BNWL-665

EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD JANUARY-JUNE, 1967

THE ENVIRONMENTAL STUDIES SECTION STAFF

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD JANUARY-JUNE, 1967

by

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD JANUARY-JUNE, 1967

SUMMARY STATEMENT

Surveillance of the Hanford environs during the first half of 1967 showed that the concentrations of radioactive materials in the vicinity were well within the appropriate limits and that radioactive wastes were under sound and continuous control. Most of the environmental radiation dose for the majority of persons living in the Hanford environs was due to natural sources and world-wide fallout rather than to Hanford operations.

The major source of low-level radioactive waste released to the environment from Hanford plants is reactor cooling water discharged to the Columbia River. ^{32}P continued to be the radionuclide of Hanford origin that contributed the largest radiation dose to individuals who consistently ate sizable quantities of locally caught fish.

To estimate the maximum radiation dose received by persons residing in the Hanford environs, a hypothetical Maximum Individual was postulated. Included in this individual's annual diet were 200 meals of Columbia River fish. The Maximum Individual's estimated intake of ^{32}P from fish for the 12 month period ending June 30, 1967 was about 6% of the Maximum Permissible Rate of Intake (with bone as the critical organ). This intake is essentially the same as that reported in the 1966 Annual Report.(1)

The Typical Richland Resident received most of his radiation dose from natural background and world-wide fallout. The radiation dose from Hanford sources received by this population group originates, for the most part, from drinking water obtained from the Columbia River. An evaluation of estimated doses received by the various body organs of such an individual indicated that the dose to the GI (gastro-intestinal) tract was the largest percentage of appropriate limits. The GI tract dose from drinking water for a Typical Richland Resident for the 12-month period ending June 30, 1967 was about 5% of the limit.

Generally, ^{131}I concentrations in the Hanford environs were at very low levels during the first half of 1967. The estimated thyroid dose for a small child (2 g thyroid) drinking Richland water for the 12 month period ending June 30, 1967 was 13 mrem, or 3% of the appropriate limit, as compared to 35 mrem during 1966.(1) Radioactive fallout caused a brief increase in ^{131}I concentrations in the environment during January, but concentrations soon returned to the low levels experienced during most of 1966.

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INTRODUCTION

Results of the environmental surveillance program, conducted for the Hanford Plant by Battelle-Northwest's Environmental Studies Section, are summarized in this report for the first half of 1967. To show trends in radiological conditions, data collected for this reporting period have been added to graphs showing the results of measurements from previous years.

This report supplements and updates data presented in the 1966 Annual Report,[1] which evaluates the combined off-project effects of the radioactive waste disposal practices of all contractors at Hanford (Figgures 1 and 2). Radiation protection practices, including radioactive waste disposal, are governed by AEC Manual Chapters 0524 and RL 0524.[3]

Radiation dose estimates for people living in the Hanford environs during 1966[1] are presented for reference in Figures 3 and 4. These figures represent the MPRI (Maximum Permissible Rate of Intake) and the radiation dose received by the GI tract, the infant thyroid, and the whole body for the Maximum Individual and the Typical Richland Resident. Recommended dose standards are indicated, and several sources of radionuclide intake are identified. The Maximum Individual has been assigned eating and living habits that would result in the largest probable percent of limit:

FIGURE 1. Geographical Relationship of Hanford to Pacific Northwest

- Consumption of 200 meals per year of fish caught down river from the reactors
- Spending 500 hours per year on the riverbank to catch the above quantity of fish
- Consumption of meat, milk, fruit, and vegetables from irrigated farms in the Riverview District
- Consumption of drinking water from the Pasco system.

The Typical Richland Resident was assumed to have no unusual eating or living habits. Essentially all of his foodstuffs were assumed to have been purchased from commercial outlets.

The term "analytical limit" is used in this report to provide an

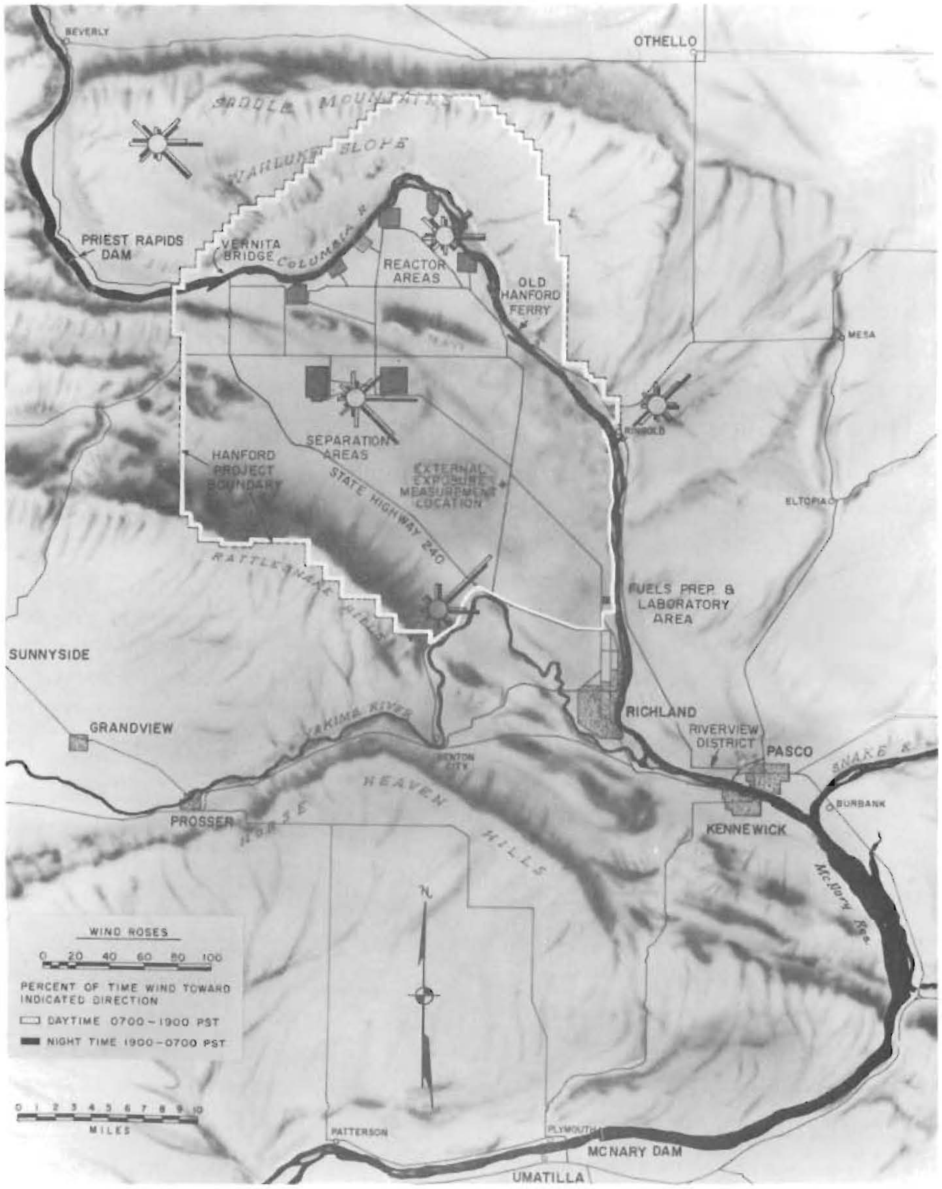

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FIGURE 2. Features of Hanford Project and Vicinity

indication of the reliability of the data. The "analytical limit" is defined as the concentration at which the laboratory can measure a radionuclide with an accuracy of ±100% at the 90% confidence level. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and the amounts of interfering radionuclides present. The "analytical limits" were chosen to represent upper bounds to these fluctuating detection limits.

The radiochemical data presented in this report were supplied by the U.S. Testing Co., Inc., which performed all routine radioassays of environmental samples.

The units used throughout much of this report are mrems (dose-equivalent). When the nuclides of

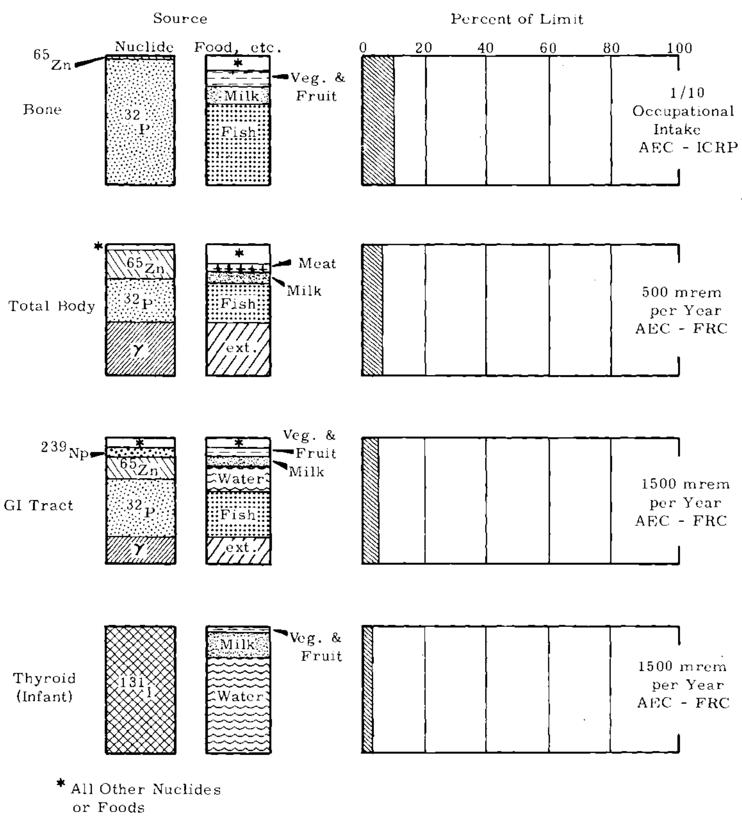

FIGURE 3. Estimated Dose to Maximum Individual, 1966

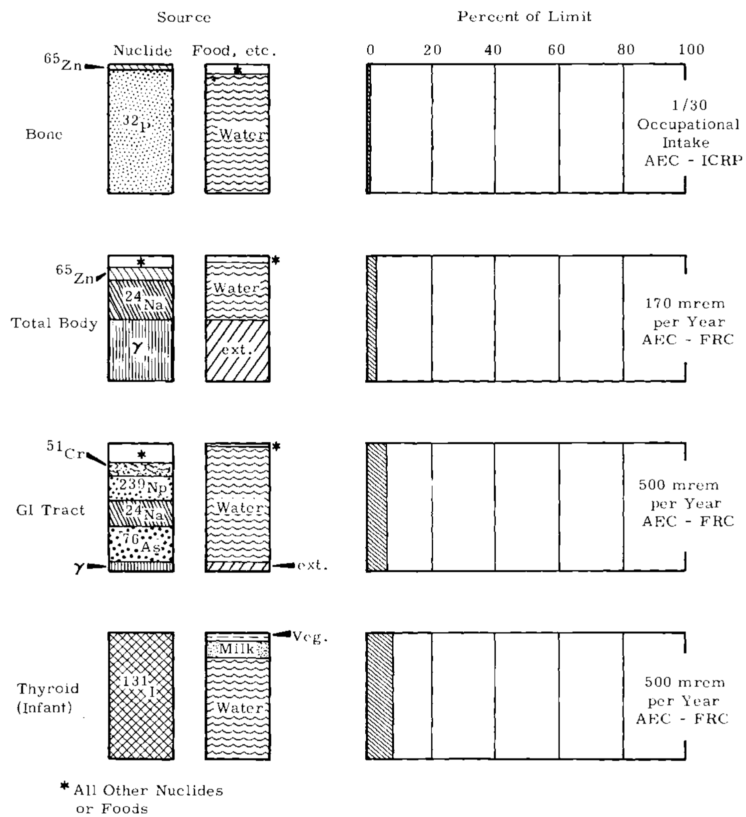

FIGURE 4. Estimated Dose to Typical Richland Resident, 1966

interest at Hanford are considered with the organs for which radiation doses (in mrads) are calculated, the units rad and rem are then numerically equal.

ENVIRONMENTAL CONCENTRATIONS

The radionuclides of particular interest during the first half of 1967 were ^{32}P, ^{51}Cr, ^{65}Zn, ^{76}As, ^{122}Sb,* ^{131}I, and ^{239}Np, all primarily from reactor cooling water.

Near the end of this reporting period, another Hanford production reactor was shut down. Of the eight Hanford production reactors, D Reactor is the fourth to be retired since 1964.

RADIONUCLIDES IN THE COLUMBIA RIVER

All of Hanford's production reactors use Columbia River water for cooling. The seasonal variation in radionuclide concentrations in river water (Figure 5) are due primarily to changes in river flow rates (Figure 6). Transport rates of certain radionuclides (Figure 7) are obtained by multiplying the radionuclide concentrations by the river flow rate corresponding to the sampling period.

** In April, 1967, the U.S. Testing Co. reported the presence in river water samples of a nuclide thought to be 2.8 day ^{122}Sb. The presence of ^{122}Sb has been confirmed, and its concentrations in river and drinking water are now measured routinely.*

The average concentrations and transport rates of ^{64}Cu, ^{65}Zn, ^{239}Np, and RE+Y in the Columbia River at Richland were slightly higher and ^{24}Na, ^{32}P, ^{51}Cr, ^{76}As and ^{131}I average concentrations and transport rates were slightly lower during the first 6 months of 1967 than during the same period of 1966.[1,2]

RADIONUCLIDES IN DRINKING WATER

The city of Richland is the first community downstream from the Hanford reactors that uses the Columbia River as a source of drinking water. The cities of Pasco and Kennewick, a few kilometers further downstream, also use it. The average concentrations of several radionuclides in Richland, Pasco, and Kennewick drinking water measured during the first half of 1967 are summarized in Table I. Not included in Table I are measurements of ^{122}Sb concentrations in drinking water at each of the three cities, since only June measurements were available: Richland, 110 pCi/liter; Pasco, 49 pCi/liter; and Kennewick, 13 pCi/liter.

The concentrations of short-lived radionuclides in water at the time it is consumed are less than shown in Table I, because there is a significant, though varying, transport time between the water plant and most consumers. The transport time may vary from hours to days, according to the location of the customers on the distribution system and the water demand.

The calculated dose to the GI tract, whole body, and thyroid, and

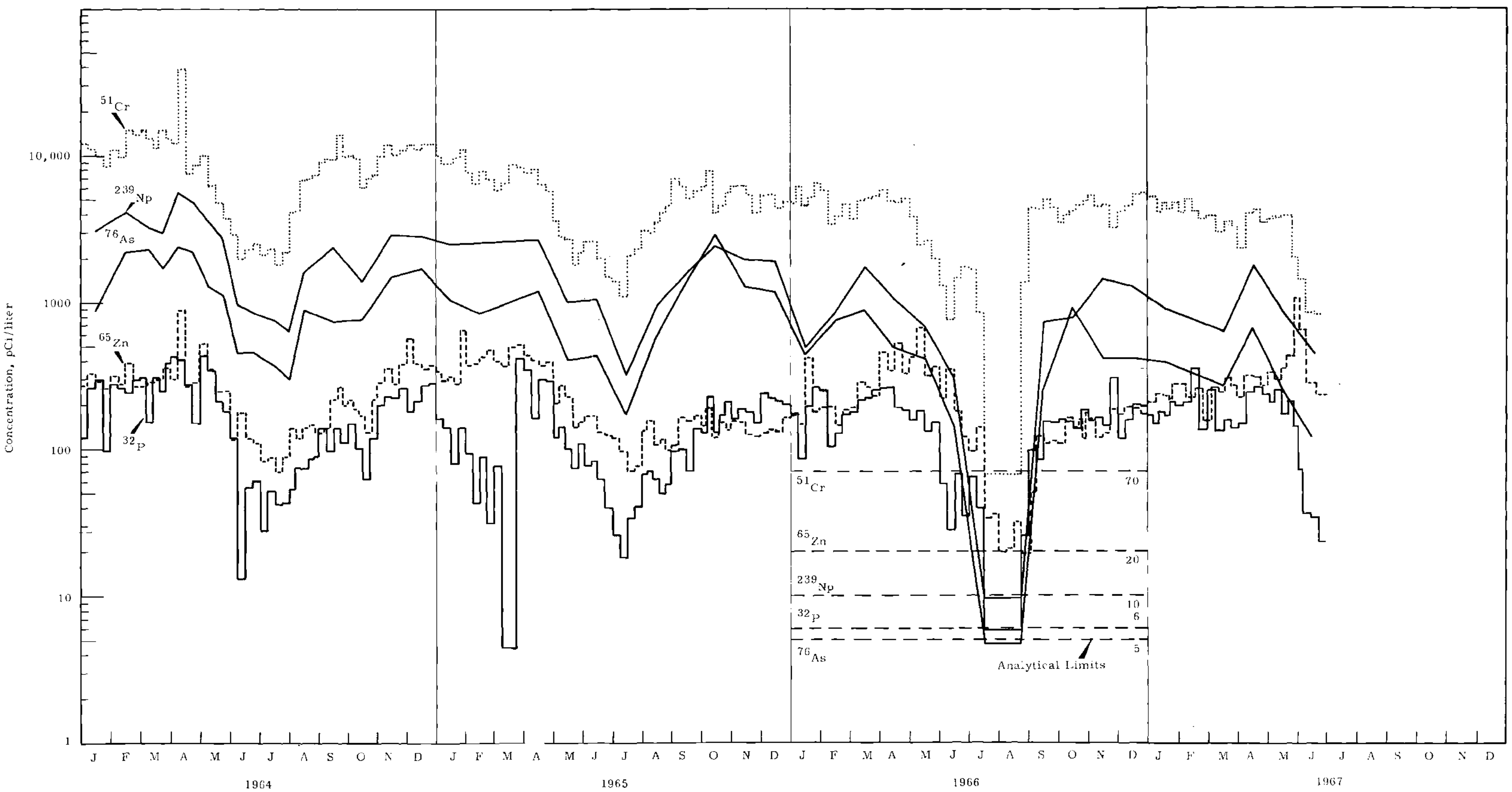

FIGURE 5. Radionuclides in Columbia River Water at Richland, Washington

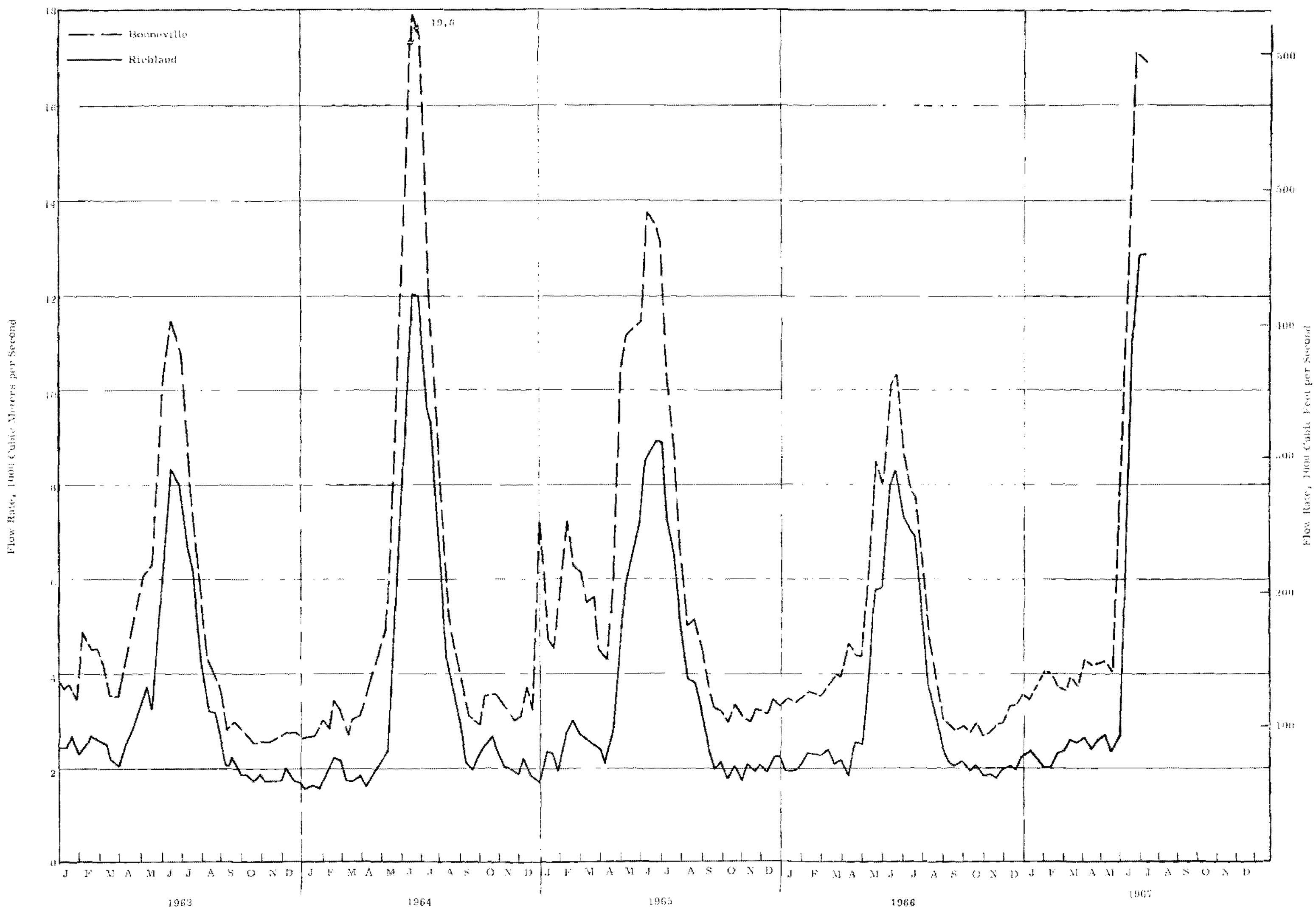

FIGURE 6. Flow Rate of Columbia River at Priest Rapids and Bonneville Dams

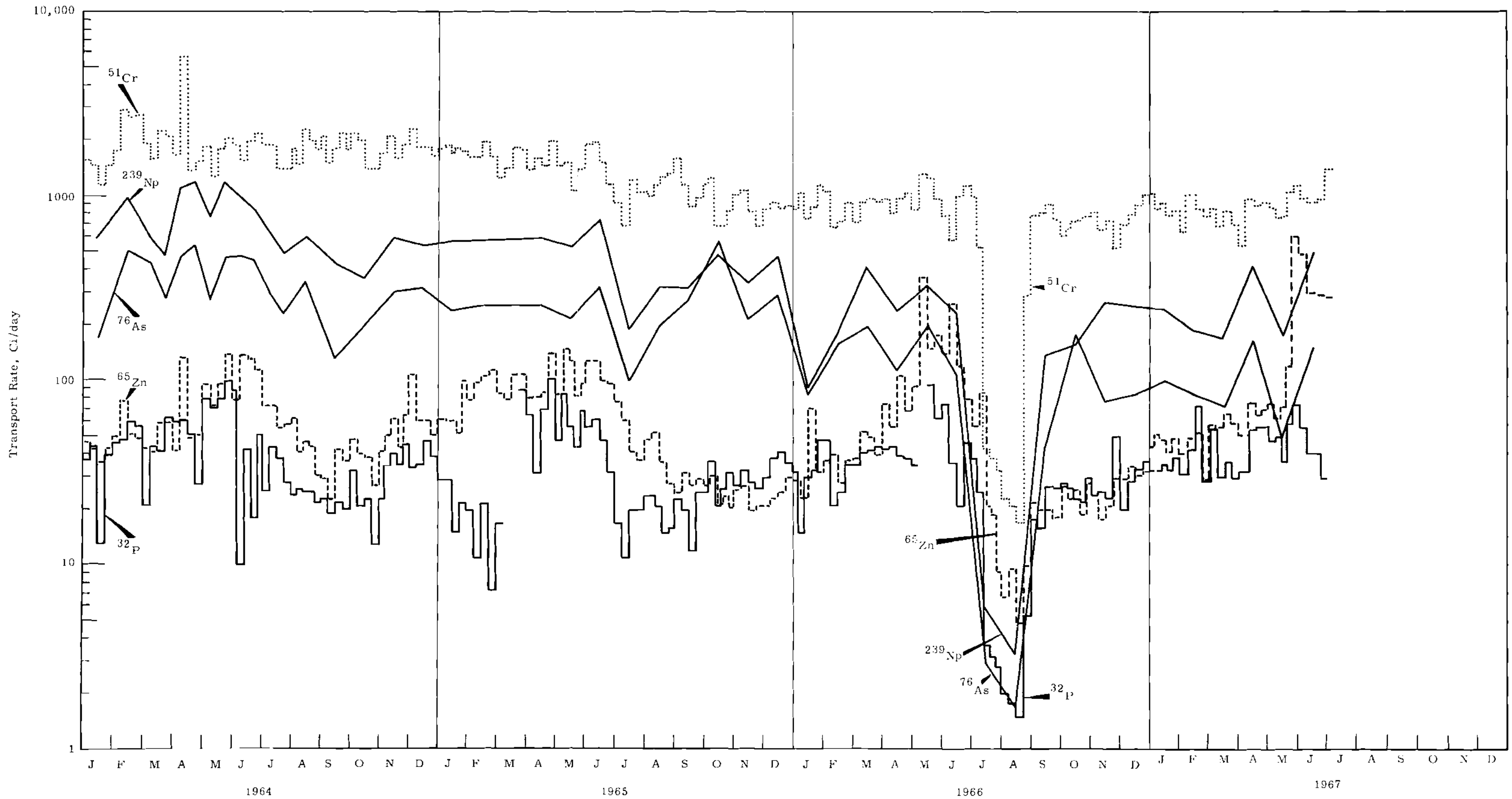

FIGURE 7. *Transport Rate of Radionuclides at Richland, Washington*

the percent MPRI for bone from sustained consumption of drinking water for the 12 month period ending June 30, 1967, are shown in Table II. The data in Table II include the effects of ^{122}Sb; however, this nuclide contributes measurably only to the GI tract dose.

The calculated GI tract dose from drinking water at Richland and Pasco for the past few years is shown in Figure 8. The break in the dose curves during January, 1966 is due to both the contribution from ^{122}Sb* and a revision in the method of GI dose calculation. The GI tract dose (27 mrem) at Richland for the 12-month period ending June 30, 1967 was somewhat lower than for the year

* *Although routine measurements of ^{122}Sb concentrations were not made during 1966, estimates were obtained to permit determination of the dose increment (1-4 mrem/yr).*

TABLE I. Concentrations of Several Radionuclides Measured in Drinking Water, January-June, 1967 (pCi/liter)

Radionuclide	Richland	Pasco	Kennewick
RE + Y[a]	62	47	--[b]
^{24}Na	1700	930	120
^{32}P	68	77	23
^{51}Cr	3600	3100	1400
^{64}Cu	550	150	50
^{65}Zn	120	100	<20
^{76}As	170	51	19
^{90}Sr	1	1	--
^{131}I	6.4	5.7	<2.2
^{239}Np	650	450	63
Total Beta, (counts/min/ml)	5.4	2.1	0.45

(a) *Rare Earths + Yttrium*

(b) *The (--) indicates insufficient data to provide a meaningful average.*

TABLE II. Calculated Dose for Selected Organs from Routine Ingestion of Drinking Water (July, 1966-June, 1967)

	GI Tract,[a] mrem	Whole Body,[a] mrem	Bone,[a] % MPRI	Thyroid,[b] mrem
Richland	27	2	0.5	13
Pasco	12	<1	0.4	12
Kennewick	3	<1	0.1	5

(a) *The "standard man"[(4)] water intake of 1.2 liter/day was used in this calculation.*

(b) *The radiation dose is estimated for a 2 g thyroid of a small child and an average water intake rate of 0.4 liters/day.*

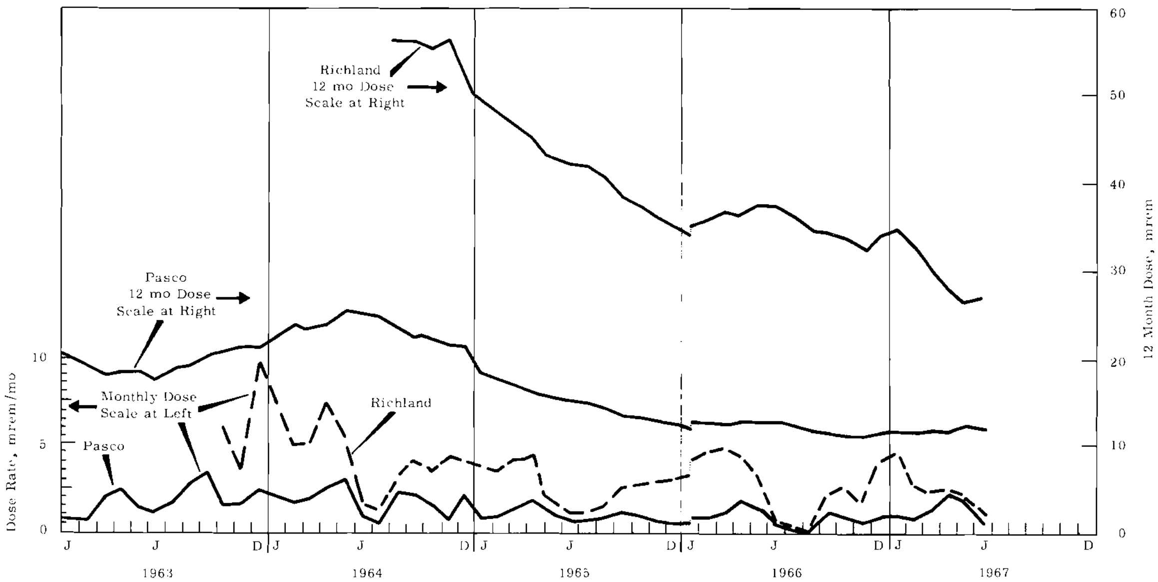

FIGURE 8. Calculated Dose to GI Tract from Pasco and Richland Drinking Water

ending December 31, 1966 (31 mrem).[1] The whole body doses for the two periods were about equal, as were the percentages of MPRI for bone.

The calculated thyroid doses from drinking water for the year ending June 30, 1967 at Richland, Pasco, and Kennewick (13, 12, and 5 mrem, respectively) were much less than for the year ending December 31, 1966 (35, 22, and 30 mrem, respectively).[1] This difference is due mostly to the unusual release of radioiodines to the Columbia River that occurred during February, 1966.[1,2]

RADIONUCLIDES IN FISH AND WATERFOWL

The Columbia River provides popular sports fishing areas both above and below the Hanford reservation. Those fish that feed downstream from the reactors acquire some reactor effluent radionuclides through the normal food chains. The two principal radionuclides found in these fish are ^{32}P and ^{65}Zn, the levels of which vary according to species and season of the year.

Whitefish usually contain the highest concentration of ^{32}P (Figure 9); in addition, they may be caught during the winter months when other sports fish are very difficult to sample. Therefore, data accumulated from whitefish sampling are used as trend indicators, even though whitefish are not the most significant source of radionuclides for the local population. As in 1966, concentrations of ^{32}P in whitefish during the first 6 months of 1967 reached a maximum in early spring. The average concentration of 100 pCi ^{32}P/g during the first 6 months of 1967 was essentially the same as that for the first 6 months of 1966[1] and 1965.[5]

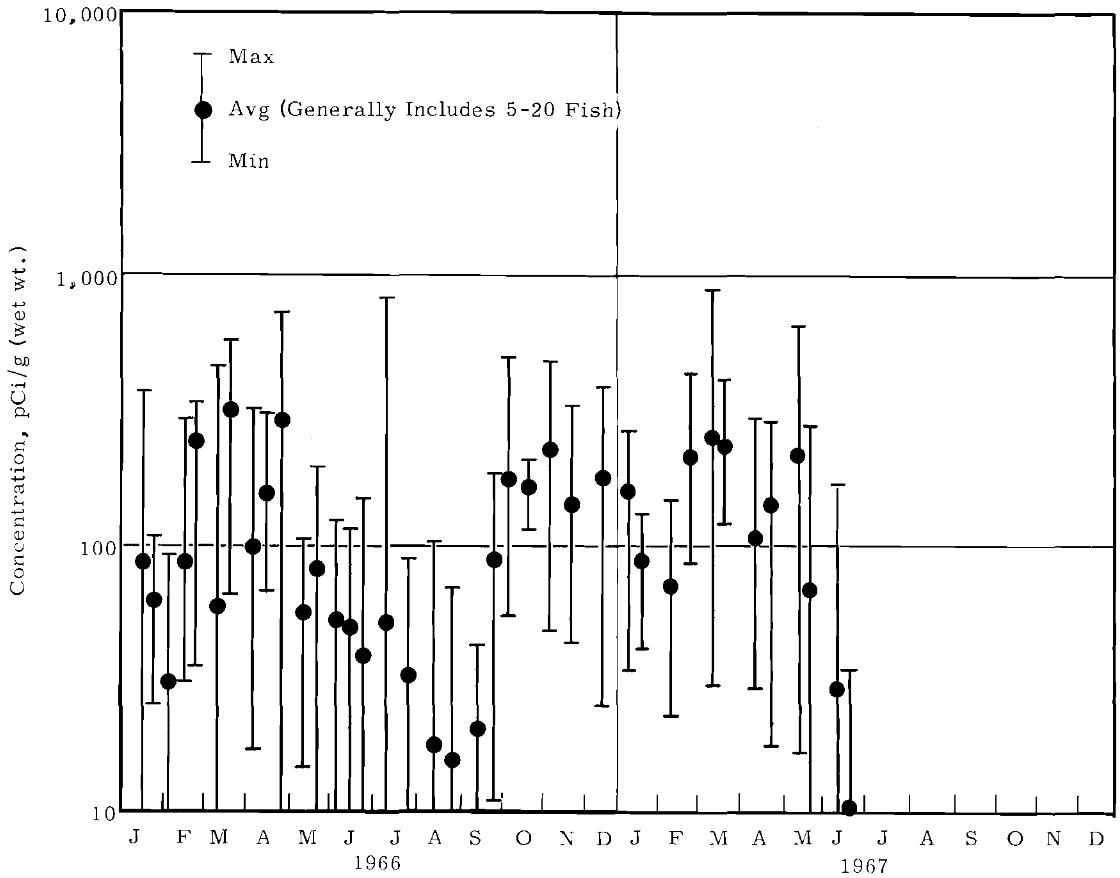

FIGURE 9. ^{32}P in Whitefish Caught in Columbia River Between Ringold and Richland

A small number of waterfowl samples was obtained early in 1967 during the closing weeks of the 1966-67 hunting season. Results of radiochemical analyses indicated that concentrations of radionuclides generally agree with data collected during 1966.

RADIONUCLIDES IN SHELLFISH

^{32}P and ^{65}Zn are the only two radionuclides of Hanford origin that are found beyond the mouth of the Columbia River in sufficient quantities to be of radiological interest. Oysters have been found to contain higher concentrations of ^{65}Zn than other common seafoods, and samples of oysters are obtained regularly from the Washington Coast for radiochemical analysis (Figure 10). The average concentration of 28 pCi $^{65}Zn/g$ during the first 6 months of 1967 was the same as that observed during 1966.[(1)]

RADIONUCLIDES IN THE ATMOSPHERE

Hanford gaseous waste is released to the atmosphere through high stacks after most of the radioactive materials have been removed. The radionuclide of primary interest in the

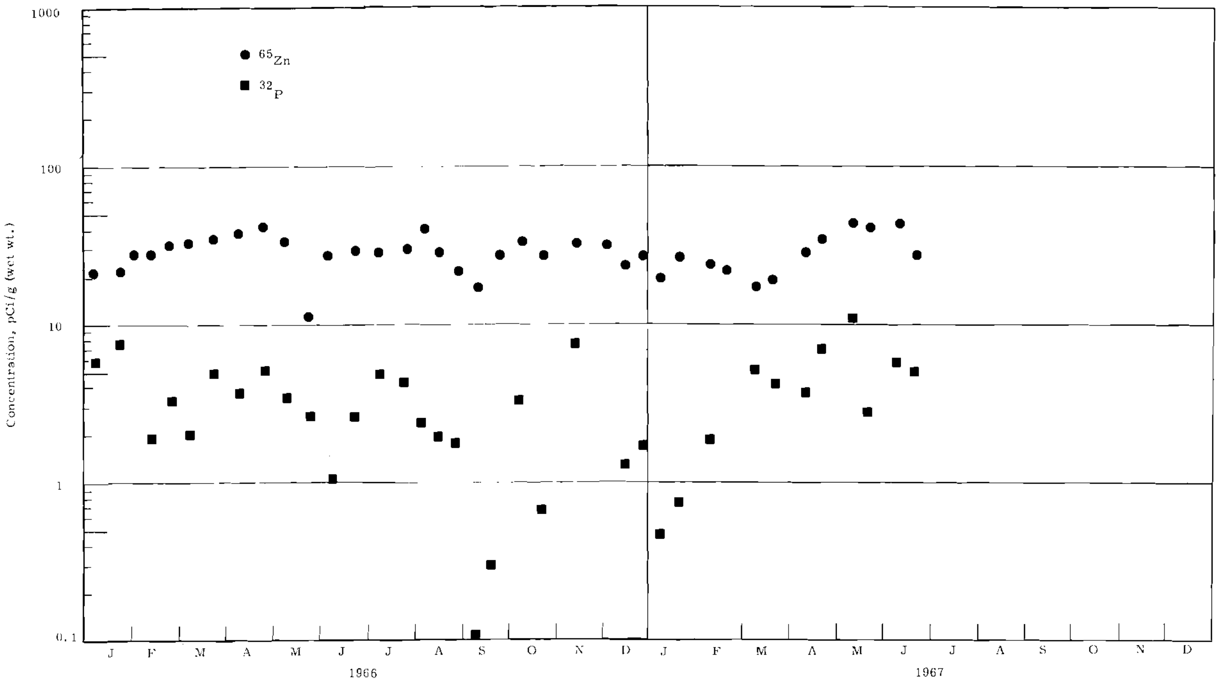

FIGURE 10. ^{65}Zn and ^{32}P in Willapa Bay Oysters

effluent gases of the chemical separations facilities is ^{131}I.

An extensive network of air sampling stations is maintained around the Hanford project perimeter for ^{131}I and radioactive particulates. Routine measurements of ^{131}I in the air at Richland, Pasco, and Kennewick during the 12 months ending June 30, 1967, averaged less than the analytical limit of 0.02 pCi/m^3 of air. A sustained concentration of ^{131}I at this level in inspired air would imply an annual radiation dose to the thyroid of the "standard man"(4) of less than 1 mrem from this source.

The principal sources of radioactive particulate material in the local environs are world-wide fallout and natural radioactive materials. The concentration of beta emitters in the atmosphere of eastern Washington and northeastern Oregon was generally less than 0.2 pCi/m^3 during the first 6 months of 1967, although a sharp transient increase in beta activity was noted in early January during an influx of fallout (Figure 11).

RADIONUCLIDES IN MILK AND PRODUCE

The radioactivity found in local produce and local milk can be influenced by deposition of airborne radionuclides and by irrigation with river water containing reactor effluent radionuclides.

The comprehensive milk surveillance program includes samples from local farms and dairies and from commercial supplies available in local stores. Concentrations of ^{131}I in locally available milk are shown in Figures 12 and 13. During the first half of 1967, ^{131}I concentrations in milk were generally near or below the analytical limit (3 pCi/liter),

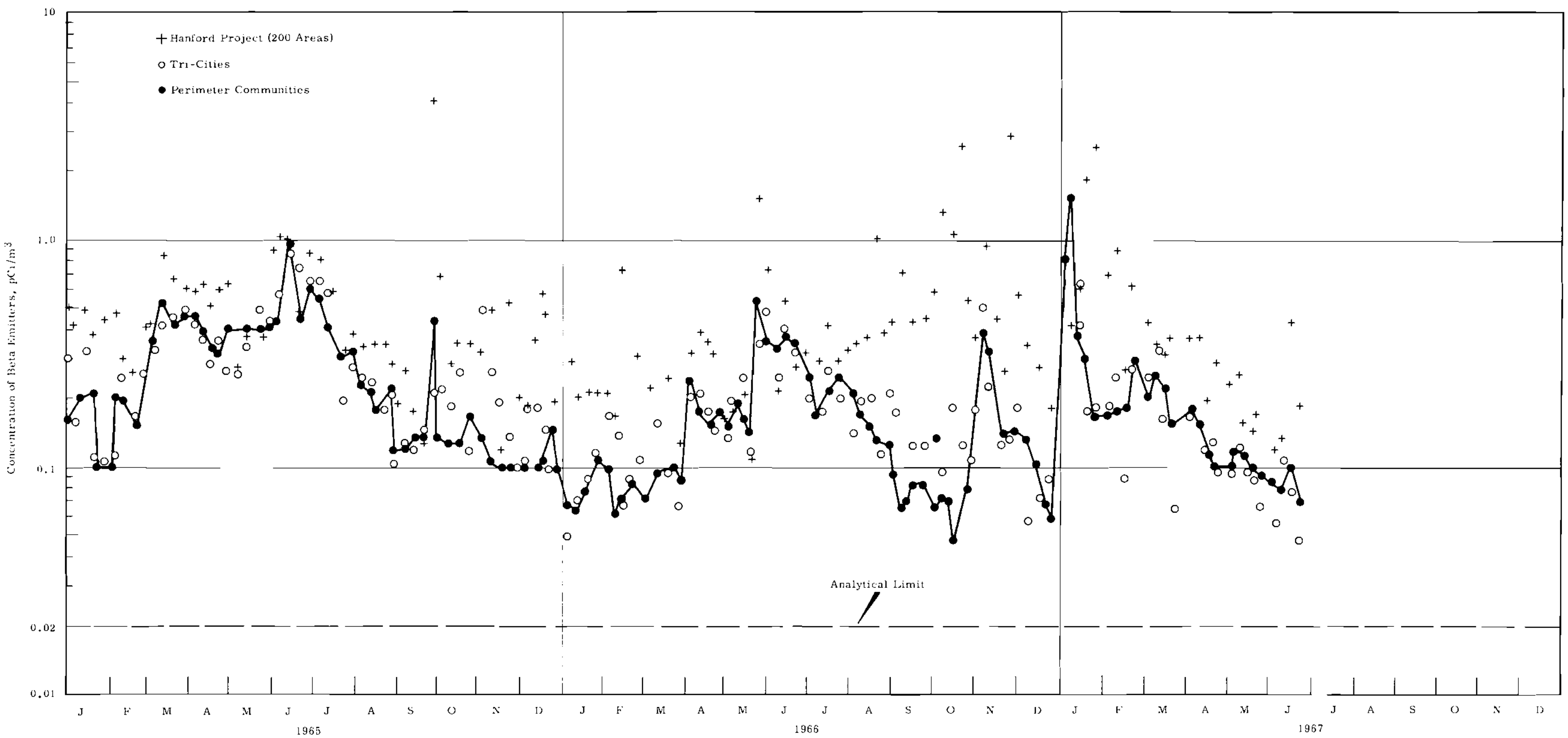

FIGURE 11. Radioactive Particulates in the Air in the Hanford Environs

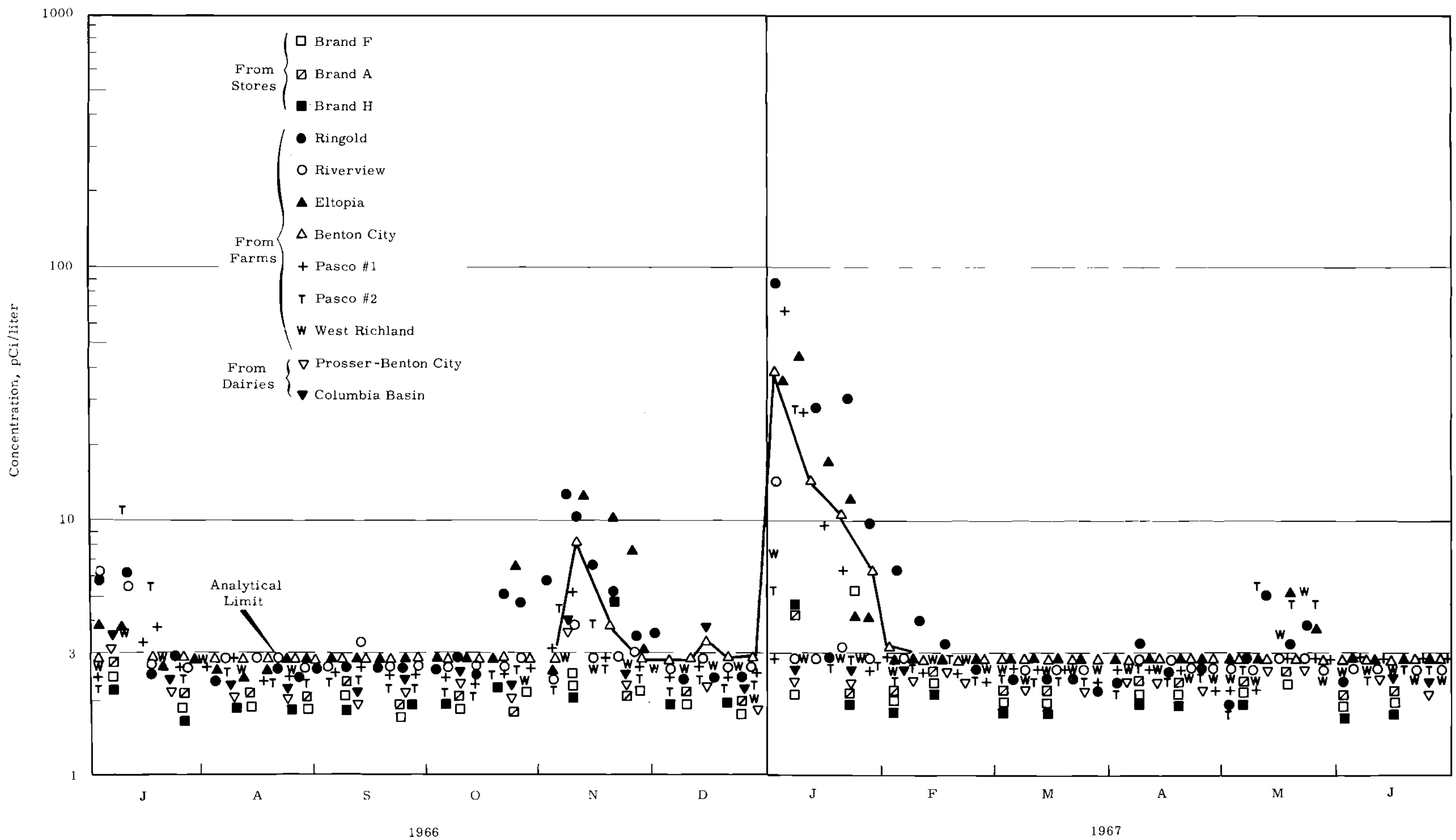

FIGURE 12. ^{131}I *in Locally Available Milk, July, 1966-June, 1967*

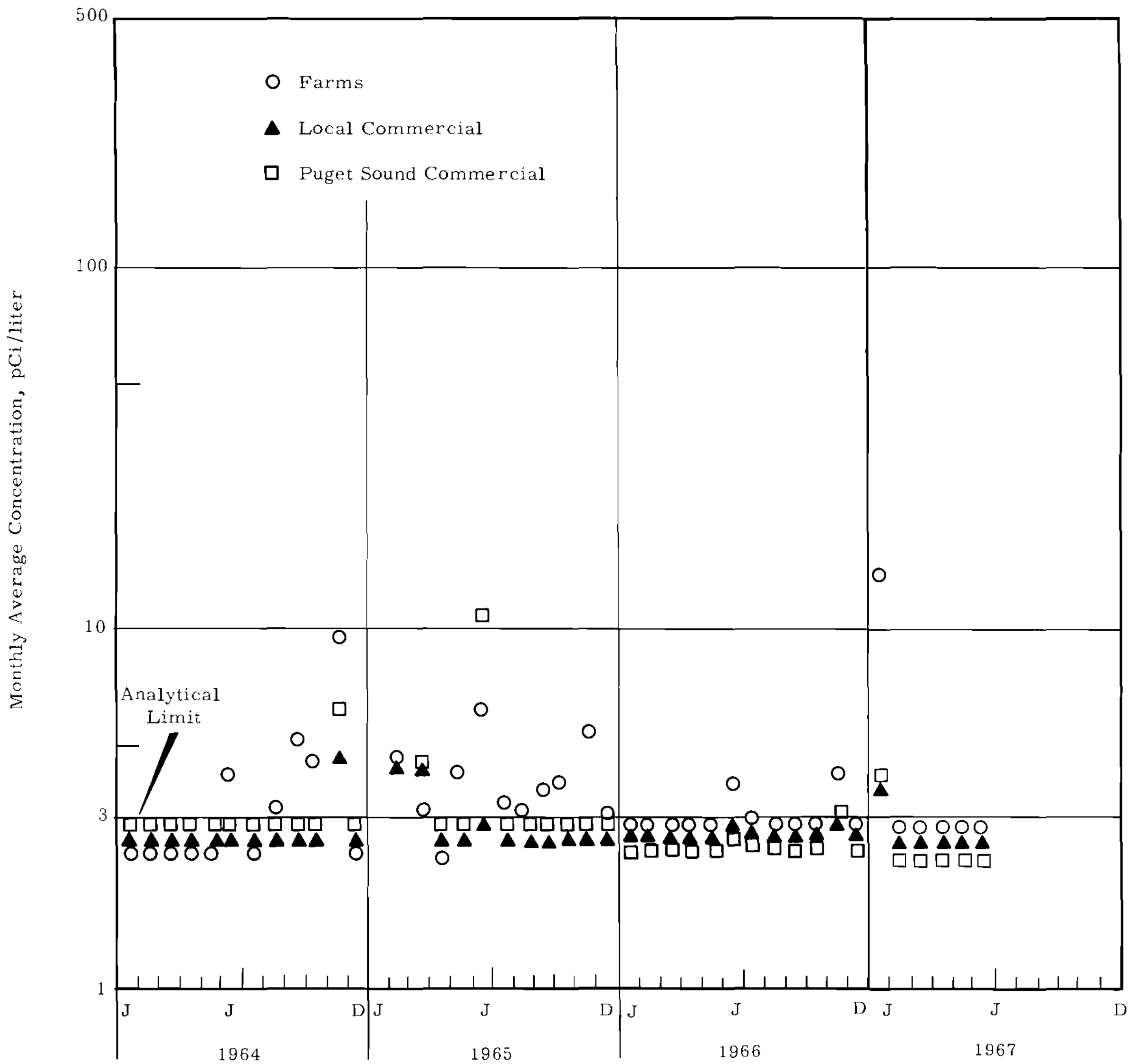

FIGURE 13. ^{131}I *in Locally Available Milk, January, 1964-June, 1967*

except for a sharp transient increase during the influx of fallout in January.

Dairy farms in the Ringold and Riverview area using the Columbia River for irrigation of pasture land and hay fields produce milk containing ^{32}P and ^{65}Zn. The concentrations of ^{32}P in farm milk (single samples) are shown in Figure 14. In 1967, the analytical limit for ^{32}P analyses in milk was reduced from 200 to 20 pCi/liter, in order to follow lower-level trends. The monthly average concentrations of ^{65}Zn in farm milk are shown in Figure 15. Seasonal fluctuations, caused primarily by irrigation and feeding practices, followed expected trends.

Concentrations of ^{131}I measured in samples of vegetables and fruit collected during the first half of 1967 were near or below the analytical limit of 0.05 pCi/g.

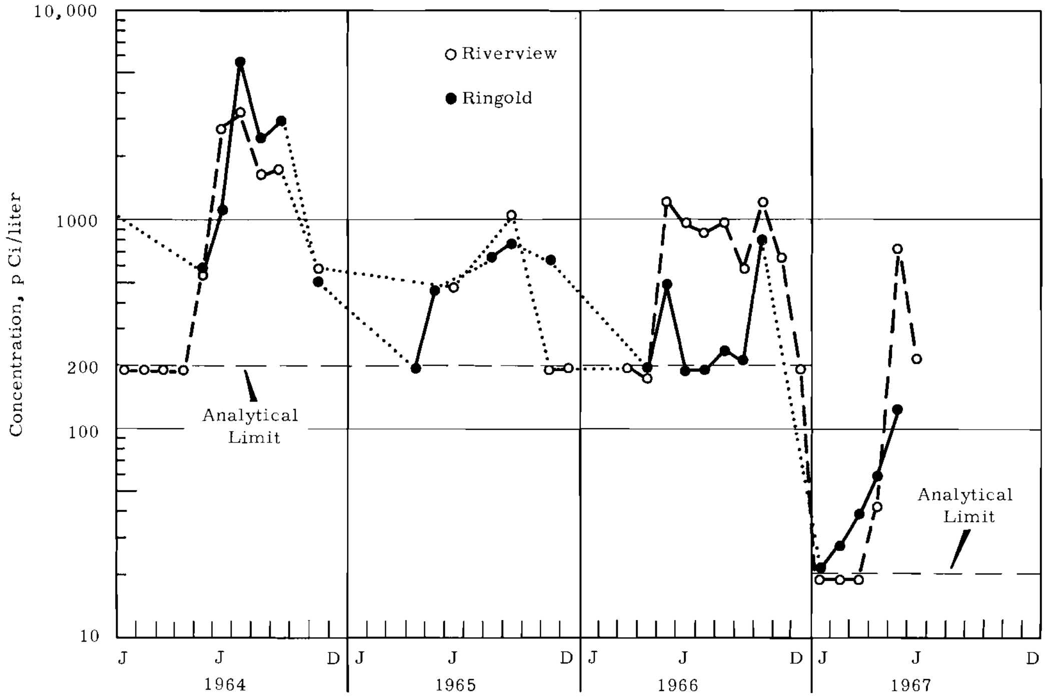

FIGURE 14. ^{32}P *in Locally Produced Milk*

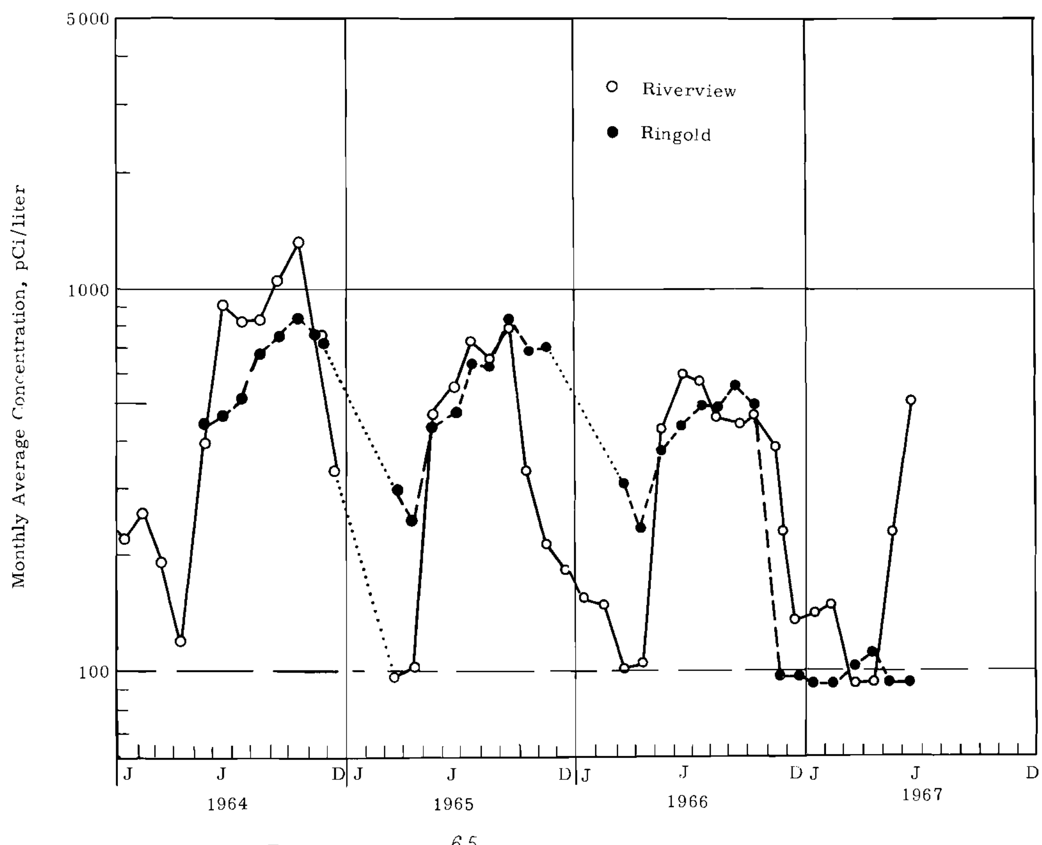

FIGURE 15. ^{65}Zn *in Locally Produced Milk*

^{131}I IN CATTLE THYROIDS

To follow low-level trends in ^{131}I concentrations in the environs, beef cattle thyroids are collected periodically for radioanalysis from slaughter-houses in Moses Lake, Toppenish, Walla Walla, Wenatchee, and Pasco. During the early part of 1967, ^{131}I concentrations in beef thyroids increased sharply during an influx of fallout. The maximum concentration was 160 pCi/g in a sample collected on January 6 at Walla Walla, but ^{131}I concentrations soon decreased to values generally near or below the analytical limit (Figure 16).

EXTERNAL RADIATION

Measurements of external gamma radiation exposure rates are made with ionization chambers positioned on the Hanford reservation and at Richland, and submerged at several locations in the Columbia River. Measurements taker in air 1 m above ground indicated the exposure rate for the first half of 1967 averaged 0.36 mR/day at Hanford (Figure 17) and 0.25 mR/day at Richland (Figure 18). The average exposure rate at Richland during 1966 was 0.28 mR/day (100 mR/year).(1) Essentially all of this exposure is due to natural background and fallout.

Measurements of the external gamma exposure rate at Sacajawea Park (near principal fishing sites) averaged 0.5 mR/day, which is about the same as that measured during 1966.(1)

Radiation measurements taken in the Columbia River near Richland during the first half of 1967 indicated the immersion exposure rate

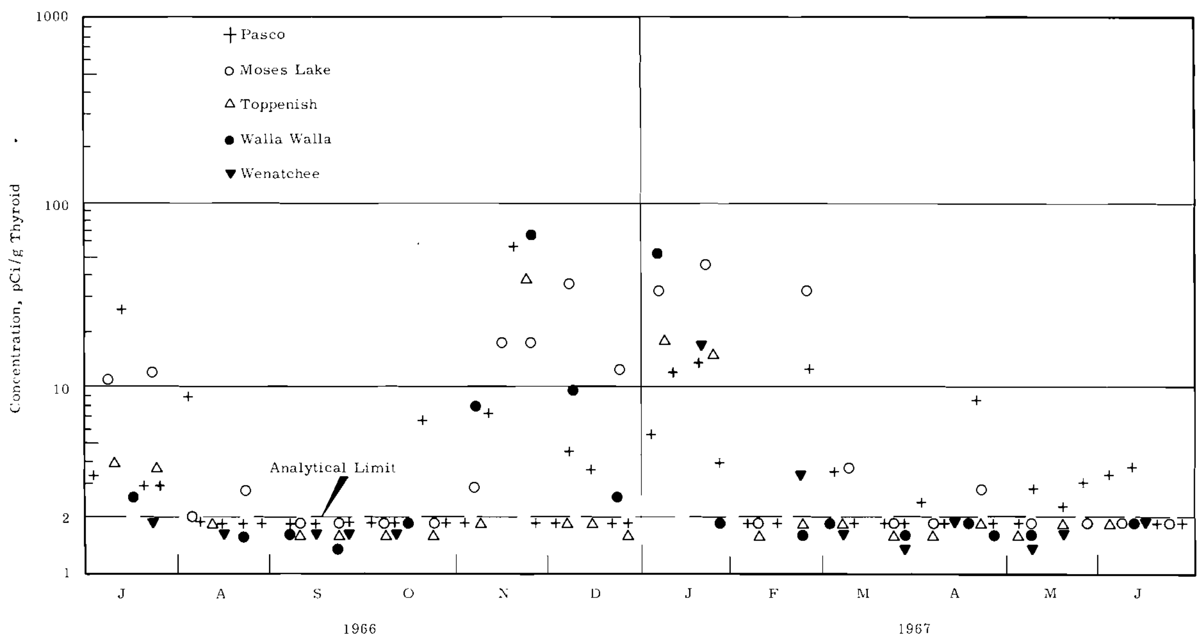

FIGURE 16. ^{131}I *in Cattle Thyroids*

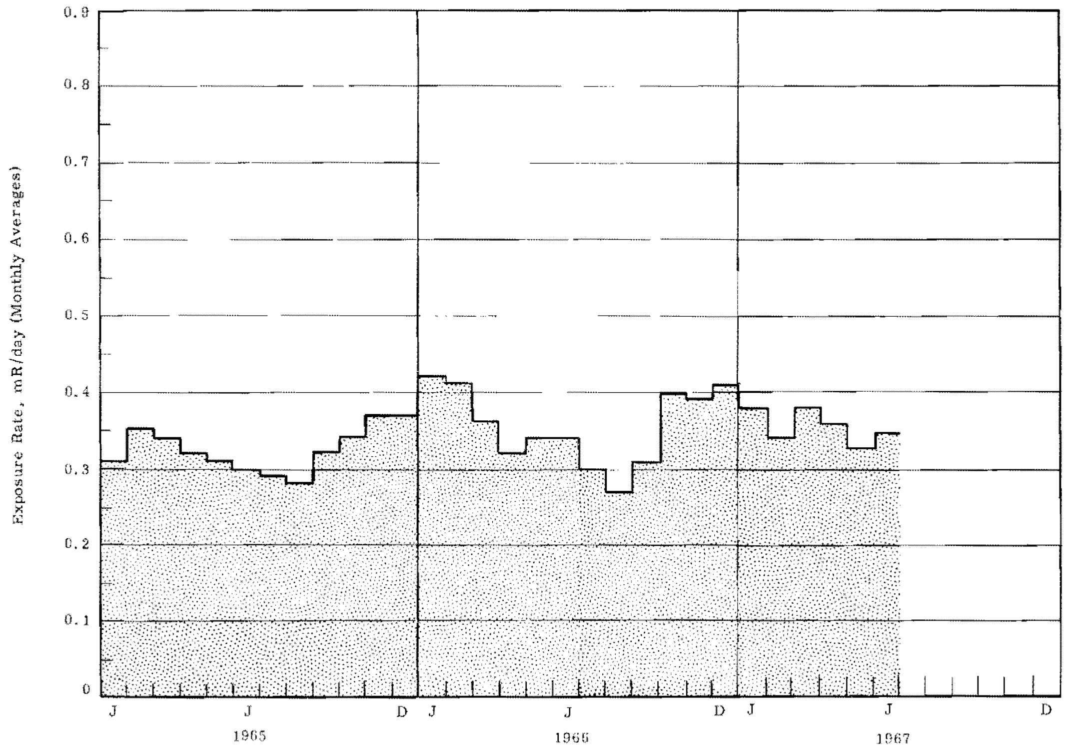

FIGURE 17. External Exposure Rate as Measured at Hanford Test Location

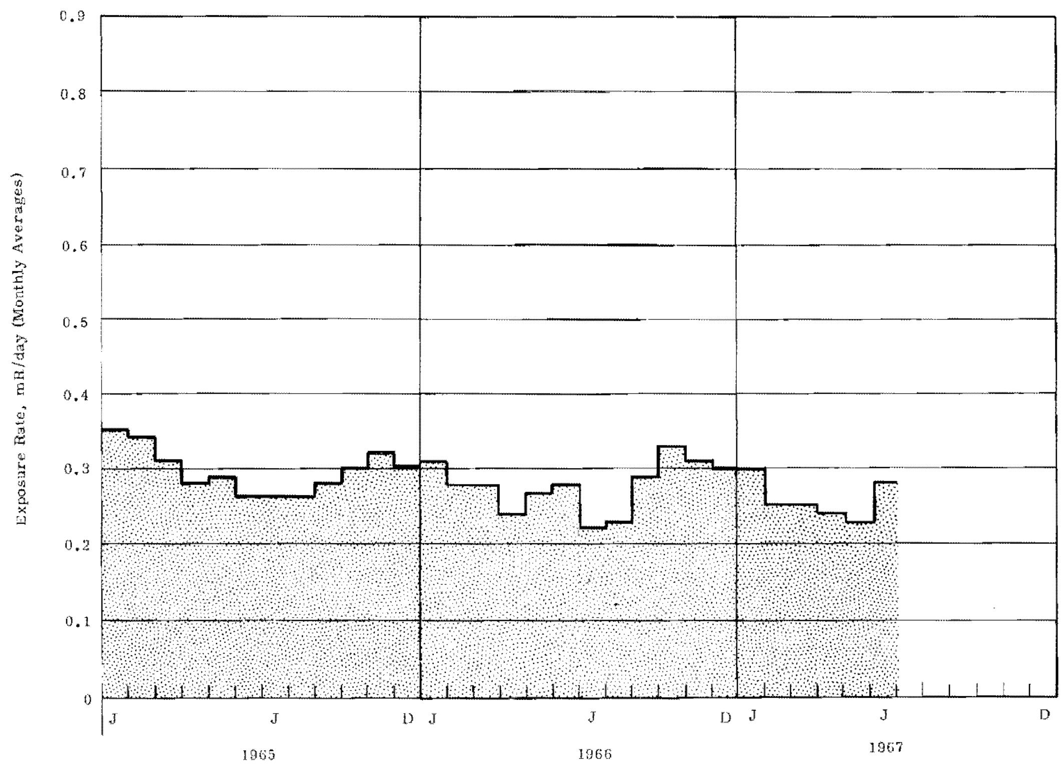

FIGURE 18. External Exposure Rate as Measured at Richland

averaged about 2 mR/day, principally from ^{24}Na introduced into the river with reactor cooling water.

RADIONUCLIDES ASSOCIATED WITH FALLOUT

The fallout nuclides of greatest interest during the first half of 1967 were ^{3}H, ^{90}Sr, ^{131}I, and ^{137}Cs. During a large influx of fallout early in 1967, the ^{131}I concentration in milk increased to a peak value of 83 pCi/liter in a single sample collected on January 3, which is the highest concentration from fallout measured at Hanford since October, 1962 (Figure 12).

Concentrations of ^{3}H in river water are measured upstream from Hanford at Priest Rapids Dam and downstream from Hanford at Richland. The average concentrations of ^{3}H at both Priest Rapids Dam and Richland were 1.5 nCi/liter for the first half of 1967, which is about half of the concentrations measured during the first 6 months of 1966.(2)

Concentrations of ^{90}Sr in locally available milk are shown in Figure 19. These values are similar to concentrations found in commercial milk produced in other areas of low rainfall remote from the Hanford plant. ^{90}Sr in locally available milk averaged about 4 pCi/liter during the first half of 1967, which is slightly lower than the average of 6 pCi/liter

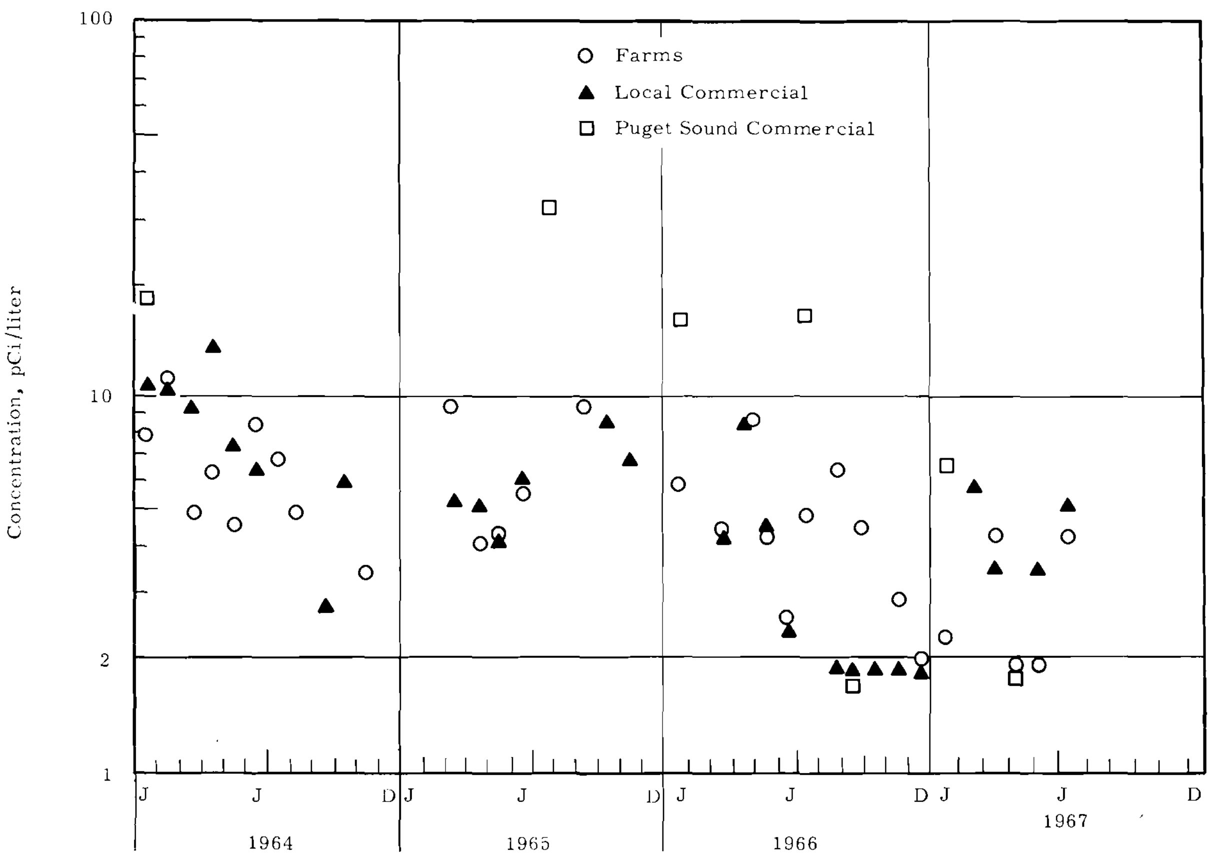

FIGURE 19. ^{90}Sr in Locally Available Milk

during the first 6 months of 1966.[2] The concentration of ^{137}Cs in locally available milk (Figure 20) was generally near or below the analytical limit of 30 pCi ^{137}Cs/liter.

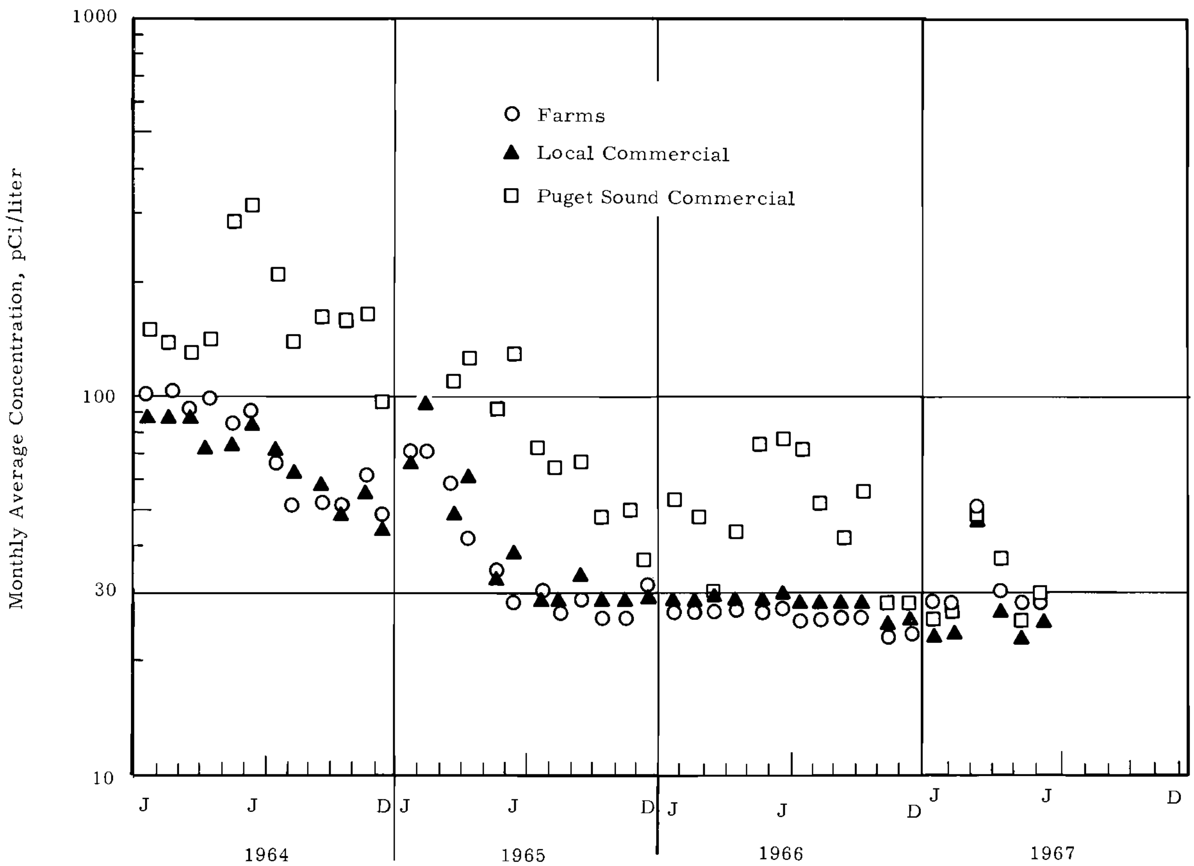

FIGURE 20. ^{137}Cs in Locally Available Milk

APPENDIX

The AEC Manual, Chapter 0524, in specifying dose-equivalent standards, states that "the calculation of organ dose shall be based on methods recommended by the Federal Radiation Council and the International Commission on Radiological Protection."

The significance of bone seekers, such as ^{32}P and ^{90}Sr, requires special consideration and treatment because the rate of intake of ^{32}P has not been specifically studied by the Federal Radiation Council (FRC)(6-8) in relation to a dose-equivalent for the bone or bone marrow. We note that the FRC, in developing intake guides for ^{90}Sr and ^{89}Sr, apparently did not believe that a relative damage factor (n) should be used to change absorbed dose (rads) to dose-equivalent (rem). Use of a computational scheme for ^{32}P like that used by the FRC for ^{90}Sr leads to a Maximum Permissible Rate of Intake that is substantially greater than that recommended by the International Commission on Radiological Protection (ICRP).(4) Rather than introduce additional confusion associated with dose-equivalents for bone derived by different techniques, we have expressed the data for bone seekers in terms of a Maximum Permissible Rate of Intake (MPRI).

The MPRI is taken as the Maximum Permissible Concentration (MPC) in water for a given radionuclide, as recommended by the ICRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man.

It is noted that the MPC_w, listed in the AEC Manual, Chapter 0524, (Annex I, Table II)(3) for the Maximum Individual is 1/10 of the ICRP(4) MPC_w, for continuous occupational exposure (2×10^{-5} μCi/ml). Thus, an MPRI derived from either AEC Manual, Chapter 0524, or ICRP Publication 2 would be the same.

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