <sup>-5</sup> )	(1.6x10 <sup>-5</sup> )	(1.6x10 <sup>-5</sup> )
Total Water Pathways		7.7x10 <sup>-4</sup>	1.2x10 <sup>-2</sup>	4.1x10 <sup>-2</sup>	4.1x10 <sup>-2</sup>	0.11
TOTAL ADULT		5x10 <sup>-3</sup>	2x10 <sup>-2</sup>	4x10 <sup>-2</sup>	4x10 <sup>-2</sup>	0.2
<b>Infant Thyroid Dose</b>						
Airborne Tritium	8766 hr					7.6x10 <sup>-10</sup>
Air Submersion	8766 hr					2.6x10 <sup>-3</sup>
Inhalation	2045 m <sup>3</sup>					8.5x10 <sup>-3</sup>
Milk	274 liters(c)					0.74
Drinking Water	292 liters					9.5x10 <sup>-2</sup>
TOTAL INFANT						0.9

(a) Dose commitment for 50 years (1975-2024, inclusive) due to effluents released during 1975.

(b) Internal dose from external exposure indicated by parenthesis ( ).

(c) One liter per day for a 9-month grazing season.

(d) 200 g/d for a 5-month growing season.

(e) Only the potentially irrigated produce is included.

The 50-year dose commitment to the bone was estimated to be 0.04 mrem, as shown in Table 25. The dose received after 1975 is due primarily to  $^{90}\text{Sr}$ .

For comparison, the maximum individual would also receive each year approximately 72 mrem from background external radiation (page 39), 11 mrem from naturally occurring  $^{40}\text{K}$  in milk (1000 pCi/l from Table 12 and 274 liters of milk), 7 mrem from  $^{40}\text{K}$  in fish (4 pCi/gr from Table 15 and 40 kilograms of fish), approximately 4 mrem from fallout radionuclides<sup>4</sup>, and additional exposure from other natural sources not calculated. Therefore, the maximum individual would have received an additional dose which is 0.02% of the background dose of 103 mrem/year in the Hanford environs during 1975 due to Hanford operations.

#### 80-Kilometer Radius Population Dose

The total body population dose received during 1975 by the population within an 80-kilometer (50-mile) radius of the Hanford Reservation and the 50-year dose commitment from effluent released during 1975 were estimated for all of the radionuclides listed in Table 23. Table 26 lists the population dose received during 1975 by the total body, bone, GI-LLI (Gastro-Intestinal tract - Lower Large Intestine), lung, and thyroid. The estimated total body population dose received by the approximate 250,000 people living within the 80-kilometer radius during 1975 was 0.9 man-rem or an average annual dose per capita of  $4 \times 10^{-3}$  mrem. This dose is primarily due to external irradiation from  $^{41}\text{Ar}$ . The dose received by the bone, GI-LLI, and lung is due primarily to external irradiation. The dose to the thyroid is primarily due to isotopes of iodine released to the atmosphere and Columbia River. The population thyroid dose was estimated to be 2.8 man-thyroid-rem during 1975.

Table 27 lists the 50-year dose commitment (1975 to 2024, inclusive potentially received by the 250,000 people from effluents released during 1975. The total-body population dose commitment was estimated to be 1.5 man-rem, the 0.6 man-rem received by the population after 1975 is primarily from  $^{90}\text{Sr}$ ; with a contribution from  $^{239}\text{Pu}$ . The 50-year dose commitment to the thyroid is all received during 1975 since the iodine isotopes which contribute the majority of the thyroid dose have short half-lives and the external exposure

TABLE 26. Estimated Population Dose During 1975 from Effluents Released from Hanford Facilities During 1975

Exposure Mode	Radionuclide	Annual Dose (man-rem)(a)				
		Total Body	Bone	GI-LLI	Lung	Thyroid
<u>Gaseous Effluent</u>						
Air (Inhalation and Submersion)	H-3	2.2x10 <sup>-4</sup>		2.2x10 <sup>-4</sup>	2.2x10 <sup>-4</sup>	2.2x10 <sup>-4</sup>
	Ar-41	0.8	(0.8)(b)	(0.8)	(0.8)	(0.8)
	Sr-90+D	0.02	0.06		0.26	
	Xe-135	0.04	(0.04)	(0.04)	(0.04)	(0.04)
	Pu-239	3.5x10 <sup>-4</sup>	7.9x10 <sup>-3</sup>		5.3x10 <sup>-2</sup>	
	U-Nat	3.0x10 <sup>-4</sup>	2.5x10 <sup>-3</sup>		9.0x10 <sup>-2</sup>	
<u>Radioiodine (Inhalation, Milk, Vegetables)</u>						
	I-131					1.03
	I-132					8.0x10 <sup>-4</sup>
	I-133					0.1
	I-135					0.05
Total Gaseous Pathways		0.86 (c)	0.91 (c)	0.84 (c)	1.2 (c)	2.0 (c)
<u>Liquid Effluent</u>						
Drinking water	(d)	7.4x10 <sup>-3</sup>	7.9x10 <sup>-3</sup>	3.1x10 <sup>-2</sup>	3.2x10 <sup>-3</sup>	0.7
Fish Consumption	(d)	1.3x10 <sup>-3</sup>	1.7x10 <sup>-3</sup>	1.0x10 <sup>-2</sup>	1.8x10 <sup>-4</sup>	9.5x10 <sup>-3</sup>
Aquatic Recreation	(d)	2.9x10 <sup>-3</sup>	(2.9x10 <sup>-3</sup> )	(2.9x10 <sup>-3</sup> )	(2.9x10 <sup>-3</sup> )	(2.9x10 <sup>-3</sup> )
Irrigated Foodstuffs	(d)	1.7x10 <sup>-4</sup>	5.9x10 <sup>-4</sup>	1.4x10 <sup>-3</sup>	1.6x10 <sup>-4</sup>	7.6x10 <sup>-3</sup>
Total Liquid Pathways		1.2x10 <sup>-2</sup>	1.3x10 <sup>-2</sup>	4.5x10 <sup>-2</sup>	6.4x10 <sup>-3</sup>	0.72
TOTAL		0.9	0.9	0.9	1.2	2.7

- (a) Dose received during 1975 from effluent released during 1975.  
 (b) Internal dose from external exposure indicated by parenthesis ().  
 (c) Total is for all radionuclides released to the atmosphere as indicated in Table 23.  
 (d) Radionuclides released to the river as listed in Table 23.

sources are no longer present after 1975. The 50-year dose commitment for the G.I. tract is also all received in 1975 since there is no accumulation of material within the tract. The estimated 50-year dose commitments to the bone and lung are 4.2 (man-bone-rem) and 2.6 (man-lung-rem), respectively. The doses received by these two organs after 1975 are due primarily to <sup>90</sup>Sr and <sup>239</sup>Pu.

For comparison the population receives approximately 25,000 man-rem total body dose each year from background radiation (total: external plus internal). The dose received by the population during 1975 from Hanford operations was an addition of about 0.004% of the background dose. Assuming the people within 80 kilometers of the Hanford Reservation are typical of the national average, they probably received total body population doses of 5,100 man-rem

**TABLE 27. Estimated 50-Year Population Dose Commitment from Effluents Released from Hanford Facilities During 1975**

Exposure Mode	Dose Commitment (man-rem) <sup>(a)</sup>					
	Radionuclide	Total Body	Bone	GI-LLI	Lung	Thyroid
<u>Gaseous Effluent</u>						
Air (Inhalation and Submersion)	H-3(HTO)	2.2x10 <sup>-4</sup>	--	2.2x10 <sup>-4</sup>	2.2x10 <sup>-4</sup>	2.2x10 <sup>-4</sup>
	Ar-41	0.8	(0.8) <sup>(b)</sup>	(0.8)	(0.8)	(0.8)
	Sr-90+D	0.63	2.6	---	1.1	---
	Xe-135	0.04	(0.04)	(0.04)	(0.04)	(0.04)
	Pu-239	0.04	0.8	---	0.24	---
	U-Nat	5.6x10 <sup>-4</sup>	9.0x10 <sup>-3</sup>	---	0.42	---
Radioiodine (Inhalation, Milk, Vegetables)	I-131					1.03
	I-132					8.0x10 <sup>-4</sup>
	I-133					0.1
	I-135					0.05
Total Gaseous Pathways		1.5 <sup>(c)</sup>	4.2	0.8	2.6	2.0
<u>Liquid Effluent</u>						
Drinking Water	(d)	2.3x10 <sup>-2</sup>	6.4x10 <sup>-2</sup>	6.5x10 <sup>-2</sup>	3.2x10 <sup>-3</sup>	0.7
Fish Consumption	(d)	2.9x10 <sup>-3</sup>	8.2x10 <sup>-3</sup>	1.0x10 <sup>-2</sup>	2.0x10 <sup>-4</sup>	9.5x10 <sup>-3</sup>
Aquatic Recreation	(d)	3.0x10 <sup>-3</sup>	(3.0x10 <sup>-3</sup> )	(3.0x10 <sup>-3</sup> )	(3.0x10 <sup>-3</sup> )	(3.0x10 <sup>-3</sup> )
Irrigated Foodstuffs	(d)	2.8x10 <sup>-3</sup>	1.6x10 <sup>-2</sup>	1.0x10 <sup>-2</sup>	1.6x10 <sup>-4</sup>	6.3x10 <sup>-2</sup>
Total Liquid Pathways		3.2x10 <sup>-2</sup>	9.1x10 <sup>-2</sup>	8.8x10 <sup>-2</sup>	6.6x10 <sup>-3</sup>	0.78
TOTAL		1.5	4.2	0.9	2.6	2.8

- (a) Dose commitment for 50 years (1975-2024, inclusive) from effluents released during 1975.
- (b) Internal dose from external exposure indicated by parenthesis ( ).
- (c) Total is for all radionuclides released to the atmosphere as indicated in Table 23.
- (d) Radionuclides released to the river as listed in Table 23.

from medical exposures, 250 man-rem from jet air travel, 25 man-rem from television receivers, and 370 man-rem from miscellaneous consumer products during 1975.<sup>12</sup>

In summary, the maximum "fence-post" exposure rate was calculated to be 6x10<sup>-6</sup> mR/hr along the northwest boundary of the Hanford site. The total body dose received by the maximum individual during 1975 and the 50-year dose commitment from effluent released during 1975 are 0.01 mrem and 0.02 mrem, respectively. The total-body dose potentially received by the assumed 250,000 people living within an 80 kilometer radius of the Hanford site during 1975 and the 50-year dose commitment from effluents released during

1975 are 0.9 man-rem and 1.5 man-rem, respectively. For comparison, the total background dose (external and internal) received by all members of the population in the Hanford region is approximately 100 mrem per year, resulting in a population dose of 25,000 man-rem.

#### RADIOLOGICAL IMPACT FROM OBSERVED RADIOACTIVITY DUE TO PAST HANFORD OPERATIONS

Previous sections (Columbia River, Wildlife, Soil and Vegetation) concerned with the evaluation of monitoring data collected during 1975 discussed the presence of radioactivity, primarily  $^{60}\text{Co}$ , in Columbia River sediments, wildlife, and soil on the Columbia River islands due to past once-through cooling production reactor operation at Hanford. The last of these reactors was deactivated in January 1971. Radioactivity released to the river from these reactors became attached to sediments in the river. The observed radioactivity has steadily decreased due to radioactive decay and dilution.

During the spring of 1974, an aerial survey of the Columbia River shoreline and islands was conducted by EG&G of Las Vegas, Nevada.<sup>9</sup> This survey covered an area from approximately four kilometers above Vernita Bridge to approximately ten kilometers below the intersection of the Snake River with the Columbia River. The highest radiation level observed offsite during this survey occurred on the islands between the old Hanford townsite and the 300 Area. A maximum reading of 0.014 mR/hr of  $^{60}\text{Co}$  was obtained. This exposure rate will have decreased since 1974 due to radioactive decay ( $^{60}\text{Co}$  has a 5.3 year half-life) and dilution by the river. However, since no measurement was made in 1975, the 1974 value of 0.014 mR/hr is assumed to be still applicable.

During 1975, the levels in fish and gamebirds were occasionally detected at levels near the detection limit of the analyses. Levels of  $^{65}\text{Zn}$  in Willapa Bay oysters continued to decrease and are now five-hundred-fold less than during the early part of 1970. The majority of radioactivity observed in Columbia River water due to past Hanford operations is attached to resuspended sediment, and the levels observed during 1975 were generally lower than those observed during 1974.

The contribution of these sources of radioactivity to the maximum "fence-post" exposure rate, maximum individual dose, and 80-kilometer population dose calculated from 1975 effluent, range from insignificant to predominant. The maximum "fence-post" exposure rate calculated from 1975 effluent was  $6 \times 10^{-6}$  mR/hr along the uninhabited northwest boundary of the Hanford site. The highest external exposure rate measured on the Columbia River islands<sup>9</sup> was much greater than the exposure rate calculated for the northwest boundary. The contribution of the radioactivity observed on some of the islands to the dose received by an individual would depend on the amount of time spent by the individual on the islands and where the time was spent. The distribution of radioactivity on the islands from Hanford operations is quite variable. Assuming an individual was at the point of highest observed external exposure rate, an external dose of approximately 0.014 mrem/hr would be received in addition to background external radiation. It is unlikely that anyone would spend more than a few hours each year on the islands. The contribution to the population dose received during 1975 is an insignificant numerical addition to the previously calculated dose of 0.9 man-rem from 1975 effluents due to the low levels of radioactivity involved, the remoteness of the islands, and the small number of people potentially affected.

## STANDARDS

Operations at the Hanford site must conform to a variety of Federal and State standards designed to insure 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.<sup>2</sup> Of interest to Hanford operations is the designation of the Hanford reach of the Columbia River as Class A or excellent. This designation requires the water to be usable for substantially all needs including sanitary water, recreation, and wildlife. Air quality standards have been promulgated by both the State of Washington<sup>2</sup> and the EPA.<sup>3</sup>

Environmental radiation protection standards are published in Manual Chapter 0524, "Standards for Radiation Protection"<sup>1</sup> of ERDA. These standards are based on guidelines recommended by the President's Federal Radiation Council (FRC), whose functions have been assigned to the EPA, 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 ionizing radiation exposure to ERDA and ERDA contractor personnel and to members of the public who may be exposed to ionizing radiation resulting from ERDA and ERDA contractor operations.

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

- (1) State of Washington  
Department of Ecology  
Olympia, WA 98504
- (2) U. S. Environmental Protection Agency, Region 10  
1200 Sixth Avenue  
Seattle, WA 98101
- (3) Energy Research and Development Administration  
Richland Operations Office  
P. O. Box 999  
Richland, WA 99352

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APPENDIX A

SYNOPSIS OF FILTER-RESIN SAMPLING METHOD



## APPENDIX A

### SYNOPSIS OF FILTER-RESIN SAMPLING METHOD

This method involves running a known quantity of river water through a nylon filter, a series of fiberglass filters, and a mixed-bed ion exchange column. The sampler operates continuously during which the river water flows (~3 liters/hour) through the nylon filter which removes all macro (>5 microns) particles, through the series of fiberglass filters which remove all particles greater than 0.3 microns, and then the filtered water flows through the resin to remove all soluble radionuclides with the exception of tritium. The filters and resin are changed biweekly and directly counted with a high sensitivity multi-dimensional (coincidence) gamma ray spectrometer to measure the different radionuclides. This method results in a much lower detection level and separates the collected radioactivity into a particulate fraction (collected on filters) and a soluble fraction (absorbed on resin).



APPENDIX B

RADIOCHEMICAL ANALYSES



## APPENDIX B

### RADIOCHEMICAL ANALYSES

The majority of the routine environmental radioanalyses for the Hanford program are performed by the U. S. Testing Company in Richland, Washington. Analytical limits are specified in a services contract between U. S. Testing and the Energy Research and Development Administration (ERDA). The term "analytical limit" is contractually defined as the concentration at which the laboratory can measure a radionuclide with an accuracy of  $\pm 100\%$  at the 90% confidence level given the required volume of sample material. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and amounts of interfering radionuclides present. The "analytical limits" represent upper bounds to the fluctuating detection limits.

U. S. Testing maintains an internal quality control program consisting of routine instrument calibration and background counts to insure the integrity of their results. They also participate in the Interlaboratory Comparison program of the Environmental Protection Agency (EPA) involving the analysis of several environmental media (milk, water and air) and a variety of radionuclides of interest. A number of different environmental samples, containing known amounts of one or more radionuclides, are prepared and routinely distributed to all laboratories in the program. These laboratories perform the required analyses (3 separate determinations) and return their results to EPA for comparison with the known value and the results from the other laboratories. If there is an error in the preparation of any sample, the results from the different laboratories should form a consensus around the correct value. In this manner, the program enables a laboratory to document the precision and accuracy of their results relative to the other laboratories.

The data in the following table and figures have been supplied by U. S. Testing and provide a comparison between their reported results, the results from other laboratories, and the EPA value for each analysis. The EPA samples are generally at least a factor of 10, and in some cases 1000,

higher than the routine environmental samples. Since the preparation and analysis of environmental samples with levels of radioactivity near the background levels present in the environment is quite difficult, the requirement for extensive data to prevent unrealistic reliance on any single result is of particular importance.

TABLE B-1. Interlaboratory Comparison of Analytical Results<sup>(a)</sup>

Medium	Date	Isotope	Concentration <sup>(b)</sup>		
			UST <sup>(c,d)</sup>	Expected <sup>(d)</sup>	Other <sup>(e)</sup> Labs
Milk	1/15/75	<sup>40</sup> K	1370±210	1510±228	1486±330
		<sup>90</sup> Sr	70±5.0	75±11.4	71±30
		<sup>131</sup> I	100±60	101±15.3	104±24
		<sup>137</sup> Cs	90±45	75±15	77±27
	3/14/75	<sup>40</sup> K	1575±240	1514±228	1504±330
		<sup>89</sup> Sr	0±8	(f)	
		<sup>90</sup> Sr	39±5.0	50±7.5	47±33
		<sup>131</sup> I	84±96	76±15	79±33
		<sup>137</sup> Cs	51±44	50±15	53±18
	5/9/75	<sup>40</sup> K	1588±240	1514±228	1525±264
		<sup>90</sup> Sr	26±4.0	25±4.5	23±12.0
		<sup>131</sup> I	29±96	49.8±15	47±21
		<sup>137</sup> Cs	22±44	24.9±15	27±12
	11/7/75	<sup>40</sup> K	1500±225	1549±233	1528±369
		<sup>89</sup> Sr	34±15	(f)	
		<sup>90</sup> Sr	77±6	74.6±11.2	71±21
<sup>131</sup> I		72±96	75±15	74±30	
<sup>137</sup> Cs		69±60	75±15	77±21	
Air Filter	2/28/75	<sup>90</sup> Sr	140±9	159±24	164±72
		<sup>137</sup> Cs	162±30	151±22.5	161±57
		Alpha	148±9	149.5±112.2	144±126
		Beta	542±19	470±72	506±210
	6/27/75	<sup>137</sup> Cs	143±27	135±26	142±51
		Alpha	109±8	123±92	128±78
		Beta	379±9	371±56	389±132
	9/19/75	<sup>137</sup> Cs	83±23	99±15	96±33
		Alpha	62±5.5	99±74.3	89±66
		Beta	266±12	295±44	304±87
	12/26/75	<sup>90</sup> Sr	33.5±4	38±5.7	36±21
		<sup>137</sup> Cs	24.7±23	25±15	28±21
Alpha		33.4±4.4	38±28.5	40±21	
Beta		109±10	101±15	107±24	

TABLE B-1. (Cont.)

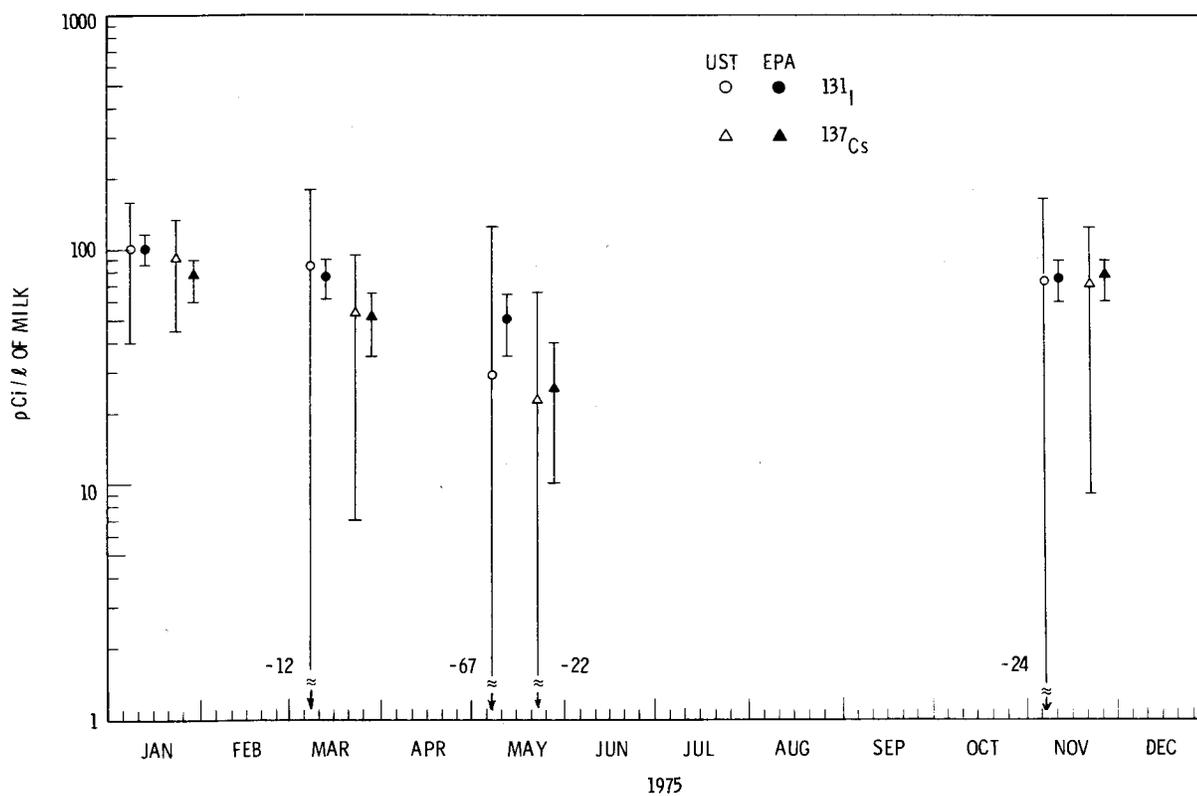
Medium	Date	Isotope	Concentration <sup>(b)</sup>		
			UST <sup>(c,d)</sup>	Expected <sup>(d)</sup>	Other <sup>(e)</sup> Labs
Water	1/31/75	Alpha	18±6	25±19	22±27
		Beta	69±13	95±15	97±13
	2/14/75	<sup>3</sup> H	3027±470	2803±1050	2796±903
	2/21/75	<sup>60</sup> Co	327±163	437±66	443±75
		<sup>65</sup> Zn	458±83	472±71	481±180
		<sup>106</sup> Ru	276±285	(f)	
		<sup>134</sup> Cs	475±270	422±63	418±150
		<sup>137</sup> Cs	420±45	472±71	473±132
	3/28/75	Alpha	93±19	98±76.5	76±90
		Beta	23±8	26±15	39±36
	4/11/75	<sup>3</sup> H	2490±467	1499±1002	1549±525
	4/18/75	<sup>60</sup> Co	366±33	425±64	425±93
		<sup>65</sup> Zn	424±195	497±75	502±147
		<sup>106</sup> Ru	491±270	497±75	495±156
		<sup>134</sup> Cs	272±68	400±60	407±93
		<sup>137</sup> Cs	402±38	450±68	455±111
	5/30/75	Alpha	45±8	40±30	32±42
		Beta	42±10	60±15	63±42
	6/13/75	<sup>3</sup> H	2591±600	2204±1044	2184±951
	6/20/75	<sup>60</sup> Co	287±32	350±53	341±123
		<sup>65</sup> Zn	308±48	327±49	349±63
		<sup>106</sup> Ru	373±72	325±49	334±129
		<sup>134</sup> Cs	251±23	304±46	302±75
		<sup>137</sup> Cs	239±26	378±57	382±78
	7/25/75	Alpha	86±10	85.7±64.3	65±63
		Beta	9±8	(f)	
	8/15/75	<sup>3</sup> H	2193±225	3200±1083	3185±882
	8/22/75	<sup>51</sup> Cr	513±375	255±38	278±177
		<sup>60</sup> Co	581±129	307±46	305±66
		<sup>65</sup> Zn	533±180	281±42	293±111
		<sup>106</sup> Ru	616±300	379±57	369±180
		<sup>134</sup> Cs	404±105	256±38	254±27
		<sup>137</sup> Cs	391±90	305±29	307±46

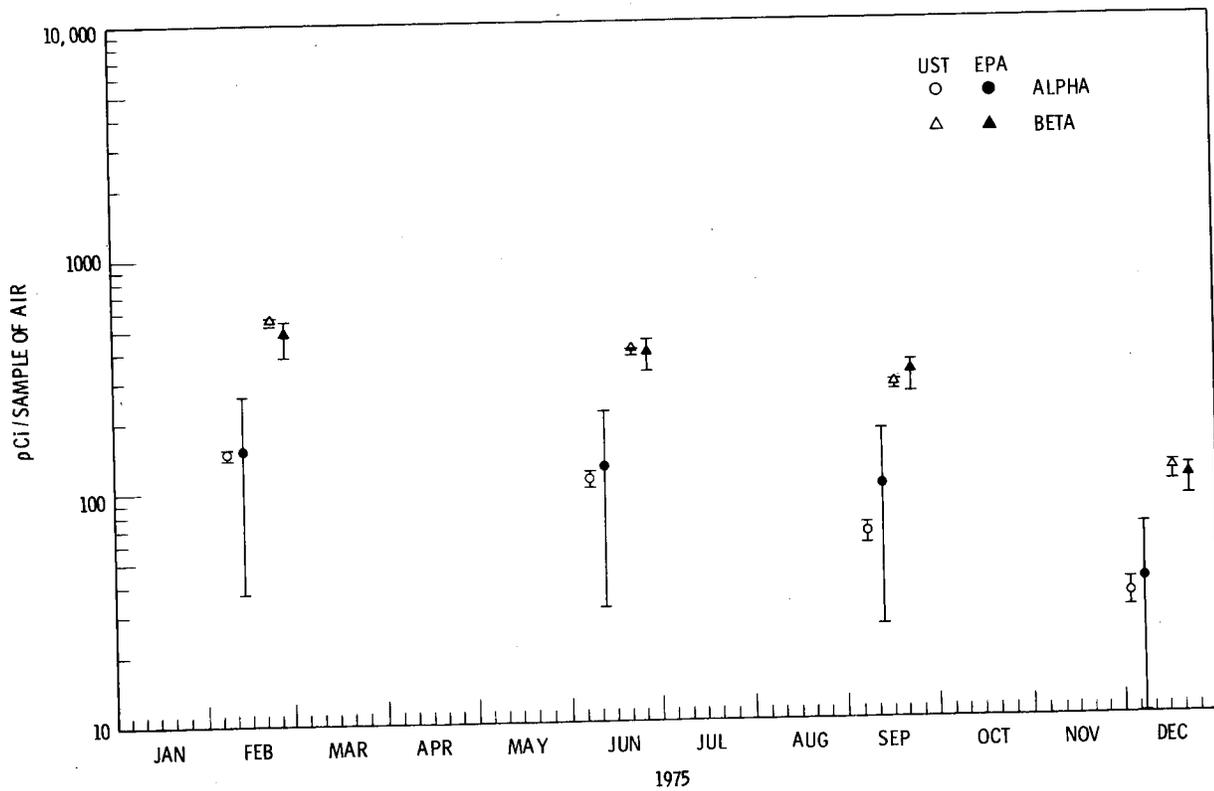
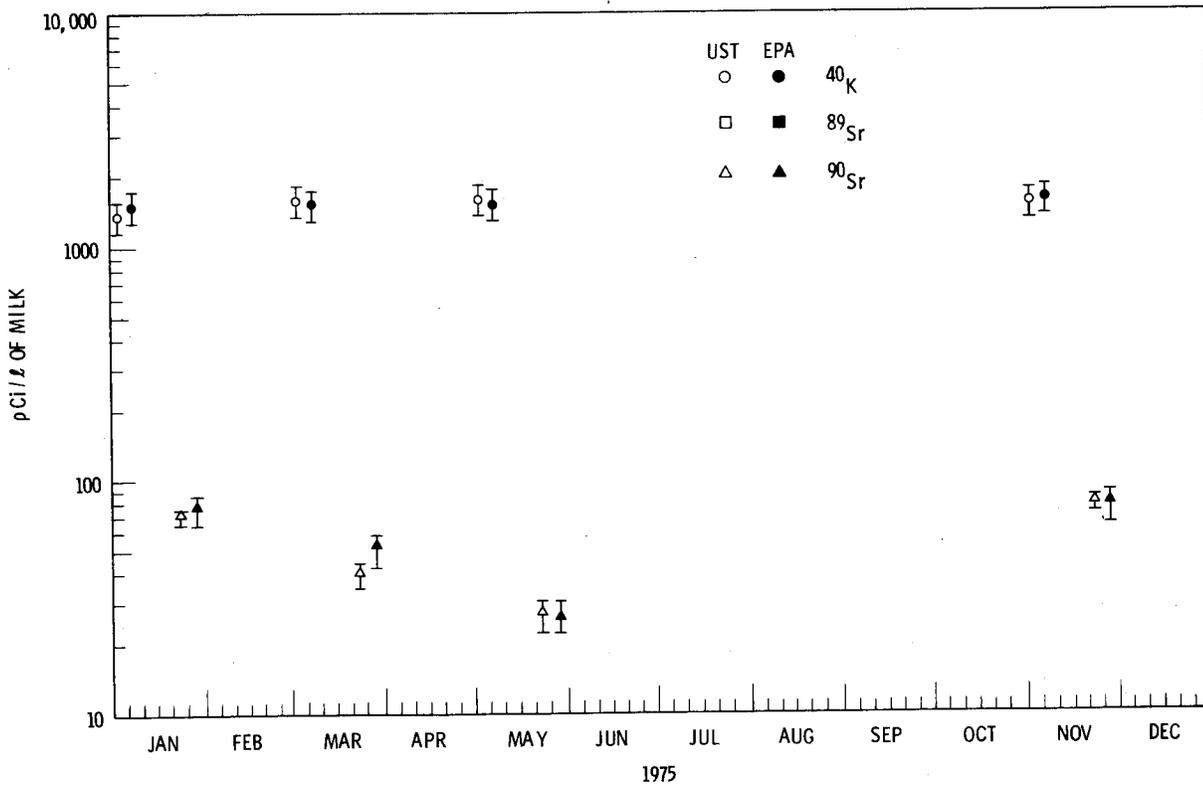
TABLE B-1. (Cont.)

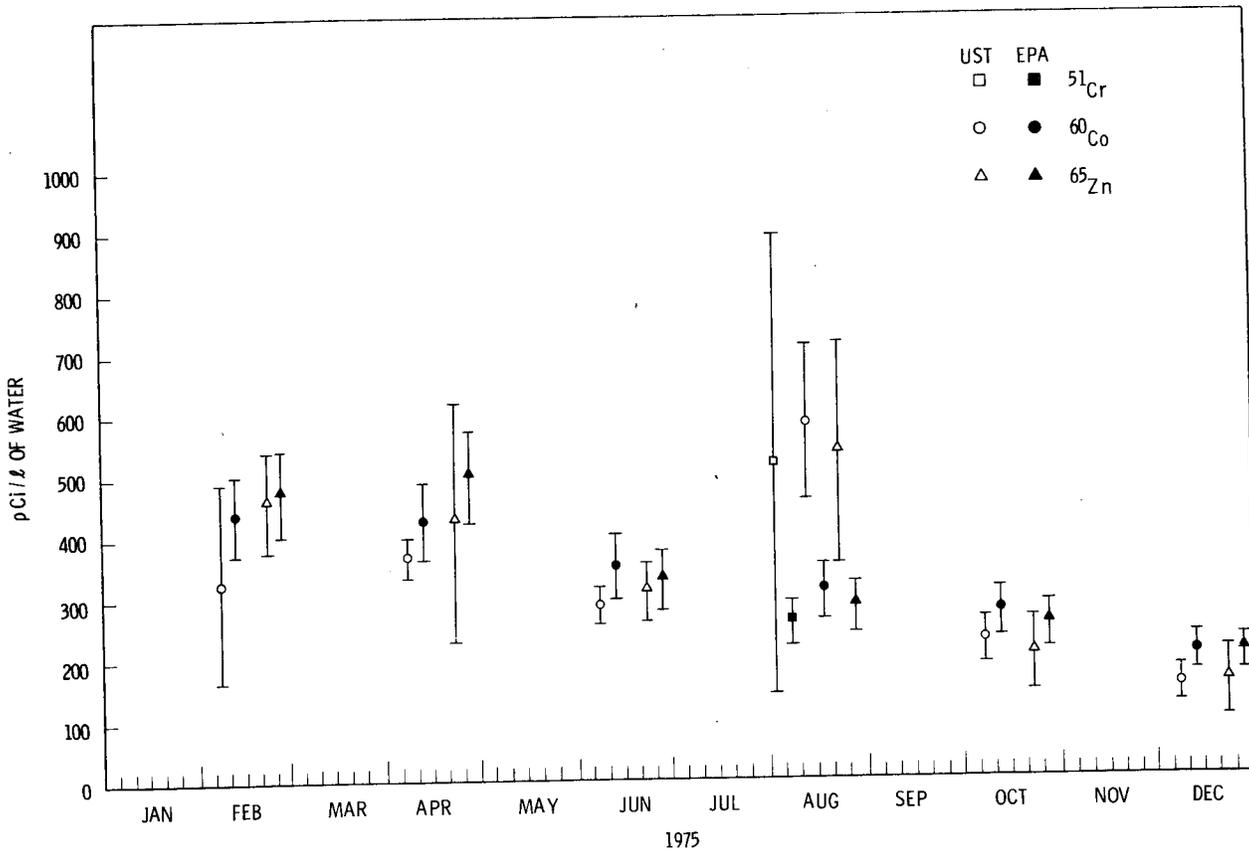
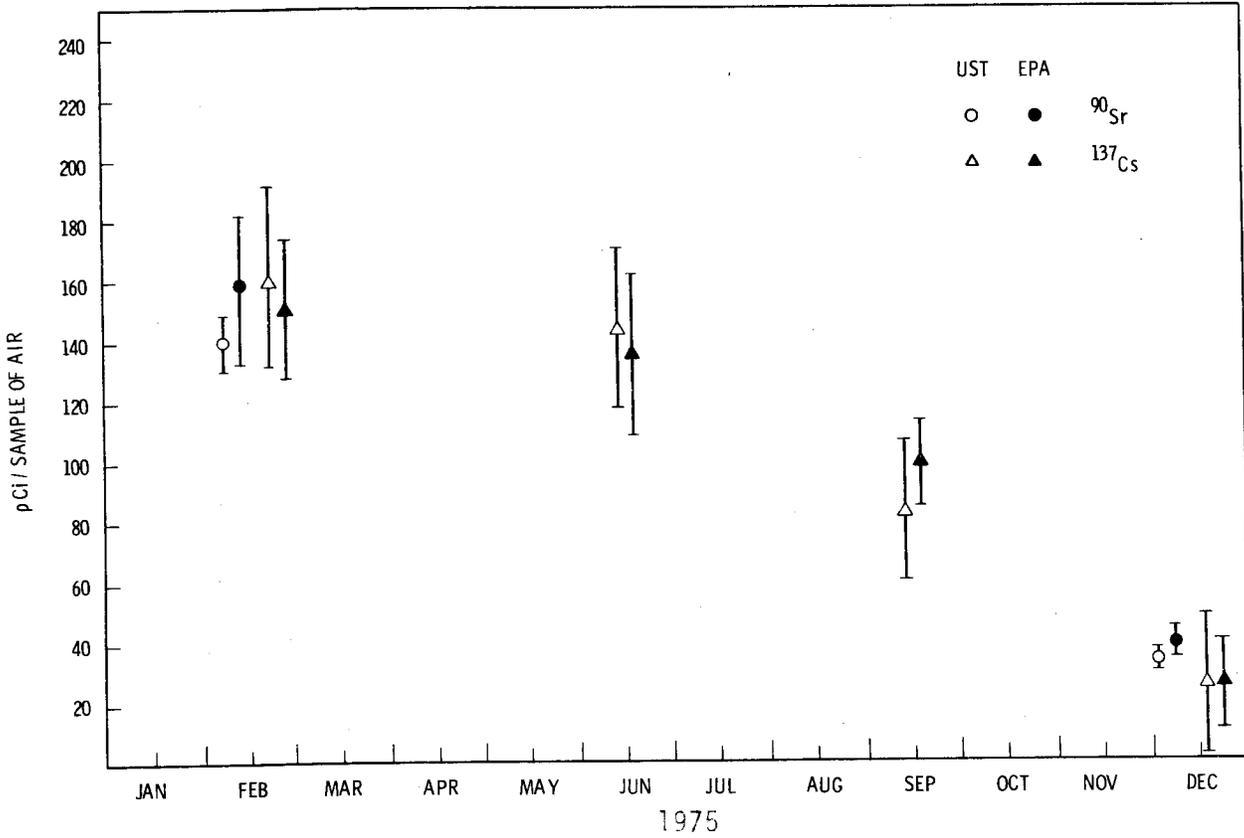
Medium	Date	Isotope	Concentration <sup>(b)</sup>		
			UST <sup>(c,d)</sup>	Expected <sup>(d)</sup>	Other <sup>(e)</sup> Labs
Water	9/26/75	Alpha	0.35±3.0	(f)	
		Beta	40±15	52±15	49±21
	10/17/75	<sup>3</sup> H	1130±450	1203±975	1304±837
	10/24/75	<sup>60</sup> Co	225±38	271±41	277±39
		<sup>65</sup> Zn	202±60	250±38	250±99
		<sup>106</sup> Ru	181±270	247±37	259±108
		<sup>134</sup> Cs	250±117	349±52	344±66
		<sup>137</sup> Cs	177±38	274±41	275±69
	11/21/75	Alpha	28±7	31±23	27±24
		Beta	59±18	31±15	34±18
	12/19/75	<sup>60</sup> Co	151±30	203±31	206±51
		<sup>65</sup> Zn	154±57	201±30	201±87
		<sup>106</sup> Ru	190±270	181±27	191±90
		<sup>134</sup> Cs	188±117	202±30	195±51
		<sup>137</sup> Cs	123±32	151±23	153±51

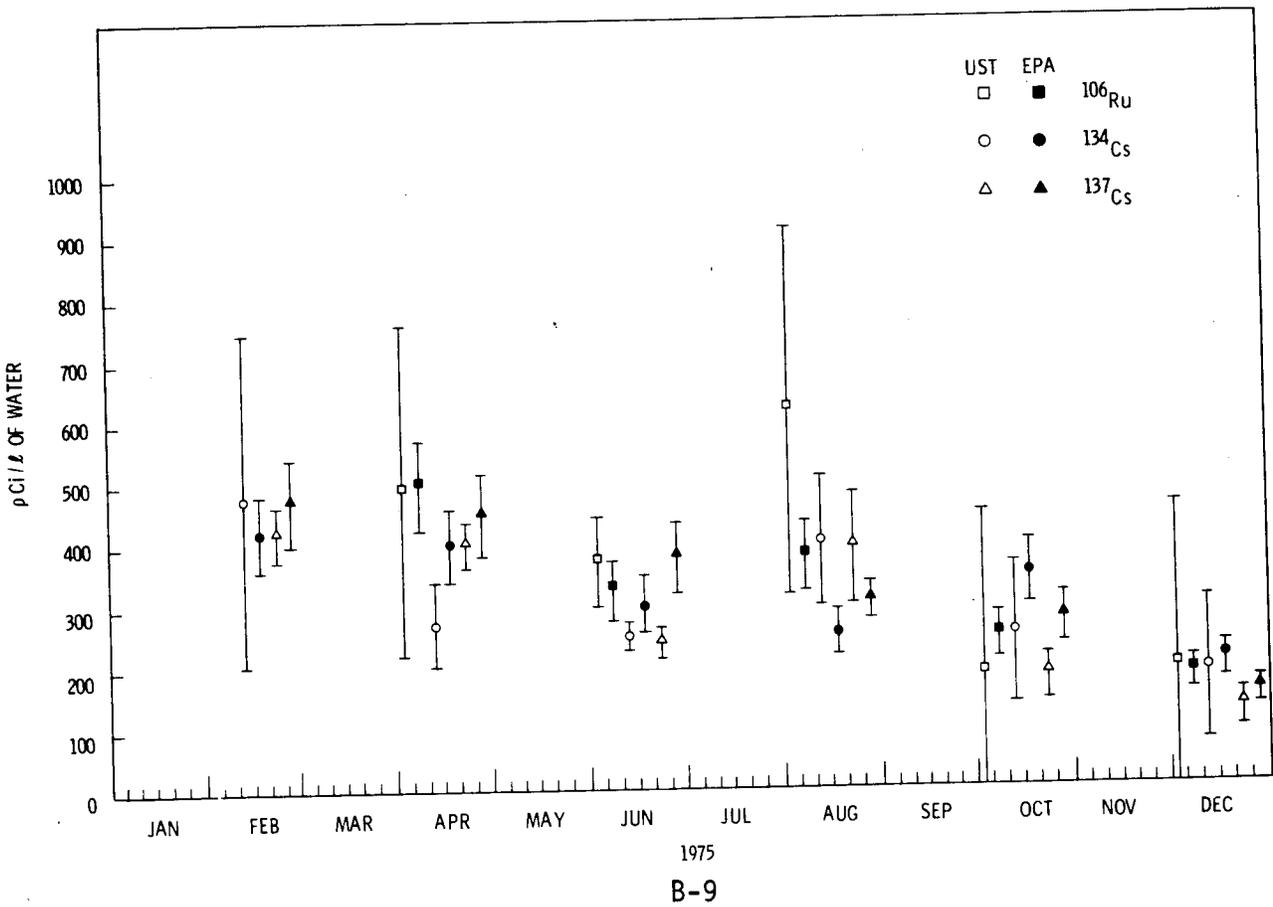
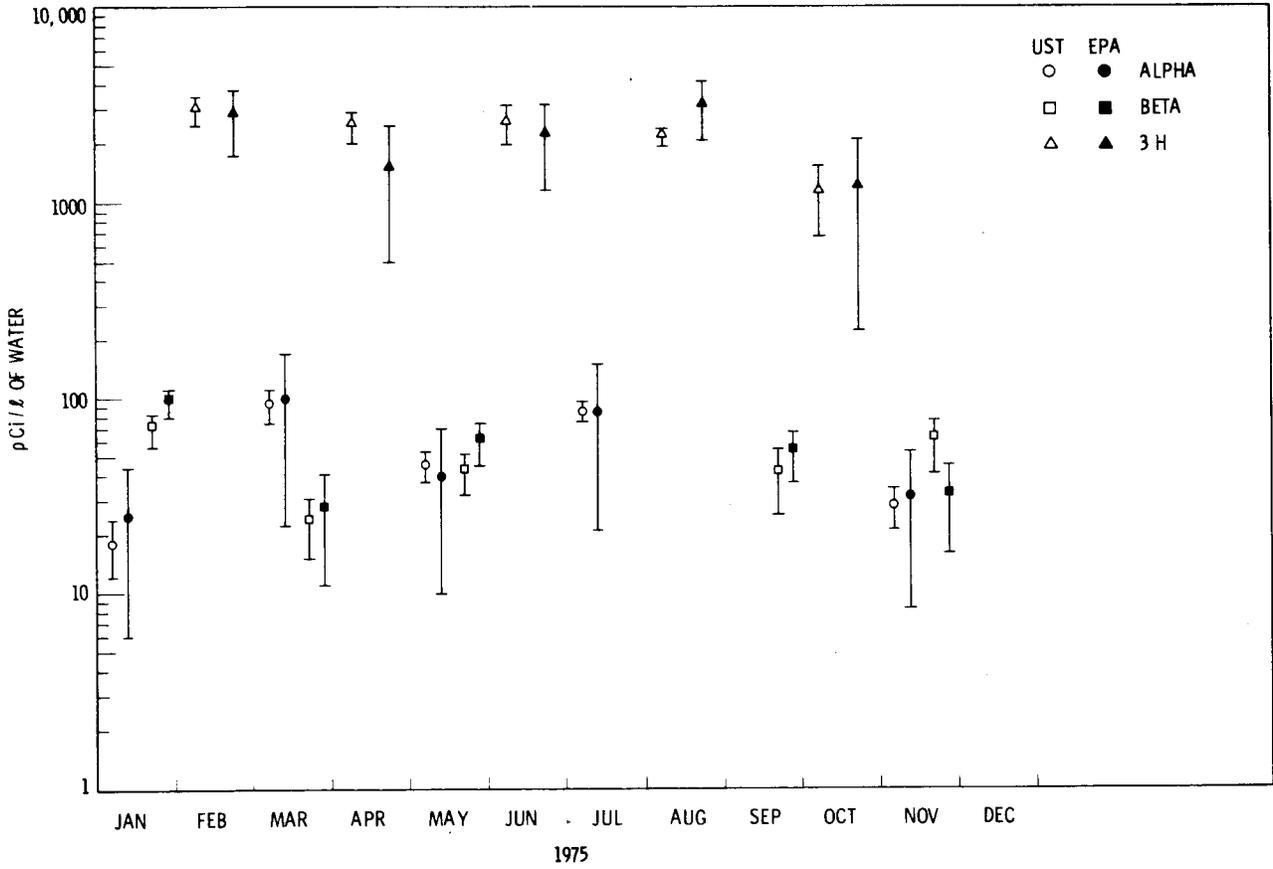
- (a) The Environmental Protection Agency prepares spiked samples and distributes them to radiochemistry laboratories who wish to participate in the inter-laboratory comparisons.
- (b) PicoCuries per liter for water and milk; picoCuries per sample for air.
- (c) United States Testing Co., Richland, Washington.
- (d) Concentration plus or minus three sigma based on counting statistics.
- (e) Average concentration plus or minus three sigma based upon range of values encountered.
- (f) Sample was not spiked with the nuclide.

The following tables demonstrate the relative accuracy of analyses by U. S. Testing of various isotopes in air, water and milk at the three sigma (99.9%) confidence level.











APPENDIX C

HANFORD ENVIRONMENTAL HEALTH FOUNDATION'S  
CHEMISTRY LABORATORY CERTIFICATION



# AMERICAN INDUSTRIAL HYGIENE ASSOCIATION



This Certifies That the  
Environmental Health Sciences Laboratory  
Harvard Environmental Health Foundation

Has Met

the American Industrial Hygiene Association's  
Standards of Accreditation and is

Hereby Accredited Until June 1, 1977

James O'Leary  
Chairman  
Laboratory Accreditation Committee

Accreditation Number 14  
Date JUNE 1, 1974

John P. Guay  
President  
American Industrial Hygiene Association

Richard E. White  
Coordinator of Laboratory Accreditation



APPENDIX D

GLOSSARY OF TERMS



## APPENDIX D

### Glossary of Terms

**Analytical detection limit:** That value below which a concentration of a contaminant cannot be determined with at least a 95% accuracy; usually 3 times the background level of the contaminant.

**BOD:** Biochemical Oxygen Demand is the oxygen required during stabilization of the decomposable organic matter by aerobic bacterial action in water or wastewater.

**Coliform:** All microorganisms that ferment lactose and produce gas. Used herein as an indicator for the possible presence of sewage in water.

**Curie (Ci):** The special unit of radioactivity. One curie equals  $3.700 \times 10^{10}$  nuclear transformations per second.

**Dosimeter:** A device for measuring the quantity of radiation or energy absorbed.

**Effluent:** Material released from a facility in one of its waste streams. Usually refers to non-natural waste material streams such as carbon dioxide or Cobalt-60.

**Enterococci:** That group of bacteria normally found in the intestine of man and animals. Used herein as a positive indicator of sewage contamination of waters.

**Micro ( $\mu$ ):** A prefix meaning one millionth of.

**Milli (m):** A prefix meaning one thousandth of.

**Nitrate:** Any compound containing the univalent group -  $\text{ONO}_2$  or  $\text{NO}_3$ ; used here to refer to the presence of untreated sewage or commercial fertilizer residue from agricultural practices.

**pH:** A measure of the acidity or alkalinity of a water solution; neutral is 7, acids are less than 7 and alkalies are greater than 7.

**Pico (p):** A prefix meaning one million millionths of.

**Rad:** The unit of absorbed radiation dose equal to 0.01 Joules per kilogram in any material.

**Rem:** A special unit of radiation dose equivalent. The dose in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor, and any other necessary modifying factors.

## Glossary of Terms (Con't)

Roentgen: The special unit of radiation exposure. One roentgen equals  $2.58 \times 10^{-4}$  coulomb per kilogram of air.

Spectrometry: Used herein to refer to a process by which gamma or X rays emitted from a radioactive sample can be measured and categorized according to their energy and intensity. The process uses a crystal that emits light, when struck by a gamma or X ray, in proportion to the energy of the ray and an electronic analyzer which receives the light pulses, categorizes them, and stores them for later analysis.

Thermoluminescent: Refers to a material with the ability to store energy and release it in the form of light when heated. Used herein to refer to a type of crystal used as a dosimeter to measure the amount of X or gamma energy absorbed in a specified amount of time.

Turbidity: An expression of an optical property of the fine suspended matter in water. Pure distilled water would equal 0.

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