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RINGOLD FARMS—A HANFORD ENVIRONMENTAL STUDY

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Abstract—Estimates of radiation exposure to persons living near atomic energy installations are usually developed from an interpretation of environmental data together with certain dietary assumptions. The very low, but often highly variable, levels of radioactivity encountered in the environs and the relatively incomplete dietary information result in a lack of precision in exposure estimates for any particular individual.

In mid-1962, Hanford's whole-body counter was made available for environmental studies. The twenty inhabitants of a small, well-defined, farming area which is closest to the production facilities at Hanford were chosen for study. Late in 1962, twelve of these people were examined in the whole-body counter and four persons provided urine for bioassay analysis.

Simultaneous measurements were made with a 9-in. diameter by 4-in. thick NaI crystal and a 3-in. diameter by 3-in. thick NaI thyroid monitor. The radionuclides which were detected were potassium-40, zinc-65, cesium-137 and iodine-131. The quantity of zinc-65 ranged from 4 to 82 nc on the twelve individuals examined. The quantity of cesium ranged from 1 to 10 nc. Thyroid burdens of iodine-131 ranged from less than 30 to 300 pc. Phosphorus-32 was found in the urine, and ranged from 0.1 to 0.2 nc $^{32}P/l$.

The source of iodine-131 and cesium-137 was primarily world-wide fallout from nuclear detonations. Zinc-65 and phosphorus-32 are radionuclides identified with cooling water from the Hanford reactors. These radionuclides enter the food chain in irrigation water drawn from the Columbia River. The principal mode of exposure was through ingestion of milk and other farm produce.

The individual whole-body counter examination results indicated the presence of less than 2 per cent of the maximum permissible body burden established by the NCRP. Thyroid dose estimates ranged from 20 to 80 mrads/year for the individuals having measurable radioiodine burdens.

INTRODUCTION

THE Hanford operation at Richland, Washington, is a complex of nuclear reactors, fuel fabrication plants, chemical separation facilities and research and development laboratories. During the course of operating these facilities various radioactive wastes are generated. The high level wastes are concentrated and retained in storage within the project area. Low level wastes are released to the atmosphere, the Columbia River and to the ground in a controlled manner. These low level wastes are potential sources of radiation exposure to persons living in the vicinity of the project. Controlling low level waste releases so that radiation exposures are within applicable limits is one of the attendant responsibilities to the operation of the plant.

The relationship of the Hanford facilities to local geographical features in general is shown in Fig. 1. The project boundary encloses a controlled area of about 600 square miles. The project is situated along the Columbia River in a semi-arid portion of South-eastern Washington. The natural vegetation of the area is sparse and consists mainly of sagebrush and grasses and is primarily suited to grazing. Irrigation projects associated with upper Columbia River dams are reclaiming sizeable areas for agricultural purposes. The population of the surrounding communities totals about 80,000 people.

In assessing off-site exposures the environmental surveillance program has regularly sampled and analyzed air, water, and farm produce for radioactive materials and made measurements of external radiation. From the results of these analyses, estimates of internal

depositions and radiation exposure to hypothetical individuals of assumed dietary habits are developed. In mid-1962 the use of Hanford's whole-body counter facilities in conjunction with the environmental surveillance program was initiated. The use of these facilities permits direct determination of many radionuclides in the body and avoids many of the assumptions necessary in the usual exposure estimate. The first population group to which this technique was applied was the people from the small and well defined-Ringold farm area. This paper describes the Ringold area, the people who live there and the results of their examinations.

THE RINGOLD FARMS

The Ringold area is the first and one of the few farming areas using Columbia River water drawn for irrigation purposes downstream from the reactors. Ringold amounts to about 500 acres of land situated on a flat between the Columbia River on the west and high bluffs on the east. The area is bounded on the north by the Hanford project boundary and ends on the south where the river meets the bluffs. The area is shown in the aerial photograph of Fig. 2. Ringold is about 13 miles downstream from the nearest production reactor. It is also about 13 miles east of the chemical separations facilities—the shortest air distance to a farming area from the separations plants. The community is about 9 miles upstream from the laboratories and fuel fabrications areas.

The Ringold area and the people who live there are of particular interest in relation to radiation exposure from environmental sources because it is the area nearest the production facilities and therefore would be expected to have the greatest potential for radiation exposure as a result of plant operations. Also significant is the fact that the farming area is small, which makes direct acquaintance with each family practical. There were twenty people living in the Ringold area at the time of this study.

Next to the north boundary (left margin of photograph) is farm A of about 30 acres belonging to A1, age 59 and A2, his wife, age 52. These people have lived at Ringold 16 years. The principal crop produced by the farm is apricots. Though a garden was kept, most of the meat, milk, etc. used by this family is purchased in town. Their water supply is from a well fed by water from Ringold springs. These springs occur on the hillside above their property. These people make little use of Columbia River fish. Recently, the farm was sold to provide for expansion of fish ponds of the State Fisheries Department.

The next area involves about 140 acres which contain newly built fish-rearing ponds under the direction of the State Fisheries and Game Departments. The family, B1, age 22 and his wife, B2, age 19, are the caretakers for the Game Department. They have been at Ringold for about 9 months. They obtain their meat exclusively from game obtained at Ringold. (Both shot deer a short distance from their house.) Their milk is purchased from a local farm beyond the bluffs. They have a garden for vegetables and their water is obtained from a well fed by Ringold Springs. As time permits they expect to make use of Columbia River fish in their food supply.

In the photograph the southern boundary of the Game Department land is a water waste way that terminates in the river just downstream of the ponds. Beyond this, family C leases about 15 acres of land which is in orchards. Family C includes C1, age about 25 years and his wife, C2, age 25 and children, C3—male, age 6 ; C4—female, age 5; C5—male, age 4 and C6—male, age 1. This family has lived at this location for about 2 years and has made almost no use of Ringold produce. Their meat, vegetables, milk, etc. were all purchased in stores. Until recently when their cow came fresh, their milk was prepared exclusively from powdered milk with water from Ringold Springs. They made no use of Columbia River fish. Their orchard was irrigated with water from the waste way and their water supply was from the springs.

The next farm is that belonging to D1, age 58 and his wife D2, age 54 and consists of about 160 acres of permanent pasture. Until recently D1 kept a dairy herd. Presently cattle are kept for meat or for replacements in dairy herds. Irrigation water is taken from the river. Their drinking water is from a well and most of their food is purchased in town.

This family has lived on their Ringold farm for 21 years.

Where Ringold flat is bounded by bluffs an essentially frost free area exists which is ideal for production of fruit. The E farm immediately south of the D pasture is such an area. The principal crop is peaches, but pears, apples, apricots etc. are also grown. A good year would yield over 100 tons of produce from the 45-acre E farm. The E family is composed of E1, male, age 52; his wife—age 46; and children, E3—male, 20; E4—male, 13 and E5—female, age 9. This family has resided at Ringold for 19 years. Their water is from a well and their irrigation water is pumped from the river. They keep a cow or two for their milk needs and a garden for their vegetables and they raise their own beef. They make little use of Columbia River fish.

The last farm consists of 76 acres belonging to F1 and is primarily devoted to raising sheep. There are two members in this family, F1, male, age 50 and daughter, F2, age 15. F1 has lived at Ringold for about 50 years. Most of the food supply used by this family is purchased in stores. Their water supply comes from a well. F1 is an ardent fisherman for Columbia River Steelhead and claims an annual catch of about fifteen such fish.

SOURCE OF ENVIRONMENTAL EXPOSURE

During the past several years the environmental surveillance program has regularly sampled produce from these farms. This produce was radioassayed and the results were used to develop estimates of radiation exposure to a hypothetical Ringold resident of assumed dietary habits. The radionuclides which have been detected in a sufficient number of these samples to be of interest are zinc-65, phosphorus-32, iodine-131 and strontium-90. Zinc-65 and phosphorus-32 are identified with reactor effluent water. These radionuclides enter man through ingestion of Columbia River water downstream from the reactors, from ingestion of milk, meat or produce raised on land irrigated with such water or from consumption of fish and water fowl which inhabit the river. Although small amounts of ^{131}I and ^{90}Sr are released by Hanford facilities, at the time of this study these radionuclides were identified primarily with fallout from nuclear weapons testing.[1] Cesium-137 is also primarily identified with world wide fallout. The foodstuffs of primary interest have been milk and Columbia River fish. Results of the environmental surveillance program have been documented in considerable detail in quarterly and annual reports of the Hanford Laboratories Environmental Studies and Evaluation Operation which are available from the Office of Technical Services, U.S. Department of Commerce.[1]

WHOLE-BODY COUNTER LABORATORY

In November 1962 the families of the Ringold area were invited to be examined in Hanford's whole-body counter. The Hanford whole-body counter facility consists of a low background iron room which is about 10 ft square and whose walls, ceiling and floor are made of steel 10 in. thick. The room weighs about 120 tons. Various scintillation detectors are used in conjunction with a transistorized, multichannel, pulse-height analyzer to satisfy a number of internal dosimetry needs.

For the examination of the Ringold families the pulse-height analyzer was electronically divided into two 200-channel units which could receive signals from two detectors simultaneously. In this way a $9\frac{3}{8} \times 4$ in. NaI detector was used for whole-body counting and a 3×3 in NaI detector was used to measure ^{131}I in the thyroid. The measurement apparatus with a subject in place is shown in Fig. 3. The sensitivity of the thyroid counter for ^{131}I is taken nominally to be 30 pc for a 20-min examination. The sensitivity of the whole-body counter is taken to be 1 nc for either cesium-137 or zinc-65.

RESULTS

The results of the whole-body and thyroid counts of the Ringold families are presented in Table 1.

C1 declined whole-body counter measurement for himself and his children. Based on the dietary habits of the C family it is unlikely that the measurement results for the remainder of the family would differ significantly from those obtained from C2.

Zinc-65 and cesium-137 were detected in all subjects in addition to naturally occurring potassium-40. Iodine-131 was detected in those drinking fresh milk from farms. Fallout

Table 1. Ringold whole-body counter results

Subject	Sex	Age	Exam. date	^{65}Zn		^{137}Cs		^{131}I thyr	
				nc	%NCRPL*	nc	%NCRPL*	pc	%FR
E1	M	52	12/1/62	82	1.4	4.5	0.15	110	1.
E2	F	46	12/1/62	43	0.7	1.1	0.04	48	0.
E3	M	20	12/2/62	20	0.33	2.6	0.09	—	-
E4	M	13	12/1/62	57	0.9	2.2	0.08	300	
			12/22/62	54	0.9	2.5	0.08	170	
E5	F	9	12/1/62	33	0.55	1.4	0.05	120	
			12/22/62	30	0.55	1.4	0.05	55	
C2	F	26	12/2/62	8.6	0.14	4.3	0.14	—	
A1	M	59	12/5	3.6	0.06	4.7	0.14	35	
A2	F	52	12/15	3.6	0.06	4.5	0.15	—	
B1	M	22	12/15	12	0.20	10	0.33	—	
B2	F	19	12/15	4.0	0.07	5.3	0.18	150	
F1	M	50	1/5/63	10	0.17	6.7	0.22	—	
F2	F	15	1/5	5.5	0.09	8.0	0.25	—	

* The values in the column headed "%NCRPL" are the whole-body-counter results expressed as per of the maximum permissible body burden for the critical organ under the "neighborhood" co described by the National Committee on Radiation Protection and Measurements.[2]

† The values in the column headed "%FRCL" are the measured thyroid burdens assumed to 1 year and expressed as percentages of the recommended annual dose to the thyroid for individuals as d by the Federal Radiation Council.[3]

from weapons testing was relatively high in this area at the time of examination which accounts for the occurrence of ^{131}I in the thyroid glands. Fallout was the predominant source of the ^{137}Cs.

In the twelve individuals counted the amount of ^{65}Zn present ranged from 3.6 to 82 nc, ^{137}Cs from 1.1 to 10 nc and ^{131}I ranged from below detection to 300 pc. The whole-body dose corresponding to the largest ^{65}Zn body burden observed (82 nc), assuming standard man parameters and that the amount observed is sustained, is about 7 mrem/year.

An estimate of the thyroid dose in cases of significant measurement of ^{131}I in the thyroid was developed for adults assuming standard man parameters and thyroid burdens sustained at the observed amount. The dose children's thyroids was modified acco the estimated weight of their thyroid. measurements over an extended pe larger of the two measurements for eac children was considered sustained for The thyroid dose estimates on these h presented in Table 2.

Table 2. Estimated thyroid dose

Subject	Age	Thyroid wt. (g)	Thyroid burden ^{131}I (pc)	Dose (rad/year)
B2	19	20	150	0.03
E1	52	20	110	0.02
E4	13	15	300	0.08
E5	9	8	120	0.06

BIOASSAY RESULTS

Of the families at Ringold the most nearly fits the image of a far which makes optimum use of farm for their sustenance. Because of this cooperative spirit in this study t requested (except E3) to provide a 4 urine collection. Hopefully, radioa the urine would indicate the presen radionuclides not observed in the w counter. Radiochemical analyses formed for tritium, plutonium-239, phosphorus-32 and strontium-90. I a gamma scan was performed on Trace amounts of chromium-51, c zirconium-niobium-95, strontium-90 131 were identified in some samples. has been made to interpret trace

FIG. 1. Features of Hanford project and vicinity.

FIG. 2. The Ringold area.

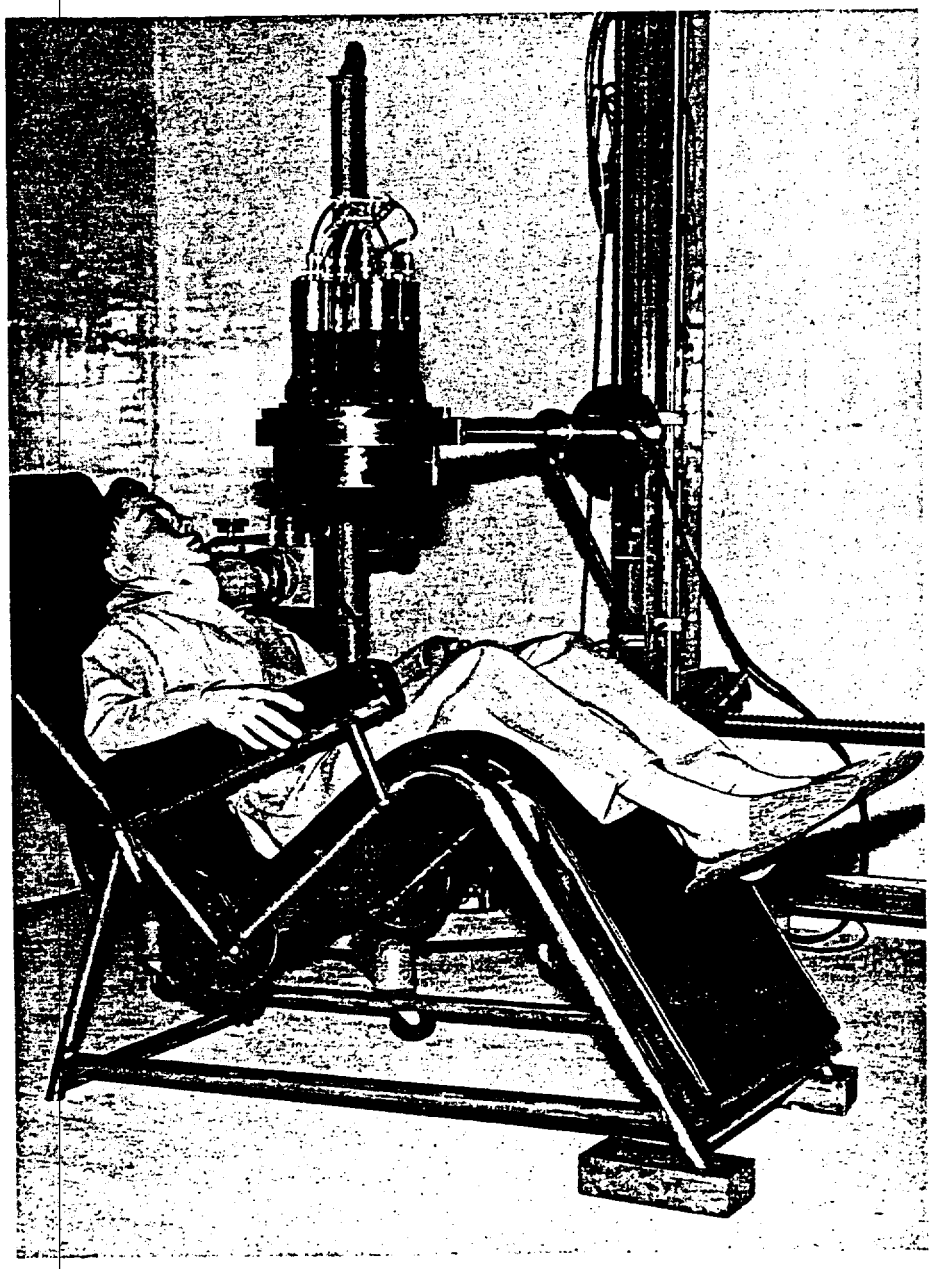

FIG. 3. Ringold examinee and equipment.

terms of body burdens. Neither ^{3}H nor ^{239}Pu were detected in the urine. Small amounts of U on the order of 1–2 μg/l. were found in each sample. The presence of uranium was attributed to its occurrence in well water, which in the Hanford locality is on the order of 2–30 μg/l.[4]

Phosphorus-32 was detected in each member of the E family and ranged from 1.0 to 1.8 $\times$ 10^{-4} μc ^{32}P/l. A comparison may be made between these results and the excretion rate of a man whose body burden of ^{32}P had been established in the course of development of an *in vivo* measurement technique for ^{32}P. This person excreted about 3.5×10^{-3} μc ^{32}P/24-hr voiding while at a level of 0.4 μc in the body. Comparing the E's excretion rates with that above would imply burdens of 0.03 μc for E1, 0.02 for E2, 0.01 for E4 and 0.008 μc for E5. These values in terms of NCRP limits range from 1–5 per cent of the maximum permissible body burden. By another comparison the equilibrium amount of ^{32}P in the body may be determined using standard man parameters and the average concentration of 8×10^{-4} μc ^{32}P/l. measured in milk from the E farm for 1962. Assuming each of the E family consumed such milk at a rate of 1 l./day, the implied body burden would be 0.01 μc which is in fair agreement with the estimate from the analysis of urine.

CONCLUSIONS

The results from examining the Ringold residents have confirmed the place of whole-body counting in environmental surveillance programs. Of primary importance, the whole-body count provides a direct measurement on the subject of interest and avoids dietary assumptions, uptake parameters, etc. It is unlikely that a significant quantity of any gamma-emitting nuclide would go unnoticed. That only a few radionuclides were detected in the Ringold residents and that those present were in sufficiently small amounts to be comfortably within applicable limits were gratifying conclusions of this study.

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