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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD JANUARY-JUNE, 1968

August 1969

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Health and Safety

EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD
JANUARY-JUNE, 1968

by
The Environmental Evaluations Staff
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Edited by
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Radiation Protection Department
Technical Services Division

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ABSTRACT

Surveillance of the Hanford environs during the first half of 1968 showed that measured concentrations of radioactive materials and radiation doses received by nearby population groups were well within the appropriate limits and that radioactive wastes were under sound and continuous control.

The major source of low-level wastes released from the Hanford plant to the environment in the first half of 1968 continued to be 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. The estimated intake of ^{32}P from 200 meals (40 kg) of Columbia River fish for the 12 months ending June 30, 1968, was about 9% of the Maximum Permissible Rate of Intake (with bone as the critical organ). This intake was somewhat less than the estimate for the 12 months of 1967.

Doses from drinking water were estimated for the adult GI Tract, whole body, and bone, and for the infant thyroid because, for Richland residents, water is the major source of radiation dose from Hanford releases. The estimated thyroid dose of 58 mrem for a typical Richland infant from drinking water during the 12 months ending June 30, 1968 was somewhat greater than during the calendar year 1967. However, estimated doses to the GI Tract, whole body, and bone of the adult Richland resident were similar to or less than comparable 1967 doses from drinking water.

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INTRODUCTION

Results of the environmental surveillance program, conducted for the Hanford Plant by Battelle-Northwest's Environmental Evaluations Section, are summarized herein for the first half of 1968.

This report partially updates data presented in the 1967 Annual Report[1] which evaluated the combined effects of the radioactive waste disposal practices of all contractors at Hanford in terms of estimated radiation doses to the environmental population.* The Atomic Energy Commission regulations governing radioactive waste disposal at Hanford are described in the AEC Manual Chapter RL 0510.[2]

* *See Appendix.*

SUMMARY

Surveillance of the Hanford environs during the first half of 1968 showed that the concentrations of radioactive materials in the Hanford 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 caused by natural sources and worldwide fallout rather than by 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[(1)] has been 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, 1968, was about 9% of the Maximum Permissible Rate of Intake (with bone as the critical organ). This intake is slightly less than the 10% MPRI from ^{32}P in fish that was reported for 12 months of 1967.[(1)]

The major source of the radiation dose from Hanford operations for the Richland population continued to be drinking water obtained from the Columbia River. An evaluation of estimated doses received by the various body organs indicated that the dose to the infant thyroid was the largest percentage of appropriate limits. The thyroid dose from drinking water for a Typical Richland infant for the 12-month period ending June 30, 1968, was about 12% of the limit, somewhat greater than that reported for the calendar year 1967.[(1)] For the

Typical Richland Resident, the estimated doses from drinking water to other organs for the same period were similar to or less than comparable 1967 values.[1]

The concentration of total beta activity associated with airborne particulate material during the first half of 1968 was sustained at higher concentrations than in the last half of 1967, primarily because of increased fallout.

REVIEW OF 1967 ENVIRONMENTAL DOSE ESTIMATES

Radiation dose estimates for people in the Hanford environs during 1967 are presented[1] as a comparative review. Figures 1 and 2 show the geographical relationship of Hanford to the Northwest and the features of the project itself. Figures 3, 4, and 5 present the radiation dose received by the whole body, GI tract, and infant thyroid and the percentage of the MPRI (Maximum Permissible Rate of Intake) for bone-seeking radionuclides for the Maximum Individual, the Average Richland Resident, and the Typical Richland Resident. The relative significance of various nuclides, several sources of radionuclide intake, and the numerical values of the appropriate dose standards are also shown. Table 1 summarizes the estimated doses for 1967.

TABLE 1. Summary of Radiation Doses[a] in the Hanford Environs, 1967

Organ	Annual Dose, mrem	Limit, mrem	% of Limit
Maximum Individual			
GI Tract	82	1500	5
Whole Body	32	500	6
Bone	--[b]	--[c]	12
Thyroid (infant)	97	1500	6
Typical Richland Resident			
GI Tract	24	500	5
Whole Body	4	170	3
Bone	--[b]	--[c]	0.6
Thyroid (infant)	50	500	10
Average Richland Resident			
GI Tract	30	500	6
Whole Body	4	170	3
Bone	--[b]	--[c]	2
Thyroid (infant)	38	500	8

a. *Doses from fallout and natural background not included.*
b. *Not calculated (see Appendix)*
c. *AEC-ICRP (International Commission on Radiological Protection) derived MPRI: for Maximum Individual - 16 μCi ^{32}P/yr and 800 μCi ^{65}Zn/yr; for Typical and Average Richland Resident - 5.3 μCi ^{32}P/yr and 270 μCi ^{65}Zn/yr.*

The hypothetical Maximum Individual[1,3,4] has been assigned plausible eating and living habits that would probably result in an individual's receiving the largest percentage of radiation dose limits:

- Consumption of 200 meals/yr of fish caught down river from the reactors
- Standing 500 hr/yr on the riverbank to catch the above 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[1,3,4] was assumed to have no unusual eating or living habits with dietary intakes derived from the literature. Essentially all of his foodstuffs were assumed to have been purchased from commercial outlets as were those of the Average Richland Adult. However, dietary intakes for the Average Richland Adult have been based on local dietary surveys,[1] and the concentrations of radionuclides in his drinking water have been adjusted for decay and dilution in the Richland water system. Although, in our judgment, doses estimated for the Average Richland Resident are more appropriate for comparison with the standards, the dose estimates for the Typical Richland Resident will be continued as a comparison with past years.

SOURCES AND LEVELS OF ENVIRONMENTAL RADIOACTIVITY

RADIOACTIVITY IN THE COLUMBIA RIVER

In February 1968, "B" reactor was retired leaving three Hanford production reactors operating with a single pass of treated Columbia River water for cooling. The N reactor, using recirculating demineralized coolant and a slightly different method of liquid waste handling, contributes a negligibly small fraction of the total radioactivity entering the river from the Hanford reactors. Some radionuclides also enter the river from wastes disposed to ground, but their contribution to the total radioactivity is extremely small.

Changes in river flow rates (Figure 6) are the major cause of the seasonal variations in radionuclide concentrations in river water (Figure 7). Transport rates of selected radionuclides (Figure 8) are obtained by multiplying the radionuclide concentrations by the average river flow rate during the cumulative sampling period or during the day of the grab sample.

During the first six months of 1968, significantly lower average concentrations of several radionuclides were observed by comparison with the first half of 1967. For ^{65}Zn and RE+Y, a decrease of about 70% was noted; whereas, decreases for ^{32}P, ^{51}Cr, ^{56}Mn, and ^{64}Cu were about 50%. No significant changes from comparable 1967 values were noted for ^{24}Na, ^{76}As, or ^{239}Np, but a slight increase was observed for ^{131}I, and a major increase for ^{46}Sc concentrations.

Transport rates for the first half of 1968 for the measured radionuclides followed trends similar to the concentration trends. Decreased transport rates were noted for ^{32}P, ^{51}Cr, ^{65}Zn, ^{56}Mn, ^{64}Cu, and Re+Y, with the most marked decreases for ^{65}Zn and RE+Y. There was little change for ^{24}Na, ^{76}As, and ^{239}Np, but a slight increase for ^{131}I and a major increase in ^{46}Sc transport rates compared to similar 1967 averages.(1)

The Columbia River is popular for sports fishing both above and below the Hanford reservation. Those fish that feed downstream from the reactors acquire some reactor effluent radionuclides through food chains with the ultimate uptake dependent on complex environmental relationships. The most significant radionuclide contained in these fish is ^{32}P because it provides the major portion of dose to fish-consumers. To follow trends in biological concentrations, ^{32}P and ^{65}Zn concentrations in whitefish taken from the Columbia River between Ringold and Richland are routinely measured. Figure 9 shows the average and range of ^{32}P concentrations measured in each batch of whitefish collected from January, 1966 through June, 1968. Whitefish are the sports fish usually containing the greatest concentration of radioactive materials; furthermore, they can be caught during winter months when other sports fish are difficult to sample. Therefore, data accumulated from whitefish sampling are useful as a trend indicator, even though whitefish are not the most significant source of radionuclides for the local population. Peak concentrations of ^{32}P in whitefish during the first six months of 1968 occurred in May. The average ^{32}P concentration of 94 pCi/g during the first six months of 1968 was essentially the same as that for the first six months of 1967, 1966, and 1965.[5,6,7]

RADIOACTIVITY IN THE ATMOSPHERE

At Hanford, gaseous wastes from the chemical separations facilities are released to the atmosphere through elevated stacks after most of the radioactive materials have been removed. Laboratory stacks, reactor-building stacks, and stacks from waste-storage facilities release relatively minor amounts of radioactive materials under normal operating conditions. Figure 10 shows off-plant air sampling locations.

Measurements of airborne ^{131}I, the radionuclide of primary interest, were made routinely during early 1968 at 31 locations within and near the Hanford reservation. Figure 11 shows the data from off-plant air samples from near-by locations in the direction of the prevailing wind (Southeast Quadrant). The ^{131}I concentrations during the 12 months ending June 30, 1968, averaged less than the analytical limit of 0.02 pCi/m^3 at Richland, Pasco, and Kennewick. A sustained concentration of ^{131}I at this level in breathing air would imply an annual radiation dose to the thyroid of the Standard Man[8]* of less than 1 mrem from inspired air.

Continuous sampling for radioactivity associated with airborne particles was maintained during early 1968 at 42 locations, including those within the Hanford reservation and around the plant perimeter at distances up to 75 miles. The gross beta activity of each sample filter (calculated as ^{90}Sr-Y) was routinely measured, with specific radioanalysis performed on filters showing unusual beta activity.

Figure 12 shows average total beta concentrations for the group of samples collected from the Southeast Quadrant and from other more distant locations (Perimeter Communities). The higher atmospheric concentrations of radioactive particulate material during the first half of 1968 compared to fall 1967 were attributed primarily to fallout following a foreign nuclear weapons test in late December 1967. The observed concentrations were comparable with those observed during similar events of recent years.

RADIOACTIVITY IN GROUNDWATER

The presence of radioactivity in the groundwater beneath the Hanford project arises primarily from ground disposal of wastes in the chemical separations areas. These wastes are routed to various facilities, dependent upon their radionuclide

* *Assuming that volume breathing rate is proportional to thyroid size, the thyroid dose from inhalation of ^{131}I is independent of age and thyroid size.*[9]

burden and chemical content. High-level wastes* are stored in underground concrete tanks lined with steel. Intermediate-level wastes** are sent to underground "cribs" (covered liquid waste disposal sites) from which they percolate into the soil. The areas selected for intermediate-level waste disposal and high-level waste storage have soil with good ion exchange capacity and groundwater depths of 50 to 100 m. Low-level wastes† are usually sent to depressions in the ground where surface ponds or "swamps" have been formed as the result of the continuous addition of relatively large volumes of water.

One important objective in the management of wastes placed in the ground is the prevention of radiologically important radionuclides from reaching the groundwater in quantities that could ultimately cause significant human radiation exposure should they migrate to the Columbia River. An extensive groundwater surveillance program is maintained at Hanford to aid in achieving this objective. Hundreds of wells have been drilled at various locations around the Hanford project, including sites within and near crib and tank storage areas, to monitor the movement of radionuclides in the groundwater.

Outside the exclusion areas, the radioactivity in groundwater from the chemical separations areas disposal sites is primarily ^{3}H and ^{106}Ru-Rh although ^{60}Co and ^{99}Tc have also been found but at much lower concentrations. The more radiotoxic nuclides (e.g., ^{90}Sr) have been detected in groundwater only near certain disposal sites.

Figures 13 and 14 show the probable extent of detectable ^{3}H and ^{106}Ru-Rh in groundwater beneath the Hanford project as of June 30, 1968.[10] The outer boundary of the contamination

---

* *High-level: >100 μCi/ml*
** *Intermediate-level: 50 pCi/ml - 100 μCi/ml*
† *Low-level: <50 pCi/ml*

contours, i.e., 0.1% CG* for ^{3}H and 2% CG for ^{106}Ru-Rh represent the detection levels routinely achievable for these radionuclides.

In all probability, some radionuclides from the chemical processing areas are presently entering the Columbia River. However, the concentrations of these nuclides are too small to be routinely measurable in the groundwater near the river or in the river itself, and any radiation dose from them is negligible.

FALLOUT FROM NUCLEAR WEAPONS TESTS

Fresh fallout from the foreign nuclear weapons test of December, 1967, resulted in a sharp increase in airborne particulate radioactivity in January 1968 (Figure 12) which was sustained throughout the reporting period. In early January, peak total beta concentrations in the atmosphere were in the range of 1.0 to 1.7 pCi/m^3 at several offsite locations. The maximum concentration of ^{131}I in milk samples in January, 1968, was 25 pCi/liter, somewhat lower than the peak from fallout (83 pCi/liter) observed in January, 1967.(1)

Routine measurements in foods of the fallout nuclides ^{131}I, ^{90}Sr, and ^{137}Cs are discussed in the next section (Exposure Pathways).

Concentrations of ^{3}H in river water were measured upstream from Hanford at the Priest Rapids Dam and Gauge Station and downstream from Hanford at Richland from January through March. The average concentrations of ^{3}H at Priest Rapids and at Richland for January-March 1968 were 1800 pCi/liter and 1400 pCi/liter, respectively.

* *Concentration Guide (CG) is the new terminology of the AEC Manual Chapter 0524(11) and is equivalent to the term Maximum Permissible Concentration (MPC) as used in previous reports in this series. The Concentration Guide (CG) referred to is that for continuous exposure to individual members of the public, which is about three times the concentration permitted for a suitable sample of the exposed population, but only one-tenth that permitted for occupational exposure.*

EXPOSURE PATHWAYS

RADIONUCLIDES IN DRINKING WATER

The city of Richland is the first community downstream from the reactors that uses the Columbia River as a source of drinking water. Pasco and Kennewick, a few kilometers farther downstream, also use the river as a source. The Richland and Pasco water plants use a modern flocculation-filtration treatment of the water; Kennewick water is pumped from Rainey well collectors (infiltration pipes) laid in the riverbank. During the first half of 1968, weekly cumulative drinking water samples were collected at the Richland and Pasco water plants, and monthly grab samples at all three communities. Figures 15 and 16 show concentrations of selected radionuclides in Richland drinking water. Table 2 summarizes the average concentrations of selected radionuclides in samples from all three cities for this reporting period.

The concentrations of short-lived radionuclides in water at the time it is consumed are less than shown in Table 2 because there is a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of the customers on the distrubution system and the water demand. During part of the year, well water is used to bolster the Richland water system supply in some areas of the city. This well water dilutes the treated Columbia River water so that radionuclide concentrations in sanitary water are lower than those measured at the water plant.

Table 3 shows calculated annual average doses to the whole body, GI tract, and thyroid, and the percent MPRI for bone from sustained consumption (at a standard intake of 1.2 liters/day) of drinking water throughout the 12 month period ending June 30, 1968.

TABLE 2. Average Concentrations of Selected Radionuclides in Richland, Pasco, and Kennewick Drinking Water - January-June, 1968 (pCi/liter)

Radionuclide	Richland	Pasco	Kennewick
RE+Y[a]	49	20	9
^{24}Na	1700	360	140
^{32}P	48	26	13
^{51}Cr	1700	1200	480
^{64}Cu	330	<33	38
^{65}Zn	48[b]	45[b]	<24
^{76}As	160	28	15
^{90}Sr	<0.60	<0.50	--[c]
^{122}Sb	150	130	22
^{131}I	7.9[b]	7.2[b]	<2
^{133}I	47[d]	29[e]	8[e]
^{239}Np	670	230	57
Total Beta (counts/min/ml)	3.4	1.	0.25

a. *Rare Earths plus Yttrium - 1967 Annual Report.*[1]
b. *Based on the cumulative sample.*
c. *Insufficient data to provide a meaningful average.*
d. *Based on an estimated average ratio of* ^{133}I *to* ^{131}I *of 6 to 1 during the first 6 months of 1968.*
e. *Based on an estimated ratio of* ^{133}I *to* ^{131}I *of 4 to 1 during the first 6 months of 1968.*

TABLE 3. Estimated Dose for Selected Organs from Routine Ingestion of Drinking Water, July, 1967 - June, 1968

	Whole Body,[a] mrem	GI Tract,[a] mrem	Thyroid,[b] mrem	Bone,[a] % MPRI
Limit	170	500	500	100
Richland	1.6	23	58	1
Pasco	0.3	9	39	<0.1
Kennewick	0.2	3	12	<0.1

a. *The "Standard Man"[8] water intake rate of 1.2 liter/day was used in this calculation. Recent local data[1] indicate an average water intake of 1.86 liter/day for Richland residents; however, comparable data were not available for Pasco or Kennewick.*

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

Figure 17 shows the relative contribution during 1967 of several radionuclides in the Richland drinking water to the calculated annual dose to the GI tract and Figure 18 shows long-term trends in the GI tract doses from Pasco and Richland drinking water. The break in the dose curves during January, 1966, is due to a revision in the method of calculating GI tract dose. For the 12-month period ending June 30, 1968, the GI tract dose from drinking water at Richland was 23 mrem, somewhat lower than for the year ending December 31, 1967 (28 mrem). The whole body dose from drinking water was 1.6 mrem compared to 1.7 mrem for 1967. The percentages of MPRI for bone from drinking water for both periods were about the same.

The calculated thyroid doses from drinking water for the year ending June 30, 1968 at Richland, Pasco, and Kennewick (58, 39, and 12 mrem, respectively) include the contributions of ^{131}I and ^{133}I. The comparable thyroid doses estimated for the year 1967 were 41, 35, and 13 mrem, respectively.[1]

RADIONUCLIDES IN COLUMBIA RIVER FISH

Radionuclide concentrations measured in whitefish (trend indicators) showed similar spring concentrations for ^{32}P in fish in 1967 and in 1968 (see section on Radioactivity in the Columbia River). Similar ^{32}P concentrations in panfish for the 12-month periods ending June 30, 1968 and December 31, 1967, resulted in estimated intakes of ^{32}P from fish for the Maximum Individual of 9% compared to 10% MPRI, respectively.

A small number of game bird samples was collected near the Columbia River early in 1968 during the closing weeks of hunting season. Radioanalyses indicated that concentrations for these birds were generally comparable to data collected during early 1967.(1)

RADIONUCLIDES IN SHELLFISH

^{32}P and ^{65}Zn are the only two radionuclides of Hanford origin 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 from the Washington Coast are routinely analyzed for ^{32}P and gamma-emitting nuclides (Figure 19).

For the first six months of 1968, the average ^{32}P and ^{65}Zn concentrations were 2.2 pCi $^{32}P/g$ and 30 pCi $^{65}Zn/g$ (wet weight), which indicates a slight decrease in ^{32}P from comparable 1967 values, but no significant change in ^{65}Zn values.

RADIONUCLIDES IN MILK AND PRODUCE

Irrigation with river water containing reactor effluent radionuclides can contribute radioactivity to locally grown farm products. Deposition of airborne materials from Hanford sources and from fallout can also affect radionuclide content. The chemical separations facilities are usually the principal local source of airborne radionuclides, although radioactive materials released from ventilation stacks of laboratory facilities are occasionally detectable in the environment.

The milk surveillance program maintained during early 1968 was similar to that of past years,[1] including samples from commercial supplies available to people in the Tri-Cities. Milk from local farms irrigated with water obtained downstream from the reactors contained ^{32}P, ^{65}Zn, and ^{131}I during the irrigation season beginning in April, as well as fission products of fallout origin. Commercial milk distributed in the Tri-Cities does not usually contain detectable ^{32}P and ^{65}Zn because the majority of the milk is produced on farms not irrigated with Columbia River water.

Figures 20 and 21 show the ^{32}P and ^{65}Zn concentrations in single samples of milk from farms in the Riverview district. Seasonal fluctuations, caused primarily by irrigation and feeding practices, followed expected trends.

Figure 22 shows monthly average concentrations of ^{131}I in locally available milk. During the first half of 1968, ^{131}I concentrations in milk were generally at or below the analytical limit (3 pCi/liter). The maximum ^{131}I concentration for the period (25 pCi/liter) was measured in a single sample of farm milk collected on January 17 and was attributed to increased worldwide fallout.

EXTERNAL RADIATION

Ionization chambers mounted 1 m above groundlevel on the Hanford reservation and in Richland measure the ambient gamma radiation exposure. Figure 23 shows monthly averages of these measurements for both locations. The exposure rate for the first half of 1968 averaged 0.38 mR/day at Hanford and 0.28 mR/day at Richland. These were not significantly different from the averages for 1967[1] and 1966.[12] Essentially all of the external radiation exposure at Richland is from natural background and worldwide fallout.

Estimates of external radiation doses resulting from recreational use of the Columbia River are based on shoreline exposure rates measured at Richland and Sacajawea Park and immersion exposure rates at Richland.

At the shoreline, the exposure rate is measured with a 40 liter ionization chamber centered three feet back from the water's edge and three feet above the ground to approximate the dose rate to the gonads of a person standing on the riverbank. Data for Richland and Sacajawea Park appear in Figure 24. For the first half of 1968, the average exposure rate at Sacajawea Park (near principal fishing sites) was about one-half of that at Richland (0.65 mR/day and 1.3 mR/day, respectively). Included in these measurements is an estimated 8 μR/hr or 0.19 mR/day from natural background radiation at the shoreline.

Below the surface of the Columbia River, the exposure rate was measured with pocket-type ionization chambers positioned 0.5 to 1.5 m under water. In the vicinity of Richland, this immersion exposure rate averaged 1.5 mR/day and was principally due to ^{24}Na introduced into the river with reactor cooling water.

FALLOUT FROM NUCLEAR WEAPONS TESTS

The fallout nuclides of greatest interest during the first half of 1968 were ^{3}H, ^{90}Sr, ^{131}I, and ^{137}Cs. During the early influx of fallout in 1968 following a foreign weapons test in December of 1967, the peak ^{131}I concentration in milk was 25 pCi/liter. For comparison, the peak concentration of ^{131}I in milk during 1967 was 83 pCi/liter, also from fallout.

Concentrations of ^{3}H in drinking water were assumed to be the same as in river water (discussed on page 11).

Concentrations of ^{90}Sr in locally available milk (Figure 25) are similar to values found in commercial milk produced in other areas of low rainfall remote from the Hanford plant. ^{90}Sr in locally produced milk averaged about 3 pCi/liter during the first half of 1968, which is not significantly different from comparable 1967 values. Concentrations of ^{137}Cs in locally available milk (Figure 26) were generally below the analytical limit of 30 pCi ^{137}Cs/liter.

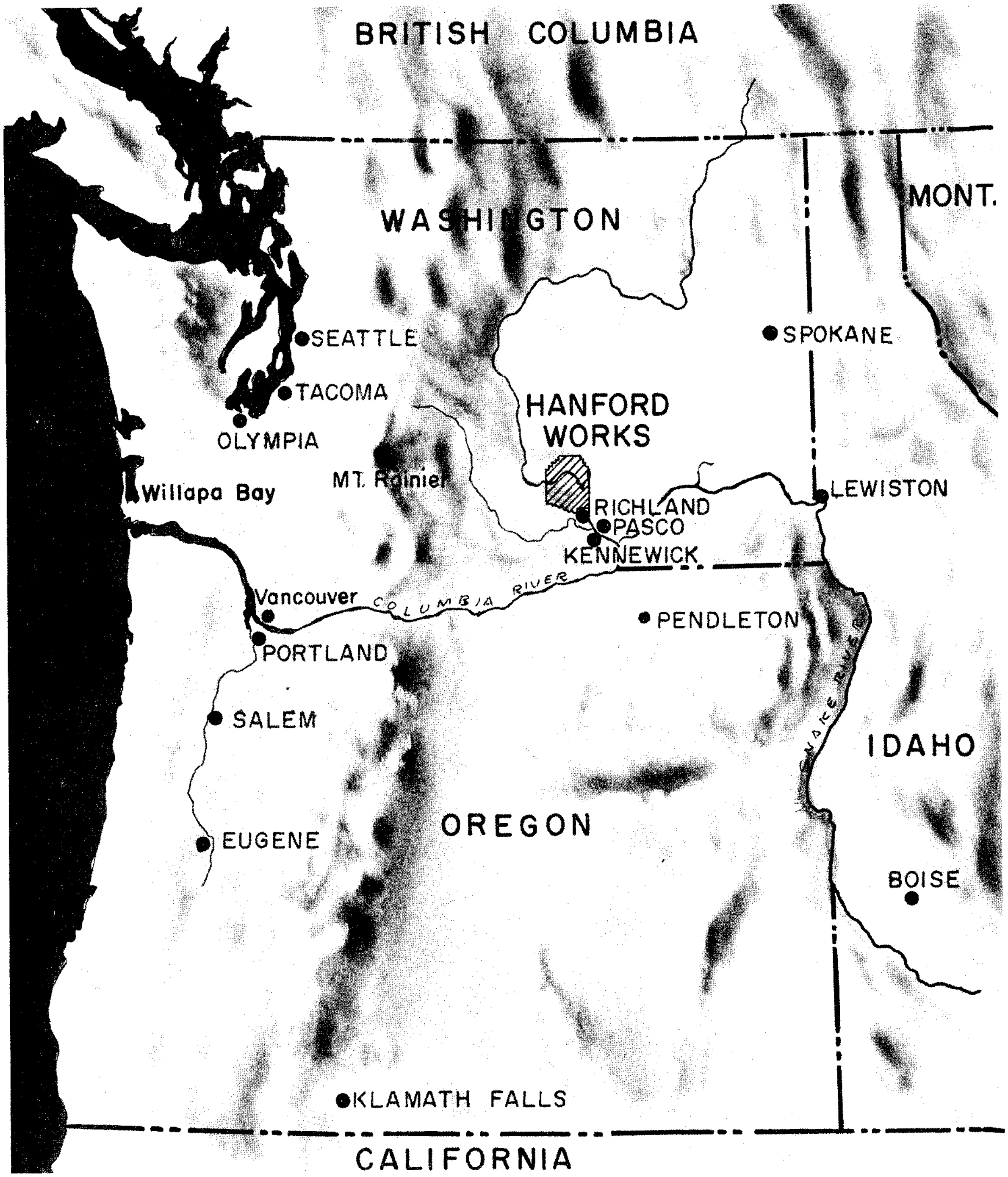

FIGURE 1. Geographical Relationship of Hanford Works to Pacific Northwest

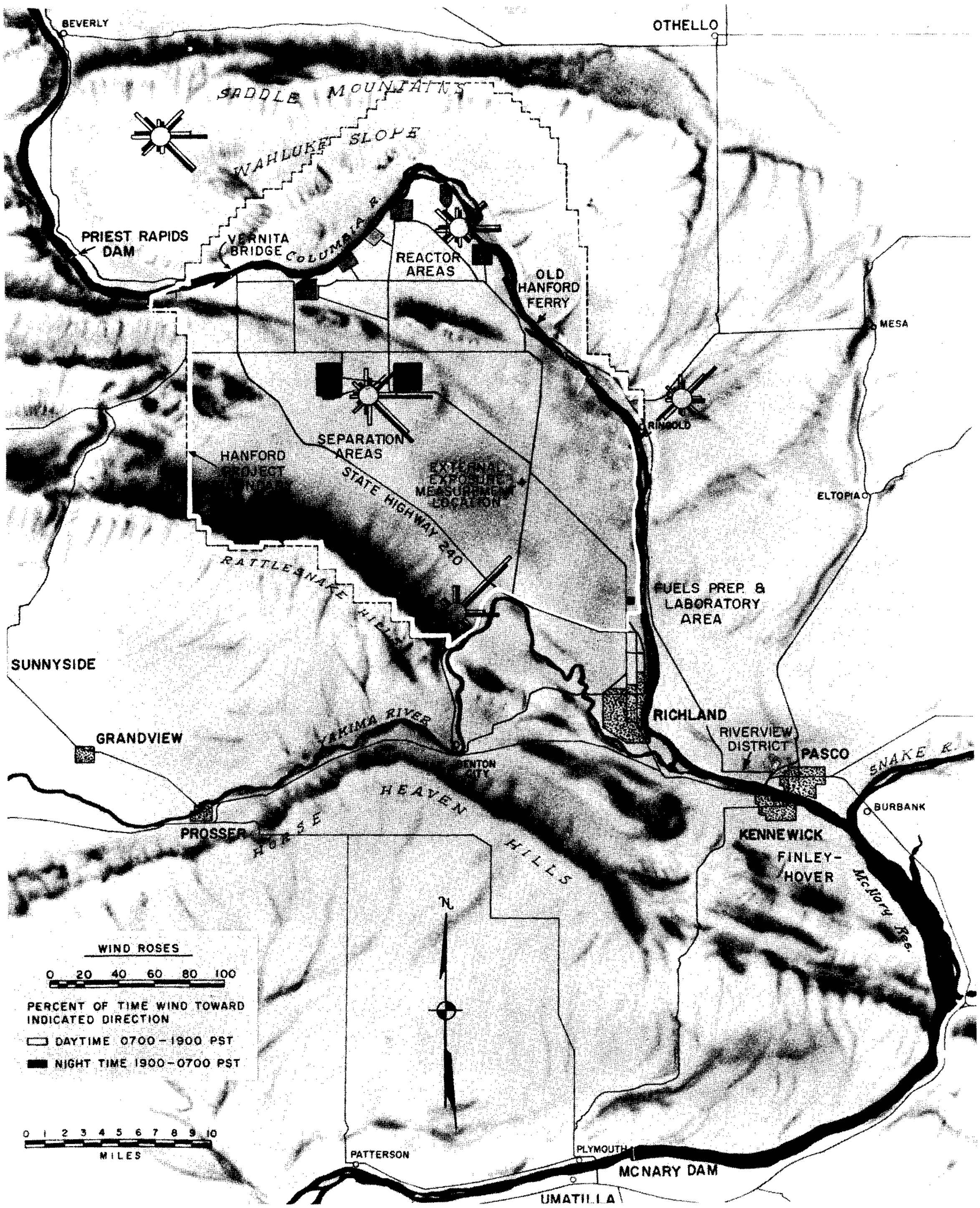

FIGURE 2. Features of Hanford Project and Vicinity

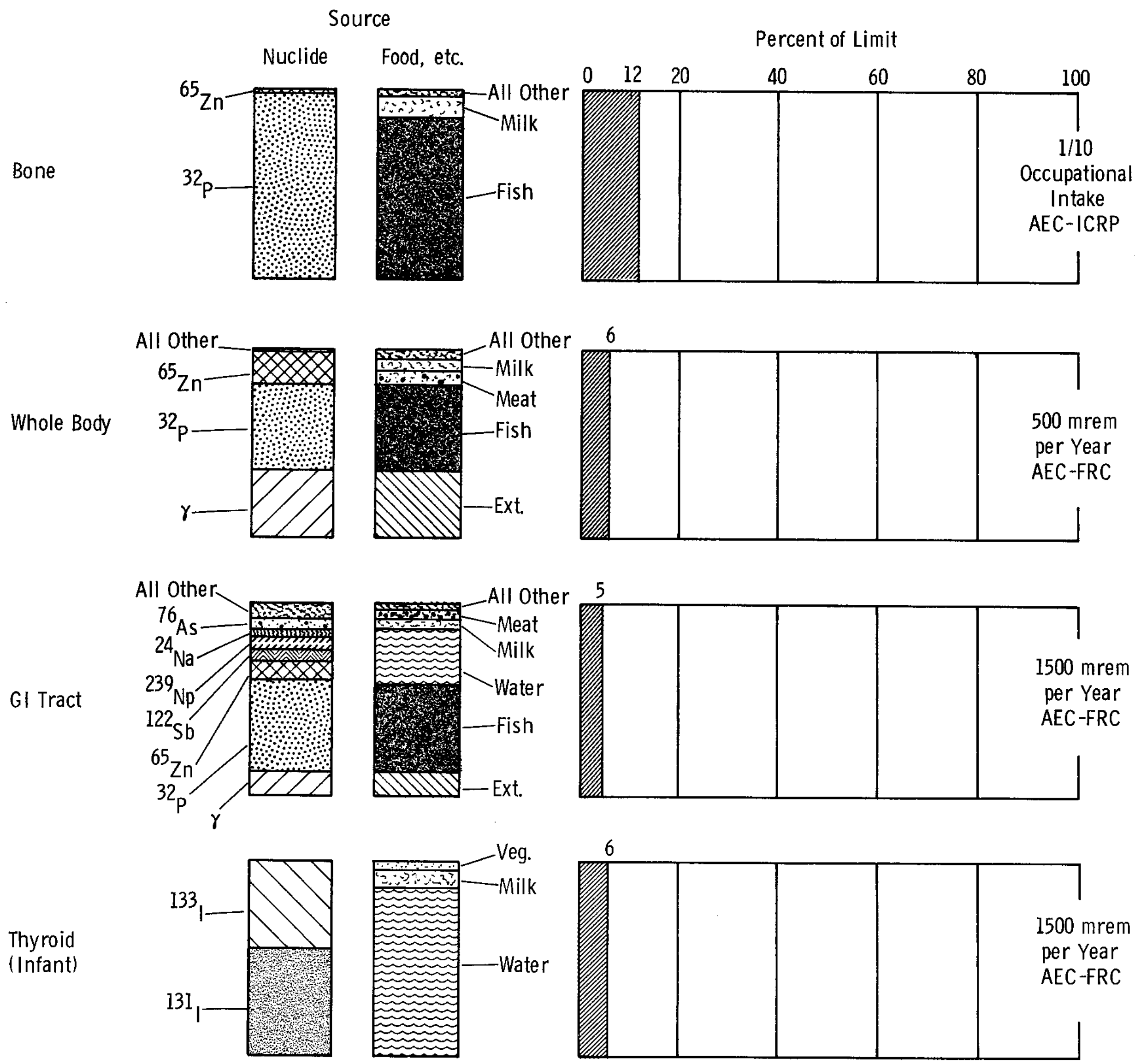

FIGURE 3. Estimated Doses to the Maximum Individual - 1967

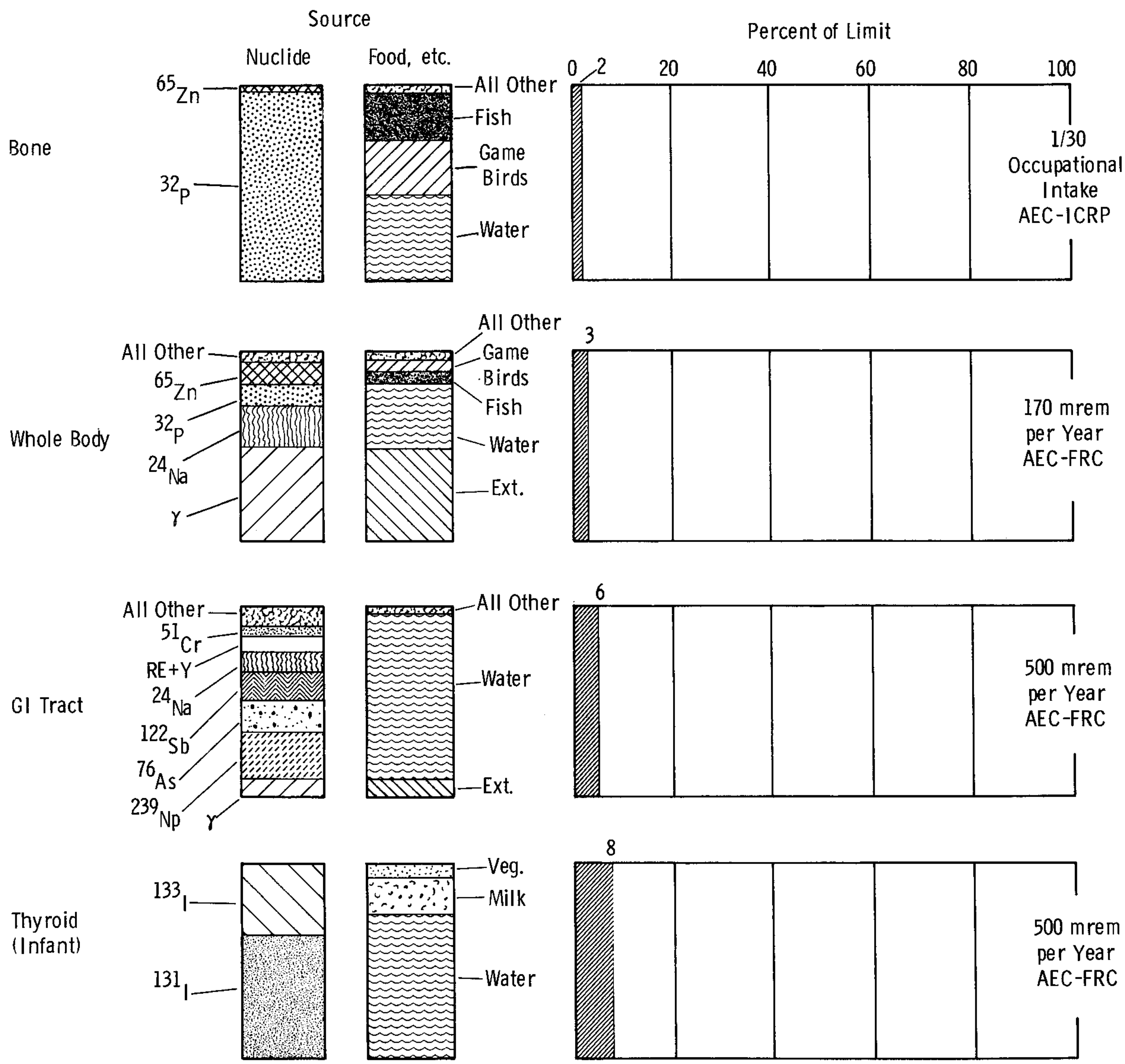

FIGURE 4. Estimated Doses to the Average Richland Resident - 1967

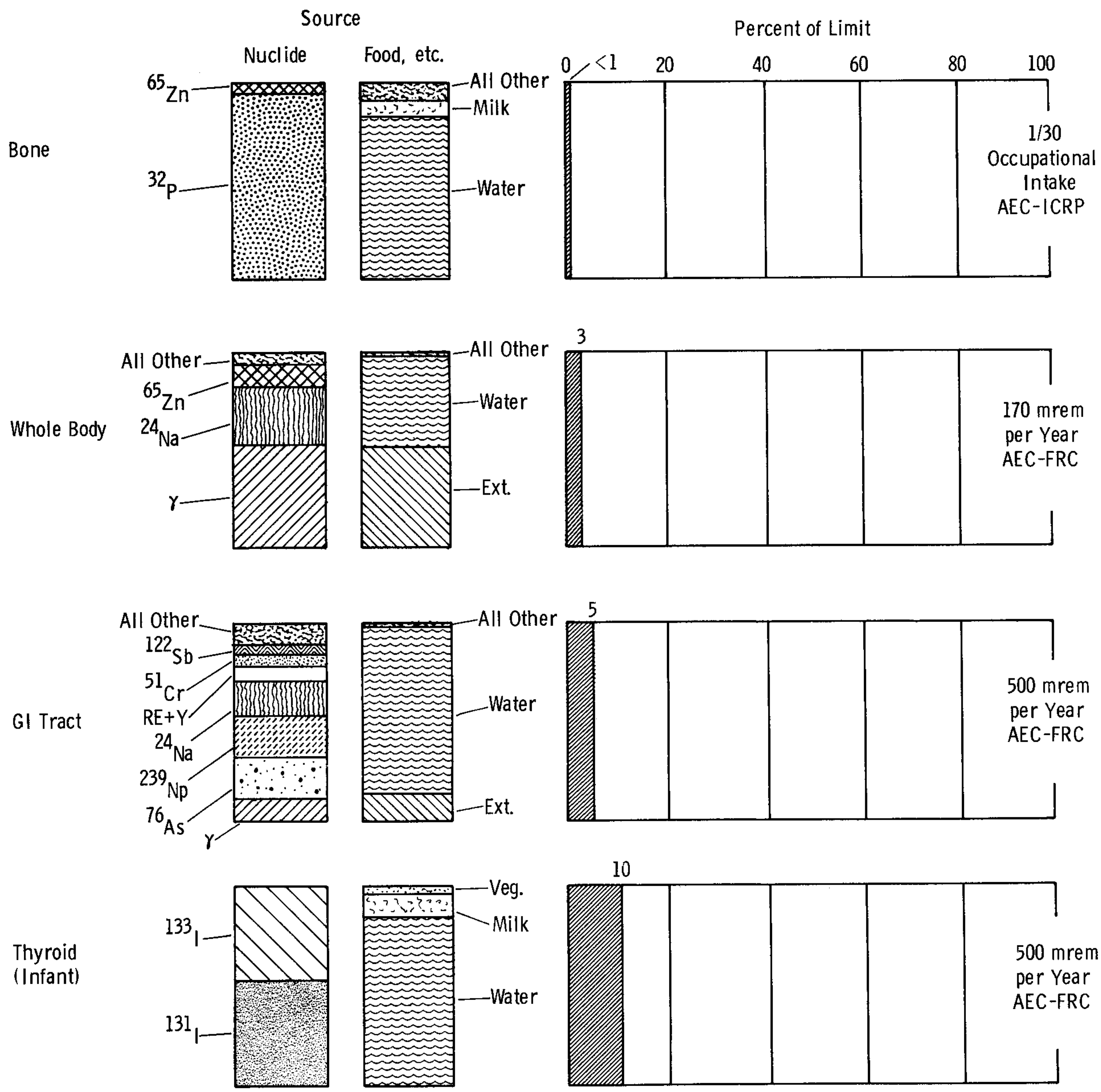

FIGURE 5. Estimated Doses to the Typical Richland Resident - 1967

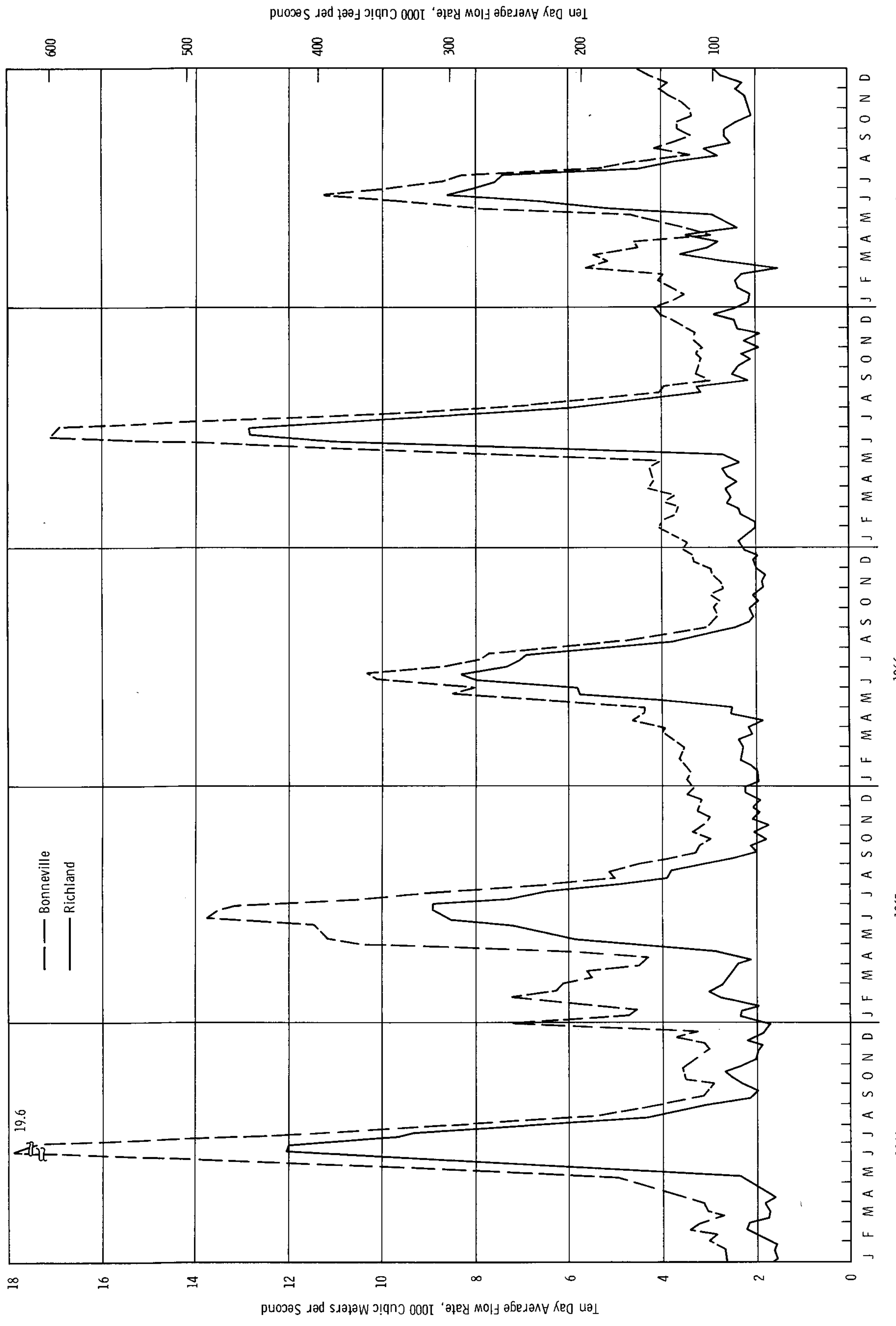

FIGURE 6. Ten-Day Average Flow Rate of the Columbia River at Priest Rapids and Bonneville Dams

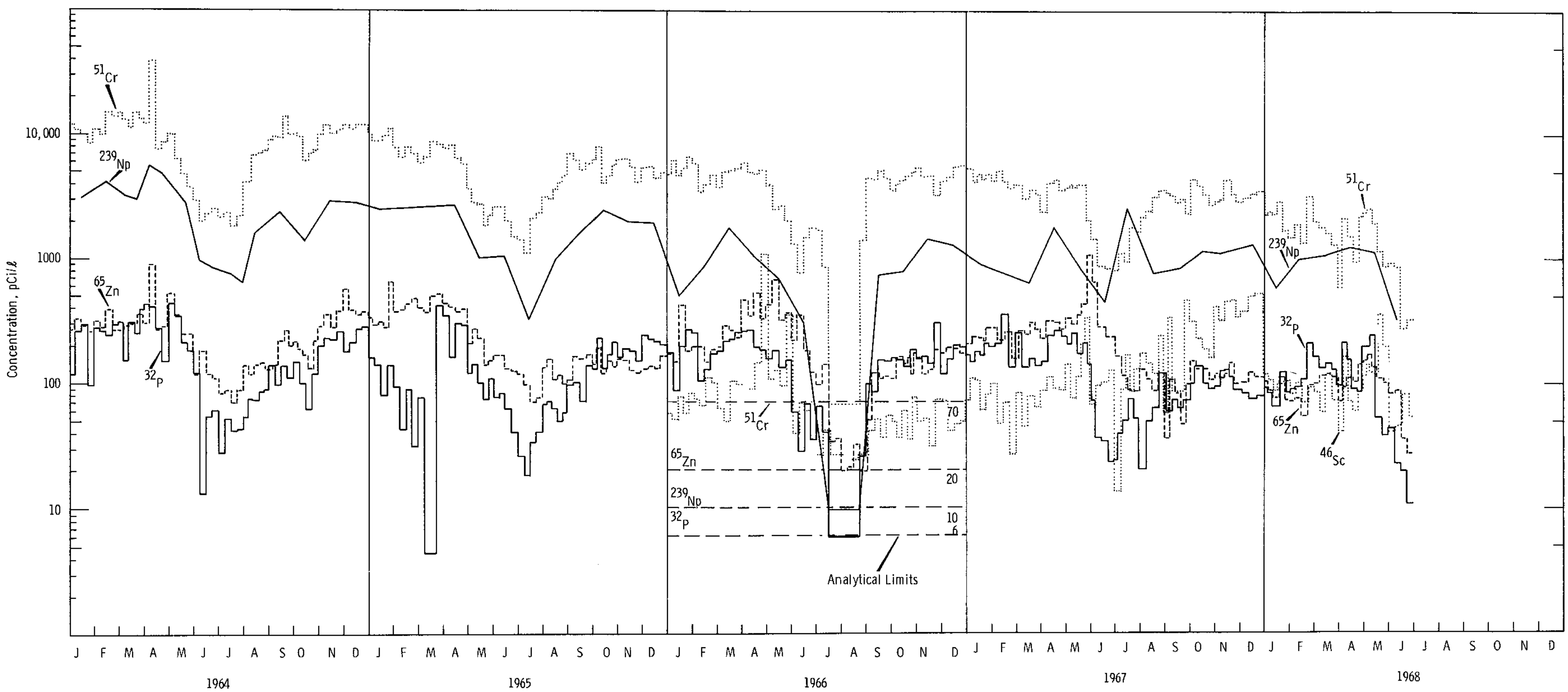

FIGURE 7. ^{32}P, ^{46}Sc, ^{51}Cr, ^{65}Zn, and ^{239}Np Concentrations in the Columbia River at Richland

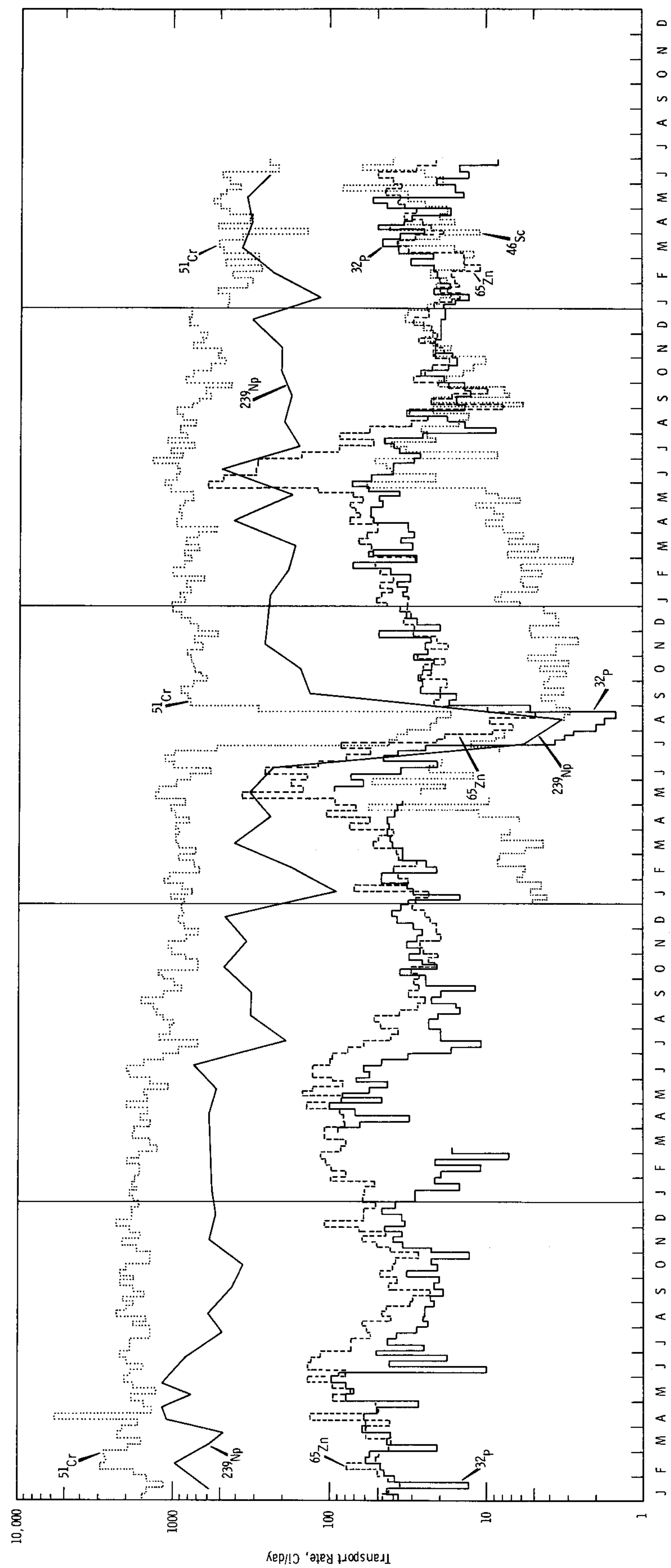

FIGURE 8. ^{32}P, ^{46}Sc, ^{51}Cr, ^{65}Zn, and ^{239}Np Transport Rates in the Columbia River at Richland

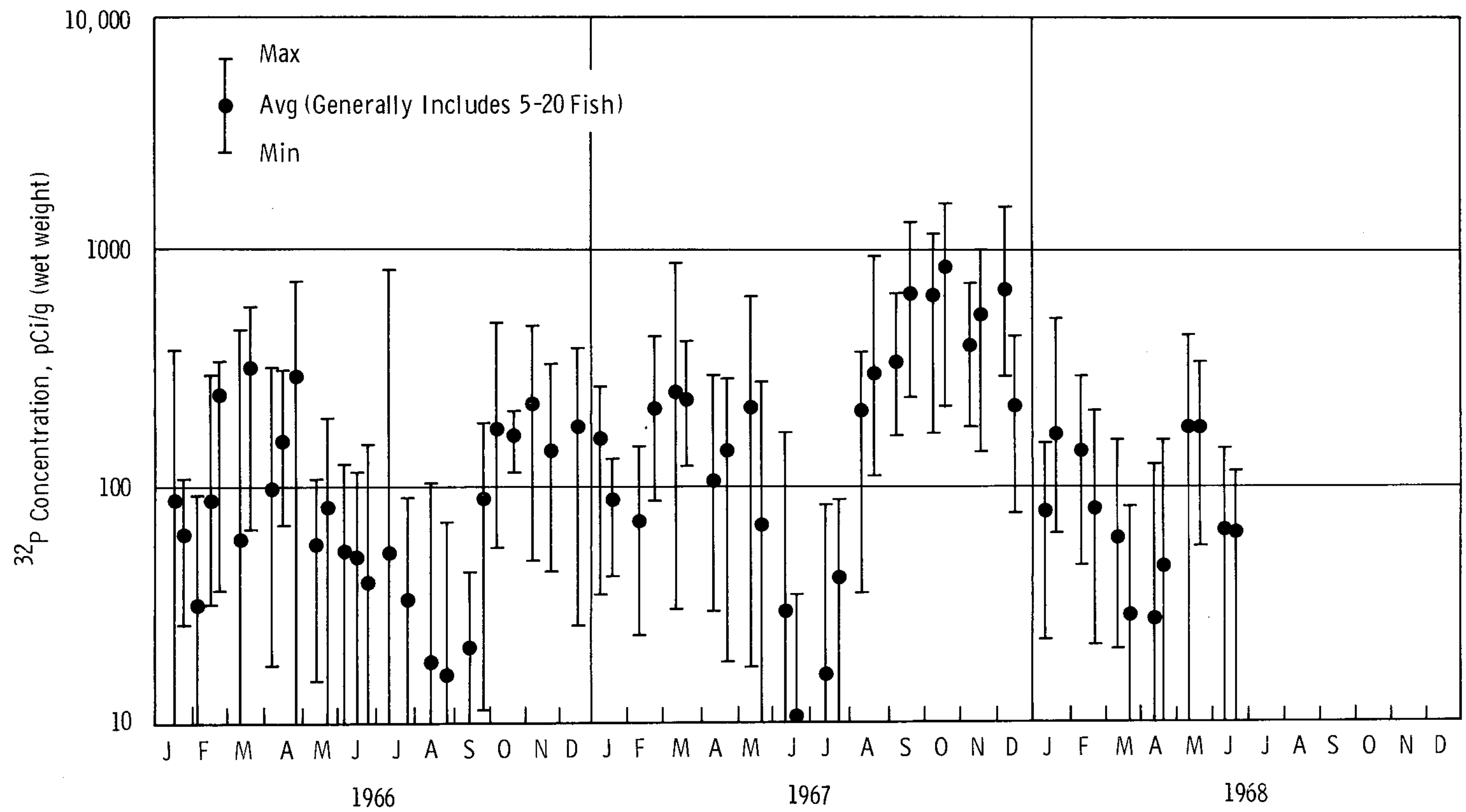

FIGURE 9. ^{32}P Concentrations in the Flesh of Whitefish Caught in the Columbia River Between Ringold and Richland

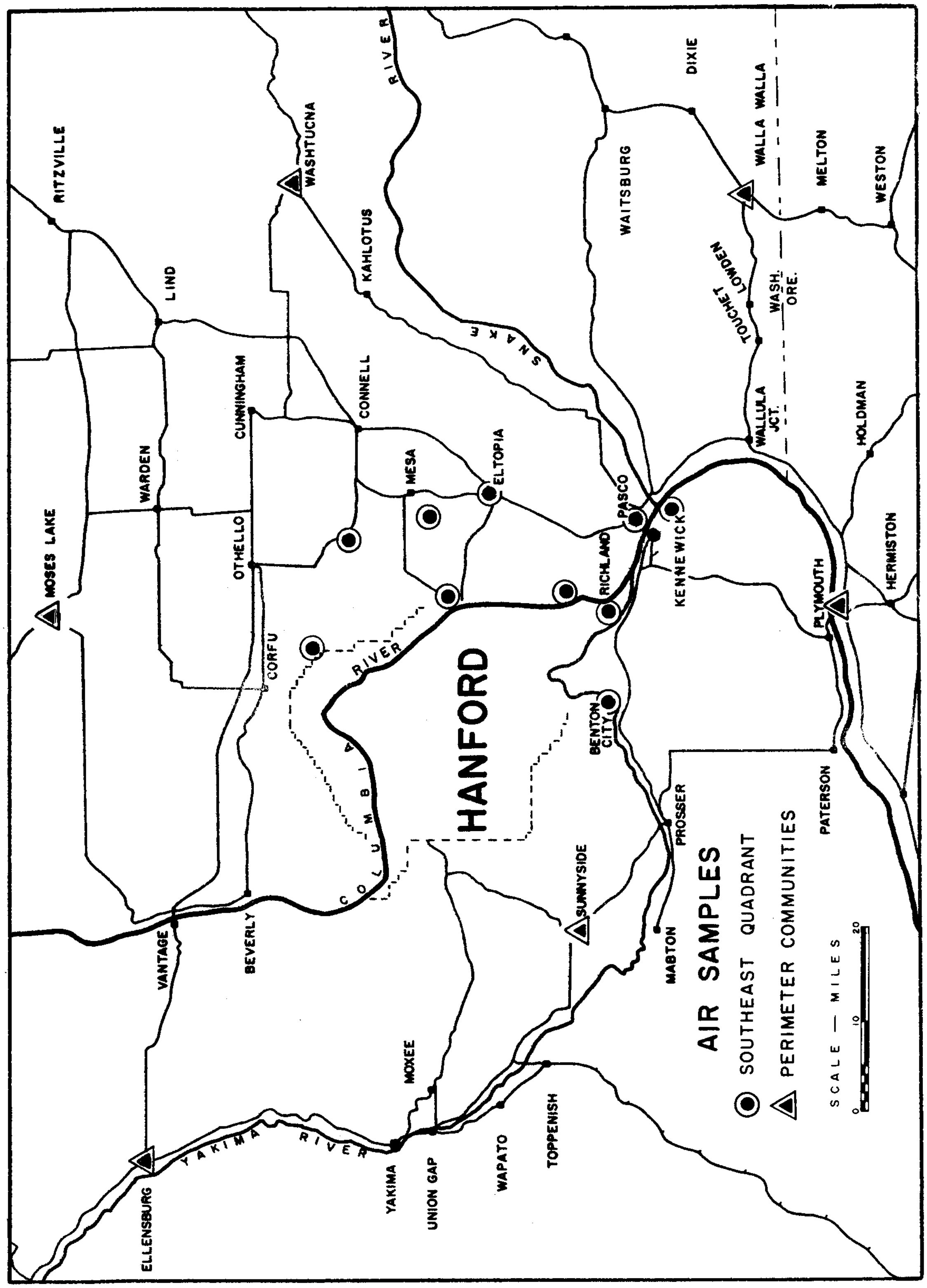

FIGURE 10. Air Sampling Locations

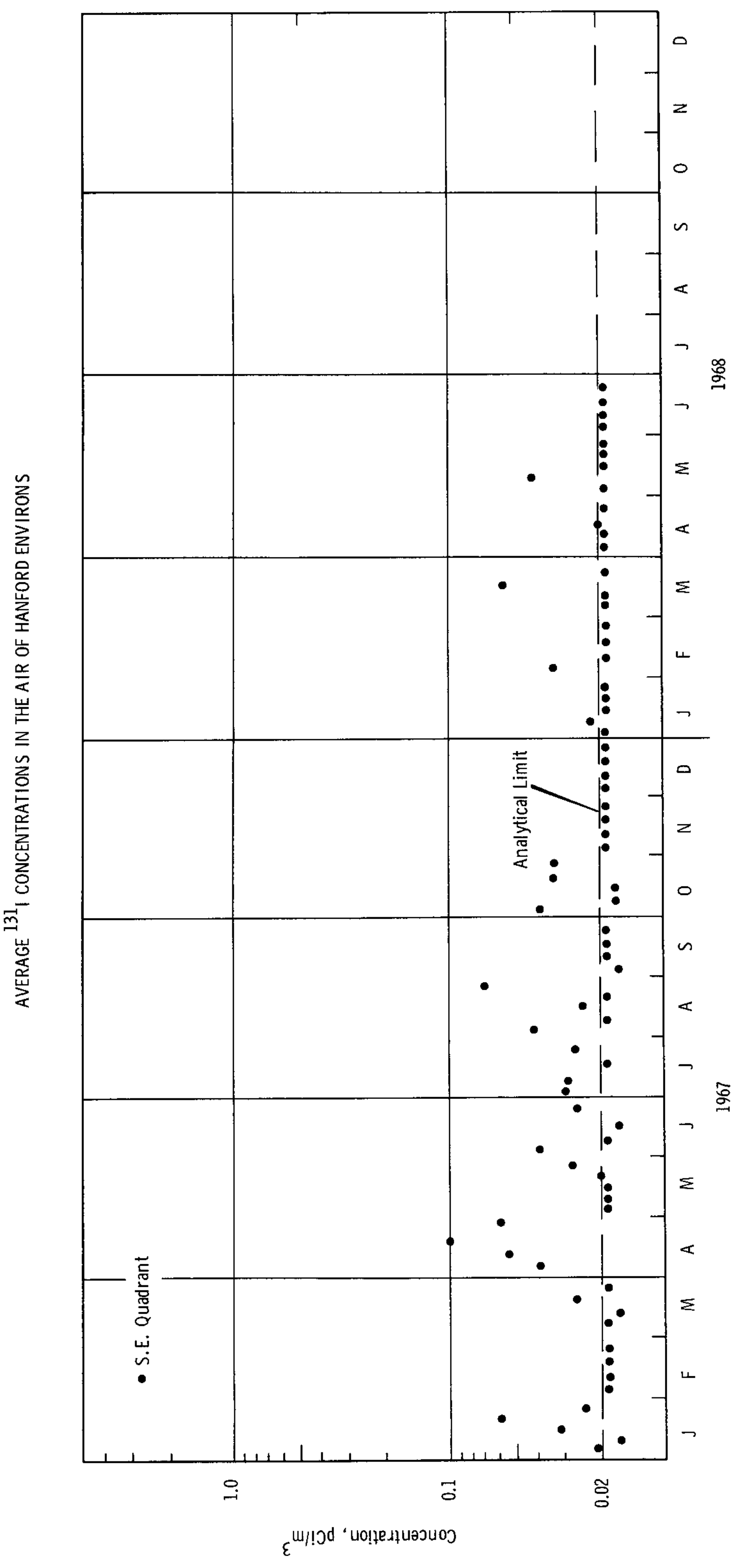

FIGURE 11. Average ^{131}I Concentrations in the Air of Hanford Environs

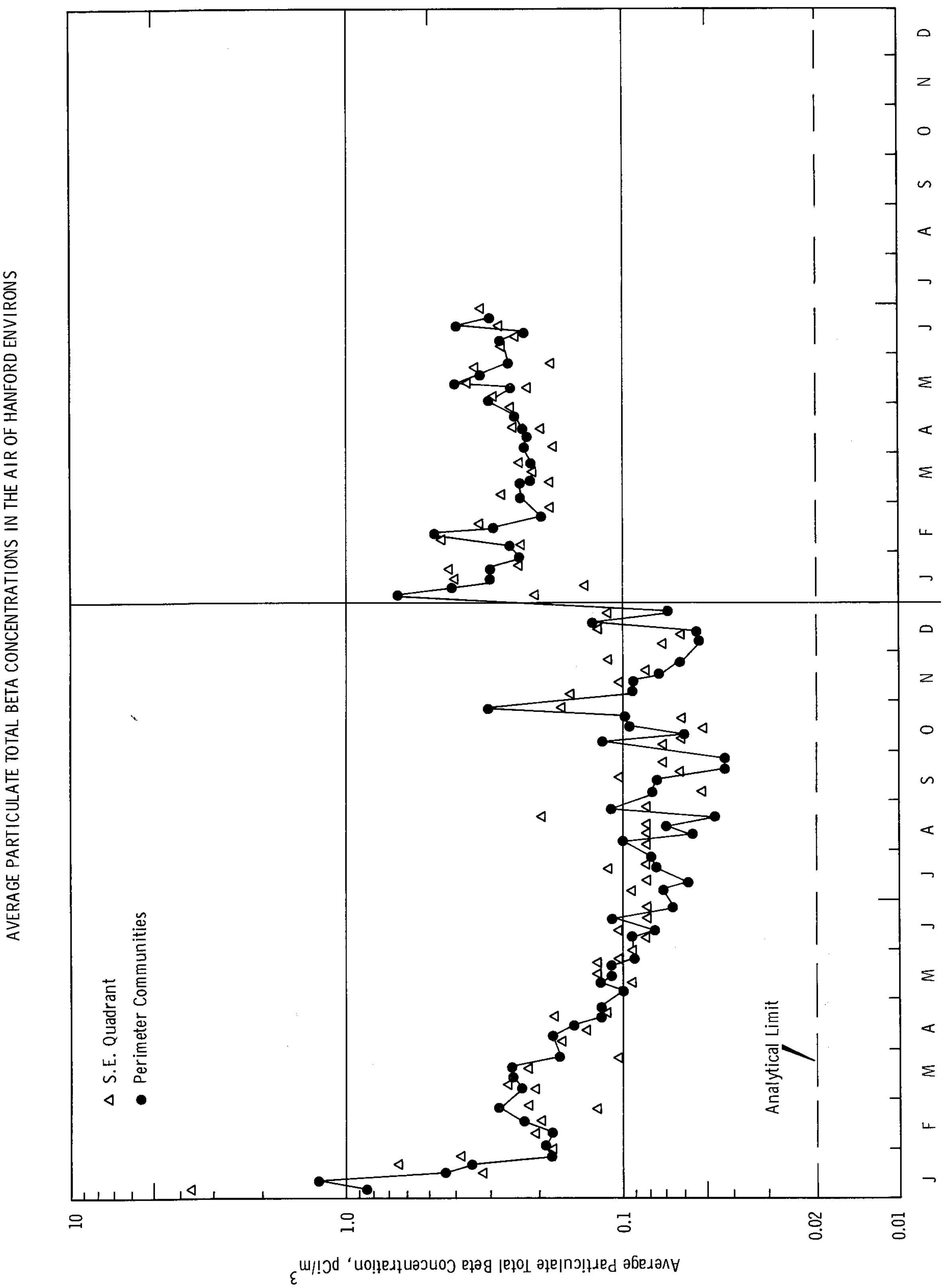

FIGURE 12. Average Particulate Total Beta Concentrations in the Air of Hanford Environs

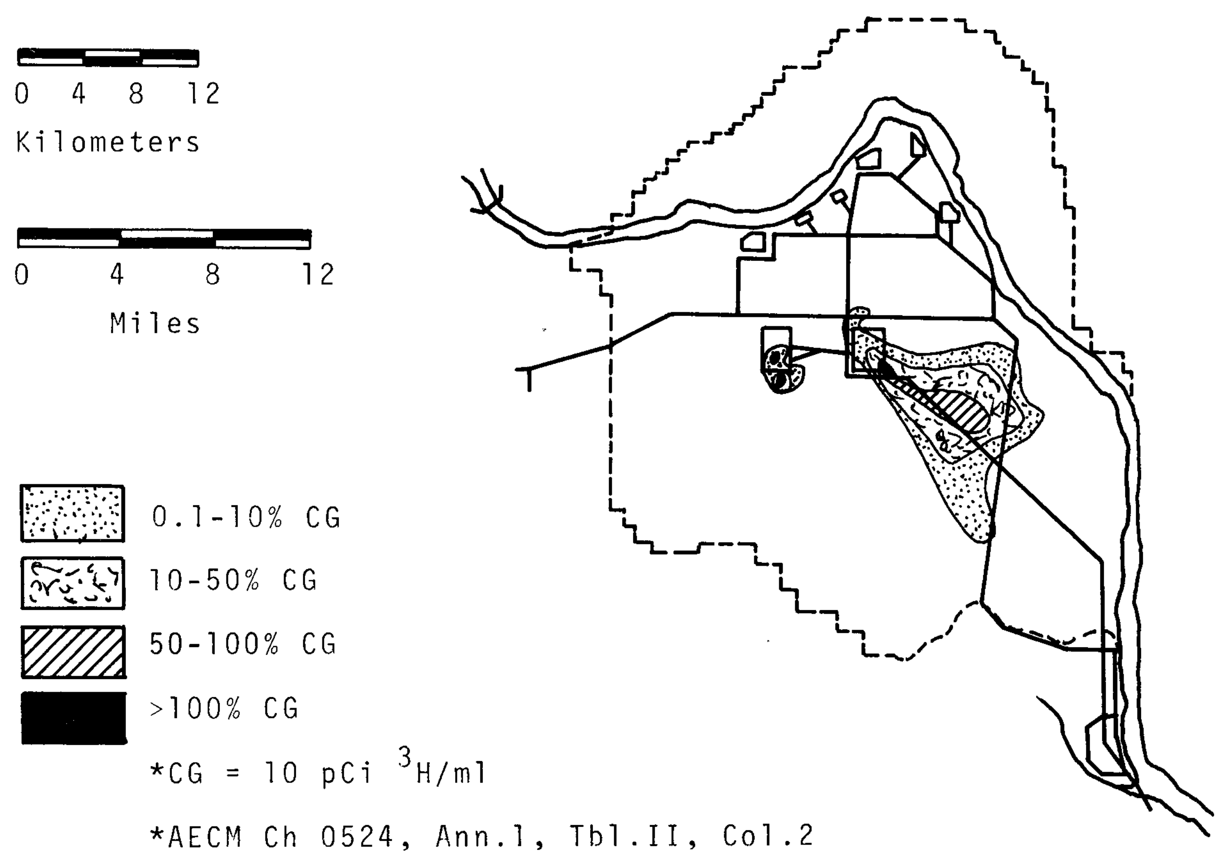

FIGURE 13. ^3H Concentrations in Groundwater, January-June 1968

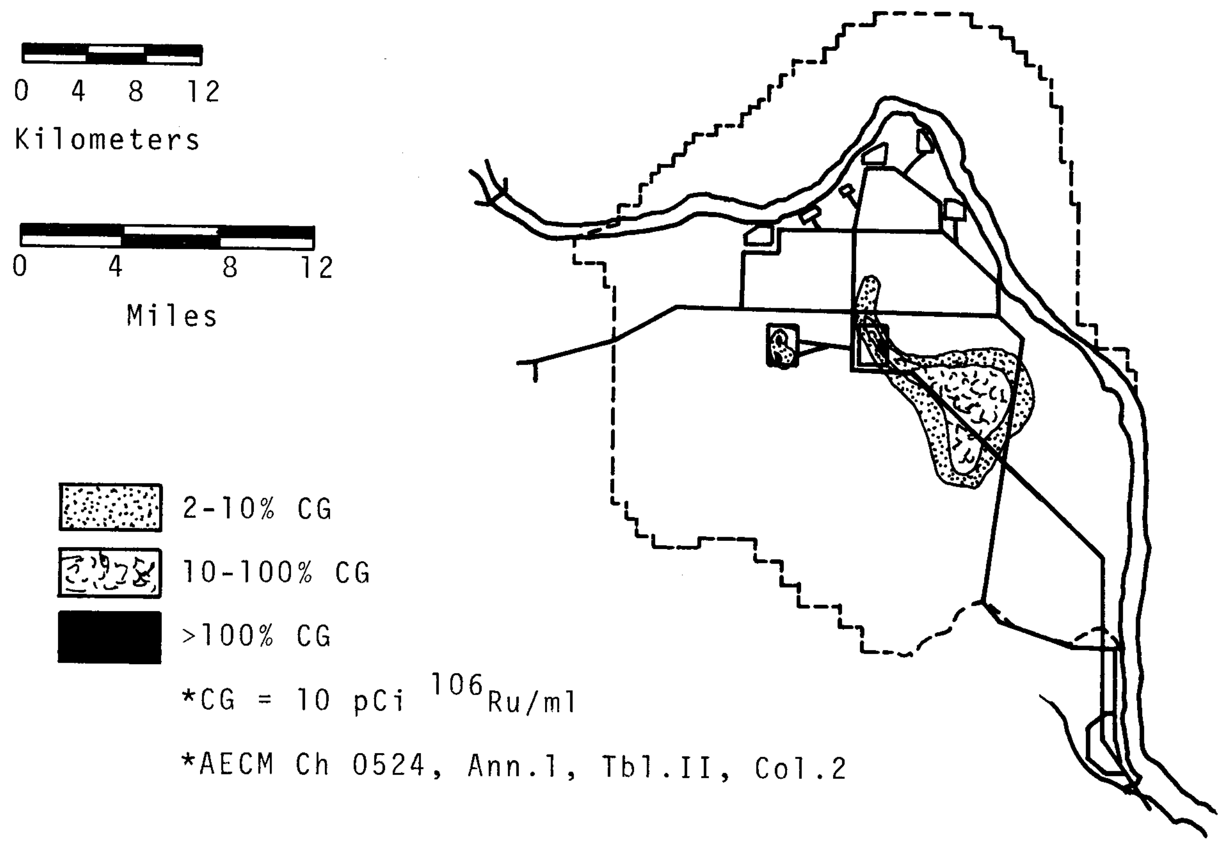

FIGURE 14. ^{106}Ru-Rh Concentrations in Groundwater, January-June 1968

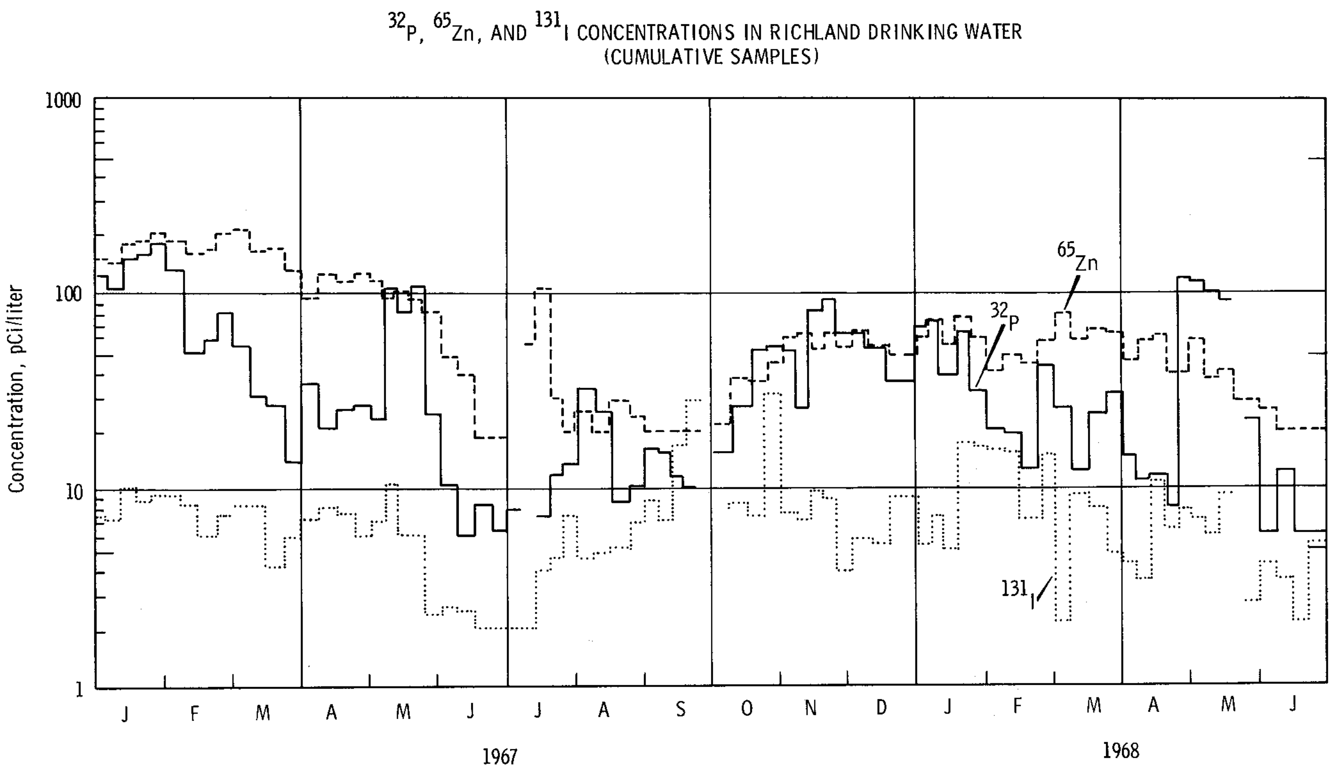

FIGURE 15. ^{32}P, ^{65}Zn, and ^{131}I Concentrations in Richland Drinking Water (Cumulative Samples)

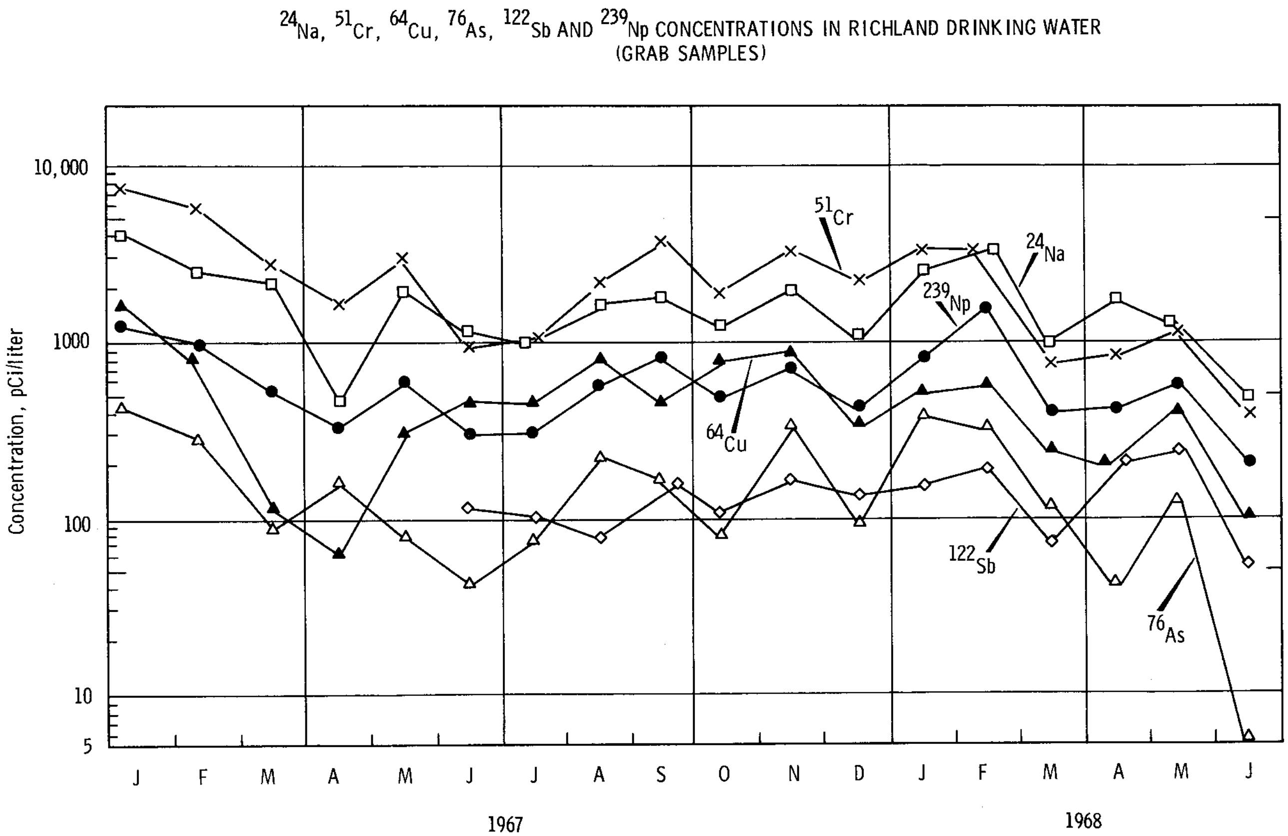

FIGURE 16. ^{24}Na, ^{51}Cr, ^{64}Cu, ^{76}As, ^{122}Sb, and ^{239}Np Concentrations in Richland Drinking Water (Grab Samples)

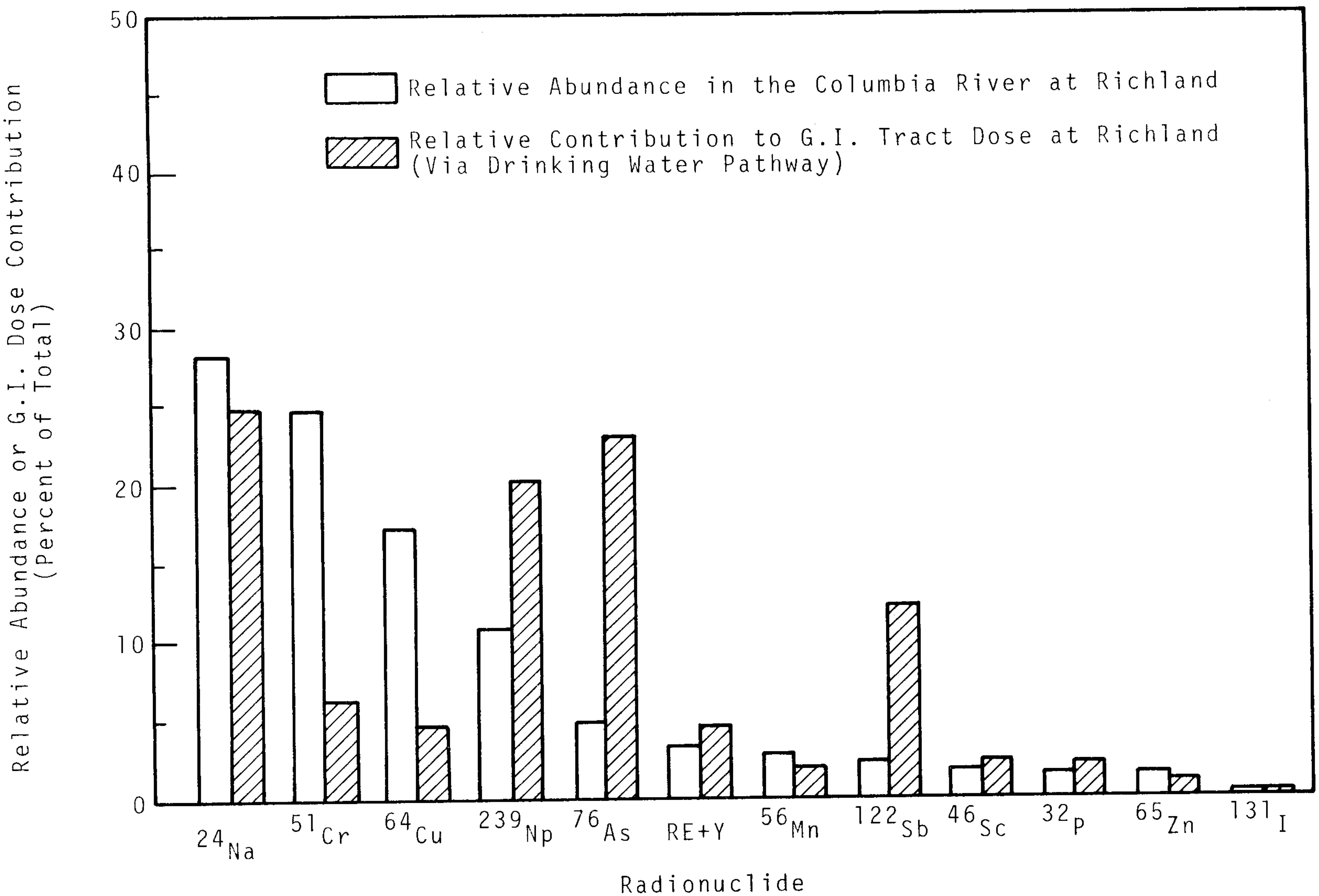

FIGURE 17. Relative Contributions of Radionuclides to GI Tract Dose from Richland Drinking Water, 1967

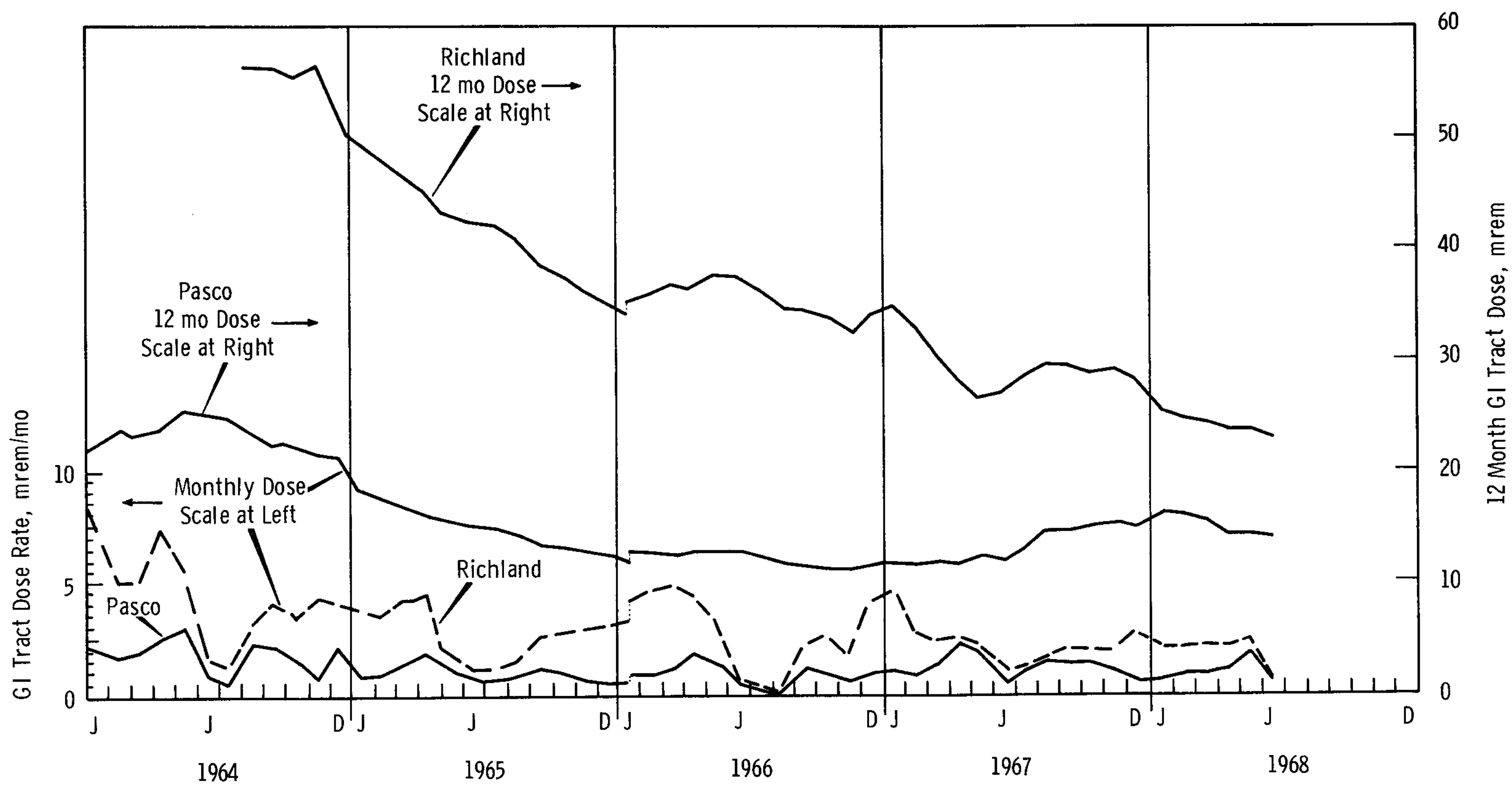

FIGURE 18. Doses to the GI Tract from Richland and Pasco Drinking Water (Based on 1.2 liter/day Intake)

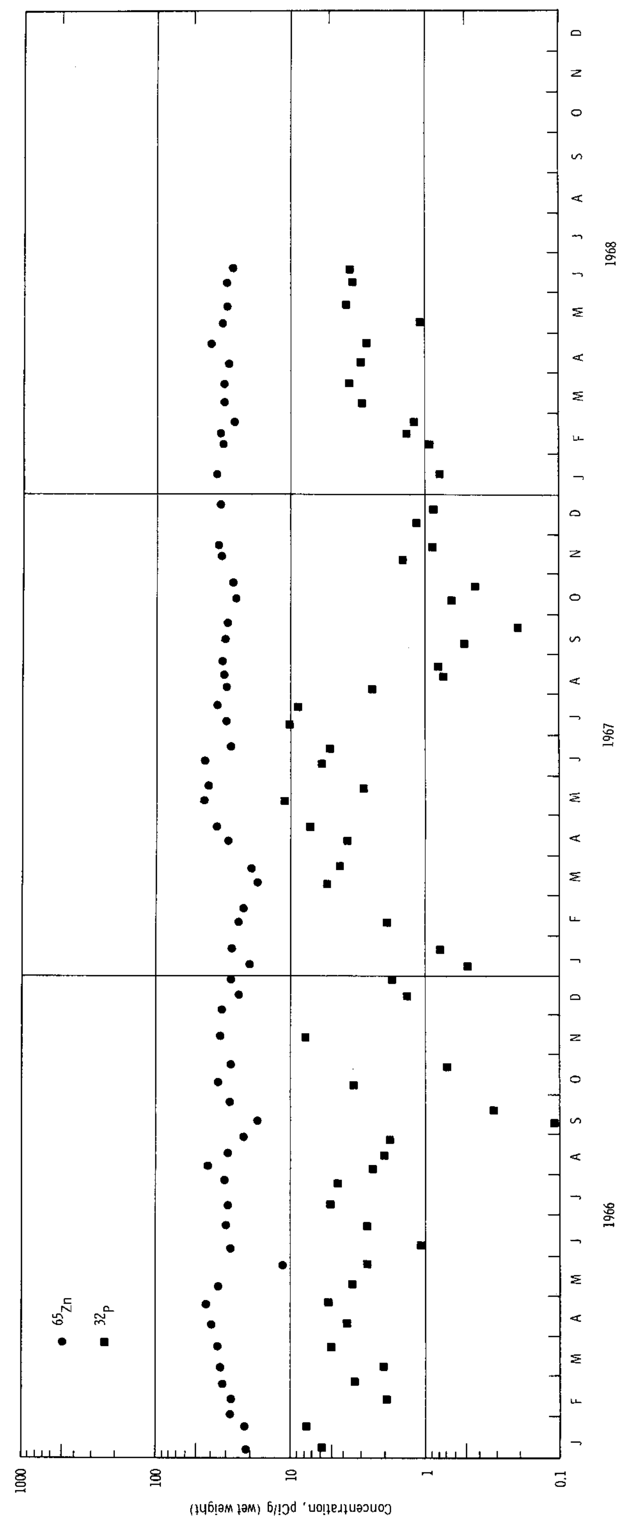

FIGURE 19. ^{32}P and ^{65}Zn Concentrations in Willapa Bay Oysters

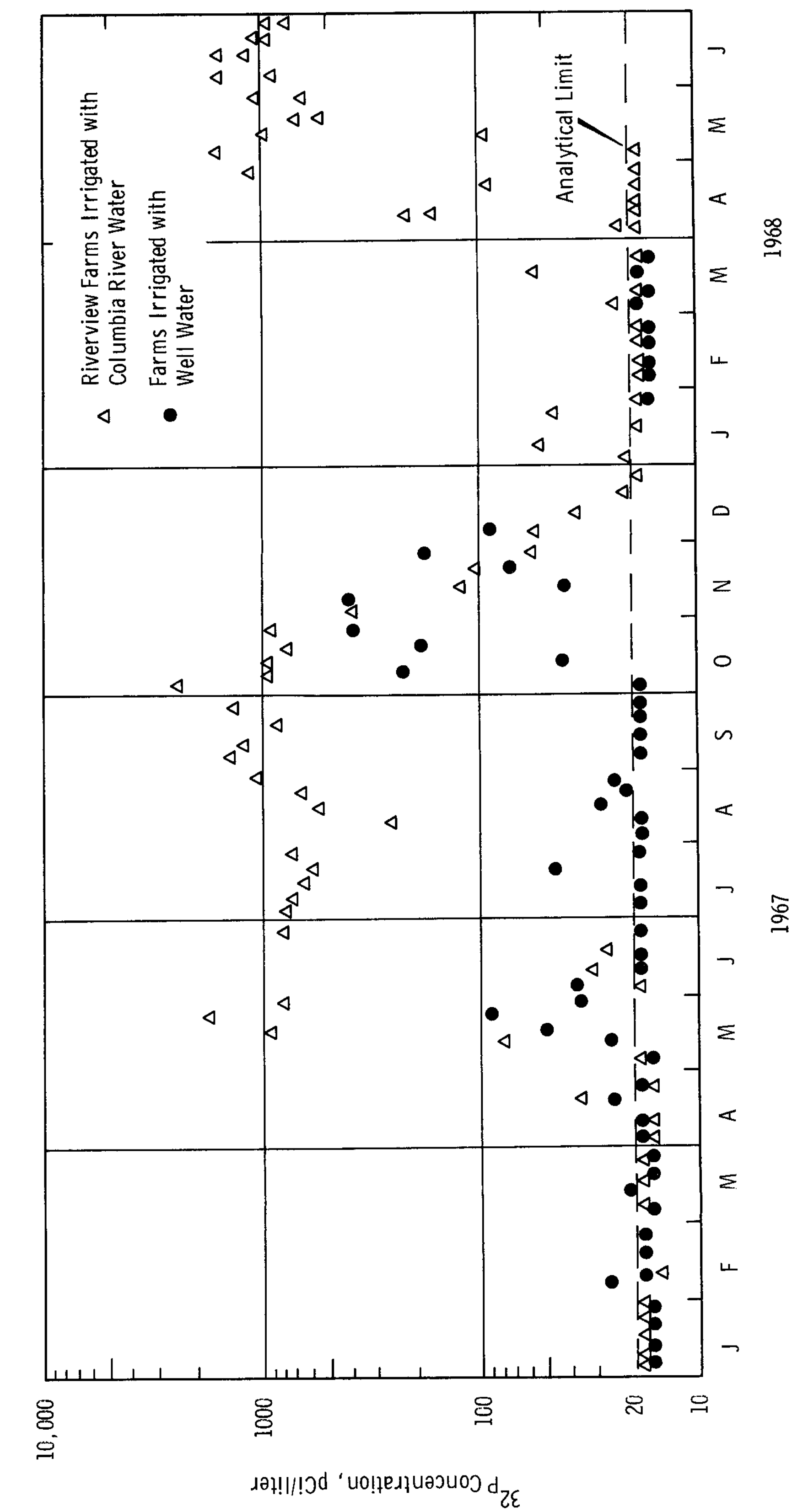

FIGURE 20. ^{32}P Concentrations in Local Farm Milk

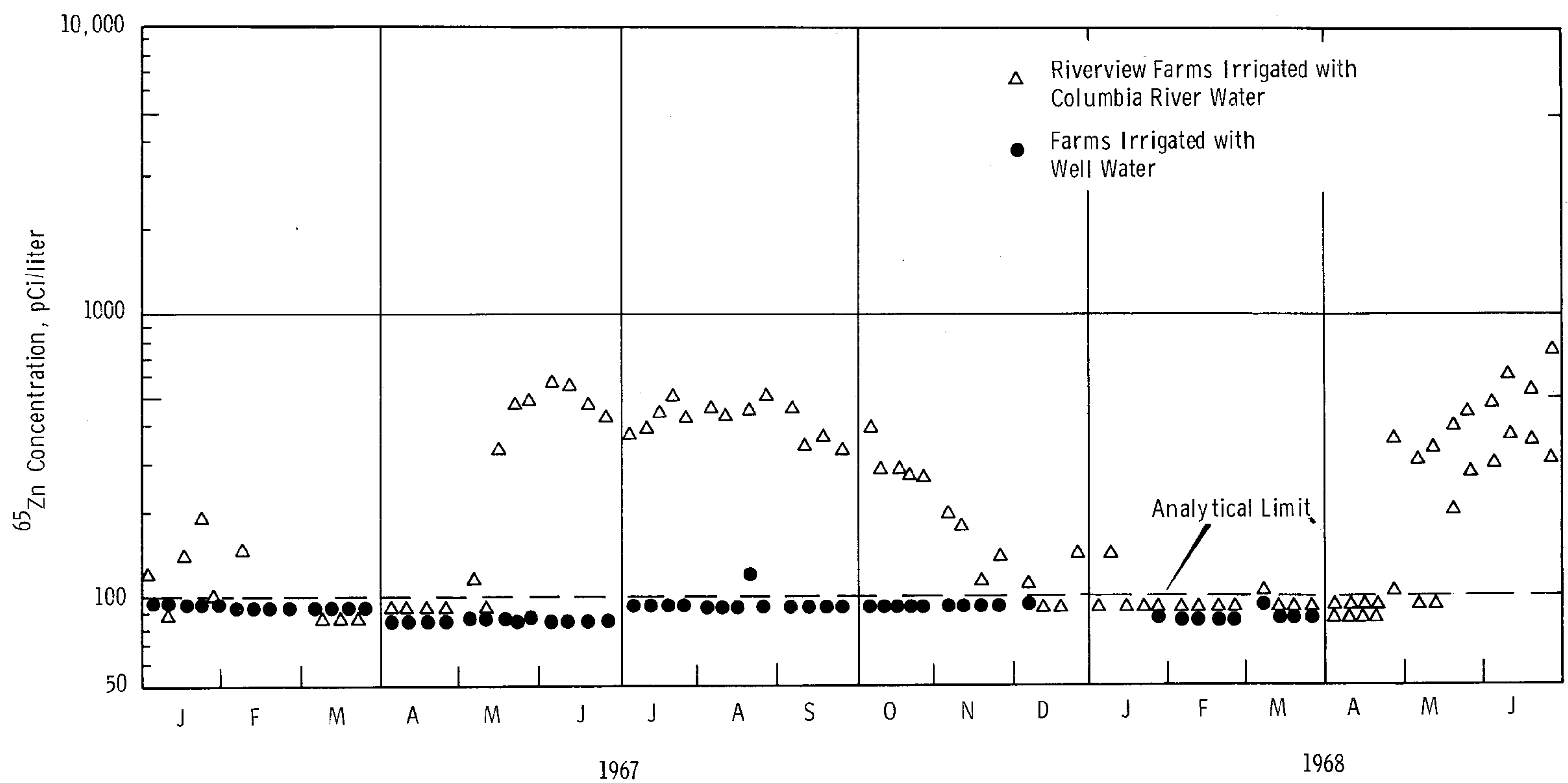

FIGURE 21. ^{65}Zn Concentrations in Local Farm Milk

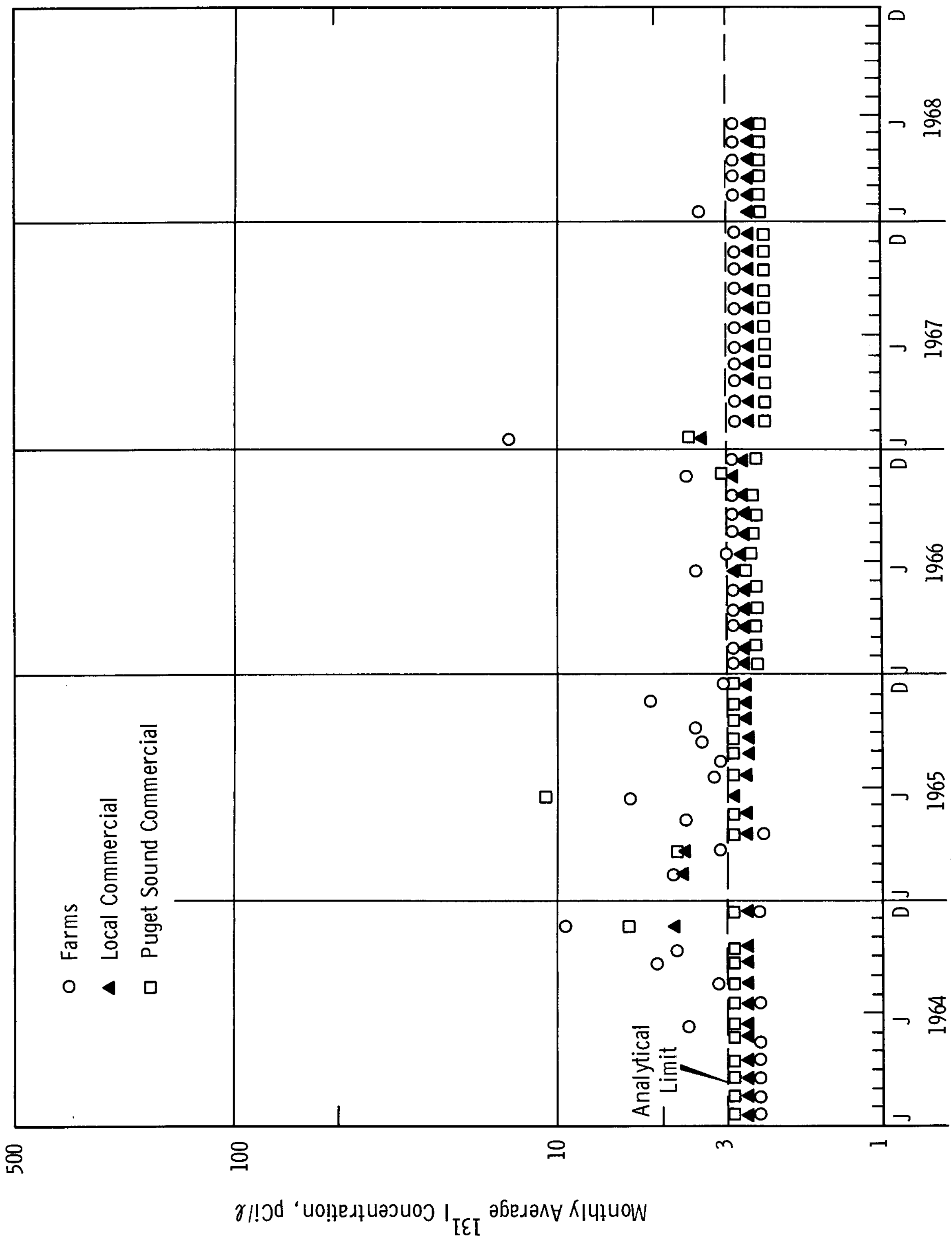

FIGURE 22. Average ^{131}I Concentrations in Locally Available Milk

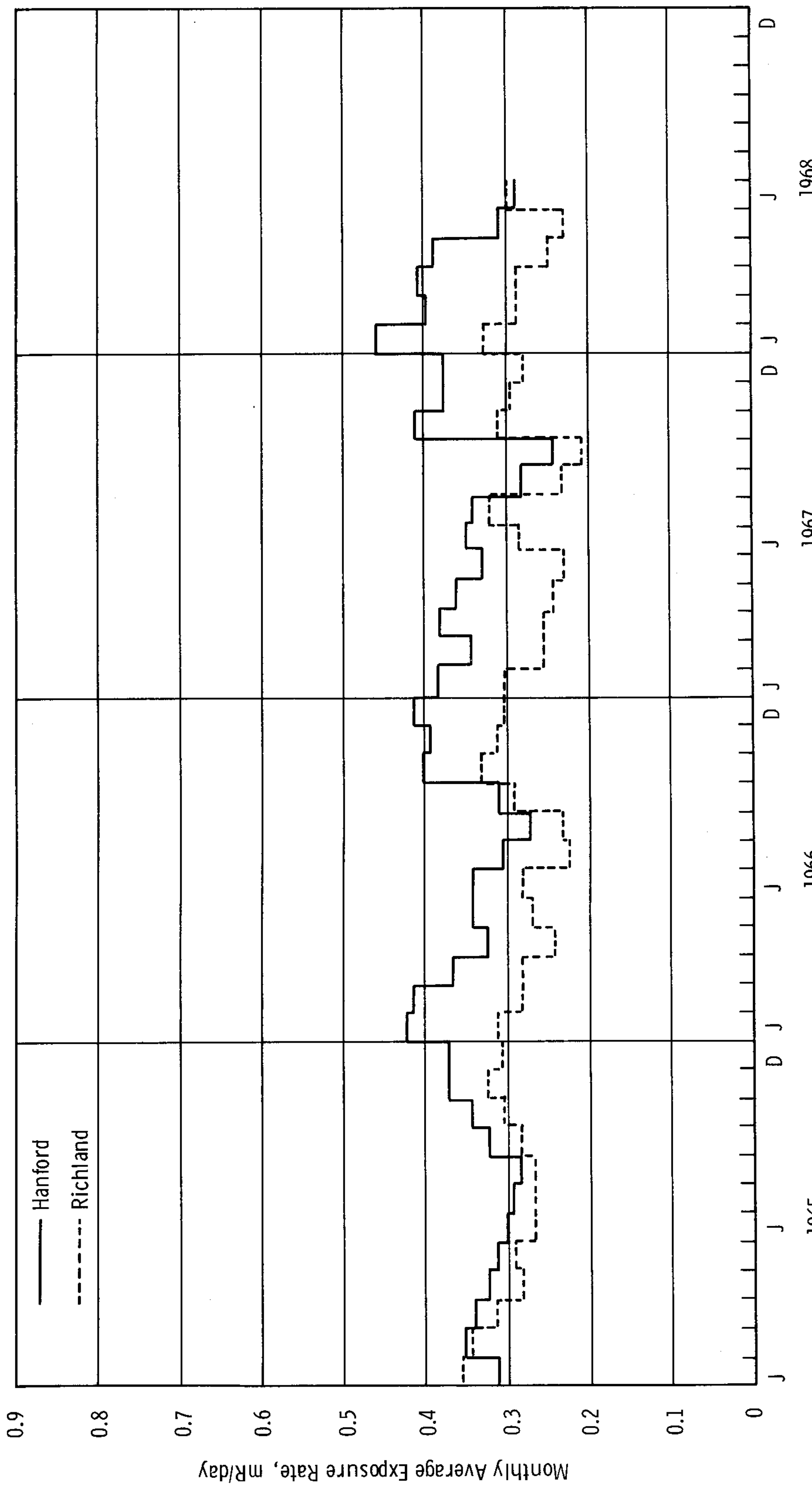

FIGURE 23. Monthly Average Gamma Exposure Rate at Hanford Test Location and at Richland

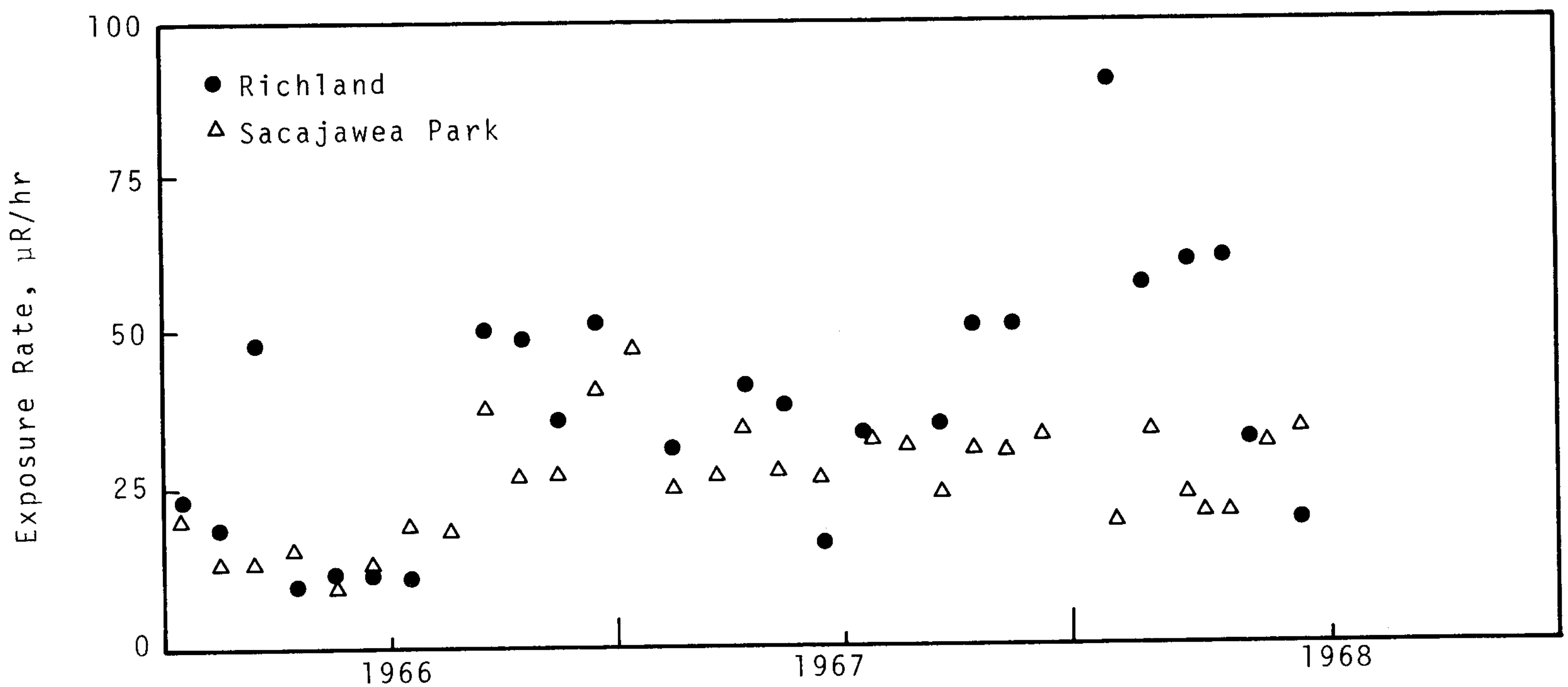

FIGURE 24. External Gamma Exposure Rate at the Columbia River Shoreline at Richland and Sacajawea Park

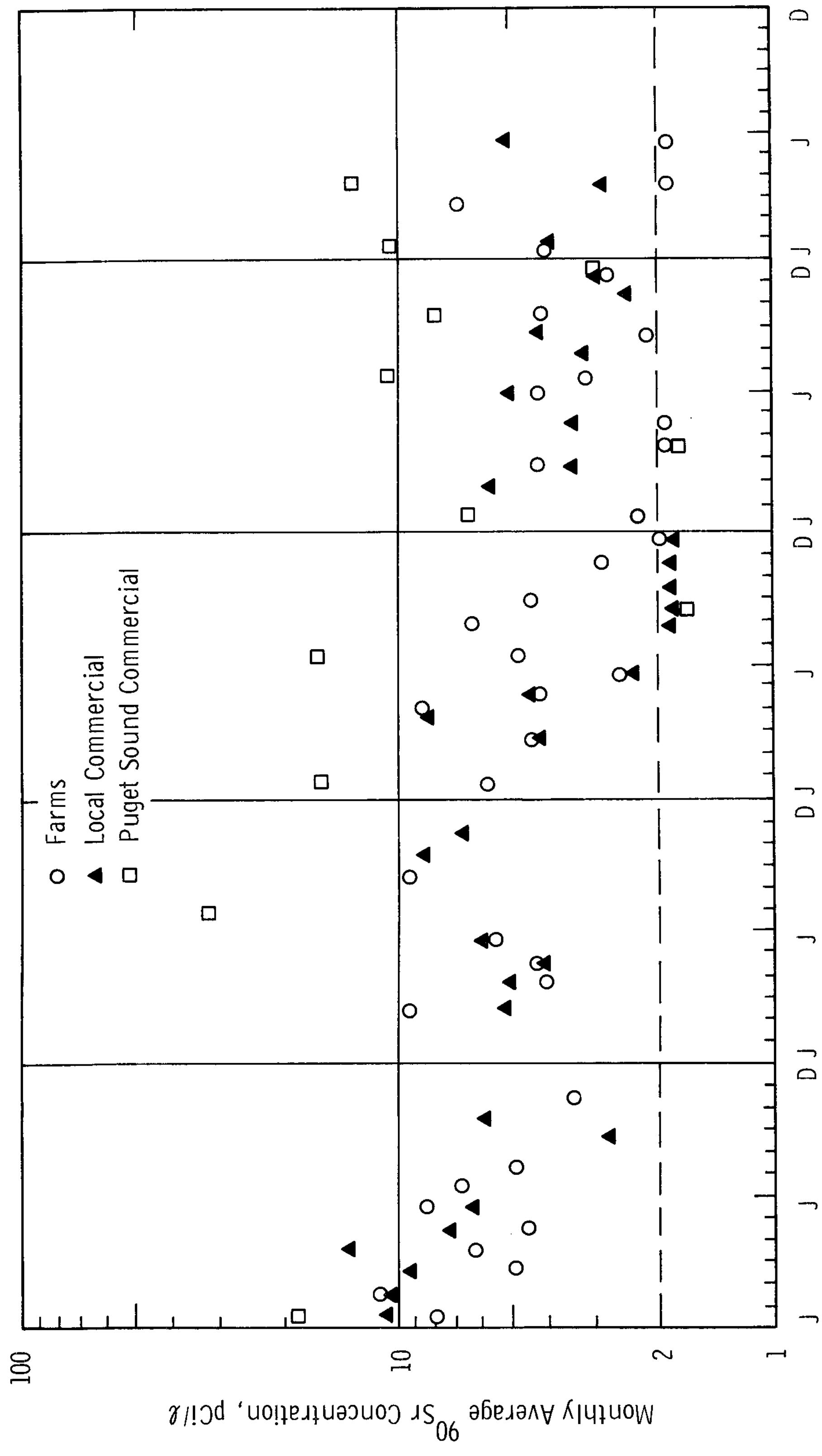

FIGURE 25. Average ^{90}Sr Concentrations in Locally Available Milk

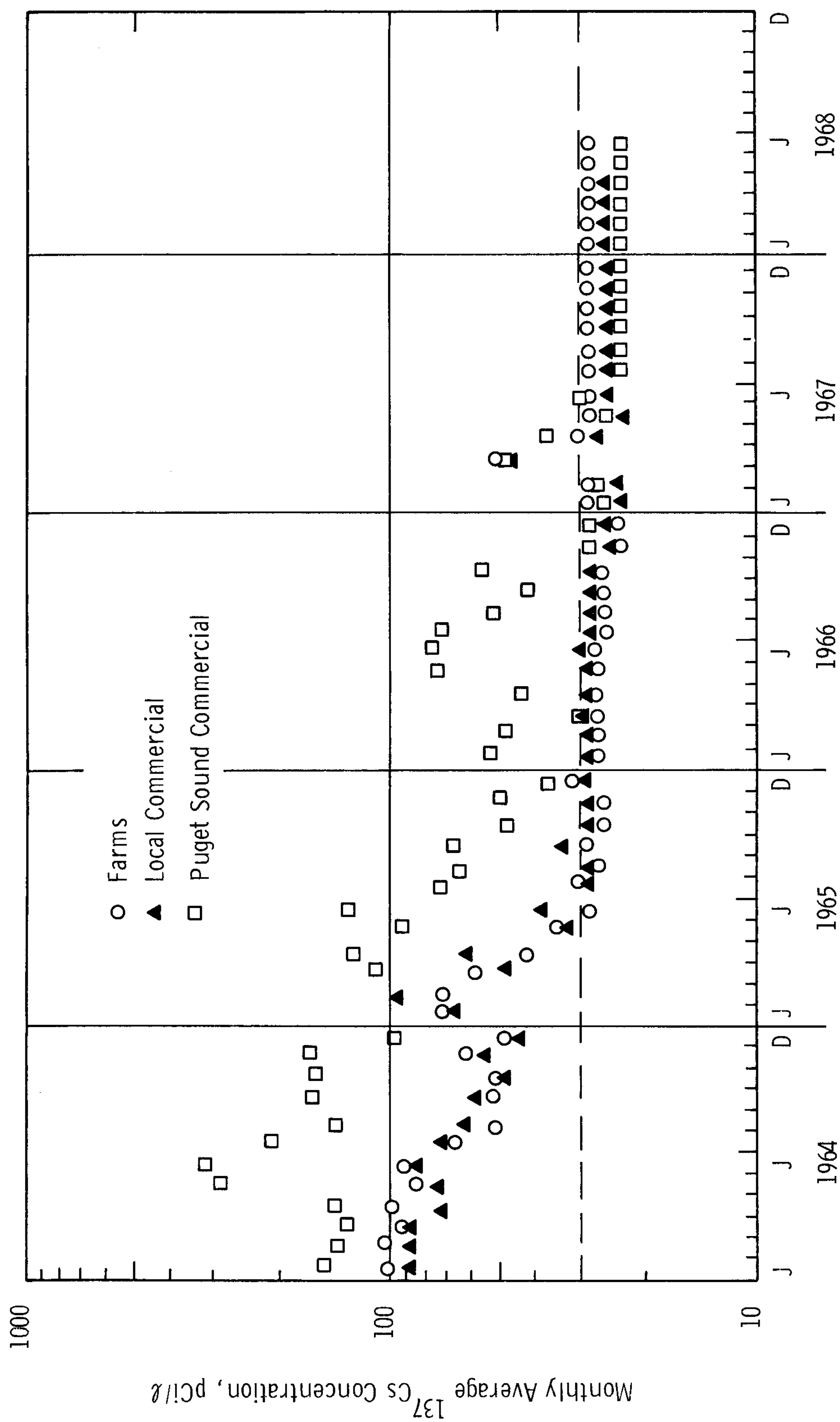

FIGURE 26. Average ^{137}Cs Concentrations in Locally Available Milk

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APPENDIX

DOSE STANDARDS FOR EVALUATION

Radiation protection practices at Hanford, including radioactive waste disposal, are governed by the AEC Manual.(2)

More specifically, Chapters 0524 and RL 0524(9) provide standards for permissible radiation exposures. The section of RL 0524 Appendix to which this evaluation is addressed is as follows:

"II. RADIATION PROTECTION STANDARDS FOR INDIVIDUALS AND POPULATION GROUPS IN UNCONTROLLED AREAS

A. Radiation dose standards for external and internal exposure

	Dose (rem/year)	
	Based on exposure of individuals	Based on the average exposure of a suitable sample of the exposed population.
Type of Exposure		
Whole body or gonads	0.5	0.17
Thyroid, bone or G.I. tract	1.5	0.5

"

It is not possible to determine the precise radiation dose received by every individual because of variations in the kinds and quantity of food consumed, variations in sources of food supply, and many variations in personal living habits. These inherent variations between individuals require a somewhat subjective approach when estimating probable radiation doses in relation to various established limits. The Federal Radiation Council (FRC) and AEC have provided two sets of guides against which doses from environmental sources may be judged; i.e., one for the individuals that receive the greatest dose, and the other for the average dose received by the general population (taken as one-third of that set for individuals).

The significance of bone seekers, such as ^{32}P and ^{90}Sr, has required special consideration and treatment because the rate of intake of ^{32}P has not been specifically studied by the FRC (Federal Radiation Council)[13,14,15] in relation to a dose-equivalent for the bone or bone marrow. 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 a 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 ICRP (International Commission on Radiological Protection).[8]

The ICRP has a new publication in process which is expected to provide revised dose computation schemes for a number of nuclides, including ^{32}P. In the absence of definitive guidance, it has been our judgment that the dose equivalent for ^{32}P in bone derived by the ICRP (with the use of an n factor of 5) is not directly comparable with the dose specified in the FRC guide (1.5 rem/yr). In view of the AEC instruction that ICRP-NCRP (National Committee on Radiation Protection and Measurements**) dosimetry methods[8,16] be used where the FRC does not provide direct guidance, and in view of the more conservative rate of intake for ^{32}P implied by the ICRP-NCRP recommendations, we have continued to use the ICRP intake values as a reference base. Further, 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

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* Used for evaluation of fallout dose in this report.

** Formerly the National Council on Radiation Protection

ICRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man. This amounts to one-tenth of the MPC for continuous occupational exposure multiplied by intake rates of 2.2 liter/day or 800 liter/yr (for annual estimates). In the case of ^{32}P the MPRI is 16 μCi/yr.

For thyroid dose calculations, the Federal Radiation Council has given specific guidance for permissible daily ^{131}I intake for infants, assuming a thyroid size of 2 grams. We have used this guidance, both for the translation of radioiodine intake to dose and for the selection of appropriate groups for dose evaluation.

For whole body and GI tract dose calculations, we have used ICRP values for the several physiological factors involved in translating intake to dose.

The radiological units used throughout most of this report are rems (dose-equivalent). When the nuclides of interest at Hanford are considered with the organs for which radiation doses (in rads) are calculated, the units rad and rem are numerically equal.

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