

LIBRARY OF
E. G. WATSON
NO.

BNWL-1910
UC-41
Special
Distribution

ENVIRONMENTAL SURVEILLANCE
AT HANFORD FOR CY-1974



Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

APRIL 1975

Prepared for the U.S. Atomic Energy
Commission under Contract AT(45-1):1830

BNWL-1910

NOTICE

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

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Under Contract AT(45-1)-1830

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5385 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy \$5.45; Microfiche \$3.25

BNWL-1910
UC-41

ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1974

Compiled
by

Jack J. Fix

Occupational and Environmental Safety Department

April 1975

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 1974.

CONTENTS

| | |
|---|----|
| FOREWORD. | ii |
| LIST OF FIGURES | v |
| LIST OF TABLES. | v |
| INTRODUCTION | 1 |
| SUMMARY | 7 |
| ENVIRONMENTAL SAMPLE COLLECTION, ANALYSIS, AND EVALUATION | 10 |
| General | 10 |
| Air. | 11 |
| <i>Radiological Evaluation</i> | 11 |
| <i>Nonradiological Evaluation</i> | 15 |
| Water | 17 |
| Columbia River | 17 |
| <i>Radiological Evaluation</i> | 18 |
| <i>Nonradiological Evaluation</i> | 20 |
| Sanitary Water | 23 |
| <i>Radiological Evaluation</i> | 24 |
| <i>Nonradiological Evaluation</i> | 25 |
| Groundwater | 25 |
| Foodstuff. | 26 |
| Wildlife | 28 |
| External Radiation Measurement. | 35 |
| Ambient Radiation Dose. | 35 |
| Portable Instrument Surveys | 38 |
| Aerial Surveys | 39 |
| RADIOLOGICAL IMPACT OF HANFORD OPERATIONS. | 41 |

| | |
|---|-----|
| Radiological Impact from 1974 Effluent. | 44 |
| Maximum "Fence-Post" Exposure Rate | 44 |
| Maximum Individual Dose | 44 |
| 80-Kilometer Radius Population Dose | 48 |
| Radiological Impact from Observed Radioactivity Due to Past Hanford Operations | 50 |
| STANDARDS | 52 |
| ACKNOWLEDGMENT | 53 |
| APPENDIX A | |
| Radiochemical Analysis | A-1 |

LIST OF FIGURES

| | |
|---|----|
| 1. Geographical Location of Hanford and Surrounding Communities in the State of Washington. | 3 |
| 2. Features of Hanford Project and Vicinity | 4 |
| 3. Hanford Environmental Air Sampling Locations During 1974. | 12 |
| 4. Monthly Average Gross Beta Activity in the Atmosphere | 14 |
| 5. Columbia River Monthly Temperature at Richland and Priest Rapids Dam for 1974 | 21 |
| 6. Columbia River Daily Flow and Temperature During 1974. | 22 |
| 7. Zn-65 Concentration in Willapa Bay Oysters During 1970 Through 1974 | 30 |
| 8. Soil and Vegetation Sampling Locations During 1974. | 31 |
| 9. Exposure Pathways to Man | 42 |

LIST OF TABLES

| | |
|---|----|
| 1. Radioactivity in Air. | 13 |
| 2. Concentration of Specific Radionuclides in Air | 16 |
| 3. Hanford Environs Air Quality Measurements. | 17 |
| 4. Routine Analyses of Columbia River Water | 18 |
| 5. Concentrations of Radionuclides in the Columbia River. | 19 |
| 6. Columbia River Biological Analyses | 22 |
| 7. Columbia River Chemical Analyses. | 23 |
| 8. Radiological and Chemical Analyses of Drinking Water | 24 |
| 9. Groundwater Analyses from Wells in the Vicinity of Hanford | 25 |
| 10. Concentrations of Radionuclides in Milk | 26 |
| 11. Concentrations of Radionuclides in Meat, Chicken, and Eggs. | 27 |

LIST OF TABLES (Cont.)

| | | |
|-----|--|-----|
| 12. | Concentrations of Radionuclides in Leafy Vegetables | 27 |
| 13. | Concentrations of Radionuclides in Muscle Tissue of Selected Wildlife Obtained from the Hanford Environs | 29 |
| 14. | Concentrations of Radionuclides in Vegetation | 32 |
| 15. | Concentrations of Radionuclides in Surface Soil. | 33 |
| 16. | Ambient Radiation Dose | 36 |
| 17. | Columbia River Immersion Dose. | 37 |
| 18. | Columbia River Shoreline Dose. | 38 |
| 19. | Gamma Emitting Radionuclides in Island Soil Samples | 40 |
| 20. | Radionuclide Composition of Effluent | 43 |
| 21. | Estimated Dose to the Maximum Individual During 1974 from Effluents Released During 1974. | 46 |
| 22. | Estimated 50 Year Dose Commitment to the Maximum Individual from Effluents Released During 1974. | 47 |
| 23. | Estimated Population Dose During 1974 from Effluent Released During 1974 | 48 |
| 24. | Estimated 50 Year Population Dose Commitment from Effluent Released During 1974 | 49 |
| A-1 | Comparison of Quality Assurance Sample Analyses | A-3 |

ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY1974

Compiled
by
Jack J Fix

INTRODUCTION

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 No. 1 Station. By the end of 1974, N Reactor had supplied steam to produce 27.9 billion kilowatt-hours of electrical energy which was fed to the Bonneville Power Administration grid covering the Pacific Northwest.

During 1974, 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 Reservation.

The Hanford Reservation 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 reactor facilities along the Columbia River in what is 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 Reservation.

The Hanford climate is mild and dry, receiving approximately 16 cm (6.3 in.) of rain 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,

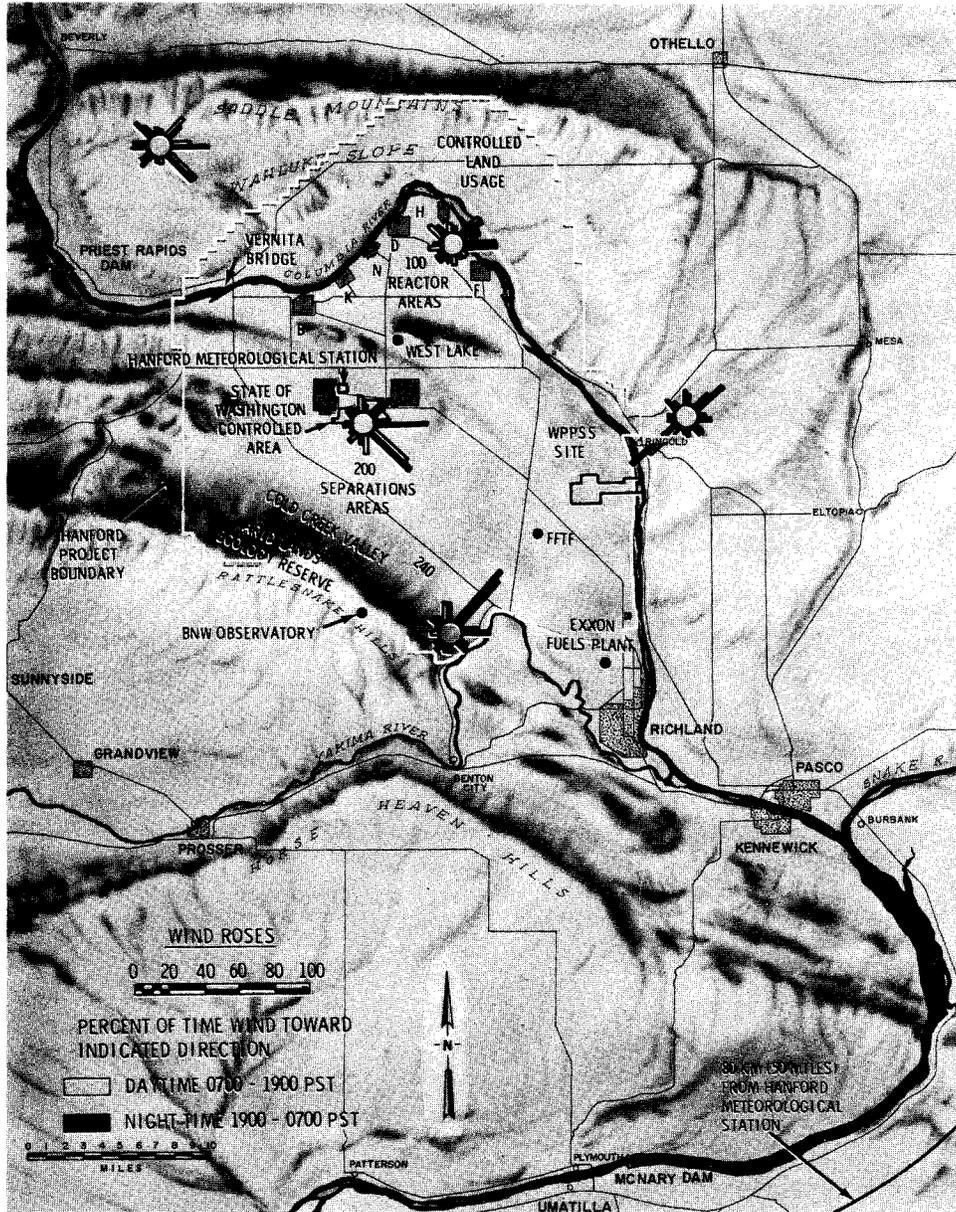


FIGURE 2 Features of Hanford Reservation and Vicinity

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, fallout of nuclear testing debris, 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 1974. Detailed analytical data are published as an addendum (BNWL-1910 ADD).

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 analysis 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.¹ Observed concentrations of nonradioactive pollutants were compared to applicable standards promulgated by the State of Washington² or the Environmental Protection Agency.³

SUMMARY

Environmental data collected during 1974 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 fallout from nuclear detonations in the atmosphere. Air quality measurements of NO₂ in the Hanford environs recorded a maximum yearly average concentration of 0.006 ppm or 12% of the ambient air standard. There was no indication that Hanford operations contributed significantly to these levels. All SO₂ 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 due to 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 exceeded 20°C (68°F) during a few days during the latter part of August and the early part of September. The annual average temperature and 95% confidence interval for Priest Rapids Dam and Richland during 1974 were 11.2±10.9°C and 11.3±11.3°C, respectively, based on 365 daily measurements.

Beginning in 1973, a new method of sampling radioactivity in the Columbia River was added. The method resulted in a much lower analytical detection limit and separates the collected radioactivity into particulate (suspended sediments) and soluble fractions. During 1973 and 1974, radioactivity attached to suspended sediments in the river water due to past once-through cooling production reactor operation was observed. The levels during 1974 were less than 0.01% of ERDA 0524 drinking water standards for all radionuclides due to Hanford operations.

The majority of radioactivity measured in foodstuffs during 1974 was the result of naturally occurring ^{40}K and ^{90}Sr due to fallout. Other radionuclides detected occasionally are believed to be due to worldwide fallout. Radioactivity, notably ^{65}Zn and ^{60}Co from past once-through cooling production reactor operation, was observed in selected wildlife; ^{60}Co was observed in several fish samples, one duck and one goose while ^{65}Zn was observed in several fish samples, one duck, and Willapa bay oysters. 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. 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. Radioactivity from past once-through cooling production reactor operations was associated with the sediment.

External radiation levels in the Hanford environs were measured during 1974 by thermoluminescent dosimeters (TLDs) deployed at 19 different locations, TLDs immersed in the Columbia River at 4 locations, several portable instrument surveys, and an aerial survey by E.G.&G. of Las Vegas. There was not any observable contribution to measured levels of radioactivity at the different locations due to Hanford operations with the exception of ^{60}Co detected on the river islands with the aerial survey. The data collected during 1974 indicate that the average dose and 95% confidence interval received from background radiation in the Hanford environs is approximately 76 ± 15 mrem/year. Adding the approximate 25 mrem received annually due primarily to internal dose from ^{40}K yields an estimate of approximately 101 ± 15 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 1974 has been estimated for three parameters: 1) the maximum "fence-post" exposure rate, 2) the maximum dose to an individual received during 1974 and the 50-year dose commitment due to 1974 effluent, and 3) the population dose received during 1974 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 1974 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 1974 and the 50-year dose commitment to this individual from effluent released during 1974 were 0.03 mrem and 0.05 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.
- The total body dose to the population received during 1974 and the 50-year dose commitment received from effluents released during 1974 were estimated to be 1.1 and 1.6 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. 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, fallout from nuclear detonations in the atmosphere, 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 1974 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 nonradioactive 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}Zn . External radiation levels were measured with environmental dosimeters, portable survey instruments, and aerial surveys.

In evaluating radiological data collected during 1974, 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 nuclear testing 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. For each program, the location of each sampling station, the number of samples collected in 1974, and a summary and interpretation of the data are presented.

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. The following discussion is separated into radiological and nonradiological evaluations of monitoring activities.

Radiological Evaluation

Radioactivity in the atmosphere was sampled by a network of 15 perimeter and 6 distant continuous air samplers during 1974 as shown in Figure 3. Each air sampler maintains a flow of $2.5 \text{ m}^3/\text{hr}$ 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 nearly 100% of the radioactivity associated with airborne dust and both organic and elemental forms of radioiodine. The system does not collect noble gases or tritium. The filters were collected biweekly and analyzed for gross beta and alpha activity after 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}Sr and plutonium.

The results of gross beta, gross alpha, and ^{131}I analyses for perimeter and distant sampling locations are shown in Table 1. The distant stations are sufficiently remote from Hanford operations to insure that observed levels of radiation were due to natural causes or fallout. During 1974, airborne beta concentrations followed the typical annual cycle with a mid-summer maximum and a midwinter minimum. Figure 4 illustrates these annual cycles for the years 1971 through 1974 in which the average monthly beta concentrations observed at eastern quadrant stations, which are located in the predominately downwind direction from Hanford operations, are compared

HANFORD ENVIRONMENTAL AIR SAMPLING NETWORK
(1974)

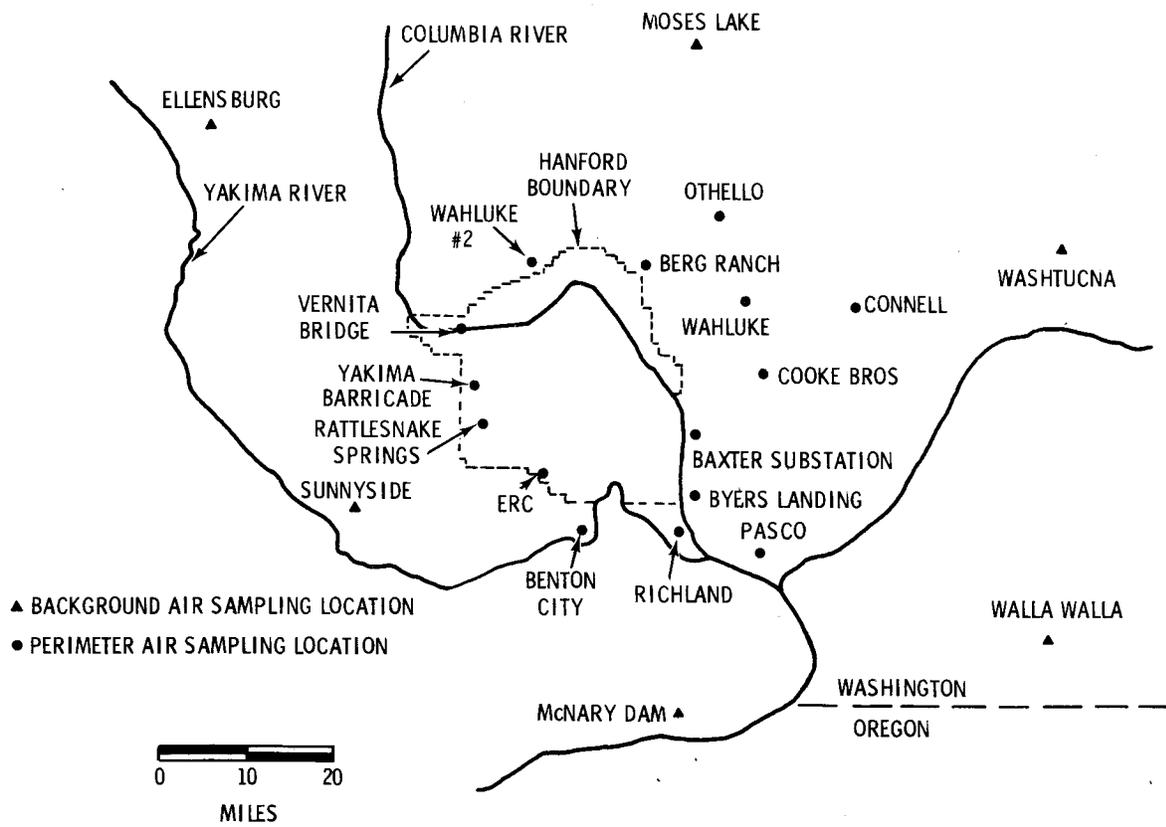


FIGURE 3. Hanford Environmental Air Sampling Locations During 1974

with the concentrations observed at the distant stations. The gross beta concentration in the atmosphere usually begins to rise each spring following an increased rate of transfer of radioactivity (natural and fallout) from the lower stratosphere to the troposphere. The average beta concentration during 1974 observed at all perimeter stations was 1.7×10^{-13} $\mu\text{Ci/ml}$, compared to 1.6×10^{-13} $\mu\text{Ci/ml}$ observed at all distant stations. The highest observed gross beta concentration during 1974, 5.6×10^{-13} $\mu\text{Ci/ml}$, occurred at Benton City on June 25, 1974. During this time, daily samples were being collected to detect an expected increase in fallout radioactivity following a nuclear detonation in the atmosphere by the Peoples Republic of China on June 17, 1974. The observed increases coincided with the usual midsummer maximum (Figure 4) and were only a small addition to the normal background due to natural radioactivity and fallout from previous nuclear detonations in the atmosphere.

TABLE 1. Radioactivity in Air - 1974

| Location | No. of Samples | Concentration (10^{-12} $\mu\text{Ci/ml}$) ^a | | | | | | | | | | |
|------------------------------------|----------------|---|------|--------------------------|----------------------------|-------|---------|----------------|------|------|------|---|
| | | Gross Beta | | | Gross Alpha ^(b) | | | Iodine-131 | | | | |
| | | Max. | Min. | Average | Max. | Min. | Average | No. of Samples | Max. | Min. | Avg. | |
| Analytical Limit | | 0.02 | | | 0.0004 | | | | 0.07 | | | |
| Concentration Guide ^(c) | | 100. | | | 0.03 | | | | 100. | | | |
| Perimeter Stations | | | | | | | | | | | | |
| Baxter Substation | 25 | 0.35 | 0.03 | 0.16±0.19 | | | | | 24 | * | * | * |
| Benton City | 37 | 0.56 | 0.03 | 0.21±0.26 | 37 | 0.04 | * | <0.002 | 27 | * | * | * |
| Berg Ranch | 24 | 0.33 | 0.04 | 0.19±0.16 | 23 | 0.004 | <0.001 | <0.002 | | | | |
| Byers Landing | 36 | 0.48 | 0.04 | 0.21±0.24 | 36 | 0.02 | * | <0.002 | 27 | * | * | * |
| Connell | 24 | 0.33 | 0.03 | 0.14±0.18 | | | | | | | | |
| Cooke Bros. | 27 | 0.31 | 0.03 | 0.13±0.16 | | | | | 26 | * | * | * |
| ERC | 27 | 0.36 | 0.04 | 0.17±0.20 | | | | | | | | |
| Othello | 27 | 0.33 | 0.04 | 0.14±0.18 | | | | | | | | |
| Pasco | 27 | 0.40 | 0.04 | 0.18±0.20 | | | | | | | | |
| Rattlesnake Springs | 27 | 0.35 | 0.05 | 0.17±0.18 | | | | | | | | |
| Richland | 35 | 0.97 | 0.04 | 0.21±0.36 | 37 | 0.004 | * | <0.002 | 27 | * | * | * |
| Vernita Bridge | 27 | 0.33 | 0.03 | 0.17±0.18 | | | | | | | | |
| Wahluke | 26 | 0.36 | 0.01 | 0.16±0.18 | | | | | | | | |
| Wahluke #2 | 25 | 0.34 | 0.02 | 0.16±0.16 | | | | | | | | |
| Yakima Barricade | 25 | 0.36 | 0.03 | 0.17±0.20 | | | | | | | | |
| | | | | 0.17±0.05 ^(d) | | | | | | | | |
| Distant Stations | | | | | | | | | | | | |
| Ellensburg | 16 | 0.28 | 0.04 | 0.15±0.13 | | | | | | | | |
| McNary Dam | 26 | 0.43 | 0.06 | 0.16±0.18 | 25 | 0.005 | * | <0.002 | | | | |
| Moses Lake | 26 | 0.29 | 0.03 | 0.16±0.15 | | | | | | | | |
| Sunnyside | 26 | 0.34 | 0.03 | 0.15±0.16 | | | | | | | | |
| Walla Walla | 22 | 0.48 | 0.04 | 0.18±0.25 | 22 | 0.003 | * | <0.001 | | | | |
| Washtucna | 21 | 0.41 | 0.06 | 0.17±0.22 | | | | | | | | |
| | | | | 0.16±0.02 ^(d) | | | | | | | | |

No entry indicates no analysis.

* Less than detectable.

(a) $1 \text{ pCi/m}^3 = 10^{-12} \text{ } \mu\text{Ci/ml}$. Average ± 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 ± 2 Sample Standard Deviations.

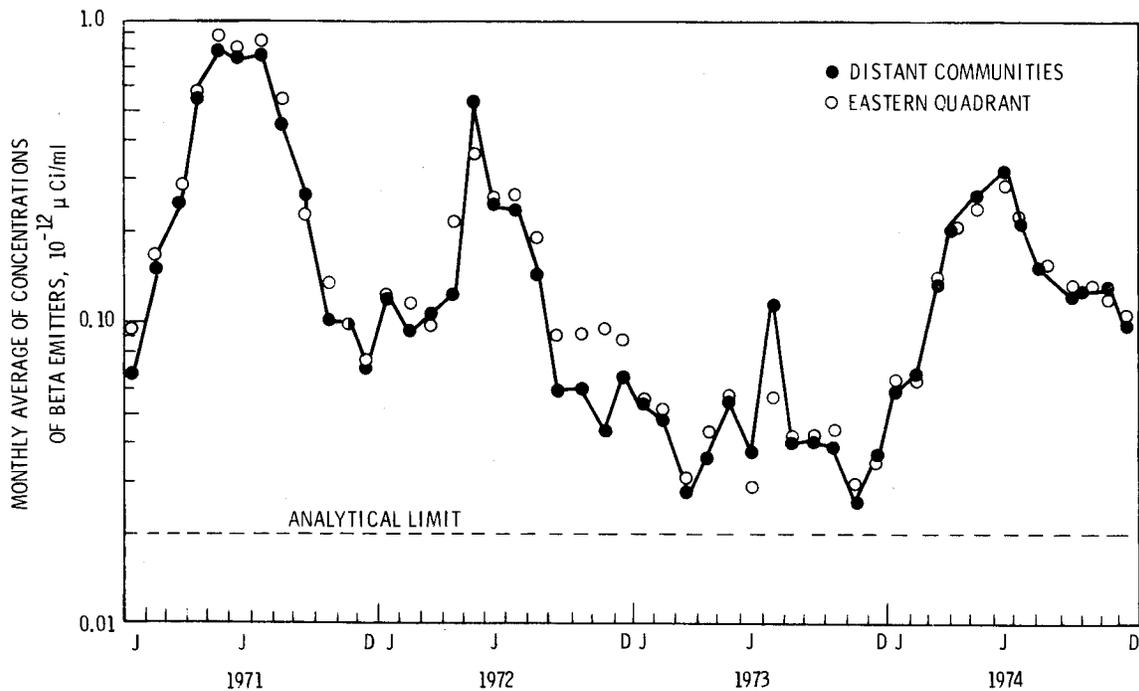


FIGURE 4. Monthly Average Gross Beta Activity in the Atmosphere

Analyses for gross alpha concentrations in the atmosphere lack the sensitivity required to detect possible 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 highest observed concentrations during 1974 occurred at Benton City ($4.0 \times 10^{-14} \mu\text{Ci/ml}$) and Byers Landing ($2.4 \times 10^{-14} \mu\text{Ci/ml}$) on June 26, 1974. These increases were apparently due to the nuclear detonation in the atmosphere by the Peoples Republic of China. The annual average concentration of gross alpha radioactivity was less-than $2 \times 10^{-15} \mu\text{Ci/ml}$ at all locations.

Analysis for ^{131}I concentrations in the atmosphere were performed on a biweekly interval for 5 of the 15 perimeter sampling stations during 1974. Although charcoal cartridges were located at all perimeter and distant sampling stations, the majority were not analyzed but provided available samples if there had been any indication that iodine was present in the atmosphere. The charcoal for these stations was changed monthly. All ^{131}I analyses during 1974 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 1×10^{-10} for uncontrolled areas.¹

Results of specific radionuclide analyses are shown in Table 2. Beryllium-7 is a naturally occurring radionuclide formed by the interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. The other radionuclides are fission or activation products and result from either fallout, Hanford operations, or other nuclear facilities. An inspection of the data shows that all radionuclides, except for ^{103}Ru and ^{134}Cs , were observed in each composite group at approximately the same concentration. Cesium-134 (half-life = 2 years) was detected only once during the year during the time interval from the middle of June to the middle of July. Fallout from the Chinese test on June 17, 1974, was observed during this interval and was assumed to be the source of ^{134}Cs activity. Ruthenium-103 (half-life = 40 days) was also detected only once during the year during the time interval from the middle of May to the middle of June. The source was assumed to be fallout from past nuclear testing in the atmosphere. Neither ^{103}Ru nor ^{134}Cs were detected at any of the onsite air sampling stations.

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

Nonradiological Evaluation

HEHF, under contract to ERDA, has the responsibility for monitoring the nonradiological quality of the atmosphere in the Hanford environs. Monitoring activities during 1974 included 24-hour sequential sampling for NO_2 and SO_2 at three locations across the Columbia River from Richland, North Richland, and Hanford 300 Area operations, as well as suspended particulate collection on the roof of the Federal Building in Richland. The three stations along the river were located in the southeasterly or downwind direction from Hanford operations. Table 3 summarizes the NO_2 and dust data collected during 1974. The highest yearly average concentration of NO_2 measured was 0.006 ppm, or 12% of the ambient air standard of 0.05 ppm. Suspended particulates fluctuated widely due to occasional heavy dust storms. All 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 2. Concentration of Specific Radionuclides in Air - 1974

| Location (b) | Radionuclide | Concentration (10 ⁻¹² uCi/ml)(a) | | | | |
|--------------------------|------------------------|---|--------------------|----------------------------|-----------------------|--------|
| | | Maximum Observed | Minimum Observed | Annual Average | ERDA 0524 Standard(c) | |
| Inner Northeast Quadrant | Be-7 | 0.17 | * | <0.06 | 40,000 | |
| | Mn-54 | 0.01 | * | <0.007 | 1,000 | |
| | Zn-65 | 0.02 | * | <0.001 | 2,000 | |
| | Sr-90 | 6x10 ⁻⁴ | 2x10 ⁻⁴ | (5±3)x10 ⁻⁴ | 30 | |
| | ZrNb-95 | 0.06 | 0.01 | 0.03±0.03 | 3,000 | |
| | Ru-103 | 0.02 | * | <0.002 | 3,000 | |
| | Ru-106 | 0.19 | * | <0.09 | 200 | |
| | Cs-137 | 0.01 | * | <0.003 | 500 | |
| | BaLa-140 | 0.33 | * | <0.03 | 1,000 | |
| | CePr-144 | 0.18 | * | <0.02 | 200 | |
| | Pu-total | 5x10 ⁻⁵ | 1x10 ⁻⁶ | (2±4)x10 ⁻⁵ | 0.06 | |
| Inner Southeast Quadrant | Be-7 | 0.31 | * | <0.08 | 40,000 | |
| | Mn-54 | 0.01 | * | <0.002 | 1,000 | |
| | Co-60 | 0.009 | * | <0.002 | 300 | |
| | Zn-65 | 0.01 | * | <0.001 | 2,000 | |
| | Sr-90 | 5x10 ⁻³ | 4x10 ⁻⁴ | (2±4)x10 ⁻³ | 30 | |
| | ZrNb-95 | 0.05 | 0.007 | 0.03±0.03 | 3,000 | |
| | Ru-106 | 0.28 | * | <0.12 | 200 | |
| | Cs-134 | 0.04 | * | <0.004 | 400 | |
| | Cs-137 | 0.01 | * | <0.002 | 500 | |
| | CePr-144 | 0.13 | * | <0.06 | 200 | |
| | Pu-total | 6x10 ⁻⁵ | 1x10 ⁻⁵ | (3±4)x10 ⁻⁵ | 0.06 | |
| Outer Northeast Quadrant | Be-7 | 0.21 | * | <0.009 | 40,000 | |
| | Mn-54 | 0.02 | * | <0.005 | 1,000 | |
| | Co-60 | 0.004 | * | <0.001 | 300 | |
| | Zn-65 | 0.007 | * | <0.001 | 2,000 | |
| | Sr-90 | 3x10 ⁻³ | 6x10 ⁻⁴ | (1.3±2.4)x10 ⁻³ | 30 | |
| | ZrNb-95 | 0.06 | 0.01 | 0.03±0.03 | 3,000 | |
| | Ru-106 | 0.23 | * | <0.10 | 200 | |
| | Cs-137 | 0.009 | * | <0.003 | 500 | |
| | BaLa-140 | 0.27 | * | <0.02 | 1,000 | |
| | CePr-144 | 0.15 | * | <0.05 | 200 | |
| | Pu-total | 5x10 ⁻⁵ | 1x10 ⁻⁵ | (4±4)x10 ⁻⁵ | 0.06 | |
| Outer Southeast Quadrant | Be-7 | 0.22 | * | <0.07 | 40,000 | |
| | Mn-54 | 0.006 | * | <0.002 | 1,000 | |
| | Co-60 | 0.003 | * | <0.0004 | 300 | |
| | Sr-90 | 0.006 | 6x10 ⁻⁴ | (3±5)x10 ⁻³ | 30 | |
| | ZrNb-95 | 0.08 | 0.008 | 0.04±0.06 | 3,000 | |
| | Ru-106 | 0.24 | * | <0.13 | 200 | |
| | Cs-137 | 0.01 | * | <0.002 | 500 | |
| | CePr-144 | 0.28 | * | <0.08 | 200 | |
| | Pu-total | 5x10 ⁻⁵ | 1x10 ⁻⁵ | (3±3)x10 ⁻⁵ | 0.06 | |
| | Outer Western Quadrant | Be-7 | 0.22 | * | <0.06 | 40,000 |
| | | Mn-54 | 0.01 | * | <0.005 | 1,000 |
| Zn-65 | | 0.008 | * | <0.001 | 2,000 | |
| Sr-90 | | 0.007 | 6x10 ⁻⁴ | 0.003±0.006 | 30 | |
| ZrNb-95 | | 0.06 | 0.005 | 0.03±0.04 | 3,000 | |
| Ru-106 | | 0.20 | * | <0.1 | 200 | |
| Cs-137 | | 0.009 | * | <0.003 | 500 | |
| CePr-144 | | 0.14 | * | <0.04 | 200 | |
| Pu-total | | 2x10 ⁻⁵ | * | <1x10 ⁻⁶ | 0.06 | |

*Less than detection limit. Detection limit varies from sample to sample because of different airflow volumes, counting times, and radionuclide composition. Approximate tabulated detection limits are: Be-7, 0.03; Mn-54, 0.002; Co-60, 0.003; Zn-65, 0.006; Sr-90, 0.0002; ZrNb-95, 0.002; Ru-103, 0.003; Ru-106, 0.04; I-131, 0.12; Cs-134, 0.01; Cs-137, 0.003; BaLa-140, 0.15; CePr-144, 0.03; Pu-total, 0.000002.

(a) 1 pCi/m³ = 10⁻¹² uCi/ml

(b) Weekly air filters are composited into groups for monthly analysis by gamma spectroscopy or quarterly analyses for Sr-90 and Pu-total. Specific stations included in each quadrant are: Inner Northeast: Othello, Connell, Berg Ranch, Wahluke, and Cooke Bros. Inner Southeast: Richland and Pasco. Outer Northeast: Moses lake and Washtucna. Outer Southeast: Walla Walla and McNary Dam. Outer Western; Sunnyside and Ellensburg.

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

TABLE 3. Hanford Environs Air Quality Measurements - 1974

| Location | No. of Samples | NO ₂ (ppm) | | | % of standard | Suspended Particulates (µg/m ³) | | | |
|-------------------------------------|----------------|-----------------------------|------------|------------|---------------|---|---------------------|------------|------------|
| | | Annual Air Quality Standard | Daily Max. | Daily Min. | | Annual Avg. | No. of Samples | Daily Max. | Daily Min. |
| Richland (Fed. Bldg.) | | .05 | | | | 125 | 572. ^(a) | 8. | 57. |
| Opposite Richland (Hobkirk Ranch) | 78 | | 0.022 | 0.001 | 0.006 | 12 | | | |
| Opposite N. Richland (Gillum Ranch) | 130 | | 0.020 | 0.001 | 0.006 | 12 | | | |
| Opposite 300 Area (Sullivan Ranch) | 77 | | 0.014 | 0.001 | 0.005 | 10 | | | |

No entry indicates no specific measurement was made.

(a) High value due to a local dust storm.

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 industrial uses of the river to be compatible with substantially all needs including sanitary water, recreation, and wildlife. Numerous routine samples are 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 radioactivity in river water have generally become undetectable with routine analytical methods. Table 4 is a summary of the data obtained during 1974. The alpha measurements are an approximation of the naturally occurring uranium in the river. The observed values of ⁹⁰Sr and ²³⁹Pu were attributed to fallout since concentrations measured upstream of Hanford operations did not differ from concentrations measured downstream. The majority of the observed tritium concentrations were due to fallout, although a small contribution (~10 pCi/l) was due to naturally occurring tritium. No other radionuclides were observed.

TABLE 4. Routine Analyses of Columbia River Water - 1974

| Analysis | Concentration (10 ⁻⁹ μ Ci/ml)(a) | | | | | | | | | |
|----------|---|------------------------------------|------------------|------------------|-------------------------------|--------------------------------------|------------------|------------------|----------------|------------------------------------|
| | Analytical Limit | Upstream of Hanford ^(b) | | | | Downstream of Hanford ^(c) | | | | ERDA 0524 ^(e) Standards |
| | | No. of Samples | Maximum Observed | Minimum Observed | Annual ^(d) Average | No. of Samples | Maximum Observed | Minimum Observed | Annual Average | |
| Alpha | 0.2 | 12 | 0.9 | * | <0.4 | 12 | 0.9 | * | <0.4 | 30 |
| H-3 | 390 | 12 | 710 | * | <330 | 12 | 2000 | * | <480 | 3,000,000 |
| Sc-46 | 40 | 12 | * | * | * | 53 | * | * | * | 40,000 |
| Cr-51 | 300 | 12 | * | * | * | 53 | * | * | * | 2,000,000 |
| Co-60 | 20 | 12 | * | * | * | 53 | * | * | * | 30,000 |
| Zn-65 | 40 | 12 | * | * | * | 53 | * | * | * | 100,000 |
| Sr-90 | 0.04 | 12 | 2.5 | * | <0.5 | 12 | 0.4 | 0.2 | 0.3-0.1 | 300 |
| I-131 | 2 | 12 | * | * | * | 26 | * | * | * | 300 |
| Cs-137 | 22 | 12 | * | * | * | 53 | * | * | * | 20,000 |
| Pu-239 | 0.02 | 4 | 0.04 | * | <0.02 | 4 | 0.04 | * | <0.02 | 5,000 |

* Less than analytical limit.

(a) 10⁻⁹ μ 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 ± 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 1974, a new method of sampling river water for radioactivity, refined by BNW's Radiological Chemistry staff,⁴ was used. The method results in a much lower detection level and 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. The results for these samples, collected from the 300-Area, are shown in Table 5 for 1974. Naturally occurring radionuclides observed were ⁴⁰K, ²²⁶Ra, and ²²⁸Th. The other radionuclides observed are artificially produced and must be due to either Hanford operations or worldwide fallout. All of these artificially produced radionuclides, except ¹⁵²Eu, were measurable in the atmosphere during 1974 as shown in Table 2. The source of these radionuclides was fallout. Previous operation of once-through cooling production reactors released substantial quantities of ⁵⁴Mn, ⁶⁰Co, ⁶⁵Zn, and ¹⁵²Eu as well as other radionuclides to the Columbia River. These radionuclides became attached to sediments in the river and still remain.

TABLE 5. Concentrations of Radionuclides in the Columbia River^(a)
Concentration (10^{-9} μ Ci/ml)

| Radionuclide | Detection Limit | No. of Samples | 1974 | | Annual ^(b) Average | ERDA 0524 ^(c) Standard | Percent of ^(d) Standard |
|--------------|-----------------|----------------|------------------|---------------------|-------------------------------|-----------------------------------|------------------------------------|
| | | | Maximum Observed | Minimum Observed | | | |
| K-40 | 0.009 | 23 | 2.3 | * | <1.0 | - | - |
| Mn-54 | 0.014 | 23 | <0.03 | * | <0.01 | 100,000 | <1x10 ⁻⁵ |
| Co-60 | 0.0005 | 23 | 0.04 | <6x10 ⁻⁵ | 0.02±0.02 | 30,000 | <7x10 ⁻⁵ |
| Zn-65 | 0.005 | 23 | <0.04 | <1x10 ⁻⁵ | <0.01 | 100,000 | <1x10 ⁻⁵ |
| ZrNb-95 | 0.005 | 23 | 0.57 | * | <0.12 | 60,000 | - |
| Ru-106 | 0.005 | 23 | 0.20 | 0.02 | 0.12±0.09 | 10,000 | - |
| Cs-137 | 0.005 | 23 | <0.07 | <2x10 ⁻⁴ | <0.03 | 20,000 | <2x10 ⁻⁴ |
| Eu-152 | 0.02 | 23 | <0.03 | * | <0.02 | 60,000 | <4x10 ⁻⁵ |
| Ra-226 | 0.002 | 23 | 0.14 | <0.01 | <0.05 | 30 | - |
| Th-228 | 0.0005 | 23 | 0.037 | <0.005 | <0.014 | 1,000 | - |

* 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 ±2 sample standard deviation shown in 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.
- (d) K-40, Ra-226, Th-228, occur naturally. ZrNb-95 and Ru-106 are due to fallout.

Although a definite conclusion as to the source of the observed concentrations of artificially produced radionuclides cannot be made, speculation as to the probable source can be. Past analyses of Columbia River sediments (1973 report - addendum)⁵ have shown measurable quantities of all of these radionuclides except for ¹⁰⁶Ru and ⁹⁵ZrNb. Ruthenium-106 and ⁹⁵ZrNb were observed in the atmosphere in all air filter composites as shown in Table 2 and the measured amounts in the Columbia River were primarily due to fallout. The method of sampling river water separates the collected radioactivity into either a particulate fraction (collected on filters) or a soluble fraction (adsorbed on resin). The majority of the artificially produced radionuclides were collected by filters indicating that a likely source of these radionuclides was suspended sediments in river water. Although fallout definitely contributes to the measured concentrations of these radionuclides, except ¹⁵²Eu, past Hanford operations are assumed to contribute the greater amount. Europium-152 concentrations were due to past Hanford operations. All observed concentrations of radionuclides during 1974 attributable to Hanford operations were much less than 0.01% of ERDA Manual Chapter 0524 drinking water standards as shown in Table 5.

The concentrations measured during 1974 of ⁵⁴Mn, ⁶⁰Co and ⁶⁵Zn were less than measured during 1973.⁵ The reason(s) for the reduction in both the maximum observed value and the annual average is not known but expected to be related to the dilution of sediment labeled with these radionuclides with sediment not labeled. Also, the river flow rate may affect the amount of suspended sediments in the river causing variations from year to year. The average river flow rate during 1973 was about 90,000 cfs (cubic feet per second), whereas during 1974 the average flow rate was about 150,000 cfs.

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 Quality² Standards for the Columbia River and Public Health Service⁶ recommendations for sources of drinking water.

Physical and chemical parameters measured during 1974 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 Priest Rapids Dam and at Richland during 1974. Some of the temperature difference is attributable to operations on the Hanford Reservation and some is due to natural causes.⁷ The annual average temperature and 95% confidence interval for Priest Rapids Dam and Richland during 1974 were 11.2 ± 10.9 and $11.3 \pm 11.3^\circ\text{C}$, respectively, based on 365 daily measurements. Figure 6 illustrates the daily variation of river temperature with season and flowrate during 1974.

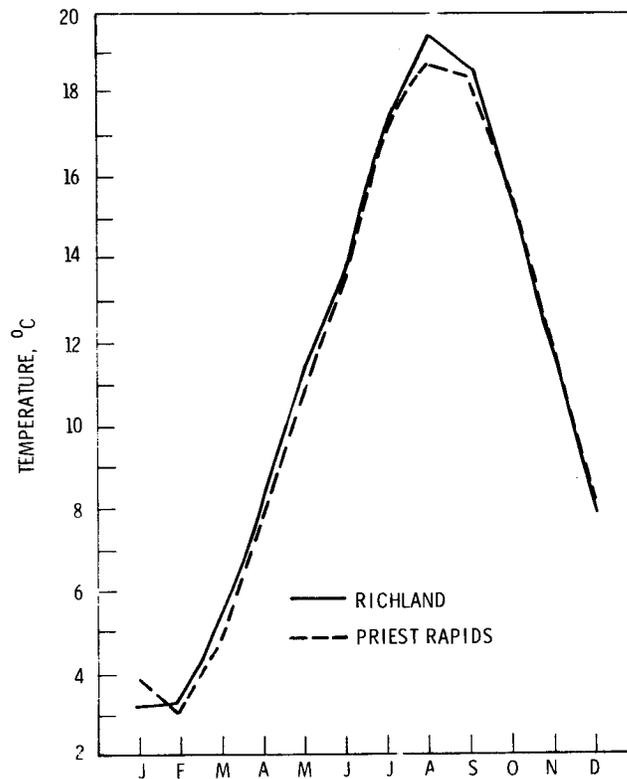


FIGURE 5. Columbia River Monthly Temperature at Richland and Priest Rapids Dam for 1974

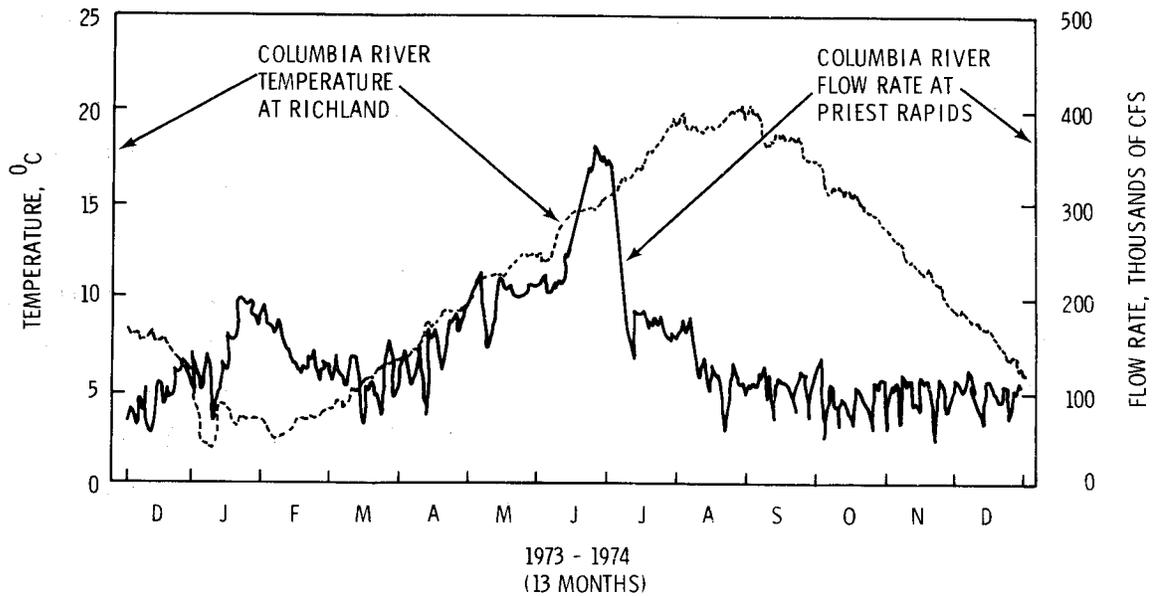


FIGURE 6. Columbia River Daily Flow and Temperature During 1974

Results of biological analyses of Columbia River water during 1974 are shown in Table 6. 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. The Hanford stretch of the river serves as a refuge for large populations of waterfowl.

TABLE 6. Columbia River Biological Analyses - 1974

| Analysis | Unit | Standard | Vernita | | | | Richland | | | |
|-------------|-----------|----------|----------------|------------------|------------------|-------------------------------|----------------|------------------|------------------|-------------------------------|
| | | | No. of Samples | Maximum Observed | Minimum Observed | Annual ^(a) Average | No. of Samples | Maximum Observed | Minimum Observed | Annual ^(a) Average |
| Coliform | No./100ml | 240 | 12 | 120 | 9 | 43-72 | 12 | 150 | 4 | 54-74 |
| Enterococci | No./100ml | -- | 12 | 64 | 3 | 29-40 | 12 | 194 | 4 | 61-98 |
| BOD | mg/l | -- | 12 | 4.4 | 1.3 | 2.5±1.9 | 12 | 5.1 | 1.3 | 2.8-2.1 |

(a) Average ±2 sample standard deviations shown.

Results of chemical analyses are shown in Table 7. 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.² Average nitrate concentrations were less than 1% of the 45 ppm standard. Average pH for 1974 was 8.1 at Vernita bridge and 7.8 at Richland, 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 1974 were 10.7 mg/l and 10.5 mg/l, respectively.

TABLE 7. Columbia River Chemical Analyses - 1974

| Analysis | Units | Standard | Vernita | | | | Richland ^(a) | | | |
|--------------------------|--------------------|------------|----------------|------------------|------------------|-------------------------------|-------------------------|------------------|------------------|-------------------------------|
| | | | No. of Samples | Maximum Observed | Minimum Observed | Annual ^(b) Average | No. of Samples | Maximum Observed | Minimum Observed | Annual ^(b) Average |
| NO ₃ | ppm | 45 | 52 | 1.4 | * | <0.4 | 52 | 1.2 | * | <0.4 |
| pH | -- | 6.5 to 8.5 | 51 | 8.7 | 7.7 | 8.1±5.2 | 242 | 8.6 | 7.0 | 7.8±0.4 |
| Turbidity | JTU ^(c) | 5+Bg | 45 | 24 | 1 | 4.4±9.0 | 241 | 23.0 | 1.0 | 4.3±0.8 |
| Dissolved O ₂ | mg/l | 8.0 min. | 40 | 13.3 | 8.4 | 10.7±19.5 | 212 | 14.1 | 7.0 | 10.5±2.2 |

* Less than detection limit. Detection limit would be a tabled value of 0.1 for NO₃ analysis.

(a) pH, turbidity and dissolved O₂ 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.

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. 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 gamma spectrometry, gross beta and gross alpha analyses. The results of these analyses for 1974 are shown in Table 8. The gross alpha measurement is an approximation of the naturally occurring uranium in the river. Strontium-90 was observed on several occasions and was due to fallout. No other radionuclides were observed. Specific analyses were not done to measure the amount of tritium in drinking water because the levels would be the same as observed in the river water (Table 5) and the source is primarily fallout (a small amount occurs naturally). Tritium cannot be removed by sanitary water treatment facilities.

TABLE 8. Radiological and Chemical Analyses of Drinking Water - 1974^(a)

| Analysis | Analytical Limit | Units | Standards ^(b) | Richland | | | |
|---------------------|------------------|-------|--------------------------|----------------|------------------|------------------|---------|
| | | | | No. of Samples | Maximum Observed | Minimum Observed | Average |
| <u>Radiological</u> | | | | | | | |
| Alpha | 0.3 | pCi/l | 30 | 52 | 0.9 | * | <0.5 |
| Beta | 0.005 | pCi/l | 2,000,000 | 52 | * | * | * |
| H-3 | 250. | pCi/l | 3,000,000 | | | | N.A. |
| Sc-46 | 25. | pCi/l | 40,000 | 52 | * | * | * |
| Cr-51 | 350. | pCi/l | 2,000,000 | 52 | * | * | * |
| Co-60 | 20 | pCi/l | 30,000 | 52 | * | * | * |
| Zn-65 | 40 | pCi/l | 100,000 | 52 | * | * | * |
| Sr-90 | 0.08 | pCi/l | 300 | 10 | 0.6 | * | <0.3 |
| Cs-137 | 20. | pCi/l | 20,000 | 52 | * | * | * |
| <u>Chemical</u> | | | | | | | |
| NO ₃ | 0.1 | ppm | 45 | 51 | 15 | 0.08 | 2.5±8.1 |

* 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 1974 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 1974 (Table 8). The annual average nitrate concentration was about 6% of the EPA drinking water standard of 45 ppm.³

Groundwater

An extensive groundwater monitoring program continued to show 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- 1860.⁸ A remote possibility exists that radioactive or process materials could penetrate to confined aquifers which generally underlie the Pasco Basin. Several farm wells on the east side of the Columbia River, which are believed to penetrate to these confined aquifers, 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 9 shows data from these wells for 1974. All analytical results were less than the detection limits.

TABLE 9. Groundwater Analyses from Wells in the Vicinity of Hanford - 1974

| Concentration Guide ^(b) Analytical Limit ^(c) | ^3H (10^{-9} Ci/ml) ^(a) | | | | NO_3^- (ppm) | | |
|---|--|-------------|-------------|-------------|-----------------------|-------------|-------------|
| | 3,000,000 | | | | 45 | | |
| | | ~950 | | | 0.5 | | |
| <u>Location</u> | <u>Samples</u> | <u>Max.</u> | <u>Min.</u> | <u>Avg.</u> | <u>Max.</u> | <u>Min.</u> | <u>Avg.</u> |
| Webber | 2 | <1200 | <600 | <900 | * | * | * |
| Vail | 2 | <1000 | <500 | <750 | * | * | * |
| W-15 | 2 | <1200 | <1000 | <1100 | * | * | * |
| White Bluffs Association | 2 | <1100 | <900 | <1000 | * | * | * |

* Less than the analytical limit

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

(b) ERDA 0524 Concentration 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. The samples were analyzed for gamma emitting radionuclides and ⁹⁰Sr. Tables 10 through 12 show the results of these analyses. The data were used to evaluate the approximate dose received from eating these particular foods which comprise a significant fraction of the typical diet. Since the 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.

TABLE 10. Concentrations of Radionuclides in Milk - 1974

| | Concentration (10 ⁻⁹ μCi/ml) ^(a) | | | | | | | | | |
|------------------------------------|--|------|------|----------|------|------|---------|------|------|---------|
| | K-40 | | | Sr-90 | | | I-131 | | | |
| Analytical Limit | 470 | | | 0.5 | | | 2.0 | | | |
| Concentration Guide ^(b) | - | | | 200.0 | | | 100.0 | | | |
| Sample Results ^(c) | | | | | | | | | | |
| Location ^(d) | No. of Samples | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| Riverview | 26 | 1400 | 710 | 996±305 | 2.6 | * | <1.7 | 3.0 | * | <0.4 |
| Wahluke | 26 | 1300 | 860 | 1063±225 | 4.6 | * | <2.0 | * | * | * |
| Benton City #1 | 14 | 1100 | 730 | 937±285 | 4.1 | * | <2.4 | * | * | * |
| Benton City #3 | 12 | 1300 | 750 | 1035±317 | | | | | | |
| Benton City #4 | 12 | 1100 | 830 | 976±179 | 3.6 | 2.8 | 3.2±1.1 | * | * | * |
| West Richland | 5 | 1200 | 1000 | 1075±191 | | | | * | * | * |
| Commercial #1 | 11 | 1300 | 820 | 1043±268 | 5.5 | * | <2.2 | * | * | * |
| Commercial #2 | 13 | 1200 | 770 | 966±270 | 3.2 | * | <1.9 | * | * | * |

No entry indicates no analysis

* Less than detectable

(a) 10⁻⁹ 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) Benton City #1 represents a composite of Benton City #3 and #4 before August 1, 1974. After August 1, the milk from each farm was analyzed separately. Milk from West Richland was obtainable only from May 2 through June 27, 1974. The commercial sources obtain milk from two different watersheds: commercial #1 west of the Cascade mountain range, commercial #2 east.

TABLE 11. Concentrations of Radionuclides in Meat, Chicken, and Eggs - 1974

| Sample Location | No. of Samples | Concentration (10^{-6} $\mu\text{Ci/gm}$) wet weight ^(a) | | | | | | | | |
|-----------------|----------------|---|------|---------------|-------|------|-----------------------|--------|------|---------|
| | | K-40 | | | Sr-90 | | | Cs-137 | | |
| | | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| Meat | | | | | | | | | | |
| Commercial | 11 | 2.6 | 1.8 | 2.1 \pm 0.5 | 0.001 | * | <0.001 | 0.04 | * | <0.01 |
| Riverview | 1 | | | 1.7 | | | * | | | * |
| Chicken | | | | | | | | | | |
| Commercial | 2 | 1.6 | 1.5 | 1.6 \pm 0.1 | * | * | * | * | * | * |
| Riverview | 4 | 2.0 | 1.0 | 1.8 \pm 1.0 | * | * | * | * | * | * |
| Eggs | | | | | | | | | | |
| Commercial | 2 | 1.0 | 1.0 | 1.0 \pm 0.0 | * | * | * | * | * | * |
| Riverview | 11 | 1.1 | 0.7 | 0.9 \pm 0.2 | 0.004 | * | <0.003 ^(b) | * | * | * |

* Less than detectable. Approximate tabled detection limits would be:
K-40, 0.4; Sr-90, 0.001; Cs-137, 0.03.

(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 of the results, including less than detectable values.

(b) Sr-90 analysis done on only 4 samples.

TABLE 12. Concentrations of Radionuclides in Leafy Vegetables - Spinach, Lettuce (leaf), Turnip Greens, Mustard Greens - 1974

| Sample Location | No. of Samples | Concentration (10^{-6} $\mu\text{Ci/gm}$) wet weight ^(a) | | | | | | | | |
|-----------------|----------------|---|-------|------------------------|---------|------|---------|--------|------|---------|
| | | K-40 | | | Mn-54 | | | Co-60 | | |
| | | Max. | Min. | Average ^(b) | Max. | Min. | Average | Max. | Min. | Average |
| Riverview | 5 | 3.6 | 1.7 | 2.4 \pm 1.4 | * | * | * | * | * | * |
| Benton City | 1 | | | 7.9 | | | * | * | * | * |
| Commercial | 6 | 5.2 | 1.4 | 2.1 \pm 1.8 | 0.36 | * | <0.07 | 0.05 | * | <0.01 |
| | | Sr-90 ^(c) | | | ZrNb-95 | | | Ru-106 | | |
| | | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| Riverview | 5 | 0.016 | 0.011 | 0.014 \pm 0.005 | 0.11 | * | <0.04 | 0.96 | * | <0.25 |
| Benton City | 1 | | | N.A. | | | 0.04 | * | * | * |
| Commercial | 6 | 0.010 | 0.009 | 0.010 \pm 0.001 | 0.77 | * | <0.18 | * | * | * |

No entry indicates no analysis.

* Less than detectable. Tabled detection limits would be approximately:
K-40, 0.8; Mn-54, 0.04; Co-60, 0.05; Sr-90, 0.002; ZrNb-95, 0.03;
Ru-106, 0.7.

N.A. Not analyzed

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

(b) Average plus or minus two sample standard deviations.

(c) Analysis for Sr-90 was not run on each sample. Number of samples analyzed was 3 for Riverview and 2 for commercial.

Potassium-40, a naturally occurring radionuclide, contributed the majority of the radioactivity measured in all samples. Strontium-90 was measured in several samples and the observed levels result from fallout, not Hanford operations. The other isotopes were detected only occasionally, and in several cases at 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.

Iodine-131 was detected on June 24, 1974 in one milk sample from the Riverview farming area. This activity was likely due to contamination of the sample due to fallout from the June 17, 1974 nuclear detonation in the atmosphere by the Peoples Republic of China. Fallout debris from this test was measured in the atmosphere during June 24 and 25. Subsequent analyses failed to detect any ^{131}I in milk samples from the Riverview area or any other area.

In summary, the majority of the radioactivity measured in foodstuffs during 1974 was the result of naturally occurring ^{40}K and ^{90}Sr due to fallout. Other radionuclides detected occasionally were believed to be from worldwide fallout.

WILDLIFE

Samples of wildlife, including gamebirds, fish, and deer, were routinely collected from the Hanford environs and analyzed for levels of radioactivity. Table 13 lists the results obtained during 1974. 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 deer were "road-kills." The radionuclide present in the greatest quantity was ^{40}K , a naturally occurring radionuclide. Cobalt-60, ^{65}Zn , ^{90}Sr , and ^{137}Cs were observed in several samples of fish at levels very near the detection limit of the analyses. Cobalt-60 was observed in one duck out of the 33 collected; the observed quantity (0.12) was very near the detection limit of the analysis (0.08). Cobalt-60 and ^{65}Zn were observed in only one

sample (different ones) out of the 14 geese analyzed and, again, at levels very near the detection limit of the analyses.

The origin of the ^{60}Co and ^{65}Zn activity is assumed to be due to previous operation of the once-through cooling production reactors, as discussed under the Columbia River Section. Strontium-90 and ^{137}Cs activity were due to fallout.

TABLE 13. Concentrations of Radionuclides in Muscle Tissue of Selected Wildlife Obtained from the Hanford Environs 1974

| Wildlife | No. of Samples | Concentration (10^{-6} $\mu\text{Ci/gm}$) wet weight ^(a,b) | | | | | | | | | | | | | | |
|-----------|----------------|---|------|---------|-------|------|-------|-------|------|-------|-------|------|--------|--------|------|-------|
| | | K-40 | | | Co-60 | | | Zn-65 | | | Sr-90 | | | Cs-137 | | |
| | | Max. | Min. | Average | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. |
| Fish | 12 | 3.9 | 2.1 | 3.1±1.1 | 0.27 | * | <0.08 | 0.16 | * | <0.06 | 0.007 | * | <0.002 | 0.09 | * | <0.06 |
| Ducks | 33 | 4.0 | * | <2±3 | 0.12 | * | <0.09 | * | * | * | 0.007 | * | <0.006 | * | * | * |
| Geese | 14 | 3.4 | 2.2 | 2.7±0.8 | 0.17 | * | <0.09 | 0.18 | * | <0.16 | 0.009 | * | <0.005 | 0.21 | * | <0.1 |
| Pheasants | 15 | 3.7 | * | <2.9 | * | * | * | * | * | * | * | * | * | * | * | * |
| Deer | 3 | 2.3 | 2.2 | 2.2±0.1 | * | * | * | * | * | * | * | * | * | 1.8 | * | <1.0 |

* Less than detectable. Tabled detection limits would be approximately: K-40, 1.0; Co-60, 0.06; Zn-65, 0.11; Sr-90, 0.002; Cs-137, 0.06.

(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 1974 and analyzed for ^{65}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 loss of approximately 64% of the activity every year. Since early 1970, an approximate one-hundred-fold decrease in activity has occurred.

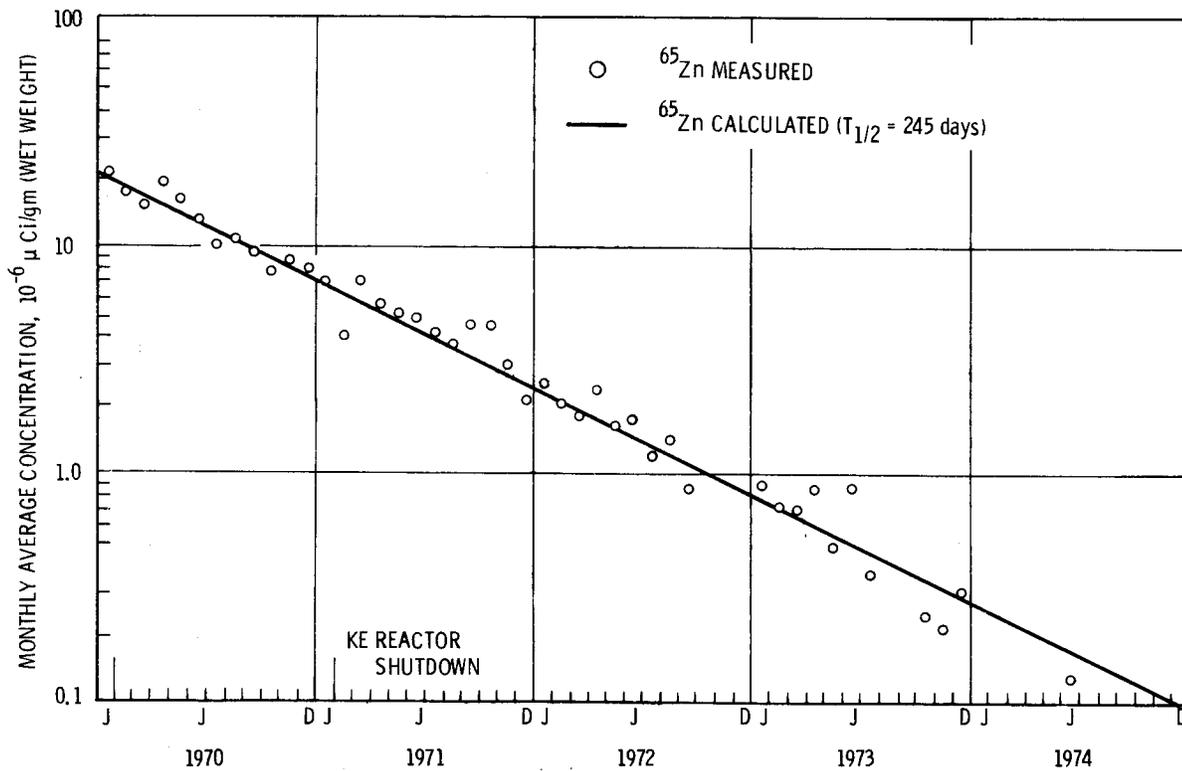


FIGURE 7. Zinc-65 Concentration in Willapa Bay Oysters During 1970 Through 1974

SOIL AND VEGETATION

Surface soil and perennial vegetation samples were collected from 17 different locations during the autumn of 1974 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 14 and 15. Each soil sample represents the composite of five "plugs" of soil from an approximate 10 m² 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 gamma emitting radionuclides using a lithium drifted germanium detector for plutonium isotopes using alpha spectroscopy, and for ⁹⁰Sr and uranium by specific analysis.

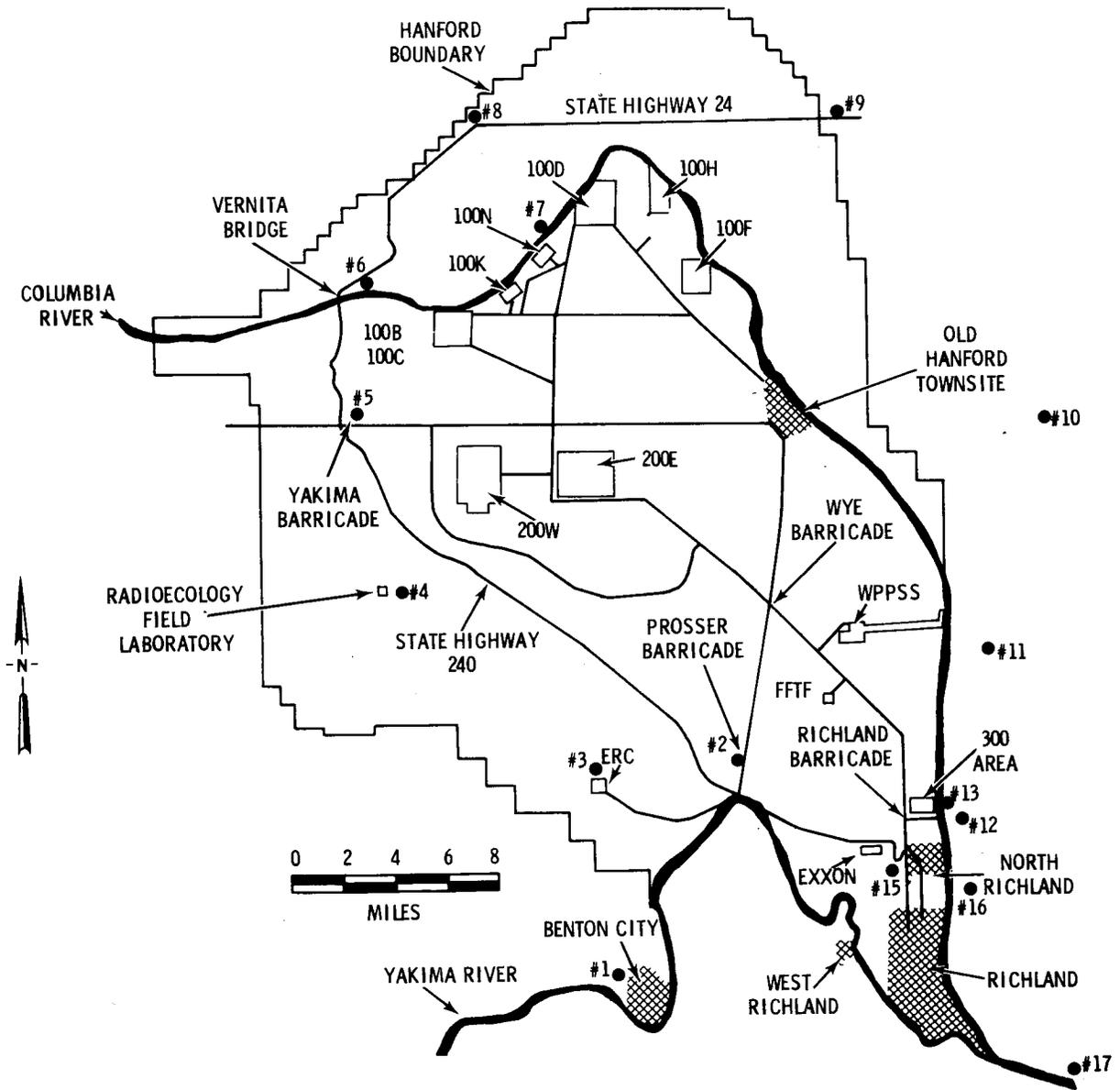


FIGURE 8. Soil and Vegetation Sampling Locations During 1974

TABLE 14. Concentrations of Radionuclides in Surface Soil - 1974

Units of 10⁻⁶ µCi/g (dry weight)

| Sample Location | Map Location | Naturally Occurring Radionuclides | | | | Artificially Produced Radionuclides | | | | | | | | | | | |
|-----------------------|--------------|-----------------------------------|-------------------|-------------------|----------|-------------------------------------|------------------|------------------|------------------|------------------|------------------|---------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|
| | | ⁴⁰ K | ²²⁴ Ra | ²²⁶ Ra | U-total | ⁵⁸ Co | ⁶⁰ Co | ⁶⁵ Zn | ⁹⁰ Sr | ⁹⁵ Zr | ⁹⁵ Nb | ¹⁰⁶ RuRh | ¹³⁴ Cs | ¹³⁷ Cs | ¹⁴⁴ Ce | ²³⁸ Pu | ²³⁹⁻²⁴⁰ Pu |
| Analytical Limit | | 0.50 | 0.04 | 0.11 | 0.034 | 0.03 | 0.03 | 0.07 | 0.002 | 0.10 | 0.10 | 0.40 | 0.03 | 0.03 | 0.10 | 0.003 | 0.001 |
| Benton City | 1 | 13 | 1.4 | 0.83 | 0.29 | * | * | 0.24 | 0.78 | * | * | 0.74 | * | 1.7 | 0.31 | * | 0.04 |
| Prosser | | | | | | | | | | | | | | | | | |
| Barricade | 2 | 14 | 0.92 | 0.48 | 0.13 | * | 0.04 | 0.23 | 0.48 | 0.20 | 0.11 | 0.75 | 0.06 | 0.91 | * | * | 0.01 |
| ERC | 3 | 13 | 0.95 | 0.73 | 0.70 | 0.02 | * | 0.21 | 0.02 | 0.24 | * | 0.40 | 0.05 | 0.11 | 0.13 | * | 0.002 |
| Radioecology | | | | | | | | | | | | | | | | | |
| Field Lab. | 4 | 12 | 0.71 | 0.46 | 0.32 | * | * | 0.08 | 0.34 | 0.13 | * | 0.50 | 0.06 | 0.96 | 0.32 | * | 0.02 |
| Yakima | | | | | | | | | | | | | | | | | |
| Barricade | 5 | 14 | 0.76 | 0.73 | 0.10 | * | * | * | 0.01 | 0.12 | * | 0.47 | * | 0.11 | 0.62 | * | 0.003 |
| Vernita | | | | | | | | | | | | | | | | | |
| Bridge | 6 | 18 | 0.81 | 0.46 | 0.13 | * | * | * | 0.02 | 0.16 | * | 0.68 | * | 0.10 | 0.33 | * | 0.004 |
| Mahluke | | | | | | | | | | | | | | | | | |
| Slope | 7 | 14 | 0.66 | 0.50 | 0.24 | * | * | * | 0.02 | 0.10 | * | 0.63 | 0.04 | 0.15 | 0.19 | * | 0.004 |
| Wanluke #2 | 8 | 13 | 5.9 | 0.91 | 0.11 | * | * | 0.08 | 0.02 | 0.15 | * | 0.85 | * | 0.23 | * | * | 0.01 |
| Berg Ranch | 9 | 12 | 1.4 | 0.72 | 0.07 | * | * | 0.15 | 0.05 | 0.29 | * | 0.43 | 0.12 | 0.45 | 0.11 | * | 0.007 |
| Cooke Bros. | 10 | 12 | 0.64 | 0.55 | 0.39 | * | * | 0.17 | 0.06 | * | * | 0.47 | * | 0.07 | 0.44 | * | 0.003 |
| Baxter Sub-station | 11 | 16 | 0.74 | 0.52 | 0.36 | 0.04 | * | 0.23 | 0.06 | 0.25 | * | 0.48 | 0.05 | 0.26 | 0.34 | 0.01 | 0.094 |
| Byers | | | | | | | | | | | | | | | | | |
| Landing | 12 | 12 | 0.97 | 0.46 | 0.39 | * | * | 0.35 | 0.25 | 0.12 | * | 0.54 | 0.06 | 0.69 | 0.20 | * | 0.006 |
| Byers Pump-house | *13 | 12 | 0.88 | 0.48 | 0.61 | * | 0.07 | 0.20 | 0.38 | 0.20 | 0.15 | 0.70 | * | 1.8 | 0.44 | * | 0.02 |
| 300 Area | | | | | | | | | | | | | | | | | |
| South Gate | 14 | 14 | 0.54 | 0.56 | 0.66 | 0.03 | 0.05 | 0.29 | 0.12 | * | * | 0.59 | * | 1.5 | 0.25 | * | 0.02 |
| North | | | | | | | | | | | | | | | | | |
| Richland | 15 | 14 | 0.92 | 0.72 | 0.26 | 0.03 | * | 0.18 | 0.26 | * | * | 0.98 | * | 0.48 | 0.16 | * | 0.007 |
| Island #340 | 16 | 12 | 0.76 | 0.78 | 0.45 | * | 2.4 | 0.19 | 0.08 | 0.33 | 0.17 | 0.62 | 0.04 | 1.9 | 0.17 | * | 0.04 |
| Riverview | 17 | 13 | 0.56 | 0.31 | 0.42 | * | 0.04 | 0.27 | 0.04 | 0.10 | * | 0.40 | 0.06 | 0.06 | * | * | 0.002 |
| Maximum | | 18 | 5.9 | 0.91 | 0.66 | 0.04 | 2.4 | 0.35 | 0.78 | 0.33 | 0.17 | 0.98 | 0.12 | 1.9 | 0.62 | 0.01 | 0.04 |
| Minimum | | 12 | 0.54 | 0.46 | 0.07 | * | * | * | 0.01 | * | * | 0.40 | * | 0.06 | * | * | 0.002 |
| Avr. ±2 | | | | | | | | | | | | | | | | | |
| Sample Deviations (a) | | 13±3 | 1.2±2.5 | 0.60±0.3 | 0.33±0.4 | <0.01 | <0.16 | <0.17 | 0.18±0.4 | <0.15 | <0.07 | 0.60±0.3 | <0.04 | 0.68±1 | <0.24 | <0.001 | 0.01±0.02 |

* 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 15. Concentrations of Radionuclides in Vegetation - 1974

Units of 10^{-6} $\mu\text{Ci/g}$ (dry weight)

| Sample Location | Map Location | Naturally Occurring Radionuclides | | | | Artificially Produced Radionuclides | | | | | | | | | | | |
|-----------------------------------|--------------|-----------------------------------|-------------------|-------------------|---------|-------------------------------------|------------------|------------------|------------------|--------------------|---------------------|------------------|-------------------|---------------------|-------------------|-----------------------|--------|
| | | ^{40}K | ^{224}Ra | ^{226}Ra | U-total | ^{58}Co | ^{60}Co | ^{65}Zn | ^{90}Sr | $^{95}\text{ZrNb}$ | $^{106}\text{RuRh}$ | ^{131}I | ^{137}Cs | $^{144}\text{BaLa}$ | ^{238}Pu | $^{239-240}\text{Pu}$ | |
| Analytical Limit | | 1.0 | 0.04 | 0.11 | 0.034 | 0.06 | 0.07 | 0.13 | 0.002 | 0.05 | 1.0 | 1.1 | 0.06 | 2.1 | 0.62 | 0.003 | 0.001 |
| Benton City | | 10 | * | * | 0.19 | * | * | 0.63 | 0.06 | 0.78 | * | * | 0.10 | 7.9 | * | * | 0.002 |
| Prosser Barricade | | 2 | * | * | * | * | * | 0.80 | 0.04 | 0.28 | * | * | 0.18 | 14 | * | * | * |
| ERC | | 13 | * | * | 0.12 | * | * | 0.98 | 0.02 | 0.14 | * | * | 0.13 | 14 | * | 0.003 | 0.001 |
| Radioecology Lab. | | 4 | 9.0 | * | * | * | * | 0.52 | 0.05 | 0.28 | * | * | 0.16 | 11 | 0.58 | * | 0.003 |
| Yakima Barricade | | 5 | 8.5 | * | * | 0.67 | * | 0.36 | 0.05 | 1.1 | * | * | 0.09 | 7.7 | * | * | 0.002 |
| Vernita Bridge | | 11 | * | * | * | * | * | 0.77 | 0.06 | 1.3 | * | * | 0.24 | 14 | 1.2 | * | 0.001 |
| Wahlake Slope | | 7 | 9.6 | * | 0.05 | * | * | 0.76 | 0.03 | 0.37 | * | * | 0.12 | 15 | 0.98 | * | * |
| Wahlake #2 | | 8 | 11 | * | 0.08 | * | * | 0.80 | 0.13 | 0.30 | * | * | 0.15 | 17 | * | * | 0.001 |
| Berg Ranch | | 9 | 11 | * | 0.16 | * | * | 0.84 | 0.06 | 0.22 | * | * | 0.12 | 15 | * | * | 0.003 |
| Cooke Bros. | | 10 | 20 | * | 0.23 | * | * | 1.8 | 0.04 | 0.13 | * | * | 0.12 | 29 | 2.3 | * | * |
| Baxter Substation | | 11 | 18 | * | 0.34 | * | * | 1.3 | 0.14 | 0.14 | * | * | 0.10 | 20 | * | * | 0.002 |
| Byers Landing | | 12 | 10 | * | 7.2 | * | * | 0.79 | 0.02 | 0.30 | * | * | 0.19 | 11 | 0.52 | * | 0.002 |
| Byers Pumphouse | | 13 | 11 | * | * | * | * | 1.0 | 0.02 | 4.0 | * | * | 0.46 | 15 | * | * | 0.001 |
| 300 Area South Gate | | 14 | 11 | * | 0.21 | * | * | 0.63 | 0.17 | 0.52 | * | * | 0.46 | 10 | 2.2 | * | 0.005 |
| North Richland | | 15 | 8.4 | * | 0.09 | * | * | 0.43 | 0.07 | 0.26 | * | * | 0.13 | 8.8 | 0.51 | * | 0.004 |
| Island #340 | | 16 | 4.7 | * | 0.32 | * | * | * | 0.12 | 0.31 | 1.3 | * | 0.15 | 3.6 | 1.0 | 0.002 | 0.02 |
| Riverview | | 17 | 10 | * | 0.22 | * | * | 0.45 | 0.06 | 0.32 | * | * | 0.14 | 9.7 | 0.41 | * | 0.002 |
| Maximum | | 20 | * | * | 7.2 | 0.67 | * | 1.8 | 0.17 | 4.0 | 1.3 | * | 0.46 | 29 | 2.3 | 0.003 | 0.02 |
| Minimum | | 4.7 | * | * | * | * | * | * | 0.02 | 0.14 | * | * | 0.09 | 3.6 | * | * | * |
| Avg. ± 2 Sample Deviations(a) | | 11 ± 7 | * | * | <0.55 | * | * | <0.76 | 0.07 ± 0.09 | 0.63 ± 1.9 | * | * | 0.18 ± 0.2 | 13 ± 11 | <0.43 | <0.0005 | <0.003 |

* 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.

The radionuclides observed in soil samples from all locations were ^{40}K , ^{90}Sr , ^{137}Cs , ^{224}Ra , ^{226}Ra , and uranium. All of these radionuclides occur naturally except for ^{90}Sr and ^{137}Cs . Strontium-90 and ^{137}Cs , as well as the other artificially produced radionuclides shown in Tables 14 and 15, are produced by fission and must be due to either Hanford operations, other nuclear facilities, or to fallout of radioactive debris from the atmosphere due to past nuclear device testing. Hanford operations would be expected to contribute, much more so, to radionuclide concentrations measured at predominately downwind sampling locations (Baxter Substation, Byers Landing, 300 Area south gate, etc.) than to sampling locations lying in an improbable wind direction from Hanford facilities (Vernita Bridge, Wahluke #2, etc.). No distinct pattern is apparent due to the variability in results measured at all locations. Hence, contributions to radioactivity measured at the different sampling locations by Hanford operations were indistinguishable from the variability in concentrations due to fallout.

Partly because of other information (aerial survey section), the ^{60}Co concentration for the sample collected on Island #340 is expected to be due to past Hanford operations. As discussed in the Columbia River section, Radiological Evaluation, certain radionuclides, notably ^{60}Co still remained in the river sediments due to past operation of once-through cooling production reactors. The flooding of Island #340 during periods of high river flow resulting in deposition on the island of sediments suspended in the river is expected to be the reason for the observed concentration of ^{60}Co .

In summary, the radionuclide observed at all locations with the highest concentration was ^{40}K , a naturally occurring radionuclide. Other naturally occurring radioactivity observed in soil at all locations included ^{224}Ra , ^{226}Ra , and uranium. Several radionuclides due to fallout were observed at the different sampling locations. Cobalt-60 concentrations measured on Island #340 were attributed to past Hanford operations.

EXTERNAL RADIATION MEASUREMENT

External radiation levels in the Hanford environs were measured during 1974 by several methods. Thermoluminescent dosimeters (TLDs) were deployed at 13 perimeter and 6 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 4 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. An aerial survey, using sensitive monitoring equipment, was flown over the Columbia River by E.G.&G. of Las Vegas.

Ambient Radiation Dose

TLDs were used to measure the external background dose at several perimeter and distant communities. Table 16 shows the results of these measurements. The dosimeter employed consisted of 3 chips of $\text{CaF}_2:\text{Dy}$ (Harshaw TLD-200) encased in an opaque plastic capsule lined with 0.010" of tantalum and 0.002" of lead to flatten the lower energy response.⁹ The dosimeters were mounted approximately one meter above ground level and changed either biweekly or monthly.

The external dose measured at any location is affected by several parameters, including the height of the dosimeter, 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 16. Ambient Radiation Dose - January-December 1974^(a)

| Location | No. of (b) Measurements | Dose (mrad/yr) ^(c) | | |
|--|----------------------------|-------------------------------|---------|--------------|
| | | Maximum | Minimum | Average |
| <u>Perimeter Community Dose</u> | | | | |
| Eltopia | 11 | 69 | 55 | 62±9 |
| Pasco | 14 | 80 | 66 | 73±9 |
| Richland | 27 | 80 | 55 | 66±14 |
| Vernita | 15 | 116 | 69 | 84±22 |
| Benton City | 13 | 66 | 55 | 62±9 |
| Othello | 14 | 73 | 55 | 62±9 |
| Connell | 14 | 73 | 55 | 66±11 |
| Berg Ranch | 14 | 95 | 69 | 80±15 |
| Wahluke Wm | 14 | 84 | 66 | 77±12 |
| Cooke Bros. | 14 | 77 | 55 | 69±13 |
| Ringold | 11 | 69 | 55 | 62±17 |
| Baxter Sub. | 13 | 77 | 44 | 66±18 |
| Byers Landing | 14 | 88 | 69 | <u>77±11</u> |
| Average ± 2 sample standard deviations | | | | 70±15 |
| <u>Distant Community Dose</u> | | | | |
| Ellensburg | 10 | 66 | 44 | 51±13 |
| Walla Walla | 13 | 80 | 62 | 73±10 |
| Sunnyside | 14 | 69 | 55 | 66±9 |
| McNary | 14 | 80 | 62 | 73±11 |
| Moses Lake | 14 | 73 | 58 | 66±7 |
| Washtucna | 14 | 84 | 58 | <u>69±13</u> |
| Average ± 2 sample standard deviations | | | | 66±16 |

- (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 6 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.

From the information in Table 16, the external background dose received by the population in the Hanford environs can be estimated. The average measured dose and 95% confidence interval was about 70 ± 15 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.¹⁰ Thus an estimate of 76 ± 15 mrem/year 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}K , in our bodies.¹⁶ Therefore, the average total background dose received in the Hanford environs is approximately 101 ± 15 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 17) are similar to 1973.¹⁸ 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 16).

TABLE 17. Columbia River Immersion Dose Rate - 1974

| Location | No. of Measurements | Radiation Dose (mrad/hr) ^(a) | | |
|--------------------|---------------------|---|------------------|-------------------------------|
| | | Maximum Observed | Minimum Observed | Annual ^(b) Average |
| Coyote Rapids | 11 | 0.007 | 0.004 | 0.005 ± 0.002 |
| Below 100-N | 13 | 0.008 | 0.004 | 0.005 ± 0.002 |
| Hanford Powerline | 10 | 0.01 | 0.003 | 0.007 ± 0.004 |
| Richland Pumphouse | 13 | 0.005 | 0.004 | 0.004 ± 0.001 |

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

(b) Average ± 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 detector¹¹ attached to the bumper of a truck and positioned about 0.6 meters (2 ft) above the edge of the road surface (described in BNWL-62). During 1974, no radioactivity other than background was detected.

Eleven small areas, called control plots, were located around the Hanford boundaries. These plots, measuring 3m x 3m (10' x 10') were surveyed monthly or semi-monthly with a Geiger-Muller survey meter for deposited radioactive material. No surface radioactivity of Hanford origin was detected on these control plots during 1974.

Each month, the shoreline of the Columbia River was surveyed 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 1974 for three of these locations, Vernita, Richland and Sacajawea, are summarized in Table 18. No statistical difference is apparent between the results for the three locations given the wide variability in observed values.

TABLE 18. Columbia River Shoreline Exposure Rate - 1974

| Shoreline Location | No. of Measurements | Exposure (mR/hr) | | |
|--------------------|---------------------|------------------|------------------|--------------------|
| | | Maximum Observed | Minimum Observed | Annual Average (a) |
| Vernita | 10 | 0.013 | 0.005 | 0.010±0.006 |
| Richland | 12 | 0.014 | 0.009 | 0.011±0.003 |
| Sacajawea | 25 | 0.015 | 0.008 | 0.011±0.003 |

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

Aerial Surveys

Between March 26 and April 28, 1974, a detailed aerial survey of Columbia River shoreline and islands was conducted by E.G.&G. of Las Vegas.¹² The survey covered an area from approximately four kilometers above Vernita Bridge to approximately 10 kilometers below the intersection of the Snake River with the Columbia River. An additional 20 kilometers downstream from McNary Dam was also surveyed. The survey was conducted at an altitude of 45 meters using a Navy helicopter. A minimum of three lines, spaced 60 meters apart, were flown along each bank, starting at the shoreline and moving inland. Similar patterns were flown over the islands. The counting system employed consisted of two pods, each containing twenty 12.5 cm diameter by 5 cm thick NaI(th) detectors, mounted externally on the helicopter. The signals from the detectors were fed into three units: a gross count scaler, a set of five adjustable window single channel analyzers, and a 300 channel multichannel analyzer.

The highest radiation levels observed offsite during the aerial survey occurred on the islands between the old Hanford townsite and the 300 Area. A maximum reading of 0.014 mR/hr of ^{60}Co was obtained. No ^{137}Cs activity, above background levels, was observed. The average external exposure rate in the Hanford environs is approximately 0.010 mR/hr. Subsequent to the aerial survey, soil samples were taken on the islands. The samples were analyzed for all gamma emitting radionuclides. The results are shown in Table 19. A comparison of the average concentrations of the different radionuclides observed on the islands with the concentrations observed in surface soil (Table 14) reveals that the island samples were higher for all radionuclides, including naturally occurring radionuclides. Previous measurements of Columbia River sediments (1973 report addendum)⁵ have shown similar quantities of the observed radionuclides except $^{106}\text{RuRh}$. Ruthenium-rhodium-106 is routinely observed in the atmosphere (Table 2) and in the Columbia River (Table 5). An inspection of the biweekly data available in the BNWL-1910 ADD shows that the $^{106}\text{RuRh}$ levels measured in the Columbia River parallel the diurnal cycle observed for fallout radionuclides in the atmosphere (Figure 4). The values observed in island soil samples (including Island #340 sample)

are expected to be due to past Hanford operations for all radionuclides except $^{106}\text{RuRh}$ and naturally occurring radionuclides. $^{106}\text{RuRh}$ was primarily due to fallout. The higher concentrations observed may be due to the time of sample collection. Island soil samples were collected in the spring; surface soil samples in the autumn.

TABLE 19. Gamma Emitting Radionuclides in Island Soil Samples - 1974

Units of 10^{-6} $\mu\text{Ci/gm}$ (dry weight)

| Sample Location (a) | Naturally Occurring Radionuclides | | | | Artificially Produced Radionuclides | | | | | | |
|--|-----------------------------------|---------------|---------------|---------------|-------------------------------------|-----------|---------------|---------------|---------------|---------------|---------------|
| | K-40 | Ra-224 | Ra-226 | Mn-54 | Cr-51 | Co-60 | Zn-65 | RuRh-106 | Cs-137 | Eu-152 | Eu-154 |
| Island #348 | 16. | 0.7 | 0.7 | 0.3 | 0.5 | 10. | 3.0 | 2.9 | 3.6 | 6.7 | 1.5 |
| Island #345 | 18. | 3.5 | 1.2 | 0.5 | * | 11. | 0.7 | 3.4 | 2.6 | 5.1 | 1.5 |
| Island #344 | 16. | 2.1 | 0.8 | 0.3 | 0.2 | 6. | 1.3 | 1.7 | 2.7 | 6.7 | 1.0 |
| Island #342 | 18. | 6.1 | 1.0 | 0.2 | * | 3. | 0.4 | 1.1 | 1.8 | 2.6 | 0.6 |
| Island #341 | 16. | 4.1 | 1.0 | 0.4 | * | 6. | 1.4 | 2.0 | 1.9 | 2.9 | 0.6 |
| Island #340 | 19. | 4.4 | 0.7 | 0.3 | * | 7. | 2.4 | 2.3 | 2.4 | 4.3 | 2.1 |
| Island #333 | 18. | 4.3 | 0.6 | 0.3 | * | 1. | 0.6 | 1.5 | 1.1 | 1.1 | 0.3 |
| Island #332 | 19. | 5.0 | 0.6 | 0.2 | 0.1 | 4. | 1.1 | 1.6 | 1.4 | 1.7 | 0.7 |
| Maximum | 19. | 6.1 | 1.2 | 0.5 | 0.5 | 11. | 3.0 | 3.4 | 3.6 | 6.7 | 2.1 |
| Minimum | 16. | 0.7 | 0.6 | 0.2 | * | 1 | 0.4 | 1.1 | 1.1 | 1.1 | 0.3 |
| Average \pm 2 sample standard deviations (b) | 18 \pm 3 | 3.8 \pm 3.4 | 0.8 \pm 0.4 | 0.3 \pm 0.2 | <0.3 | 6 \pm 7 | 1.4 \pm 1.8 | 2.1 \pm 1.5 | 2.2 \pm 1.6 | 3.9 \pm 4.3 | 1.0 \pm 1.2 |

*Less than detectable

(a) River mile of island used as identification.

(b) Average plus or minus two sample standard deviations shown if radionuclide detected at all locations. Otherwise, a less-than number is shown.

Although not contributing significantly to the measured exposure rates, seven discrete radioactive particles were detected during follow-up ground survey, buried one to four inches deep in sandy areas showing elevated exposure rates. The only measurable radionuclide was ^{60}Co . The particles are believed to have resulted from past Hanford reactor operations. Even if disturbed, these particles would afford no significant exposure risk from either inhalation or ingestion, in view of their scarcity, size, and insolubility.

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 1974 to the radiation levels measured in all environmental media (atmosphere, water, foodstuffs, wildlife, soil, and vegetation) were indistinguishable from preexisting 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 20 lists the radionuclide composition of effluent reported by all Hanford contractors during 1974. 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 1974 was estimated from theoretical models relating releases of radioactivity from Hanford operations with subsequent radiation dose to the population. The models^{13,14} have been used previously to determine the radiological impact from Hanford facilities (Waste Management Operations - Hanford Reservation - WASH-1538).¹⁵ 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 1974. The radiological impact from radioactivity measured in wildlife, island soil samples, river sediments, and oysters from past Hanford operations are addressed separately.

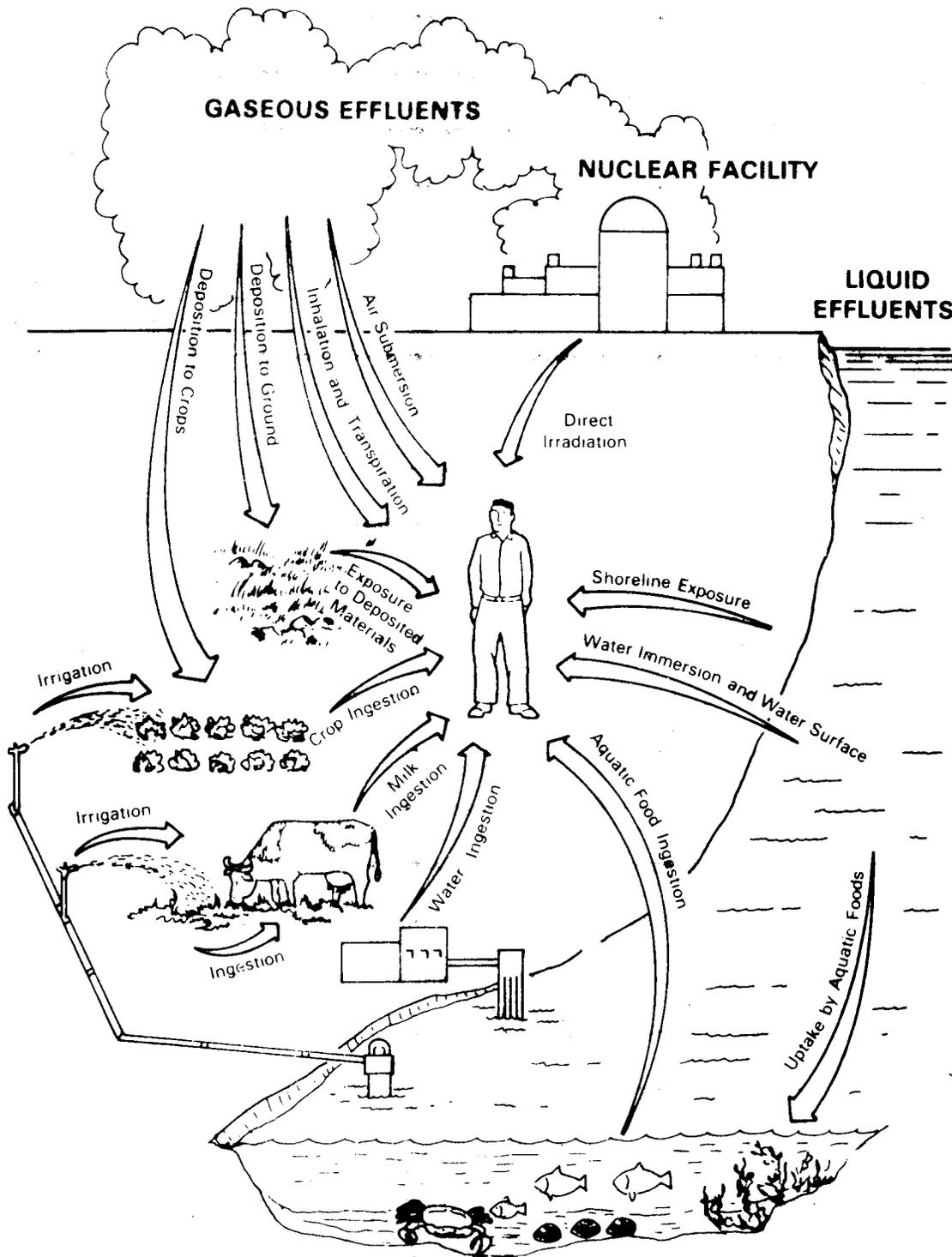


FIGURE 9. Exposure Pathways to Man¹³

TABLE 20. Radionuclide Composition of Effluent - 1974^(a)

| | Half life | Effluent (Curies) | | |
|-----------------------------|------------------------|-------------------|---------------------|---|
| | | Liquid to River | 100 Areas | Gaseous 200 Areas 300 Areas |
| H-3(HTO) | 12.3 yr | 190. | 4.2 | |
| Na-24 | 15 hr | 1.0 | | |
| P-32 | 14.3 d | 0.004 | | |
| Ar-41 | 1.8 hr | | 50,000 | |
| Sc-46 | 84 d | 0.02 | | |
| Cr-51 | 28 d | 0.22 | | |
| Mn-54 | 303 d | 0.5 | | |
| Mn-56 | 2.6 hr | 5.0 | | |
| Co-58 | 71 d | 0.02 | | |
| Fe-59 | 46 d | 0.18 | | |
| Co-60 | 5.3 yr | 1.2 | | <5x10 ⁻⁵ (b) |
| Zn-65 | 245 d | 0.2 | | |
| As-76 | 26.4 hr | 0.03 | | |
| Sr-90 | 28 yr | 0.3 | 5x10 ⁻⁶ | <0.2(c) <4x10 ⁻⁴ (c) |
| Nb-95 | 35 d | 0.1 | | |
| Zr-95 | 66 d | 0.11 | | |
| Mo-99 | 67 hr | <0.6 | | |
| Tc-99 | 2.1x10 ⁵ yr | <0.1 | | |
| Ru-103 | 40 d | 0.12 | | |
| Ru-106 | 368 d | 0.5 | | |
| Sb-122 | 2.8 d | <0.01 | | |
| Sb-124 | 60 d | <0.07 | | |
| Sb-125 | 2.7 yr | 0.02 | | |
| I-131 | 8 d | 2.33 | 0.5 | <3x10 ⁻³ |
| I-132 | 2.3 hr | | 0.1 | |
| I-133 | 20.3 hr | | 2.2 | |
| Xe-133 | 5.3 d | 0.003 | 0.15 | |
| Cs-134 | 2.0 yr | 0.02 | | |
| I-135 | 6.7 hr | | 3.1 | |
| Xe-135 | 9.1 hr | | 1.8 | |
| Cs-137 | 30.0 yr | 0.12 | | |
| BaLa-140 | 12.8 d | 0.8 | | |
| Ce-141 | 32.5 d | 0.05 | | |
| Ce-144 | 284 d | 0.103 | | |
| W-187 | 23.9 hr | <0.01 | | |
| Np-239 | 2.3 d | 0.02 | | |
| Am-241 | 458 yr | | | <3x10 ⁻⁷ |
| Pu-Alpha ^(d) | 24,390 yr | | <4x10 ⁻⁷ | <2x10 ⁻³ <4x10 ⁻⁵ |
| U-Alpha ^(d) | 4.5x10 ⁹ yr | | | <4.3x10 ⁻⁴ |
| Particulates ^(e) | --- | | 0.23 | |

- (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. For 300 Area, 2x10⁻⁴ curies of Sr-90 was reported. The additional, <2x10⁻⁴, was reported as mixed fission products.
- (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.
- (e) Gross activity collected on particle filter. Subsequent analyses have shown the majority of the particulate activity to be Mo-99. This radionuclide was used in the dose calculations.

RADIOLOGICAL IMPACT FROM 1974 EFFLUENT

Three separate parameters are suggested by ERDA Manual Chapter 0513¹⁷ 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 1974 was calculated to be 2×10^{-5} 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 0.17 mrem. The majority of the dose received would be from ⁴¹Ar (half-life 1.8 hours) released at N Reactor.

Maximum Individual Dose

The maximum dose to an individual member of the public during 1974 and the 50-year dose commitment from 1974 effluent were calculated for all of the radionuclides listed in Table 20.

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. The calculated doses are conservative since less-than numbers in Table 20 were assumed to be positive measurements for purposes of dose calculation.

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 1974 for such an individual from effluent released during 1974 is 0.03 mrem as shown in Table 21. The dose received was primarily the result of external radiation from ^{41}Ar releases from N Reactor (0.02 mrem) and radionuclides ingested with fish from the Columbia River and foodstuffs irrigated with Columbia River water (0.01 mrem).

The dose potentially received by the thyroid of an infant (one year old) was estimated to be 0.5 mrem from effluent released during 1974, as shown in Table 21. The dose was primarily due to ^{131}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 1974 since ^{131}I has an eight-day half-life.

TABLE 21. Estimated Dose to the Maximum Individual During 1974 from Effluents Released from Hanford Facilities During 1974

| Pathway | Annual Exposure | Annual Dose (mrem) ^(a) | | | | |
|------------------------------------|---------------------------|-----------------------------------|---------|--------------------------|-----------|-----------|
| | | Skin | Body | GI-LLI | Bone | Thyroid |
| <u>Gaseous Effluents</u> | | | | | | |
| Air Submersion | 8766 hr | 3.0E-02 | 2.0E-02 | (2.0E-02) ^(b) | (2.0E-02) | (2.0E-02) |
| Tritium-Inhalation & Transpiration | 8766 hr | 7.0E-10 | 7.0E-10 | 7.0E-10 | - | 7.0E-10 |
| Radioiodine-Inhalation | 7300 m ³ | - | - | - | - | 2.0E-03 |
| Milk | 274 liters ^(c) | - | - | - | - | 6.0E-02 |
| Vegetables (leafy) | 30 kg ^(d) | - | - | - | - | 1.0E-02 |
| Total Air Pathways | | 3.0E-02 | 2.0E-02 | 2.0E-02 | 2.0E-02 | 9.0E-02 |
| <u>Liquid Effluents</u> | | | | | | |
| Drinking Water | 730 liters | - | 2.4E-04 | 4.9E-04 | 2.0E-04 | 1.7E-02 |
| Fish Consumption | 40 kg | - | 5.7E-03 | 2.1E-02 | 6.2E-03 | 1.8E-02 |
| Irrigated Foods | 710 kg | - | 4.8E-03 | 7.5E-02 | 2.5E-03 | 6.3E-02 |
| Shoreline Swimming | 500 hr | 4.0E-03 | 3.0E-03 | (3.0E-03) | (3.0E-03) | (3.0E-03) |
| Boating | 100 hr | 2.0E-05 | 2.0E-06 | (2.0E-06) | (2.0E-06) | (2.0E-06) |
| | 100 hr | 1.0E-05 | 8.0E-06 | (8.0E-06) | (8.0E-06) | (8.0E-06) |
| Total Water Pathways | | 4.0E-03 | 1.4E-02 | 3.2E-02 | 1.2E-02 | 1.0E-01 |
| Total (Adult) | | 3.4E-02 | 0.03 | 0.05 | 0.03 | 0.19 |
| <u>Infant Thyroid Dose</u> | | | | | | |
| Airborne Tritium | 8766 hr | | | | | 4.0E-10 |
| Air Submersion | 8766 hr | | | | | (2.0E-02) |
| Inhalation | 2045 m ³ | | | | | 6.0E-03 |
| Milk | 274 liters ^(c) | | | | | 0.4 |
| Drinking Water | 292 liters | | | | | 5.0E-02 |
| Total (Infant) | | | | | | 0.5 |

- (a) Dose received during 1974 due to effluent released during 1974.
 (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 total body dose commitment to the maximum individual from 1974 effluents is 0.05 mrem as shown in Table 22. The additional 0.02 mrem received after 1974 is due primarily to the consumption during 1974 of ⁹⁰Sr in drinking water, fish, and irrigated foods. The bone dose received during 1974 was estimated to be 0.03 mrem due primarily to external exposure. The 50-year dose commitment to the bone was estimated to be 0.1 mrem, as shown in Table 22. The dose received after 1974 is due primarily to ⁹⁰Sr.

TABLE 22. Estimated 50-Year Dose Commitment to the Maximum Individual from Effluents Released from Hanford Facilities During 1974

| Pathway | Annual Exposure | Dose Commitment (mrem) ^(a) | | | | |
|------------------------------------|---------------------------|---------------------------------------|---------|--------------------------|-----------|-----------|
| | | Skin | Body | GI-LLI | Bone | Thyroid |
| <u>Gaseous Effluents</u> | | | | | | |
| Air Submersion | 8766 hr | 3.0E-02 | 2.0E-02 | (2.0E-02) ^(b) | (2.0E-02) | (2.0E-02) |
| Tritium-Inhalation & Transpiration | 8766 hr | 7.0E-10 | 7.0E-10 | 7.0E-10 | - | 7.0E-10 |
| Radioiodine-Inhalation | 7300 m ³ | - | - | - | - | 2.0E-03 |
| Milk | 274 liters ^(c) | - | - | - | - | 6.0E-03 |
| Vegetables (leafy) | 30 kg ^(d) | - | - | - | - | 1.0E-02 |
| Total Air Pathways | | 3.0E-02 | 2.0E-02 | 2.0E-02 | 2.0E-02 | 9.0E-02 |
| <u>Liquid Effluents</u> | | | | | | |
| Drinking Water | 730 liters | - | 8.3E-04 | 4.9E-04 | 2.6E-03 | 1.7E-02 |
| Fish Consumption | 40 kg | - | 1.1E-02 | 2.1E-02 | 2.6E-02 | 1.8E-02 |
| Irrigated Foods | 710 kg ^(e) | - | 1.5E-02 | 7.5E-02 | 4.6E-02 | 6.3E-02 |
| Shoreline | 500 hr | 4.0E-03 | 3.0E-03 | (3.0E-03) | (3.0E-03) | (3.0E-03) |
| Swimming | 100 hr | 2.0E-05 | 2.0E-06 | (2.0E-06) | (2.0E-06) | (2.0E-06) |
| Boating | 100 hr | 1.0E-05 | 8.0E-06 | (8.0E-06) | (8.0E-06) | (8.0E-06) |
| Total Water Pathways | | 4.0E-03 | 3.0E-02 | 3.2E-02 | 7.8E-02 | 1.0E-01 |
| Total (Adult) | | 3.4E-02 | 0.05 | 0.05 | 0.10 | 0.19 |
| <u>Infant Thyroid Dose</u> | | | | | | |
| Airborne Tritium | 8766 hr | | | | | 4.0E-10 |
| Air Submersion | 8766 hr | | | | | (2.0E-02) |
| Inhalation | 2045 m ³ | | | | | 6.0E-03 |
| Milk | 274 liters ^(c) | | | | | 0.4 |
| Drinking Water | 292 liters | | | | | 5.0E-02 |
| Total (Infant) | | | | | | 0.5 |

- (a) Dose commitment for 50 years (1974-2023, inclusive) due to effluents released during 1974.
 (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 5-month growing season.
 (e) Only the potentially irrigated produce is included.

For comparison, the maximum individual would also receive each year approximately 76 mrem from background external radiation (page 37), 11 mrem from naturally occurring ⁴⁰K in milk (1000 pCi/l from Table 10 and 274 liters of milk), 5 mrem from ⁴⁰K in fish (3 pCi/gr from Table 13 and 40 kilograms of fish), 0.02 mrem from ⁴⁰K in drinking water (0.7 pCi/l from Table 5 and 730 l/yr) and additional exposure from other natural and fallout sources not calculated. Therefore, the maximum individual would have received an additional dose which is 0.03% of the background dose of 100 mrem/year in the Hanford environs during 1974 due to Hanford operations.

80-Kilometer Radius Population Dose

The total body population dose received during 1974 by the population within an 80-kilometer (50-mile) radius of the Hanford Reservation and the 50-year dose commitment from effluent released during 1974 were estimated for all of the radionuclides listed in Table 20. Table 23 lists the population dose received during 1974 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 1974 was 1.1 man-rem or an average annual dose per capita of 0.004 mrem. This dose is primarily due to external irradiation from ^{41}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 4.2 man-thyroid-rem during 1974.

TABLE 23. Estimated Population Dose During 1974 from Effluents Released from Hanford Facilities During 1974

| Exposure Mode | Radionuclide | Annual Dose (man-rem) ^(a) | | | | |
|--|--|--------------------------------------|----------------------|-----------|---------|-----------|
| | | Total Body | Bone | GI-LLI | Lung | Thyroid |
| <u>Gaseous Effluent</u> | | | | | | |
| Air (Inhalation & Submersion) | H-3 | 2.5E-04 | | 2.5E-04 | 2.5E-04 | 2.5E-04 |
| | Ar-41 | 1.1 | (1.1) ^(b) | (1.1) | (1.1) | (1.1) |
| | Co-60 | 3.8E-07 | | | 3.2E-07 | |
| | Sr-90+D | 7.8×10^{-3} | 2.9×10^{-2} | | 1.3E-01 | |
| | Mo-99+D | 2.5E-05 | | | 7.1E-04 | |
| | Am-241 | 2.3×10^{-7} | 2.8E-06 | | 3.5E-05 | |
| | Pu-239 | 7.2×10^{-4} | 1.7×10^{-2} | | 1.1E-01 | |
| | U-nat | 1.4E-04 | 1.1E-03 | | 4.1E-02 | |
| Radioiodine (Inhalation, Milk, Vegetables) | $\left\{ \begin{array}{l} \text{I-131} \\ \text{I-133} \end{array} \right\}$ | | | | | 2.5 |
| Total Gaseous Pathways | | 1.1 | 1.1 | 1.1 | 1.4 | 3.6 |
| <u>Liquid Effluent</u> | | | | | | |
| Drinking Water | (c) | 7.3E-03 | 6.0E-03 | 1.5E-02 | | 0.5 |
| Fish Consumption | (c) | 2.1E-03 | 2.3E-03 | 8.0E-03 | | 6.7E-03 |
| Aquatic Recreation | (c) | 1.3E-02 | (1.3E-02) | (1.3E-02) | | (1.3E-02) |
| Irrigated Foodstuffs | (c) | 4.8×10^{-3} | 2.5E-03 | 7.5E-03 | | 6.3E-02 |
| Total Liquid Pathways | | 2.7E-02 | 2.4E-02 | 4.4E-02 | | 5.8E-01 |
| <u>Total</u> | | 1.1 | 1.1 | 1.1 | 1.4 | 4.2 |

(a) Dose received during 1974 from effluent released during 1974.

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

(c) Radionuclides released to the river listed in Table 20.

Table 24 lists the 50-year dose commitment (1974 to 2023, inclusive) potentially received by the 250,000 people from effluents released during 1974. The total-body population dose commitment was estimated to be 1.6 man-rem, the 0.5 man-rem received by the population after 1974 is due primarily to ^{90}Sr ; ^{239}Pu also contributes. The 50-year dose commitment to the thyroid is all received during 1974 since the iodine isotopes which contribute the majority of the thyroid dose have short half-lives and the external exposure sources are no longer present after 1974. The 50-year dose commitment for the G.I. tract is also all received in 1974 since there is no accumulation of material within the tract. The estimated 50-year dose commitments to the bone and lung are 4.4 (man-bone-rem) and 2.4 (man-lung-rem), respectively. The doses received by these two organs after 1974 are due primarily to ^{90}Sr and ^{239}Pu .

TABLE 24. Estimated 50-Year Population Dose Commitment from Effluents Released from Hanford Facilities During 1974

| Exposure Mode | Radionuclide | Dose Commitment (man-rem) ^(a) | | | | |
|--|--------------------|--|----------------------|-----------|---------|-----------|
| | | Total Body | Bone | GI-LLI | Lung | Thyroid |
| <u>Gaseous Effluent</u> | | | | | | |
| Air (Inhalation & Submersion) | H-3 | 2.5E-04 | | 2.5E-04 | 2.5E-04 | 2.5E-04 |
| | Ar-41 | 1.1 | (1.1) ^(b) | (1.1) | (1.1) | (1.1) |
| | Co-60 | 3.8E-07 | | | 3.2E-07 | |
| | Sr-90+D | 0.3 | 1.3 | | 0.6 | |
| | Mo-99+D | 2.5E-05 | | | 7.1E-04 | |
| | Am-241 | 2.0E-05 | 2.7E-04 | | 1.6E-04 | |
| | Pu-239 | 8.3E-02 | 1.8 | | 0.5 | |
| | U-nat | 2.5E-04 | 4.1E-03 | | 1.9E-01 | |
| Radioiodine (Inhalation, Milk, Vegetables) | {I-131} {I-133} | | | | | 2.5 |
| Total Gaseous Pathways | | 1.5 | 4.2 | 1.1 | 2.4 | 3.6 |
| <u>Liquid Effluent</u> | | | | | | |
| Drinking Water | (c) | 2.9E-02 | 7.9E-02 | 1.5E-02 | | 0.5 |
| Fish Consumption | (c) | 3.9E-03 | 9.8E-03 | 8.0E-03 | | 6.7E-03 |
| Aquatic Recreation | (c) | 1.3E-02 | (1.3E-02) | (1.3E-02) | | (1.3E-02) |
| Irrigated Foodstuffs | (c) | 1.5E-02 | 4.6E-02 | 7.5E-03 | | 6.3E-02 |
| Total Liquid Pathways | | 5.7E-02 | 1.5E-01 | 4.3E-02 | | 5.8E-01 |
| <u>Total</u> | | 1.6 | 4.4 | 1.1 | 2.4 | 4.2 |

- (a) Dose Commitment for 50 years (1974-2023, inclusive) from effluents released during 1974.
 (b) Internal dose from external exposure indicated by parenthesis ().
 (c) Radionuclides released to the river listed in Table 20.

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 1974 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 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 1974.¹⁶

In summary, the maximum "fence-post" exposure rate was calculated to be 2×10^{-5} mR/hr along the northwest boundary of the Hanford Reservation. The total body dose received by the maximum individual during 1974 and the 50-year dose commitment from effluent released during 1974 are 0.03 mrem and 0.05 mrem, respectively. The total-body dose potentially received by the assumed 250,000 people living within an 80 kilometer radius of the Hanford Reservation during 1974 and the 50-year dose commitment from effluents released during 1974 are 1.1 man-rem and 1.6 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, Aerial Survey) concerned with the evaluation of monitoring data collected during 1974 discussed the presence of radioactivity, primarily ^{60}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 1974, the levels in fish and gamebirds were only occasionally detected and at levels near the detection limit of the analyses. Levels of ^{65}Zn in

Willapa Bay oysters continued to decrease and are now a 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 1974 were lower than those observed during 1973. External radiation levels observed on the Columbia River islands are expected to gradually decrease due to further dilution during periods of high water flow and radioactive decay.

The contribution of these sources of radioactivity to the maximum "fence-post" exposure rate, maximum individual dose, and 80-kilometer population dose calculated from 1974 effluent range from insignificant to predominate. The maximum "fence-post" exposure rate calculated from 1974 effluent was 2×10^{-5} mR/hr along the uninhabited northwest boundary of the Hanford Reservation. The highest external exposure rate measured on the Columbia River islands was 0.014 mR/hr, or 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 would be received each hour in addition to the approximate 0.010 mrem received from background external radiation. The contribution to the population dose received during 1974 is an insignificant numerical addition to the previously calculated dose of 1.1 man-rem from 1974 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.² 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 Washington² and the EPA.³

Environmental radiation protection standards are published in Manual Chapter 0524, "Standards for Radiation Protection"¹ of ERDA. These standards are based on guidelines recommended by the President's Federal Radiation Council (FRC), whose functions have now 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) U.S. Energy Research and Development Administration
Richland Operations Office
P.O. Box 999
Richland, WA 99352

ACKNOWLEDGMENT

Acknowledgment is given to several other people who participated in the preparation of this report. Loren Maas of HEHF supplied data regarding non-radiological analyses of air and sanitary water. Harold Oens supplied data regarding U.S. Testing Company participation in the EPA Interlaboratory Comparison Program for environmental sample analyses (Appendix A). Ed Watson and Dennis Streng performed the atmospheric dose calculations. Joe Soldat performed all other dose calculations appearing in the tables contained in the "Radiological Impact" section. Emily Porath edited the report and arranged for its typing and printing.

REFERENCES

1. "Standards for Radiation Protection," ERDA Manual, Chapter 0524, with Appendix. U.S. Energy Research and Development Administration, Washington D.C., 1963. Revised October 1973.
2. Water Quality Standards, Department of Ecology, State of Washington, June 1973.
3. "Natural Primary and Secondary Ambient Air Quality Standards," Federal Regulations, 40 CFR 50, Environmental Protection Agency, January 1973.
4. D. E. Robertson, et al., "Transport and Depletion of Radionuclides in the Columbia River," IAEA, Vienna, 1973.
5. W. L. Nees and J. P. Corley, Environmental Surveillance at Hanford for CY-1973 Data, BNWL-1811 ADD (Data Tables), Battelle-Northwest, Richland, WA, April 1974.
6. Drinking Water Standards - 1962, Public Health Service, Washington D.C. 1962.
7. R. T. Jaske and M. R. Sysogorumd, Effect of Hanford Plant Operations on the Temperature of the Columbia River, 1964 to present, BNWL-1345, Battelle-Northwest, Richland, WA, November 1970.
8. K. L. Kipp, Radiological Status of the Groundwater Beneath the Hanford Project - January-December 1973, BNWL-1860, Battelle-Northwest, Richland, WA.
9. D. H. Denhan, et al., A $\text{CaF}_2:\text{Dy}$ Thermoluminescent Dosimeter for Environmental Monitoring, BNWL-SA-4191, Battelle-Northwest, Richland, WA, August 1972.
10. D. T. Oakley, Natural Radiation Exposure in the United States, ORP/SID 72-1, Environmental Protection Agency, Washington D.C., June 1972.
11. L. L. Philipp and E. M. Sheen, Aerial and Ground Gamma Survey Monitors, BNWL-62, Battelle-Northwest, Richland, WA (May 1965).
12. W. J. Tipton, An Aerial Radiological Survey of the U.S. Atomic Energy Commission's Hanford Reservation, EG&G, Las Vegas, NV, in press.
13. J. K. Soldat, et al., Models and Computer Codes for Evaluating Environmental Radiation Doses, BNWL-1754, Battelle-Northwest, Richland, WA, February 1974.

14. D. L. Streng and E. C. Watson, KRONIC - A Computer Program for Calculating Annual Average External Doses From Chronic Atmospheric Releases of Radionuclides, BNWL-B-264, Battelle-Northwest, Richland, WA, June 1973.
15. U.S. Energy Research and Development Administration, Hanford Waste Management Operations Draft Environmental Impact Statement, WASH 1538, ERDA Hanford Operations, September, 1974.
16. U.S. Environmental Protection Agency, Estimates of Ionizing Radiation Doses in the United States 1960 - 2000, ORP/CSD 72-1, Rockville, MD, August 1972.
17. "Effluents and Environmental Monitoring and Reporting," ERDA Manual, Chapter 0513, U.S. Energy Research and Development Administration, March 1972, Revised February 1974.
18. W. L. Nees and J. P. Corley, Environmental Surveillance at Hanford for CY-1973, BNWL-1811, Battelle-Northwest, Richland, WA, April 1974.

APPENDIX A

RADIOCHEMICAL ANALYSES

APPENDIX A

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, air, food, and soil) 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 Table A-1 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 level of radioactivity present on

each type of routine environmental sample delivered to U.S. Testing has also been included. 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 A-1. Comparison of U.S. Testing and EPA's Analyses of Quality Assurance Samples

| Environmental Medium | Date | Analysis | (1974) | | Analytical Results ^(b) | | | | |
|----------------------|-------|----------------|------------|--------------------------|-----------------------------------|-----------|------------|--------|-------|
| | | | Units | (a) Hanford Env. Samples | US Testing | EPA | Other Labs | | |
| Air | 6/21 | Alpha | pCi/sample | ~ 0.4 | 138±12 | 196±147 | 177±39 | | |
| | | Beta | " | ~ 0.4 | 547±50 | 735±111 | 770±162 | | |
| | | Sr-90 | " | ~ 7 | 191±6 | 198±30 | 187±16 | | |
| | | Cs-137 | " | * | 196±30 | 200±30 | 199±31 | | |
| | 11/8 | Alpha | " | | 148±12 | 174±131 | 171±65 | | |
| | | Beta | " | | 486±30 | 519±78 | 596±101 | | |
| | | Sr-90 | " | | 183±6 | 172±26 | 164±18 | | |
| | | Cs-137 | " | | 178±18 | 174±26 | 184±18 | | |
| | | Water | 2/15 | Alpha ^(c) | pCi/l | ~ 0.5 | 1.4±0.6 | 51±39 | 38±19 |
| | | | | Beta | " | ~ 1.0 | 43±8 | 25±15 | 39±9 |
| 4/19 | Alpha | | " | | 45±6 | 95±75 | 64±28 | | |
| | Beta | | " | | 177±8 | 190±30 | 199±39 | | |
| 7/26 | Alpha | | " | | 47±12 | 75±56 | 59±26 | | |
| | Beta | | " | | 124±24 | 103±15 | 112±21 | | |
| 9/27 | Alpha | | " | | 25±5 | 25±19 | 21±8 | | |
| | Beta | | " | | 81±17 | 77±15 | 80±15 | | |
| 12/4 | Alpha | | " | | 59±9 | 50±38 | 41±15 | | |
| | Beta | | " | | 43±9 | 51±15 | 57±13 | | |
| | 3/15 | ³ H | pCi/l | ~ 300. | 3382±375 | 3400±1040 | 3331±332 | | |
| | 5/24 | ³ H | " | | 2810±567 | 2673±1059 | 2669±236 | | |
| | 8/9 | ³ H | " | | 3226±1050 | 1438±993 | 1491±255 | | |
| | 10/11 | ³ H | " | | 1805±366 | 1975±1050 | 1979±301 | | |
| | 4/1 | Co-50 | pCi/l | 0.3 | 455±22 | 490±73 | 478±29 | | |
| | 6/5 | Cr-51 | " | * | 273±255 | 349±51 | 331±53 | | |
| | 8/23 | Ru-106 | " | * | 590±225 | 420±63 | 423±49 | | |
| | 10/18 | Cs-134 | " | * | 388±62 | 481±72 | 467±40 | | |
| | Milk | 4/5 | Sr-89 | pCi/l | * | 153 | 204±30 | 172±38 | |
| | | | Sr-90 | " | < 2 | 146±7 | 172±26 | 167±22 | |
| I-131(d) | | | " | < 1 | 59 | 150±22 | 152±19 | | |
| Cs-137 | | | " | < 5 | 135±45 | 174±26 | 170±15 | | |
| 7/12 | | Sr-89 | " | | 136±4 | 152±23 | 129±27 | | |
| | | Sr-90 | " | | 143±5 | 152±23 | 151±31 | | |
| | | I-131(d) | " | | --- | 142±21 | 146±17 | | |
| | | Cs-137 | " | | 136±45 | 155±23 | 156±10 | | |
| 9/13 | | Sr-89 | " | | 189±15 | 158±24 | 138±27 | | |
| | | Sr-90 | " | | 105±7 | 124±19 | 124±18 | | |
| | | I-131(d) | " | | 26±2 | 188±28 | 193±22 | | |
| | | Cs-137 | " | | 126±45 | 126±19 | 132±8 | | |

* less than detectable

- (a) Approximate radioactivity present on routine environmental samples delivered to U.S. Testing.
- (b) U.S. Testing and EPA results include 1-sigma (99.9% confidence limit) uncertainty. The results from the other labs include 1-sigma (68% confidence limit) uncertainty.
- (c) First sample analyzed with an ether extraction technique which is not suitable for removing ²⁴¹Am activity. Americium-241 is not a significant component of the activity in air in the Hanford environs.
- (d) Iodine is analyzed by the method described in Regulatory Guid 4.3. Samples supplied by EPA are apparently not compatible with this method.

DISTRIBUTION

| <u>No. of Copies</u> | | <u>No. of Copies</u> | |
|--------------------------|--|--------------------------|--|
| <u>Off-Site</u> | | <u>Off-Site</u> | |
| 1 | <u>ERDA Chicago Patent Group</u> A. A. Churm | 5 | <u>Environmental Protection Agency</u> <u>Region X</u> Seattle, Washington 98101 E. Cowan |
| 1 | <u>ERDA Office of Biomedical, Environmental Research, and Safety Programs</u> J. L. Liverman | 1 | <u>Los Alamos Scientific Laboratory</u> Los Alamos, New Mexico H. S. Jordan |
| 1 | <u>ERDA Directorate of Reg. Oper. Region V</u> 211 Bancroft Way Berkeley, Calif. 94707 R. Smith | 1 | <u>Oregon State Department of Environmental Quality</u> 1234 SW Morrison Portland, Oregon 97205 L. B. Day, Director |
| 1 | <u>ERDA Division of Reactor Development & Technology</u> Asst. Dir. for Nuclear Safety A. T. Pressesky | 2 | <u>Oregon State Health Division</u> P. O. Box 231 Portland, Oregon 97207 G. Toombs M. W. Parratt |
| 261 | <u>ERDA Technical Information Center</u> | 1 | <u>Washington State Department of Social & Health Services</u> 1514 Smith Tower Seattle, Washington 98104 R. R. Mooney |
| 1 | <u>ERDA Idaho Operations</u> Operational Safety Division Idaho Falls, Idaho 83401 R. E. Tiller | 1 | <u>Washington State Department of Social & Health Services</u> P. O. Box 1788, MS 56-1 Olympia, Washington 98504 C. Lewis |
| 1 | <u>ERDA Headquarters Library</u> Charles Sherman | 3 | <u>Washington State Department of Ecology</u> Olympia, Washington 98501 J. A. Briggs G. Hansen J. Raymond |
| 5 | <u>ERDA Division of Operational Safety</u> M. R. Biles (4) A. A. Schoen (1) | 1 | <u>Yakima County Health District</u> City Hall Yakima, Washington 98901 Health Officer |
| 1 | <u>ERDA Division of Military Application</u> Gordon Facer | 1 | <u>Benton-Franklin Health Center</u> Pasco, Washington 99301 V. E. Michael |
| 2 | <u>ERDA Division of Production</u> G. B. Pleat E. F. Greenleaf | | |
| 1 | <u>ERDA Nevada Operations Office</u> Office of Safety P. O. Box 14100 Las Vegas, Nevada 89114 W. J. Larkin | | |

No. of
Copies

No. of
Copies

Off-Site (Con't)

1 City of Richland
Water & Sewer Department
505 Swift Blvd.
Richland, Washington 99352
K. R. Engstrom

2 Westinghouse Hanford Company
R. O. Budd
R. B. Hall

68 Battelle-Northwest

W. J. Bair
P. J. Blumer
R. E. Burns
L. A. Carter
J. P. Corley
C. E. Cushing
G. M. Dalen
J. R. Eliason
J. J. Fix (32)
R. F. Foster
J. J. Fuquay
W. T. Hinds
J. J. Jech
L. J. Kirby
H. V. Larson
M. W. Leale
J. M. Nielsen
D. E. Olesen
H. M. Parker
E. H. Phinney
R. W. Perkins
W. H. Richard
W. D. Richmond
J. M. Selby
C. L. Simpson
J. H. Soehnlein
J. K. Soldat
C. M. Unruh
B. E. Vaughan
D. A. Waite
D. G. Watson
Technical Publications
Technical Information (5)

On-Site Hanford

1 ERDA/RL Patent Attorney
R. M. Poteat

14 ERDA Richland Operations Office
O. J. Elgert
P. G. Holsted
L. F. Perkins
P. G. Rhoades
M. W. Tiernan (10)

7 Atlantic Richfield Hanford
Company
G. E. Backman
G. L. Hanson
R. E. Isaacson
H. L. Maxfield
Keith Price
A. T. White
ARHCO Files

5 United Nuclear, Inc.
T. E. Dabrowski
R. E. Dun
A. E. Engler
N. R. Miller
UNI File

1 Hanford Environmental Health
Foundation
R. G. Anderson

1 J. A. Jones Construction Co.
L. L. Crass

1 U. S. Testing Company, Inc.
W. V. Baumgartner